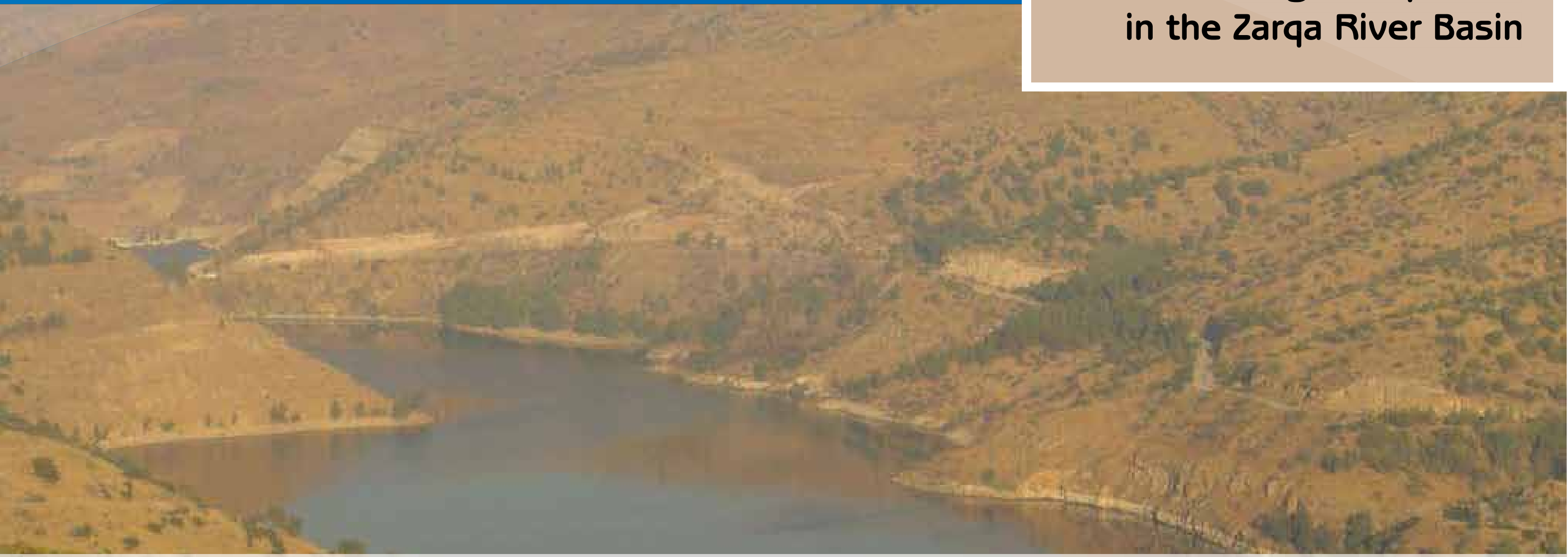
THE HASHEMITE KINGDOM OF JORDAN

Climate Change Adaptation in the Zarqa River Basin



Assessment of Direct and Indirect Impacts of Climate Change Scenarios

(Socio - economical Study, Vol. ll)

MDG-F MDG ACHIEVEMENT FUND

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Assessment of Direct and Indirect Impacts of Climate Change Scenarios

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Assessment of Direct and Indirect Impacts of Climate Change Scenarios

(I) Macro Impacts

Foreword

Jordan is classified as one of the four most water scarce countries in the world. The National Agenda that sets Jordan's development vision till 2015, as well as the United Nations Development Assistance Framework (UNDAF) document (2008-2012), stress that Jordan's remarkable development achievements are under threat due to the crippling water scarcity, which is expected to be aggravated by Climate Change. The UNDAF (2008-2012) addresses four key related challenges to sustain progress towards the MDGs, which include: (i) water scarcity; (ii) drinking water supply security and quality; (iii) health, agriculture and food production vulnerability to Climate Change; and (iv) vulnerability of local biodiversity to Climate Change.

Jordan's Initial National Communication (INC) to the United Nations Framework Convention to Climate Change (UNFCCC) foresees that over the next three decades, Jordan will witness a rise in temperature, drop in rainfall, reduced ground cover, reduced water availability, heat-waves, and more frequent dust storms. The Second National Communication (SNC) to the UNFCCC identifies water as a priority area.

There are several barriers to water sector adaptation to Climate Change that threaten the sustainability of Jordan's achievement of the MDG targets, these include: (i) climate change risks not sufficiently taken into account within sectoral policies and investment frameworks; (ii) existing climate information, knowledge and tools are not directly relevant for supporting adaptation decisions and actions; and (iii) weak national capacity to develop sectoral adaptation responses. Jordan's success in adapting to increased water scarcity and related threats to health, food security, productivity, and human security induced by Climate Change is the key to sustaining its human development achievements and growth.

The government of Jordan represented by the Ministry of Planning and international Cooperation (MOPIC), the Ministry of Water and Irrigation (MWI), the Ministry of Health (MOH), the Ministry of Agriculture (MOA), and the Ministry of Environment (MoEnv) have been the implementing partners in carrying out the activities of the United Nations Country Team (UNCT) Joint programme (JP) on "adaptation to Climate Change to sustain Jordan's MDG achievement" which is supported by a team of UN agencies in Jordan consisting of UNDP, UNESCO, WHO-CEHA, and FAO. The JP has worked on the identification of adaptation barriers and gaps have to be addressed, assessment of the direct and indirect impacts of Climate Change on the health, nutrition, and livelihood security of people, screening and assessing potential adaptation strategies prior to wide scale application, and assessing and strengthening existing national adaptation capacities.

In addition to the key role of the JP to strengthen and develop the capacity of different institutions and communities in adaptation to climate change the JP is to disseminate the wealth of results, information, and studies accumulated during the period of its implementation to stakeholders, scientific and research community, and the public at large.

The component of the JP implemented by the MoEnv in cooperation with UNDP has been focusing on the Zarqa River Basin (ZRB) for its activities. The major activities of this component are: Identifying the direct and indirect impacts of Climate Change on the water sources of the ZRB, identifying barriers and opportunities for Climate Change adaptation in the basin, Developing a Climate Change adaptation programme for the basin, and pilot Climate Change intervention for groundwater protection on one local community in the basin.

This document is the result of the assessment of Climate Change impacts on water resources of the ZRB. It details the impact on the quality and the quantity of both the surface and groundwater resources of the basin. It is hoped that this study will be a motivator for other studies in other basins of the country.

We at the MoEnv hope that this and other studied of the JP will provide a practical guide for the harmonization of the implementation of Climate Change adaptation and issues within the conceptual system of the strategic planning of all concerned parties.

Nayef Hmeidi Al Fayez

Minister of Environment

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This component (MoEnv-UNDP project) was coordinated by a national participatory process that lasted for three and a half years and involved tens of national experts and organizations resulted in the preparation of this and many other studies. The project was funded by the Spanish MDGF, administered by UNDP, and implemented by the Ministry of Environment.

The project was coordinated by:

• Dr. Munjed Al-Sharif – JP and Chief Technical Advisor
• Ms. Rana Saleh - JP assistant

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1 Executive Summary

The study aims at optimizing the water allocation in the ZRB through maximizing the net value added by considering the climate change scenarios developed by the team of the study The current water allocation suffers from unmet demands. In the future, more wastewater will be produced and more treated wastewater is expected to be used due to the increasing population and the increased connection rate and rehabilitation and expansion of the existing treatment plants, allocating more treated wastewater for the irrigation sector would save the fresh water sources for the municipal sector. Currently the irrigation sector suffers high amounts of losses. An improvement in efficiency would contribute in saving more fresh water too.

The mathematical programming approach follows the linear programming model, which is an optimization model that combines unit processes of water utilization systems in the form of linear inequalities. The variables are the levels of the systems› operations and the inequalities express constraints of the overall system (Salman, et al. 2001; Al Weshah, 2000, Doppler et al. 2002; Salman and Al-Karablieh, 2004; A-Karablieh et al., 2006). These models are developed to represent the optimum allocation of water and other inputs so as to maximize profits, subject to constraints on resource availability and institutional capabilities. The procedure usually follows the construction of a flow diagram of sectoral activities, linking up the components of the flow diagram, algebraically formulating linear inequalities and constraints, and estimating the coefficients of the decision variables.

This approach articulate the links between water input alternatives, their availability and other input choices to produce output, and identifies the best or optimal input strategies or the profit maximizing production path that could be followed by firms. In effect, it identifies the most efficient water utilizing options by the production sectors in terms of GDP maximization

As estimated by the consultant, the estimated GDP of horticulture in ZRB was about 70 million JD. About JD 62 million are generated from irrigated system, whereas only about JD 7.7 million are generated form rainfed agriculture. The employment compensation is estimated with JD 16.3 million in irrigated system compared with only about 1.37 million in rainfed system. The total labor compensation is estimated with about JD 17.66 million, by taken an average of JD 2400 annual salaries of agricultural labor, one can estimate the total employment in agricultural activities in ZRB with about 7,358 employees.

Irrigated system employs about 6,783 employees, whereas rainfed system employs about 575 employees. Net irrigation requirements for crops was used to estimate total water used in irrigated horticulture, whereas for the rainfed agriculture the effective rainfall was used to estimate green water used by rainfed agriculture. The estimated water use in ZRB in agricultural sector is estimated with 3.12 mcm, 21.2 mcm and 66.8 mcm for irrigated field crops, vegetables and fruit trees, respectively. The estimated green water utilized form soil moisture is estimated with 44 mcm, 0.23 mcm and 30.7 mcm for rainfed field crops, rainfed vegetables and rainfed fruit trees, respectively. The total water use in agriculture in ZRB was estimated with about 166.3 mcm. Of them 91 mcm are from ground and surface water, 75 mcm from green water.
In this study, future water use are evaluated according to different climate change scenarios through modeling the current socioeconomic situation and forecasting future scenarios of socioeconomic situation based on the Climate Change CC scenarios. The modeling was done through the Water Allocation Model (WAM), and calibrated for the base year 2007 then verified and validated and applied for conducting balances on the future horizon.

The results shows that increase in temperature by 1°C will reduce the total agricultural production by 3.5%, increase water cost by 4.3% and reduce the gross output by 4%, reduce the agricultural DGP in ZRB by 5%. Furthermore, it will increase water consumption by 3.8%. as shown in table below.

Increase in temperature by 2°C will reduce the total agricultural production by 13%, increase water cost by 4.9% and reduce the gross output by 13%, it will reduce the agricultural GDP in ZRB by 15.3%. Furthermore, it will increase water consumption by 4.5%.

The simulation results shows that increase in temperature by 3°C will reduce the total agricultural production by 17.3%, increase water cost by 8.6% and reduce the gross output by 17.3%, it will reduce the agricultural GDP in ZRB by 20.8%. Furthermore, it will increase water consumption by 7.2%.

Increase temperature by 4°C will reduce the total agricultural production by 25.3%, It will increase water cost by 10% and reduce the gross output by 25.8%, it will reduce the agricultural GDP in ZRB by 30.4%. Furthermore, it will increase water consumption by 9.3%.

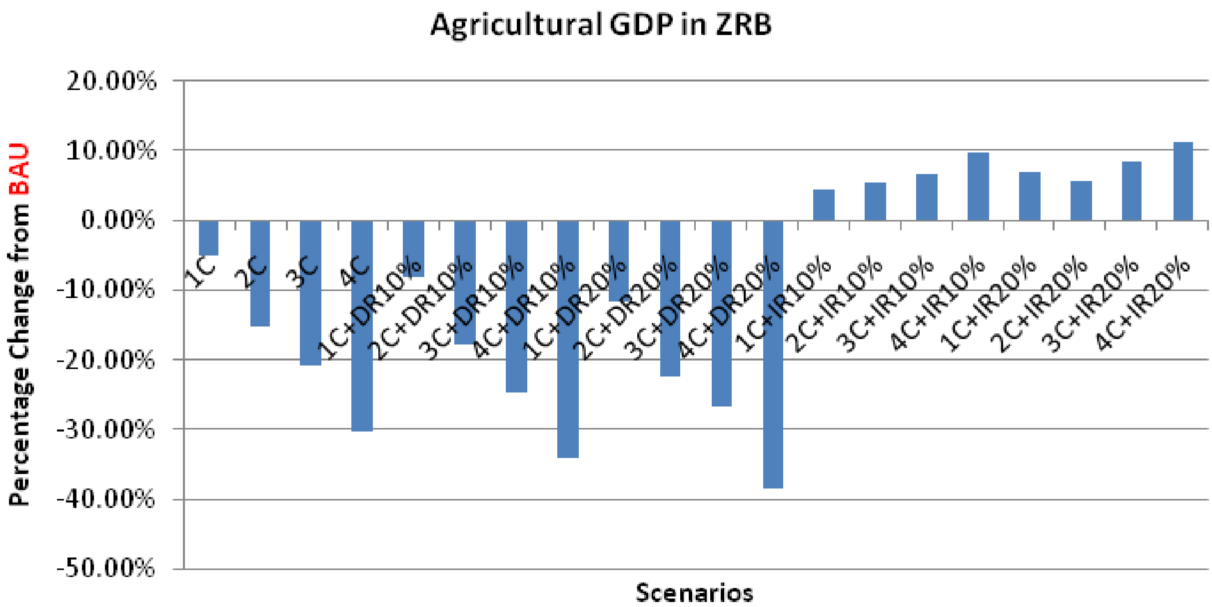
Increase temperature by 1°C companied with decreasing rainfall by 10% will reduce the total cultivated areas by 3.9%, agricultural production will reduce by 6.2%, labor compensations will decrease by 7%, and the agricultural GDP will reduce by 8.2%. Furthermore, it will increase water consumption by only 0.5% as a result of decreasing cultivated areas by 3.9%..

Increase temperature by 4°C will reduce the total agricultural production by 25.3%, It will increase water cost by 10% and reduce the gross output by 25.8%, it will reduce the agricultural GDP in ZRB by 30.4%. Furthermore, it will increase water consumption by 9.3%.
Increase temperature by 4°C and decreasing rainfall by 10% will reduce the total cultivated areas by 12.4%, labor compensations will decrease by 29%%, and the agricultural GDP will reduce by 34.1%. Furthermore, it will decrease water use by 1.2% as a result of decreasing cultivated areas in ZRB
Decreasing Rainfall by 20% under the 4 scenario of increasing temperature will lead to a decrease in cultivated areas form 9.1% , 13.8%, 13.8% and 25.8% for increasing temperatures by 1 °C, 2 °C, 3°C, 4°C, respectively. However, the agricultural GDP will decrease by 11.8%, 22.5%, 26.7% and 38.6% form Business as Usual (BUA) scenario, respectively as shown in the figure below.
Increasing rainfall by 10% under the 4 scenario of increasing temperature will lead to a an increase of cultivated areas between 2.4-3.0% . However, the agricultural GDP will increase by 4.3% to 9.8%. The water consumed by crops will increase from 6.6% to 8.8%.

Summary of Expected Change in Socioeconomic indicators in ZRB as a result of Climate Change

Indicators	Production	Planted Areas	Inter-mediate Consump-tion)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
BAU	586.79	800.61	45.32	9.39	17.66	82.17	124.59	166.29	69.87	42.41
1C	-3.5%	0.0%	-4.0%	4.3%	-4.0%	-3.0%	-4.0%	3.8%	-5.0%	-5.7%
2C	-13.0%	0.0%	-12.9%	4.9%	-12.9%	-10.9%	-13.0%	4.5%	-15.3%	-16.9%
3C	-17.3%	0.0%	-17.2%	8.6%	-17.3%	-14.3%	-17.3%	7.2%	-20.8%	-23.1%
4C	-25.3%	0.0%	-26.1%	10.0%	-25.6%	-21.8%	-25.8%	9.3%	-30.4%	-33.4%
1C+DR10%	-6.2%	-3.9%	-7.2%	2.4%	-7.0%	-6.0%	-7.0%	0.5%	-8.2%	-8.9%
2C+DR10%	-15.6%	-6.2%	-15.5%	2.1%	-15.6%	-13.5%	-15.5%	-0.8%	-17.9%	-19.5%
3C+DR10%	-20.9%	-8.0%	-21.0%	4.8%	-21.0%	-18.0%	-21.1%	-0.1%	-24.7%	-27.0%
4C+DR10%	-28.8%	-12.4%	-29.1%	6.6%	-29.0%	-25.0%	-29.2%	-1.2%	-34.1%	-37.3%
1C+DR20%	-10.6%	-9.2%	-9.8%	1.0%	-10.2%	-8.7%	-10.1%	-3.8%	-11.8%	-12.8%
2C+DR20%	-20.1%	-13.8%	-19.4%	-0.2%	-19.7%	-17.3%	-19.7%	-6.5%	-22.5%	-24.4%
3C+DR20%	-22.9%	-15.4%	-22.9%	3.4%	-23.1%	-19.9%	-23.1%	-5.6%	-26.7%	-29.2%

4C+DR20%	-32.7%	-25.8%	-33.6%	0.6%	-33.4%	-29.7%	-33.8%	-12.5%	-38.6%	-41.9%
1C+IR10%	4.6%	3.0%	4.3%	6.1%	4.5%	4.6%	4.5%	6.6%	4.3%	4.3%
2C+IR10%	5.8%	2.5%	5.2%	6.2%	5.4%	5.4%	5.4%	6.9%	5.4%	5.4%
3C+IR10%	6.7%	2.4%	7.3%	9.2%	7.0%	7.4%	7.1%	8.8%	6.8%	6.6%
4C+IR10%	9.9%	2.9%	9.8%	11.8%	9.9%	10.1%	9.9%	11.5%	9.8%	9.7%
1C+IR20%	7.8%	5.5%	6.9%	8.2%	7.2%	7.1%	7.1%	8.9%	7.0%	7.0%
2C+IR20%	5.6%	4.6%	5.8%	8.1%	5.7%	6.1%	5.9%	8.8%	5.6%	5.5%
3C+IR20%	9.0%	5.0%	8.5%	9.3%	8.7%	8.6%	8.6%	10.6%	8.6%	8.6%
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%



Change in Agricultural GDP in ZRB as a result of Expected climate Change Scenarios

Decreasing Rainfall by 20% under the 4 scenario of increasing temperature will lead to a decrease in cultivated areas form 9.1% , 13.8%, 13.8% and 25.8% for increasing temperatures by 1 °C, 2 °C, 3°C, 4°C, respectively. However, the agricultural GDP will decrease by 11.8%, 22.5%, 26.7% and 38.6% from BUA scenario, respectively.

A positive relationship was found between average monthly temperatures and per-capita consumption with high statistical significance. The result indicate than an increase of 1 C in monthly average temperatures will increase the per capita water demand of (1.18) l/c/d. This relationship was used for future projections for the impact of gradual increase in the average monthly temperature of (1-4 C) on per capita consumption.

The municipal water demand projections indicates that there will be an increase in municipal water demand of approximately 142,000 cubic meter per year due to increases in temperature associated with an increase of temperature of one degree Celsius.

The water demand projections are based on the ones made by the MWI under the National Water Master Plan [MWI, 2004]. These projections were displayed at the AZB level for the period 2010-2050. The overall results of the baseline scenario projection reveal that the total water demand will increase by 52% in 2030 to reach approximately 291 MCM/year (Figure 4). Thus, the total water deficit in the basin will be appreciatively about 108 MCM in 2030 from the recent water demand data of 192 mcm in 2010.

For example, an increase in average monthly temperatures by one degree in the year 2020, the water demand in ZRB will increased from 237 mcm in BAU scenario to 239 mcm. If the average monthly temperature increased with 4 C, the water demand will increase from 237 mcm to 264 mcm, with an increase of 27 mcm as a result of climate change.

The lack of water and poor sanitation standards are also a possible barrier to bridging the gap in the roles played by men and women. When it comes to the individual home, there is a clear bias towards certain tasks for each gender; women have the duties of cooking, cleaning, bathing children, filling the water tanks during 'Water Day,' and determining how much water to be used on which task. It is considered the man's duty to contact the government or company, water the garden, clean the car, order and purchase water services. Although, more women are making decisions regarding buying extra water, ordering the waste disposal truck for cesspits, for complaining to, and purchasing from, the WAJ. The task of cleaning the tank is varied across different communities, with some having women, and others having men, do it.

2 Introduction

There are no site-specific, regional or national short- and long-term socioeconomic assessments of climate change impacts performed to date. Many of the research and assessment activities to date have focused on the development of climate change scenarios, impact of climate change on water budget, agriculture aspects without taking fully into account the socioeconomic aspects of vulnerability that inherently change with time and as a result of policies implemented . For example, increased population growth may place more people and property at risk from increased frequency or intensity of extreme climate events. Conversely, economic growth and development may increase the capacity of a community to withstand and adjust to future changes, thereby reducing the measured impact compared to current circumstances. There is a need to promote the availability of information on the socio-economic aspects of climate change and improve the integration of socio-economic information into impact and vulnerability assessments.

The limited fresh water capacity in Jordan is used as domestic water, in the tourist sector, in industry, in public parks and in agriculture. These competitors for fresh water use have different economic, social and political relevance. With increasing demand in domestic water use as a consequence of increasing population, tourism and individual needs the domestic and tourist sector requires more water in the future. Intensification in agriculture also is mainly based on an increase in water use. In the agriculture sector the main source of irrigation depends on ground water in ZRB and to some extent on rainfall, the range of rainfall is between 100-500mm per year in average leading to an annual fluctuation of the yield depending on the fluctuation of the rainfall. This is especially relevant for strategic crops like wheat and barley.

The latest on population demonstrated that the population of Jordan was about 6.1 million, and still increasing at 2.2 percent per year. Clearly, as the population increases the demand for water increases as well. Furthermore, the distribution of population is unevenly throughout the country as about 60% of the population is located towards governorate of Amman, Zarqa, and Mafraq, all of which are water deficit areas and depend on water importation from other areas. Although the current population growth rate is expected to decline, due to education and birth spacing, the population will continue to place a massive pressure on water resources.

Increasing scarcity of water and requirements in agriculture and strategies to overcome this bottleneck, however, have to consider the fact, that the re-use of water is one strategy to increase water use based on the same natural water capacity. Re-use of used water will bring the problems of consequences of using water of low quality.

2.1 Jordan's Economy: Overview

Jordan's economy is among the smallest in the Middle East, with limited water, oil, and other natural resources, underlying the government's heavy reliance on foreign assistance. Other economic challenges for the government include chronic high rates of poverty, unemployment, inflation, and a large budget deficit. Jordan implemented significant economic reforms, such as opening the trade regime, privatizing state-owned companies, and eliminating most fuel subsidies, which in the past few years have spurred economic growth by attracting foreign investment and creating some jobs. The global economic slowdown, however, has depressed Jordan's GDP growth and foreign assistance to the government in 2009 plummeted, hampering the government's efforts to reign in the large budget deficit.

Jordan is a lower middle income country with a population of 5.9 million and a per-capita Gross National Income (GNI) of JD 2,637 (2009). Jordan has a service-based economy with a moderate Gross Domestic Product (GDP) per capita of 2,979 JD in 2009, which increased from 1,333 JD in 2002. The services sector account for over 70 percent of GDP and more than 75 percent of jobs. Since the late 1990s Jordan has undertaken broad economic reforms in a long-term effort to improve living standards. Since Jordan's graduation from its most recent IMF program in 2002, Jordan has continued to follow IMF guidelines, practicing careful monetary policy, making substantial headway with privatization, and opening trade. Jordan's exports have significantly increased under the free trade accord with the US, which allowing Jordan to export goods duty free to the US. Jordan's economic relationship with the US also extends to its currency, the dinar, which is pegged to the US dollar at $1.41 per dinar (DOS, 2010, and World Bank 2010).

Recently, Jordan used privatization proceeds to significantly reduce its debt-to-GDP ratio. These measures have helped improve productivity and have made Jordan more attractive for foreign investment. The government ended subsidies for petroleum and other consumer goods in 2008 in an effort to control the budget. The main economic challenges facing Jordan are reducing dependence on foreign grants, reducing the budget deficit, attracting investments, and creating jobs (CIA World Fact Book, 2010).

The Kingdom consistently invests more than 25 percent of GDP on human development including education, health, pensions, and social safety nets. The investments in education are important for a resource-poor, yet demographically young country to develop a competitive knowledge-based economy (World Bank 2010).

2.2 Industrial Sector in Jordan

Industry plays a key role in the process of modernization and economic development as it provides the framework within which national resources and factors of production are utilized, know-how acquired, technology transferred and new skills developed. It links all the economic activities of society together and interacts with all sections in meaningful ways. Industry is one of the key contributors to economic growth and main generators of national income in Jordan. Some 17.7 per cent of Jordan's GDP in 2009 or JD 3.12 billion was contributed by the relatively fast-growing industrial sector (CBJ, 2010). More importantly, industry contributes about 90 per cent of the total value of national exports, a very significant and welcome phenomenon for a country keen to establish itself in world markets.

Jordanian industry has also developed a significant degree of diversity. The Amman Chamber of Industry classifies its associated range of productive activities into 10 sub-sectors. These include several traditional sectors, such as the mining of national resources (potash and phosphate), and a number of new ones, such as engineering and manufacturing industries that provide products to meet consumer needs and other requirements, both local and export. The total value of national industrial exports reached about JD 3.58 billion in 2009 of which JD 2.97 billion was made up of industrial products

Industrial water use includes water used to manufacture products such as steel, chemical, and paper, as well as water used in petroleum and metals refining. Industrial water use includes water used as process and production water, boiler feed, air conditioning, cooling, sanitation, washing, transport of materials, and steam generation for internal use

Industrial water-use activities include water withdrawal from ground and surface water; deliveries from public water suppliers. Large industrial water users are more likely to obtain water directly from private wells and may supplement this with water purchased from public water suppliers. Small industries, especially in cities, are more likely to obtain water from public water suppliers. Even if water is purchased from a public water supplier, the water may be treated by the industry before use, especially if pure water is required, as in boiler feed.

2.3 Agricultural Sector in Jordan and in ZRB

The agriculture sector is a major consumer of water, and the returns to water from crop production tend to be low in comparison to other sectors. Below is a summary of the importance of the agricultural sector to the Jordanian economy.

Jordan's economy has continued to perform well over the last five years. The GDP growth at market prices reached 10% in the years 2009. The main contributing sectors were services, manufacturing and producers of government services. The percentage share of agriculture in Jordan's gross domestic product (GDP) has stagnated around 2.5 during the last three years. The annual growth rate of agricultural GDP was fluctuating during the last decade.

The importance of the agricultural sector stems from the fact that it is the major source of food items especially fruits and vegetables and also one of the sources of hard currencies originated from exports. In addition, the agro-industrial sector is characterized by a large number of small enterprises. The total horticultural GDP is estimated by DOS in 2008 by JD 252 million. The contribution of ZRB horticulture is estimated by JD 70 million. Which represent about 27.7% of the total horticultural production in Jordan. Total horticultural output is amounted to JD 450 million. The total output in ZRB is estimated with JD 125 million, which represent 27.6% of total agricultural output in Jordan as shown in Table 1.

Table 1: Economic of Horticultural Production in Jordan in 2008 (Million JD)

Gross output	Jordan	ZRB	Percent
Cereal crops	15,606	13.89	0.894
Vegetables	252,829	57.50	0.227
Fruits tress	143,982	53.19	0.369
Others output such fishers, bees	38,125		
Total Plant Gross Output	450,541	124.59	0.276
Total Horticulture Intermediate Consumption	197,870	45.32	0.229
Total Horticulture Value Added (GDP)	252,670	69.87	0.276
Total Value Added in Agricultural Sector	373,610		
Percentage of Horticulture Contribution to Agr. GDP	68		

Despite its low contribution of 2.5% in the GDP, agricultural exports represent about 9% of Jordan's total exports of which fruit, vegetables and nuts represented 67%. The main destinations of most of these exports are United Arab Emirates, Kuwait, Bahrain, Syria, Lebanon, Qatar and Oman. In contrast to the sophisticated markets in the EU, these destinations do not have high quality and packaging requirements. In the last two years vegetable and fruit exports have jumped and that together they represent almost 70 percent of total agricultural exports. This indicates that there is a high potential for increasing horticultural exports. This potential can be realized in the future depends on tackling major obstacles related to water quantity and quality. Expanding horticultural exports require the availability of additional water resources of high quality to meet sanitary requirements such as the EuropGap and SPS regulations.

Jordan is one of the leading countries of the region in horticultural exports to traditional Arabian Gulf countries and to some EU countries. Total exports amounted to JD 3,179 million whereas agricultural exports amounted to JD 490 million (13% of total exports). The value of vegetable exports amounted to JD 262 million (53% of total agricultural exports). Total volume of horticultural exports amounted to a record figure in 2007 which is 735 thousand tons of which 695 thousand tons are vegetables and 40 thousand tons fruits. While the total volume of exports in 2006 was 578 thousand tons of which 538 thousand tons were vegetables. Total agricultural production of vegetables in 2009 amounted to 1,508 thousand tons. While the production of fruits amounted to 419 thousand tons of which one third is olive (DOS, 2011) In other words, the vegetable exports in 2009 represented more than one-third of Jordan production. While fruits exports constituted only 10 percent of the national production of fruits

The vast majority of irrigated agricultural production is in the form of fresh fruits and vegetables. As indicated in Table 2 more that ninety percent of the irrigated areas in Jordan is under fruits and vegetables. Table 3 shows the percentage of areas in ZRB compared to Jordan, about 78% of cultivated areas of fruit trees are in ZRB..

Table 2: Irrigated and non-irrigated areas under tree crops, field crops and vegetables in 2007

	Jordan			ZRB		
Crops	Total Area (Dunum)	Irrigated Area (Dunum)	Nob-Irrigated Area (Dunum)	Total Area (Dunum)	Irrigated Area (Dunum)	Nob-Irrigated Area (Dunum)
Field Crops	694,869	25,920	668,949	327,782	13,548	314,234
Vegetables	146,799	138,330	8,469	62,202	61,328	873

Fruit Tress	712,545	334,137	378,408	410,631	262,409	148,221
Total	1,554,212	498,387	1,055,825	800,614	337,285	463,329

Source : DOS, 2010. Annual Agricultural Statistics for Jordan and DOS database for ZRB.

Table 3: Percent of Irrigated and non-irrigated areas in ZRB to Jordan in 2007

	Percent ZRB to Jordan		
Crops	Total Area (%)	Irrigated Area (%)	Nob-Irrigated Area (%)
Field Crops	47.2%	52.3%	47.0%
Vegetables	42.4%	44.3%	10.3%
Fruit Tress	57.6%	78.5%	39.2%
Total	51.5%	67.7%	43.9%

Source: Compiled from Agricultural Census for 2007. (DOS, 2010 open file)

In the late sixties and early seventies, the government began developing pilot projects in the desert and the upland of Jordan using groundwater. The expansion in irrigation began in eighties and early nineties by the private sectors through utilizing the groundwater. These activities concentrated on the major basins of Azraq, Amman-Zarka, upper Yarmouk, and the Dead Sea basins. The uncontrolled pumping from these aquifers has exceeded their safe yield to about 150%. The irrigation activities have also been extended to utilize the non-renewable resources of Dissi and Mudwarah area where about 100-110 MCM are being pumped annually from the aquifers and are used for agriculture. Recent studies have estimated that it would be possible to pump about 120 MCM annually from the non-renewable aquifers of Dissi for about 100 years. The total irrigated area in the highland and southern Desert increased from 362 thousand dunums in 1994 to 628 thousand dunums in 2009, the main increase was in the planted areas of fruit tress, mainly olives as shown in Table 4. Furthermore, the total irrigated areas in Jordan during 2009 are about 948,195 dunum.

Table 4: Total Cropped Area by Crop in the Highland, 1994 & 2009 (dunum)

	1994			**2009**		
Crops	**Total Area**	**Irrigated Area**	**Non-Irrigated Area**	**Total Area**	**Irrigated Area**	**Non-Irrigated Area**
Field Crops	1,104,833	68,308	1,036,525	977,080.4	88,816.0	888,264.4
Vegetables	160,691	150,231	10,460	223,153.9	200,039.5	23,114.4
Tree Crops	615,399	143,572	471,826	717,969.5	339,467.8	378,501.8
Total	1,880,922	362,110	1,518,811	1,918,204	628,323	1,289,881

Source: Department of Statistics (2010), Amman, Jordan

Excessive groundwater abstractions from the different aquifers for all purposes have resulted in the decline of groundwater levels and degradation of water quality of some aquifers in the country. Prohibition of well drilling for agriculture in 1992 has been taken as a measure to reduce abstractions from the depleting groundwater resources. In the immediate future, it is expected that other measures and actions undertaken by MWI will also assist to remedy the groundwater management situation

The use of surface water for irrigation in Jordan has declined in both absolute and relative terms from 249 MCM (42%) of total irrigation use in 1996, to 132 MCM (31%) in 2007. Groundwater use decreased from 290 MCM in 1996 to 216 MCM in 2002, with a steady relative portion of 48% of total uses. The amount of reclaimed water used in irrigation rose from 59 MCM (10%) in 1996 to 80 MCM in 2006 (16%) nationwide. Due to the progressive replacement of fresh water with reclaimed originating at the highlands, mostly from Amman-Zarqa urban area, the use of reclaimed water for or irrigation in the downstream of AZB has been increasing steadily and is currently estimated at some 82 MCM; about 81% of the total effluent reuse nationwide.

Volume of irrigation water used in the production of the export crops and the value added there for the period (1994-2002) averaged 74x106 m3 and U.S $0.50/m3, respectively (Haddadin, 2006). The picture soon accelerated thereafter. Jordan's commodity exports in 2002 earned JD 3,179 million (1 JD≈$1.41) of which agricultural exports accounted for JD 490 million or 13% of the total Jordan export activities. Vegetables' export value amounted to JD 262x106 or 53% of total agricultural exports value. Total volume of horticultural exports peaked in 2007 at 735 thousand tons of which 695 thousand tons were vegetables and 40 thousand tons were fruits, up from 578 thousand tons in 2006 of which 538 thousand tons were vegetables and the balance was in fruits. Vegetable exports in 2006 accounted for more than one third of the total vegetable production of the country while fruit export accounted for about 10% of the country's fruit production.

Furthermore, previous studies on the competitiveness of agricultural production and production trends have shown that Jordan enjoys strong comparative advantage in the production of almost all types of vegetable crops and selected tree crops. The calculated comparative advantage indicators in the form of domestic resource coefficients showed a strong comparative advantage for seedless table grapes, green beans and strawberries that are mainly produced during the winter season in the Jordan Valley (Jabarin, 1997).

Therefore, Jordan's indigenous agricultural production provides for food needs and reduces foreign trade deficits in food commodities. It saves on foreign currency demands and improves the current accounts of the country. Agriculture and its downstream activities in Jordan are important employers. Agriculture directly employs about 5% of Jordan's labor force but is source to about 6% of the country's Gross Domestic Product (GDP) when downstream activities are included. Agriculture is the only user of Jordan's "green water" thereby enhancing the efficiency of use of water resources through rain-fed farming. The diversity in Jordan micro-climate allows the production of off-season fruits and vegetables with market advantages for exports. Jordanian agricultural products enjoy status in neighboring countries, especially the Gulf States and Syria. There is inter-annual variability in Jordan's agricultural production owing to the variability in rainfall patterns. Changing political scenes and occasional instability in the Middle East impact the returns from Jordan's agricultural exports.

3 Previous Studies

There are no site-specific, regional or national short- and long-term socioeconomic assessments of climate change impacts performed to date. Many of the research and assessment activities to date have focused on the development of climate change scenarios, impact of climate change on water budget, agriculture aspects without taking fully into account the socioeconomic aspects of vulnerability that inherently change with time and as a result of policies implemented. There is a need to promote the availability of information on the socio-economic aspects of climate change and improve the integration of socio-economic information into impact and vulnerability assessments. However, the following are summarizing the most relevant studies and their results to socio-economic aspects:

- In the First national communication (FNC), the results indicated that climatic changes had a very significant impact on irrigation requirements.
- A study carried out by Salman et al. (2009) discussed the different scenarios /policy options to see their effect on cropping pattern, income, and willingness to pay. Those scenarios are 1) impact of increasing water supply assuming wet year 2) impact of decreasing water supply assuming dry year. The results of the first scenario demonstrated that increasing water supply by 20% led to an increase in the total vegetable production area by 23.8%, the fruit trees area by 9% and field crops by 13.7%. Consequently, this led to an increase in the total net income from JD30.5 million to JD33.5 million (8.7%). While results of the second scenario demonstrated that decreasing water supply has a negative impact on cropping pattern, the total cultivated area will decrease and few crops will leave the solution (tomatoes planted in spring in pen filed, cabbage, cauliflower, banana and citrus were negatively affected by the reduction in water supply, consequently the total net income will decrease and willingness to pay for water will increase as long

as there income was enough to cover the required costs.

- The results of a study carried out by Wolff et al. (2008) indicate that assumptions about political, demographic and economic changes have a far greater impact on agricultural potentials than anticipated changes in the status of climate, water, and land.
- Wolff et al. (2007) based on the estimations from research on Global Climate Change anticipate significant shifts in precipitation and temperatures in the Jordan River watershed forecasted the social and economic impacts from Climate Change on farming systems in riparian countries of the Jordan River. The consequences will unfold in an area with a high variety of institutional, social and economic conditions, which makes it an exemplary case for the need of combined modeling approaches for prognoses on socio-economic impacts. Modeling for Jordan is based on a regional LP model that is more adequate for the use of water for fully irrigated agriculture. The second track focuses on farming systems and enterprises and tries to predict the best decisions of farmers with regard to their economic success. A Ricardian model serves this purpose on the Israeli side, while LP-based farm"=household models are more suitable for impact analyses in Palestinian and Jordanian farming systems. First results from modeling on track 1 show, that improvements in the institutional set"=up and management of water still have a leeway that may probably equalize expected impacts from Climate Change. Results from track 2, however, indicate that both, impacts from Climate Change as well as changes in institutions and management, will lead to a clear distinction between winners and losers among the highly heterogeneous farming systems in the study area.

4 Objectives of Socioeconomic study

The objective of this part of the study is to assess the potential direct and indirect impacts of climate change on socio-economic factors of the vulnerable groups and regions in ZRB

The specific objectives are as follows:

1. To investigate the impact of variability of water quantity on income, cropping patterns, labor and use of inputs at the regional level.
2. To investigate the impact of using water qualities in different regions of the study area at the cropping patterns, income and other production inputs
3. To investigate the consumers' reaction on farm products in the market produced with different types of water and to quantify preferences of different types of consumers in rural and urban markets.
4. To discuss the competitiveness of water use as a comparison between different sectors.

5. To investigated the women role in water and irrigation sector in addition to any other relevant sectors.

5 Methodology for socio-economic study

This part of this research rely on the main report that analyzed the potential direct and indirect impacts of climate change on water availability and quality in Zarqa River Basin (ZRB).

1. The methodology of this study will rely on collecting primary data and secondary data so as to describe the socio-economic status without any change in Climate (Business as usual "BAU").
2. Determination of the main Driving forces that are affecting the socio-economic status like Urbanization & other economics activities. This will be done in the following sectors: Agriculture sector depending on ground water (GW) for irrigation and quality of treated wastewater as well as the rainfall.
3. Building the water allocation model for each of the study areas and feed in the data needed in each sub-macro model.
4. Verification and validation of the base run model that will describe the actual situation of the study area without considering any change in water quantity or quality (Business as usual).
5. Evaluate the impact of climate change scenarios on new optimal cropping patterns and income and the other socio-economic factors
6. Explore the development of women's contribution in the study area and in the agricultural sector as well, in term of holding owners, credit, machinery, land use and the use of source of irrigation… etc.
7. Evaluate the impact of water availability and quality under the climate change scenarios on the socio-economic of stakeholders in the different sectors.
8. Evaluating the impact of water quantity and quality under different climate change scenarios on agricultural income at the macro level of the study sub-areas, labor, productivity and profitability of water, the change in cropping pattern and restriction of planted areas and agricultural production supply and demand.
9. Evaluating the impact of water availability under climate change scenarios on the municipal, industrial, and tourism sectors by calculating water consumption per capita and the increase of monthly water bill (water expenses).

6 Modeling approach for socio-economic

In this study a Water Allocation Model (WAM) will be used as a decision support system to study the impact of changing water quantity of different qualities on socio-economics, mainly for the of the Agriculture sector, after subtracting the amount needed for the other sectors such as Municipal and Industrial sectors of ZRB. WAM has two main goals, first, to provide district and national level planners with a decision support tool for planning agricultural and other sectors activities under various water amounts, qualities, and prices as a result of climate change scenarios; and second to provide with a soundly based analysis of agricultural water demand and its optimal allocation of water and cropping pattern and agricultural income.

WAM is an optimizing model and will deal mainly with irrigated agriculture sector. It uses data on available land, water requirements per unit land area for different crops, and net revenues per unit of land area generated by the growing of those crops. WAM is characterized by the following: (1) application of WAM to actual data suggests that the model closely approximates the actual response of farmers to water prices. (2) WAM results can serve planners as an approximation. (3) A departure of actual behavior from the optima generated by WAM can serve as a signal to planners that further study should be done. (4) WAM provides a quantitative post-optimal sensitivity analysis that can be used to analyze uncertainty, stability of plans and risks. (5) WAM can serve as a decision-support device suggesting to planners what crop patterns are likely to prove optimal under various conditions and relating these to different water policies.

The parametric linear programming model was used of which water demand functions for both water qualities were derived and demand price elasticities estimated. In the normative analysis, a linear programming (LP) was used (Salman, et al. 2001, Doppler et al. 2002, Salman and Al-Karablieh, 2004; Al-Assaf, et al., 2007; Al-Karablieh and Salman 2006; Al-Karablieh et al., 2006)

The mathematical structure of the LP model is consisted of the objective function (Salman et. al, 2001) which can be written as follows:

$$[\ Max\ Z = \sum_{j}\sum_{m}\sum_{K} X_{jmk} * \left[WRC_{jmk} - \sum_{i}\ \sum_{m} \left(P_{in} W_{in} \right) \right]\ ]; \qquad 1$$

where (Z) is the total Gross Margin (GM), ( ) is total planted area by crop (J), and(m) is the water quality (fresh or fresh blended with TWW and rainfall water), (k) is the sub-basin (Above Al-Samra WWTP, Below Al-Samra WWTP and Lower KTD), (i) is months (12 months started from October), (j) is vegetable crop types, ( ) is the Water Related contribution which is the GM of Crop (J) using water

quality (m) in basin (k) without subtracting the costs of irrigation water, ( ) is the price of one cubic meter of irrigation water in month(i) of water quality (m), and ( ) is the available water supply in cubic meters in month (i) according to water quality (m).
The model constraints can be represented as follows:
The water constraints are represented by the equation number (2);

$$[\sum_{j} \sum_{m} \sum_{k} a_{ijmk} X_{jmk} + \sum_{i} \sum_{m} \left(-W_{im}^{0} - W_{i-1,m}^{+} + W_{i+1,m}^{-} \right) \leq 0 \ ]; \qquad 2$$

where ( ) is the water requirements of crop(j)in cubic meters in month (i) irrigated by water quality (m) in sub-basin (k) , ( ) is the total water supply quantity in cubic meters in month (i) of water quality (m). ( ) is the water quantity transferred from month (i -1) of quality (m).( ) is the water quantity transferred to the later month (i +1) of quality (m).
The labor constraint represented with equation number (3);

$$[\sum_{j} \sum_{m} \sum_{k} l_{jk} X_{jmk} \geq 0 \ ]; \qquad 3$$

where (Ljk) is the requirements of labor of crop (j) in hours in sub-basin (k).
The fertilizer constraint represented with equation number (4),

$$[\sum_{j} \sum_{m} \sum_{k} f_{jk} X_{jmk} \geq 0)]; \qquad 4$$

where (fjk) is the requirements of crop (j) of fertilizer in sub-basin (k).
Finally the land constraint which is represented with equation number (5);

$$[\sum_{j} \sum_{k} \sum_{n} X_{jmk} \geq A_{kn} \ ]; \qquad 5$$

where (Akn) is the total allocated area for all crops in sub-basin (k) for crops (n).

WAM is formulated at the regional level for ZRB. Its objective function is the net agricultural income of the district, which is maximized by selecting the optimal mix of water-consuming activities (Vegetables, fruits and field crops). The constraints in WAM involve two factors: water, land area, labor, and production capacity of all crops. For example, one can impose constraints on the availability of

7 Data Collection

Available data and information needed for this project are collected and tabulated in proper format for further analysis. The collected data are checked for completeness, accuracy and representation so as to make it reliable for the application in the study. In addition the data and information of all parameters included in the modeling processes are assessed in terms of its availability to the models.

A single farm enterprise budget for main crops was done, and the data collection took place during the period of 2006-2007. The data were update to represent the current price level of 2010, since the production technology will not change rapidly within a short period of time. As for the data related to production technologies in addition to necessary information of irrigation system, water quantity and quality, the data was gathered by means of questionnaires by MSc. Students, and rapid appraisal by interviewing farmers in ZRB to verify and validate the enterprise budget prepared for the main crops grown in ZRB.

This study also include, but not limited to, published materials, annual statistical yearbooks, databases available at the different ministries and institutions, and interviews and discussions with relevant experts. The main stakeholders are contacted by the project team to obtain the necessary data for updating the existing data on ZRB

Data collection and data bases accessed in the frame of this study relied predominantly on secondary information from official Jordanian sources, which included, beside the Ministry of Water and Irrigation (MWI) and the Department of Statistics (DOS), also other relevant ministries and administrative units. The current state of official data sources includes data from 2008 as the last year of finalized data entries.

The basic source of data was the records of the Department of Statistics' (DOS) agricultural census conducted in 2007. The GIS unit of DOS provides a list of communities in ZRB and necessary agricultural information related to many socioeconomic indicators. Data on producer prices (farm gate price) and production included also most recent and hitherto unpublished information on the year 2009. Further information was obtained from ongoing programs at The Water and Environmental Research and Study Centre (WERSC) and other research units of the University of Jordan.

7.1 Horticultural Crops

The data was collected to estimate gross and net revenue of crops grown in ZRB was performed on a per crop basis. The crops selected for the application are those for which available information exists on maximum and average yields and yield-response factors. The main field crops, vegetables and fruit trees in ZRB are selected. A total of 54 crops were used in the analysis.

12 field crops are: Wheat, Barley, Lentils, Vetch, Chick-peas, Corn, Sorghum, Broom millet, Tobacco, Garlic, Common Vetch, Sesame, Clover, Alfalfa and other filed crops.

The vegetables are consist of 22 crops, these are : Tomatoes, Squash, Eggplants, Cucumber, Potato, Cabbage, Cauliflower, Hot pepper, Sweet pepper, Broad Beans, String Beans, Peas, Cow-peas, Jew's mallow, Okra, Lettuce, Sweet melon, Water melon, Spinach, Onion green, Onion dry, Snake cucumber, Turnip, Carrot, Parsley, Radish and other vegetables crops.

Fruit trees are consist of 14 crops, these are Citrus fruits, Olives, Grapes, Figs, Almonds, Peaches, Plums, prunes, Apricots, Apples, Pomegranates, Pears, Guava, Dates and other fruit trees as well as Bananas.

Figure 1 (Next Page), shows the cultivated areas of horticulture crops in ZRB for minor crops, the figure is restricted to crops with less than 7000 dunum. Figure 2 shows the cultivated areas of Major crops in ZRB. .

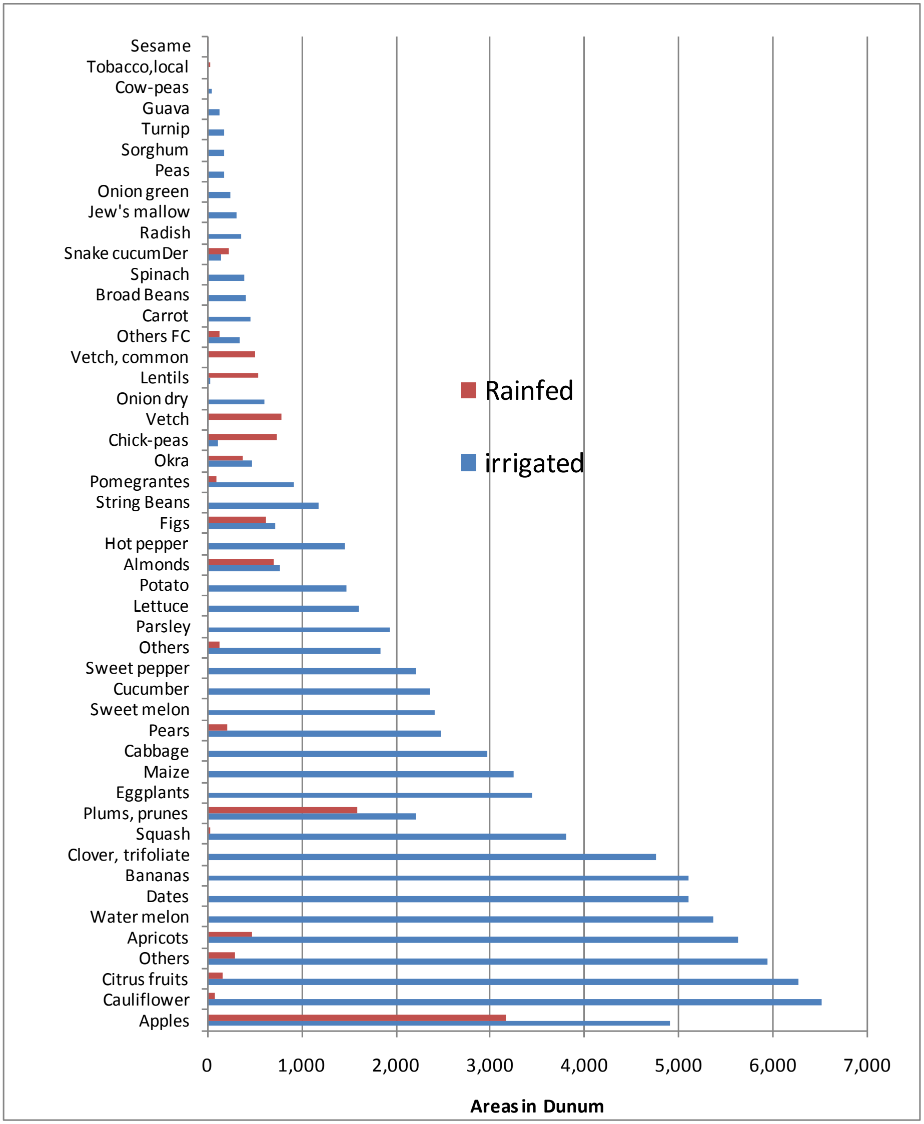


Figure 1: Cultivated Areas in ZRB for Minor Crops by Irrigation Type

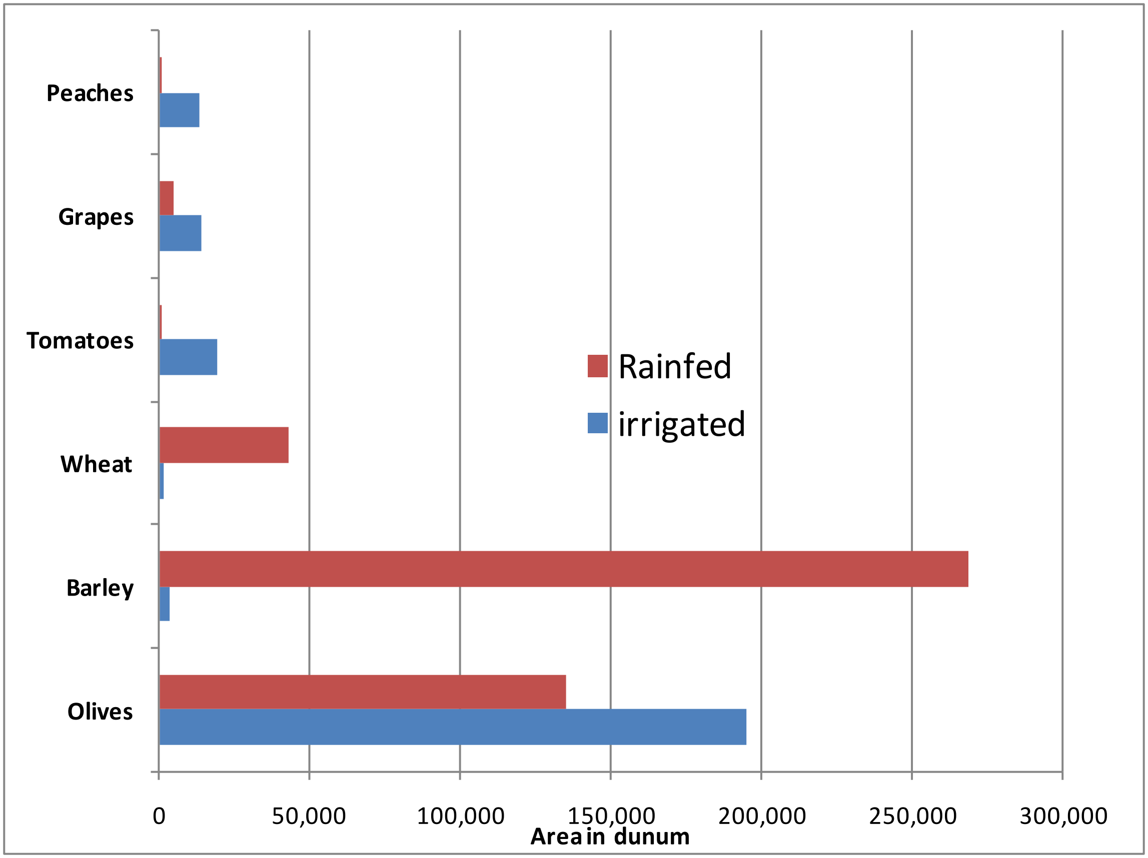


Figure 2: Cultivated Areas in ZRB for Major Crops by Irrigation Type

Table 5: Production, Cultivate Areas and Yield of Crops grown in ZRB by Irrigation System

		Irrigated system			Rainfed system			Total		
No	Crops	Production (ton)	Planted Areas (du)	Crops	Production (ton)	Planted Areas (du)	Crops	Production (ton)	Planted Areas (du)	
1	Wheat	187	1,208	0.155	2,535	42,980	0.059	2,722	44,187	0.062
2	Barley	590	3,689	0.160	16,114	268,562	0.060	16,704	272,251	0.061
3	Lentils	2	19	0.123	25	539	0.047	27	558	0.049
4	Vetch	2	14	0.142	42	777	0.054	44	790	0.055
5	Chick-peas	31	104	0.297	82	725	0.113	113	829	0.136
6	Maize	12,602	3,250	3.877	0	0		12,602	3,250	3.877
7	Sorghum	392	173	2.265	0	0		392	173	2.265
8	Tobacco, local	0	0		2	24	0.073	2	24	0.073
9	Vetch, common	0	0		23	496	0.046	23	496	0.046
10	Sesame	1	6	0.113	0	8	0.043	1	14	0.073
11	Clover, trifoliate	34,967	4,754	7.355	0	0		34,967	4,754	7.355
12	Others FC	33	331	0.099	5	123	0.038	37	454	0.082
13	Tomatoes	187,490	19,024	9.856	101	27	3.746	187,591	19,051	9.847
14	Squash	10,763	3,809	2.826	20	18	1.087	10,783	3,827	2.817
15	Eggplants	13,841	3,440	4.023	3	2	1.547	13,844	3,442	4.022
16	Cucumber	27,415	2,360	11.617	25	5	4.468	27,439	2,365	11.600
17	Potato	5,655	1,473	3.840	0	0	1.477	5,655	1,473	3.840
18	Cabbage	17,805	2,965	6.006	0	0	2.310	17,805	2,965	6.006
19	Cauliflower	27,642	6,524	4.237	129	79	1.630	27,771	6,603	4.206
20	Hot pepper	5,543	1,452	3.818	0	0		5,543	1,452	3.818
21	Sweet pepper	7,273	2,214	3.285	1	1	1.263	7,274	2,215	3.284
22	Broad Beans	627	396	1.583	2	4	0.609	630	400	1.574
23	String Beans	2,462	1,179	2.089	2	3	0.803	2,464	1,182	2.085
24	Peas	435	177	2.461	3	4	0.946	439	181	2.431
25	Cow-peas	49	37	1.354	1	2	0.521	51	39	1.307

26	Jew's mal-low	581	307	1.890	0	1	0.727	581	308	1.888
27	Okra	350	473	0.741	107	375	0.285	457	848	0.539
28	Lettuce	11,521	1,601	7.195	4	2	2.767	11,526	1,603	7.190
29	Sweet melon	13,865	2,416	5.740	0	0	2.208	13,865	2,416	5.740
30	Water melon	33,890	5,369	6.312	11	4	2.428	33,901	5,373	6.309
31	Spinach	1,608	386	4.163	1	1	1.601	1,609	387	4.160
32	Onion green	728	241	3.023	1	1	1.163	730	242	3.015
33	Onion dry	1,767	594	2.974	4	3	1.144	1,771	598	2.964
34	Snake cucum	249	143	1.742	149	223	0.670	398	366	1.089
35	Turnip	970	173	5.619	0	0		970	173	5.619
36	Carrot	2,795	447	6.258	0	0		2,795	447	6.258
37	Parsley	7,235	1,938	3.733	2	2	1.436	7,237	1,939	3.731
38	Radish	1,082	354	3.062	0	0		1,082	354	3.062
39	Others	3,176	1,838	1.727	78	118	0.664	3,254	1,956	1.663
40	Citrus fruits	5,408	6,273	0.862	53	160	0.332	5,461	6,434	0.849
41	Olives	49,364	194,824	0.253	9,204	135,125	0.068	58,568	329,949	0.178
42	Grapes	14,446	13,882	1.041	1,308	4,677	0.280	15,755	18,559	0.849
43	Figs	361	717	0.503	84	620	0.135	445	1,338	0.332
44	Almonds	407	765	0.532	99	692	0.143	506	1,457	0.347
45	Peaches	16,245	13,523	1.201	363	1,124	0.323	16,607	14,647	1.134
46	Plums, prunes	1,297	2,214	0.586	251	1,594	0.157	1,548	3,808	0.407
47	Apricots	3,864	5,626	0.687	87	473	0.185	3,952	6,099	0.648
48	Apples	8,371	4,906	1.706	1,449	3,159	0.459	9,820	8,065	1.218
49	Pomegran-ates	801	908	0.882	23	98	0.237	824	1,006	0.819
50	Pears	2,908	2,479	1.173	66	209	0.315	2,974	2,688	1.106
51	Guava	49	129	0.380	0	0		49	129	0.380
52	Dates	1,878	5,107	0.368	0	0		1,878	5,107	0.368
53	Bananas	6,955	5,104	1.363	0	0		6,955	5,104	1.363
54	Others	6,271	5,951	1.054	82	291	0.283	6,353	6,241	1.018

This study is relied on secondary data for Gross margin that has been collected previously during the period 2007-2008 cropping season and updated according to the input and output prices for the year 2009. Since the recent data on farm gate prices still not relased for the year 2010 from the Department of Statistics. These data are the gross margins for all crops by irrigation system (Irrigated and Rainfed), including the farm gate prices, cost and level of intermediate consumption. Several factors affecting the production process were taken into consideration, such as the planting seasons (spring and autumn), different planting methods (plastic houses, plastic tunnels, and open field).

7.2 The crop coefficients

From the literature available in MWI and Faculty of Agriculture, the crop water requirement will be gathered, more specifically, the data on net water requirements for crop cultivated in different agro-climatological zones in ZRB are averaged into a single figure for the purpose of this study. It is not possible to take into account the influence of aspects such different rainfall precipitation in different location of agro-climatological zones in ZRB as well as the seed varieties that could be used by the farmers.

7.3 Crop Production

Data on crop production in ZRB are fully available from DOS database for each crop considered in each of the 6 governorates and 2 sub-governorate in Jordan Valley. These data encompass cultivated area by crop types, area harvested (du), yield (kg/du). Table 6 show the cultivated areas of by crop type in ZRB compared to total cultivated areas of crop grown in the six governorates that compasses ZRB. Table 7 show the quantities of filed crop production in ZRB, it is clearly shows that clover represent 71% of filed crop cultivated under irrigation system, or about 51% of the total filed crop production followed by barley in rainfed system and corn in irrigated system. Table 8 shows the quantities of vegetable produced in ZRB. Tomatoes represent about 48.4% of the total vegetables production in ZRB followed by water melon (8%, Cauliflowers (7%) and cucumber (7%). Table 9 show the fruit tress production in ZRB, Of course olives represent about 44% of total fuit tress production followed by Peaches (12%) and Grapes (12%).

Table 6: Cultivate Areas in dunum of crops grown in ZRB compared to six Governorates belong to ZRB

Total Gov	Amman	Zerka	Balqa	Mafreq	Jerash	Ajloun	6 GOV.
All Governorates							
Field Crops	135,386	35,185	17,677	161,364	9,795	3,989	363,396
Vegetables	22,805	12,190	116,247	46,779	1,059	427	199,507
Fruit Trees	85,498	101,041	72,195	120,897	67,666	40,102	487,399
Total	243,689	148,416	206,119	329,040	78,520	44,518	1,050,302
Zerka River Basin							
Field Crops	119,075	34,960	6,982	155,552	9,678	1,575	327,822
Vegetables	12,326	10,002	3,444	34,570	789	40	61,172
Fruit Trees	74,868	101,031	34,856	115,527	67,666	18,598	412,546
Total	206,269	145,993	45,282	305,649	78,134	20,214	801,541
Percent of ZRB to Governorate							
Field Crops	0.8795	0.9936	0.3950	0.9640	0.9881	0.3948	0.9021
Vegetables	0.5405	0.8205	0.0296	0.7390	0.7451	0.0948	0.3066
Fruit Trees	0.8757	0.9999	0.4828	0.9556	1.0000	0.4638	0.8464
Total	0.8464	0.9837	0.2197	0.9289	0.9951	0.4541	0.7632

Table 7: Field Crop Production in ZRB under Irrigated and Rainfed System in Tones.

No.	Crops	Irrigated	Rainfed	Total
1	Wheat	187	2,535	2,722
2	Barley	590	16,114	16,704
3	Lentils	2	25	27
4	Vetch	2	42	44
5	Chick-peas	31	82	113
6	Maize	12,602	0	12,602
7	Sorghum	392	0	392
8	Tobacco,local	0	2	2
9	Vetch, common	0	23	23
10	Sesame	1	0	1
11	Clover, trifoliate	34,967	0	34,967
12	Others FC	33	5	37
	Total Filed Crops	48,807	18,827	67,634

Table 8: Vegetable Production in ZRB under Irrigated and Rainfed System in Tones.

No.	Crops	Irrigated	Rainfed	Total
13	Tomatoes	187,490	101	187,591
14	Squash	10,763	20	10,783
15	Eggplants	13,841	3	13,844
16	Cucumber	27,415	25	27,439
17	Potato	5,655	0	5,655
18	Cabbage	17,805	0	17,805
19	Cauliflower	27,642	129	27,771
20	Hot pepper	5,543	0	5,543
21	Sweet pepper	7,273	1	7,274
22	Broad Beans	627	2	630
23	String Beans	2,462	2	2,464
24	Peas	435	3	439
25	Cow-peas	49	1	51
26	Jew's mallow	581	0	581
27	Okra	350	107	457
28	Lettuce	11,521	4	11,526
29	Sweet melon	13,865	0	13,865
30	Water melon	33,890	11	33,901
31	Spinach	1,608	1	1,609
32	Onion green	728	1	730
33	Onion dry	1,767	4	1,771
34	Snake cucumber	249	149	398
35	Turnip	970	0	970
36	Carrot	2,795	0	2,795
37	Parsley	7,235	2	7,237
38	Radish	1,082	0	1,082
39	Others	3,176	78	3,254
	Total Vegetables	386,820	646	387,465

Table 9: Fruit Tress Production in ZRB under Irrigated and Rainfed System in Tones.

No.	Crops	Irrigated	Rainfed	Total
40	Citrus fruits	5,408	53	5,461
41	Olives	49,364	9,204	58,568
42	Grapes	14,446	1,308	15,755
43	Figs	361	84	445
44	Almonds	407	99	506
45	Peaches	16,245	363	16,607
46	Plums, prunes	1,297	251	1,548
47	Apricots	3,864	87	3,952
48	Apples	8,371	1,449	9,820
49	Pomegranates	801	23	824
50	Pears	2,908	66	2,974
51	Guava	49	0	49
52	Dates	1,878	0	1,878
53	Bananas	6,955	0	6,955
54	Others	6,271	82	6,353
	Total Fruit tress	118,624	13,070	131,694
	Total Crop Production	554,251	32,542	586,793

7.4 Cultivation Methods

Data on 2009 crop production are fully available from DOS database for each crop does not distinguishes between crop cultivated under irrigation or in rainfed condition. It is necessary to determine the crop cultivated using different irrigation technology, since the net irrigation requirement will be differ. We use the results of agricultural census conducted in 2007 to estimate the cultivated area under irrigation for different crops in the study.

7.5 Crop Water Requirements

Crop water use, consumptive use and evapo-transpiration (ET) are the terms that are used interchangeably to describe the water consumed by a crop. Water requirement depend mainly on the nature and stage of growth of the crop and environmental conditions. Different crops have different water-use requirements under the same weather conditions. Hence the crop coefficients appropriate to the specific crops are used along with the values of reference evapo-transpiration for computing the consumptive use at different growth stages of the crop by water-balance approach. Crops will transpire water at the maximum rate when soil water is at field capacity. When soil moisture decreases, crops have to exert energy to extract water from soil. Usually, the transpiration rate does not decrease significantly until the soil moisture falls below 50% of field capacity. The evapo-transpiration (Etc in mm) of a crop under irrigation is obtained by the following equation (Sharma, 2001)

$ETc = Kc \times Eto$;

where

Eto is the reference evapo-transpiration and Kc is the crop coefficient. Crop coefficient is dynamic in nature and varies according to crop characteristics, dates of (trans) planting, stage of growth and climatic conditions.

Various methods have been developed to determine the water requirements for specific plants. A comprehensive guide to the details of these methods is Doorenbos and Pruitt (1992). The calculation method is not explained here. For more details on the calculation method, consult an authoritative reference such as Critchley and Siegert (1991), Doorenbos and Pruitt (1992), or Allen et al., (1998).

Several studies were conducted in Jordan on crop water requirements and irrigation scheduling, mainly by researchers Shatanawi et. al. (1986), Shatanawi et al. (1987), Fardous (1983), Ghaw (1988) and Mazahreh (2001), Shatanawi et al. (1994) measured the water consumption of wheat and barley in the Jordan Valley. They found that the ET for wheat and Barley to be 326mm and 304mm, respectively. Ghawi (1988) measures the actual crop evapotranspiration for fodder corn crop, and reported a value of 348 mm, compared to 517mm of the alfalfa crop. Under cover plastic houses, Suwwan et. al. (1985) studied the water consumption for tomatoes, and found that tomatoes plants consumed 490 mm of water inside the plastic house at the Jordan Valley. Mazahreh (1993) used several methods to determine the actual water consumption of mature bananas. She found actual water consumption of mature banana were found to be 1476 mm. Shatanawi et al. (1998) used the literature above to determine the net water requirements of crops planted in Jordan according to agroclimatic zones. The crop net water requirements stated below were adopted from Ministry of Water and Irrigation as shown in Table 10. The total crop-water requirements have been assigned to each crop from different agroclimatic zones of ZRB part of the Jordan Valley.

Table 10: Annual Net Irrigation Requirements (m3/du.) in Jordan Valley of ZRB

Group	MJV Irrigation Project	South Irrigation Project	14.5 km Extension Area
Field Crops	528	527	527
Vegetables	453	337	337

Fruit Tress	1187	984	984
Banana	1992	1625	1625
Citrus	1334	1134	1134

The situation considered is such that there are no available data on quantity of water used in agriculture production for each crop. Therefore, the first step of the method is a quantitative estimation of the water used by the crops. As there are available data on production per crop, the water use of each crop can be estimated. These data on crop water requirement are also obtained from The Ministry of Water and Irrigation and then filled in the models as shown in Table 11. In this case it is preferred to estimate the net irrigating crops water requirements for the crops not the gross water requirements. The average irrigation crop-water requirements for main crops produced in Jordan are shown in Table 11.

Table 11: Annual Average net irrigation Requirements (m3/du) in ZRB

Filed Crops	**CWR**	**Vegetables**	**CWR**	**Fruit Tress**	**CWR**
Wheat	353	Tomatoes	400	Citrus fruits	950
Barley	236	Squash	351	Lemons	950
Lentils	350	Eggplants	293	Oranges, local	950
Vetch	250	Cucumber	320	Oranges, navel	950
Chick-peas	350	Potato	326	Oranges, red	950
Maize	723	Cabbage	326	Oranges, Valencia	950
Sorghum	600	Cauliflower	328	Oranges, French	950
Broom millet	600	Hot pepper	274	Oranges, shamouti	950
Tobacco, local	300	Sweet pepper	318	Clementine	950
Tobacco, red	523	Broad beans	231	Mandarins	950
Garlic	320	String beans	235	Grapefruits	950
Vetch, common	400	Peas	278	Medn. mandarins	950
Sesame	529	Cow-peas	242	Pummelors	784
Clover, trifoliate	529	Jew's mallow	379	Sour oranges	755
Alfalfa	300	Okra	207	Olives	600
Others FC	459	Lettuce	356	Grapes	750

	Sweet melon	356	Figs	750
	Water melon	208	Almonds	750
	Spinach	532	Peaches	750
	Onion green	823	Plums, prunes	1300
	Onion dry	248	Apricots	750
	Snake cucumber	248	Apples	750
	Turnip	237	Pomegranates	750
	Carrot	245	Pears	1395
	Parsley	248	Guava	1400
	Radish	250	Dates	600
	Others Veg.	950	Bananas	1600
			Others Fruit tress	600

7.5.1 Producer prices

The term "prices received by farmers" as a farm-gate price used in to estimated the agricultural national account available from DOS Database, should in theory refer to the national average of individual crops comprising all grades, kinds, and varieties. These prices are determined by the farm gate or first-point-of-sale transactions when farmers participate in their capacity as sellers of their own products. Of course, data might not always refer to the same selling points depending on the prevailing institutional set-up in the country. In addition, different practices prevail in regard to individual crops.

7.5.2 Production Cost

The gross margins needed to be calculated for each crop grown in Jordan in order to analyze the value of water for these crops. The main components of the gross margin analysis are the total return, which is the field production in kg/du multiplied by the farm gate price JD/kg minus the variable cost and the cost of water in JD/du.

The general components of the variable cost are:

1. Water.
2. Fertilizers (trace elements, organic and compound or chemical fertilizer).
3. Pesticides and herbicides.
4. Containers and threads.
5. Plastic mulch used in vegetable production with drip irrigation, and under plastic houses.
6. Soil fumigants.
7. Plastic cover used in plastic tunnels crop enterprises.
8. Fuel and electricity.
9. The costs of hired machinery and seasonal hired labor expressed in hours/ labor, which include planting, spraying, tillage, land preparation, rearing, and crop harvesting , have been calculated for all these operations.

The gross margins were calculated, it was calculated without including irrigation water cost in the total variable cost.

7.6 Data Analysis

Analyses of water demand in the agricultural sector resorted to more detailed data, which allowed for more specific calculations. For crops produced in ZRB, crop water requirements (m3 du-1) are quoted from different sources as shown in Table 11. Total water requirements for each locally produced crop was calculated using another set of DOS data on average land productivity (ton du-1) and total cultivated area (du) Total crop yield (ton) can, thus, be calculated and the respective total water requirements for each crop can be calculated

The revenue earned for each crop was calculated by multiplying their production by farm gate price drawn from DOS. The cost of production for a specific crop was calculated.

On the input side, costs of fertilizers, pesticides, herbicides, fuel and labor were taken into account. These were considered the relevant inputs in the production process. For fertilizers, pesticides and herbicides, the competitive market prices were used to determine costs. For these inputs and the output, market prices are thus considered to equal the shadow price. On the other hand, for the costs of family labor a shadow price was calculated based on previous studies conducted in Jordan and on the scarce data on wage labor in the dataset. A value of JD 7 per day was used. This minimum wage per day would be a correct reflection of the cost of family labor. This type of price corrections, as proposed by Lange & Hassan (2007), is necessary to fulfill the assumptions of the total variable Costs. These net returns were further divided by the amount of water applied (M3) to get the price of water. The contribution of water in the production of each crop was represented by this value.

8 Results and Discussion

8.1 Background information of ZRB

The Zarqa River Basin (ZRB) is the second main tributary to River Jordan after Yarmouk River Basin, and thus one of the most significant basins in the country with respect to its economical, social and agricultural importance. The Basin is located in the central part of Jordan and extends from Jabal Druz east to the river of Jordan in the Ghor west. The ZRB covers an area of 3567 km2 from the upper northern point to its outlet near King Talal Dam (KTD), and part of five governorates, namely; Amman, Balqa, Jarash, Mafraq and Zarqa and it hosts three major cities (Amman is the largest) where about 40% of the country population are living.

The basin is the most complex resource system in Jordan. At the lower end of the basin the King Talal Dam (KTD) with a capacity of 85 Million Cubic Meter (MCM) is located. The stream flow conditions of river are governed by torrential discharge characteristic with very low base flow that ranges from 0.5 to 1.0 m3/s contrasted with irregular flood caused by rain storms of about 54 MCM. The water sources for King Talal Dam are the base flow, flood flows and the effluent of the wastewater treatment plants in the catchment area. King Talal dam is the main source for the irrigation water in middle Ghore area of Jordan Valley (about 120000 dunum). The water quality of King Talal dam is variable all over the year and governed by the blended ratio of water from the different sources. The best quality occurs when the floodwater in the dam is dominant and the waste quality occurs when the effluent of the wastewater treatment plant is dominant.

The groundwater safe yield of the basin is about 90 MCM while the abstraction rate amounts to about 158 MCM in the year 2008 (MWI, 2009). Part of the deficit in Baqa'a and Amman-Zarqa aquifers may be compensated from seepage due to leaks in pipe network or excess irrigation. Amman area receives about 40 MCM from the basin groundwater for municipal uses. Industries in the basins pump about 8 MCM. Extractions for irrigation are estimated at 110 MCM SNC, 2010). The annual effluent of the wastewater treatment plants totals about 85 MCM where most of it flows into KTD while only about 5 MCM are used in the basin and along the river banks for restricted irrigation. Municipal use for all sources, including Amman, totals about 183 MCM/yr in 2008 (consultant estimate, section ??). Industries use about 8 MCM coming mostly from groundwater from their own private wells (SNC, 2010).

Four wastewater treatment plants (WWTPs) (As-Samra, Baq'a, Jarash and Abu Nuseir) are located in the ZRB. As the largest WWTP in Jordan, As-Samra plant serves about one third of Jordan's population . The effluent from the four WWTPs constitutes a significant input to the ZRB dominating the runoff during the summer season.

The topography and runoff in Zarqa River area are dominated by the Amman-Zarqa synclinal structure, which forms a long depression starting in Wadi Abdon west of Amman and runs towards the northeast and then widens gradually. The ground level elevations fall from 800 to 550m a.m.s.l. along the syncline. Zarqa River originates in the upstream part of Amman area at elevation of about 800 m a.m.s.l to form Sail Amman and Sail Al Zarqa and then Zarqa River with the other tributaries. Zarqa River drains to the Jordan River at an elevation of 350 m below sea level (Grabow, and McCornick, 2007).
The average annual precipitation in the western part of Zarqa river basin reaches about 400 mm, while in the eastern part it rarely exceeds 150 mm. The bulk amount of precipitation falls is in the winter season (i.e., between October to May). This area is mainly categorized as semi humid to arid type, covered sparsely with shrub type vegetation. A variety of crops are planted along the river, using some of the available water resources in the basin.
The soil types in the ZRW can be classified into four texture groups (clay, silty clay, silty clay loam, and

silty loam). Soil layer thickness ranges from 50 to 250 cm. In certain parts of the basin soil thickness can be less than 50 cm. (Al-Omari et al. 2009, Al Kuisi et al. 2009)

8.2 Baseline Scenarios (Business as Usual) BAU

A baseline socioeconomic status in ZRB is that conditions that are representative of present day or recent prevailing climatic trends for a given period of time in a specific geographic area. A baseline socioeconomic describes average conditions of water use and current land use. The baseline provides sufficient information on those present-day conditions that will be characterized in the scenarios under a changing climate at the appropriate temporal and spatial scales. It also provides a benchmark against which to measure future changes in climatic variables and to assess the impacts of future changes on the socioeconomic status. A baseline climate scenario may be created to examine the behavior of variables under the current climate (e.g. rainfall under current climate). Table 12 shows the current land use in ZRB as drawn from DOS database. Fruit tress occupy about 35% of the total agricultural land in the ZRB followed by field crops with about (28%) and fallow land with about 15%.

Table 12: Land use in ZRB by Governorate in dunum

Land Use in Dunum	Amman	Zerka	Balqa	Mafreq	Jerash	Ajloun	Grand Total
Field Crops	119,075	34,960	6,982	155,552	9,678	1,575	**327,822**
Vegetables	12,326	10,002	3,444	34,570	789	40	**61,172**
Fruit Trees	74,868	101,031	34,856	115,527	67,666	18,598	**412,546**
Non Residential Building and Construction	1,721	2,396	365	2,135	346	111	**7,074**
Nurseries	65	1	89	2	39	1	**197**
Open Field Cut Flowers	75	3	3	3	6	18	**108**
Covered Cut Flowers	146	0	52	45	1	0	**243**
Temporary Meadows	94	55	0	1,044	156	10	**1,359**
Permanent Meadows	4	308	12	290	43	0	**657**
Forests	2,713	2,999	40	879	581	1,452	**8,663**
Currently Fallow	32,232	60,500	11,262	63,922	14,396	2,886	**185,199**
Potentially Productive Land	6,628	57,956	1,185	13,720	7,655	8,815	**95,960**
Unarable Land	2,913	24,757	1,003	14,380	7,195	2,584	**52,832**

Land Not Classified Else Where	1,992	834	286	2,288	282	24	**5,706**
38	Radish	1,082	0	1,082			
39	Others	3,176	78	3,254			
	Total Vegetables	386,820	646	387,465			

Source: DOS (2010). Database of agricultural census 2007

In addition to other factors, farmers in the short runs rely on Gross Margin (GM) of crops to decide which crops are to be grown, However, in the long run farmers rely on net profit to decide which crops are to be grown, where farmers normally avoid growing risky crops with low GM's
Table 13 shows a comparison between selected vegetables according to their GM's, productivity per dunum. Results show that in general there is an increase in the productivity of vegetable crops that are irrigated with fresh ground water compared to those irrigated with blended TWW from KTD. Consequently, The average GM value and the profitability of one dunum for irrigated and rainfed agriculture in ZRB are shown in

For example, the net profit of irrigated wheat is 18 JD/du compared to 13 JD/du for rainfed wheat. The resulting 5 JD/du is due to irrigation. Divided this amount to additional supplemental irrigation of 135 m3/du , this yield a net revenue of 0.037 JD/m3. However, it can be noticed that the productivity and the GM of vegetables during the spring season are in general greater than those during autumn season, this can be attributed to high temperatures during spring season.

Table 13: Result of Enterprise Budget of Irrigated and Rainfed Crop grown in ZRB

No.	Crops	Irrigated				Rainfed			
		Total Return (JD/du)	Total Cost (JD/du)	Gross Margin (JD/du)	Net Profit (JD/du)	Total Return (JD/du)	Total Cost (JD/du)	Gross Margin (JD/du)	Net Profit (JD/du)
1	Wheat	67	49	24	18	25	13	15	13
2	Barley	51	34	20	17	19	9	12	10
3	Lentils	60	50	11	10	23	15	8	8
4	Vetch	42	38	5	4	16	11	6	5
5	Chick-peas	178	129	52	49	68	45	24	22
6	Maize	671	526	179	146	255	184	84	71
7	Sorghum	249	194	67	55	95	64	35	30
8	Tobacco, local	77	60	22	17	29	21	10	8

9	Vetch, common	30	32	0	-2	12	8	4	3
10	Sesame	74	64	14	10	28	20	9	8
11	Clover, trifoliate	1,066	599	532	468	405	219	211	186
12	Others FC	25	28	-2	-3	9	7	3	3
13	Tomatoes	1,125	643	588	482	428	230	238	198
14	Squash	635	453	214	182	244	161	95	83
15	Eggplants	592	400	212	193	228	143	92	85
16	Cucumber	2,579	1,430	1,390	1,149	992	538	546	454
17	Potato	730	542	224	187	281	196	98	84
18	Cabbage	723	429	323	294	278	153	136	125
19	Cauliflower	794	469	358	326	306	168	150	137
20	Hot pepper	344	226	157	118	132	77	71	56
21	Sweet pepper	811	563	340	248	312	205	143	107
22	Broad Beans	674	362	339	312	259	127	143	132
23	String Beans	1,175	439	771	736	452	157	309	295
24	Peas	1,162	596	612	566	447	219	246	228
25	Cow-peas	875	479	431	396	336	172	178	165
26	Jew's mallow	211	155	67	56	81	46	40	36
27	Okra	1,059	698	423	361	407	253	178	154
28	Lettuce	995	557	497	438	383	201	205	182
29	Sweet melon	1,238	936	356	301	476	347	150	129
30	Water melon	858	640	261	218	330	231	115	99
31	Spinach	570	385	219	185	219	128	104	91
32	Onion green	1,101	762	416	339	424	263	191	161
33	Onion dry	692	511	229	181	266	184	101	82
34	Snake cucum.	591	402	225	190	227	141	99	86
35	Turnip	624	421	240	203	240	149	105	91
36	Carrot	803	523	327	280	309	192	135	117
37	Parsley	448	303	172	145	172	107	75	65
38	Radish	464	313	179	151	179	111	78	67
39	Others	250	248	18	3	96	60	42	36
40	Citrus fruits	371	355	53	16	143	114	43	29

41	Olives	97	80	26	17	26	16	12	10
42	Grapes	472	334	162	138	127	81	52	46
43	Figs	211	125	99	86	57	25	35	32
44	Almonds	415	227	213	188	112	52	66	59
45	Peaches	396	262	166	134	107	62	53	45
46	Plums, prunes	538	502	89	36	145	116	43	29
47	Apricots	578	377	247	201	155	90	78	65
48	Apples	515	267	295	249	139	61	90	78
49	Pomegran-ates	394	289	125	105	106	66	46	40
50	Pears	778	533	307	245	209	121	105	88
51	Guava	171	166	19	5	46	27	23	19
52	Dates	221	126	128	95	59	28	40	31
53	Bananas	687	432	338	255	185	89	118	96
54	Others	100	94	16	6	27	17	13	10

Table 14: Cropping Pattern in ZRB by Irrigation Technology (in dunum)

No.	Technology	Plastic Houses Drip	Plastic Tunnels		Open Field			Irrigated	Non-Irrigated	Total Area of crop
			Drip	Surface	Sprinklers	Drip	Surface			
1	Wheat				134	86	988	1,208	42,980	44,187
2	Barley				1,832	77	1,780	3,689	268,562	272,251
3	Lentils				0	0	19	19	539	558
4	Vetch				10	0	4	14	777	790
5	Chick-peas				0	0	104	104	725	829
6	Maize				9	1,968	1,273	3,250	0	3,250
7	Sorghum				0	64	109	173	0	173
8	Tobacco, local				0	0	0	0	24	24
9	Vetch, com-mon				0	0	0	0	496	496
10	Sesame				0	0	6	6	8	14
11	Clover, trifoliate				2,599	86	2,070	4,754	0	4,754
12	Others FC				1	146	184	331	123	454

13	Tomatoes	279.1	720.2	23.5	5.1	15,843.8	2,152.2	19,023.8	27.0	19,051
14	Squash	33.2	443.7	20.5	5.4	3,077.1	229.3	3,809.1	18.0	3,827
15	Eggplants	56.8	131.7	16.2	6.7	2,502.1	726.9	3,440.4	1.9	3,442
16	Cucumber	2,105.3	98.4	0.0	10.8	138.3	7.1	2,359.9	5.5	2,365
17	Potato	1.0	5.9	0.0	5.4	1,431.4	29.0	1,472.7	0.0	1,473
18	Cabbage	0.0	0.0	0.0	6.7	2,743.5	214.4	2,964.6	0.0	2,965
19	Cauliflower	0.0	0.0	0.0	23.9	5,043.7	1,456.4	6,524.0	79.3	6,603
20	Hot pepper	21.1	51.5	0.0	1.6	1,087.1	290.4	1,451.6	0.0	1,452
21	Sweet pep-per	250.1	136.6	0.0	0.7	1,633.3	193.4	2,214.1	0.6	2,215
22	Broad beans	0.0	0.4	0.6	7.5	306.3	81.4	396.1	3.9	400
23	String beans	50.4	0.3	0.0	0.7	1,012.2	115.1	1,178.8	3.0	1,182
24	Peas	58.0	0.0	0.0	2.2	70.1	46.6	176.9	3.6	181
25	Cow-peas	0.0	0.0	0.0	0.0	25.0	11.5	36.5	2.2	39
26	Jew's mal-low	15.0	30.7	0.0	0.0	203.6	58.1	307.3	0.5	308
27	Okra	0.0	0.8	0.0	0.0	408.9	63.4	473.1	374.7	848
28	Lettuce	0.0	0.0	0.0	4.0	1,431.8	165.6	1,601.4	1.6	1,603
29	Sweet melon	0.1	334.2	20.5	0.0	1,834.3	226.5	2,415.6	0.0	2,416
30	Water melon	0.0	953.8	287.2	0.0	3,732.2	395.6	5,368.8	4.4	5,373
31	Spinach	0.0	0.0	0.0	8.9	262.6	114.8	386.3	0.5	387
32	Onion green	0.0	0.0	0.0	0.0	202.6	38.3	240.9	1.1	242
33	Onion dry	0.0	0.0	0.0	2.2	452.3	139.7	594.2	3.4	598
34	Snake cucumber	0.0	0.0	0.0	0.0	73.2	69.7	142.9	222.8	366
35	Turnip	0.0	0.0	0.0	0.0	162.7	10.0	172.7	0.0	173
36	Carrot	0.0	0.0	0.0	3.6	319.4	123.6	446.6	0.0	447
37	Parsley	0.0	0.0	0.0	1.5	1,846.1	90.2	1,937.8	1.6	1,939
38	Radish	0.0	0.0	0.0	1.6	250.0	101.9	353.6	0.0	354
39	Others Veg	364.1	194.5	0.0	2.9	891.8	385.2	1,838.5	117.8	1,956
40	Citrus fruits					3,137	3,137	6,273	160	6,434

41	Olives					97,412	97,412	194,824	135,125	329,949
42	Grapes					6,941	6,941	13,882	4,677	18,559
43	Figs					359	359	717	620	1,338
44	Almonds					382	382	765	692	1,457
45	Peaches					6,762	6,762	13,523	1,124	14,647
46	Plums, prunes					1,107	1,107	2,214	1,594	3,808
47	Apricots					2,813	2,813	5,626	473	6,099
48	Apples					2,453	2,453	4,906	3,159	8,065
49	Pomegran-ates					454	454	908	98	1,006
50	Pears					1,239	1,239	2,479	209	2,688
51	Guava					65	65	129	0	129
52	Dates					2,553	2,553	5,107	0	5,107
53	Bananas					2,552	2,552	5,104	0	5,104
54	Others FT					2,975	2,975	5,951	291	6,241
	Total	**3,234**	**3,103**	**369**	**4,686**	**180,617**	**145,278**	**337,285**	**463,329**	**800,614**

8.2.1 Main socioeconomic indicators

The quantities of water consumed by field crops under irrigation (Blue water mainly ground water) are estimated with about 3 mcm, whereas the water used form the root zone of the plant though precipitation (green Water) was estimated with about 44 mcm. The water quantities consumed by vegetables are estimated with about 21.2 mcm from blue water and only about 0.2 mcm from green water. The water quantities used in ZRB was for fruit tress using ground water with about 66 mcm, the green water consumed by fruit tress is estimated with about 30.7 mcm. The total blue water used in horticulture in ZRB was estimated with about 91.1 mcm and green water with about 75.1 mcm. As shown Table 15.

As shown in Table 15 the main water consuming actives are Olive tress, tomatoes, banana in lower ZRB, grapes and Peaches

Table 16 shows the result of WAM model applied to ZRB. The total volume of field crop production amounted to 48 thousand tones from irrigated areas in ZRB mainly clover. The total volume of horticultural production amounted to 586.8 thousand tones. The total cultivated areas in ZRB are estimate with 800 thousand dunum distributed as 337 thousand dunum under irrigation system and

463 thousand dunum under rainfed system. The fruit tress occupy 262 thousand dunums whereas rainfed field crop occupy 327 thousand dunums

The estimated GDP of horticulture in ZRB was about 70 million JD. About JD 62 million are generated from irrigated system, whereas only about JD 7.7 million are generated form rainfed agriculture. The employment compensation is estimated with JD 16.3 million in irrigated systems compared with only about JD 1.37 million in rainfed system. The total labor compensation is estimated with about JD 17.66 million, by taken an average of JD 2400 annual salaries of agricultural labor, one can estimate the total employment in agricultural activities in ZRB with about 7,358 employees.
Irrigated system employs about 6,783 employees, whereas rainfed system employs about 575 employees

The estimated water use in ZRB in agricultural sector is estimated with 3.12 mcm, 21.2 mcm and 66.8 mcm for irrigated field crops, vegetables and fruit trees, respectively. The estimated green water utilized form soil moisture is estimated with 44mcm, 0.23 mcm and 30.7 mcm for rainfed field crops, rainfed vegetables and rainfed fruit trees, respectively. The total water use in agriculture in ZRB was estimated with about 166.3 mcm. Of them 91 mcm are from ground and surface water, 75 mcm from green water based on the above calculations. .

Table 15: Water use by crops in ZRB by Irrigation Technology (in m3)

No.	Crops	Blue Water Consumptio	Green Water Consumpt
1	Wheat	185,502	8,595,973
2	Barley	409,590	34,913,106
3	Lentils	1,896	134,797
4	Vetch	1,464	116,484
5	Chick-peas	10,400	181,355
6	Maize	1,291,990	0
7	Sorghum	41,665	0
8	Tobacco, local	0	8,433
9	Vetch, common	0	148,799
10	Sesame	592	3,389
11	Clover, trifoliate	1,146,315	0
12	Others FC	31,661	44,052

13	Tomatoes	7,010,946	6,738
14	Squash	1,219,335	3,603
15	Eggplants	949,042	475
16	Cucumber	613,443	1,391
17	Potato	434,309	0
18	Cabbage	884,212	0
19	Cauliflower	2,022,998	20,302
20	Hot pepper	373,389	0
21	Sweet pepper	638,056	162
22	Broad Beans	123,913	1,007
23	String Beans	357,148	781
24	Peas	45,375	936
25	Cow-peas	12,035	566
26	Jew's mallow	108,674	142
27	Okra	178,445	98,931
28	Lettuce	525,161	430
29	Sweet melon	790,804	0
30	Water melon	2,015,421	1,174
31	Spinach	198,120	145
32	Onion green	184,748	291
33	Onion dry	195,993	918
34	Snake cucumber	49,603	60,377
35	Turnip	53,043	0
36	Carrot	104,706	0
37	Parsley	437,066	444
38	Radish	84,729	0
39	Others	1,611,037	32,518
40	Citrus fruits	3,547,499	51,308
41	Olives	37,990,692	27,024,923
42	Grapes	4,331,286	1,309,444
43	Figs	223,819	173,640
44	Almonds	238,596	193,768
45	Peaches	4,219,299	314,602
46	Plums, prunes	1,554,416	446,251

47	Apricots	2,303,903	132,535
48	Apples	1,913,378	947,774
49	Pomegranates	398,479	24,401
50	Pears	1,981,728	58,627
51	Guava	84,441	0
52	Dates	1,095,426	0
53	Bananas	5,076,111	0
54	Others	1,856,590	81,381
	Filed Crops	3,121,076	44,146,387
	Vegetables	21,221,751	231,332
	Fruit tress	66,815,663	30,758,656
	Total (M3)	**91,158,489**	**75,136,375**

Table 16: Socioeconomic indicators (Business as Usual)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	48.81	13.55	2.77	0.31	1.28	4.80	7.59	3.12	4.51	2.79
Vegetables	386.82	61.33	19.89	2.23	9.10	35.32	57.23	21.22	35.11	21.92
Fruit Tress	118.62	262.41	18.70	6.85	5.90	35.79	48.03	66.82	22.48	12.25
Total Irrigated	**554.25**	**337.29**	**41.36**	**9.39**	**16.28**	**75.90**	**112.86**	**91.16**	**62.11**	**36.96**
Field Crops	18.83	314.23	1.80	0.00	0.71	2.96	6.30	44.15	4.50	3.34
Vegetables	0.65	0.87	0.09	0.00	0.05	0.16	0.27	0.23	0.18	0.11
Fruit Tress	13.07	148.22	2.08	0.00	0.60	3.15	5.16	30.76	3.08	2.01
Total Rainfed	**32.54**	**463.33**	**3.97**	**0.00**	**1.37**	**6.27**	**11.73**	**75.14**	**7.76**	**5.46**
Field Crops	67.63	327.78	4.56	0.31	2.00	7.76	13.89	47.27	9.02	6.14
Vegetables	387.47	62.20	19.98	2.23	9.15	35.48	57.50	21.45	35.29	22.02
Fruit Tress	**131.69**	**410.63**	**20.78**	**6.85**	**6.51**	**38.94**	**53.19**	**97.57**	**25.56**	**14.26**
Total ZRB	**586.79**	**800.61**	**45.32**	**9.39**	**17.66**	**82.17**	**124.59**	**166.29**	**69.87**	**42.41**

8.3 Socioeconomic Status as a Result of Climate Change Scenarios

Climate change scenarios describe plausible future changes in climate variables and are usually measured with respect to baseline climate conditions. Although climate change scenarios can be applied directly to support risk analysis, most (biophysical) impact assessments require inputs of future climate states, rather than changes, with relation to the baseline reference period, in order to assess potential impacts of projected changes in climate. Climate scenarios usually combine observed baseline climate with estimates of future climate changes. These possible changes are often derived from climate model outputs

The team developing incremental scenarios is the simplest way to obtain climate change scenarios. They provide a wide range of potential regional climate changes and help identify sensitivities to changes in temperature and precipitation. For each location in the study area, increases in temperature of +1°C, +2°C, +3°C and +4°C were combined with no change, and with –20%, –10%, +10%, and +20% changes in precipitation (Table 17). As a result, 20 incremental climate change scenarios were developed for each station

Table 17: Increments used to construct the 20 incremental climatic change scenarios

Dry Scenarios							
– 20%				– 10%			
+ 1 °C	+ 2 °C	+ 3 °C	+ 4 °C	+ 1 °C	+ 2 °C	+ 3 °C	+ 4 °C
Normal Precipitation Scenarios							
0%							
+ 1 °C		+ 2 °C		+ 3 °C		+ 4 °C	
Wet Scenarios							
+ 20%				+ 10%			
+ 1 °C	+ 2 °C	+ 3 °C	+ 4 °C	+ 1 °C	+ 2 °C	+ 3 °C	+ 4 °C

In order to detect any trends in the socioeconomic status in ZRB a climate change scenario was fed in the model by taking into account the available water, yield response to climate change and changes in cropping pattern as a result of increasing or decreasing available water

Changes in climate in terms of precipitation patterns and evapo-transpiration will directly affect soil moisture status, surface runoff and groundwater recharge. In regions with decreasing precipitation, soil moisture may be substantially reduced

Climate change can affect food production in the region in several ways. Changes in temperature and precipitation regimes are likely to impact agro-ecological potential and constraints, including

1. changes in the area suitable for growing rain-fed production of cereals and other food crops,
2. modifying crop irrigation requirements, (increase of crop water requirements)
3. shorter growing period
4. changing in cropping pattern such as shorter growing season and some expected benefit from the increase in winter temperatures and a longer growing season in the highland.

Thus, agricultural production and productivities will be vulnerable to climate change, if the shifts in weather patterns can impact yields significantly. Increasing temperature is expected to increase evapotranspiration rates thereby reducing soil moisture, infiltration and aquifer recharge. A study of aquifers in Saudi Arabia shows that increase in temperature by 5 °C will reduce groundwater recharge by 465 million m3/year. Moreover, increasing evapotranspiration will significantly increase crop water requirement and irrigation demand.

Table 18 summarize the magnitude of change on the socioeconomic indicators in ZRB as a result of 20 climate change scenarios, whereas Table 19 shows the percentage change in the socioeconomic indicators compared to BAU baseline.

Increasing temperature is expected to increase evapotranspiration rates thereby reducing soil moisture, infiltration and aquifer recharge. Assuming that the cultivated areas will not change as a result of increasing temperatures, the simulation results shows that increase in temperature by 1°C will reduce the total agricultural production by 3.5%, increase water cost by 4.3% and reduce the gross output by 4%, reduce the agricultural DGP in ZRB by 5%. Furthermore, it will increase water consumption by 3.8%.

The simulation results shows that increase in temperature by 2°C will reduce the total agricultural production by 13%, increase water cost by 4.9% and reduce the gross output by 13%, it will reduce the agricultural GDP in ZRB by 15.3%. Furthermore, it will increase water consumption by 4.5%.

The simulation results shows that increase in temperature by 3°C will reduce the total agricultural production by 17.3%, increase water cost by 8.6% and reduce the gross output by 17.3%, it will reduce the agricultural GDP in ZRB by 20.8%. Furthermore, it will increase water consumption by 7.2%.

Increase temperature by 4°C will reduce the total agricultural production by 25.3%, It will increase water cost by 10% and reduce the gross output by 25.8%, it will reduce the agricultural GDP in ZRB by 30.4%. Furthermore, it will increase water consumption by 9.3%. The Table 30 to Table 33 in the annex shows the detail results of increasing temperatures from 1-4°C on the irrigated and rainfed agriculture in ZRB.

Table 18: Socioeconomic Impact of CC on ZRB by Scenarios compared to BAU

Indicators	Production	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
BAU	586.79	800.61	45.32	9.39	17.66	82.17	124.59	166.29	69.87	42.41
1C	566.34	800.61	43.51	9.79	16.96	79.67	119.66	172.69	66.37	39.99
2C	510.69	800.61	39.46	9.85	15.38	73.2	108.45	173.84	59.15	35.25
3C	485.24	800.61	37.53	10.2	14.6	70.45	103.07	178.25	55.34	32.62
4C	438.62	800.61	33.51	10.33	13.14	64.26	92.5	181.71	48.66	28.24
1C+DR10%	550.44	769.35	42.05	9.62	16.42	77.22	115.84	167.09	64.16	38.62
2C+DR10%	494.97	750.58	38.3	9.59	14.91	71.1	105.22	164.98	57.33	34.12
3C+DR10%	464.18	736.9	35.81	9.84	13.95	67.34	98.28	166.09	52.63	30.94
4C+DR10%	417.55	701.61	32.15	10.01	12.53	61.64	88.23	164.23	46.07	26.59
1C+DR20%	524.37	726.56	40.88	9.48	15.86	75.03	112.01	159.96	61.65	36.97
2C+DR20%	468.98	690.34	36.52	9.37	14.18	67.96	100.03	155.46	54.14	32.07
3C+DR20%	452.23	677.17	34.94	9.71	13.58	65.79	95.84	157.04	51.19	30.04
4C+DR20%	395.11	594.11	30.08	9.45	11.76	57.77	82.44	145.48	42.91	24.66
1C+IR10%	613.81	824.82	47.29	9.96	18.46	85.93	130.15	177.23	72.9	44.22
2C+IR10%	621.11	820.71	47.68	9.97	18.62	86.61	131.32	177.74	73.67	44.71
3C+IR10%	625.9	820.18	48.63	10.25	18.89	88.27	133.49	180.9	74.61	45.22
4C+IR10%	645.05	823.68	49.76	10.5	19.4	90.44	136.95	185.47	76.69	46.51
1C+IR20%	632.38	844.63	48.45	10.16	18.93	88.03	133.38	181.16	74.78	45.36
2C+IR20%	619.58	837.09	47.97	10.15	18.67	87.18	131.92	180.94	73.8	44.74
3C+IR20%	639.78	840.91	49.17	10.26	19.19	89.24	135.3	183.96	75.86	46.06
4C+IR20%	653.64	859.12	50.43	10.6	19.67	91.59	138.83	192.38	77.79	47.24

Increase temperature by 1°C companied with decreasing rainfall by 10% will reduce the total cultivated areas by 3.9%, agricultural production will reduce by 6.2%, labor compensations will decrease by 7%, and the agricultural GDP will reduce by 8.2%. Furthermore, it will increase water consumption by only 0.5% as a result of decreasing cultivated areas by 3.9%.. The Tables 26-29 in the annex shows the detail results of increasing temperatures from 1-4°C companied with decreasing rainfall by 10%. Figure 3 shows the expected change in agricultural GDP in ZRB as a result of different scenarios of climate change. The severe decrease in agricultural GDP will occur when an increase of temperature by 4°C companied with a decrease in rainfall by 20%. The reduction will be about 40%

of the current GDP.

Increase temperature by 2°C companied with decreasing rainfall by 10% will reduce the total cultivated areas by 6.29%, agricultural production will reduce by 16.6%, labor compensations will decrease by 15.6%, and the agricultural GDP will reduce by 17.2%. Furthermore, it will decrease water use by 0.8% as a result of decreasing cultivated areas by 6.2.

Increase temperature by 3°C companied with decreasing rainfall by 10% will reduce the total cultivated areas by 8%, labor compensations will decrease by 21.1%, and the agricultural GDP will reduce by 24.7%. Furthermore, it will decrease water use by 0.1% as a result of decreasing cultivated areas by 8%.

Increase temperature by 4°C and decreasing rainfall by 10% will reduce the total cultivated areas by 12.4%, labor compensations will decrease by 29%%, and the agricultural GDP will reduce by 34.1%. Furthermore, it will decrease water use by 1.2% as a result of decreasing cultivated areas in ZRB

Decreasing Rainfall by 20% under the 4 scenario of increasing temperature will lead to a decrease in cultivated areas form 9.1% , 13.8%, 13.8% and 25.8% for increasing temperatures by 1 °C, 2 °C, 3°C, 4°C, respectively. However, the agricultural GDP will decrease by 11.8%, 22.5%, 26.7% and 38.6% form BUA scenario, respectively.

Increasing rainfall by 10% under the 4 scenario of increasing temperature will lead to a an increase of cultivated areas between 2.4-3.0% . However, the agricultural GDP will increase by 4.3% to 9.8%. The water consumed by crops will increase from 6.6% to 8.8%.

Increasing rainfall by 20% under the 4 scenario of increasing temperature will lead to a an increase of cultivated areas between 4.6-7.3% . On the other hand, the agricultural GDP will increase by 5.6% to 15.7%. The water consumed by crops will increase from 8.8% to 11.3%.

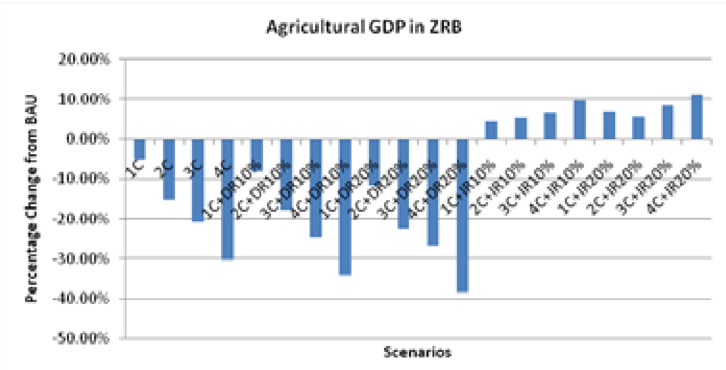


Figure 3: Change in Agricultural GDP in ZRB as a result of Expected climate Change Scenarios

Table 19: Summary of Expected Change in Horticulture in ZRB as a result of Climate Change

Indicators	Production	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	**(000,ton)**	**(000, du)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MCM))**	**(MJD)**	**(MJD)**
BAU	586.79	800.61	45.32	9.39	17.66	82.17	124.59	166.29	69.87	42.41
1C	-3.5%	0.0%	-4.0%	4.3%	-4.0%	-3.0%	-4.0%	3.8%	-5.0%	-5.7%
2C	-13.0%	0.0%	-12.9%	4.9%	-12.9%	-10.9%	-13.0%	4.5%	-15.3%	-16.9%
3C	-17.3%	0.0%	-17.2%	8.6%	-17.3%	-14.3%	-17.3%	7.2%	-20.8%	-23.1%
4C	-25.3%	0.0%	-26.1%	10.0%	-25.6%	-21.8%	-25.8%	9.3%	-30.4%	-33.4%
1C+DR10%	-6.2%	-3.9%	-7.2%	2.4%	-7.0%	-6.0%	-7.0%	0.5%	-8.2%	-8.9%
2C+DR10%	-15.6%	-6.2%	-15.5%	2.1%	-15.6%	-13.5%	-15.5%	-0.8%	-17.9%	-19.5%
3C+DR10%	-20.9%	-8.0%	-21.0%	4.8%	-21.0%	-18.0%	-21.1%	-0.1%	-24.7%	-27.0%
4C+DR10%	-28.8%	-12.4%	-29.1%	6.6%	-29.0%	-25.0%	-29.2%	-1.2%	-34.1%	-37.3%
1C+DR20%	-10.6%	-9.2%	-9.8%	1.0%	-10.2%	-8.7%	-10.1%	-3.8%	-11.8%	-12.8%
2C+DR20%	-20.1%	-13.8%	-19.4%	-0.2%	-19.7%	-17.3%	-19.7%	-6.5%	-22.5%	-24.4%
3C+DR20%	-22.9%	-15.4%	-22.9%	3.4%	-23.1%	-19.9%	-23.1%	-5.6%	-26.7%	-29.2%
4C+DR20%	-32.7%	-25.8%	-33.6%	0.6%	-33.4%	-29.7%	-33.8%	-12.5%	-38.6%	-41.9%
1C+IR10%	4.6%	3.0%	4.3%	6.1%	4.5%	4.6%	4.5%	6.6%	4.3%	4.3%
2C+IR10%	5.8%	2.5%	5.2%	6.2%	5.4%	5.4%	5.4%	6.9%	5.4%	5.4%
3C+IR10%	6.7%	2.4%	7.3%	9.2%	7.0%	7.4%	7.1%	8.8%	6.8%	6.6%
4C+IR10%	9.9%	2.9%	9.8%	11.8%	9.9%	10.1%	9.9%	11.5%	9.8%	9.7%
1C+IR20%	7.8%	5.5%	6.9%	8.2%	7.2%	7.1%	7.1%	8.9%	7.0%	7.0%
2C+IR20%	5.6%	4.6%	5.8%	8.1%	5.7%	6.1%	5.9%	8.8%	5.6%	5.5%
3C+IR20%	9.0%	5.0%	8.5%	9.3%	8.7%	8.6%	8.6%	10.6%	8.6%	8.6%
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%

Table 20 shows the impact of climate change scenarios in irrigated agriculture in ZRB, whereas Table 21 shows the percentage change in the indicators compared to BAU scenario. The decrease in irrigated areas ranged between 1.5% to 9%. The agricultural GDP will decrease from 5% to 33% according to different scenario of climate change

Table 22 shows the impact of climate change scenario in the rainfed agriculture in ZRB. Table 23 shows the percentage change in the socioeconomic indicators compared to BAU. It clearly shown, the rainfed agriculture is more vulnerable to climate change compared to irrigated agriculture. The decrease in irrigated areas ranged between 5.75% to 38%. The agricultural GDP will decrease from 6% to 50% according to different scenario of climate change

Table 20: Socioeconomic Impact of CC on Irrigated Agriculture in ZRB by Scenarios compared to BAU

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	**(000,ton)**	**(000, du)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MCM))**	**(MJD)**	**(MJD)**
BAU	554.25	337.29	41.36	9.39	16.28	75.9	112.86	91.16	62.11	36.96
1C	535.56	337.29	39.76	9.79	15.67	73.74	108.57	94.97	59.03	34.83
2C	482.31	337.29	36	9.85	14.19	67.73	98.22	95.57	52.38	30.49
3C	458.79	337.29	34.29	10.2	13.48	65.33	93.52	99	49.02	28.19
4C	414.25	337.29	30.56	10.33	12.12	59.59	83.73	100.2	42.85	24.14
1C+DR10%	520.66	332.35	38.42	9.62	15.17	71.47	105.1	93.39	57.06	33.63
2C+DR10%	468.39	328.54	35.03	9.59	13.79	65.93	95.61	93.05	50.99	29.68
3C+DR10%	440.6	330.44	32.89	9.84	12.95	62.73	89.73	95.45	47.01	27
4C+DR10%	397.05	324.82	29.58	10.01	11.65	57.59	80.77	97.09	41.18	23.18
1C+DR20%	497.39	327.47	37.53	9.48	14.71	69.75	102.23	92.02	55.21	32.48
2C+DR20%	446.09	321.81	33.62	9.37	13.19	63.4	91.66	90.95	48.66	28.26
3C+DR20%	430.59	320.75	32.21	9.71	12.65	61.5	87.96	94.22	46.04	26.46
4C+DR20%	378.9	306.93	27.95	9.45	11.05	54.44	76.43	91.69	39.03	21.99
1C+IR10%	579.37	343.38	43.08	9.96	17	79.28	117.72	96.67	64.67	38.44
2C+IR10%	585.84	341.63	43.41	9.97	17.14	79.84	118.63	96.74	65.26	38.79
3C+IR10%	590.59	341.88	44.36	10.25	17.4	81.5	120.79	99.45	66.19	39.3
4C+IR10%	608.17	342.1	45.32	10.5	17.85	83.39	123.7	101.87	67.88	40.31
1C+IR20%	596.74	350.72	44.12	10.16	17.42	81.17	120.55	98.54	66.27	39.38
2C+IR20%	583.45	345.67	43.6	10.15	17.15	80.26	118.93	98.5	65.18	38.67
3C+IR20%	604.48	344.52	44.91	10.26	17.71	82.49	122.62	99.59	67.44	40.13
4C+IR20%	615.12	346.35	45.82	10.6	18.06	84.28	125.04	102.89	68.62	40.76
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%

Table 21: Percentage Change in Socioeconomic Indicators on Irrigated Agriculture as a result of CC on ZRB by Scenarios

Indicators	Produc-tion	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
BAU	554.25	337.29	41.36	9.39	16.28	75.9	112.86	91.16	62.11	36.96
1C	-3.4%	0.0%	-3.9%	4.3%	-3.7%	-2.8%	-3.8%	4.2%	-5.0%	-5.8%
2C	-13.0%	0.0%	-13.0%	4.9%	-12.8%	-10.8%	-13.0%	4.8%	-15.7%	-17.5%
3C	-17.2%	0.0%	-17.1%	8.6%	-17.2%	-13.9%	-17.1%	8.6%	-21.1%	-23.7%
4C	-25.3%	0.0%	-26.1%	10.0%	-25.6%	-21.5%	-25.8%	9.9%	-31.0%	-34.7%
1C+DR10%	-6.1%	-1.5%	-7.1%	2.4%	-6.8%	-5.8%	-6.9%	2.4%	-8.1%	-9.0%
2C+DR10%	-15.5%	-2.6%	-15.3%	2.1%	-15.3%	-13.1%	-15.3%	2.1%	-17.9%	-19.7%
3C+DR10%	-20.5%	-2.0%	-20.5%	4.8%	-20.5%	-17.4%	-20.5%	4.7%	-24.3%	-26.9%
4C+DR10%	-28.4%	-3.7%	-28.5%	6.6%	-28.4%	-24.1%	-28.4%	6.5%	-33.7%	-37.3%
1C+DR20%	-10.3%	-2.9%	-9.3%	1.0%	-9.6%	-8.1%	-9.4%	0.9%	-11.1%	-12.1%
2C+DR20%	-19.5%	-4.6%	-18.7%	-0.2%	-19.0%	-16.5%	-18.8%	-0.2%	-21.7%	-23.5%
3C+DR20%	-22.3%	-4.9%	-22.1%	3.4%	-22.3%	-19.0%	-22.1%	3.4%	-25.9%	-28.4%
4C+DR20%	-31.6%	-9.0%	-32.4%	0.6%	-32.1%	-28.3%	-32.3%	0.6%	-37.2%	-40.5%
1C+IR10%	4.5%	1.8%	4.2%	6.1%	4.4%	4.5%	4.3%	6.0%	4.1%	4.0%
2C+IR10%	5.7%	1.3%	5.0%	6.2%	5.3%	5.2%	5.1%	6.1%	5.1%	5.0%
3C+IR10%	6.6%	1.4%	7.3%	9.2%	6.9%	7.4%	7.0%	9.1%	6.6%	6.3%
4C+IR10%	9.7%	1.4%	9.6%	11.8%	9.6%	9.9%	9.6%	11.7%	9.3%	9.1%
1C+IR20%	7.7%	4.0%	6.7%	8.2%	7.0%	6.9%	6.8%	8.1%	6.7%	6.5%
2C+IR20%	5.3%	2.5%	5.4%	8.1%	5.3%	5.7%	5.4%	8.1%	4.9%	4.6%
3C+IR20%	9.1%	2.1%	8.6%	9.3%	8.8%	8.7%	8.6%	9.2%	8.6%	8.6%
4C+IR20%	11.0%	2.7%	10.8%	12.9%	10.9%	11.0%	10.8%	12.9%	10.5%	10.3%
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%

Table 22: Socioeconomic Impact of CC on Rainfed Agriculture in ZRB by Scenarios compared to BAU

Indicators	Produc-tion	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)	(MJD)
BAU	32.54	463.33	3.97	1.37	6.27	11.73	75.14	7.76	5.46	36.96
1C	30.78	463.33	3.74	1.29	5.92	11.09	77.72	7.34	5.17	-5.8%

2C	28.38	463.33	3.46	1.2	5.47	10.23	78.27	6.77	4.76	-17.5%
3C	26.45	463.33	3.24	1.12	5.12	9.55	79.25	6.31	4.43	-23.7%
4C	24.37	463.33	2.95	1.02	4.67	8.76	81.52	5.81	4.1	-34.7%
1C+DR10%	29.78	437	3.63	1.26	5.75	10.74	73.71	7.1	4.99	-9.0%
2C+DR10%	26.58	422.04	3.27	1.13	5.16	9.61	71.93	6.34	4.44	-19.7%
3C+DR10%	23.58	406.46	2.92	1	4.61	8.54	70.64	5.62	3.94	-26.9%
4C+DR10%	20.5	376.79	2.57	0.87	4.05	7.46	67.13	4.89	3.41	-37.3%
1C+DR20%	26.98	399.08	3.34	1.15	5.28	9.78	67.95	6.43	4.5	-12.1%
2C+DR20%	22.89	368.53	2.9	0.99	4.56	8.38	64.51	5.48	3.81	-23.5%
3C+DR20%	21.64	356.43	2.73	0.93	4.29	7.88	62.81	5.15	3.59	-28.4%
4C+DR20%	16.21	287.18	2.13	0.71	3.34	6.01	53.8	3.88	2.67	-40.5%
1C+IR10%	34.45	481.44	4.21	1.46	6.65	12.43	80.56	8.23	5.78	4.0%
2C+IR10%	35.27	479.09	4.28	1.48	6.77	12.69	81	8.41	5.91	5.0%
3C+IR10%	35.32	478.3	4.27	1.48	6.77	12.69	81.45	8.42	5.92	6.3%
4C+IR10%	36.88	481.57	4.45	1.55	7.05	13.25	83.6	8.81	6.21	9.1%
1C+IR20%	35.64	493.91	4.33	1.5	6.86	12.84	82.62	8.5	5.98	6.5%
2C+IR20%	36.13	491.42	4.37	1.52	6.92	12.99	82.45	8.62	6.06	4.6%
3C+IR20%	35.3	496.39	4.26	1.48	6.75	12.68	84.37	8.42	5.93	8.6%
4C+IR20%	38.52	512.76	4.62	1.61	7.32	13.79	89.49	9.18	6.47	10.3%
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%

Table 23: Percentage Change in Socioeconomic Indicators on Rainfed Agriculture as a result of CC on ZRB by Scenarios

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	**(000,ton)**	**(000, du)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MJD)**	**(MCM))**	**(MJD)**	**(MJD)**	**(MJD)**
BAU	32.54	463.33	3.97	1.37	6.27	11.73	75.14	7.76	5.46	36.96
1C	-5.4%	0.0%	-5.8%	-5.8%	-5.6%	-5.5%	3.4%	-5.4%	-5.3%	-5.8%
2C	-12.8%	0.0%	-12.8%	-12.4%	-12.8%	-12.8%	4.2%	-12.8%	-12.8%	-17.5%
3C	-18.7%	0.0%	-18.4%	-18.2%	-18.3%	-18.6%	5.5%	-18.7%	-18.9%	-23.7%
4C	-25.1%	0.0%	-25.7%	-25.5%	-25.5%	-25.3%	8.5%	-25.1%	-24.9%	-34.7%
1C+DR10%	-8.5%	-5.7%	-8.6%	-8.0%	-8.3%	-8.4%	-1.9%	-8.5%	-8.6%	-9.0%
2C+DR10%	-18.3%	-8.9%	-17.6%	-17.5%	-17.7%	-18.1%	-4.3%	-18.3%	-18.7%	-19.7%
3C+DR10%	-27.5%	-12.3%	-26.4%	-27.0%	-26.5%	-27.2%	-6.0%	-27.6%	-27.8%	-26.9%
4C+DR10%	-37.0%	-18.7%	-35.3%	-36.5%	-35.4%	-36.4%	-10.7%	-37.0%	-37.5%	-37.3%

1C+DR20%	-17.1%	-13.9%	-15.9%	-16.1%	-15.8%	-16.6%	-9.6%	-17.1%	-17.6%	-12.1%
2C+DR20%	-29.7%	-20.5%	-27.0%	-27.7%	-27.3%	-28.6%	-14.1%	-29.4%	-30.2%	-23.5%
3C+DR20%	-33.5%	-23.1%	-31.2%	-32.1%	-31.6%	-32.8%	-16.4%	-33.6%	-34.2%	-28.4%
4C+DR20%	-50.2%	-38.0%	-46.3%	-48.2%	-46.7%	-48.8%	-28.4%	-50.0%	-51.1%	-40.5%
1C+IR10%	5.9%	3.9%	6.0%	6.6%	6.1%	6.0%	7.2%	6.1%	5.9%	4.0%
2C+IR10%	8.4%	3.4%	7.8%	8.0%	8.0%	8.2%	7.8%	8.4%	8.2%	5.0%
3C+IR10%	8.5%	3.2%	7.6%	8.0%	8.0%	8.2%	8.4%	8.5%	8.4%	6.3%
4C+IR10%	13.3%	3.9%	12.1%	13.1%	12.4%	13.0%	11.3%	13.5%	13.7%	9.1%
1C+IR20%	9.5%	6.6%	9.1%	9.5%	9.4%	9.5%	10.0%	9.5%	9.5%	6.5%
2C+IR20%	11.0%	6.1%	10.1%	10.9%	10.4%	10.7%	9.7%	11.1%	11.0%	4.6%
3C+IR20%	8.5%	7.1%	7.3%	8.0%	7.7%	8.1%	12.3%	8.5%	8.6%	8.6%
4C+IR20%	18.4%	10.7%	16.4%	17.5%	16.7%	17.6%	19.1%	18.3%	18.5%	10.3%
4C+IR20%	11.4%	7.3%	11.3%	12.9%	11.4%	11.5%	11.4%	15.7%	11.3%	11.4%

8.4 Estimated Increases in Municipal Water Demands in ZRB due to Climate Change

Water poverty is one of the most pertinent cases of poverty within Jordan; this can be clearly illustrated in Zarqa, with its poor, and inequitable, supplies of water. Only on 'Water Day,' is water supplied (usually between 4-5 hours during the day). The water network is outdated and dilapidated, suffering from leaks, broken sections and extensive rusting. Zarqa's rapidly growing population, due to regular population increases as well as inter-governmental immigration, has put additional strains on this weak system tanks (GFA Consulting Group, 2008(. The lack of water in Jordan is obviously exacerbated during the summer months, with almost all households going without water for long lengths of time.

Demand for water during the summer, from water tanks specifically, jumps 12% and 17% in Zarqa and Russeifa, respectively. Water prices from these private sources are not moderated by oversight or governmental action. While most Jordanians have to pay 4-7 JD per cubic meter, this can rise to 8 JD per cubic meter in Zarqa and Russeifa. Many individuals have to wait for up to 3 weeks to obtain water from this source; in summer and Ramadan, the waiting time increases. During 2006, WAJ stated that water usage per person amounted to 75 liters per person daily in Balqa, and 67 liters per person daily in Zarqa for residential use (not municipal use which include industries).

The first step is to investigate how domestic water supply have been allocated among Jordan's governorates and in particularly among the ZRB Governorates through conducting analysis the historical data of monthly water supply, mean monthly temperatures and, population growth.

As part of its ongoing assessment of long term water supply needs, the MWI are identifying water demands through the year 2050, including an assessment of the potential effects that climate change could have on municipal water demands. In Jordan, temperatures are projected to increase by 2 to 4 degrees Celsius by 2050, with relatively more warming in summer.

8.4.1 Methodology to assess the impact of Climate change on Municipal Water

The projected increases in temperature will lead to increased municipal demands due to higher consumptive use demands from residential landscaping. The approach to estimating changes in municipal water demands involved an increasing per capita consumption from the current consumption. The more precise approach used in this to obtaining data on predicted temperatures for representative municipal locations in ZRB, using the temperature data to correlate the increases in consumptive use water demand on a monthly basis at main location, and then estimating changes in municipal monthly demand based on years 1996-2008 population. Furthermore the monthly change in per capita water consumption has been estimated and the regressed with mean monthly temperatures for main metrological station in ZRB. The relationship between average monthly temperatures and change in per-capita consumption has been established. A future projections for the impact of gradual increase in the mean monthly temperature of (1-4 C) on per capita consumption in relation to demographic pressure has been establish to forecast the impact on climate change on municipal water demand.

8.4.2 Overview of Historical Municipal Water Supply in ZRB

The first step is to investigate how domestic water demand supply allocated among governorates in ZRB and in particularly among the large communities. An analysis of the historical data on monthly water supply has been carried out. Since in absence of real water demand of water as a result of water shortage and rationing of supply, distorted price of water that reflect the real value of water, a proxy for water demand is used. The monthly water supply is used to estimate the per capita consumption of water in ZRB, since the MWI increase the water supply as a result of increased demand and public pressures to augment supply in summer months.

Demand growth as a result of population growth is a key factor that is expected to influence the amount of water supply among governorates in ZRB. Population growth is driven by the economic growth and wealth in Jordan's governorates as shown in Table 24. Using the similar approach used by the Higher Population Council to forecast Jordan's population till 2050. The forecasted populations for the year 2050 were predicted for the ZRB population as shown in

Table 25. The estimated ZRB population in 2010 was about 3.5 million inhabitants. For the year 2030 it was predicted to be 6.5 million inhabitants and for the year 2050 it was predicted to be about 8.0 million inhabitants.

The historical municipal water supplies in ZRB are estimated according to water supply per governorates, the proportion of population in each governorate was taken into consideration for the estimate of water supply in ZRB. As shown in Table 26 that Amman, Zarqa and Balqa had enjoyed the largest water supply and Amman had the largest share. The total water supply in 2008 was estimated with 184 mcm with an average per capita water supply of 54.5 m3/capita/year.

The historical per capita water supply is increasing in ZRB during the period 2000-2008. The per capita water supply increased from 156 l/c/d to 149.6 l/c/d in 2008. Considering that only 50% of Unaccounted for Water (UfW) are physical loss and the remaining 50% of UfW are consumed but not billed. This amount of UfW are added to the consumed quantities. Therefore, the water supply are converted to water consumption by considering the UfW in ZRB. The historical UfW in each orates of ZRB was obtained from MWI report to estimate the per capita water consumption in ZRB as shown in Table 27.

Table 24: Historical population in ZRB governorates.

Governorate	1994	2000	2005	2009
Amman	1,497,471	1,790,275	2,019,130	2,199,820
Balqa	248,490	292,860	330,480	360,540
Zarqa	447,675	506,590	567,350	623,700
Mafraq	62,587	79,905	90,020	98,385
Jarash	98,684	116,560	131,440	143,520
Ajlun	14,157	16,755	18,915	20,625
Total ZRB	2,369,063	2,802,945	3,157,335	3,446,590
Jordan	4,139,400	4,857,000	5,473,000	5,980,000

Source: extrapolated from DOS population census.

Table 25: Forecasted Population in ZRB.

Growth Rate Scenarios in ZRB	Growth Rate in 2030	2010	2020	2030	2040	2050
ZRB population BAU	2.08%	3,514,590	4,326,454	5,325,857	6,556,120	8,070,572

High Population Growth	2.22%	3,548,862	4,639,893	5,863,609	7,291,634	9,027,368
Decline Medium Growth	1.79%	3,547,703	4,546,174	5,503,171	6,570,503	7,756,531
Low Population Growth	1.31%	3,546,543	4,452,454	5,142,734	5,849,372	6,485,695

Source : Consultant estimate

Table 26: Historical Municipal Water Supply in ZRB.

Supply ZRB	1996	2000	2005	2008
Amman	84,137,077	85,446,142	113,274,203	122,271,069
Balqa	15,552,674	3,775,955	19,179,407	19,250,906
Zarqa	9,125,864	20,818,382	26,506,592	31,385,556
Mafraq	7,041,494	11,010,548	6,111,458	6,518,484
Jarash	6,756,409	7,313,720	3,214,365	3,647,868
Ajlun	280,599	337,249	545,414	572,205
Total Supply in (ZRB(m3)	122,894,116	128,701,996	168,831,438	183,646,089
m3/capita/year	48.99	45.92	53.47	54.47

Source: extrapolated by consultant from MWI annual report (1994-2009)

Table 27: Historical Per Capita Municipal Water Demand in ZRB (l/c/d).

ZRB	2000	2001	2002	2003	2004	2005	2006	2007
Amman	96.79	96.01	94.73	103.64	114.27	116.36	117.61	120.95
Balqa	25.03	23.82	51.71	101.23	105.82	113.95	110.85	113.35
Zarqa	79.80	79.97	79.12	87.27	85.15	91.92	96.73	103.02
Mafraq	96.79	96.01	94.73	103.64	114.27	116.36	117.61	120.95
Jaresh	25.03	23.82	51.71	101.23	105.82	113.95	110.85	113.35
Ajlun	79.80	79.97	79.12	87.27	85.15	91.92	96.73	103.02
ZRB	96.79	96.01	94.73	103.64	114.27	116.36	117.61	120.95

Source: extrapolated by consultant from MWI annual report (1994-2009)

The water demand projections are based on the ones made by the MWI under the National Water Master Plan [MWI, 2004]. These projections were displayed at the AZB level for the period 2010-2050. The overall results of the baseline scenario projection reveal that the total water demand will increase by 52% in 2030 to reach approximately 291 MCM/year (Figure 4). Thus, the total water deficit in the basin will be appreciatively about 108 MCM in 2030 from the recent water demand data of 192 mcm in 2010.

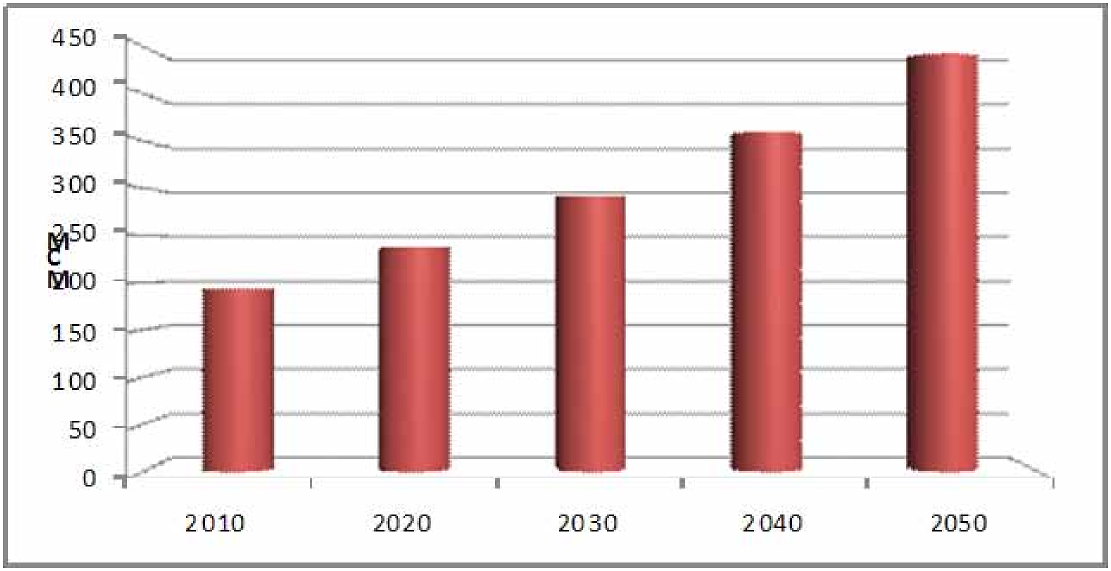


Figure 4: Future Water Demand in AZB up to 2050 (MCM/year)

Regression analysis was used to estimate the relative change between monthly average temperatures of representative metrological stations in ZRB with monthly per capita water consumption. A positive relationship was found between average monthly temperatures and per-capita consumption with high statistical significance as shown in Figure 5. The result indicate than an increase of 1 C in monthly average temperatures will increase the per capita water demand of (1.18) l/c/d. This relationship was used for future projections for the impact of gradual increase in the average monthly temperature of (1-4 C) on per capita consumption; furthermore, the increase in per-capita consumption was multiplied with projected population for the period (2020-2050) in order to quantify the impact of expected climate change on future water demand. Figure 6 shows the expected impact of climate change on per capita water consumption in ZRB. The municipal water demand projections indicates that there will be an increase in municipal water demand of approximately 142,000 cubic meter per year due to increases in temperature associated with an increase of temperature of one degree Celsius.

Table 28 shows the expected impact of climate change by increasing average monthly temperatures of 2 C and 4 C on monthly water demand for the year (2020, 2030, 2040 and 2050). An increase of one degree in average monthly temperatures will lead to an increase of water demand in ZRB of 6.6 mcm annually. Table 29 and Figure 7 summarize the expected Impact of climate change on municipal water demand in ZRB (mcm). For example, an increase in average monthly temperatures by one degree in the year 2020, the water demand in ZRB will increased from 237 mcm in BAU scenario to 239 mcm. If the average monthly temperature increased with 4 C, the water demand will increase from 237 mcm to 264 mcm, with an increase of 27 mcm as a result of climate change.

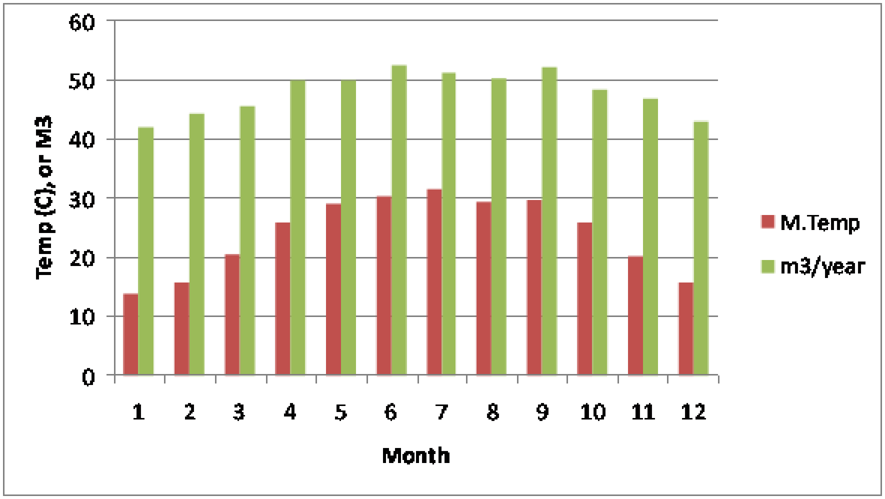


Figure 5: Historical Relationship between Average Monthly Temperature and Per Capita water Supply

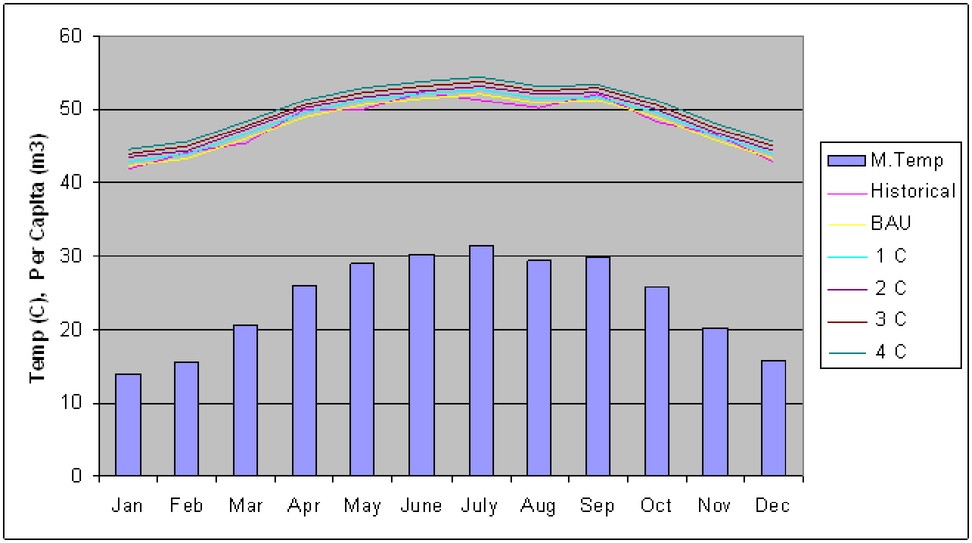


Figure 6: Expected impact of CC on Municipal Water Per Capita Consumption

Table 28: Expected Impact of CC on Monthly Municipal Water Demand in ZRB (mcm).

	2 0C				4 0C			
	2020	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**
Jan	18.08	22.26	27.40	33.73	20.49	25.22	31.04	38.22
Feb	18.45	22.72	27.96	34.42	20.33	25.03	30.81	37.93
Mar	19.59	24.12	29.69	36.55	22.88	28.17	34.67	42.68
Apr	20.77	25.57	31.48	38.75	22.14	27.25	33.55	41.30
May	21.46	26.42	32.52	40.03	23.90	29.42	36.21	44.58
June	21.75	26.78	32.96	40.58	22.70	27.94	34.39	42.34
July	22.03	27.12	33.39	41.10	22.98	28.28	34.82	42.86
Aug	21.56	26.54	32.67	40.22	23.78	29.28	36.04	44.37
Sep	21.64	26.64	32.80	40.38	21.46	26.41	32.51	40.02
Oct	20.75	25.55	31.45	38.71	21.55	26.53	32.65	40.20
Nov	19.48	23.98	29.52	36.34	19.26	23.71	29.19	35.94
Dec	18.49	22.76	28.02	34.49	22.04	27.13	33.40	41.12
Total	**244.07**	**300.45**	**369.85**	**455.29**	**263.50**	**324.37**	**399.30**	**491.54**

Table 29: Expected Impact of CC on Municipal Water Demand in ZRB (mcm).

Year	BAU	1C	2C	3C	4C
2020	237	239	244	251	264
2030	292	295	300	309	324
2040	359	363	370	381	399
2050	442	446	455	469	492

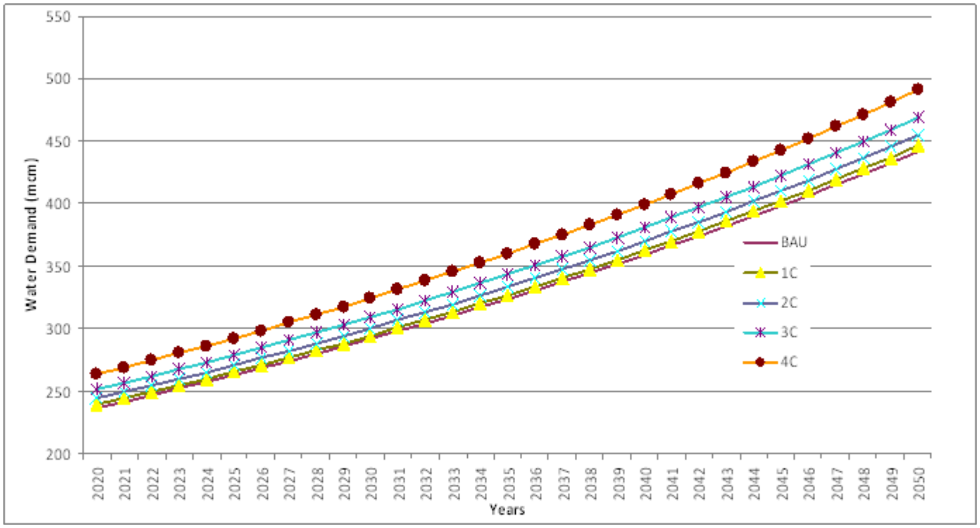


Figure 7: Expected Impact of CC on Municipal Water Demand in ZRB

8.5 Impact of Climate Change on Human Health

As a result of climate change and water shortage, potentially thousands of people could be at risk from increased morbidity or mortality resulting from climate change. Infectious and water borne diseases may become more prevalent as their reach increases and seasonality expands; the frequency and intensity of heat waves and natural hazards such as droughts, floods, and cyclones may increase, causing adverse health effects; and levels of air pollution may increase. Small changes in climate can result in substantial changes in risk. The increased health risks are likely to be most acute in low consumption poor peoples. This is because many climate-related infectious and vector-borne diseases are associated with warm or hot weather conditions and, most importantly, because public health systems. A key factor in reducing future risks is the strengthening of public health systems, including monitoring and surveillance, public health infrastructure, and the development of effective adaptation measures

Most of the diseases found in the Zarqa Governorate are gastrointestinal (mainly diarrhoea; with 6% of homes reporting cases) although other diseases such as Hepatitis are also found. Amoebic infections are found particularly in students; many maintained this was due to poor hygienic conditions in schools, as well as the dirty water supplied by WAJ and dirty water tanks (GFA Consulting Group) 2008)).

8.6 Gender and Water and Climate Change

Environmental change associated with a changing climate affects people in different ways, depending on a myriad of factors that determine their vulnerability to it and their ability to adapt to it and sustain their health, security and livelihoods. Gender, a fundamental organizing principle in all societies, is a central factor in determining vulnerability and ability to adapt. Research has shown that women's/girls" and men's/boys" differential vulnerabilities and ability to adapt to the impacts of climate-related environmental change or disaster events primarily result from socially constructed gender-specific vulnerabilities that are built into socioeconomic and sociocultural norms and practices

The lack of water and poor sanitation standards are also a possible barrier to bridging the gap in the roles played by men and women. Although there is little discrimination in water provision between men and women, the significant exception is when a woman is the leader of the home; there have been impediments to women attempting to receive water from WAJ when they lead the household. Also, when it comes to the individual home, there is a clear bias towards certain tasks for each gender; women have the duties of cooking, cleaning, bathing children, filling the water tanks during 'Water Day,' and determining how much water to be used on which task. It is considered the man's duty to contact the government or company, water the garden, clean the car, order and purchase water services. Although, more women are making decisions regarding buying extra water, ordering the waste disposal truck for cesspits, for complaining to, and purchasing from, the WAJ. The task of cleaning the tank is varied across different communities, with some having women, and others having men, do it.

The Socio-Economic Baseline Survey in the Water Supply and Sanitation Sector conducted by (GFA, 2008) identified family care as the priority of women; water is carefully rationed during the week, primarily for the care of the young members of the family, the sick, then water used for internal consumption, after that for home maintenance, after that hygiene and finally gardening. More women are turning to plants that can survive with minimal water to cope with the lack of water. The roles performed by men and women, relating to water are usually absorbed and imitated by the younger generation, to be repeated when they are older.

8.7 Suggested Adaptation & Policy Options to Mitigate Climate Change in ZRB

Adaptation to climate is not a new phenomenon. Indeed, throughout human history, societies have adapted to natural climate variability by altering settlement and agricultural patterns and other facets of their economies and lifestyles. Human-induced climate change lends a complex new dimension. While the ongoing adaptation-related activities in the country focus on mainstreaming climate change adaptation into national policy,

Given the expected server scarcity of water in the region, water demand management and water conservation shall continue to play an important role in achieving sustainable use of water resources in Jordan by:

8.7.1 Integrated planning,

It is predicted, ZRB in Jordan will experience a reduction in average rainfall during the wet season and available surface and groundwater resources of the country are insufficient to support the required agricultural production. Furthermore, reduced vegetation cover due to deforestation, over-pumping, overgrazing and poor surface management of cultivated lands, have led to reduced infiltration rate, increased runoff and soil erosion, and a decline in ground water recharge. Due to this alarming situation, various efforts should be made in ZRB to mitigate the impacts of climate change on water resources and agriculture. However, providing a national strategy which can be applicable for the whole country is very difficult due to different agro-climatological zone, but long-term policies at both national and regional levels, assessing the vulnerability of water and agriculture in each area, nevertheless, needs to be localized. Sectoral level policy makers, planners and managers are relatively more likely to mainstream adaptation to climate change into their on-going and planned work (provided the information on impacts is given to them in a suitable form), (v) High level policy makers need to be especially targeted (with suitable material), (vi) National and international experts and researchers need to share their knowledge with people making decisions and plans on the ground more effectively.

Therefore, Long-term planning for climate-sensitive resources should incorporate changes in conditions that will affect the services provided by those resources. Changes in population and income, economic growth, and changes in the supply of and demand for water will affect resource use. Including climate change in long-term plans could result in changes being made that will enhance the ability of future generations to cope with these changes.

8.7.2 Build institutional and technical capacity,

It is necessary to enhance the technical capacity of different institutions involved in water management mainly meteorological and hydrological monitoring networks (systematic collection and data processing). But coordination and cooperation between different water stakeholders is still lacking

8.7.3 Effective regulation,

While adaptation must be integrated across existing institutions, focal points are needed at the national and international levels to garner expertise, develop and coordinate comprehensive strategies, and advocate for broad-based planning and action

8.7.4 Engineering and infrastructure

Rainfall harvesting from rural/urban catchments has not received large attention in Jordan. In the absence of run-off sewer systems in most Jordanian rural and urban areas, rainfall harvesting from roads, parking lots and rooftops can increase water supply for various domestic uses and help combat the chronic water shortages in the country. Results in Jordan (Abdulla, and Al-Shareef, 2009) show that a maximum of 15.5 Mm3/y of rainwater can be collected from roofs of residential buildings provided that all surfaces are used and all rain falling on the surfaces is collected. This is equivalent to 5.6% of the total domestic water supply of the year 2005. The potential for water harvesting varies among the governorates, ranging from 0.023×106 m3 for the Aqaba governorate to 6.45×106 m3 for the Amman governorate. The potential for potable water savings was estimated for the 12 governorates, and it ranged from 0.27% to 19.7% (Abdulla, and Al-Shareef, 2009)

Water harvesting techniques can reduce rainwater loss by runoff and evaporation from 90% to 40%. In the rangelands of ZRB ,it was demonstrated that micro-catchment techniques improve vegetation cover, reduce erosion and increase water productivity. Since improved technologies for water management help conserve and protect natural resources, and improve food security for the poor despite the effects of climate change,

Marginal changes may be made in the planned construction of water resources infrastructure such as reservoirs and flood control works to adapt to increased variability in runoff or to a need for greater storage capacity. Increases in the size of dams or marginal changes in the construction of canals, pipelines, pumping plants, size and distribution of wastewater treatment plants and storm drainages system should be considered especially in heavily populated areas in Russeifa and Zarka city.

Promote rainwater harvesting techniques : to store rain water as an alternative source of drinking water so that communities aren't solely reliant on groundwater. Use of Hafeers, contour bunding, gully plugging, and check dams and dykes to catch rainwater and increase water available for agricultural use.

8.7.5 Investment in Water Saving Technologies

Agricultural technology, especially irrigation technology should focuses on promoting a pro-poor and community-based approach. As climate change will require more severe adjustment in the management of water resources in the country, the new irrigation alternative should aims to increase the resilience to climate change of agriculture, focusing on water as a key natural resource for agricultural production in the country. For example, one of the innovative and environmentally-friendly technologies, named Dutyion Root Hydration System (dRHS), particularly promising in arid and semi-arid areas as an adaptation measure to climate change. This new technology enables agriculture to use water more efficiently as an effective adaptation measure.

The dRHS irrigation system consists of a network of sub-surface pipes that can be filled with almost any type of water, including salted or waste-water. The technology is expected to improve water use efficiency by at least 30%. The pipes are made of a plastic that retains virtually all contaminants while releasing clean water through the plants' roots. Because contaminants are retained within the irrigation pipes, land does not suffer from raised levels of salinity. Thus, the technology also produces environmental benefits other than climate change adaptation; these include climate change mitigation benefits and better management of natural resources

8.7.6 Training on the Water saving technology

Farmers and local stakeholders should have training on the installation, use and maintenance of the water saving technology (equipments and apparatus). Also, extension services providers will be a target of the proposed training program. Training sessions will be tailored to the needs and capabilities of the beneficiaries. An awareness campaign at the local level on climate change impact should be also carried out. Furthermore, Government authorities (at both national and local level) should be trained on the potential of the new water saving technology, as an adaptation to climate change measure in the country.

National and International research in rainfed areas has shown that water productivity under supplemental irrigation is as high as 2.5 kg of wheat grain per cubic meter of water, compared to 0.5 kg under rainfed conditions and 1 kg under full irrigation.

8.7.7 Public awareness on the issue of climate change

In Jordan is still in its early stage of development, and most of them highlighted the challenges they faced in improving it. This awareness could be achieved using means included, workshops, radio and television programmers, newspapers, films, pamphlets and web sites.

9 Recommendations

Climate change is expected to have significant impacts on water supplies— creating or exacerbating chronic shortages—and on water quality. There is already widespread and acceleration of water shortage in ZRB governorates. If continued, these shifts could affect the availability of water for agriculture and other uses. Changes in quantity and intensity of precipitation are likely to result in more floods and droughts and increased demand for irrigation water. Water management often requires costly investment in infrastructure. Given the long economic and physical life of reservoirs, water withdrawal, treatment, delivery, and disposal systems, adaptive responses are generally slower in water management than in agriculture

It is important for policymakers to be able to put climate change impacts in the context of other social, economic, and technological conditions, such as: Demographic change, Land-use change, Land degradation. Clearly, the above assessments have not been made across all potentially affected sectors, so many potential areas remain to be examined and, where possible, quantified. Nevertheless, we believe the present report summarizes a substantial body of work that, if carefully interpreted, may provide useful guidance to policymakers.

Unfortunately, water stress in ZRB is becoming a significant challenge for many sectors. The situation is made worse where poor management practices collide with declining availability occasioned by climate change and climate variability. Therefore, mitigation and adaptation strategies suggested above to protect water resources on ZRB is required if national socio-economic goals are to be attained.

It has been the objective of this study to summarize some important vulnerability issues associated with the present and potential future hydrological responses due to climate change and highlight those areas where further research is required.. Large-scale planning would be clearly required for adaptation measures for climate change impacts, if future catastrophic in water resources shortage is to be avoided.

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Annex 1
Model Result of

Table 30: Socioeconomic indicators (Increase Temperature 1 C)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	46.95	13.55	2.65	0.32	1.23	4.63	7.30	3.22	4.32	2.67
Vegetables	374.65	61.33	19.19	2.30	8.78	34.24	55.28	21.94	33.79	21.04
Fruit Tress	113.96	262.41	17.92	7.16	5.65	34.88	46.00	69.82	20.92	11.12
Total Ir-rigated	535.56	337.29	39.76	9.79	15.67	73.74	108.57	94.97	59.03	34.83
Field Crops	17.89	314.23	1.71	0.00	0.68	2.82	5.99	45.43	4.28	3.18
Vegetables	0.60	0.87	0.09	0.00	0.05	0.15	0.25	0.24	0.16	0.10
Fruit Tress	12.28	148.22	1.95	0.00	0.56	2.95	4.85	32.04	2.90	1.89
Total Rain-fed	30.78	463.33	3.74	0.00	1.29	5.92	11.09	77.72	7.34	5.17
Field Crops	64.85	327.78	4.36	0.32	1.91	7.45	13.29	48.65	8.61	5.85
Vegetables	375.25	62.20	19.27	2.30	8.83	34.39	55.52	22.17	33.95	21.14
Fruit Tress	126.24	410.63	19.87	7.16	6.21	37.83	50.84	101.86	23.81	13.01
Total ZRB	566.34	800.61	43.51	9.79	16.96	79.67	119.66	172.69	66.37	39.99

Table 31: Socioeconomic indicators (Increase Temperature 2 C)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	43.59	13.55	2.47	0.33	1.15	4.34	6.78	3.29	3.98	2.44
Vegetables	336.04	61.33	17.35	2.32	7.92	31.15	49.85	22.06	30.18	18.70
Fruit Tress	102.68	262.41	16.18	7.20	5.12	32.25	41.59	70.21	18.21	9.35
Total Ir-rigated	482.31	337.29	36.00	9.85	14.19	67.73	98.22	95.57	52.38	30.49
Field Crops	16.43	314.23	1.57	0.00	0.62	2.58	5.50	45.60	3.93	2.92
Vegetables	0.57	0.87	0.08	0.00	0.05	0.15	0.24	0.24	0.16	0.09
Fruit Tress	11.37	148.22	1.81	0.00	0.52	2.74	4.49	32.43	2.68	1.75

Total Rain-fed	28.38	463.33	3.46	0.00	1.20	5.47	10.23	78.27	6.77	4.76
Field Crops	60.02	327.78	4.04	0.33	1.77	6.92	12.28	48.89	7.91	5.36
Vegetables	336.61	62.20	17.43	2.32	7.97	31.29	50.09	22.31	30.34	18.80
Fruit Tress	114.06	410.63	17.99	7.20	5.64	34.99	46.08	102.64	20.90	11.10
Total ZRB	510.69	800.61	39.46	9.85	15.38	73.20	108.45	173.84	59.15	35.25

Table 32: Socioeconomic indicators (Increase Temperature 3 C)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	40.54	13.55	2.30	0.33	1.07	4.06	6.31	3.30	3.68	2.25
Vegetables	319.25	61.33	16.38	2.39	7.49	29.64	47.14	22.74	28.37	17.51
Fruit Tress	99.00	262.41	15.61	7.48	4.92	31.63	40.06	72.96	16.98	8.43
Total Ir-rigated	458.79	337.29	34.29	10.20	13.48	65.33	93.52	99.00	49.02	28.19
Field Crops	15.09	314.23	1.44	0.00	0.57	2.37	5.05	46.20	3.61	2.68
Vegetables	0.53	0.87	0.08	0.00	0.05	0.14	0.22	0.24	0.15	0.09
Fruit Tress	10.83	148.22	1.72	0.00	0.50	2.61	4.28	32.81	2.56	1.66
Total Rain-fed	26.45	463.33	3.24	0.00	1.12	5.12	9.55	79.25	6.31	4.43
Field Crops	55.64	327.78	3.75	0.33	1.64	6.44	11.36	49.50	7.29	4.93
Vegetables	319.78	62.20	16.46	2.39	7.54	29.77	47.37	22.99	28.52	17.59
Fruit Tress	109.82	410.63	17.33	7.48	5.42	34.24	44.34	105.77	19.53	10.10
Total ZRB	485.24	800.61	37.53	10.20	14.60	70.45	103.07	178.25	55.34	32.62

Table 33: Socioeconomic indicators (Increase Temperature 4 C)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	37.71	13.55	2.11	0.35	0.99	3.78	5.84	3.45	3.39	2.06
Vegetables	290.68	61.33	14.89	2.46	6.83	27.29	43.05	23.40	25.71	15.77
Fruit Tress	85.86	262.41	13.56	7.52	4.30	28.52	34.84	73.35	13.75	6.32
Total Ir-rigated	414.25	337.29	30.56	10.33	12.12	59.59	83.73	100.20	42.85	24.14

Field Crops	14.40	314.23	1.37	0.00	0.55	2.26	4.82	47.73	3.44	2.55
Vegetables	0.49	0.87	0.07	0.00	0.04	0.13	0.21	0.25	0.13	0.08
Fruit Tress	9.48	148.22	1.50	0.00	0.44	2.28	3.74	33.53	2.24	1.46
Total Rain-fed	24.37	463.33	2.95	0.00	1.02	4.67	8.76	81.52	5.81	4.10
Field Crops	52.11	327.78	3.48	0.35	1.54	6.04	10.66	51.18	6.83	4.62
Vegetables	291.17	62.20	14.96	2.46	6.87	27.41	43.26	23.65	25.84	15.85
Fruit Tress	95.33	410.63	15.06	7.52	4.73	30.80	38.58	106.88	15.99	7.78
Total ZRB	438.62	800.61	33.51	10.33	13.14	64.26	92.50	181.71	48.66	28.24

Table 34: Socioeconomic indicators (Increase Temperature 1 C & Decrease Rainfall 10%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	45.43	13.36	2.59	0.32	1.19	4.51	7.08	3.17	4.17	2.57
Vegetables	365.91	60.08	18.64	2.26	8.53	33.29	53.77	21.50	32.87	20.47
Fruit Tress	109.32	258.91	17.19	7.05	5.44	33.66	44.25	68.71	20.01	10.58
Total Irrigated	520.66	332.35	38.42	9.62	15.17	71.47	105.10	93.39	57.06	33.63
Field Crops	17.13	290.89	1.63	0.00	0.65	2.69	5.72	42.06	4.09	3.04
Vegetables	0.60	0.85	0.09	0.00	0.05	0.16	0.26	0.23	0.17	0.10
Fruit Tress	12.05	145.26	1.91	0.00	0.56	2.91	4.76	31.41	2.85	1.85
Total Rain-fed	29.78	437.00	3.63	0.00	1.26	5.75	10.74	73.71	7.10	4.99
Field Crops	62.56	304.25	4.23	0.32	1.84	7.20	12.81	45.23	8.26	5.61
Vegetables	366.51	60.93	18.73	2.26	8.58	33.45	54.02	21.74	33.04	20.57
Fruit Tress	121.36	404.17	19.10	7.05	6.00	36.57	49.01	100.12	22.86	12.44
Total ZRB	550.44	769.35	42.05	9.62	16.42	77.22	115.84	167.09	64.16	38.62

Table 35: Socioeconomic indicators (Increase Temperature 2 C & Decrease Rainfall 10%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	41.54	13.01	2.34	0.32	1.09	4.11	6.45	3.15	3.80	2.34
Vegetables	325.60	59.25	16.74	2.23	7.66	30.08	48.16	21.28	29.19	18.08

Fruit Tress	101.25	256.29	15.96	7.04	5.04	31.73	41.00	68.62	18.00	9.26
Total Irrigated	468.39	328.54	35.03	9.59	13.79	65.93	95.61	93.05	50.99	29.68
Field Crops	14.89	276.47	1.42	0.00	0.56	2.34	4.98	40.14	3.56	2.64
Vegetables	0.55	0.85	0.08	0.00	0.05	0.14	0.23	0.24	0.15	0.09
Fruit Tress	11.13	144.72	1.77	0.00	0.51	2.69	4.40	31.56	2.63	1.71
Total Rainfed	26.58	422.04	3.27	0.00	1.13	5.16	9.61	71.93	6.34	4.44
Field Crops	56.43	289.48	3.76	0.32	1.66	6.45	11.43	43.28	7.36	4.98
Vegetables	326.15	60.10	16.82	2.23	7.70	30.22	48.39	21.51	29.34	18.17
Fruit Tress	112.38	401.01	17.72	7.04	5.55	34.42	45.39	100.18	20.63	10.97
Total ZRB	494.97	750.58	38.30	9.59	14.91	71.10	105.22	164.98	57.33	34.12

Table 36: Socioeconomic indicators (Increase Temperature 3 C & Decrease Rainfall 10%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	38.08	12.96	2.16	0.32	1.00	3.82	5.93	3.24	3.44	2.10
Vegetables	308.01	59.40	15.83	2.31	7.25	28.67	45.57	22.02	27.42	16.90
Fruit Tress	94.51	258.09	14.90	7.20	4.70	30.24	38.24	70.20	16.15	8.00
Total Irrigated	440.60	330.44	32.89	9.84	12.95	62.73	89.73	95.45	47.01	27.00
Field Crops	12.87	262.42	1.23	0.00	0.49	2.02	4.30	38.63	3.08	2.28
Vegetables	0.51	0.83	0.07	0.00	0.04	0.13	0.21	0.23	0.14	0.08
Fruit Tress	10.20	143.20	1.62	0.00	0.47	2.46	4.03	31.78	2.41	1.57
Total Rainfed	23.58	406.46	2.92	0.00	1.00	4.61	8.54	70.64	5.62	3.94
Field Crops	50.95	275.38	3.39	0.32	1.49	5.85	10.23	41.86	6.52	4.39
Vegetables	308.52	60.23	15.91	2.31	7.29	28.80	45.78	22.26	27.56	16.98
Fruit Tress	104.71	401.29	16.52	7.20	5.17	32.70	42.27	101.98	18.55	9.57
Total ZRB	464.18	736.90	35.81	9.84	13.95	67.34	98.28	166.09	52.63	30.94

Table 37: Socioeconomic indicators (Increase Temperature 4 C & Decrease Rainfall 10%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)

Field Crops	34.62	12.95	1.96	0.33	0.91	3.51	5.38	3.32	3.09	1.87
Vegetables	278.15	58.59	14.25	2.35	6.53	26.07	41.02	22.34	24.42	14.95
Fruit Tress	84.29	253.27	13.37	7.33	4.22	28.00	34.37	71.43	13.67	6.36
Total Irrigated	397.05	324.82	29.58	10.01	11.65	57.59	80.77	97.09	41.18	23.18
Field Crops	10.76	234.89	1.03	0.00	0.41	1.69	3.60	35.32	2.57	1.91
Vegetables	0.46	0.82	0.07	0.00	0.04	0.11	0.19	0.23	0.12	0.07
Fruit Tress	9.29	141.08	1.48	0.00	0.43	2.24	3.67	31.57	2.19	1.43
Total Rainfed	20.50	376.79	2.57	0.00	0.87	4.05	7.46	67.13	4.89	3.41
Field Crops	45.38	247.84	2.98	0.33	1.32	5.20	8.98	38.65	5.66	3.78
Vegetables	278.60	59.41	14.32	2.35	6.56	26.19	41.21	22.58	24.54	15.02
Fruit Tress	93.57	394.35	14.85	7.33	4.65	30.25	38.04	103.00	15.86	7.79
Total ZRB	417.55	701.61	32.15	10.01	12.53	61.64	88.23	164.23	46.07	26.59

Table 38: Socioeconomic indicators (Increase Temperature 1 C & Decrease Rainfall 20%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	44.25	12.92	2.49	0.31	1.16	4.36	6.87	3.07	4.08	2.52
Vegetables	343.12	58.88	17.78	2.21	8.10	31.69	50.96	21.01	30.97	19.26
Fruit Tress	110.02	255.67	17.27	6.97	5.46	33.70	44.40	67.94	20.17	10.70
Total Irrigated	497.39	327.47	37.53	9.48	14.71	69.75	102.23	92.02	55.21	32.48
Field Crops	14.70	255.98	1.40	0.00	0.56	2.30	4.91	36.96	3.51	2.60
Vegetables	0.57	0.82	0.08	0.00	0.05	0.15	0.24	0.22	0.16	0.10
Fruit Tress	11.71	142.29	1.86	0.00	0.54	2.83	4.63	30.77	2.76	1.80
Total Rainfed	26.98	399.08	3.34	0.00	1.15	5.28	9.78	67.95	6.43	4.50
Field Crops	58.95	268.89	3.89	0.31	1.72	6.66	11.78	40.03	7.59	5.12
Vegetables	343.69	59.70	17.86	2.21	8.14	31.84	51.20	21.23	31.13	19.36
Fruit Tress	121.73	397.97	19.13	6.97	6.00	36.53	49.03	98.71	22.93	12.50
Total ZRB	524.37	726.56	40.88	9.48	15.86	75.03	112.01	159.96	61.65	36.97

Table 39: Socioeconomic indicators (Increase Temperature 2 C & Decrease Rainfall 20%)

Indicators	Production	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	38.04	12.46	2.16	0.30	1.00	3.80	5.93	3.02	3.46	2.12
Vegetables	309.97	56.89	15.95	2.15	7.30	28.69	45.90	20.47	27.81	17.22
Fruit Tress	98.07	252.46	15.52	6.92	4.89	30.91	39.83	67.46	17.39	8.92
Total Irrigated	446.09	321.81	33.62	9.37	13.19	63.40	91.66	90.95	48.66	28.26
Field Crops	11.60	226.02	1.12	0.00	0.44	1.84	3.91	33.22	2.79	2.07
Vegetables	0.54	0.83	0.08	0.00	0.05	0.14	0.23	0.23	0.15	0.09
Fruit Tress	10.75	141.67	1.70	0.00	0.50	2.59	4.24	31.06	2.54	1.65
Total Rain-fed	22.89	368.53	2.90	0.00	0.99	4.56	8.38	64.51	5.48	3.81
Field Crops	49.65	238.48	3.28	0.30	1.45	5.64	9.83	36.24	6.25	4.19
Vegetables	310.51	57.72	16.03	2.15	7.35	28.82	46.13	20.70	27.95	17.31
Fruit Tress	108.82	394.14	17.22	6.92	5.39	33.50	44.07	98.53	19.93	10.57
Total ZRB	468.98	690.34	36.52	9.37	14.18	67.96	100.03	155.46	54.14	32.07

Table 40: Socioeconomic indicators (Increase Temperature 3 C & Decrease Rainfall 20%)

Indicators	Production	Planted Areas	Intermediate Consumption)	Water Cost	Labor cost	Total Cost	Gross Output	Water Use	Value Added	Operation Surplus
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	36.26	12.39	2.06	0.31	0.95	3.65	5.65	3.10	3.28	2.00
Vegetables	300.52	57.11	15.38	2.23	7.04	27.84	44.35	21.23	26.74	16.51
Fruit Tress	93.81	251.25	14.77	7.17	4.66	30.01	37.96	69.89	16.02	7.95
Total Irrigated	430.59	320.75	32.21	9.71	12.65	61.50	87.96	94.22	46.04	26.46
Field Crops	10.94	217.13	1.04	0.00	0.41	1.71	3.65	32.03	2.61	1.94
Vegetables	0.48	0.80	0.07	0.00	0.04	0.12	0.20	0.22	0.13	0.08
Fruit Tress	10.22	138.50	1.62	0.00	0.47	2.46	4.03	30.56	2.41	1.57
Total Rain-fed	21.64	356.43	2.73	0.00	0.93	4.29	7.88	62.81	5.15	3.59
Field Crops	47.20	229.52	3.10	0.31	1.37	5.36	9.30	35.13	5.89	3.94

Vegetables	301.00	57.91	15.45	2.23	7.08	27.97	44.55	21.45	26.87	16.59
Fruit Tress	104.03	389.75	16.39	7.17	5.13	32.47	41.99	100.45	18.43	9.52
Total ZRB	452.23	677.17	34.94	9.71	13.58	65.79	95.84	157.04	51.19	30.04

Table 41: Socioeconomic indicators (Increase Temperature 4 C & Decrease Rainfall 20%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	34.61	12.28	1.95	0.32	0.91	3.48	5.37	3.17	3.11	1.89
Vegetables	266.24	55.80	13.65	2.22	6.25	24.94	39.33	21.16	23.46	14.39
Fruit Tress	78.05	238.85	12.36	6.91	3.90	26.01	31.73	67.35	12.46	5.71
Total Ir-rigated	378.90	306.93	27.95	9.45	11.05	54.44	76.43	91.69	39.03	21.99
Field Crops	6.94	151.02	0.67	0.00	0.27	1.10	2.34	23.13	1.67	1.24
Vegetables	0.41	0.75	0.06	0.00	0.04	0.11	0.18	0.21	0.12	0.07
Fruit Tress	8.86	135.41	1.40	0.00	0.41	2.13	3.49	30.45	2.09	1.36
Total Rain-fed	16.21	287.18	2.13	0.00	0.71	3.34	6.01	53.80	3.88	2.67
Field Crops	41.56	163.30	2.61	0.32	1.18	4.59	7.71	26.31	4.78	3.13
Vegetables	266.65	56.55	13.71	2.22	6.28	25.05	39.51	21.38	23.57	14.46
Fruit Tress	86.91	374.26	13.75	6.91	4.31	28.14	35.21	97.80	14.55	7.08
Total ZRB	395.11	594.11	30.08	9.45	11.76	57.77	82.44	145.48	42.91	24.66

Table 42: Socioeconomic indicators (Increase Temperature 1C & Increase Rainfall 10%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	51.73	13.86	2.93	0.33	1.36	5.08	8.04	3.30	4.78	2.96
Vegetables	405.50	62.65	20.88	2.35	9.55	37.09	60.14	22.41	36.91	23.05
Fruit Tress	122.14	266.87	19.28	7.28	6.09	37.11	49.54	70.96	22.98	12.43
Total Ir-rigated	579.37	343.38	43.08	9.96	17.00	79.28	117.72	96.67	64.67	38.44
Field Crops	19.90	329.22	1.90	0.00	0.76	3.14	6.67	47.58	4.77	3.54
Vegetables	0.68	0.90	0.10	0.00	0.06	0.17	0.29	0.25	0.19	0.11
Fruit Tress	13.87	151.33	2.20	0.00	0.64	3.34	5.47	32.73	3.27	2.13

Total Rain-fed	34.45	481.44	4.21	0.00	1.46	6.65	12.43	80.56	8.23	5.78
Field Crops	71.64	343.07	4.83	0.33	2.12	8.22	14.71	50.88	9.55	6.50
Vegetables	406.18	63.55	20.98	2.35	9.61	37.26	60.43	22.66	37.10	23.16
Fruit Tress	136.00	418.20	21.48	7.28	6.73	40.45	55.01	103.69	26.25	14.56
Total ZRB	613.81	824.82	47.29	9.96	18.46	85.93	130.15	177.23	72.90	44.22

Table 43: Socioeconomic indicators (Increase Temperature 2C & Increase Rainfall 10%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	52.35	13.87	2.99	0.34	1.38	5.17	8.16	3.35	4.83	2.98
Vegetables	409.82	62.32	20.95	2.35	9.60	37.25	60.39	22.40	37.09	23.14
Fruit Tress	123.67	265.44	19.46	7.28	6.16	37.42	50.09	70.99	23.34	12.67
Total Ir-rigated	585.84	341.63	43.41	9.97	17.14	79.84	118.63	96.74	65.26	38.79
Field Crops	20.71	327.12	1.97	0.00	0.79	3.25	6.92	47.62	4.95	3.67
Vegetables	0.69	0.89	0.10	0.00	0.06	0.18	0.29	0.25	0.19	0.11
Fruit Tress	13.87	151.08	2.21	0.00	0.64	3.35	5.48	33.13	3.27	2.13
Total Rain-fed	35.27	479.09	4.28	0.00	1.48	6.77	12.69	81.00	8.41	5.91
Field Crops	73.05	340.99	4.97	0.34	2.16	8.42	15.08	50.97	9.78	6.66
Vegetables	410.52	63.21	21.05	2.35	9.66	37.42	60.68	22.65	37.27	23.25
Fruit Tress	137.54	416.52	21.67	7.28	6.80	40.76	55.56	104.12	26.62	14.80
Total ZRB	621.11	820.71	47.68	9.97	18.62	86.61	131.32	177.74	73.67	44.71

Table 44: Socioeconomic indicators (Increase Temperature 3C & Increase Rainfall 10%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	54.69	13.83	3.10	0.35	1.44	5.37	8.51	3.46	5.07	3.14
Vegetables	407.73	62.33	20.93	2.43	9.57	37.25	60.21	23.16	36.86	22.97
Fruit Tress	128.16	265.71	20.34	7.47	6.39	38.88	52.07	72.83	24.27	13.19
Total Ir-rigated	590.59	341.88	44.36	10.25	17.40	81.50	120.79	99.45	66.19	39.30
Field Crops	20.76	327.40	1.98	0.00	0.79	3.26	6.94	48.08	4.96	3.68

Vegetables	0.70	0.88	0.10	0.00	0.06	0.18	0.29	0.25	0.19	0.11
Fruit Tress	13.85	150.02	2.19	0.00	0.64	3.33	5.46	33.12	3.26	2.13
Total Rain-fed	35.32	478.30	4.27	0.00	1.48	6.77	12.69	81.45	8.42	5.92
Field Crops	75.46	341.23	5.08	0.35	2.23	8.63	15.45	51.54	10.03	6.82
Vegetables	408.43	63.22	21.03	2.43	9.63	37.42	60.51	23.41	37.05	23.08
Fruit Tress	142.01	415.73	22.53	7.47	7.03	42.21	57.53	105.95	27.53	15.32
Total ZRB	625.90	820.18	48.63	10.25	18.89	88.27	133.49	180.90	74.61	45.22

Table 45: Socioeconomic indicators (Increase Temperature 4C & Increase Rainfall 10%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	54.72	13.86	3.10	0.36	1.44	5.39	8.52	3.60	5.05	3.12
Vegetables	423.03	62.55	21.71	2.50	9.94	38.62	62.48	23.82	38.27	23.86
Fruit Tress	130.42	265.69	20.51	7.64	6.48	39.37	52.70	74.45	24.56	13.33
Total Ir-rigated	608.17	342.10	45.32	10.50	17.85	83.39	123.70	101.87	67.88	40.31
Field Crops	22.15	329.86	2.12	0.00	0.84	3.49	7.43	49.35	5.31	3.94
Vegetables	0.71	0.89	0.10	0.00	0.06	0.18	0.29	0.25	0.19	0.11
Fruit Tress	14.02	150.82	2.23	0.00	0.65	3.38	5.53	33.99	3.31	2.15
Total Rain-fed	36.88	481.57	4.45	0.00	1.55	7.05	13.25	83.60	8.81	6.21
Field Crops	76.87	343.72	5.22	0.36	2.28	8.88	15.94	52.96	10.36	7.06
Vegetables	423.74	63.45	21.81	2.50	10.00	38.80	62.77	24.07	38.46	23.97
Fruit Tress	144.44	416.51	22.73	7.64	7.12	42.75	58.24	108.44	27.87	15.49
Total ZRB	645.05	823.68	49.76	10.50	19.40	90.44	136.95	185.47	76.69	46.51

Table 46: Socioeconomic indicators (Increase Temperature 1C & Increase Rainfall 20%)

Indicators	**Produc-tion**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	52.27	14.12	2.97	0.34	1.37	5.15	8.14	3.36	4.83	2.99
Vegetables	420.00	64.17	21.51	2.41	9.85	38.23	62.00	22.96	38.07	23.77
Fruit Tress	124.47	272.43	19.63	7.41	6.20	37.79	50.41	72.23	23.37	12.63

Total Irrigated	596.74	350.72	44.12	10.16	17.42	81.17	120.55	98.54	66.27	39.38
Field Crops	20.78	337.61	1.98	0.00	0.79	3.27	6.95	48.77	4.97	3.69
Vegetables	0.71	0.93	0.10	0.00	0.06	0.18	0.29	0.25	0.19	0.12
Fruit Tress	14.15	155.37	2.25	0.00	0.65	3.42	5.59	33.59	3.34	2.17
Total Rainfed	35.64	493.91	4.33	0.00	1.50	6.86	12.84	82.62	8.50	5.98
Field Crops	73.05	351.74	4.96	0.34	2.16	8.42	15.09	52.13	9.80	6.67
Vegetables	420.71	65.10	21.62	2.41	9.91	38.41	62.29	23.21	38.26	23.88
Fruit Tress	138.62	427.80	21.88	7.41	6.85	41.20	56.00	105.82	26.71	14.80
Total ZRB	632.38	844.63	48.45	10.16	18.93	88.03	133.38	181.16	74.78	45.36

Table 47: Socioeconomic indicators (Increase Temperature 2C & Increase Rainfall 20%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	52.54	14.16	3.02	0.34	1.38	5.21	8.20	3.41	4.84	2.99
Vegetables	405.59	63.15	20.89	2.38	9.55	37.14	60.13	22.71	36.86	23.00
Fruit Tress	125.32	268.37	19.69	7.42	6.22	37.91	50.60	72.38	23.48	12.69
Total Irrigated	583.45	345.67	43.60	10.15	17.15	80.26	118.93	98.50	65.18	38.67
Field Crops	21.37	337.13	2.04	0.00	0.81	3.36	7.15	48.90	5.11	3.79
Vegetables	0.69	0.91	0.10	0.00	0.06	0.18	0.29	0.25	0.19	0.11
Fruit Tress	14.06	153.38	2.23	0.00	0.65	3.39	5.55	33.29	3.32	2.16
Total Rainfed	36.13	491.42	4.37	0.00	1.52	6.92	12.99	82.45	8.62	6.06
Field Crops	73.92	351.29	5.06	0.34	2.19	8.57	15.35	52.31	9.95	6.78
Vegetables	406.28	64.06	20.99	2.38	9.61	37.31	60.42	22.96	37.05	23.11
Fruit Tress	139.38	421.75	21.92	7.42	6.87	41.30	56.15	105.67	26.80	14.85
Total ZRB	619.58	837.09	47.97	10.15	18.67	87.18	131.92	180.94	73.80	44.74

Table 48: Socioeconomic indicators (Increase Temperature 3C & Increase Rainfall 20%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	57.14	14.09	3.23	0.35	1.50	5.59	8.87	3.51	5.29	3.28

Vegetables	420.08	63.47	21.59	2.46	9.86	38.35	62.09	23.43	38.05	23.74
Fruit Tress	127.27	266.97	20.10	7.45	6.35	38.55	51.65	72.64	24.10	13.10
Total Irrigated	604.48	344.52	44.91	10.26	17.71	82.49	122.62	99.59	67.44	40.13
Field Crops	21.02	344.09	2.01	0.00	0.80	3.30	7.03	50.48	5.03	3.73
Vegetables	0.68	0.90	0.10	0.00	0.06	0.17	0.28	0.25	0.19	0.11
Fruit Tress	13.60	151.40	2.16	0.00	0.63	3.27	5.37	33.64	3.21	2.09
Total Rainfed	35.30	496.39	4.26	0.00	1.48	6.75	12.68	84.37	8.42	5.93
Field Crops	78.15	358.18	5.23	0.35	2.30	8.90	15.91	53.99	10.32	7.01
Vegetables	420.76	64.36	21.68	2.46	9.92	38.53	62.38	23.68	38.23	23.85
Fruit Tress	140.87	418.36	22.26	7.45	6.98	41.82	57.02	106.28	27.31	15.20
Total ZRB	639.78	840.91	49.17	10.26	19.19	89.24	135.30	183.96	75.86	46.06

Table 49: Socioeconomic indicators (Increase Temperature 4C & Increase Rainfall 20%)

Indicators	**Production**	**Planted Areas**	**Intermediate Consumption)**	**Water Cost**	**Labor cost**	**Total Cost**	**Gross Output**	**Water Use**	**Value Added**	**Operation Surplus**
Unit	(000,ton)	(000, du)	(MJD)	(MJD)	(MJD)	(MJD)	(MJD)	(MCM))	(MJD)	(MJD)
Field Crops	58.25	14.15	3.30	0.37	1.53	5.72	9.06	3.65	5.39	3.34
Vegetables	426.63	63.78	21.98	2.55	10.05	39.10	63.22	24.24	38.69	24.12
Fruit Tress	130.24	268.42	20.53	7.69	6.48	39.46	52.76	75.00	24.54	13.31
Total Irrigated	615.12	346.35	45.82	10.60	18.06	84.28	125.04	102.89	68.62	40.76
Field Crops	23.37	357.16	2.22	0.00	0.88	3.66	7.80	54.25	5.58	4.14
Vegetables	0.72	0.91	0.10	0.00	0.06	0.18	0.30	0.26	0.19	0.12
Fruit Tress	14.43	154.70	2.29	0.00	0.67	3.48	5.69	34.97	3.40	2.22
Total Rainfed	38.52	512.76	4.62	0.00	1.61	7.32	13.79	89.49	9.18	6.47
Field Crops	81.62	371.31	5.53	0.37	2.42	9.38	16.86	57.90	10.97	7.48
Vegetables	427.35	64.69	22.09	2.55	10.11	39.28	63.52	24.50	38.88	24.23
Fruit Tress	144.67	423.12	22.82	7.69	7.15	42.93	58.46	109.98	27.94	15.53
Total ZRB	653.64	859.12	50.43	10.60	19.67	91.59	138.83	192.38	77.79	47.24

Assessment of Direct and Indirect Impacts of Climate Change Scenarios

(II) Micro Impacts

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1 General Description

1.1 Introduction

In Jordan more than 80 % of the country's area is arid and receives less than 200 mm annual rainfall. The climate varies from dry sub-humid Mediterranean in the northwest of the country with rainfall of about 600 mm to desert conditions with less than50 mm in Wadi Araba in the south (An Environmental Profile of Jordan, 2006).

The competition between different water users in different sectors as domestic water, tourist sector, industry, public parks and agriculture is rapidly increased. In the year 2007 agriculture consumes about 64% of the available water resources while 30% is for domestic use. Industry consumes about 5% of the available water resources (Royal Commission on Water, 2009).
These competitors for fresh water use have different economic, social and political relevance. The domestic and agriculture sectors require more water in the future as a consequence of increasing population.

The Zarqa basin is considered the most important basin in Jordan because it hosts about 70% of the industrial activities and about 50% of the population of the country reside on it. A large wastewater treatment plant is situated in the basin, the effluent of this plant discharges to the main river contributing to about 50% of its annual yield (University of Jordan, 2006).

The basin now is facing many environmental problems such as land degradation and desertification, salination of ground water and deforestation processes. The expectation of climatic changes and its effect on the eco-system and the water resources is imposing another dimension to the future scenario of the basin. The frequent occurrence of drought and weather externalities has become a known phenomenon in this region.
This study focuses on the competitiveness of water use in agriculture and other sectors and use of water of different quality. Also this study will evaluate and assess the different scenarios of water availability and quality – as a consequence of climate change in the region - depending on economic and social aspects.
To simulate the complexity of the system, a base line scenario was built using the Water Resources Model (WRM). Scenario has been tested to reflect the expectation of the impact of climate change in the future.

1.2 The study area: Zarqa River Basin

The Zarqa River is the second largest river in Jordan after Yarmouk River. The river basin drains an area of 4120 square kilometers where about 95% of its area is within Jordan and only 5% is in Syria. The basin extends from the Syrian city of Salkhad in Jebal al-Arab with an elevation of 1460 m to south of Amman and then westward to discharges its water at its confluence with River Jordan at an elevation of -350 m.

The basin represents a transitional area between the semi arid highlands in the west to the arid desert in the east. The basin is subdivided into two main catchments; Wadi Dhuliel sub-basin representing the arid conditions and flat land and Seil al-Zarqa sub-basin which represent the most populated mountainous area. The main agricultural area in this basin is from Northwest of Jordan and stretching from the Wastewater treatment plant As Samra down the river Zarqa to Jordan Valley including Deir Alla.

The Zarqa River is perennial with typical monthly flows of 2 to 3 MCM during summer and 5 to more than 8 MCM during winter. The Zarqa River is controlled by the King Talal Dam, which provides a storage capacity of 86 MCM. Connected through a canal and pipes to the King Abdullah Canal, the River provides irrigation for a further 8,400 hectares of land (ministry of Environemnet, 2006).These zones cover different water qualities. The water quality of King Talal Dam fluctuates all over the year; the best quality occurs when the floodwater in the dam is dominant and the worst quality occurs when the effluent of the wastewater treatment plant is dominant.

Therefore it will be three main areas for the study:

1. Highlands of the ZRB that use fresh water (Groundwater).
2. The ZRB which represents the area between As-Samra Treatment Plant and KTD. In this area the quality of water before King Talal Dam is better than that after the treatment plant, because of that it could be divided into two different sub-regions.
3. Lower ZRB which represents the Jordan Valley.

1.3 Objectives

The overall objective of this study is to evaluate the impact of different scenarios of the water resources availability and quality as a result of Climate Change on the Zarqa River Basin an in-depth socio economic analysis.

The specific objectives are as follows:

1. To analyse and measure the effect of different water qualities in farm organisation, families' living standard and sustainability of farming systems under different conditions of water availability and water quality
2. To simulate and measure the future impact of different scenarios of water availability and quality on farm organisation and income as well as living standard of farm families.
3. To discuss the competitiveness of water use in comparison to between different sectors.

1.4 Methodology

1. Describing the socio-economic status without any change in Climate by analyzing Factors (Driving forces) that are affecting the socio-economic status like population growth, income level & other economics activities. This has been done in the agriculture sector depending on water quality for irrigation.
2. Measuring the impact of water quantity and quality on Agricultural income at different levels (farm Income, Gross Income), labor, productivity and profitability of water, the change in cropping pattern and restriction of planted areas.
3. Evaluate the impact of different scenarios of water availability and quality as a result of climate change on agriculture sectors and consequence on the availability of water in other sectors like domestic and industrial sectors.

1.4.1 Modeling Approach

In this study a Water Allocation Model (WAM) will be used as a decision support system to study the impact of changing water quantity of different qualities on socio-economics of the Agriculture, Municipal and Industrial sectors of ZRB. WAM has two main goals, first, to provide district and national level planners with a decision support tool for planning agricultural activities under various water amounts, qualities, and prices as a result of climate change scenarios; and second to provide with a soundly based analysis of agricultural water demand and it optimal allocation of water, cropping pattern and agricultural income.

WAM is an optimizing model and will deal mainly with irrigated agriculture sector. It uses data on available land, water requirements per unit land area for different crops, and net revenues per unit of land area generated by the growing of those crops. WAM is characterized by the following: (1) application of WAM to actual data suggests that the model closely approximates the actual response of farmers to water prices. (2) WAM results can serve planners as an approximation. (3) A departure of actual behaviour from the optima generated by WAM can serve as a signal to planners that further study should be done. (4) WAM provides a quantitative post-optimal sensitivity analysis that can be used to analyze uncertainty, stability of plans and risks. (5) WAM can serve as a decision-support device suggesting to planners what crop patterns are likely to prove optimal under various conditions and relating these to different water policies.

WAM is formulated at the regional level. Its objective function is the net agricultural income of the district, which is maximized by selecting the optimal mix of water-consuming activities (Vegetables, fruits and field crops). The constraints in WAM involve two factors: water, land area, labor, fertilizers and marketing capacity of all crops. The user can impose constraints on the availability of water by quality and by season and on land quality represented by it class level. As an example, for lower ZRB, the categories of activities subject to land-area constraints are all activities; crops of the same group (vegetables, fruit trees and field crops); crops irrigated by the same water quality and crops grown during the same season.

1.4.2 Scenarios of the study:

Two main scenarios expected to be analyzed in this study as follows:

Business as Usual (BAU): The purpose of this scenario is to identify what course of action would be taken in the absence of climate change adaptation, and how climate change is likely to affect development activities. It seeks to answer the question: "What development activities would be pursued by the Government of Jordan (MoEnv) at the Zarqa River Basin in the absence of climate change? How would the targeted human systems develop without adaptation?" Without adaptation, how would development activities be affected by climate change?

Adaptation scenario: The purpose of this scenario is to identify the course of action that will have to be taken to respond to the adverse impacts of climate change, so as to achieve sustainable results. It seeks to answer the question: "How should the development objective be achieved, taking into account the impacts of climate change, and what immediate and urgent measures are necessary to respond to such impacts?" determine what will the future water availability and quality impact the overall economical conditions of the basin. Determine how the use of alternative water supplies with different qualities will affect cropping pattern and types and may be marketing. Determine how will the industrial sector be forced to adopt different measures to deal with water availability which will impact the eventually impact the consumer. Under this main scenario three sub-scenarios will be analyzed as follows:

1. Decreasing fresh water quantity.
2. Increasing TWW quantity.
3. Degradation of fresh water quality.

1.4.3 Design of survey and collection of information

The study is based on secondary and primary data. Secondary data were obtained from different governmental services and non-governmental institutions and services. Likewise a discussion with governmental and non-governmental officers in the study area has been carried out. Nevertheless the secondary data were obtained from other studies have done for the study area.
Since the time is limited Primary data were obtained through Rapid Rural Appraisal (RRA), meeting with key persons and short surveys on the level of farms, families and households. The experience of researchers and the rate of inflation were be considered in estimating and determining the present values

2 Socioeconomic Status of Zarqa River Basin

This part deals with the socio-economic issues of the family and farm in different zones in Zarqa Basin. The first section describes the availability of the resources in Zarqa Basine, such as labour, land, water and capital. The second section deals with the resulting living standard of the concerned rural population through the analysis of social and economic criteria including parameters such as education and health, economic criteria focused on income and cash availability.

2.1 Resource analysis

The resource analysis is important for understanding the decision-making process because it gives information about the availability, quality and differences of using resources in different zones. This section deals with human, water, land and capital resources of farm-household-family in the study area.

2.1.1 Land resource

Agricultural land occupies more than 24% of the total land area in Zarqa River basin. Natural forests occurring in the mountainous part are composed of oak, pine, juniper, wild olive and cypress. Agricultural activities and their associated weeds have supplanted the indigenous flora communities. Agriculture is scattered with the basin from rainfed orchards, olive and field crops to irrigated agriculture on the river banks and the Jordan valley. Private Irrigated area using groundwater as a source of irrigation water can be found in scattered places in the middle and the eastern part of the basin. The rainfed land represents about 10% of total area (e.g. orchards, olive and field crops) and irrigated area represents 12% on the river banks and the Jordan Valley. Pasture activities represents 17% . Land capacities of farms in the study area were between 36-58 dun and the lowest was in area before King Talal Dam. The highest percent of farmers using greenhouses were in Jordan Valley.

In the past vegetables and fruit were the main products in the area between treatment plant and King Tallal Dam but now the pattern of plants changed. In the area after treatment plant the main product is clover and in before king Tallal dam it is fruit trees, especially olives. The reason for these changes is the quality of water, which became worse. Due to the bad quality of treated wastewater, irrigation was limited to fodder and trees, it was not allowed to plant vegetables in these areas according to the Jordanian standards for the use of wastewater in irrigation (Environmental Health Directorate, 1999).

2.1.1.1 Industrial sector

ZRB is the most industrialized area in Jordan. About 60% to 70% of industrial activities are located in the basin. Sixty one industries were identified and localised in the ZRB. In terms of water use, the most important industries include: the Jordan petroleum refinery, Al-Hussein thermal power plant, the Jordan paper & cardboard MFG (paper and carton processing), the Jordan paper ice & aerated water co., the national industry of Ghreise (cement product) and the yeast industries co. Other industrial sub-sectors concern the textile and leather production, food Industries, distilleries, drugs and chemical industries, intermediate petrochemicals, engineering industries, iron and steel manufacturing.

2.1.1.2 Touristic sector

At national level, the tourist sector contribute to more than 10% of the Gross Domestic Product and about 2.5% of total active population is working in this sector (Taha et al., 2004). At basin level, the tourist activities are mainly concentrated around Amman city. In the context of the Jordanian Water Master Plan, the touristic water use assessment was based on the number of bed-places and occupancy rate in tourist accommodation.

2.1.2 Water Resources

The main source of water for the agricultural area between As-Smara and King Talal Dam is the effluent from As-Samra treatment plant. The mixed water from the King-Talal Dam is the main source for Jordan Valley. In total, about 100 MCM/yr of surface water are presently developed for irrigation, municipal and industrial use in the whole Basin. Groundwater is considered to be the major source of water in ZRB. The majority of the groundwater abstraction occurs in the highlands (121 MCM) 46% of which was used for irrigation, 48% for domestic, 4.1% for industrial and 1.4% for pastoral use. Currently, there are over 800 wells in ZRB used for different purposes of domestic, agricultural, tourist and industrial uses. Large number of which are privately owned.

The safe yield of ZRB aquifer is about 87.5 MCM which makes about 32% of the country's renewable groundwater resources (USAID/ARD, 2001).

Other groundwater resources in the ZRB include the springs and the brackish water. There are about 150 springs in ZRB, the flow of which ranges between 0.1 MCM to larger than 1 MCM. Desalination plants are constructed at some of these springs, the effluent of which is used for domestic purposes such as Kayrawan spring which supplies part of Jarash. The main springs within ZRB that have considerable flow are: Kayrawan ; Hazzir ; Wadi Sir.

There are 4 wastewater treatment plants (WWTP) serving most of the major urban areas in the ZRB. The effluents of Al-Baq'a, Jarash, Abu-Nuseir, and As-Samra treatment plants are discharged to the Zarqa River where it flows to the reuse sites or to the KTD (MWI, 2004).

The agricultural water demand represents about 230 MCM (51% of total water demand in the basin) (MWI, 2004). Agricultural water demand in ZRB is concentrated in two areas which are Zarqa river watershed and the high lands. It is important to note that a high percentage (46%) of the groundwater abstraction in ZRB happens at the highlands and is used for irrigation (USAID/ARD, 2001).

Municipal water demand makes the second in volume of the water users in ZRB. Within ZRB, 252 domestic demand centres was identified in the National Water Master Plan some of which are large parts of big cities like Amman and Zarqa which represents hundreds of thousands of people. The average per capita per day domestic water consumption over the whole basin is estimated to be about 110 l/c/d, however there is some disparity across the basin. The present water demand amount to 150 MCM/y, of witch about 50% are for Amman governorate Amman city is actually supplied with domestic water from the three main groundwater basins occurring in the highland aquifer systems and partly from Zai Water Treatment Plant, which utilizes the Yarmouk River water through King Abdullah Canal (MWI, 2004).

The total industrial water demand amount 7.5 MCM for the year 2005, representing around 1.7% of total water demand in ZRB. It should be noted that the estimated industrial water demand refers to the self yield water, mainly abstracted locally from industrial wells. The largest industrial consumers within the basin use more than 100,000 m3/yr. Part of industrial water use is computed in the municipal water demand – small and medium industries which are connected to public water supply network. Most of these industries consume small amounts of water less than 300 m3/yr or less (MWI, 2004, Meditate, 2006).

The touristic sector in ZRB absorbs about 0.5 % of the total present water demand (2 MCM/yr). The per capita water use in this sector was estimated at an average of 2 l/c/d in Amman governorate (Taha et al., 2004).

2.1.2.1 The Quality of Water in the Basin

The over abstraction of groundwater has resulted in water quality deterioration of some wells. Pollution of surface water is from domestic and industrial effluents as well as solid wastes.

Water quality is the lowest in the effluent near the As-Samra treatment plant and improves due to natural causes during its flow down to King-Talal Dam where it is mixed with fresh water. This mixed water constitutes the water of the second best quality in the study area, topped only by the quality of pure fresh water from groundwater in the study area.

Now the quantities of irrigation water per dun between As-samra and King Talal Dam increased as compared with the past (before 20 years). This means the water was more available in this area and the farmers could use more water but with low quality. In other zones in basin the quantity of water (mixed water or fresh water) decreased as compared with the past. This means in the zones of treated wastewater the water is more available comparing with the past.

About 70% of the irrigation systems are high-tech mainly micro irrigation. Also, water distribution to irrigation projects are mainly through pressurized pipe systems. The low quality of water reflected the using of irrigation systems; where in treated wastewater zones the using of drip irrigation system is low comparing with other zones in the basin. This is due to the fact that this kind of technology needs good quality water otherwise the dripper becomes clogged. Additional reason was the availability of water, which was high in low quality water zones.

2.1.3 Human resource analysis

The analysis of human resources focuses first on demographic criteria such as sex and age. Both factors determine the capacity and availability of labour for the farm and off-farm activities. The family allocates labour among the household, farm and off-farm activities.

2.1.3.1 Demography

The ZRB is shared among 5 administrative governorates: Amman, Al Balqa'a, Az Zarqa, Al Mafraq and Jarash. ZRB is the most populated basin in Jordan, the population was estimated about 3.2 million in 2005, representing about 58% of the total Jordan's population. (Department of Statistics (DOS), 2005).

Four main indicators are discussed in this part for describing the human resources in the study area: family size, sex and age of the head and members of family, and the level of education of the head of family.

For analytical purposes, the labour capacity of family members was standardized according to age classes. A full man-equivalent (ME) was assigned to members at an age between 14 and 16 years, 0.5 ME for members above 60 years and 0.2 ME for members below 14 years.

The level of education of head of the family affects decision-making and his age gives an indicator of his potential active participation in labour activities. In the entire study area the head of the family was male; in Jordanian society the head of the family is the father and when he dies the eldest son becomes the head of the family. Women rarely become the head of the family. From the result of the RRA and the discussion with key persons the demographic data has been analyzed. As a result the average age of the head of family is between 46 and 53 years in all zones, and an average 1 ME was attributed to this position.

The family size, an average total population, was between 7.4 and 11.3 members per family (RRA and Key persons). All of these areas were rural and agricultural areas, characterized by large families due to the farmers' need of labour force to aid him in his work. The average age the family members are between 14 and 60 years old. The number of family members who were over 60 years old was low; it was within the average of 0.2 to 0.4 members but not more than 5.5% of the total members of the family. At the same time 60% to 68% of the members of the family in all of the study areas were between 14 to 60 years old. This means the labour capacity of the family was high in the study areas.

2.1.3.2 Family labor and off-farm activities

Family labour is allocated between farm and off-farm activities. The labour capacity and the labour use were analysed in this part. Labour capacity depends on the family size and the age of the members of the family.

The total labour capacity was between 5.4 to 7.7 ME per family in the whole study area. Impacts on the allocation of these labour capacities in household, farm and off-farm activities derive from factors like income, the availability of off-farm employment, the requirements of farming activities and social constraints, such as the willingness of individual family members to participate in specific activities. About half of the families (40% to 65%) had at least one member who worked in an off-farm activity. The off-farm labour was between 0.56 to 1.32 ME per family. The availability of family labour after subtracting the off farm labour from the total labour capacity was between 4.84 ME and 6.98 ME. (RRA, Key persons, previous studies).

The off-farm work is allocated between military, government and private work. The private business provides better opportunities in the Jordan Valley. The reason for this is that the Jordan Valley is a large agricultural area
and provides many related activities such as renting tractors and selling fertilizers and pesticides

2.1.3.3 Hired labour

In the farm, labour can be provided by family members or by hired labour, the hired labour can be both permanent and temporary. The farm requires temporary labour at the time of harvesting, fertilizing or other agricultural processes during specific times during the year. Small farmers use temporary labour because their farms do not need permanent labour. In all of the study area, permanent labour was only performed by males. Temporary labour was performed by males or females but the number of males was higher. The temporary female labour in the study area contributed 18% to 46% to the total temporary labour force.

2.1.4 Capital resources

This part discusses the value of average investment in different zones and the source of capital, credit or cash. Since the quality of water is better in Jordan valley comparing with that near the treatment plant, the highest average investment was in Jordan Valley, the farmers in Jordan Valley used new technology more than in the areas near treatment plant e.g. drip irrigation systems, which do not work with low quality water due to technical problems. The lowest investment was in zones near treatment plant, where farmers planted clover as a main crop and this type of crop does not need much investment. While more than 75% of farmers in Jordan Valley their main investments are in irrigation systems and about 48% are in greenhouses.

In the study area there were many farmers dependent on credit to obtain capital; about 24% to 68% of the farmers received credit but the average value of the credit was not high near As-Samara while it is higher in the Jordan Valley.

2.2 Living standard in Zarqa River Basin

This part discusses the living standard of the family in the study area by using criteria of living standard. Doppler (2002) emphasized the role of living standard as a part of the quality of life and defined the following basic criteria:

- Family income.
- Cash and liquidity.
- Independence from resource owners.
- Food supply and food security.
- Supply of water, housing, sanitary equipment, energy and clothes.
- Health conditions of the family.
- Education and qualification.
- Social security.

The living standards analysis in the study area (Zarqa Basin) will depend on previous mentioned criteria. These criteria include economical and social indicators which reflect the present situation in the study area. Depending on these criteria the expectation of future impact of climate change will be analyzed in this basin.

2.2.1 Family income

Income is one of the economic criteria of the living standard and reflects the ability of the families to satisfy their needs in terms of food, clothes etc., also the possibility to accumulate capital through net revenues. The family income consists of the farm and the off-farm income. The farm income represents the difference between all revenues and all expenses from activities resulting from the own agricultural enterprise (Doppler, 1998).

In Jordan Valley the total cost of farm activities is high due to the level of investments, and the resulting depreciation and maintenance costs, also expenses for plant production are high in this zone, because both use high quantity and good quality of fertilizer and pesticides compared to other zones as shown in Table 2-1. The pattern of crop and using high technology in zones of Jordan valley comparing with other zones (zones of low quality of water) leads to make a difference in the level of income between these zones. The average farm income near treatment plant is low comparing to the other two zones. This indicates that the climate change will affect the living standard of people in this zone highly comparing to other zones.

The lowest farm income per unit of area was in Zones near treatment plant and the farm income per unit of water is very low in this Zone (0.13 JD /m3) compared to other zones (Table 2-2), this indicates that the farmers in this zone could pay the lowest price for water compared to other zones. The necessity to increase the quantity of water is present in other zones. The farm income per unit of capital is between 0.38 and 0.6 JD/JD.

The highest off-farm income in the study area is between 29%-41% of the family income. This indicates that many farmers work in off-farm activities, which reduces the possible risk incurred from agricultural production.

The differences between the family incomes are high in different zones. The reason for this is that the agricultural activities practiced by farmers are different. The investment is very high for the farmers, who planted vegetables in greenhouses where the returns were very high. The others planed in the traditional way and their farm income is low. The conclusion here is that the potential to improve the farm income in zones of high quality water is higher than in the other zones. As a result of using treated wastewater water, the potential to improve the income is limited due to the limited types of crops that are allowed for planting.

Table 2 1: The farm, off-farm and family income in different zones in Zarqa Basin, Jordan 2009/2010

Zones	Near treatment Plant	Before King Talal Dam	Jordan Valley
Total expenses	11424	18242	25067
Rent of the land	1230	4,424	3,190
Labour	2,722	3,192	4,649
Transportation	2,038	930	2,487
Water	121	26	332
Fertilizer and pesticides	630	2300	5200
Seeds and feeding for animals	1130	2,706	2,246
Reduction in stock	496	380	0
Depreciation and maintenance	2,618	3,641	4,288
Others	439	643	2,675
Total revenue	18347	28549	34493
Revenue from plant production	12,620	24136	30826
Revenue from livestock	3,677	1546	584
Rent out resources	2,050	2,867	3,083
Farm income	6923	10307	9426
Off-farm income	2,801	5,286	6,605
Family income	9724	15593	16031

Table 2 2: Farm income per unit of land, unit of water, unit of labour and unit of invested capital, Jordan 2009/2010

Criteria	Unit	Near treatment Plant	Before King Talal Dam	Jordan Valley
Farm income per year	JD/year	6923	10307	9426
Farm income per area	JD/dun	192.3	134.7	162.5
Farm income per quantity of water	JD/m3	0.13	0.46	0.33
Farm income per invested capital	JD/JD	0.61	0.57	0.38
Family income per year	JD/ year	9724	15593	16031

2.2.2 Cash and liquidity

Liquidity indicates the availability of cash when it is urgently needed, e.g. when the loan has to be repaid. Liquidity analysis deals with the cash availability and requirements on a farm or family in different periods over time (Doppler, 2002).

Time periods can be different based on a weekly or monthly basis the cash situation of the household. Annual cash balances, provide information on the general situation of the family and the liquidity over many years reflects cash problems related to draughts and other general occurrences in the region. While the short-term analysis reflects more the condition of the individual family, long-term cash problems are more typical for a large number of families in the region. The liquidity reflects how much the farmer can pay for the external resources such as land, water or credit. Also, it is important if the farmer needs to change the pattern of crops when he faces problems.

Liquidity is the cash which farmers have after deducting cash out-flows from the cash in-flows from all activities in the farm and household. Cash out-flows are very high in Zone near the dam and in Jordan Valley, and cash in-flows as well. The average value of liquidity in different zones is high (Table 2-3) but it is the lowest near the treatment plant. The farmer needs cash mainly in March, April and May in Zones of Jordan Valley, where vegetable crops are the main activities, while revenue is produced in May, June and July. Farmers in the Jordan Valley can buy what they need on credit from the shops there for their planting activities such as fertilizers and pesticides. When they sell their products they pay back these loans at no interest rate, so they have cash if the products and the prices are high. The farmers in the Jordan Valley depend on the traders to get what they need for planting. In Zone of olive cultivation, cash is available in September and October. In Zone of clover cultivation, cash is available in all months of the year, because the farmers harvest and sell clover, about ten times per year, from February to November.

The lowest farm cash income per unit of area is in the Zones near treatment plant, the highest is in Jordan Valley zones. This means renting more land in Jordan Valley is more efficient than the Zones of treatment plant. The farm cash income per unit of water is very low in the Zones near treatment plant compared to other Zones. This indicates that the farmers in this Zone could pay the lowest price for water compared to other Zones. The need to increase the quantity of water presents in Zones of Jordan Valley. This means the climate change will affect these zones (Jordan valley zones) highly in case the fresh water decreased.

Table 2 3: The annual cash in-flow and out-flow in different farming systems, Zarqa Basin, Jordan 2009/2010

Zones	Near treatment Plant	Before King Talal Dam	Jordan Valley
Expenses for plant and animal production	8367	13958	18104

Household expenses	5,880	7,100	6500
Other expenses	1,266	1,843	2251
Total cash out flow	15,513	22,901	26,855
Plant production	12620	24136	30826
Livestock	3677	1546	584
Rent of resources and others	2050	2867	3083
Off-farm income	2801	5286	6605
Inflow cash	21148	33835	41098
Cash balance	5635	10934	14242

2.2.3 Food and water supply, housing, and expenditure in the household

These criteria reflect the main needs in the household and reflect the ability of farmers to satisfy these needs. In all of the study area the expenditure for food is between 37%-44% of the total expenses of the household as shown in Table 2-4. The food subsistence in the study area is between 10%-18% of the total value of food for household, it means the families depend on the market to satisfy their food needs. The reason behind that is the aim of farmers is to plant what the markets need, so the orientation to the market in all of the study area is high. At the same time, the diversity of crops in the farm is not enough to cover all the needs of the families. The household expenses are 40% to 60% of the family income in different zones of the study area. The highest percent of the household expenses in the family income are in Zones near treatment plant, they are 60% of family income. This indicates that the expenses in the farm activities are low in these zones, which reflects the low ability to change agricultural activities in case the farmer wants to improve his living standard.

The water quantity for the household (m3 /per person) in the study area is between 110 m3 to 175 m3. In the study area all families had electricity except about 4%. Also in all of the study area 92% or more of families in each zone own their houses.

Table 2 4: Household expenses and food consumption of the family, Zarqa Basin, Jordan 2009/ 2010

Zones	Near treatment Plant	Before King Talal Dam	Jordan Valley
-Total food consumption (JD)	2587	2840	2405
-Food from market (JD)	2328	2442	1972
-Food from farm (JD)	259	398	433

-% Value of food subsistence from total food expenses	10%	14%	18%
-% Value of food consumption from total household expenses			
- %Value of other expenses from total expenses in household			
Total household expenses (JD)	44%	40%	37%
Total household expenses as percent of family income	56%	60%	63%
Off-farm income	5880	7100	6500
Inflow cash	60%	46%	41%
Cash balance	5635	10934	14242

2.2.4 Health of the family

Health is a social criterion to provide an impression of how families take care of their members and their financial ability to pay for physician services when needed. It also reflects the availability of health services in each zone. This part discusses how often family members visited the doctor annually within the previous five years when one was sick and what the main diseases in each zone are.

The average number of times in the previous five years that members of the family were sick in the year of the study is between 4 to 5 times per year and about 62% to 87% of these saw the doctor. Many members suffered from fever while in the area near the treatment plant about (24%) suffered from Asthma.

2.2.5 Education and qualifications

Education and qualification are important to add to the knowledge and experience of the decision maker, and in the long term to provide the coming generation with improved knowledge in the society.

In the study area 12%-24% of heads of the families were illiterate. On the other hand, 4%-24% of them studied after school in college or at universities. Most of them (56%-84%) finished at least one phase in the school. The situation in the new generation is better. At least 76% of the families in each zone had a member at school. The average number of members in school is between 2.4- 4.3 per family nevertheless there is about 4%-5% members of the family who studied after school. The situation of education is not only for males but there is also interest in teaching the females in the families. In some zones the percentage of females who studied after finishing school is more than that for male.

2.2.6 Social security

This aspect of the living standard gives an idea about what happens to the member of the family in the future when they become old or sick, or, if they suffer an accident how they can maintain a good quality of life. Two indicators were considered in the discussion of social security. The first one is how many families had health insurance; the second is how many families had social insurance.

About 32% of families in the study area had health insurance and most of them were covered if one of the family members was working in the government or military sector. Social insurance was very low in the study area; it was between 0%- 12%. This kind of insurance is private and covers accidents. At the same time, families with a member working in the government or military sector get pensions when they retire.

3 The efficiency of Resources use

Different methods are available for the partial analysis of the economic efficiency of resource use: such as production coefficients, cost coefficients for resources services, productivity of resources and gross margins (Doppler, 2000).

In this study the gross margin was used and calculated from the average variable costs and the average values of the output of plant and animal production in each zone, taking in consideration that the pattern of crops is different in different zones. The data of cost and return have been estimated depending on a survey has been done in the part of the study area, secondary data from the statistical department, discussions with key persons and on the previous studies and surveys in addition to the experiences of the researchers.

The permanent labour implied fixed costs and, contrary to temporary labour, was not considered. The cost of water was considered as a variable cost because it depends on the quantity of water, which changes depending on the crop.

3.1 Crop competitiveness within the study area

In the zone near treatment plant the main crops were clover and olives, in the zone before King Talal Dam the main crops were olives and citrus, while in the Jordan Valley vegetables and citrus were the main crops. In this part, the gross margin was calculated per unit of land (dun), per unit of cubic meter of water. These calculations will help to compare the efficiency of using the land in different zones, also to give an idea of the efficiency of using different qualities of water in different zones.

3.1.1 Gross margin for Field Crops

3.1.1.1 Gross margin for clover

The variable cost of clover was is relatively low; farmers use small quantities of fertilizer or pesticides as shown in Table 3-1. The gross margin for clover is about 858 JD/ dun, but the gross margin per cubic meter for clover is down to 0.35 JD/ m3. The reason behind that is the quantity of water per dun of clover is very high. It is the highest quantity in all of the study area. Planting clover in this zone could be the right decision, regarding the availability of water, because in this area the quantity of water is available but the quality is not good which is not necessary for this type of crops.

Table 3 1: Gross margin for clover in the zone near treatment plant, Jordan, 2009-2010

-Value of production (JD/ dun)	1033
Quantity of sales the product (Kg)	15000
Quantity for feeding livestock (Kg)	1210
Total quantity of production	17,210
Average price (JD/kg)	0.06
-Average variable cost (JD/dun)	175
Water (for energy)	20
Fertilizer, seeds and pesticides	42
Labour	52
Transportation	35
Others	10.1
Interest of operation capital (JD/dun)	15.9
-Average gross margin in JD/Dun	858
-Average gross margin in JD/m3	0. 35

3.1.1.2 Gross margin for wheat, Barley and Sorghum

Field crops in the study area are depending on rainfall. The variable cost for these crops is relatively low, also the productivity is low except the sorghum which is the highest gross margin comparing with wheat and barley as shown in table 3-2.

The land use efficiency is high for sorghum and low for other two crops. It indicates that the farmers could pay a high price for renting more land if they plant sorghum as compared to the farmers who plant wheat or barley.

Table 3 2: Gross margin for barley in rainfed area, Zarqa Basin-Jordan 2009/2010

Crop	Barley	Wheat	Sorghum
-Value of production (JD/ dun)	31.4	66.0	880
Quantity of sales production (Kg)	120	150	20000
Quantity of consumption (Kg)	5.5	10	200
Total quantity of production	125.5	160	22000
Average price (JD/kg)	0.25	0.35	0.04
Value of hey (JD/Dun)		10	
-Average variable cost (JD/dun)	16.5	36.8	495
Water (JD/dun)	-	-	20
seeds (JD/dun)	3.5	3.5	20
Fertilizer (JD/dun)	2.0	10	35
Labour (JD/dun)	10	20	25
Machine rental (JD/dun)	-	-	-
Transportation (JD/dun)	-	-	50
Rent of land (JD/Dun)	-	-	300
Interest of operation capital (JD/ dun)	1.5	3.3	45
-Average gross margin in JD/Dun	14.9	29.2	385

3.1.1.3 Gross margin for olives

The gross margin for olives per unit of land (see table 3-3) is less than that for clover; while the gross margin per unit of water for olives was about double that for clover, because the variable cost and the quantity of water for olives were lower than that for clover. In Zone before King Talal Dam many of farmers started to plant fruit trees few years earlier and they had changed their planting area from vegetables to olives so these trees were still young and their productivity is still low, but the gross margin per unit of water is high because the quantity of irrigation water in is low and the farmers are depending mainly on the rainfall.

It can be concluded that land use efficiency is higher in the area near treatment plant comparing with the area of before King Tallal Dam, but the water use efficiency is lower. It indicates that the value of water in the area near treatment plant is lower than the area of before the dam but the land is higher as compared to the other zone.

Table 3 3: Gross margin for olives, Zarqa Basin - Jordan 2009/2010

-Value of production (JD/ dun)	165.0
Quantity of sales production (L oil)	50
Quantity of Consumption (L oil)	3.0
Total quantity of production	43
Average price (JD/L)	3.5
-Average variable cost (JD/dun)	106
Water (energy for pumping)	25
Fertilizer (JD/dun)	15
Pesticide (JD/dun)	2.0
Labour (JD/dun)	45
Machine rental (JD/dun)	3.8
Transportation (JD/dun)	8
Share of installation cost (JD/Dun)	7.5
Interest of operation capital (JD/ dun)	4.6
-Average gross margin in JD/Dun	69
-Average gross margin in JD/m3	0.08

3.1.1.4 Gross margin for vegetables

Most of the farmers in Jordan Valley plant vegetables. In these zones, farmers plant many different vegetable crops in the same season to reduce the risk which might occur if they planted only one crop, but the major area in the farm is one or two main crops.

In this part, the gross margin analysis is analysed for crops that are produced large amount in these zones. Many farmers in Jordan Valley zones owned greenhouses and used drip irrigation systems, at the same time they used more and better quality fertilizer and pesticides than other zones in the Zarqa Basin. They also used expensive seeds in planting. The better quality and higher quantity make the cost of these in-puts higher and as a consequence the total variable cost is higher comparing to other crops in other zones. As a result of using good quality and suitable quantities of in-puts, in addition to using technology, the productivity in these zones is high. The cost of transportation in these zones in the Jordan Valley for vegetables is high because there are many farmers depending not only on the Deir-Alla market which is in the same area but also they depend on the main market in Amman which is about 50 km from this area. The reason for that is the quantity of products of vegetables in this area is high as a result of the high number of farmers who plant vegetables in this area.

The main vegetables crops in the study area are potatoes, onions, squash, tomato and cucumber. The gross margin per the area of land in the opened field is between 113-473 JD/dun (table 3-4). The highest value is for squash crop because of the price of this crop is usually higher than the other vegetables crops. In the case of gross margin per cubic meter the highest value is also for squash which is about 0.9 JD/ m3 and the second value is for tomato which is 0.43 JD/m3 (table 3.5), while the lowest value is for eggplant and onion which are less than the value of clover. The low value for gross margin per unit of water is acceptable in the zones of treated wastewater but in the zones of fresh scarcity water should be re-evaluated considering the demand of the markets and the expectation of the quality and quantity of fresh water as results of climate change in the future.

Table 3 4: Gross margin for vegetables Zarqa Basin- Jordan 2009/2010

Crop	Potato	Eggplant	Squash	Onion
-Value of production (JD/ dun)	630	608	891	594
Quantity of sales (Kg)	3000	3600	2500	2,700
Quantity of consumption (Kg)	150	200	200	50
Total quantity of production	3150	3800	2700	2750
Average price (JD/kg)	0.2	0.16	0.33	0.22
-Average variable cost (JD/dun)	459.8	495	411,4	345.4
Water (JD/dun)	30	60	55	25
Fertilizer (JD/dun)	50	80	35	35
Pesticide and chemicals (JD/dun)	30	50	65	35
Temporary Labour (JD/dun)	60	80	100	92

Machine rental (JD/dun)	10	10	12.0	30
Transportation (JD/dun)	88	150	92	75
Seeds (JD/dun)	150	20	15	50
Interest of operation capital (JD/dun)	41.8	45	37.4	3.4
-Average gross margin in JD/Dun	170.2	113	479.6	248.6
-Average gross margin in JD/m3	0.38	0.25	0.96	0.31

Table 3-5 shows the gross margin for tomatoes in open field and under green houses. It is clear that the gross margin in the opened field is very low compared with the gross margin for crops under greenhouses, because of the productivity, which is much higher under green houses. In Zones where greenhouses are used, the cost of fertilizers, seeds and pesticides for tomatoes and cucumbers are high but the productivity is very high. The gross margin per unit of water under the green houses production is high. This indicates that the farmers could pay a higher price for water and a higher price for renting more land compared to the farmers of opened field production, which reflects the high value of land and water. The water use efficiency in the case of tomatoes in greenhouses is 70% more than that in the case of planting cucumbers. It indicates that the farmers can pay higher prices for water if they plant tomatoes in greenhouses instead of planting cucumber in greenhouses.

The other advantage of the planting under the green houses is the prices of products; the farmers can produce when the demand at markets is high and supply is low.

Table 3 5: Gross margin for tomatoes and cucumbers in opened field and under greenhouses, Zarqa Bain Jordan 2009/2010

	Opened field	Green houses	
Crops	Tomato	Tomato	Cucumber
-Value of production (JD/GH)	690	2280	2321
Quantity of sales production (Kg/GH)	4,500	15000	13500
Quantity of consumption (Kg)	120	200	150
Total quantity of production	4600	15200	13650
Average price (JD/kg)	0.15	0.14	0.17
-Average variable cost (JD/GH)	491	764.5	957
Water (JD/GH)	30	35	35
Fertilizer (JD/GH)	50	55	70

Pesticide (JD/GH)	60	70	120
Chemicals (JD/GH)		60	70
Temporary Labour (JD/GH)	150	180	300
Machine rental (JD/GH)	30	35	35
Transportation (JD/GH)	96	120	120
Seeds (JD/GH)	75	140	120
Interest of operation capital (JD/GH)	49.1	69.5	87.0
-Average gross margin in JD/GH	199	1515.5	1364
-Average gross margin in JD/m3	0.47	3.69	2.17

4 The Impact of Climate Change on Resources and Living Standard

This chapter focuses on the analysis of the future impact of different strategies and policies for climate change on the living standard of farm families. A set of scenarios was selected in order to measure the impact on the living standard of farm families and to measure the availability and quality of the water in the regional level. These scenarios were derived from the results of the socio-economic analysis in the study area.

4.1 Development of scenarios

The scenarios relevant for testing were derived from the analyses in the previous chapters. The results indicate that the use of mixed water could be an alternative to the use of fresh water. In addition, growing crops suitable to the quality of water could affect negatively on family income. The expectation of the impact of climate change that the using of treated wastewater increases and the quality of water becomes worse over time. As a consequence of increasing low quality water, the quantity in King-Talal Dam (mixed water) will increase and water will be more available in Jordan Valley but with low quality. Scenarios were derived from these results and their impacts measurement. The testing of different scenarios focused on the micro level by measuring the impact on the living standard and the use of resources in farm-family-household system. The availability of water resources will be determined on the macro level.

The expectation of the impact of climate change indicates that problems related to water supply in zones with freshwater arise from the scarcity of water. The zones of treated and mixed wastewater suffer less from restrictions in water quantity but have to deal with the effects of water pollution. Both problems are likely to increase in the future.

Estimations of impacts from decreasing water qualities have to be based on assumptions on potential effects from polluted water since precise knowledge of interrelationships is not available. Prognoses of impacts from changing water quantities can rely on the knowledge of the applied production methods and allow the testing of two main scenarios for development in the future. The first scenario assumed a decrease in freshwater availability and there is no alternative for replacing fresh water (same quality but less quantity). The second scenario predicted an increase in the availability of mixed and treated wastewater, which might offer an alternative for replacing freshwater in other zones (same quantity but less quality).

4.2 Model structure

In this study a linear programming model is applied to investigate the respective impact on farm, off-farm and family income, and to measure the impact of strategies in different zones. Linear Programming is a method of determining an income maximizing combination of farm enterprises that is feasible with respect to a set of fixed farm constraints (Hazell, 1986).

The impact of climate change is determined by testing different scenarios by comparing the results of the model to the income of the farmers both by using these scenarios and without using them.

The programming model, which has been used in this analysis, can be mathematically presented as follows:

Objective function $$\text{Max } Z=\sum_{j=1}^{n} Pj\ Xj - Cj\ Xj \qquad (1)$$

The Constraints $$\sum_{j=1}^{n} aij\ Xj = bi, \quad \text{all } i=1 \text{ to } m \qquad (2)$$

$$Xj \geq 0 \qquad \text{all } j=1 \text{ to } n \qquad (3)$$

Where:

Z	=	the objective function (family income)
Xj	=	the level of activity j
Pj	=	the price per unit of the j output activity
Cj	=	the cost per unit of j input activity
n	=	number of possible activities
m	=	number of resources and constraints
aij	=	technical coefficient (amount of i the input required to produce one unit of j the activity)
bj	=	amount of i the resource available

The programming model was created depending on the last mathematical concepts. The data was based on a short field survey, Rapid Rural Appraisal and meeting with key persons in the study area carried out in 2010. The objective function is intended to maximize the family income under the condition of the resources availability. To maximize the family income the resources are allocated between different activities in a way that the difference between the total cost and the total revenue is the maximum. The model maximizes the objective function under the conditions of limited constraints and resources for the various activities. The family-household models are constructed to represent the four zones in the study area, these are:

- Zone 1: near the treatment plant, very low quality.
- Zone 2: before King Tallal Dam, low quality.
- Zone 3 & 4: mixed water fresh water zones in Jordan Valley.

The objective function contains the following components:

- The variable costs -excluding costs of hired labour- per unit area of different crops (dun), per greenhouse in the zones where they are used, and per unit of head for the livestock production.
- The sale prices of crops and livestock products
- The consumption activity of crops and livestock products.
- The wage of the hired labour as a farming wage rate per man-day.
- The family labour in the farm.
- Off-farm income.
- The monthly irrigation water.
- The value of the rented land.
- Transfer Activities; any cash surplus at the end of each month can be transferred to the next month through cash transfer activity.

The model contains the following constraints:

- Greenhouses in the basic model were restricted as the average number of greenhouses in the study area because they require high investments.
- The average number of sheep was restricted as the average number in the study area.
- Household consumption items were displayed, as a minimum required of family annual requirements as in the Rapid Rural Appraisal. The farm families satisfy their requirements from their own production or through purchases at the markets.
- To estimate the quantity of water in the model, it is assumed that the quantity of consumed water is open.
- Family labour, which works on the farm, was classified into two main types; the first one is heavy work, for which men are used, and the second one is light work, like harvesting, for which both men and women are used. The first one is restricted to the male members of the family between 14-60 who are not studying. The second one is restricted to the labour capacity in the family. No restriction was applied to hired labour activities.

- Off-farm work was equal to the male members of the family between 14-60 who are not studying.
- Monthly cash inflow and outflow was considered in the model. The cash inflow consists of the cash from selling farm products and off-farm activities. The cash outflow consists of the cost of production, purchasing activities, home consumption goods from the market and family expenses.

The following assumptions were assumed in the models:

- It was assumed that farmers could hire labour throughout the year at an average wage between 8-12 JD per day.
- Water constraints in cubic meters were used for irrigation and none for animals because the quality and source of water in all zones for livestock production is different, many farmers had access to free water sources like springs, or they purchase water from other zones.

Cash is transferred from month to month with the financial year beginning in January. The farmer can buy on credit from the traders at the beginning of the year and repay when his products are sold.

4.3 The Results of the models

To validate the model the results of the static models were compared with the farm survey results (the situation in reality). Since models optimize resource allocation or maximize income, the results are more an indicator of reality and therefore may not be identical with the survey results. In reality, the farmer may not reach the optimal situation as he will be affected by some factors, which happen during the season of production especially in agricultural sectors in which the uncertainty and the risks are high.

Criteria for validation of the models consist of:

- Farm, off-farm and family income.
- Water quantity as a resource.

4.3.1 Farm, off-farm and family income

Farm income is calculated from the objective function by calculating the differences between all the cost and all the revenue from using the resources. Off-farm income is the income from off-farm activities. Family income consists of farm and off-farm income. The results of the basic linear programming models show that the family income was higher than the family income of the real income in the study area. The differences between the family practices and the model results can be explained by two reasons. The first one is that there are many members of the family who can work off-farm but did not, thus the difference in off-farm income is high as shown in Table 4.1. The second reason is that the main activities in the model in Zones of treatment plant are olives and clover cultivation and in Zones of Jordan Valley they are tomato and cucumber cultivation in greenhouses depending on the data at the time of the survey. These activities in the model need high investments in the first year and in the case of olives and citrus the productivity differs from one year to the next, thus the data from one year is not sufficient to provide the real solution.

In this study crop activities were divided into three main groups: vegetables, fruit and olive trees, and field crops. Livestock production was goats and sheep. The results of the static model show that the use of land in Zones near treatment plant is allocated mainly for olive trees with between 35- 70 Dun. While in the Jordan Valley is allocated mainly for tomato under the greenhouses and to use these greenhouses for tomato and then plant it to produce Gewish-mellow. The results show also that the greenhouses that were available in the farm are used, which means if there are more greenhouses they could be used, but they require high investments.

Table 4 1: Farm, off-farm and family income as results from basic models comparing to the real situation in different water qualities zones, Zarqa Basin Jordan 2009/2010

Zone	Near treatment plant		Before King Talal Dam		Jordan Valley	
	Present situation	Basic model	Present situation	Basic model	Present situation	Basic model
Family income JD	9724	7125	15593	11845	16031	13074
Off farm income JD	2801	1500	5286	2340	6605	3000
Farm income JD	6923	5624	10307	9505	10026	10074

4.3.2 The quantity of water in the model

Results of the model show that the quantity of water in the model is less than what is used in the reality in zones near treatment plant where water is available and farmers can consume as much as they need from the treatment plant. In this zone, in reality, they planted clover, which requires a high quantity of water. In the zones before the Dam where the treated wastewater is used also, the quantity of water in the model is higher than that in reality. In Jordan Valley where mixed water and fresh water are used, the quantity of water in the model is less than in the survey. The scarcity of water will be in where fresh water is used. One solution to the expected water scarcity is to use mixed water in this zone instead of fresh water.

Water for irrigation is used in all months of the year except December, January and February because in these months all zones are dependent on the rainfall. In the zones where the vegetable crops are the main activities in the model, water for irrigation is very low in August and September.

4.3.3 Conclusions of main results of the model

The model results are close but not identical to the survey considering that the models optimize resource allocation and maximize income. The comparison of data in one year in the model is the reason behind the high difference between the farm income in the survey and in the static model. Some crops need high investments in the first year and the revenue is very low at the beginning, then after many years the revenue increases. In addition to that, many farmers refused to take loans to cover the high investment. This explains the differences between the results of the survey and the models in these zones.

4.4 Impact of different scenarios of the expectation of climate

For analytical purposes in this study, potential effects of climate change on changing water qualities were assumed on two levels. The first assumption supposed a negative impact on yields from polluted water, which might be regarded as a hypothesis on long-term effects. The second assumption makes reference to the current Jordanian legislation, which restricts the choice of cropping patterns in areas with low quality water, and supposes that these restrictions will also apply to any further extension of those areas. The scenarios from these assumptions and their application to models of the study area are compiled in Figure 4-1.

Scenario of very low quality zones o If the concentration of salts in water is increased.
Scenarios of low quality water zones-quality becomes worse o If the concentration of salts in water is increased.
Scenarios of fresh water zones o Replacing the fresh water with mixed water.

Figure 4 1 The main scenarios in the models

4.4.1 Future impact in the very low quality water zone

In this zone, the increase of water quantity has no effect on the optimal solution because the quantity of water in the model is less than that in the survey, but there could be an effect if the quality becomes worse. Regarding the different possibilities in the water quality in this zone, the following scenario was tested:

- If the productivity of crops decreases when the concentration of salts in the water increases. The electrical conductivity of water (ECw) was used to measure the water salinity in this analysis. As the value of ECw increases the productivity of crops decreases but the percent of decrease is different from one crop to another depending on the sensitivity of the crop to the water salinity (FAO, 1979). Regarding the sensitivity of crops to water salinity, the crops are classified to four main groups: tolerant, moderately tolerant, moderately sensitive and sensitive. At the level of ECw of the water in this zone the productivity of moderately tolerant crops is 90% of the normal productivity for olives and clover. Productivity of tolerant crops like barley is 100% (RJSS, 2000). The effect of increasing the salinity of water was tested if the ECw is increased by 50% more than the present value. The decrease in productivity of moderately tolerant crops is 17% less and 0% for the others.

The family income of the farmer is highly affected if the salinity of water increases. In this case, the average family income is 5480 JD if the water salinity increases 50%. The effect of increasing water salinity is very great on family income after eight years; if the ECw increases 50% more than the value of ECw in the year of the survey, the family income decreases about 23%.

In all cases, any policy to increase the quantity of water from the treatment plant will negatively affect the living standard of the farmers in this area. To decrease the negative effect of increasing the quantity of treated wastewater, the quality of water should be suitable for planting olives in all cases and there should be no change in the salinity of the water.

4.4.2 Future impact in the low quality water zone (before KTD)

The following scenario was tested in theses zones:

- Regarding the salinity of water before applying these scenarios, the productivity of sensitive crops like citrus was 75% of the normal productivity and 90% for the moderately tolerant crops e.g. olives in this zone. The effect of increasing the salinity of water was tested if the ECw increases 50% more than its present value. The decrease in productivity of sensitive crops is 33%

less and 17% for the moderately tolerant.

Any change in the quality of water or the salinity will decrease the income greatly especially if the quality is not suitable for planting olives because olives are dominant in this zone. In the case If the ECw increases 50% more than its present value, the average income becomes 8176 JD by 31% decreased comparing to the basic model. This means in this zone the increase in the quantity of water is important and could be a good option for improving the living standard of the farmers because the revenue from olives is high, but a change in water quality will greatly affect the living standard of the farmers in this zone in a negative way. An increase in suitable quality water is a good strategy for improving the living standard of farmers in the long term and also by considering the development over time.

4.4.3 Future impact in the mixed and fresh water zone in Jordan Valley

The following scenarios were tested in zone of Jordan Valley:

- The quantity of water increases and the salinity of water increases by 50%. The assumption is that the productivity of all products in the survey is 100% of the normal productivity. The decrease in productivity of sensitive crops is 10% less and 0% for the moderately tolerant crops.
- The quantity of water increases and the salinity of water increases by 100%. The assumption is that the productivity of all products in the survey is 100% of the normal productivity. The decrease in productivity of sensitive crops is 25% less and 10% for the moderately tolerant crops.

The 50% increase in the Ec will not affect the family income because the main crops in this zone are moderately tolerant crops, which means the small change in the Ec will not affect the productivity, but the change of Ec by 100% will affect these crops and in this case the average income of will be 10681 JD, this signifies a decrease of 18% less than the average income in the basic model.

4.4.4 Conclusions of the results of the scenarios

Applying and testing scenarios were carried in each zone. These scenarios mainly reflect the impact of climate change in the future. The application of these scenarios is at the macro level but the impacts of these strategies are at the macro level and micro levels. The main scenario is to test the impact of the increase of low quality water from the treatment plant and decrease fresh water in the study area. The testing of these scenarios was done by using different sub-scenarios.

The quantity of water in the optimal solution will be less than that before applying these scenarios, if the quality becomes worse or the salinity of water is very high. The average income is highly affected in all scenarios in case of very high salinity. This reflects that the effect of water with high salinity, influences income negatively. This means if the quality becomes worse the impact of climate change will be highly in all zones on the living standard of the people. This result reflects the indirect impact of climate change on the quality of water; by using treated wastewater, which its quality is worse than fresh water, for irrigation as a result of decreasing the rainfall.

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Appendixes

Appendix 1 **1Worksheet: [Linear model.xls] Near As-Samra Treatment Plant Zones**				
Report Created: 1/11/2011 7:25:25 PM				
Target Cell (Min)				
	Cell	**Name**	**Original Value**	**Final Value**
	DB5	objective function RHS	1232.3126	-7124.946086
Adjustable Cells				
	Cell	**Name**	**Original Value**	**Final Value**
	B6	extent clov(dun)	1	6.43818E-13
	C6	extent barl dun	1	4.74065E-13
	D6	extent corn dun	1	2.721428571
	E6	extent oliv dun	1	35
	F6	extent goats head	1	8.93507E-13
	G6	extent sheeps head	1	15
	H6	extent goats purch	1	0
	I6	extent sheeps purch	1	0
	J6	extent selclov.Jan.	1	6.81772E-10
	K6	extent selclov.feb.	1	6.8301E-10
	L6	extent selclov.mar.	1	6.82381E-10
	M6	extent selclov.apr..	1	6.81772E-10
	N6	extent selclov.may.	1	6.81801E-10
	O6	extent selclov.jun.	1	6.81772E-10
	P6	extent selclov.Jul.	1	6.81763E-10
	Q6	extent selclov.ouq.	1	6.81807E-10

	R6	extent selclov.sep.	1	6.81807E-10
	S6	extent selclov.oct.	1	6.81801E-10
	T6	extent selclov.nov.	1	6.8301E-10
	U6	extent selbarl.jun	1	2.49543E-10
	V6	extent selhay. Jun	1	0
	W6	extent selcorn	1	0
	X6	extent seloliv.oct	1	17375
	Y6	extent selgaots	1	0
	Z6	extent selsheeps	1	13.5
	AA6	extent selgaots	1	1.54679E-10
	AB6	extent selsheeps	1	1536
	AC6	extent cons.far.olv	1	125
	AD6	extent cons far meatgt	1	0
	AE6	extent cons far meat sh	1	3.3
	AF6	extent cons far milkgt	1	0
	AG6	extent cons far milk sh	1	339
	AH6	extent cons.mark.olv	1	0
	AI6	extent cons mark meatgt	1	0
	AJ6	extent cons mark meat sh	1	0
	AK6	extent cons mark milkgt	1	0
	AL6	extent cons mark milk sh	1	0
	AM6	extent seed far barl.	1	2.25242E-12
	AN6	extent seed mark barl.	1	0
	AO6	extent feedgt far hay	1	0
	AP6	extent feedsh far hay	1	0
	AQ6	extent feedgt far corn	1	8.80557E-11
	AR6	extent feedsh far corn	1	3810
	AS6	extent feedgt mark hay	1	0
	AT6	extent feedsh markhay	1	0
	AU6	extent feedgt mark corn	1	0
	AV6	extent feedsh mark corn	1	0
	AW6	extent family expen.	1	1
	AX6	extent miantnance and dep	1	1
	AY6	extent male lab prep+seeding	1	63

	AZ6	extent malelab pest+irrig	1	0
	BA6	extent male lab harv.	1	0
	BB6	extent malelab harv.olv	1	0
	BC6	extent male labfert	1	67.08214286
	BD6	extent malelab clover	1	0
	BE6	extent male labour animal	1	99.16428571
	BF6	extent female lab harv.olv	1	43
	BG6	extent fam male lab prep	1	0
	BH6	extent fam male lab pest+irrig	1	95.08214286
	BI6	extent fam male lab harv.	1	4.082142857
	BJ6	extent fam male lab harv.olv	1	0
	BK6	extent fam male labfert	1	0
	BL6	extent fam male lab clover	1	0
	BM6	extent fam male labour animal	1	50.83571429
	BN6	extent fam female lab harv.olv	1	90
	BO6	extent off-farmJan	1	0
	BP6	extent off-farmfab	1	0
	BQ6	extent off-farmmar	1	0
	BR6	extent off-farmapr	1	25
	BS6	extent off-farmmay	1	25
	BT6	extent off-farmJun	1	25
	BU6	extent off-farmJul	1	25
	BV6	extent off-farmaug	1	25
	BW6	extent off-farmsep	1	25
	BX6	extent off-farmoct	1	0
	BY6	extent off-farmnov	1	0
	BZ6	extent off-farmdec	1	0
	CA6	extent irrgjan	1	0

	CB6	extent irrgFab.	1	0
	CC6	extent irrgmar.	1	195.9428571
	CD6	extent irrgapr.	1	3660.942857
	CE6	extent irrgmay	1	3660.942857
	CF6	extent irrgjune	1	3660.942857
	CG6	extent irrgjul.	1	3465
	CH6	extent irrgaug.	1	3465
	CI6	extent irrgsep.	1	3465
	CJ6	extent irrgoct.	1	3465
	CK6	extent irrgnov.	1	5.94468E-10
	CL6	extent irrgdec	1	1.25596E-10
	CM6	extent cred	1	3394.362529
	CN6	extent transjan	1	2951.757124
	CO6	extent transFab.	1	2509.151719
	CP6	extent transmar.	1	1290.495
	CQ6	extent transapr.	1	3009.508281
	CR6	extent transmay	1	2660.703191
	CS6	extent transjune	1	2134.816215
	CT6	extent transjul.	1	1890.23581
	CU6	extent transaug.	1	1645.655405
	CV6	extent transsep.	1	0
	CW6	extent transoct.	1	5291.041446
	CX6	extent transnov.	1	3980.667934
	CY6	extent transdec	1	0

Appendix 2

Worksheet: [Linear model.xls]Treated WW Zones less17% prod				
Report Created: 1/16/2011 7:30:41 AM				
Target Cell (Min)				
	Cell	**Name**	**Original Value**	**Final Value**
	DB5	objective function RHS	1232.3126	-5480.598448
Adjustable Cells				
	Cell	**Name**	**Original Value**	**Final Value**
	B6	extent clov(dun)	1	6.41598E-13
	C6	extent barl dun	1	11.31578947
	D6	extent corn dun	1	0
	E6	extent oliv dun	1	23.68421053
	F6	extent goats head	1	9.97535E-13
	G6	extent sheeps head	1	15
	H6	extent goats purch	1	0
	I6	extent sheeps purch	1	0
	J6	extent selclov.Jan.	1	1.05864E-10
	K6	extent selclov.feb.	1	1.05864E-10
	L6	extent selclov.mar.	1	1.05864E-10
	M6	extent selclov.apr..	1	1.05864E-10
	N6	extent selclov.may.	1	1.05864E-10
	O6	extent selclov.jun.	1	1.05864E-10
	P6	extent selclov.Jul.	1	1.05864E-10
	Q6	extent selclov.ouq.	1	1.05864E-10
	R6	extent selclov.sep.	1	1.05864E-10
	S6	extent selclov.oct.	1	1.05864E-10
	T6	extent selclov.nov.	1	1.05864E-10
	U6	extent selbarl.jun	1	5001.578948
	V6	extent selhay. Jun	1	8263.947369

	W6	extent selcorn	1	0
	X6	extent seloliv.oct	1	9703.947369
	Y6	extent selgaots	1	0
	Z6	extent selsheeps	1	6.589732793
	AA6	extent selgaots	1	1.52049E-10
	AB6	extent selsheeps	1	1536
	AC6	extent cons.far.olv	1	125
	AD6	extent cons far meatgt	1	0
	AE6	extent cons far meat sh	1	10.21026721
	AF6	extent cons far milkgt	1	0
	AG6	extent cons far milk sh	1	339
	AH6	extent cons.mark.olv	1	0
	AI6	extent cons mark meatgt	1	0
	AJ6	extent cons mark meat sh	1	0
	AK6	extent cons mark milkgt	1	0
	AL6	extent cons mark milk sh	1	0
	AM6	extent seed far barl.	1	316.8421053
	AN6	extent seed mark barl.	1	0
	AO6	extent feedgt far hay	1	0
	AP6	extent feedsh far hay	1	3810
	AQ6	extent feedgt far corn	1	1.11611E-10
	AR6	extent feedsh far corn	1	1.09037E-09
	AS6	extent feedgt mark hay	1	0
	AT6	extent feedsh markhay	1	0
	AU6	extent feedgt mark corn	1	0
	AV6	extent feedsh mark corn	1	0
	AW6	extent family expen.	1	1
	AX6	extent miantnance and dep	1	1
	AY6	extent male lab prep+seeding	1	58.47368421
	AZ6	extent malelab pest+irrig	1	0
	BA6	extent male lab harv.	1	0
	BB6	extent malelab harv.olv	1	0
	BC6	extent male labfert	1	60.73684211
	BD6	extent malelab clover	1	0
	BE6	extent male labour animal	1	100.0526316

	BF6	extent female lab harv.olv	1	0
	BG6	extent fam male lab prep	1	0
	BH6	extent fam male lab pest+irrig	1	77.42105263
	BI6	extent fam male lab harv.	1	22.63157895
	BJ6	extent fam male lab harv.olv	1	0
	BK6	extent fam male labfert	1	0
	BL6	extent fam male lab clover	1	0
	BM6	extent fam male labour animal	1	49.94736842
	BN6	extent fam female lab harv.olv	1	90
	BO6	extent off-farmJan	1	0
	BP6	extent off-farmfab	1	0
	BQ6	extent off-farmmar	1	0
	BR6	extent off-farmapr	1	25
	BS6	extent off-farmmay	1	25
	BT6	extent off-farmJun	1	25
	BU6	extent off-farmJul	1	25
	BV6	extent off-farmaug	1	25
	BW6	extent off-farmsep	1	25
	BX6	extent off-farmoct	1	0
	BY6	extent off-farmnov	1	0
	BZ6	extent off-farmdec	1	0
	CA6	extent irrgjan	1	0
	CB6	extent irrgFab.	1	0
	CC6	extent irrgmar.	1	803.4210527
	CD6	extent irrgapr.	1	3148.157895
	CE6	extent irrgmay	1	3148.157895
	CF6	extent irrgjune	1	3148.157895
	CG6	extent irrgjul.	1	3148.157895
	CH6	extent irrgaug.	1	2344.736842
	CI6	extent irrgsep.	1	2344.736842
	CJ6	extent irrgoct.	1	2344.736842
	CK6	extent irrgnov.	1	803.4210527
	CL6	extent irrgdec	1	803.4210526
	CM6	extent cred	1	2068.114974
	CN6	extent transjan	1	1624.769281

	CO6	extent transFab.	1	1181.423588
	CP6	extent transmar.	1	0
	CQ6	extent transapr.	1	1163.823596
	CR6	extent transmay	1	851.4959297
	CS6	extent transjune	1	1879.155895
	CT6	extent transjul.	1	1451.588755
	CU6	extent transaug.	1	1223.072009
	CV6	extent transsep.	1	0
	CW6	extent transoct.	1	3938.531491
	CX6	extent transnov.	1	2699.733562
	CY6	extent transdec	1	0

Appendix 3

Basic model of the zones before KTD			
Cell	**Name**	**Original Value**	**Final Value**
BJ5	objective function RHS	997.42402	-11845.15574
Cell	**Name**	**Original Value**	**Final Value**
B6	extent citrus dun	1	0.264150943
C6	extent olives dun	1	59.73584906
D6	extent wheat dun	1	0
E6	extent sel citrus	1	0
F6	extent sel oliv.oct	1	38738.30189
G6	extent sel Wh.	1	7.81351E-11
H6	extent cons mark citrus	1	0
I6	extent cons mark oliv	1	0
J6	extent cons far citrus	1	140
K6	extent cons faroliv	1	90
L6	extent seed farwh.	1	2.94986E-13
M6	extent seed markwh.	1	0
N6	extent r.land	1	60
O6	extent maint and dep	1	1
P6	extent male lab prep+seeding	1	0
Q6	extent male lab pest+irrig	1	0
R6	extent male lab harv.	1	0
S6	extent male lab harv.olv	1	0
T6	extent male labfert	1	0
U6	extent female lab harv.	1	0
V6	extent female lab harv.olv	1	0

W6	extent off-farmJan	1	25
X6	extent off-farmfab	1	25
Y6	extent off-farmmar	1	25
Z6	extent off-farmapr	1	4.211320754
AA6	extent off-farmmay	1	0
AB6	extent off-farmJun	1	25
AC6	extent off-farmJul	1	25
AD6	extent off-farmaug	1	25
AE6	extent off-farmsep	1	25
AF6	extent off-farmoct	1	25
AG6	extent off-farmnov	1	5
AH6	extent off-farmdec	1	25
AI6	extent irrgjan	1	0
AJ6	extent irrgFab.	1	0
AK6	extent irrgmar.	1	26.41509433
AL6	extent irrgapr.	1	4274.264151
AM6	extent irrgmay	1	4274.264151
AN6	extent irrgjune	1	4261.056604
AO6	extent irrgjul.	1	4261.056604
AP6	extent irrgaug.	1	4267.660377
AQ6	extent irrgsep.	1	4267.660377
AR6	extent irrgoct.	1	26.41509433
AS6	extent irrgnov.	1	0
AT6	extent irrgdec	1	0
AU6	extent cred	1	7893.548887
AV6	extent transjan	1	8001.285887
AW6	extent transFab.	1	8109.022887
AX6	extent transmar.	1	7496.759887
AY6	extent transapr.	1	7223.526321
AZ6	extent transmay	1	5712.934264
BA6	extent transjune	1	4271.549755
BB6	extent transjul.	1	2530.693547
BC6	extent transaug.	1	2465.610924
BD6	extent transsep.	1	0
BE6	extent transoct.	1	7878.074887

BF6	extent transnov.	1	7785.811887
BG6	extent transdec	1	0

Appendix 4

Scenario of 33% less Productivity of Zones Before King Tallal Dam			
Cell	**Name**	**Original Value**	**Final Value**
BJ5	objective function RHS	997.42402	-8175.844134
Cell	**Name**	**Original Value**	**Final Value**
B6	extent citrus dun	1	0.394255139
C6	extent olives dun	1	59.60574486
D6	extent wheat dun	1	9.21485E-14
E6	extent sel citrus	1	0
F6	extent sel oliv.oct	1	32067.29935
G6	extent sel Wh.	1	0
H6	extent cons mark citrus	1	0
I6	extent cons mark oliv	1	0
J6	extent cons far citrus	1	140
K6	extent cons faroliv	1	90
L6	extent seed farwh.	1	0
M6	extent seed markwh.	1	2.29039E-12
N6	extent r.land	1	60
O6	extent maint and dep	1	1
P6	extent male lab prep+seeding	1	0
Q6	extent male lab pest+irrig	1	0
R6	extent male lab harv.	1	0
S6	extent male lab harv.olv	1	0

T6	extent male labfert	1	0
U6	extent female lab harv.	1	0
V6	extent female lab harv.olv	1	0
W6	extent off-farmJan	1	25
X6	extent off-farmfab	1	25
Y6	extent off-farmmar	1	25
Z6	extent off-farmapr	1	4.315404111
AA6	extent off-farmmay	1	0
AB6	extent off-farmJun	1	25
AC6	extent off-farmJul	1	25
AD6	extent off-farmaug	1	25
AE6	extent off-farmsep	1	25
AF6	extent off-farmoct	1	25
AG6	extent off-farmnov	1	5
AH6	extent off-farmdec	1	25
AI6	extent irrgjan	1	0
AJ6	extent irrgFab.	1	0
AK6	extent irrgmar.	1	39.42551393
AL6	extent irrgapr.	1	4281.289777
AM6	extent irrgmay	1	4281.289777
AN6	extent irrgjune	1	4261.577021
AO6	extent irrgjul.	1	4261.577021
AP6	extent irrgaug.	1	4271.433399
AQ6	extent irrgsep.	1	4271.433399
AR6	extent irrgoct.	1	39.42551393
AS6	extent irrgnov.	1	0
AT6	extent irrgdec	1	0
AU6	extent cred	1	7893.933995
AV6	extent transjan	1	8001.670995
AW6	extent transFab.	1	8109.407995
AX6	extent transmar.	1	7497.144995
AY6	extent transapr.	1	7223.630404
AZ6	extent transmay	1	5714.058364
BA6	extent transjune	1	4273.303559

BB6	extent transjul.	1	2533.337264
BC6	extent transaug.	1	2467.062887
BD6	extent transsep.	1	0
BE6	extent transoct.	1	7878.459995
BF6	extent transnov.	1	7786.196995
BG6	extent transdec	1	0

Appendix 5

Basic model of the zones Jordan Valley

Cell	**Name**	**Original Value**	**Final Value**
CL6	objective function RHS	3832.26462	-13074.01503
Cell	**Name**	**Original Value**	**Final Value**
B7	extent Tomato dun	1	0
C7	extent Tom G.h.	1	14.92307692
D7	extent Cuc G.H	1	0.076923077
E7	extent onion dun	1	3.76588E-13
F7	extent potato dun	1	0.057416268
G7	extent Gewish mellow gh	1	14.82669138
H7	extent only Gewish mellow gh	1	0
I7	extent squesh dun	1	0.048192771
J7	extent peper dun	1	7.28084E-13
K7	extent citrusdun	1	12.44258373
L7	extent sel tomato may	1	61293.53846
M7	extent selTomato jun	1	59592.30769
N7	extent selcuc gh may	1	0
O7	extent selcuc jun gh	1	53.84615395
P7	extent selonionmay	1	5.16707E-10
Q7	extent selonionjun	1	0
R7	extent selpotato may	1	0
S7	extent selpotato june	1	54.83253599
T7	extent selGewish mellow	1	27833.65987
U7	extent selsquash	1	0
V7	extent selpeper may	1	0

W7	extent selpeper june	1	2.40844E-11
X7	extent selcitrus june	1	20908.42584
Y7	extent selcitrus juli	1	18643.8756
Z7	extent cons farTomato	1	200
AA7	extent cons farcucumber	1	200
AB7	extent cons faronion	1	0
AC7	extent cons farpotato	1	120
AD7	extent cons farGewish mellow	1	85
AE7	extent cons farsquash	1	80
AF7	extent cons farpeper	1	0

AG7	extent cons farcitrus	1	40
AH7	extent cons markTomato	1	0
AI7	extent cons markcucumber	1	0
AJ7	extent cons markonion	1	100
AK7	extent cons markpotato	1	0
AL7	extent cons markGewish mellow	1	0
AM7	extent cons marksqaush	1	0
AN7	extent cons markpeper	1	20
AO7	extent cons markcitrus	1	0
AP7	extent r.land	1	20
AQ7	extent miant and dep	1	1
AR7	extent mian and dep g.h	1	15
AS7	extent family expen.	1	1
AT7	extent male lab prep+seeding	1	197.9305998
AU7	extent male lab pest+irrig	1	112.8640044
AV7	extent male lab harv.	1	0
AW7	extent male labfert	1	127.7307249
AX7	extent female lab harv.	1	326.8263932
AY7	extent off-farmJan	1	25
AZ7	extent off-farmfab	1	25
BA7	extent off-farmmar	1	25
BB7	extent off-farmapr	1	25
BC7	extent off-farmmay	1	25
BD7	extent off-farmJun	1	25
BE7	extent off-farmJul	1	25
BF7	extent off-farmaug	1	25
BG7	extent off-farmsep	1	25
BH7	extent off-farmoct	1	25
BI7	extent off-farmnov	1	25
BJ7	extent off-farmdec	1	25
BK7	extent irrgjan	1	0
BL7	extent irrgFab.	1	0
BM7	extent irrgmar.	1	1500.910705
BN7	extent irrgapr.	1	1559.919618

BO7	extent irrgmay	1	3923.859155
BP7	extent irrgjune	1	4235.209298
BQ7	extent irrgjul.	1	3241.685346
BR7	extent irrgaug.	1	647.014354
BS7	extent irrgsep.	1	647.014354
BT7	extent irrgoct.	1	647.014354
BU7	extent irrgnov.	1	2294.244578
BV7	extent irrgdec	1	0
BW7	extent cred	1	9375.564785
BX7	extent transjan	1	6166.389645
BY7	extent transFab.	1	3174.890545
BZ7	extent transmar.	1	2467.246646
CA7	extent transapr.	1	0
CB7	extent transmay	1	0
CC7	extent transjune	1	4345.676332
CD7	extent transjul.	1	13929.83109
CE7	extent transaug.	1	13179.18352
CF7	extent transsep.	1	12978.00316
CG7	extent transoct.	1	11065.99994
CH7	extent transnov.	1	9567.039925
CI7	extent transdec	1	0

Appendix 6

Scenarios of the zones before KTD

Target Cell (Min)				
	Cell	**Name**	**Original Value**	**Final Value**
	CL6	objective function RHS	3832.26462	-10681.09683
Adjustable Cells				
	Cell	**Name**	**Original Value**	**Final Value**
	B7	extent Tomato dun	1	0
	C7	extent Tom G.h.	1	14.91452991
	D7	extent Cuc G.H	1	0.085470086
	E7	extent onion dun	1	5.19362E-13
	F7	extent potato dun	1	0.057416268
	G7	extent Gewish mellow gh	1	14.81814437
	H7	extent only Gewish mellow gh	1	0
	I7	extent squesh dun	1	0.048192771
	J7	extent peper dun	1	7.28084E-13
	K7	extent citrusdun	1	12.44258373
	L7	extent sel tomato may	1	55122.53846
	M7	extent selTomato jun	1	53592.30769
	N7	extent selcuc gh may	1	0
	O7	extent selcuc jun gh	1	53.84615395
	P7	extent selonionmay	1	1.09658E-10
	Q7	extent selonionjun	1	0
	R7	extent selpotato may	1	0
	S7	extent selpotato june	1	54.83253599
	T7	extent selGewish mellow	1	25027.30927
	U7	extent selsquash	1	0
	V7	extent selpeper may	1	0
	W7	extent selpeper june	1	2.40844E-11
	X7	extent selcitrus june	1	20908.42584
	Y7	extent selcitrus juli	1	18643.8756

	Z7	extent cons farTomato	1	200
	AA7	extent cons farcucumber	1	200
	AB7	extent cons faronion	1	0
	AC7	extent cons farpotato	1	120
	AD7	extent cons farGewish mellow	1	85
	AE7	extent cons farsquash	1	80
	AF7	extent cons farpeper	1	0
	AG7	extent cons farcitrus	1	40
	AH7	extent cons markTomato	1	0
	AI7	extent cons markcucumber	1	0
	AJ7	extent cons markonion	1	100
	AK7	extent cons markpotato	1	0
	AL7	extent cons markGewish mellow	1	0
	AM7	extent cons marksqaush	1	0
	AN7	extent cons markpeper	1	20
	AO7	extent cons markcitrus	1	0
	AP7	extent r.land	1	20
	AQ7	extent miant and dep	1	1
	AR7	extent mian and dep g.h	1	15
	AS7	extent family expen.	1	1
	AT7	extent male lab prep+seeding	1	147.9220528

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