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Assessing the Impact of Potential Climate Change on Rainfed Agriculture in Jenin District

M.Sc. Thesis
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Dedication

To my dear parents, brothers, sisters and friends

Abstract

Many studies and researches have been conducted all over the world in order to analyze and study the impact of climate change on the agricultural sector specially the rainfed agriculture. Moreover, the potential impacts of climate change have not been quantified at local level yet. Based on this fact, this study aims to evaluate and study the potential impact of climate change on rainfed agriculture in Jenin district.

Jenin has been chosen because it is considered one of the largest agricultural areas in West Bank and it has large agricultural activities. The district contributes with about 16.2% of the agricultural production in the Palestinian market.

The analysis has been conducted using computer programming (CropWat) to estimate the change in yield reduction with increasing temperature (1, 2 and 3° Celsius) and decreasing precipitation (10, 20 and 30 %).

The results show that with increasing temperature by 1 °C for wheat (as example) yield reduction changes by (35.7%), and for T+2 °C and T+3 °C the changes rate were (36.6 %) and (37.3 %) respectively taking into consideration no changes in the precipitation.

But if all the climate parameter has changed it will be more significant; (41.7 %) the changes will be, if combined the increase in temperature (+3 °C) and reduction in precipitation (-30%).

Also, the impact of temperature increase was examined on irrigation requirement; from analyzing the results it was shown that the main driving factor to increase irrigation requirement is the increase in temperature. A sensitivity analysis on wheat (for example) was prepared for temperature increase by (+1, +2 and +3 °C), the analysis was based on the result obtained for the last ten years. The result was; (499.41 mm), (514.61 mm) and (530.13 mm) which indicate to the amount of water required by wheat crops to have the optimum yield. But for decreasing precipitation by (10%, 20% and 30%) the amount of water required were (506.54 mm), (517.38 mm), (531.74 mm) respectively. The results

clearly show that the scenario of increasing temperature gets worse when combined with the scenario of decreasing precipitation; where (T+3, P-30%) being the worst scenario.

There have been significant changes in rainfall pattern in Jenin district over the last ten years. These changes resulted from the climate change which affect the rainfall distribution, all the available data was analyzed and drawn for the last ten years. The results obviously show that there are variations in rainfall in the following months; January : has a very little increase, February: has a significant increase, April: has an increase and November; has a significant increase. Also the following months have variations in the amount of rainfall; March: has a significant decrease, May: little decrease, September and October: little decrease, December: significant decrease. During June, July and August there were no precipitation record ever in the district.

It is clear that Winter season is shifted a little bit toward November in the beginning of the season and toward April in the end of the season.

Finally, the economical loss is increased according to the increase in temperature and decrease the precipitation; for example, the losses occurred in wheat crops during the last ten year was expected to be about 1,461,606 ($). If the temperature is expected to increase by 1°C with no decrease in precipitation, then a loss is about 1,495,110 ($) which will be achieved in wheat crops, as well as the decrease in precipitation which has more effect of losses. If temperature doesn’t change and the amount of precipitation decrease by 10 %, the losses will be 1,557,930 ($), so the impact will be doubled or tripled if combined with changes in temperature and precipitation.

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List of Abbreviations and Symbols

ARIJ: Applied Research Institute – Jerusalem

BMRC: Bureau of Meteorological Research Center

CC: Climate Change

CCC: Canadian Climate Centre

CO_2 : Carbon Dioxide

DSSAT: Decision Support System for Agro Technology Transfer

FAO: Food and Agricultural Organization

GDP: Gross Domestic Product

GHG: Green House Gases

GMT: Global Mean Temperature

GCMs: General Circulation Models

GISS: Goddard Institute of Space Studies

GMT: Global Mean Temperature

IPCC: Intergovernmental Panel on Climate Change

IR: Irrigation Requirement

LGSs: Length of Growing Season

MoA: Ministry of Agriculture

MCM: Million Cubic Meter

Msl: Mean Sea Level

NOAA: National Oceanic and Atmospheric Administration

PCBS: Palestinian Central Bureau of Statistics

PHG : Palestinian Hydrology Group

PWA : Palestinian Water Authority

P: Precipitation

PPMv : Parts Per Million by volume.

SAR: Second Assessment Report of IPCC

SRES: Special Report on Emissions Scenarios of the IPCC

SST: Sea Surface Temperature

T: Temperature

US-EPA: United State-Environmental Protection Agency

UKTR: United Kingdom Meteorological Transient

UNFCCC :United Nations Framework Convention on Climate Change

USAID: United State for International Development

WB: West Bank

WMO: World Meteorological Organization

Chapter One: Introduction

1.1 Background

Climate summarizes the average, range and variability of weather elements, e.g. rain, wind, temperature, fog, thunder, and sunshine, observed over many years at a location or across an area (IPCC, 2007a).

Climate has profound effects on vegetation and animal life, including humans. It plays statistically significant roles in many physiological processes, from conception and growth to health and disease. Humans, in turn, can affect climate through alterations of earth's surface and introduction of pollutants and chemicals such as carbon dioxide into the atmosphere . From this point of view, the concept of global warming and climate change appears (Obese, 2001).

Climate change refers to the variation in the earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by internal processes to the earth, external forces (e.g. variations in sunlight intensity) or more recently human activities (IPCC, 2007,a).

In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming. In addition to increase in the average temperature of the atmosphere, oceans, and landmasses of earth (UNEP, UNFCC 2002).

The average surface temperature of earth is about 15 °C. Over the last century, this average has risen by about 0.6 °C. Scientists predict further warming of 1.4 to 5.8 °C by the year 2100 (Joseph…etal, 2003). This temperature rise is expected to melt polar ice caps and glaciers as well as warm the oceans, all of which will expand ocean volume and raise sea level by an estimated 9 to 100 cm, flooding some coastal regions and even entire islands. Some regions in warmer climates will receive more rainfall than before, but soil will dry out faster between storms. (Obese, 2001).

Palestine is located to the east of the Mediterranean Sea. It has arid to semi arid climate. In the same time, it has one of the lowest per capita share of water in the world (ARIJ, 1998). Figure (1.1) shows the details classification of the climate in West Bank.

Palestinians have been suffering from many problems related to food security, among them the continuing population growth, limited land and water resources. Climatic change is predicted to occur as a part of the entire climate change in the region. This is expected to appear as reduced precipitation and fewer intense rainfall events. This change in climate together with the above mentioned population growth and continuous increase in the demand on food will intensify the problem (Rabi et al, 2003a).

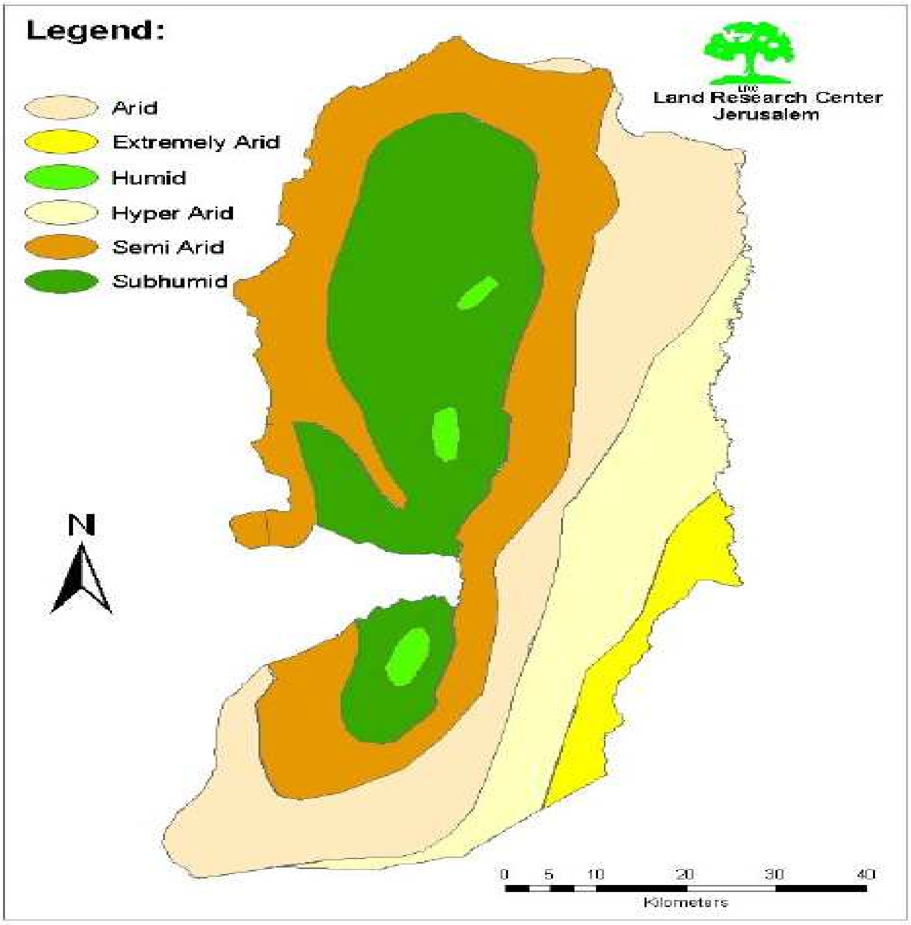

Figure (1.1) Climate classification in West Bank

Currently about 30% of the total area of the West Bank is cultivated and there are two predominant types of agricultural (land use) system in the West Bank: rain-fed and irrigated one. About 6% of the total (30%) cultivated land area of the West Bank is currently under cultivation, 6% of the total cultivated lands in the West Bank is under irrigation and 91.6% of the total cultivated lands under the rain-fed (PCBS, 2006). The actual contribution of rain-fed agriculture to the total plant product varies according to the amount and distribution of the precipitations during the growing season (ARIJ, 2007).

Due to increase water scarcity, the irrigated area is unlikely to expand in the West Bank. Palestinian Jordan valley, Jenin and Tulkarm districts contain most of the cultivated and fertilized lands in the West Bank. It has been observed that the percentage of crops suffering from water shortage is 25% in Jenin district (Faten and Isaac, 2000). The climate change in the Mediterranean region (including the WB), is like the rest of world. It is expected to undergo changes in rainfall patterns and temperature over the next several decades (Houghton, et al., 2001). Temperature is expected to increase from 0.8-2.1 ˚C in all seasons in the Middle East (El-Fadel and Bou-Zied, 2001).

Global warming is expected to have significant impacts on conditions affecting agriculture, including temperature and precipitation (IPCC, 2007,b). According to climate models for the region, there would be an increase in winter temperature combined with changes in rainfall amount and distribution (Ben-Gai et al., 1998). These climate changes are likely to affect the agricultural production (Gitay et al., 2001). In the WB, there has been an average of 4.1% decrease in annual rainfall over the past 35 years and there has already been an increase in the frequency of high rainfall intensity and a decrease in the mean annual rainfall (PWA, 2006). According to the local metrological stations in the West Bank, more than 1/4 of the precipitations had been fallen during two days of the rainy season of 2007. In 1998/99, the rainfall record in Winter was the minimum in the past 100 year long history of rainfall record (PHG, 2006).

So, the great challenge for the coming decades will be the task of increasing food production with water shortage and climate changes under the restricted cultivated lands.

1.2 Research problem

Recently, concern about the increase in all over the world temperature caused by the global warming is increased dramatically, based on the notion that there are many doubts about the effect of climate change on agriculture. The study will concentrate on rainfed crops in order to examine the potential problems facing the agriculture in Palestine; whereas 91.6 % of the agriculture in the Palestinian territory is unirrigated (PCBS, 2006). Within this context, it has become necessary to conducted this research on the vulnerability and adaptation of the rainfed agriculture due to the effects of climate change, This will clarify to decision makers in order to deal with the problem in the future by answering the following question: What is the impact of climatic change on rain fed agriculture in Jenin district?

1.3 Study hypothesis

- There is a large effect of climate change on the yield reduction.
- There is a large effect of climate change on the amount of water required for the plants.
- There is a reduction in crops yield due to shortage in the amount of rainfall.
- There is a reduction in crops yield due to the increase in temperature.
- There is a delay in the rainfall season during the last ten years due to the climate change.

1.4 Aim and Objectives

The main goal of the research is to study and assess the impact of climate change on rainfed agriculture in jenin district. The specific objectives are:

- To study the current situation associated with rainfed agriculture in Jenin governorate.
- To find the yield reduction associated with increased temperature and reduced precipitation.
- To find the irrigation requirements to compensate for the shortage in precipitation.

- To assess and evaluate the economical losses due to the changes in the climate.

1.5 Approach and Methodology

The following steps illustrate the methodology which will be explained in detail in Chapter 5:

- The required data was collected from many sources, then they were arranged and retabulated in away in order to get benefit of these data. The study has been based on many scenarios based on the previous studies, Palestinian and Israelis expectations about the climate change in the next years.
- Rainfall data was analyzed in order to find if there were shifts and changes in rainfall amount and distribution through the last ten years (study period).
- A computer model (CropWat) was used in order to calculate the irrigation requirements (IR) and the yield reduction for some selected crops in Jenin district.
- Rainfall during the last ten years was sketched compared with the actual yield of the selected crops in Jenin district in order to find the relationship between the amount of rainfall and the yield response.
- Sample calculation was tabulated.

1.6 Thesis outline

This thesis contains six chapters: Chapter one which represent an introduction about the climate change and the study, chapter two is dedicated to literature review, chapter three describes the study area, chapter four focuses on methodology and the approach adopted in the study, chapter five clarify results as discussed based on the outcomes, and the last chapter summarizes conclusions and recommendations.

Chapter Two: Literature Review

2.1 Global climate change trends

Global climate change refers to, alterations in weather features which occur across the earth as a whole, such as temperature, wind patterns, precipitation, and storms. Global temperatures are modulated by naturally occurring atmospheric gases, such as water vapor, carbon dioxide, methane, and nitrous oxide. These gases allow sunlight to earth's atmosphere, but prevent radiative heat from escaping into outer space. Thus altering the earth's energy balance is a phenomenon called the greenhouse effect (EPA, 2009).

Global surface temperatures have risen by 0.74°C ± 0.18°C as estimated by a linear trend over the last 100 years (1906–2005) (IPCC, 2007a). Figure (2.1) shows the global temperature, for shorter recent periods, the slope is greater, indicating accelerated warming.

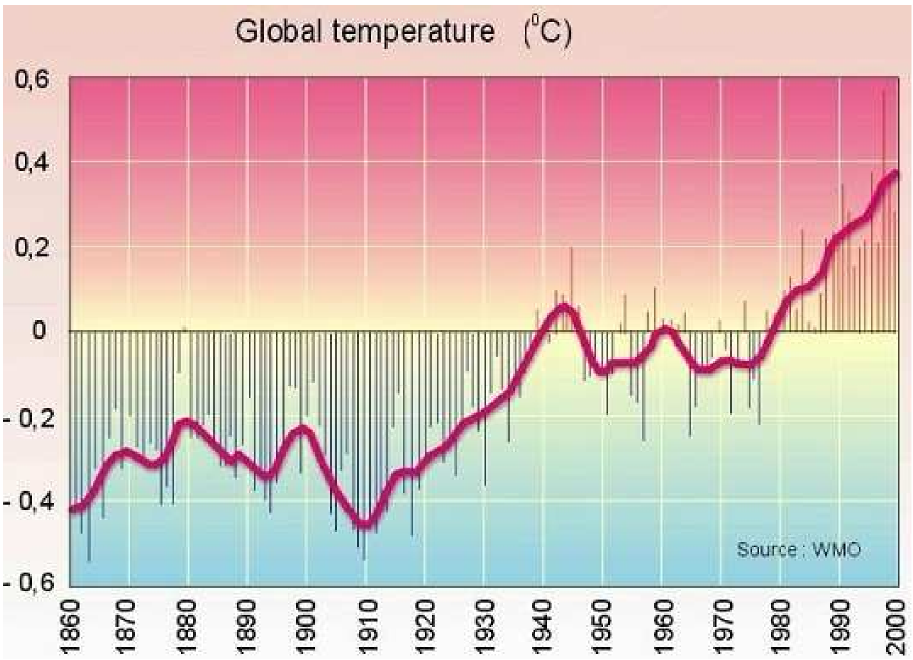

Figure (2.1) Global land surface temperature, (source: WMO)

Precipitation Patterns are more changeable spatially and seasonally than temperature change; global precipitation averages over land are not very meaningful and make large regional variations (IPCC, 2007a).

Figure (2.2) shows the trend of annual land precipitation amounts; the figure shows the trend as (%) per century for the 20th century.

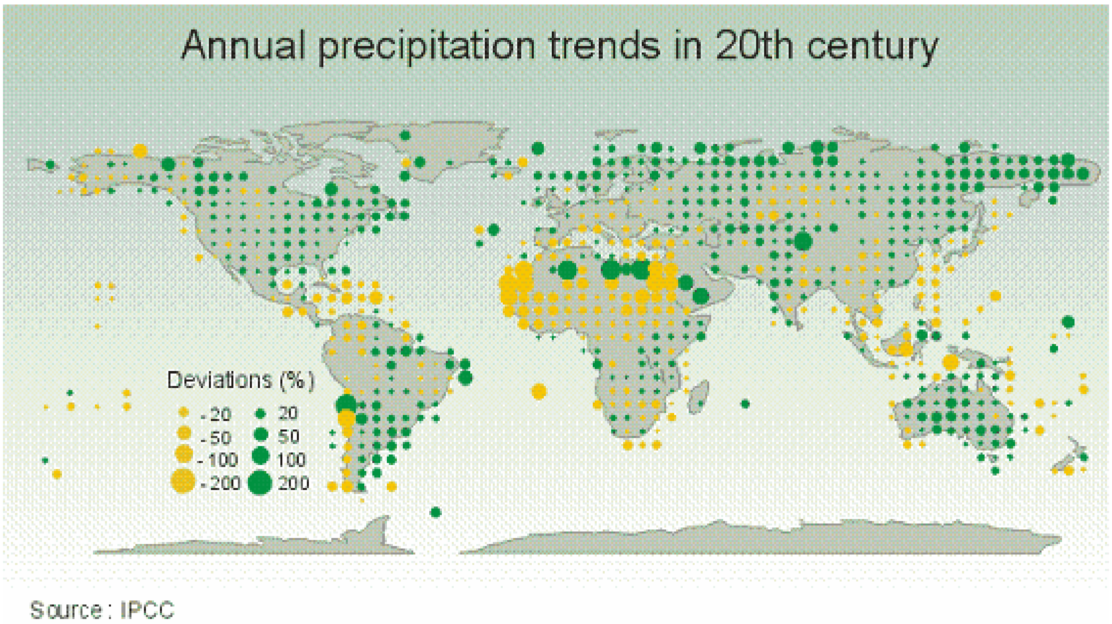

Figure (2.2) Trend of annual precipitation amounts in 20th century,(source: IPCC)

2.2 Mediterranean and Palestinian climate change trends

Palestine, along with its neighboring countries of the Mediterranean region, has experienced tumultuous rains and flooding. Such events were not frequent in the past.

An increase in rain intensity, combined with a decrease in the overall precipitation, will certainly increase the surface runoff, and, thus, soil erosion and salinization income will also increase.

Palestine Academy for Science and Technology performed an analysis of the data obtained, the simulation indicated an increase of average temperature over the simulation period (2007–2045) that reaches 0.75^{o}C. ARIJ in 2007, indicated that the increase in temperature over the past 20th century in the occupied Palestinian territory was obvious. The precipitation simulation showed expected decrease in rainfall mainly in the northern part of the domain.

2.3 Observed temperature trends over the Mediterranean

Giorgi (2002) analyzed the surface air temperature variability and trends over the larger Mediterranean land-area for the 20th century based on gridded data of New et al. (2000). He found a significant warming trend of 0.75°C per century, mostly from contributions in the early and late decades of the century. The structure of climate series differ considerably across regions showing variability at a range of scales in response to changes in the direct radiative forcing and variations in internal modes of the climate system (New et al. 2001; Hansen et al. 2001; Giorgi 2002).

2.4 Observed precipitation trends over the Mediterranean

Recent studies revealed that the 20th century was characterized by significant precipitation trends at different time and space scales (New et al. 2001, Folland et al. 2001). Giorgi (2002) found negative Winter precipitation trends over the larger Mediterranean land-area for the 20th century.

2.5 Impacts of climate change on agriculture

Agriculture is often considered the most vulnerable sector to climate change. Agriculture is affected by the vagaries of climate, and contributes to increasing climate variability and change, directly and indirectly, through the emission of greenhouse gases. Potential impacts of climate change on agricultural production depends not only on climate, but also on the internal dynamics of agricultural systems, including their ability to adapt to the changes.

The impacts of climate change on agriculture will be discussed under biophysical impacts, and socio-economic impacts (Nyong, 2008).

2.5.1 Biophysical impacts

• In Mid- to high altitude regions, moderate warming benefits cereal crop and pasture yields, but even slight warming decreases yields in seasonally dry and tropical regions.

In mid- to high-latitude regions, temperature increases between 1 ^{o}C to 3 ^{o}C across a range of CO2 concentrations and rainfall changes. This will likely have small but beneficial impacts on the main cereal crops – rice, wheat and maize. Further, warming beyond this range will likely have an increased negative impacts. In the low-latitude regions, where most developing countries are found, even moderate temperature increases which is likely to result in declining yields for the major cereals. This could increase the risk of hunger in many parts of the world. Simulations for sub-Saharan Africa estimate that countries such as Sudan, Nigeria, Somalia, Ethiopia, Zimbabwe and Chad, could lose cereal-production potential by 2080 across all emission scenarios (Fischer et al., 2005). These are countries where a large portion of the population depend on agriculture, and where capacities (e.g. technologies, finances, investments, etc.), both at national and farm level adapt to climate change, are the lowest. In addition, most of these countries are currently experiencing conflicts that would further hamper agricultural production. However, global warming will also present opportunities for some countries to expand their agricultural potentials.

• Increases in frequency of climate change extremes may decrease agricultural productivity beyond the impacts of mean climate change.

More frequent extreme events such as floods and droughts may decrease long-term yields by directly damaging crops at specific developmental stages. Heavy rainfall could precipitate soil erosion resulting in substantial agricultural loss.

• Changes in land availability for agriculture.

Agricultural crop distribution and production are largely dependent on the geographical distribution of thermal and moisture regimes. Global warming will likely increase the area that is conducive to growth and production of agricultural crops, as well as extend the length of growing periods in some countries. On the other hand, a significant decrease in land suitable for rainfed agriculture is projected for Africa by 2080, where it is estimated that the area of arid and semi-arid land could increase by five to eight percent. For southern Africa, the area that will likely be unsuitable for agriculture could increase by 11 percent in 2080 because of climate change (Fisher et al., 2005; Nyong, 2008).

2.5.2 Socioeconomic impacts

• Global cereal production and agricultural GDP

Most models generally agree that global cereal production would increase by as much as 200 percent by 2080 due to global warming because of CO2 fertilization (Fischer et al., 2005). More disaggregated regional models; however, have shown the disparity in cereal production at more localized levels. These detailed studies show an increasing gap in cereal production between developed and developing regions especially after 2020. Whereas semi-arid developing countries, notably in sub-Saharan Africa, and in some areas in South Asia where suitable arable land resources are limited, which see reductions in production in the range of 5-10 percent. So, increases are projected for North America, Europe and the Russian Federation and parts of East Asia.

Several models project that climate change could cause a modest increase between 2 and 20 percent in the price agricultural products in the short to medium term at the global level. While temperature increase is up to 5 ^{o} C, global mean temperature beyond that point could lead to a substantial increase in food prices (Easterling et al., 2007; Fisher et al, 2005). With regard to agricultural GDP, climate change could lead to an increase of about 2.6 percent in some areas, particularly the high latitude in developed countries and a reduction of about 1.5 percent in others, particularly around the tropics by 2080 (Fischer et al., 2005; Nyong, 2008).

Recent studies have shown that some parts of sub-Saharan Africa will experience a reduction in magnitude greater than what is predicted with global models. For instance, most of Africa’s agriculture is practiced on drylands and the area of semi-arid and arid lands in Africa could increase by about 60 – 90 million hectares (Boko et al, 2007).

Model results show that dryland crop revenue falls an average of $27 per hectare per 1 ^{o} C increase in temperature. Whereas irrigated crop revenue increases an average of $30 per hectare per 1^{o} C (Kurukulasuriya, et al., 2006). In South Africa, it is estimated that crop net revenues will likely fall by 90 percent by 2100, without effective adaptation (Benhin, 2006). Considering the importance of agriculture to the economy of most African countries, climate change poses a real threat to development in the continent (Nyong, 2008).

Regardless of the expected rainfall and runoff patterns, the number of dry days is conjectured to increase everywhere in the region, with the exception of some central-Saharan areas. The number of frost days should decrease everywhere, while heat waves could increase in the region's of more continental areas. The length of growing seasons (LGSs) should decrease. Apparent contradictions (such as decreasing LGS when runoff is predicted to increase) are an indicator of the uncertainties affecting the projections.

In all scenarios, the highest impacts are in Africa, Middle East, India and Southeast Asia. Once temperature increase by 3°C, 250 to 550 million additional people may be at risk worldwide – more than half in Africa and Western Asia – particularly where the declines in yield are the greatest. However this depends on agriculture highest and purchasing power which is the most limited. Yields of the key crops across Africa and Western Asia may fall 15 to 35 percent or 5 to 20 percent, depending on whether there is weak or high carbon fertilization respectively, once temperatures increases reach 3 or 4°C (Implications for Agriculture in the Near East, 2008).

In the long run, the climatic change could affect agriculture in several ways:

- productivity, in terms of quantity and quality of crops.
- Agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers.
- Environmental effects, in particular in relation to frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion and reduction of crop diversity.

- Rural space, through the loss and gain of cultivated lands, land speculation and land renunciation.
- Adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaption.

The earth's average temperature has been rising since the late 1970s, with nine of the ten warmest years on record occurring since 1995 (NOAA, 2006). In 2002, India and the United States suffered sharp harvest reductions because of record temperatures and drought. In 2003, Europe suffered very low rainfall throughout Spring and Summer, and a record level of heat damaged most crops in the United Kingdom and France in the Western Europe through Ukraine in the East. Therefore, bread prices have been rising in several countries in the region.

2.6 Climate change scenarios

Scenarios are used in order to estimate climate changes effects on crop development and yield. Each scenario is defined as a set of meteorological variables, based generally on accepted projections. For example, many models are running simulations based on doubled carbon dioxide projections, temperatures raise ranging from 1°C up to 5°C, and with rainfall levels an increase or decrease of 20%. Other parameters may include humidity, wind, and solar activity. Scenarios of crop models are testing farm-level adaptation, such as sowing date shift and climate adapted species (Karki).

To assess the impacts of climate change, it is first necessary to obtain quantitative representation of the changes in climate themselves. The methods available do not provide a confident prediction of future climate; instead, it is customary to specify a number of plausible future climates. Two types of climate scenarios used 1) Synthetic or incremental scenarios and 2) Scenarios from General Circulation Models (GCMs) (Tarekegn and Tadege, 2009).

2.6.1 Synthetic scenarios

Synthetic scenarios describe techniques where particular climatic elements are changed by a realistic but arbitrary amount, according to qualitative interpretation of climate model prediction for a region (IPCC,1994). Synthetic scenarios are used to assess the sensitivity of the basin to climate change. For this study, a different set of possible climate changes in temperature and rainfall have been considered: an increase in temperature of 1°C, 2°C and 3°C, and changes in the amount of rainfall by -10%, -20%, and -30%.

2.6.2 GCM scenarios

GCMs produce estimates of climatic variables for a regular network of grid points across the globe. There are a number of GCMs worldwide which evaluate the equilibrium response of the global climate to an abrupt increase, commonly doubling of atmospheric concentration of CO_2, by 2075 (equilibrium response). Recently, simulations have been made of climate response to a time dependent increase in greenhouse gases (transient response), (IPCC,1994). Although various GCMs outputs are available, their predictions of the amount climate change differ.

In this study, two scenarios will be discussed; the Palestinian and the Israeli scenarios.

2.7 The Palestinian climate change scenarios

The Palestine Academy for Science and Technology investigate the regional climate change scenarios and produce climate data on proper temporal interval and spatial grid size describing the climate change. The methodology and outcomes show a regional statistical downscaling model has been used for calculating the future climate change based on the meteorological observed data maintained at the (Potsdam Institute for Climate Impact Research) PIK. The domain used extends from 29^o -34^o and from 34^o - 36^o Latitude and Longitude respectively on a fine resolution of 8 x 8 km^2. The downscaling model was configured to run simulations based on GCM - ECHAM4.0 model run that used the balanced SRES A1B scenario. Two runs were done for two time slices, the first trend “control” run, which was carried out with climate observation parameters that cover the period from 1958 – 1996, and the second run simulates the climate trend for the period from 2007 – 2045. Out of the two runs, two sets of data are produced; observation climate data for the period from 1958-1996 , which include T_{max}, T_{min}, T_{av} . The daily precipitation and simulation climate data for the period 2007-2045, which include T_{max}, T_{min}, T_{av} and the daily precipitation. The analysis of the outputs indicate an increase of average temperature over the simulation period (2007 – 2045) that reaches an average of 0.75 ^{o}C over the whole domain. The precipitation distributed over the domain showed a decrease in the annual average values that may reache 100 – 200 mm on the northern part of the domain; i.e. above 31 ^{o} Latitude, and a shift in rainfall towards March and April. Scenario output showed an increase in frequent occurrences in climate extreme events (Khatib, 2009).

2.8 The Israeli climate change scenarios

The presented information and assessments are based on a survey of literature and interviews with Israeli scientists and policymakers. The following climate scenarios are projected for Israel by the year 2100 (Israel Ministry of Environmental Protection, 2008).

2.8.1 Climate changes

- Mean temperature increase of 1.6° to1.8°C.
- Reduction in precipitation by (-8)% to (-4)%.
- Increase in evapotranspiration by 10%.
- Delayed winter rains.
- Increased rain intensity and shortened rainy season.
- Greater seasonal temperature variability.
- Increased frequency and severity of extreme climate events.

- Greater spatial and temporal climatic uncertainty.

Related environmental changes:

- Sea level rise of 12-88cm.
- 560ppmv of atmospheric CO_2 concentration by the year 2040-2065.

These scenarios have low reliability due to the complexity of climatic factors affecting the region (Pe'er et al ,2000).

2.8.2 An integrated scenario for climate change in Israel

Based on the climate scenario of Dayan and Koch (1999), the following scenario for Israel is the current and most likely one:

1. Models (Palutikof and Wigley, 1996; Dayan and Koch, 1999) reinforced by observations project the following warming (Dayan and Koch 1999):

- 0.3-0.4° C by 2020
- 0.7-0.8° C by 2050
- 1.6-1.8° C by 2100

2. Models (Segal et al. 1994; Dayan and Koch 1999) partly reinforced by recent observations (Steinberger and Gazit-Yaari 1996; Ben-Gai et al. 1998a; Paz et al. 1998b; Alpert et al. 2000) project the following decreases in precipitation (Dayan and Koch 1999):

- -2 to -1% by 2020
- -4 to -2% by 2050
- -8 to -4% by 2100

3. A 10% increase in evapotranspiration with an increased temperature of 1.5^{o}C anticipated around 2100, in contrast to observations (Jeftic, 1993; Dayan & Koch, 1999).
4. Delayed winter rains, based on observed data (Kutiel, 2000).
5. Increased climatic variations and frequency of extreme events, expressed in the following increases:

- Seasonal variability in temperature, as observed worldwide (IPCC, 1996) and confirmed by data from Israel (Ben-Gai et al. 1998a, 1999)

- Climatic uncertainty due to increase in spatial and temporal uncertainty (Kutiel, 2000)
- Frequency and severity of extreme climatic conditions (Ben-Gai et al., 1998a, 1999)
- Frequency of high intensity rainstorms (Alpert et al., 2000), based on observations.

2.9 Environmental impacts

2.9.1 Hydrology

Increased rain intensity combined with a reduction in overall precipitation will diminish vegetation cover and increase surface runoff, leading to desertification, especially in the Negev. The resulting soil erosion, salinization, and loss of vegetation will further increase surface runoff. Agricultural fields—mainly rainfed ones—will become more saline from increased evapotranspiration (Israel Ministry of Environmental Protection, 2008).

2.9.2 Agriculture

Increases in seasonal temperature variability, storminess and frequency of temperature extremes may endanger cold- and heat-sensitive crops. Greater rain intensities and resulting floods may damage crops in the coastal plain. Drought damages are also expected increase with the anticipated decrease in water availability, hotter temperatures and shorter winters. More pests and pathogens will not only increase crop diseases but also their sensitivity to drought, and loss of biodiversity may reduce the natural control of agricultural pests. A delayed growing season will cause Israel to lose its advantage over countries in colder climates in early exports of flowers, fruits and vegetables.(Israel Ministry of environmental protection, 2008).

2.10 Future climate change in Israel

A global-scale scenario cannot be reliably applied to Israel, because of the small size of the country, the coarse resolution of current models and the great spatial inaccuracy of global models. When projecting local scenarios from global trends, climatic models tend to display spatial inaccuracy of certain climatic mechanisms, especially precipitation

(Wigley, 1992; Mirza et al., 1998). Although incorporating the effect of sulfate aerosols on solar radiation has somewhat improved the models. Recent studies show that the effect of urban-pollution aerosols also compromises their accuracy. These aerosols were found to suppress rain, thereby affecting spatial precipitation patterns and, indirectly, spatial temperature changes (Rosenfeld, 2000; Rosenfeld and Woodley, 2000). The pollution particles act as moisture condensers, increasing the number of water particles and decreasing their size to such an extent that they tend to float in the air instead of colliding, joining and precipitating (Rosenfeld, 2000). These tiny particles can remain liquid even under a supercooled temperature of about -40^{o}C, and are thus no longer available for rain production (Rosenfeld and Woodley, 2000). In addition to its direct impact on precipitation, rain suppression changes the spatial heat distribution by suppressing the release of potential energy within water droplets into the upper atmospheric levels. Thus, rain suppression affects upper atmosphere processes unfelt by humans, changing regional water and temperature distribution and the dynamics of depressions and highs.

In order to assess the implications of global climate change for Israel's coastal region, Dayan & Koch (1999) developed a GCM-derived scenario, using procedures developed by the Climate Research Unit of the University of East Anglia for the Intergovernmental Panel on Climate Change (IPCC, 1996), the IS92a scenario. The four GCMs of the IS92a scenario were interpolated for stations, and a sub-grid analysis was done for each model, in order to develop scenarios for temperature and precipitation change. Their results predicted 80% to 90% sensitivity to the global climate change. That is, for every 1° C change in the global mean, warming of 0.8° to 0.9° C is anticipated in Israel, with a consequent reduction in precipitation. These results are similar to those of Palutikof & Wigley (1996) for the Middle East. However, the use of GCM-derived scenarios is highly problematic in a region that is highly sensitive to local- and regional-scale effects.

Segal et al. (1994) constructed a model of winter cyclone movement and overall water balance in the Eastern Mediterranean region found that a rise in temperature will lead to decreased precipitation due to redistribution of rainfall and an increase in evapotranspiration of up to 13% in Summer and somewhat more in the winter. These results suggest an overall trend towards a greater water deficit. Dayan and Koch (1999) assessed a possible increase in storminess suggested by several authors and did not find conclusive evidence for increased frequency of storms or increased rain intensity. The scenario presented by Dayan and Koch (1999) for the coastal region of Israel pertains only to the country's coastline, which is several kilometers wide. Nevertheless, it is consistent with previous models (Palutikof and Wigley, 1996; Segal et al., 1994), and probably applies to a wider area due to the relatively coarse resolution of the model used. Furthermore, since the coastal region is inhabited by 70% of the population, this scenario is valid for most of the Israeli population.

2.11 Observed climate change in the region and in Israel

Changes in climate already detected in the region and in Israel may be instructive in assessing the exposure to those changes predicted by the above scenarios. Following a review of information on presented changes.

2.11.1 Regional warming

Price et al. (1999) observed an approximate 1^{o}C/100yr rise in annual mean temperature in Cyprus. Alpert et al. (unpublished data) observed the same warming trend in Cyprus, as well as in Italy and Spain. A relatively moderate increase in air temperature was measured in cities of the Mediterranean basin, primarily in Winter and less in the Autumn and Spring (Maheras and Kutiel, 1999; Kutiel and Maheras, 1998). Most of the increase; however, was measured in cities undergoing urbanization (Kutiel and Maheras, 1998).

A spatial analysis of temperature changes in Israel during the last 40 years shows warming mainly in the center and north (Ben-Gai et al., 1998a, 1999), with a cooling trend in the south and around Hadera (the site of a major power station). Thus, there appears to be a general warming trend, with local exceptions related to anthropogenic factors (e.g. pollution particles around Hadera power station) (Ben Gai et al, 1999).

2.11.2 Cooling trend

Some models and measurements taken in the Mediterranean basin—especially in the eastern Mediterranean—do not show warming trends (Wigley, 1992). Ben-Gai et al.,

(1999) found no changes in annual mean temperature in Israel between 1964 and1994, at 40 stations. A cooling trend in the autumn of about -0.5^{o}C/100yr was detected in most regions of the Mediterranean (Kutiel and Maheras, 1998). Nasrallah and Balling (1996) found a slight but non-significant cooling trend in the Arabian Peninsula over the last 40 years. A cooling trend is also evident from measurements of sea surface temperature (SST). Several authors (Kutiel and Bar-Tuv 1992; Paz et al. 1998b) have detected a decrease in SST in the Eastern Mediterranean. Because seawater absorbs large proportions of the incident solar energy, a decrease in SST reduces energy release into the atmosphere and affects heat distribution in the surrounding. Furthermore, reduced evaporation rates occur due to lowered SST affects precipitation in the coastal region.

To explain the cooling trend observed in the Eastern Mediterranean basin, Conte et al. (1989) hypothesized a spatial Mediterranean oscillation between the Eastern and Western Mediterranean basins (similar to a small-scale El-Niño phenomenon). According to this theory, there is a warm winter in the Western basin, there is a cold Winter in the Eastern basin and vise versa. Although such an oscillation was never proved (Kutiel 2000), some authors found opposite trends in the Western and Eastern sides of the Mediterranean, where the Western region tends to warm and the Eastern region is cooled (Wigley, 1992; Kutiel and Paz, 1998; Maheras and Kutiel, 1999). An overall warming trend from 1873 to 1989 observed by Kutiel and Maheras (1998) was more evident in the Western (+0.4^{o}C/100 yr) than in the Eastern basin (+0.2^{o}C/100 yr).

2.11.3 Precipitation

- Decreased precipitation

Several authors detected a decrease in precipitation in the last decades, primarily in the center and North of the country (Steinberger and Gazit-Yaari, 1996; Ben-Gai et al., 1998a). Paz et al. (1998b) detected a decrease in precipitation in most stations in Israel during 1950 to1990. Alpert et al. (2000) suggests an overall trend of a decrease in precipitation over the last decades. The decline in precipitation may be explained by a decrease in the frequency of mid-latitude cyclones in the East-Mediterranean (Druyan and Rind, 1993; Gačić et al., 1992). A simulation model (Segal et al. 1994) shows that increasing temperature may shift the cyclone path northward, reducing precipitation in the Southeastern Mediterranean. This model; however, is somewhat of an oversimplification of climatic processes, as it assumes that cyclone generation is not affected by climate change.

Some authors ascribe the changes in precipitation primarily to intra-seasonal changes in rain distribution. Paz et al. (1998b) found that rainfall decreased in Winter at most of the 15 stations studied around the Mediterranean (mainly in the eastern Mediterranean) but increased slightly in Spring and Summer, with no significant change in total rainfall during the period 1970-1990. Sharon (1993), on the other hand, found that changes in annual rainfall varied distinctly among regions in Israel, and only the coastal region showed a constant decline. This suggests that specific regional factors might play an important role in the local climatic trend.

Rainfall measurements at different stations in the Mediterranean basin show similar declines in most regions of the basin (Paz et al., 1998a). High correlation between changes in vegetation and changes in sea level during the last 10,000 years in the Middle East suggests that the trend of decreasing precipitation in the Middle East may be attributed to global warming (Issar, 1995).

-Shortened rainy season

Kutiel (2000), analyzed changes in the yearly distribution of rains in Israel from 1976 to 2000 and found that the Winter rainy season shortened over this period, particularly in the last decade. The length of period during which the cumulative amount of rainfall reached 20% and 50% of the annual rainfall was extended by 6 days and 4 days per decade respectively, due to lower rainfall in October and November. This observation contrasts with former reports of increased rains in October (Steinberger and Gazit-Yaari 1996). A delay in Winter rains, with no extension of the rainy period, may explain the decrease in Israel 's total annual rainfall.

-Increased frequency of extreme weather events

The temporal and spatial distribution of rains in the Mediterranean basin is highly changeable, with rainfall varying greatly both from year to year and within the year

(Kutiel, 2000). Even greater variability due to climate change will likely be as important or more important than changes in mean climate conditions for determining climate change impacts and vulnerability (IPCC, 1996). Analysis of spatial and temporal long-term trends in climate in Israel showed increased seasonal variability due to a decrease in the maximal and minimal temperatures (Tmax and Tmin, respectively) in the cool season, and an increase in Tmin and Tmax in the warm season (Ben-Gai et al., 1999). These two opposite tendencies, observed at 40 stations over 31 years (1964 to1994), may explain the absence of change in mean temperature. However, analysis of the same data did show increased temperatures in the center and in the north.

Ben-Gai et al. (1998a, 1999), studied the frequency pattern of Tmin and Tmax from 1964 to 1994, divided the years into two sub-periods -1964 to 1979 and 1980 to 1994- and compared the two. They found increased seasonal variability as well as increased frequency of extreme temperature events, demonstrated by the upper and lower tail of the temperature distributions.

Rains also markedly increased in intensity. Alpert et al. (2000) showed that high-intensity rains increased in frequency, with fewer rains of moderate and weak intensity. Interestingly, former analyses of rain intensity have failed to show this trend (Dayan and Koch 1999). Alpert’s analysis supports a prevailing notion of an increased incidence of extreme weather, particularly in the last decade. The high incidence of extreme weather events in Israel during the 1990s is apparent from the following:

- 1991/2 - Wettest year recorded in Israel over the century, with annual mean precipitation above 200% in most areas.
- 1995, 1998 - While most spring and fall hamsin events (hot, dry cyclone) occur in May-June and in September-October, respectively, the first ever recorded hamsin as late as July (accompanied by a severe forest fire in the Judean mountains) and as early as April in 1998 (causing severe agricultural damage) occurred in 1995 and 1998, respectively.
- 1998 - Hottest summer recorded in Israel.
- 1999 – First hamsin ever recorded in December, accompanied by severe forest fires on Mt. Carmel.

- 1998/9 and 1999/2000 - two consecutive years of extreme drought and the longest drought ever recorded in the south (leading to widespread mortality of trees in the Jewish National Fund [JNF] afforestation projects).
- 2000 - Heaviest snowfall in the northern Negev.
- 2000 - Hottest July in Israel in the last 50 years, with a mean temperature 4^{o}C higher than average. Highest recorded temperature (41^{o}C) in Jerusalem since 1888.

2.12 Adaptation

The concept of “adaptation” and the related terms “coping”, “resilience” and “vulnerability” are used in different ways by different disciplines and policy communities (IPCC 2001; Füssel and Klein 2002; O’Brien 2004; Easterling 2004; Moench and Dixit 2004; Adger et al. 2004; Wisner et al. 2004).

‘Adaptation’ is meant the responses to both the adverse and the beneficial effects of climate change. The term refers to any adjustment, whether passive, reactive or anticipatory, that can respond to anticipated or actual consequences associated with climate change. Reactive adaptation means responding to climate change after it occurs while anticipatory adaptation means taking steps in advance of climate change to minimize any potentially negative effects.

2.12.1 Adaptation options

The technological, economic and policy adaptations available differ greatly depending on the hydro-climatic zone. The level of economic development and the relative sensitivity of the water resource system to potential climate change (IPCC,1994). The IPCC Technical Guidelines (IPCC,1994) list six generic types of behavioral adaptation strategy for coping with the negative impacts of climate:

- Prevention of loss: involving anticipatory actions to reduce the susceptibility of an exposure unit to the impacts of climate.
- Tolerating loss: where adverse impacts are accepted in the short term because the exposure unit can absorb them without long-term damage.

- Spreading or sharing loss: where actions distribute the burden of impact over a larger region or population beyond those directly affected by the climate event.
- Changing use or activity, involving a switch of activity or resource use from one that is no longer viable following a climatic perturbation to another that is, so as to preserve a community in a region.
- Changing location: where preservation of activity is considered more important than its location, and migration occurs to areas that are more suitable under the changed climate.
- Restoration: it aims to restore a system to its original condition following damage or modification to climate. This is not strictly adaptation to climate, as the system remains susceptible to subsequent comparable climatic events.

Another way to adapt is to modify the threat, i.e. to attempt to control the environmental phenomenon itself. For example, a flood may be controlled by flood control structures and a drought may be alleviated by cloud seeding. The main way to modify long-term climate change is to slow its rate by reducing greenhouse gas emissions and eventually stabilizing the concentration of these gases in the atmosphere.

2.12.2 Barriers to adaptation

Willingness and ability to adapt are often affected by real and perceived barriers or constraints. This can lead to questioning the need for adaptation or may limit the effectiveness of a particular option. Constraints or barriers include the following:

- Limited understanding of climate risks and vulnerabilities – current and projected.
- Lack of supportive policies, standards, regulations, and design guidance, encouraging status quo and/or presenting impediments to progress.
- Existing legal or regulatory restrictions.
- Lack of availability or restricted access to appropriate technologies.
- Costs of identified adaptation options when budgets are limited.
- Lack of availability of resources such as in-house expertise.
- Social/cultural/financial rigidity and conflicts.
- Short-term nature of planning horizons – necessity of realizing return on investment.

- There are also barriers associated with perceptions of uncertainty.
- Confidence for the long-term – mismatch between business planning horizons and timeframe of projections of climate change.
- Not seen as a big problem yet. So the temptation is to wait for the impact then react.
- Belief that the uncertainty is too great to warrant taking adaptation action now.
- Lack of useful precedents or evidence of adaptation actions – what are others doing?
- Lack of acceptance/understanding of risks associated with implementation – what if the decision is wrong?

To help overcome these barriers, it can be helpful to build adaptive capacity improving the understanding of climate change, associated risks and vulnerabilities, along with actions related to understanding and updating the institutional and legal frameworks (i.e. those constraining or enhancing adaptive capacity). These are useful strategies for eliminating these barriers.

2.12.3 Principle of good adaptation

Despite the difficulties associated with defining a particular adaptation measure as being good, acceptable, or successful. There are principles of good adaptation that can be used to inform the selection process.

Such set of principles have evolved through practice and identification the following aspects of the adaptation process as being characteristic of those processes that have led to good adaptation:

- Work in partnership – identify and engage your community and ensure they are well informed.
- Understand risks and thresholds, including associated uncertainties.
- Frame and communicate (objectives/outcomes) before starting out.
- Manage climate and non-climate risks using a balanced approach – assess and implement your approach to adaptation in the context of overall sustainability and development objectives that includes managing climate and non-climate risks.
- Focus on actions to manage priority climate risks – identify key climate risks and opportunities and focus on actions to manage these.

- Address risks associated with today's climate variability and extremes as a starting point towards taking anticipatory actions to address risks and opportunities associated with longer-term climate change.
- Use adaptive management to cope with uncertainty – recognize the value of a phased approach to cope with uncertainty.
- Recognize the value of no/low regrets and win-win adaptation options in terms of cost-effectiveness and multiple benefits.
- Avoid actions that foreclose or limit future adaptations or restrict adaptive actions of others.
- Review the continued effectiveness of adaptation decisions by adopting a continuous improvement approach that also includes monitoring and re-evaluations of risks.

2.13 Mitigation

Mitigation refers to actions that reduce our contribution to the causes of climate change. This means reducing emissions of greenhouse gases, such as carbon dioxide (CO_2), through energy efficiency and using alternative forms of transport and energy (Tarekegn and Tadege, 2009).

Mitigation is important in the long term as it is only by reducing our greenhouse gas emissions that we can hope to minimize human-induced climate change. Many of the measures to help reduce emissions may also have other benefits such as saving money and encouraging a more sustainable society. Mitigation and adaptation are closely related and ideally should be considered together rather than separately. This is not always possible but it is important that any adaptation actions take account of mitigation and any mitigation takes account of the need for adaptation.

El-Fadel and Bou-Zeid (2001) found that the most important constraints on the assessment of vulnerability and adaptation were:

- The lack of capacities to conduct the type of vulnerability and adaptation assessments that would generate reliable results for incorporation into national development planning processes.
- The lack of data arises because of inadequacies in data collection and monitoring, and access to existing databases.
- The lack of capacity to analyze, manipulate and improve quality assurance in some data sets.

2.14 Previous studies

Many studies and research have been conducted all over the world in order to analyze and study the impact of climate change on the agricultural sector specially the rainfed agriculture. Most of the studied concentrate at the impact of CC on agricultural yield reduction and Production.

Abu-Jamous (2008) evaluated the agricultural water demand under different suggested climate change scenarios for Jericho district. CROPWAT computer model was used as a tools. The results show that crop water requirement (CWR) is very sensitive to temperature increase; CWR increases by an average of 2.7%, 5.4% and 8% as temperature increases by 1°C, 2°C and 3°C, respectively, to compensate the water lost in evapotranspiration. Scenarios of changing precipitation show an increase in IWR by an average of 1.47 % and 5.53% for a decrease in precipitation by 10% and 20% respectively. The other scenario of increasing precipitation shows a decrease by an average of 1.44% and 2.84% in the IWR for an increase by 10% and 20% in precipitation respectively.

Amien et al (1996) studied the effects of interannual climate variability and climate change on rice yield in Java, Indonesia. The rice self-sufficiency that has been attained and maintained since 1984 has been affected by climate variability effects of the El-Nino/Southern Oscillation phenomenon and could be threatened by changing climate. To aid policy-makers and planners to formulate strategic policy options. The effects of recurring droughts and possible climate change on rice yields were studied using climate and crop models. Three models were used to simulate climate change: those of the Goddard Institute for Space Studies; Geophysical Fluid Dynamics Laboratory; and the United Kingdom Meteorological Office. Several climate scenarios were generated for Ngawi in East Java, and Sukamandi in West Java. These models indicate that doubling GHG would increase solar radiation by a minimum 1.2%-2.1%, and transient climate change scenarios indicate that maximum and minimum temperatures would increase by 3.5% and 4.9%, in 2010, 6% and 9.8%, in 2030, and 11.1% and 15.7% respectively in 2050. The rainfall increase varies from 7% for West Java in 2010 to 8.7% for East Java in 2050.

Changes in climate in the decades of 2010, 2030, and 2050 could drastically reduce rice yields: the rice yield is estimated to decrease by about one per cent annually in East Java and less in West Java. Currently, the rice yields in dry years are about one-half those of normal years.

Amien et al (1999) studied the simulated rice yields as affected by interannual climate variability and possible climate change in Java. About 60% of the rice produced in Indonesia is grown in the fertile soil of the island of Java. Introduction of the high-yielding rice varieties and improvement of cultural technique have increased rice production, However, increasing population and decreasing land for rice cultivation could threaten the food supply in the country. Rice production is also threatened by interannual climate variability and possible climate change. Models predicted lower rice yields for different management options, compared with experiment plots, but predicted yields similar to or slightly higher than the farmers' yield.

The results show that higher yield losses were predicted because of interannual climate variability. Since the dry spell threat is more imminent and frequent, to improve preparedness a short-term climate prediction for the tropical region is urgently needed.

Alexandrov, Vesselin (1997) studied the vulnerability of agronomic systems in Bulgaria. In the study, the influence of climate change on potential crop growing season above a base of 5° and 10 °C in Bulgaria was investigated. Increases in temperature can be expected to lengthen the potential growing season, resulting in a shift of thermal limits of agriculture in Bulgaria. The Decision Support System for Agro Technology Transfer (DSSAT) Version 2.1 was used to assess the influence of climate change on grain yield of maize and winter wheat. The results show that Maize and winter wheat yields decreased with increasing temperatures and decreasing precipitation.

Another study conducted by Alexandrov, Vesselin (1999) about vulnerability and adaptation of agronomic systems in Bulgaria. The study shows that the annual temperature in the country are projected to rise between 2.9 (HCGS model) and 5.8°C (UK89 model) under effective doubling of CO2. Precipitation is expected to increase during the winter and to decrease during the warm half of the year. Under equilibrium 2 x CO2, the GCM climate change scenarios project an increase in the agroclimatic potential; however, warming would cause decreases in grain yield of winter wheat.

Baethgen, and Walter studied (1997) the vulnerability of the agricultural sector of Latin America to climate change. The vulnerability of the agricultural sector in any region to future possible climate-change scenarios is determined to a great extent by the vulnerability of the sector to current climatic, economic and policy scenarios. Agricultural systems which currently subject to extreme climatic interannual variability (drought, flood, storms, etc.) are likely to become even more vulnerable under the most commonly expected scenarios of climate change (i.e. increased temperatures, increased rainfall variability). The agricultural sector of Latin America has been subjected to important variations in economical conditions and policies. These conditions have affected the structure of agricultural production, and resulted in a large reduction of the number of small farmers, who have migrated to poor metropolitan areas. Even for larger, commercial farmers, unstable and often inconsistent agricultural policies have increased the vulnerability of the sector. The few studies conducted in the region to specifically assess the impact of climate change on agriculture have revealed expected reductions and increased variability in crop productivity. Preparing the agricultural sector to mitigate the potential negative effects of climate change will require strong and consistent efforts in both the scientific and policy sectors of the region.

Cuculeanu et al studied (1999) the climate change impact on agricultural crops and adaptation options in Romania. The aim of this study was to assess the potential effects of climate change on development, grain yield, and water balance for the main agricultural crops at 5 typical sites located in one of the most vulnerable zones of Romania. In addition, the study evaluates possible adaptation measures of crop management to future climate changes. The vulnerability assessments focused on winter wheat and maize crops due to the particular importance of these crops in the cultivated areas and the difference in the genetic type of these crops reflected in their distinct physiological responses to CO_2 concentration level.

The results of crop simulations under climate change scenarios indicated that Winter wheat benefits from the interaction of double CO_2 concentrations and higher temperatures, while irrigated maize in southern Romania shows negative responses to climate change.

Erda (1996), studied the agricultural vulnerability and adaptation to global warming in China. The study discussed the vulnerability and adaptation of the agricultural sector of China to global warming. Based on a summarization of Chinese agricultural and general circulation model trends, adverse impacts on China's agriculture caused by a warming and drying climate were identified. Because of limited irrigation potential, the sustainable development of Chinese agriculture will be difficult. On the basis of an estimation of the potential supply of agricultural products and demand for food, the annual incremental costs for adaptation to climate change would be US $0.8-3.48 billion, without adaptation, the annual agricultural loss due to global warming would be US $1.37-79.98 billion from 2000 to 2050. Adaptive measures discussed include intensive management and the possibility of a tripartite structure of planting that would entail coordinated development of grain crops, feed crops, and cash crops.

El-Shaer et al (1997), studied the impact of climate change on possible scenarios for Egyptian agriculture in the future. The study reveals that if no timely measures are taken to adapt Egyptian agriculture to possible climate warming, the effects may be negative and serious. Egypt appears to be particularly vulnerable to climate change because of its dependence on the Nile River as the primary water source. A simulation study characterized potential yield and water use efficiency decreases on two reference crops in the main agricultural regions with possible future climatic variation, even when the beneficial effects of increase CO_2 were taken into account. On-farm adaptation techniques which imply no additional cost to the agricultural system did not compensate for the yield losses with the warmer climate or improve the crop water-use efficiency.

Ghaffari et al (2002) studied the climate change and Winter wheat management: A Modelling Scenario for South-Eastern England. The study used crop models as a tool for assessing the impact of climate change on crop production. The dynamic crop-growth model, CERES-Wheat is used to examine crop management responses, including yield, under six climate change scenarios for the years 2025 and 2050 on the Estate of Imperial College at Wye, Kent, U.K.

Sensitivity analysis shows a dry matter yield decrease in response to increases in temperature alone. CERES-Wheat was then constrained to assess the crop performance under water-limited production scenarios with different soils, and the results show that crop grain yield actually increases, largely due to CO_2 fertilization leading to increased rates of photosynthesis. Different management practices (planting dates and nitrogen application) were applied to find the best adaptation strategies. In general, \`early' sowing (10th September) had the highest simulated yield, and \`late' sowing (10th November) the lowest. For the soils tested, the highest and sustained crop production was obtained from Hamble soils (silt loam) compared with either the Fyfield (sandy) or Denchworth (clay). Adding nitrogen and other fertilizers would likely be necessary to take full advantage of the CO_2 fertilization effect and to compensate, in some cases, for yield losses caused by climate change where water shortage becomes serious.

Jinghua and Erda (1996), studied the impacts of potential climate change and climate variability on simulated maize production in China. This study assessed the impacts of potential climate change on maize yields in China, using the CERES-Maize model under rainfed and irrigated conditions, the study shows that, simulated yields of both rainfed and irrigated maize decreased under climate change scenarios, primarily because of increases in temperature, which shorten maize growth duration, particularly the grain-filling period. Decreases of simulated yields varied across the GCM scenarios. Simulated yields increased at only a few northern sites, probably because maize growth is currently temperature-limited at these relatively high latitudes. To analyze the possible impacts of climate variability on maize yield, the researcher specified incremental changes to variabilities of temperature and precipitation and applied these changes to the GCM scenarios to create sensitivity scenarios. Arbitrary climate variability sensitivity tests were conducted at three sites in the North China Plain to test maize model response to a range of changes (0, +10, and +20) in the monthly standard deviations of temperature and monthly variation coefficients of precipitation. The results from the three sites showed the incremental climate variability caused simulated yield decreases, and the decreases in rainfed yield were greater than those of irrigated yield.

Jones et al (2003), studied the potential impacts of climate change on maize production in Africa and Latin America in 2055. The study shows the possible impacts on maize production in Africa and Latin America to 2055, using high-resolution methods to generate characteristic daily weather data for driving a detailed simulation model of the maize crop. The results indicate an overall reduction of only 10% in maize production to 2055, equivalent to losses of $2 billion per year.

Kapetanaki and Rosenzweig (1997), studied the impact of climate change on maize yield in central and northern Greece: A simulation study with CERES-Maize. The potential impacts of climate change on the phenology and yield of two maize varieties in Greece were studied. Three sites representing the central and northern agricultural regions were selected, many scenarios were studied. These scenarios predict consistent increases in air temperature, small increases in solar radiation and precipitation changes that vary considerably over the study regions in Greece. Physiological effects of CO_2 on crop growth and yield were simulated. Under present management practices, the climate change scenarios generally resulted in decreases in maize yield due to reduced duration of the growing period at all sites.

Karing et al (1999), studied the adaptation principles of agriculture to climate change. The study had conducted in Estonia. An analysis of climate change impacts on the level of agricultural production is presented based on long-term experimental data on yields of crops grown in different soils and climatic zones. Mathematical models combining available data on the biology of agricultural crops and their response to climatic conditions have been used. The potential and meteorologically possible yields under existing environmental conditions were calculated. The analyses were completed under different climate change scenarios which shows that; mean potato yields will increase by about 6 to 8%. The yield increase is larger (10 to 16%) on coastal islands and in North Estonia.

Luo et al (1999), studied the agricultural vulnerability and adaptation in developing countries: The Asia-Pacific Region. Many studies have been conducted; qualitatively and quantitatively show changes in average climate conditions. Climate variability will have a significant consequence on crop yields in many parts of the Asia-Pacific. Crop yield and productivity changes which vary considerably across the region. Vulnerability to climate change depends not only on physical and biological response but also on socioeconomic characteristics. Adaptation strategies that consider changes in crop varieties or in the timing of agricultural activities imply low costs and, if readily undertaken, can compensate for some of the yield loss simulated with the climate change scenarios. The study reviewed and suggested that the regions of Tropical Asia appear to be among the more vulnerable; some areas of Temperate Asia also appear to be vulnerable.

Mearns et al (1996) studied the effect of changes in daily and interannual climatic variability on CERES-Wheat. The study investigates the effect of changes in daily and interannual variability of temperature and precipitation on yields simulated by the CERES-Wheat model at two locations in the central Great Plains. Changes in daily (and interannual) variability of temperature result in substantial changes in the mean and variability of simulated wheat yields. With a doubling of temperature variability, large reductions in mean yield and increases in variability of yield result primarily from crop failures due to winter kill at both locations. Reduced temperature variability has little effect. Changes in daily precipitation variability also resulted in substantial changes in mean and variability of yield. This study demonstrates the importance of taking into account change in daily (and interannual) variability of climate when analyzing the effect of climate change on crop yields.

Magrin et al (1997), studied the vulnerability of the agricultural systems of Argentina to climate change. The researchers addressed climate change impact on the production of the main crops of the Argentinean Pampean region by means of crop growth and development simulation models for wheat, maize and soybean. The weather data used includes temperature, global solar radiation and precipitation values from 23 sites within the region (current climate conditions) and the corresponding GISS general circulation model projections for the year 2050 (future climate) with CO2 concentrations of 330 and 550 ppm respectively. According to the results obtained, a generalized increase in soybean yield and a decrease in maize yield would occur. Wheat yield is likely to increase in the southern and the western parts of the region and decrease towards the north. Wheat and soybean production in the Pampean region would increase by 3.6 and 20.7% respectively, while maize production would be reduced by 16.5%.

Murdiyarso (2000), studied the adaptation to climatic variability and change: Asian perspectives on agriculture and food security. In the study the impacts of climate change on potential rice production in Asia are reviewed in the light of the adaptation to climatic variability and change. Collaborative studies were conducted by IRRI and US-EPA reported that using process-based crop simulation models increasing temperature may decrease rice potential yield up to 7.4% per degree increment of temperature. When climate scenarios predicted by GCMs were applied, it was demonstrated that rice production in Asia may decline by 3.8% under the climates of the next century. Moreover, changes in rainfall pattern and distribution were also found suggesting the possible shift of agricultural lands in the region.

Molua et al (2007), studied the economic impact of climate change on agriculture in Cameroon. The study examines the impact of climate change on crop farming in Cameroon. Based on a farm-level survey of more than 800 farms, the study employed a Ricardian cross-sectional approach to measure the relationship between climate and the net revenue from crops. Net revenue is regressed on climate, water flow, soil, and economic variables. Further, uniform scenarios assume that only one aspect of climate changes and the change is uniform across the whole country. The analysis found that net revenues fall as precipitation decreases or temperatures increase across all the surveyed farms.

Parry et al. (1999), studied the climate change and world food security. The study reveals that climate change is expected to increase yields at high and mid-latitudes, and lead to decreases at lower latitudes. This pattern becomes more pronounced as time progresses. The food system may be expected to accommodate such regional variations at the global level, with production, prices and the risk of hunger being relatively unaffected by the additional stress of climate change. However, some regions (particularly the arid and sub-humid tropics) will be adversely affected. A particular example is Africa, which is expected to experience marked reductions in yield, decreases in production, and increases in the risk of hunger as a result of climate change.

Rosenzweig et al (1996) studied the potential impacts of climate change on citrus and potato production in the US agricultural systems. Potential impacts of global climate change on fruit and vegetable yield in the US were investigated through simulations of citrus and potato. Simulated treatments included combinations of three increased temperature regimes (+1.5, +2.5, and 5.0°C), and estimates of the impact of three levels of atmospheric carbon dioxide (440, 530, and 660 ppm). In addition to control runs representing current climatic conditions. Adaptive planting dates of -28, -14, +14 and +28 dayes were included in the potato simulations for current and increased temperature regimes. Twenty-two sites were simulated for citrus yields and 12 sites for potato, using climate records for 1951 to 1980.

Results of citrus simulations without CO2-induced yield improvement indicate that production may shift slightly Northward in the Southern states, but yields may decline in Southern Florida and Texas due to excessive heat during the Winter. CO2 effects tended to counteract the decline in simulated citrus yields. Fall potato production under current management practices appears vulnerable to an increase in temperature in the northern states; increased CO2 and changes in planting date were estimated to have minimal compensating impacts on simulated potato yields.

Rosenzweig, and Tubiello (1997) studied the impacts of global climate change on Mediterranean agriculture: Current methodologies and future directions. The study shows that current trends in Mediterranean agriculture reveal differences between the Northern and Southern Mediterranean countries as related to population growth, land and water use, and food supply and demand. The changes in temperature and precipitation predicted by general circulation models for the Mediterranean region will affect water availability and resource management, critically shaping the patterns of future crop production.

Reilly and Schimmelpfennig (1999), aimed to find the agricultural impact assessment, vulnerability, and the scope for adaptation. Climate change assessments, have found small impacts on overall production, but larger regional changes. Production shifts among regions can be considered one mechanism for adaptation. Adaptation at the farm level, through changes in crops, cultivars, and production practices, is another adaptation mechanism. Studies have considered yield effects at specific sites have found very wide ranges of impacts. A useful way to evaluate the impacts of climate change, given the uncertainty about future impacts, is to consider vulnerability. The result of the study shows that: Vulnerability and climate impacts, particularly in terms of higher order effects on profitability and sustainability, will depend on how society and the economy develop. Lower income populations and marginal agricultural regions, particularly arid or flood prone areas, are most vulnerable to climate change.

Schulze et al (1993), studied the global climate change and agricultural productivity in southern Africa. An analysis tool was developed to simulate primary productivity and crop yields for both present and possible future climate conditions. The results of this preliminary study show a large dependence of production and crop yield on the intra-seasonal and inter-annual variation of rainfall. The most important conclusion from the study is the readiness of the developed tool and associated infrastructure for future analysis into social, technological and political responses to food security in southern Africa.

Singh et al (1998), studied the impacts of a Ghg-induced climate change on crop yields. The presented study involved used the Canadian Climate Centre (CCC) and the climate change scenario to evaluate the impacts of a CO2-induced climate change on agriculture in Québec and vicinity. data are fed into a crop model (FAO) so as to gauge the changes in agro climatic factors such as growing season length and growing degree days, and subsequently potential yield changes for a variety of cereal (C3 and C4), leguminous, oleaginous, vegetable and special crops, for twelve major agricultural regions in southern Québec.

Results show that depending upon the agricultural zone and crop type, yields may increase (ex. corn and sorghum by 20%) or decrease (ex. wheat and soybean by 20 to 30%). Also, these crop yield changes appear to be related to acceleration in maturation rates, mainly to change in moisture stress and to shifts in optimal thermal growth conditions. These possible shifts in agricultural production potentials would solicit the formulation of appropriate adaptation strategies.

Southworth et al (2002) studied the changes in Soybean yields in the Midwestern United States as a result of future changes in climate, climate variability, and CO2 fertilization. This modeling study addresses the potential impacts of climate change and changing climate variability due to increased atmospheric CO2 concentration on soybean yields in the Midwestern Great Lakes Region. Nine representative farm locations and six future climate scenarios were analyzed using the crop growth model SOYGRO. Under the future climate scenarios earlier planting dates produced Soybean yield increases of up to 120% above current levels in the central and Northern areas of the study region. In the

Southern areas, comparatively small increases (0.1 to 20%) and small decreases (-0.1 to -25%) in yield are found. The decreases in yield occurred under the Hadley Center greenhouse gas run (HadCM2-GHG), representing a greater warming, and the doubled climate variability scenario - a more extreme and variable climate. Optimum planting dates become later in the Southern regions. CO2 fertilization effects (555 ppmv) are found to be significant for Soybean, increasing yields around 20% under future climate scenarios. For the study region as a whole the climate changes modeled in this research would have an overall beneficial effect, with mean Soybean yield increases of 40% over current levels.

Weber et al (2003), studied the regional analysis of climate change impacts on Canadian agriculture. Climate change is expected to alter production opportunities facing agricultural producers. Global studies of climate change impacts on agriculture suggest positive benefits for Canada. The study find that all provinces benefit from climate change and that previous estimates may be overly pessimistic.

Chapter Three: Description of the Study Area

3.1 Location and population

The West Bank and the Gaza Strip are located on the coast of Mediterranean Sea between 29° and 33° North Latitude and between 35° and 39° E Longitude. The West Bank and Gaza Strip are two geographically separated areas, but they are geo-politically an integrated unit. The two territories border Israel from almost all directions except for the West Bank, which borders Jordan on the east and Gaza Strip borders the Mediterranean Sea on the west. The total land area of Palestine is about 6,245 km^2 (365 km^2 in Gaza Strip), of which, 1,660 km^2 are under cultivation (Dudeen, 2006).

According to the Palestinian Central Bureau of Statistics 2007 survey, the population of the country is approximately 3,719 millions, 2,323 millions in the West Bank and 1,395 millions in the Gaza Strip. The Gross Domestic Product was estimated at around 4,173 million dollars, and the income per capita is estimated at 1,200 $ per person.

Jenin district is located in the Northern part of West Bank. The area is estimated about 583 Km^2 containing about 76 towns figure (3.1) shows governorate of Jenin. The population in the year 2005 is estimated about 261,756 capita with density 449 person / Km^2 (PCBS, 2006). Jenin district is considered one of the poorest governorates in the West Bank (ECHO and USAID reports, 2005, 2006).

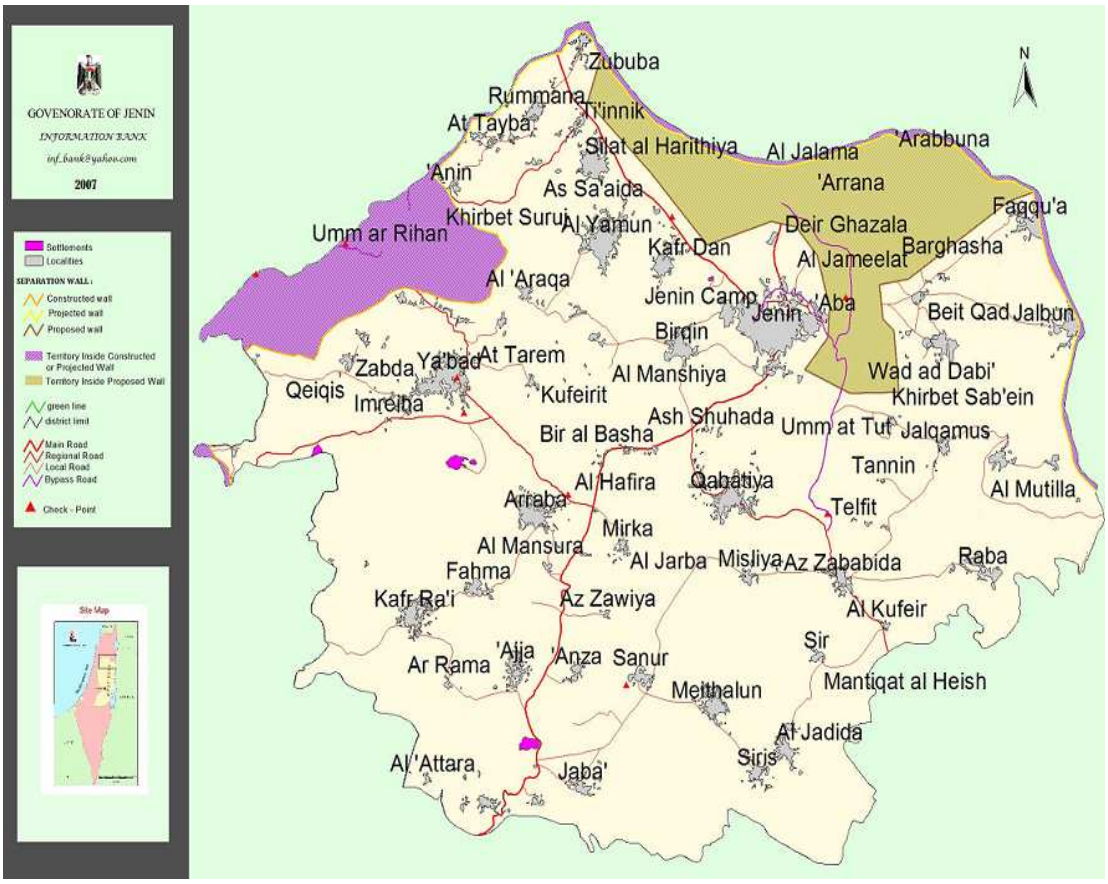

Figure (3.1) Governorate of Jenin (Information Bank, 2007)

3.2 Topography

The percentage of form of land use and land cover in the West Bank and Gaza Strip are presented as the following; the Palestinian built up areas (3.67), Israeli colonies (1.34), closed military areas (20.23), Military bases (0.28), left as state land (24.23), nature reserves (5.68), forests (1.1), Palestinian cultivated areas (28.90), Israeli cultivated area is (1.09), Dead Sea (3.05), and others (i.e. dumping sites, industrialized zones, etc) cover about 10.43 percent (PCBS,2006).

The Land Research Centre, within the land system classification study, presented estimations for the agricultural and urban areas. The estimations were as follows: cultivated hills (46%), uncultivated hills (34%), arable plains (12%) and the rest are made of other minor forms of land use. These data are approximate and depending on the general use of the land unit in each land system. In the context of the land system study for the Gaza Strip, the following is estimation for the land use: periodically irrigated land (17%), discontinuous urban fabrics (15%), non-irrigated land (42%), citrus plantations (9%), Sclerophyllous vegetation (8%) and continuous urban fabric (9%), (Land Research Centre, 2000). There are variations in land elevation from the sea level in Jenin district, for example village Al- Mqeblah which is located at the lowest part 90 msl, and the highest part 750 msl located at Al- Horsh Mountain about 3.5 Km east of Jaba' town (ARIJ,2006).

3.3 Meteorology

Palestine belongs to the sub-tropical zone. On the coast of (Gaza Strip) and on the highlands (West Bank), the climate is of Mediterranean type with a long hot and dry Summer, and short cool and rainy winter. Accordingly, the climate of Palestine is classified as an Eastern Mediterranean one. The temperature increases toward the South and towards the Jordan Valley (east). The rainfall is ranging from 100 to 700 mm annually depending on the location. In the South of the West Bank, in the area of Jerusalem Desert and Jordan Valley, prevail arid conditions (Dudeen, 2006).

Other classifications for the climate of Palestine were prepared as well. In 1953, Meige classified Palestine into three climatic regions: arid, semi-arid and Mediterranean. Arid climate has comparatively low amount of precipitation (<200mm) with temperate Winter and very hot Summer. Semi-arid has medium amount of precipitation (200-500 mm) with temperate Winter and hot Summer. Mediterranean climate has the highest amount of precipitation (>500) with cool Winters and hot Summer (Dudeen, 2006).

Rosenan in 1970 prepared a rainfall map and climatic zone map of Israel and included in here also the Palestinian territories. He divided the previous classifications defined as arid zone, into extremely arid (including the southern part of the Jordan Valley); arid and semi-desert (including part of the Eastern heights represented mainly in Jerusalem desert); mildly arid (including a strip adjacent to the Eastern heights); semi-arid (including the central heights); and humid and sub-humid (including the Western heights and the semi-coastal area).

The climate in Jenin district is governed by its position on the Mediterranean Sea, which is rainy moderate in Winter, hot dry in Summer, and the average rain in the district is about 528 mm. The average is decrease from 778 mm at Um-Al Rehan village in the West to 286 mm in Raba village at the east, that is because the Western part is exposed to the wind comes from the sea, figure (3.2) illustrate the distribution (ARIJ, 2006).

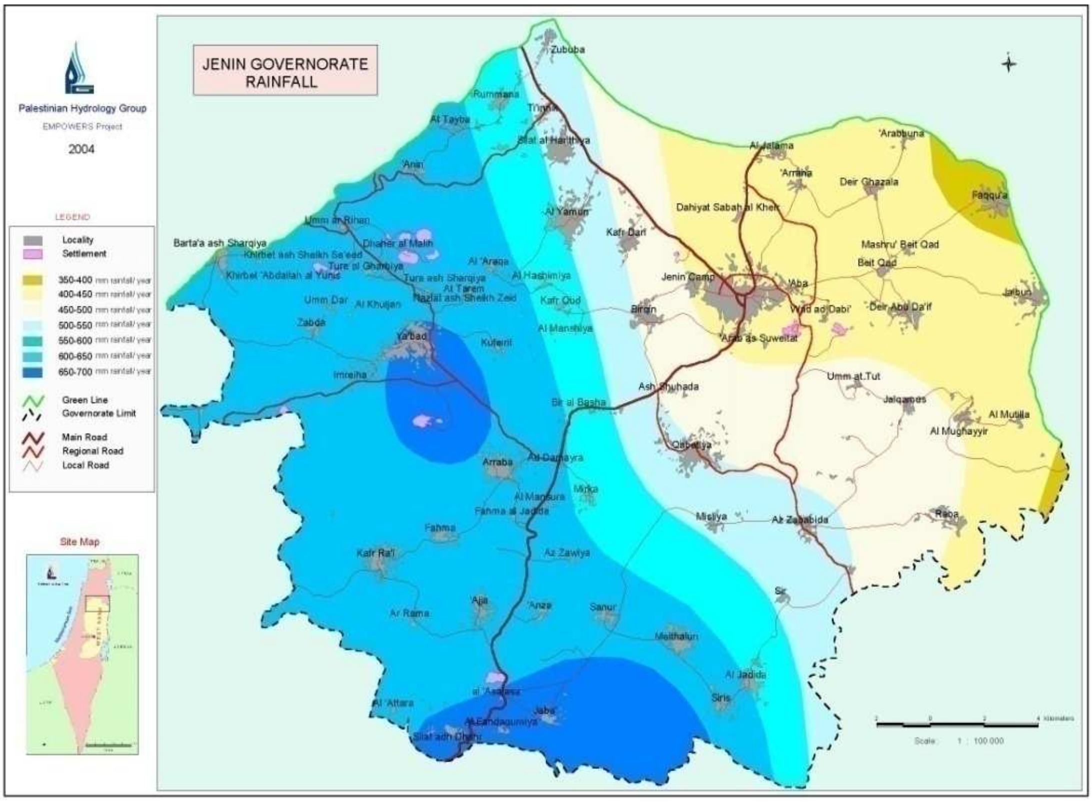

Figure (3.2) Rainfall distribution map for Jenin (PHG, 2005)

The rainy season start in the district in mid of October and last to the end of April, 3.2% of the rainfall in Oct, 80 % fall till the end of February, and in March fall about 12 % of the annual (ARIJ, 2006).

The amount and distribution of rainfall are the major factors influencing agricultural productivity. Figure (3.3) shows the instability of the average annual rainfall between 1984 and 2000 for Jenin, underscoring the need for farmers to have additional sources of water to sustain cultivation.

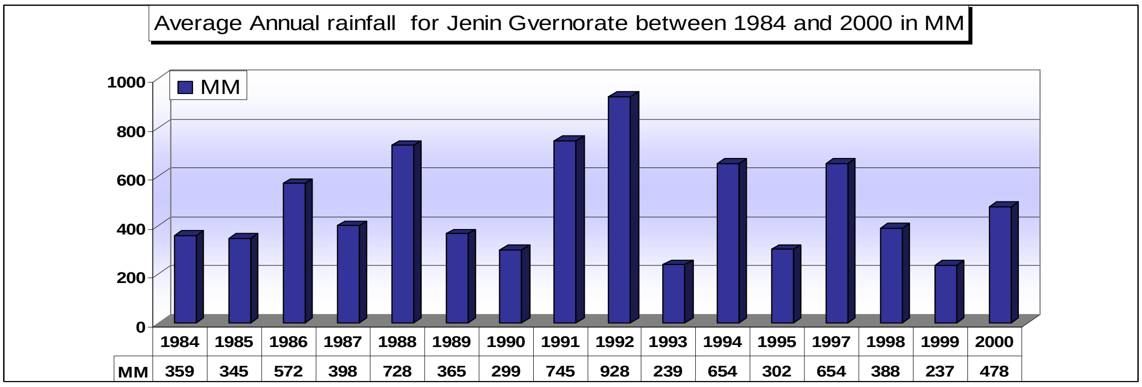

Figure (3.3) Average annual rainfall for Jenin governorate between 1984 and 2000 (mm) (ARIJ, 2002)

Jenin district divided according to rainfall to:

1- Eastern Part:

The average amount of rain fall is about 400 - 450 mm yearly, and it cultivated with unirrigated agriculture, the towns that located in that part are: Araneh, Der-Ghazaleh, Der-Abu Deef, Um Al Toot, Al-Jalameh and Bat Qad.

2- The South East Part:

The average amount of rain fall is about 350 - 550 mm, it cultivated with cereal and olive trees in Qabateah, Methloon, Sanoor, and Al-Zababdeh.

3- The Northern Part and the North West:

The average amount of rain fall is about 550 - 600 mm, it cultivated with rain fed agriculture, vegetables. The agricultural wells are considered the main sources for irrigation, the villages like Kofradan, Romaneh, Aselah al Harthea, and Al Eamoon located in this part.

4- The Western Part and the South West:

The average amount of rain fall is about 600 - 700 mm, it cultivated with almonds, unirrigated field crop, vegetables, tobacco, and olive trees. Villages like Selat Al Daheer, Arabeh, Ya'bad, Al-Fondoqomeah, Al-Rameh, and Agah located in this part.

The maximum average of temperature in Jenin district is about 27.4º C, while the average lowest temperature is about 13.4 º C (PCBS, 2005). The dominant direction of wind is Western Southern and Western Northern, at Summer time the blowing of khamsin wind is possible which cause to increase the temperature and reduce the humidity. The average wind speed in Winter is about 9.2 Km/hour and about 7.7 Km/hour in Summer (ARIJ, 2006). The relative humidity in Jenin district in Summer is about 63.7% and 67.2% in Winter, the humidity reach the maximum in Winter to about 84.5% and the minimum in May (period of khamsin wind), which is about 39% (ARIJ, 2006).

The four target communities mainly depend on agriculture as a main source for their income, especially after closing the Israeli lands for the Palestinian employees after the Intifada. These different locations represent different rainfall gradients in Jenin governorate and they are connected by road networks. The main source of water is the ground water which represented by the wells and springs in the district, and they are mainly depend on the rain water of the precipitation during Winter months. 80% of the total consumed water is used for irrigation and the remaining 20% are for the domestic used. As a part of the West Bank it has one of the lowest per-capita world water viability worldwide. The total cultivated area fluctuated from year to another and the main factor affecting on the size of the cultivated lands is the amount, the intensity and the distribution of the rainfall.

3.4 Soil

Soil, like other agro-biodiversity components in the Palestinian territory are distinguished for the high range of variety in type and nature. Soil in the Palestinian territory are formed due to several condition including climate, physical weathering from wind and water, and other topographic materials, geology, and vegetation (ARIJ, 2007).

Climate and geology have major influence on the formation of soil. Climate has two major factors for soil formation. The first is the temperature and the second is rainfall. As the two factor increase, the weathering of rocks and minerals will be faster. For every 10° C rise in the temperature, the rate of biochemical reaction doubles. Thus, the weathering process of soil is witnessed to be the highest in the Eastern parts of the West Bank, followed by the Eastern – Southern parts of mandate Palestine, and decreased to the minimum in the middle parts of West Bank (Governorates of Ramallah, Bethlehem, Hebron, and partially of Nablus). As important as temperature is the factor of rainfall. The cool- wet areas hosts more considerable percolated rainfall amounts than the hot-wet areas, where water may evaporates back to the atmosphere before leaching can occur. With an arid to hyper- arid area along the Eastern parts and semiarid to sub-humid area along the Western parts of the West Bank (all the way from North to South), there are a great variety of different soil (ARIJ, 2007).

3.4.1 Characteristics of major soil types

The most common soil associations in the Palestinian territory are Terra Rossa and Brown Rendzinas, dominating in the central highlands of West Bank figure (3.4) illustrate major soil type in the West Bank. Brown Rendzinas and Pale Rendzinas are found to the North and South of mountain ridge, in the Tubas, Qalqilyia and Hebron governorates, and also in the eastern slope region. Grumosolo are also found in the far North and far West of the West Bank, coinciding with low – lying areas that enjoy a more temperature climate than other parts of the high lands (ARIJ, 2007).

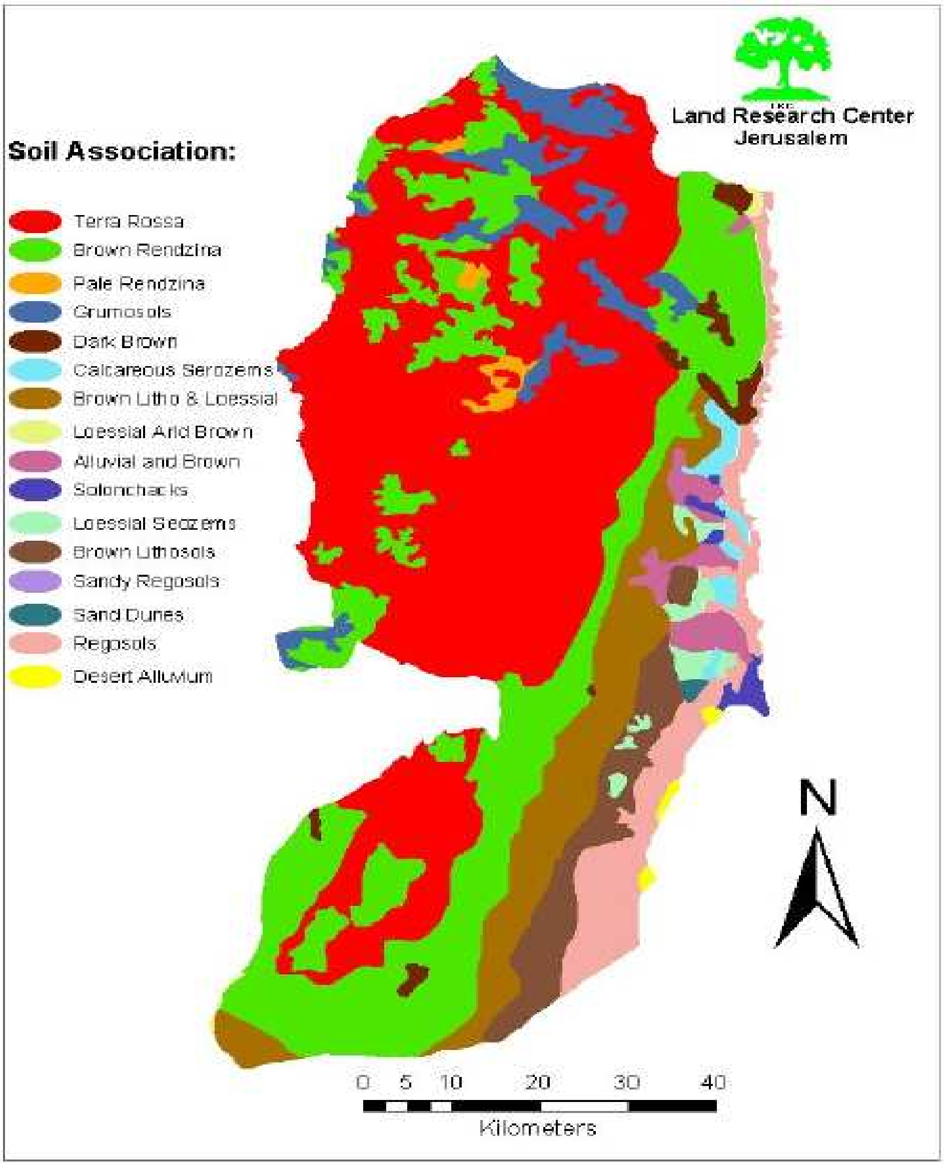

Figure (3.4) Soil map of the West Bank

3.4.2 Soil degradation

Soil is degraded as a result of many factors, including erosion, acidification and salinization. Two categories of soil deterioration process are recognized in the Palestinian territory. These are displacement of soil material (e.g.; soil erosion by water and wind), and in-situ soil deterioration, covering chemical and physical soil degradation. Incorrect agriculture management, such as scarcity of water, uncontrolled domestic and industrial dumping sites, and the heavy usage of fertilizer are the main in-situ soil degradation causes in the West Bank area (ARIJ, 2007).

3.5 Agriculture in Jenin area

Solar radiation, temperature, and precipitation are the main drivers of crop growth; therefore agriculture has always been highly dependent on climate patterns and variations. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, resulting in higher global temperatures, affecting hydrological regimes and increasing climatic variability. Climate change is projected to have significant impacts on agricultural conditions, food supply, and food security (Climate Institute, 2007).

Overall, climate change could result in a variety of impacts on agriculture. Some of these effects are biophysical, some are ecological, and some are economic, including:

1 - Changes in production patterns due to higher temperatures.
2 - Changing precipitation patterns.
3 - Increased vulnerability of the landless.

Despite the constraints and distortions inflected to the Palestinian economy in general and the productive sectors; (Industry and agriculture in particular) the agricultural activities remain dominant in the area of Jenin. The contribution of the agricultural share to GDP is about 74,128,000 ($) or (16.2%) (Palestinian Chambers of Commerce, 2009).

The value of plant production in the Palestinian territory during the agricultural year 2005/2006 totaled approximately US($) 600.6 million, of which 34.3% came from the value of fruit trees' production, 52.8% from vegetables including cut flowers, and 13% from field crops. 70.9% of plant production value was from the West Bank. The highest value of fruit trees' was in Hebron amounting to 21.6%, followed by Nablus at 16.3%. The highest value of vegetables including cut flowers was in Jenin and amounted to 14.7%, followed by Rafah at 13.8% and 11.7% in Jericho and Al-Aghwar. The value of field crops increased in Jenin at 30.9%, then Khan Yunis and Rafah governorates amounted 16.5% and 10.5% respectively.

The cost of intermediate consumption in the Palestinian territory during the agricultural year 2005/2006 was about US$ 507.7 million (of which 26.2% of plant production and 73.8% for animal production). The value added of agricultural production of the

Palestinian territory during the agricultural year 2005/2006 was about US$ 556.9 million, which includes 84% from value of plant production (69.5% for the West Bank and 30.5% for Gaza Strip) (PCBS, 2007).

3.6 Water resources in Jenin district

Palestine enjoys typical Mediterranean climate conditions. It has two distinctive seasons; a wet Winter, which lasts 5 months (November-March) and a dry Summer, which nearly lasts for seven months (May-October). Rabi (1999) demonstrated that the number of rainy days is limited and rarely exceeds 60 days a year. Rainfall depth has a non-uniform distribution and exhibits high spatial and temporal variability.

Currently, 31% of the Palestinian communities are not connected to water networks. In general, local springs and rainfall collection cisterns are the major sources of water supply for domestic and agricultural use in many Palestinian communities. Therefore, the livelihood of these communities is always threatened since these sources are directly affected by rainfall and drought incidence. Rainwater harvesting supplies approximately 6.6 MCM per year. In most cases, cisterns collect water from rooftops during the rainy season, which is then stored in subsurface containers, usually ranging in size from 60-100 cubic meters. A large percentage of water collected in cisterns is used for domestic purposes. In addition, there are 297 natural springs in the West Bank. However, it is estimated that there are actually more than 400 small and large springs throughout the West Bank. Given that recharge levels of the water table are dependent on rainfall quantities, the yield from springs varies across the years. In terms of usage, the majority of springs meet agricultural needs. However, it is worth noting that springs, particularly given the severity of the current water situation, often serve a dual purpose (PHG, 2005).

Table (3.1) represent the water resources in the Palestinian territory which restricted mainly to ground water that extracted from wells, springs and water purchased from the Israeli water company (Mekorot). The total water quantity obtained from these two sources in 2007 was 335.4 million meter cube. Wells are considered the most important source, 241.2 million meter cube of water were pumped from water wells and that represents 71.9% of water resources. The quantity of water purchased from the Israeli water company (Mekorot) totaled 49.4 million cubic meter represented 14.7% of water resources, finally springs represent the third most important source with an annual discharge of 44.8 million cubic meter representing 13.4% of water resources in the Palestinian territory. Table (3.3) illustrate the amount of water discharged from the springs in Jenin district (PWA,2007).

Table (3.1) The annual available water quantity in the Palestinian territory by region and source

Region	**Source**			
	Water pumped from Palestinian wells	**Springs discharge (1,000 m^3/year)**	**Water purchased from Israeli water company (Mekorot) (1,000 m^3/year)**	**Total**
Palestinian Territory	241,182	44,806.4	49,447	335,435.4
Remaining West Bank	68,682	44,806.4	44,848	158,336.4
Gaza Strip	172,500	---	4,599	177,099

(Source: Palestinian Water Authority, 2007)

Number of wells and its annual pumping quantity in Jenin district are tabulated as follows:

Table (3.2) Number of water wells in Jenin and its annual pumping quantity

Number of wells			**Pumping quantity (1,000 m^3/year)**		
Domestic	Agricultural	Total	Domestic	Agricultural	Total
4	51	55	3,630.1	3,237.9	6,868

(Source: Palestinian Water Authority, 2007)

Table (3.3) Springs discharge in Jenin and its annual pumping quantity (M^3/year)

		Amount per years (m^3/y)								
Location	**USE**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Silat al Daher	Domestic	168	1128	2846	3445	2850	2567,3	2954,1	2108	176
Silat al Daher	Domestic	25194	16534	23838	26684	22500	22389	23858	23480	17361
Al-Fandaqumiya	Agricultural	2326	5064	11038	13362	11215	10170	11582	8687	2442
Al-Fandaqumiya	Agricultural	2058	777	9169	15726	6850	8130,5	10236	6552	816
Jaba'	Agricultural	18098	17096	34821	55798	45500	38304	46534	34181	17951
Jaba'	Agricultural	11752	3937	20572	24891	16500	16475	19289	16325	4134
Barta'a	Domestic	124058	109993	107737	126481	110000	113553	116678	113837	109892

(Source: Palestinian Water Authority, 2007)

Chapter Four: Methodology

4.1 General

The aim of this research is to analyze the potential impact of climate change on rainfed agriculture in Jenin district, Jenin was chosen because it is considered one of the largest agricultural area in West Bank and it has large agricultural activities. The district contributes with about 16.2% of the agricultural production in the Palestinian market (PCBS, 2005). The success of agriculture in the district is related to the diversity of locations and the warm weather relatively with other district. The study take into consideration two variables increase the temperature and reduce the precipitation.

4.2 Data collection

All the required data was based primarily on administrative records of various institutions; the Meteorological station (the indicators are the following; Mean of Maximum Air Temperatures, Mean of Minimum Air Temperatures, Number of Rainfall Days, Mean Relative Humidity, Evaporation Quantity, Mean Wind Speed, Mean of Air Temperatures).

The Ministry of agriculture, (the indicators are the following; soil moisture, rain Infiltration rate, root depth, Length of growing period etc.).

The Palestine Academy for Science and Technology, The Palestinian Water Authority and the Palestinian Central Bureau of Statistics, The available data in the ministries was from the year 1998 to 2008, these data was rearranged, reclassified and tabulated in away to be used in the CROPWAT computer model to calculate the potential yield reduction for the main crops in Jenin district, and to find the irrigation requirement for the crops in order to compensate for the shortage in rainfall.

The selected crops for the analysis was chosen according to the area planted and the economical returns, so that seven field crops was chosen (Chick-peas, Wheat, Clover, Barely, Lentil, Sesame and Onion), four fruit (Olive, Almond, Plums and Grape), and four vegetables (Tomato, Okra, Squash and Snake-cucumber).

4.3 Study scenarios

Three scenarios were used in this study, increasing in temperature by (+1, +2, +3) and decrease in rainfall by (-10%, -20%, -30%). These scenarios was taken based on the previous studies which illustrate these changes in climate, a study prepared by the Palestine Academy for Science and Technology shows that there will be an increase in temperature by about 0.75°C and reduction in precipitation by (16) % to (30) % in the next 45 years. Another study prepared by Israel Ministry of Environmental Protection shows that there will be an increase in temperature by about (1.6° to1.8°C) and reduction in precipitation by (8)% to (4)% in the next 100 years.

4.4 Rainfall data analysis (seasonal shift)

The study focuses on extracting the trends and seasonal patterns of rainfall in Jenin district. The work was carried out based on monthly and annual rainfall data recorded in Jenin district within a time span of 1998 to 2008 published by Palestinian central Bureau of Statistics (PCBS) based on the data records maintained by the Department of Meteorology. Emphasis is given to find out whether there is any significant change in the rainfall time series records over the years.

In order to analyze the data; every month was figured in comparison with other months in the same years. For example to find the changes in rainfall pattern during September, the amount of rainfall during September in the year 1998 is divided on the summation of the amount of rainfall for all the months during the year 1998 in order to find the percentage of variations during the last ten years.

4.5 CROPWAT computer model

CROPWAT computer model was used in this study to calculate the yield reduction as well as irrigation requirements (IR) for different crops in the area under consideration.
CROPWAT is a decision support system developed by the Land and Water Development

Division of FAO; it uses the Penman-Monteith methods (FAO, 1998), It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rainfed conditions or deficit irrigation.

4.5.1 Calculating irrigation requirements (IR)

The irrigation requirement of a crop is the total amount of water that must be supplied by irrigation to a disease free crop, growing in a large field with adequate soil water and fertility, and achieving full production potential under the given growing environment (FAO, 1998b).

The irrigation requirement (IR) basically represents the difference between the crop water requirement and effective rain, where the effective rain is defined as the portion of the rainfall that is effectively used by the crop after rain. The amount of effective rainfall depends on the precipitation rate and soil moisture conditions.

4.5.2 Data required for CROPWAT

Three types of data are required in order to calculate the yield reduction and the irrigation requirement as mentioned before; these data are:

Soil data, including:

- Total available soil moisture (mm/m depth)
- Max rain Infiltration rate (mm/day)
- Maximum root depth (m)
- Total available moisture (%)

Crop data, including:

- Length of growing period of crops
- Crop coefficient (Kc)
- Crop yield response factor (ky)
- Root depth (m)

• Depletion factor (p)

• Planting date (Day/Month)

Metrological data, including:

• Mean maximum temperature (°C)

• Mean minimum temperature(°C)

• Mean monthly relative humidity (%)

• Daily sunshine hours (hours)

• Wind speed at two meter (km/day)

• Precipitation (mm)

4.5.3 Crop data

Crops considered in this study are rainfed agriculture crops only; and irrigated crops are excluded from this study because the dominant type of agriculture in Jenin district is the rainfed. A summary of the main crops grown in Jenin district and their respective areas were obtained from the Palestinian Ministry of Agriculture and the Palestinian Central Bureau of Statistics. Table (4.1) summarized the crops used in the study.

Table(4.1) Area, yield and production of main crops in Jenin governorate, (2005/2006).
Area: Dunums, Yield: Kg\Dunum, Production: metric tons.(PCBS,2006)

Crops	**Rainfed**		**Production (Metric ton)**
	Area	***Yield***	
Wheat	40,755	280	11,411
Chick-peas	12,271	130	1,595
Clover	21,500	550	11,825
Barely	10,235	240	2,456
Lentil	2,418	60	145
Sesame	3,070	70	215
Dry Onion	6,867	1700	11,674
Fruit Trees	**Rainfed**		**Production**
	Area	***Yield***	
Olive	175,803	195	33,536
Hard/soft Almond	8,647	120	306
Plums	1,382	300	365
Grape	1,522	1,000	1,522
Open Cultivated vegetables	**Rainfed**		**Production**
	Area	***Yield***	
Tomato	1,119	1,700	1,902
Okra	3,505	700	2,454
Squash	2,477	1,500	3,716
Snake cucumber	1,720	700	1,204

4.6 Calculating yield reduction

After obtaining data from the required sources, it was entered to the computer model (CropWat) in order to calculate the required yield and the irrigation requirements.

The calculation was carried out for all the selected crops in Jenin district for the last ten years. The result was tabulated in away where the point (0 temperature and 0 % rainfall) considered as the base point where the percentage is considered as the yield reduction occurred in the crops due to the change in climate during the last ten years. Another analysis was prepared by considering that the temperature will increase by (1, 2 and 3°C) and the precipitation will decrease by (10, 20 and 30%).

The actual yield (Kg/Dunum) for all the selected crops in Jenin district was drown in comparison with the amount of rainfall (mm). This was done in order to find the relationship between the amount of precipitation and the crop yield response to the change in the amount of precipitation.

4.7 Economics (sample calculation)

In order to find the losses in the agricultural returns for the wheat crops for the years (2005/2006) as an example, the following procedure was carried out.

Table (4.2) Yield reduction for wheat crop(%)

	Rain reduction				**T (+)**
Yield Reduction	(-)30%	(-)20%	(-)10%	0%	
	39.2	38.2	37.2	34.9	0
	40.1	39	38	35.7	1
	40.9	39.8	38.3	36.6	2
	41.7	40.6	39.6	37.3	3

After obtaining the percentage of yield reduction from the computer model as shown in table (4.2), the actual yield (280 Kg/Dunum) was taken from the ministry of agriculture.

$\left(\frac{\%\ of\ yield\ reduction)}{100}\right) * Actual\ yield\ (\frac{Kg}{Dunum})$ = (yield due to increase T (^{o} C) & reduce P (%))

$$\left(\frac{34.9}{100}\right) * 280 = 97.72\ (\frac{Kg}{Dunum})$$

Table (4.3) Yield due to change climate parameter for wheat crop(Kg/Dunum)

Yield differences(280)				**T (+)**
(-)30%	(-)20%	(-)10%	0%	
109.76	106.96	104.16	97.72	0
112.28	109.2	106.4	99.96	1
114.52	111.44	107.24	102.5	2
116.76	113.68	110.88	104.4	3

The losses occurred due to the reduction in yield calculated as the following; The area planted with wheat = 40,755 (Dunum) and the price for each kilo gram which obtained from dividing the price of the product (thousand dollar) over the production (metric ton) = 0.367 ($/Kg) so that,

$$97.72\left(\frac{Kg}{Dunum}\right) * 40{,}755(Dunum) * 0.367\left(\frac{\$}{Kg}\right) = 1{,}461{,}606\ (\$)$$

Where; 1,461,606 ($) represent the economical losses occurred in wheat crop in the last ten years due to increase temperature and reduce precipitation.

Table (4.4) Cost for wheat crop($)

Cost ($)				**T (+)**
(-)30%	(-)20%	(-)10%	0%	
1,641,690	1,599,810	1,557,930	1,461,606	0
1,679,382	1,633,314	1,591,434	1,495,110	1
1,712,885	1,666,818	1,603,998	1,532,802	2
1,746,389	1,700,321	1,658,442	1,562,118	3

In order to make a reference point; (0 T & 0% P) was chosen to be the reference cost to comparison with.

Table (4.5) The economical loss for wheat crop (2005/2006)

Final loss ($)				**T (+)**
(-)30%	(-)20%	(-)10%	0%	
180,083.3	138,203.5	96,323.63	0	0
217,775.2	171,707.3	129,827.5	33,503.87	1
251,279	205,211.2	142,391.4	71,195.72	2
284,782.9	238,715.1	196,835.2	100,511.6	3

Chapter Five: Results and Discussion

5.1 General

The changes in climatic parameters affect the agricultural yield, production and the irrigation requirement for the plants. This study examines the potential impact of climate change on the rainfied agriculture in Jenin district.

The data collected in Jenin district doesn't cover the entire district due to the lack of records and the available data cover the last ten years only (1998-2008).

5.2 Impacts of climate change

5.2.1 Impact of increasing temperature and decreasing precipitation on yield reduction

Many crops had been analyzed using Cropwat program in order to investigate the impact of yield reduction, each crop has its own characteristic with respect to changing temperature and Precipitation. Table (5.1), shows an example of how yield reduction changed for wheat crop.

Table (5.1) Yield reduction for wheat crop (%)

	Rain reduction				**T (+)**
Yield Reduction	(-)30%	(-)20%	(-)10%	0%	
	39.2	38.2	37.2	34.9	0
	40.1	39	38	35.7	1
	40.9	39.8	38.3	36.6	2
	41.7	40.6	39.6	37.3	3

The analysis was conducted to estimate the change in yield reduction with increasing temperature (1, 2 and 3^{o} Celsius) and decreasing precipitation (10, 20 and 30 %), also the current situation is analyzed without changes in precipitation or temperature.

The results show that with increasing T by 1°C for wheat (as example) yield reduction changed by (35.7%), and for T+2 °C and T+3 °C the changes rate were (36.6 %) and (37.3 %) respectively, taking into consideration no changes in the precipitation.

This result is very close to what is presented by Singh et al (1998). He indicated a decrease of (20 – 30 %) in yield reduction, but if all the climatic parameters (T & P) have changed the results will be more severe; (41.7 %) the changes will be, if combined increase in temperature (+3) and reduction in precipitation (-30%), the total yield reduction for the selected crops in Jenin district is tabulated in table (A.3)-Annexes.

It is clear from table (5.1) that the effect of decreasing precipitation is more significant than increasing temperature for wheat crop, that is because wheat is cultivated in the rainy season (Oct & Nov).

Figure (5.1) shows how the yield reduction for some selected crops changed with increasing temperature and decreasing precipitation at (10 %). Although crops have different yield reduction but the increasing trend as shown in the graph is almost the same. Also the trend of yield reduction is greater for decreasing precipitation at 20% and 30%, the change rates for all crops are shown in figure (A.4) in Annexes.

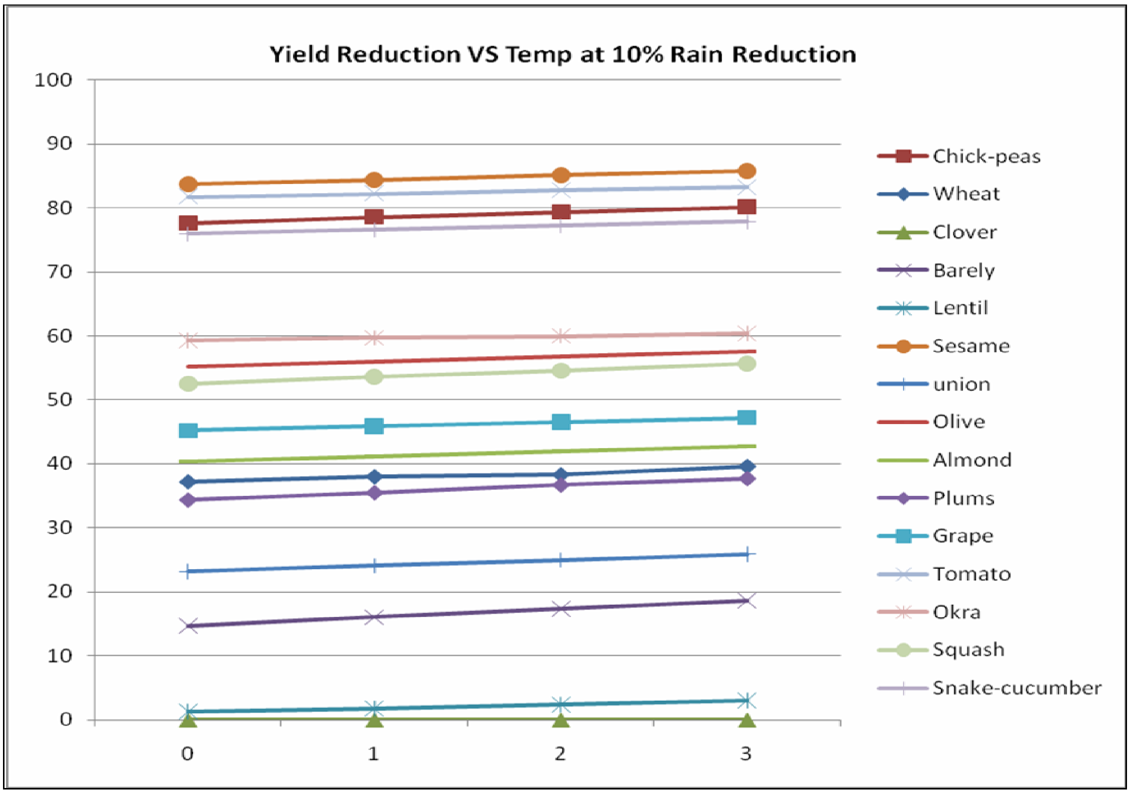

Figure (5.1) Yield reduction versus temperature at (10%) rain reduction.

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

Table (5.2) Yield reduction equations

	R-Squared value	***(approximately=1) for all value***	
Field Crop	***Line Equation at 10 % Rainfall Reduction***	***Line Equation at 20 % Rainfall Reduction***	***Line Equation at 30 % Rainfall Reduction***
Wheat	**y = 0.83x + 38.4**	**y = 0.8x + 37.4**	**y = 0.75x + 36.4**

Y : amount of yield reduction (%) , X : Temperature (°C)

Table (5.2) represent the yield reduction tabulated as equations derived from figure (5.1) in order to generalize the results, so if the temperature is exceeded the expectations (+3 °C) or less than the minimum (+1°C), it will be easy to find the yield reduction by substituting the estimated temperature in the equations in the appropriate percentage of rainfall reduction.

The results also shows that crops vary in yield sensitivity to temperature increase and precipitation decrease; all crops are very sensitive to temperature increase except Clover which has no effect due to increase temperature, but for precipitation decrease the situation is different because some crop doesn't have any changes in yield reduction with respect to change the amount of precipitation due to the time of cultivation like; Sesame which is planted in June. Chick-peas, Tomato, Okra, Snake-cucumber which is planted in April.

Another analysis was prepared by drawing the amount of rainfall in comparison with crops yield as shown in figures (5.2 and 5.3).

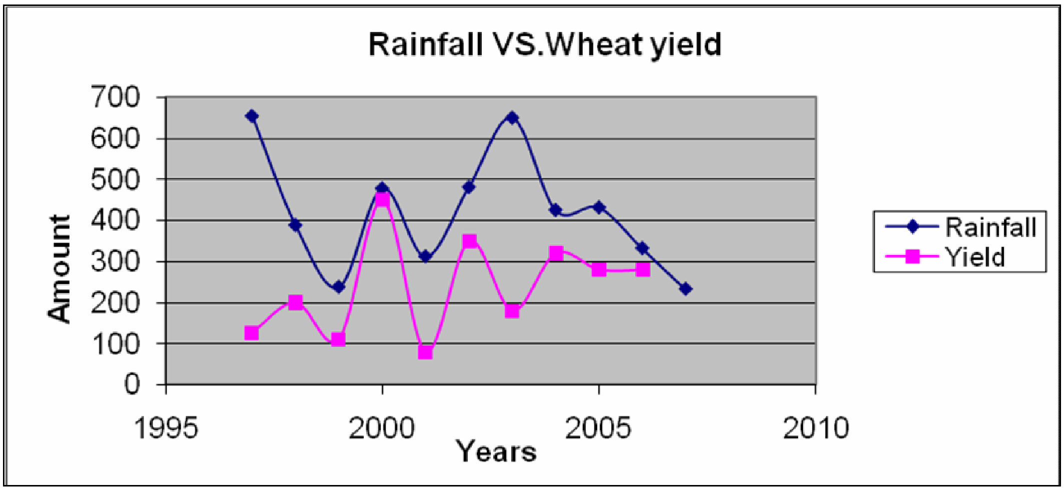

Figure (5.2) The relation between wheat yield and amount of rainfall

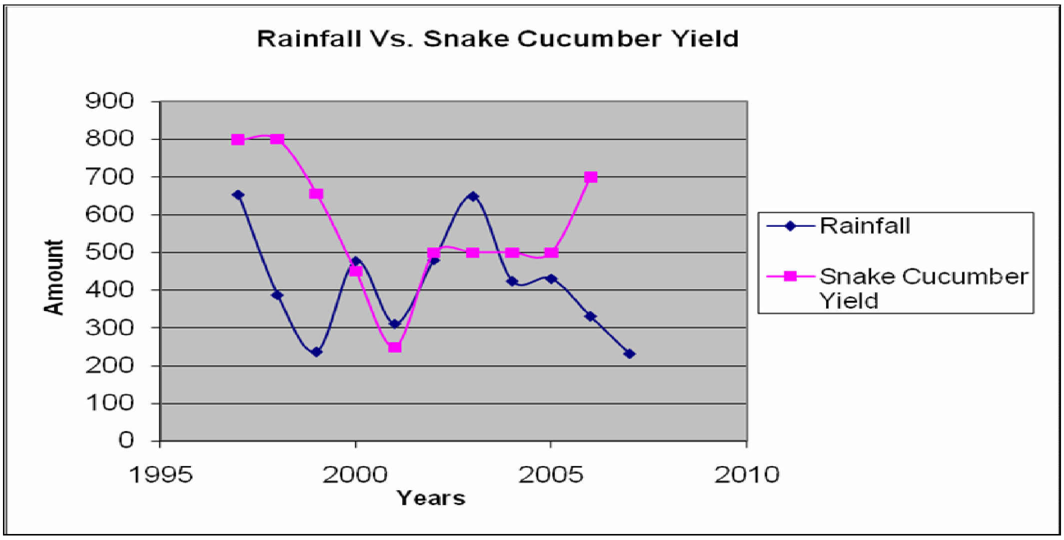

Figure (5.3) The relationship between Snake Cucumber yield and amount of rainfall

As shown in figure (5.2), it is clear that wheat yield is affected by the amount of rainfall because there is harmony between the two graphs, on the other hand there is no harmony between the amount of rainfall and Snake-cucumber yield as shown in figure (5.3).

Some crops have relationship between the amount of rainfall and the yield response; Grape, Olive, Plums, Wheat, Barely, Dry-Onion. On the other hands some crops have less relationship with the amount of rainfall; Almond, Squash, Tomato, Okra, Snake Cucumber, Chick-peas, Clover, Lentil, Sesame.

5.2.2 Impact of increasing temperature and decreasing precipitation on irrigation requirement

The impact of temperature increase on irrigation requirement was examined; from analyzing the results it was shown that the main driving factor to increase irrigation requirement is the increase in temperature. Table (5.3) represent the sensitivity analysis on wheat.

Table (5.3) Irrigation requirement (IR) for wheat (mm/Dunum).

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

As shown in table (5.3), the number 484.39 (mm) represent the amount of water required for wheat crop for each dunum; which means to have optimum yield in wheat crops the plants should take an amount equal to 484.39 (mm). so if the precipitation equal to 400 (mm) as an example; the deficit or the amount of water required equal to 84.39 (mm).

For increasing temperature by (+1, +2 and +3 °C) in comparison with the current climatic condition shows an amount of (499.41 mm), (514.61 mm) and (530.13 mm), but for decreasing precipitation by (10%), (20%) and (30%) the amount were (506.54 mm), (517.38 mm), (531.74 mm) respectively. The results clearly show that the scenario of increasing temperature gets worse when combined with the scenario of decreasing precipitation; where (T +3, P -30%) being the worst scenario.

Figure (5.4) shows how the irrigation requirement (IR) for some selected crops changes with increasing temperature and decreasing precipitation at 10 %. Although crops have different irrigation requirements but the increasing trend as shown in the graph is almost the same. Also the trend of irrigation requirements is greater for decreasing precipitation by 20 and 30%. The change rates for all crops are shown in table (A.5) in Annexes.

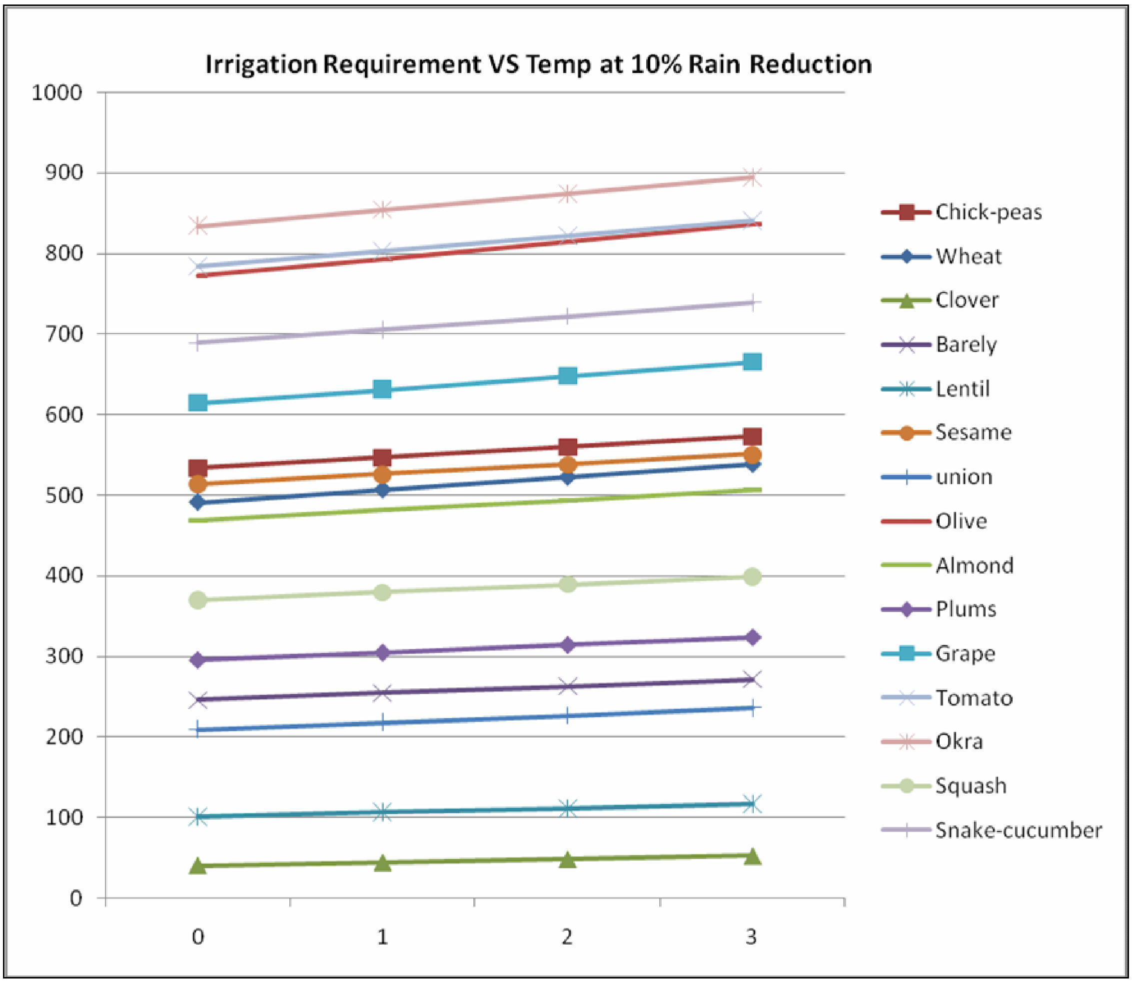

Figure (5.4) Irrigation requirements for different crops with different temperature at (10%) precipitation decrease.

Because all the previous studies based on expectations about the climatic conditions. In order to make the irrigation requirements more comprehensive for the different temperatures, an equations were derived from figure (5.4) in order to calculate the irrigation requirements even if the temperature exceeded the expected increase (+3 °C) or less than the minimum increase (+1°C). Table (5.4) illustrate the equations derived for calculating irrigation requirement (IR).

Table (5.4) Irrigation requirement equations

Y : Amount of irrigation requirement (mm/dunum) X: Temperature (°C)

Field Crop	***Line Equation at 10 % Rainfall Reduction***	***Line Equation at 20 % Rainfall Reduction***	***Line Equation at 30 % Rainfall Reduction***
Wheat	**y = 15.69x + 475.2**	**y = 16.19x + 485.3**	**y = 16.96x + 497.8**

The impacts of temperature increase and precipitation decrease on irrigation requirement for the selected crops in Jenin district are tabulated in Table (A.3) in Annexes. For example, Okra has the highest irrigation requirement of (833.9 mm/dunum) next is Tomato (784.15 mm/dunum) next is Olive (768.11 mm/dunum) finally is Snake-cucumber (689.54 mm/dunum). The lowest irrigation requirements was for Clover with amount equal to (34.18 mm/dunum) next is Lentil (96.07 mm/dunum) next is Onion (201.4 mm/dunum) next is Barely (241.06 mm/dunum) finally is Plums (293.59 mm/dunum).

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

The results also shows that crops vary in their irrigation sensitivity to temperature increase and precipitation decrease; all crops are very sensitive to temperature increase except Clover which has no effect due to increase temperature, but for precipitation decrease the situation is different because some crop doesn’t have any changes in irrigation requirements with respect to change the amount of precipitation due to the time of cultivation like; Sesame.

5.3 Impacts on the seasonal shift

There is a significant change in rainfall pattern in Jenin district over the last ten years, this change resulted from the climate change which affect the rainfall distribution. It is obvious from the graphs (Annexes A.1) that there are variations in rainfall in the following months; January: has a very little increase, February: has a significant increase, April: has an increase, November; has a significant increase. Also the following months have a variations in the amount of rainfall; March: has a significant decrease, May: little decrease, September and October: little decrease, December: significant decrease. During

June, July and August there were no precipitation recorded ever in the district. The following two figures illustrate the changes occurred in September and April.

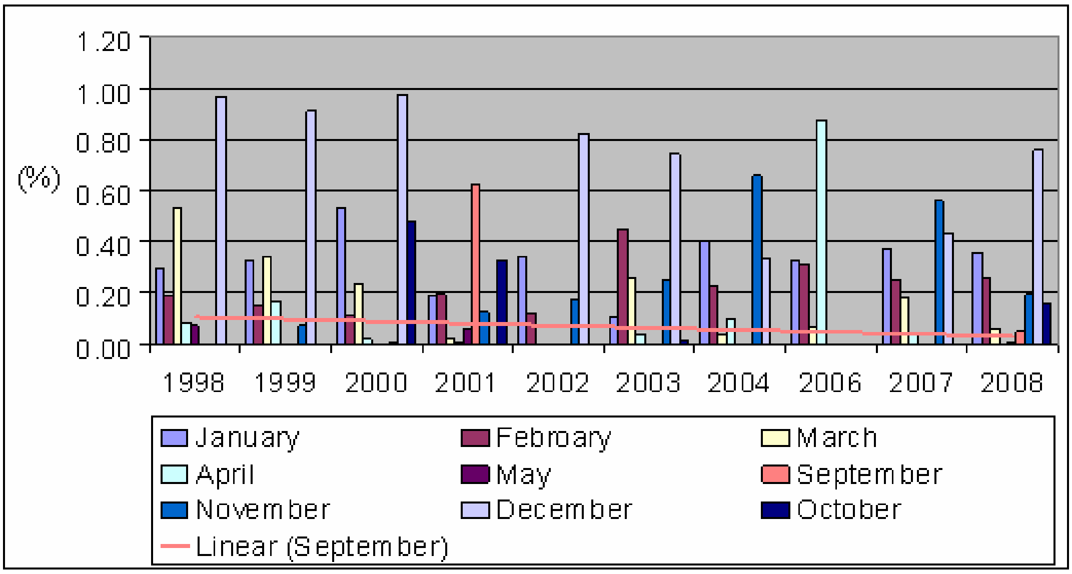

Figure (5.5) Changing in rainfall pattern during September in the last ten years

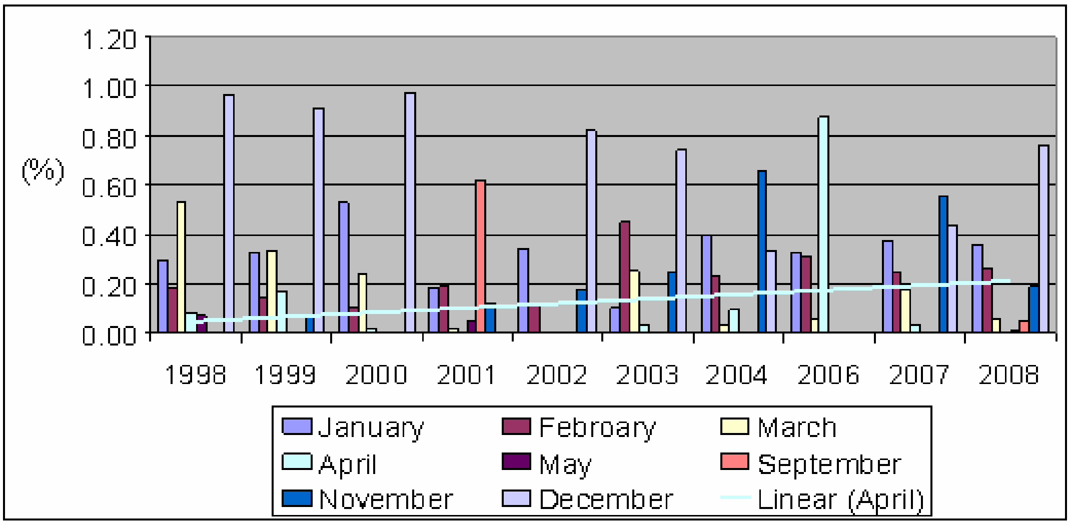

Figure (5.6) Changing in rainfall pattern during April in the last ten years

It is clear that Winter season is shifted a little bit toward November in the beginning of the season and toward April in the end of the season. So that most of the agricultural activities will be shifted (delayed) in order to benefit from the precipitation. For example, Wheat, Clover, Barely, Lentil and Onion planted in November. While Chick-peas, Tomato, Okra, and Snake-cucumber planted in April. Grapes and Squash planted in March finally Sesame planted in June.

Based on the analysis of all the selected crops, it is clear that some crops have less effect of decreasing precipitation on the amount of irrigation requirements for the plants. For example, Tomato, Okra, Snake-cucumber, Chick-peas and Squash.

5.4 The economical loss according to changes in precipitation and temperature

Table (5.5) The reference economical loss for wheat crop (2005/2006)

Final loss ($)				**T (+)**
(-)30%	(-)20%	(-)10%	0%	
180,083.3	138,203.5	96,323.63	0	0
217,775.2	171,707.3	129,827.5	33,503.87	1
251,279	205,211.2	142,391.4	71,195.72	2
284,782.9	238,715.1	196,835.2	100,511.6	3

As shown in Table (5.5), the economical loss is increased according to the increase in temperature and decrease the precipitation. The important of such results is that when policymakers and planners set the projection of the economical losses for the coming years the risk of climate change impact should not be ignored anymore; for example, if the temperature is expected to increase by 1°C then a loss of about 33,503.87 ($) will achieved, as well as the decrease in precipitation has more effect of losses, if the temperature doesn't change and the precipitation decrease (10%) the losses will be 96,323.63 ($), so the impact will be doubled or tripled if there will be combined in the changes in the temperature and precipitation, for example if precipitation decreased by (30%) and temperature increased by (3 °C) the losses will be 284,782.9 ($). The economical losses are shown in the Annexes (A.6).

Table (5.6), which represent the economical losses for wheat crop in the year (1993/1994), it is clear that there are a significant difference between the economical losses in the year (2006) and the year (1994); which means the economical losses are more occurred in the recent years.

Table (5.6) The reference economical loss for wheat crop (1993/1994).

Final loss ($)				**T (+)**
(-)30%	(-)20%	(-)10%	0%	
28,062.88	21,536.63	15,010.38	0	0
33,936.5	26,757.63	20,231.38	5,221	1
39,157.5	31,978.63	22,189.25	11,094.63	2
44,378.5	37,199.63	30,673.38	15,663	3

The study shows that the most vulnerable crops for the economical losses in the year (2005/2006) is Olive, with a loss equal to 16,747,240 ($) when temperature increased by (3 °C) and rainfall decreased by (30%), the second is Tomato with total loss of about 10,282,890 ($), the third is Squash with total loss of 2,246,406 ($), the forth is Wheat with total loss of 1,746,389 ($) and the fifth is Okra with total loss of 1,566,383 ($).

The least vulnerable crops for the economical losses in the year (2005/2006) is Clover with no losses at all, the second is Lentil with a loss equal to 6,681.37 ($), the third is Plums with total loss of 105,281.5 ($), the forth is Barely with total loss of 125,401.7 ($) and the fifth is Almond with total loss of 232,389.9 ($).

The most vulnerable crops for the climate change are; Sesame, the second is Tomato, the third is Chick-peas. The least vulnerable crops for the climate change are; Clover, Lentil, Barely, the last is Onion. The vulnerability ranking are tabulated in annexes table (A.4.4).

The most economical returns crops are ; Tomato (2.5 $/Kg), Sesame (1.787 $/Kg), Okra and Squash (1.057 $/Kg) finally Olive (0.828 $/Kg).

5.5 Commentary on previous studies

If we go through all the previous studies it is clear that some of the studies are agree with my study and others have some differences, that is; because the climate all over the world is different so some countries have advantages of the climate while the others have disadvantages.

The following studies agree:

- Abu-Jamous (2008) evaluated the agricultural water demand under different suggested climate change scenarios for Jericho district. CROPWAT computer model was used as a tools. The results show that crop water requirement (CWR) is very sensitive to temperature increase; CWR increases by an average of 2.7%, 5.4% and 8% as temperature increases by 1°C, 2°C and 3°C, respectively, to compensate the water lost in evapotranspiration. Scenarios of changing precipitation show an increase in IWR by an average of 1.47 % and 5.53% for a decrease in precipitation by 10% and 20% respectively. The other scenario of increasing precipitation shows a decrease by an average of 1.44% and 2.84% in the IWR for an increase by 10% and 20% in precipitation respectively. This study completely agree with my study which indicate an increase in amount of water requirements for plants with increasing temperature.
- Amien et al (1999) studied the simulated rice yields as affected by interannual climate variability and possible climate change in Java. The study predicted lower rice yields for different management options which confirm my results of decreasing yields for all the selected crops.
- Alexandrov, Vesselin (1997) studied the vulnerability of agronomic systems in Bulgaria. The results show that maize and winter wheat yields decreased with increasing temperatures and decreasing precipitation which is completely agree with my results.
- Kapetanaki, and Rosenzweig (1997) studied the impact of climate change on maize yield in central and Northern Greece: A simulation study with CERES-Maize. The climate change scenarios resulted in decreases in maize yield due to reduced duration of the growing period which agree with my results.
- Jinghua and Erda (1996) studied the impacts of potential climate change and climate variability on simulated maize production in China. The study shows that, simulated yields of both rainfed and irrigated maize decreased under climate change scenarios, primarily because of increases in temperature, which shorten maize growth duration, particularly the grain-filling period. the decreases in

rainfed yield were greater than those of irrigated yield which completely agree with my results.

- El-Shaer et al (1997) studied the impact of climate change on possible scenarios for Egyptian agriculture in the future. The study characterized potential yield and water use efficiency decreases on two reference crops in the main agricultural regions with possible future climatic variation. The result agree with my study.

The studies comply with my study which indicate that the climate change are really affect the crops yield.

The following studies agree for some points of view and disagree for other:

Magrin et al (1997) studied the vulnerability of the agricultural systems of Argentina to climate change. According to the results obtained, a generalized increase in Soybean yield and a decrease in Maize yield would occur. Wheat yield is likely to increase in the Southern and the Western parts of the region and decrease towards the North. Wheat and Soybean production in the Pampean region would increase by 3.6 and 20.7% respectively, while Maize production would be reduced by 16.5%. the study agree with my study in decreasing Maize production while disagree in increasing Wheat and Soybean yields.

- Singh et al (1998) studied the impacts of a Ghg-induced climate change on crop yields. Results show that depending upon the agricultural zone and crop type, yields may increase (ex. Corn and Sorghum by 20%) or decrease (ex. Wheat and Soybean by 20 to 30%). the study agree with my study in decreasing Wheat and Soybean yields while disagree in increasing Corn and Sorghum yields.

The following study disagree with my study:

- Southworth et al (2002) studied the changes in Soybean yields in the Midwestern United States as a result of future changes in climate, climate variability, and CO2 fertilization. For the study region as a whole, the climate changes modeled in this research would have an overall beneficial effect, with mean Soybean yield increases of 40% over current levels. The result disagree completely with my study where my study reveals an overall decline in crops yield.

Chapter Six: Conclusion and Recommendation

6.1 Conclusion

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

The main conclusions of this research thesis are as follows:

- It is obvious that the actual yield of the selected crops are changing based on the changes in the amount of rainfall specially for the plants cultivated in the rainy season.
- Under increasing temperature and decreasing precipitation, the yield reduction will be greater and the amount of water required (IR) for compensating the deficit in rainfall will be greater.
- The rainy season in our country shifting toward April and May with a delay in September and October.
- The results also show that the impact of the scenario of increasing temperature on the yield reduction and the irrigation requirement for Jenin district gets worse when combine with the scenario of decreasing precipitation; the worst scenario examined is when temperature increases by 3°C and precipitation decreases by 30% .
- The economical losses for the selected crops is very high in the present, and it will be greater in the future with combining the increase in temperature and decreasing the precipitation.

6.2 Recommendation

In response to the previous results and conclusions, the following measures are recommended:

- This study should be conducted in all Palestinian districts, in order to make an integration between these district. So, each district plant the most useful crop and the best economical revenues.
- There should be comparative studies between the Palestinian district in order to find the most vulnerable and affected district in all the Palestinian territory.
- It is time for planners to think in terms of expected change in yield reduction and irrigation requirement due to climate change.
- The ministry of agriculture should use the study specially the calculated irrigation requirements in order to irrigate the plants with the required amount of water.
- Adaptation measure should be considered to cope up with climate change potential impacts on yield reduction and irrigation requirement, and it should be noted that most of the adaptation measures are no-regret options, in other words, they would be beneficial regardless of climate change impacts especially that Palestine is already facing water shortage due to natural water resources scarcity and other political restrictions.
- Simulated adaptation measures--such as changing planting dates, altering varieties, changing optimum value and dates of fertilizer application, using a longer maturing hybrid and irrigation--were considered as potential responses that may modify any effects of climate change on crop production. Adaptation analyses showed that mitigation of climate change effects may be achieved through arrear sowing dates and the use of new crops varieties.
- The government should act immediatly to raise framers' awareness , also training is needed for farmers and extended farms.
- It is very important to have agricultural policies that promote certain crops in specific areas of Palestine.
- Further research is needed on the appropriate time for irrigating and planting the crops to compensate the shortage of rainfall. In addition, the research study only the largest crops in Jenin district so other crops should be studied.

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Annexes (A.1 – A.6)

Annex (A.1): Trend Of Rainfall Over The Years

January:

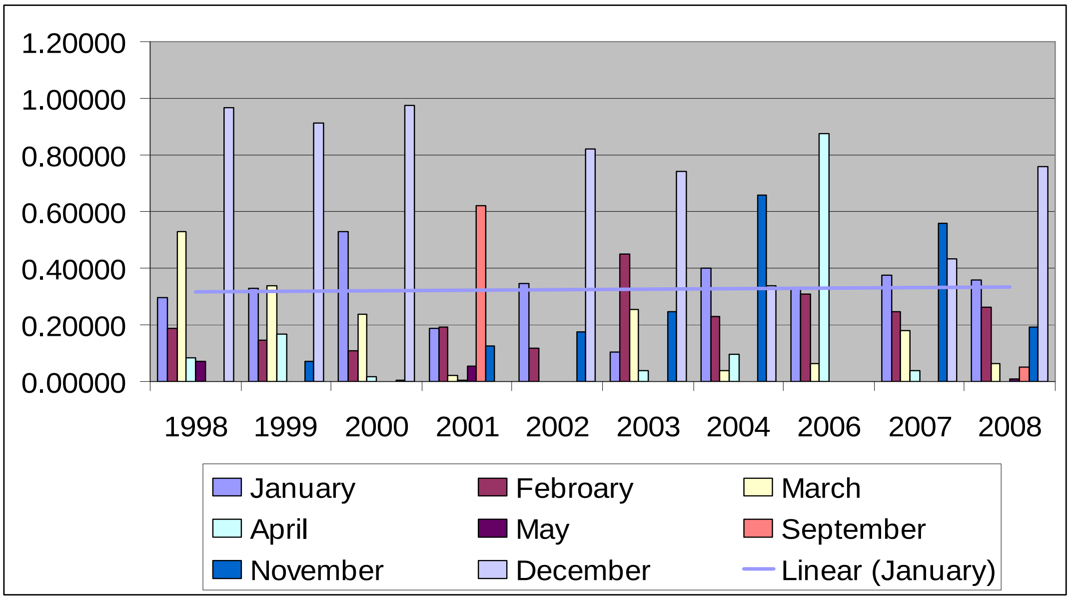

Figure (A.1.1): Rainfall trends during January in the last ten years

February:

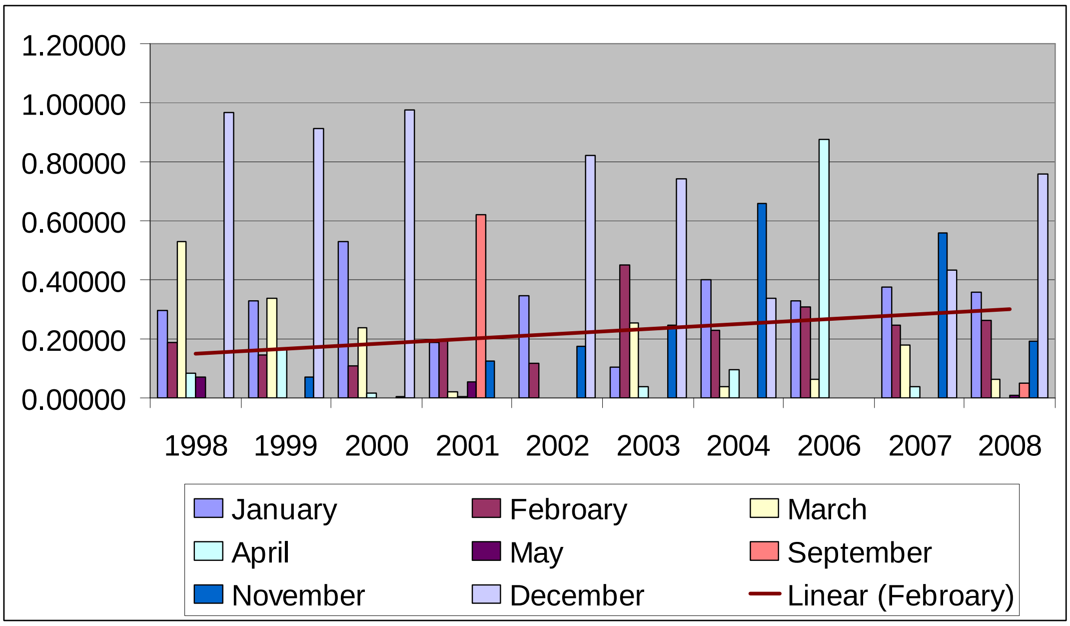

Figure (A.1.2): Rainfall trends during February in the last ten years

March:

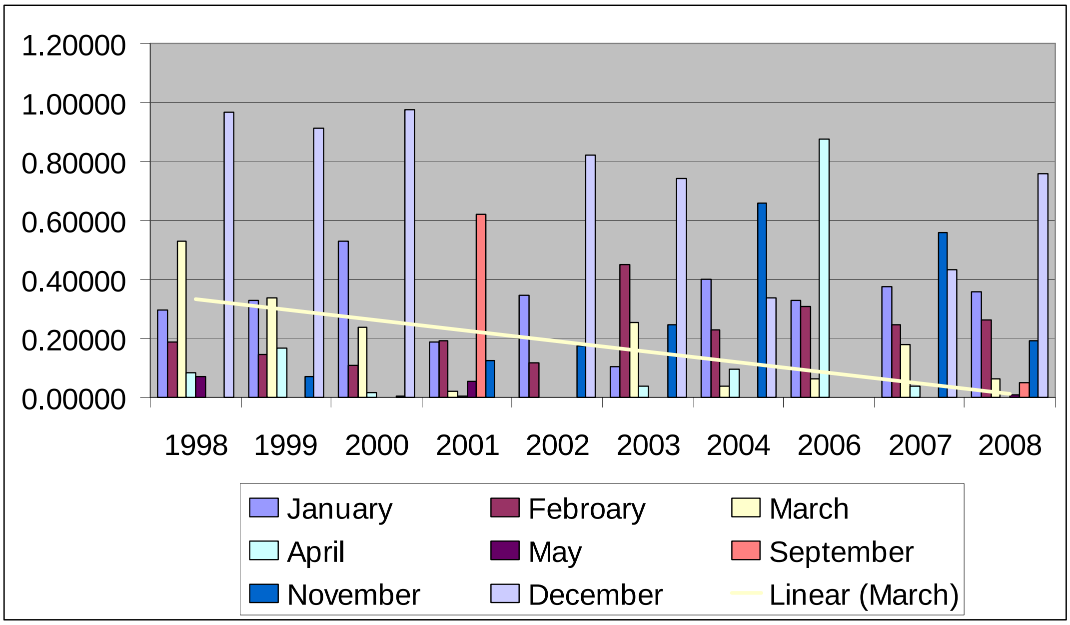

Figure (A.1.3): Rainfall trends during March in the last ten years

April:

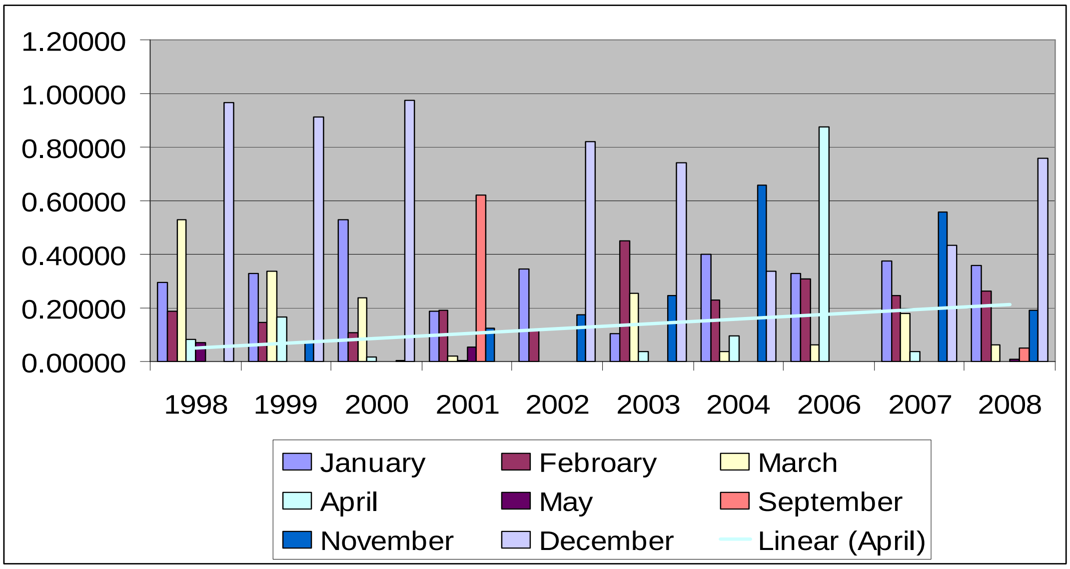

Figure (A.1.4): Rainfall trends during April in the last ten years

May:

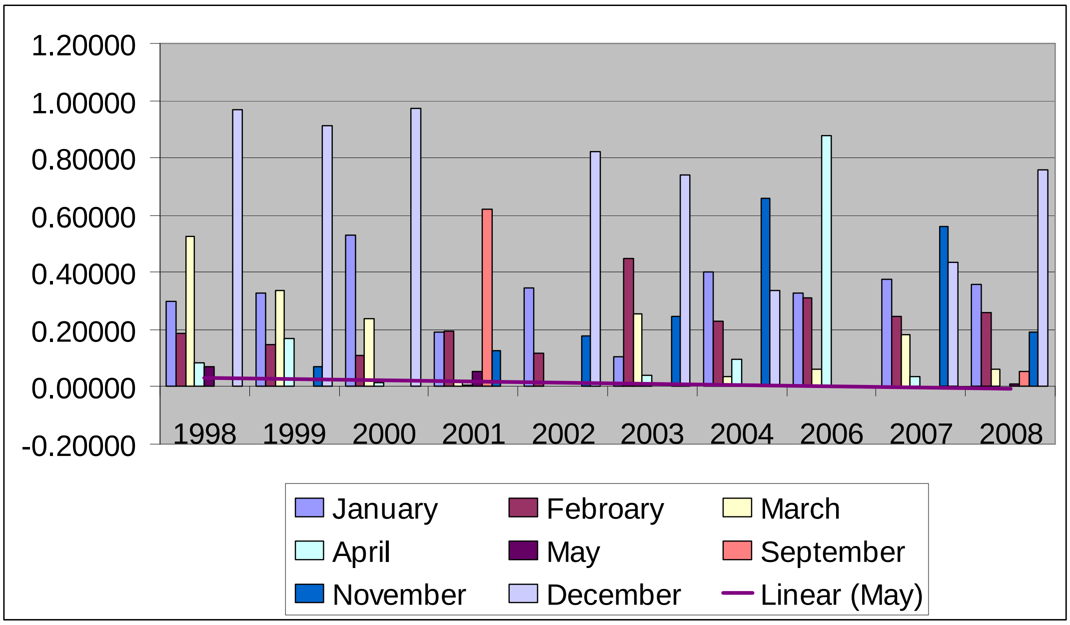

Figure (A.1.5): Rainfall trends during May in the last ten years

September:

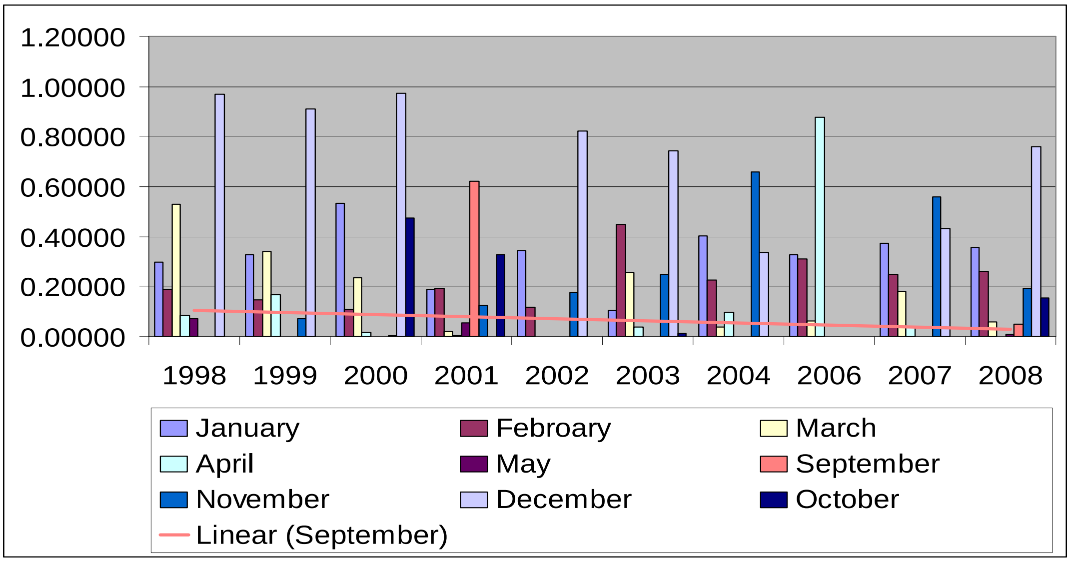

Figure (A.1.6): Rainfall trends during September in the last ten years

October:

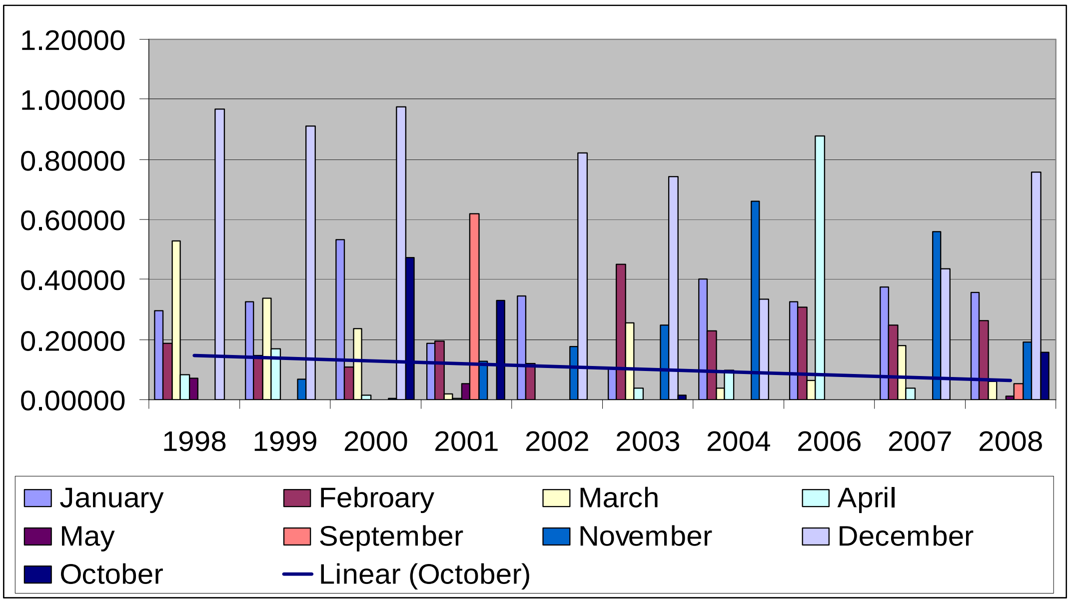

Figure (A.1.7): Rainfall trends during October in the last ten years

November:

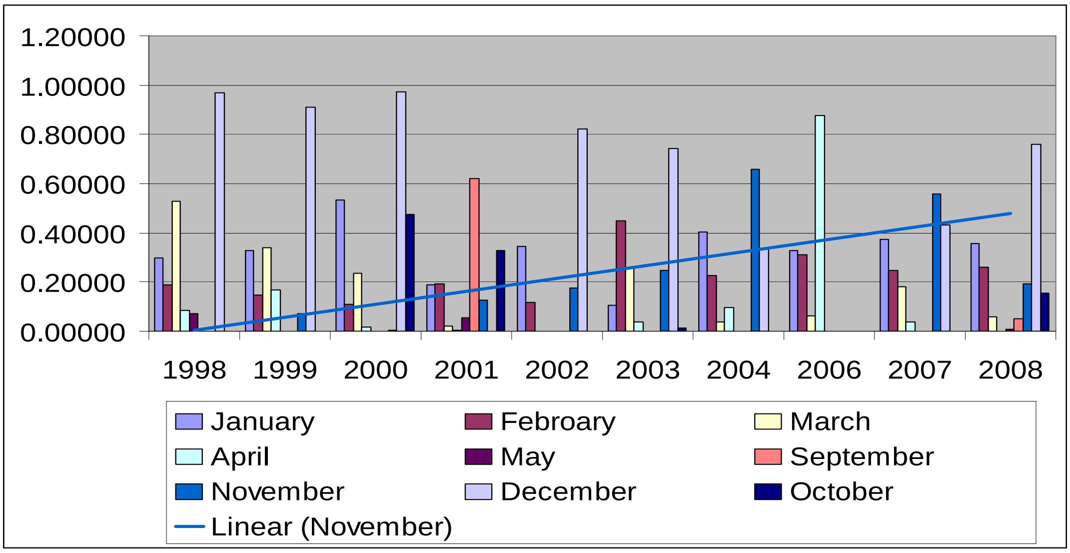

Figure (A.1.8): Rainfall trends during November in the last ten years

December:

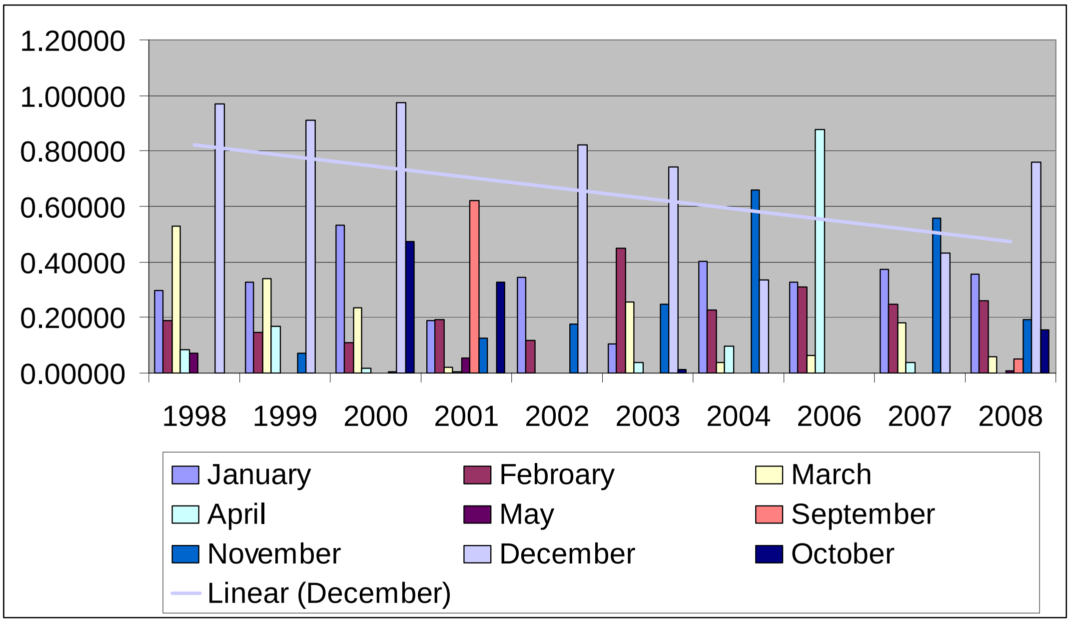

Figure (A.1.9): Rainfall trends during December in the last ten years

Annex (A.2): Crop Data

Table (A.2.1): Area, Yield and Production of Main Crops in Jenin Governorate, (1993/1994)
Area: Dunums, Yield: Kg\ dunum, production: metric tons. (PCBS, 1993/1994)

Field Crops	**Rainfed**		**Production**
	Area	***Yield***	
Wheat	28,750	100	2,875
Chick-peas	18,340	70	1,284
Clover	---	---	---
Barely	19,100	120	2,292
Lentil	6,690	20	134
Sesame	7,465	30	224
Dry Onion	10,950	922	10,096
Fruit Trees	**Rainfed**		**Production**
	Area	***Yield***	
Olive	140,930	113	15,925
Hard Almond	24,332	60	1,460
Plums	4,150	38	158
Grape	3,705	800	2,964
Open Cultivated vegetables	**Rainfed**		**Production**
	Area	***Yield***	
Tomato	10,390	300	3,117
Okra	10,680	500	5, 340
Squash	6,420	400	2,568
Snake cucumber	5,355	400	2,142

Table (A.2.2): Area, Yield and Production of Main Crops in Jenin Governorate,(2005/2006).
(Source: PCBS, 2005/2006)

Crops	**Rainfed**		**Production**
	Area	***Yield***	
Wheat	40,755	280	11,411
Chick-peas	12,271	130	1,595
Clover	21,500	550	11,825
Barely	10,235	240	2,456
Lentil	2,418	60	145
Sesame	3,070	70	215
Dry Onion	6,867	1,700	11,674
Fruit Trees	**Rainfed**		**Production**
	Area	***Yield***	
Olive	175,803	195	33,536
Hard/soft Almond	8,647	120	306
Plums	1,382	300	365
Grape	1,522	1,000	1,522
Open Cultivated vegetables	**Rainfed**		**Production**
	Area	***Yield***	
Tomato	1,119	1,700	1,902
Okra	3,505	700	2,454
Squash	2,477	1,500	3,716
Snake cucumber	1,720	700	1,204

Annex (A.3): Yield Reduction (%) and Irrigation Requirements (mm)

Table (A.3.1): Yield Reduction (%) and Irrigation Requirements (mm) for the selected crops.

Main Crops	T (+)	Rain reduction					T (+)	IR (mm)			
Chick-peas		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	74.5	77.6	77.6	77.6		0	533.66	533.74	534.04	534.33
	1	75.5	78.5	78.5	78.5		1	546.42	546.5	546.8	547.09
	2	76.3	79.3	79.3	79.3		2	559.3	559.38	559.68	559.97
	3	77.2	80.1	80.1	80.1		3	572.51	572.6	572.9	573.19
	T (+)	Rain reduction					T (+)	IR (mm)			
Wheat		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	34.9	37.2	38.2	39.2		0	484.39	491.05	501.89	514.96
	1	35.7	38	39	40.1		1	499.41	506.54	517.38	531.74
	2	36.6	38.3	39.8	40.9		2	514.61	522.16	533.4	548.58
	3	37.3	39.6	40.6	41.7		3	530.13	538.15	550.54	565.89
	T (+)	Rain reduction					T (+)	IR (mm)			
Clover		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	0	0	0	0		0	34.18	40.52	50.13	61.17
	1	0	0	0	0		1	37.63	44.2	54.24	65.83
	2	0	0	0	0		2	41.01	48.25	58.43	70.36
	3	0	0	0	0		3	44.59	52.5	63.25	75.18
	T (+)	Rain reduction					T (+)	IR (mm)			
Barely		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	11.1	14.7	16.3	18		0	241.06	245.71	253.11	262.16
	1	12.4	16.1	17.7	19.4		1	249.47	254.12	261.52	271.52
	2	13.8	17.4	19	20.8		2	258.06	262.71	270.51	281.07
	3	15.1	18.7	20.3	22.1		3	266.69	271.34	279.9	290.67

Lentil	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	0.4	1.3	2.3	3.6		0	96.07	101.21	109.52	119.77
	1	0.7	1.8	3	4.5		1	100.87	106.29	114.6	126.25
	2	1.3	2.4	3.7	5.4		2	105.92	111.45	120.16	132.83
	3	1.8	3.1	4.5	6.3		3	111.14	116.66	126.13	139.99

Sesame	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	83.7	83.7	83.7	83.7		0	513.91	513.91	513.91	513.91
	1	84.4	84.4	84.4	84.4		1	526.01	526.01	526.01	526.01
	2	85.1	85.1	85.1	85.1		2	538.12	538.12	538.12	538.12
	3	85.8	85.8	85.8	85.8		3	550.79	550.79	550.79	550.79

Onion	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	19.7	23.2	24.8	26.7		0	201.4	209.06	220.38	233.1
	1	20,6	24,1	25,7	27,6		1	209.73	217.75	229.67	242.61
	2	21,5	25	26,7	28,5		2	218.43	226.45	238.9	252.52
	3	22,4	25,9	27,6	29,5		3	227.41	235.92	248.49	262.8

Olive	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	53.6	55.2	55.2	56.6		0	768.11	772.4	780.57	788.8
	1	54.4	56	56.7	57.4		1	788.89	793.6	801.77	810
	2	55.2	56.8	57.5	58.2		2	809.73	814.82	822.29	831.47
	3	56	57.6	58.3	59		3	831.53	836.96	845.13	854.12

Almond	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	38,5	40.4	41	41.6		0	467.47	468.39	472.69	476.98
	1	39.4	41.2	41.8	42.4		1	479.47	480.91	485.2	489.49
	2	40.2	42	42.6	43.2		2	491.95	493.62	497.91	502.2
	3	41	42.8	43.4	44		3	504.86	506.53	510.82	515.11

Plums	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	31.1	34.4	35.6	37.1		0	293.59	295.53	301.98	308.45
	1	32.3	35.5	36.8	38.2		1	302.2	304.79	311.24	317.72
	2	33.5	36.7	38	39.4		2	310.99	314.26	320.71	327.19
	3	34.6	37.7	39.1	40.5		3	320.03	323.77	330.22	336.69

Grape	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	43.4	45.2	45.9	46.9		0	611.64	614.5	620.23	628.33
	1	44.1	45.9	46.6	47.6		1	628.33	631.19	637.76	645.86
	2	44.8	46.5	47.3	48.3		2	644.93	647.78	655.15	663.25
	3	45.5	47.2	48	49.1		3	662.45	665.45	673.54	681.64

Tomato	T (+)	Rain reduction				Yield Reduction	T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%			0%	(-)10%	(-)20%	(-)30%
	0	79.7	81.7	81.7	81.7		0	784.15	784.23	784.53	784.82
	1	80.3	82.2	82.2	82.2		1	802.81	802.9	803.2	803.49
	2	80.9	82.7	82.7	82.7		2	821.61	821.69	821.99	822.28
	3	81.4	83.2	83.2	83.2		3	841.03	841.11	841.41	841.7

Okra	T (+)	Rain reduction					T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	58	59.3	59.3	59.3		0	833.9	833.98	834.28	834.57
	1	58.4	59.7	59.7	59.7		1	853.76	853.84	854.14	854.43
	2	58.8	60	60	60		2	873.75	873.83	874.13	874.82
	3	59.2	60.4	60.4	60.4		3	894.42	894.5	894.8	895.09

Squash	T (+)	Rain reduction					T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	49.5	52.5	53.2	53.9		0	369.56	369.69	372.39	375.09
	1	50.7	53.6	54.2	55		1	379.3	379.44	382.14	384.92
	2	51.7	54.6	55.3	56.1		2	389.22	389.35	392.05	395.23
	3	52.8	55.7	56.3	57.2		3	399.25	399.39	402.09	405.66

Snake-Cucumber	T (+)	Rain reduction					T (+)	IR (mm)			
		0%	(-)10%	(-)20%	(-)30%	Yield Reduction		0%	(-)10%	(-)20%	(-)30%
	0	73.6	75.9	75.9	75.9		0	689.54	689.62	689.92	690.21
	1	74.4	76.5	76.5	76.5		1	705.98	706.06	706.36	706.65
	2	75.1	77.2	77.2	77.2		2	722.55	722.63	722.93	723.22
	3	75.7	77.8	77.8	77.8		3	739.62	739.7	740	740.29

Annex (A.4): Yield Reduction

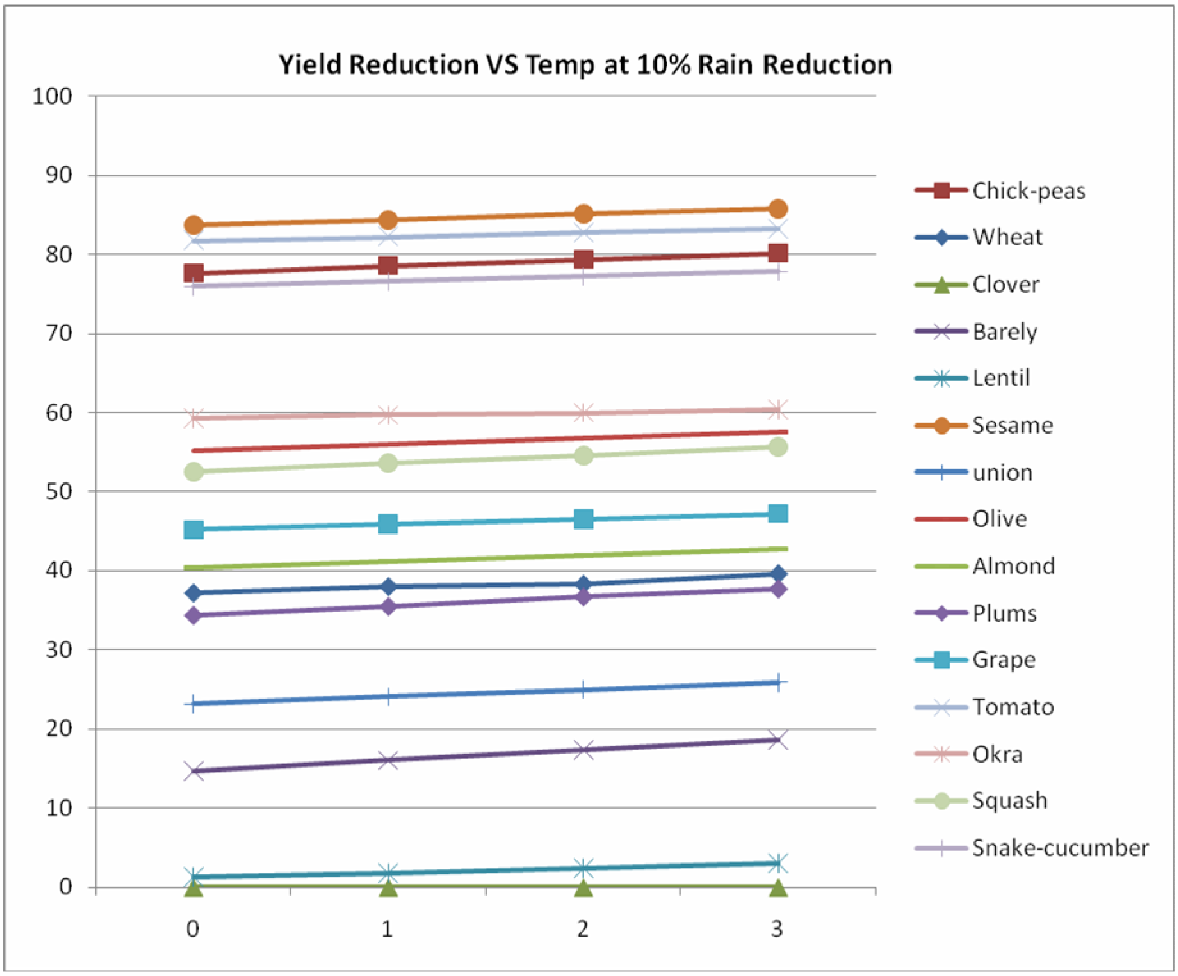

Figure (A.4.1): Yield reduction versus temperature at (10%) rain reduction

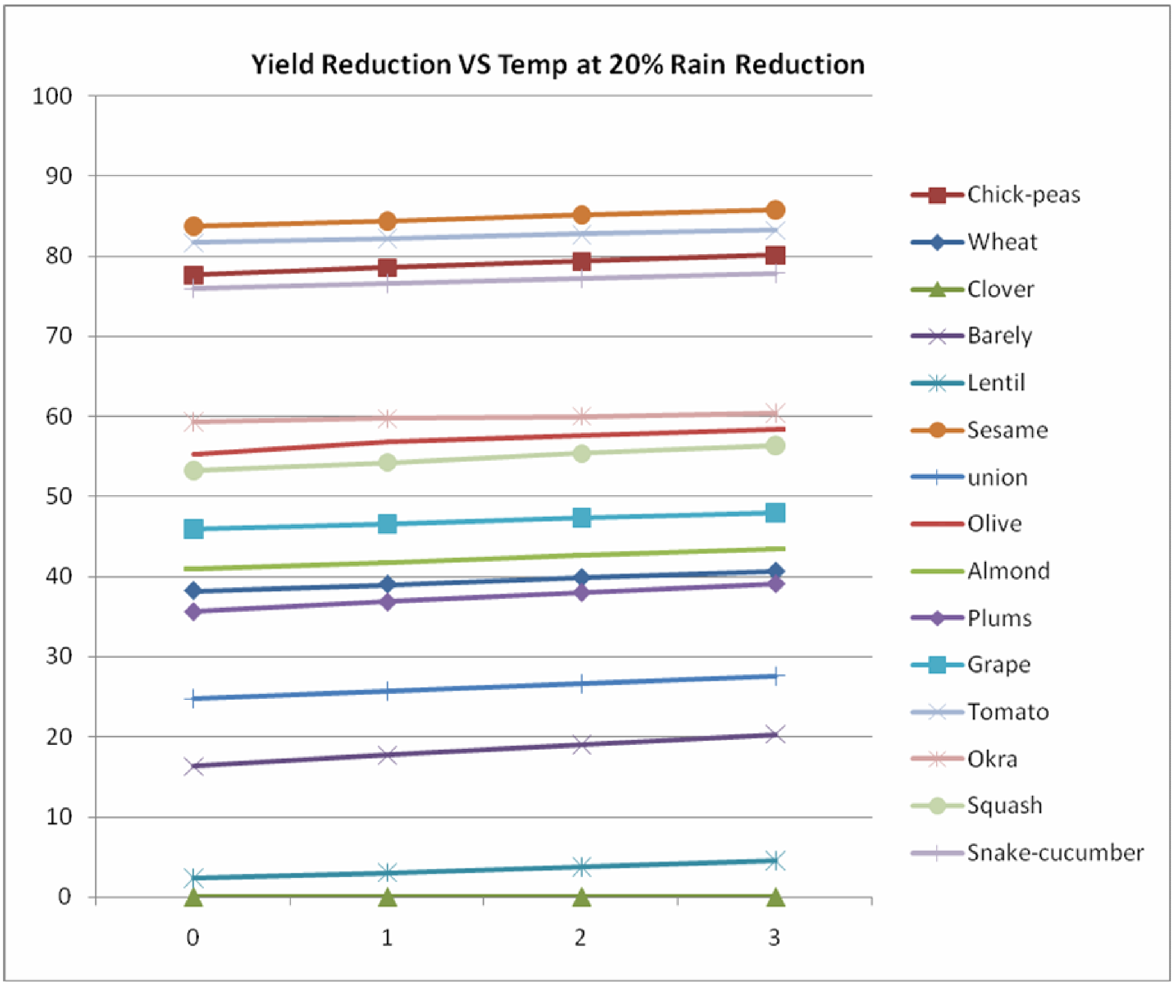

Figure (A.4.2): Yield reduction versus temperature at (20%) rain reduction

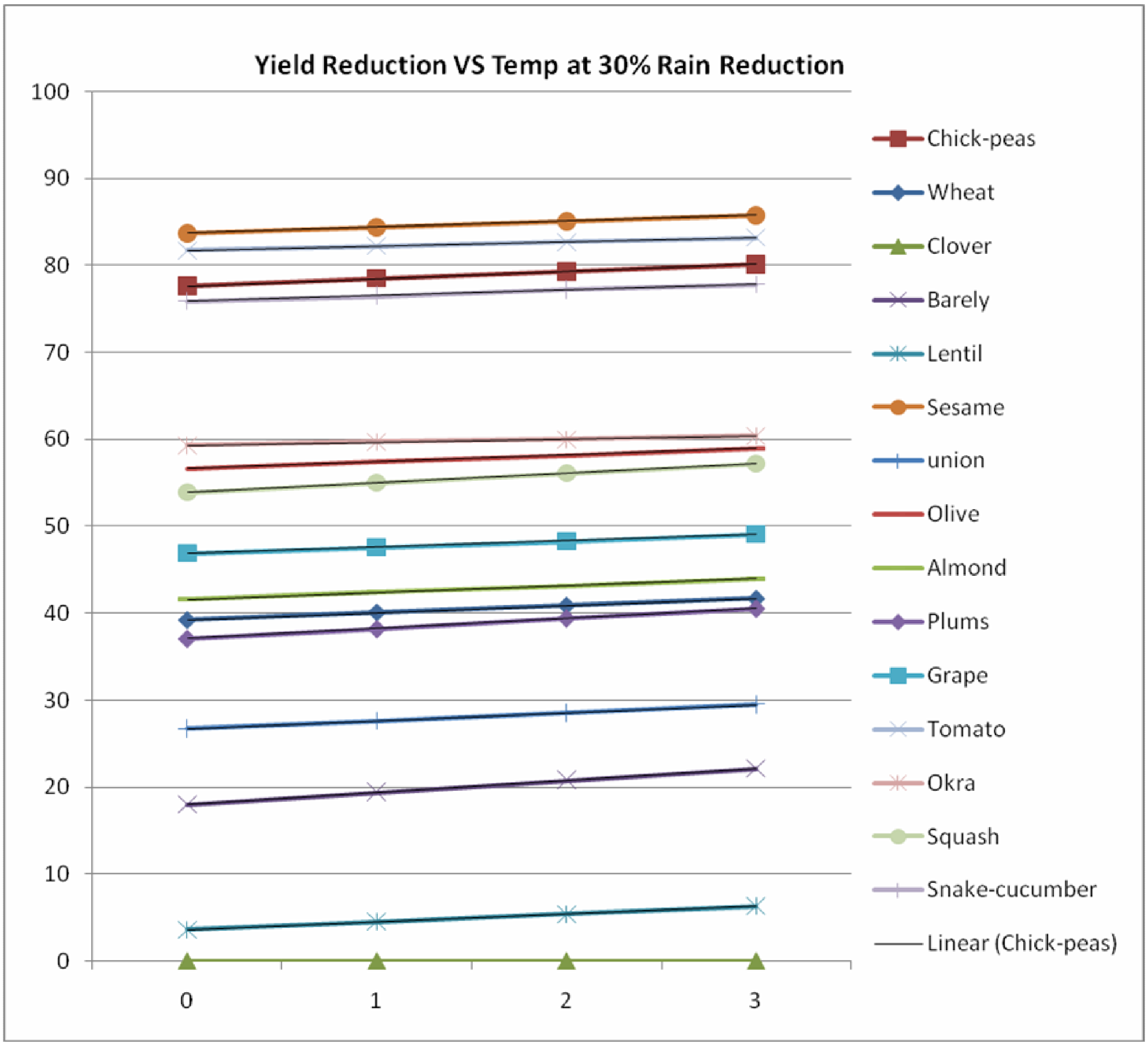

Figure (A.4.3): Yield reduction versus temperature at (30%) rain reduction

Table (A.4.4):Yield Reduction Equations
y : amount of yield reduction (%) , x : Temperature (°C)

		R-Squared	*(=1) for all value*		
Field Crops	***Line Equation at 10 % Rainfall Reduction***	***Line Equation at 20 % Rainfall Reduction***	***Line Equation at 30 % Rainfall Reduction***	***Vulnerability Rank***	***Vulnerable***
Chick-peas	**y = 0.83x + 76.8**	**y = 0.83x + 76.8**	**y = 0.83x + 76.8**	**3**	**Sesame**
Wheat	**y = 0.75x + 36.4**	**y = 0.8x + 37.4**	**y = 0.83x + 38.4**	**10**	**Tomato**
Clover	**y = 0**	**y = 0**	**y = 0**	**15(Least)**	**Chick-peas**
Barely	**y = 1.33x + 13.4**	**y = 1.33x + 15**	**y = 1.37x + 16.65**	**13**	**Snake-cucumber**
Lentil	**y = 0.6x + 0.65**	**y = 0.73x + 1.55**	**y = 0.9x + 2.7**	**14**	**Okra**
Sesame	**y = 0.7x + 83**	**y = 0.7x + 83**	**y = 0.7x + 83**	**1 (Most)**	**Olive**
Onion	**y = 0.9x + 22.3**	**y = 0.94x + 23.85**	**y = 0.93x + 25.75**	**12**	**Squash**
Fruit					**Grape**
Olive	**y = 0.8x + 54.4**	**y = 1.01x + 54.4**	**y = 0.8x + 55.8**	**6**	**Almond**
Almond	**y = 0.8x + 39.6**	**y = 0.8x + 40.2**	**y = 0.8x + 40.8**	**9**	**Wheat**
Plums	**y = 1.11x + 33.3**	**y = 1.17x + 34.45**	**y = 1.14x + 35.95**	**11**	**Plums**
Grape	**y = 0.66x + 44.55**	**y = 0.7x + 45.2**	**y = 0.73x + 46.15**	**8**	**Onion**
Vegetables					**Barely**
Tomato	**y = 0.5x + 81.2**	**y = 0.5x + 81,2**	**y = 0.5x + 81,2**	**2**	**Lentil**
Okra	**y = 0.36x + 58.95**	**y = 0.36x + 58.95**	**y = 0.36x + 58.95**	**5**	**Clover**
Squash	**y = 1.06x + 51.45**	**y = 1.04x + 52.15**	**y = 1.1x + 52.8**	**7**	
Snake-cucumber	**y = 0.64x + 75.25**	**y = 0.64x + 75.25**	**y = 0.64x + 75.25**	**4**	

Annex (A.5): Irrigation Requirements

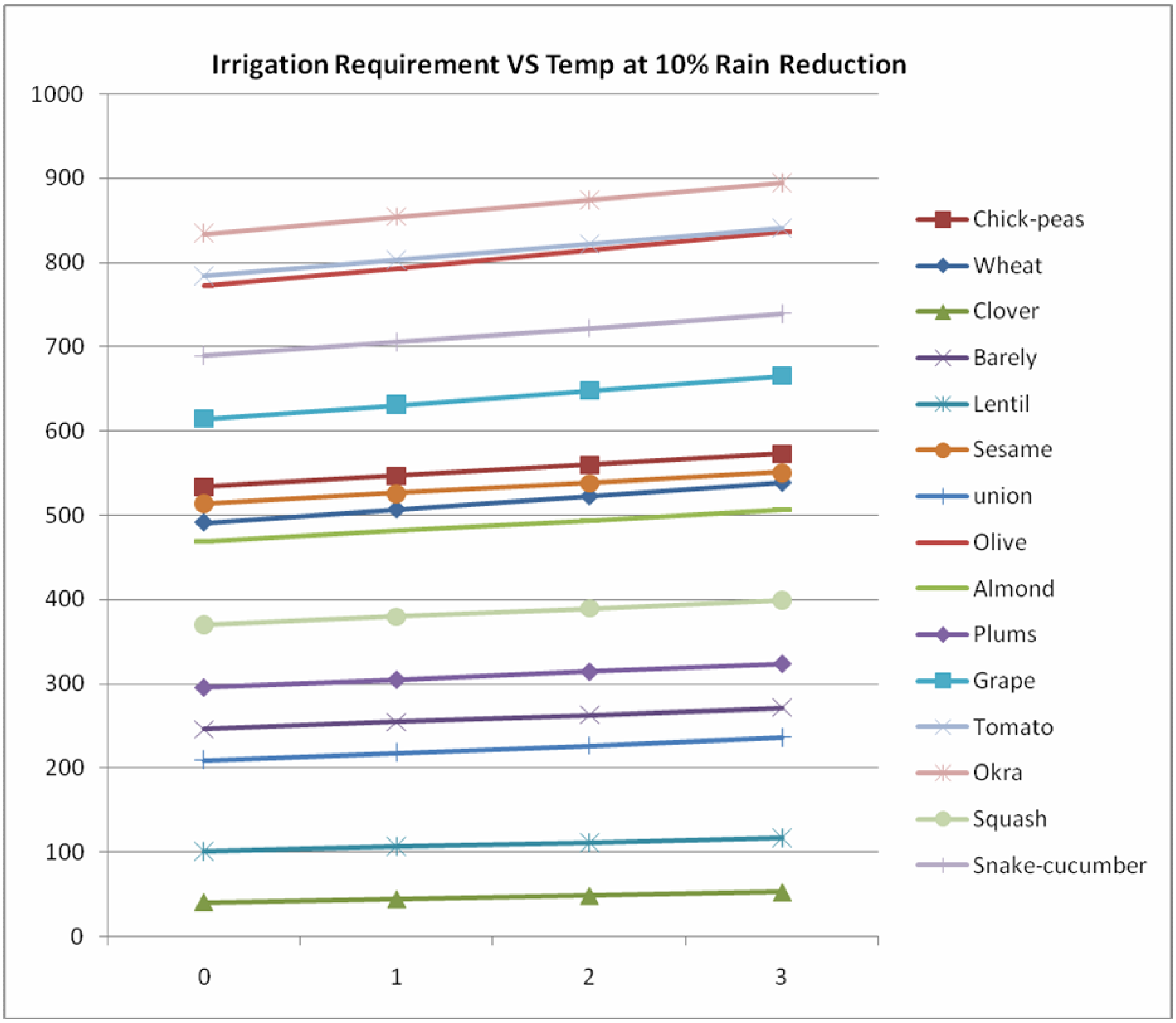

Figure (A.5.1): Irrigation requirements versus temperature at (10%) rain reduction

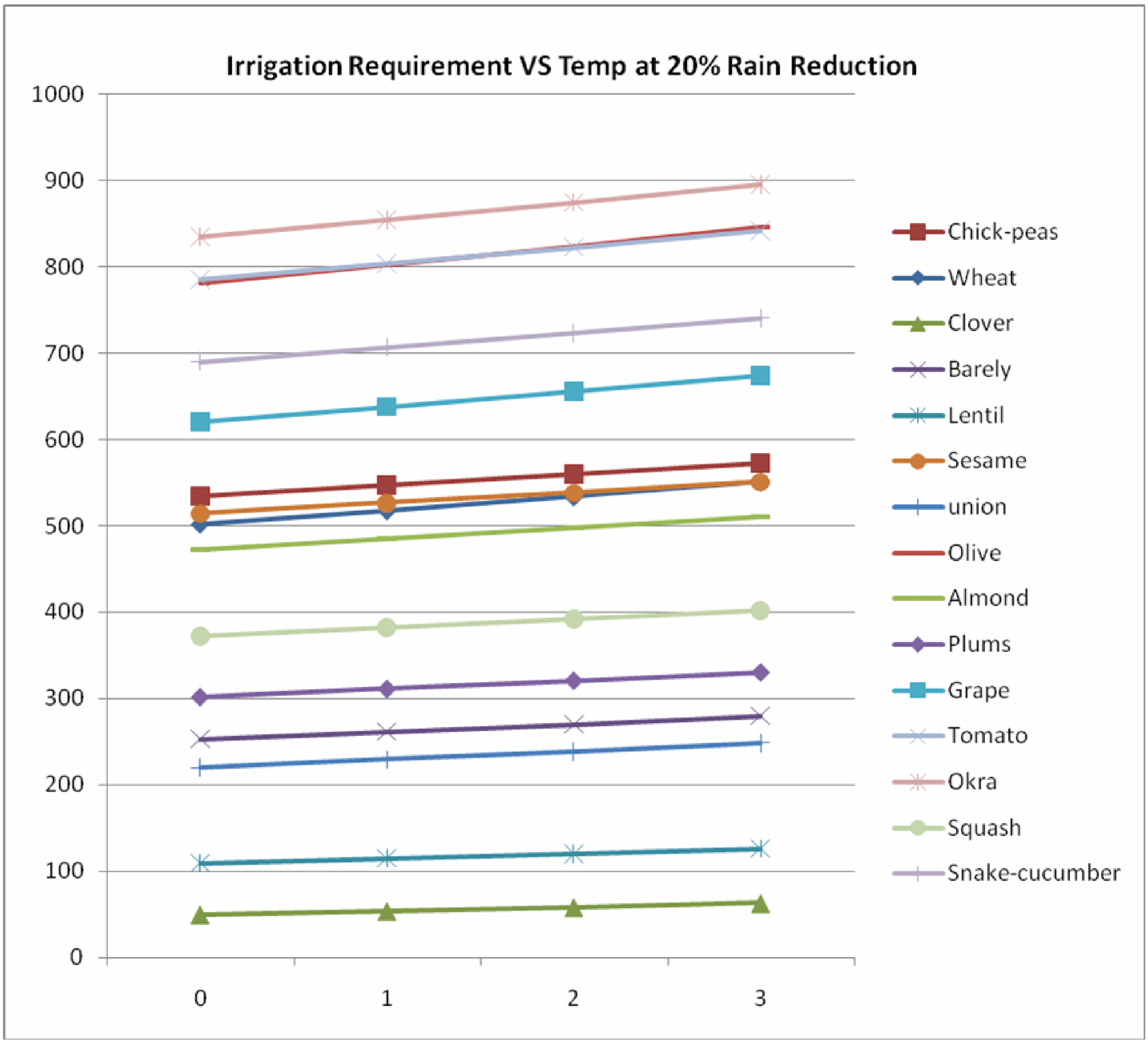

Figure (A.5.2): Irrigation requirements versus temperature at (20%) rain reduction

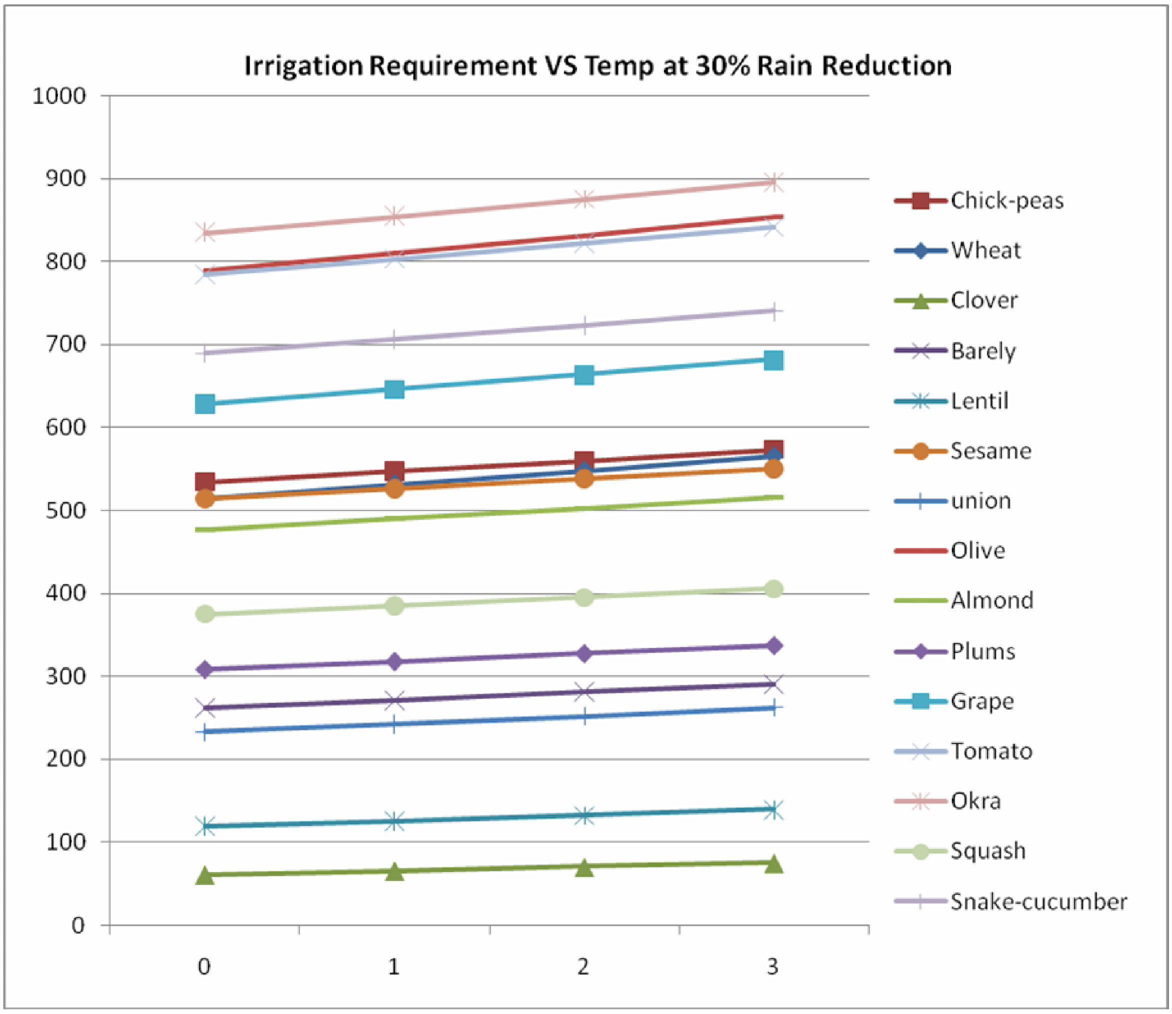

Figure (A.5.3): Irrigation requirements versus temperature at (30%) rain reduction

Table (A.5.4): Irrigation Requirements Equations
y : amount of irrigation requirement (mm) x: Temperature (°C)

	R-Squared value (=1) for all value		
Field Crops	***Line Equation at 10 % Rainfall Reduction***	***Line Equation at 20 % Rainfall Reduction***	***Line Equation at 30 % Rainfall Reduction***
Chick-peas	**y = 12.94x + 520.6**	**y = 12.94x + 520.9**	**y = 12.94x + 521.2**
Wheat	**y = 15.69x + 475.2**	**y = 16.19x + 485.3**	**y = 16.96x + 497.8**
Clover	**y = 3.999x + 36.37**	**y = 4.355x + 45.62**	**y = 4.656x + 56.49**
Barely	**y = 8.548x + 237.1**	**y = 8.936x + 243.9**	**y = 9.508x + 252.5**
Lentil	**y = 5.151x + 96.02**	**y = 5.539x + 103.7**	**y = 6.724x + 112.9**
Sesame	**y = 12.27x + 501.5**	**y = 12.27x + 501.5**	**y = 12.27x + 501.5**
Onion	**y = 8.928x + 199.9**	**y = 9.356x + 210.9**	**y = 9.901x + 223.0**
Fruit			
Olive	**y = 21.49x + 750.7**	**y = 18.94x + 765.4**	**y = 21.74x + 766.7**
Almond	**y = 12.71x + 455.5**	**y = 12.71x + 459.8**	**y = 12.71x + 464.1**
Plums	**y = 9.419x + 286.0**	**y = 9.419x + 292.4**	**y = 9.419x + 298.9**
Grape	**y = 16.94x + 597.3**	**y = 17.73x + 602.3**	**y = 17.73x + 610.4**
Vegetables			
Tomato	**y = 18.94x + 765.1**	**y = 18.94x + 765.4**	**y = 18.94x + 765.7**
Okra	**y = 20.15x + 813.6**	**y = 20.15x + 813.9**	**y = 20.19x + 814.2**
Squash	**y = 9.901x + 359.7**	**y = 9.901x + 362.4**	**y = 10.20x + 364.7**
Snake-cucumber	**y = 16.68x + 672.8**	**y = 16.68x + 673.1**	**y = 16.68x + 673.3**

Annex (A.6): The Economical Losses for all the Selected Crops in Jenin District

Table (A.6.1):Economical losses for the year (2005/2006)

Main Crops	T (+)	COST $			
Chick-peas		0%	(-)10%	(-)20%	(-)30%
	0	778,432.4	810,823.5	810,823.5	810,823.5
	1	788,881.1	820,227.4	820,227.4	820,227.4
	2	797,240.1	828,586.4	828,586.4	828,586.4
	3	806,644	836,945.4	836,945.4	836,945.4
	T (+)	COST $			
Wheat		0%	(-)10%	(-)20%	(-)30%
	0	1,461,606	1,557,930	1,599,810	1,641,690
	1	1,495,110	1,591,434	1,633,314	1,679,382
	2	1,532,802	1,603,998	1,666,818	1,712,885
	3	1,562,118	1,658,442	1,700,321	1,746,389
	T (+)	COST $			
Barely		0%	(-)10%	(-)20%	(-)30%
	0	62,984.55	83,411.97	92,490.83	102,137.1
	1	70,361.12	91,355.97	100,434.8	110,081.1
	2	78,305.12	98,732.54	107,811.4	118,025.1
	3	85,681.69	106,109.1	115,188	125,401.7
	T (+)	COST $			
Lentil		0%	(-)10%	(-)20%	(-)30%
	0	424.21	1,378.69	2,439.23	3,817.92
	1	742.37	1,908.96	3,181.60	4,772.41
	2	1,378.70	2,545.28	3,923.80	5,726.88
	3	1,908.96	3,287.66	4,772.41	6,681.37
	T (+)	COST $			
Sesame		0%	(-)10%	(-)20%	(-)30%
	0	321,430	321,430	321,430	321,430
	1	324,118.2	324,118.2	324,118.2	324,118.2
	2	326,806.4	326,806.4	326,806.4	326,806.4
	3	329,494.6	329,494.6	329,494.6	329,494.6

	T (+)	COST $			
Onion		0%	(-)10%	(-)20%	(-)30%
	0	1,004,994	1,183,547	1,265,171	1,362,099
	1	1,050,908	1,229,460	1,311,084	1,408,012
	2	1,096,821	1,275,374	1,362,099	1,453,926
	3	1,142,735	1,321,287	1,408,012	1,504,941

	T (+)	COST $			
Olive		0%	(-)10%	(-)20%	(-)30%
	0	15,214,442	15,668,604	15,668,604	16,065,996
	1	15,441,523	15,895,685	16,094,381	16,293,077
	2	15,668,604	16,122,767	16,321,463	16,520,159
	3	15,895,685	16,349,848	16,548,544	16,747,240

	T (+)	COST $			
Almond		0%	(-)10%	(-)20%	(-)30%
	0	203,341.1	213,376.1	216,545.1	219,714
	1	208,094.6	217,601.4	220,770.4	223,939.3
	2	212,319.8	221,826.7	224,995.6	228,164.6
	3	216,545.1	226,051.9	229,220.9	232,389.9

	T (+)	COST $			
Plums		0%	(-)10%	(-)20%	(-)30%
	0	80,845.76	89,424.24	92,543.7	96,443.01
	1	83,965.21	92,283.74	95,663.15	99,302.5
	2	87,084.66	95,403.19	98,782.6	102,422
	3	89,944.15	98,002.73	101,642.1	105,281.5

	T (+)	COST $			
Grape		0%	(-)10%	(-)20%	(-)30%
	0	344,145.5	358,418.8	363,969.6	371,899.2
	1	349,696.2	363,969.6	369,520.3	377,449.9
	2	355,247	368,727.3	375,071	383,000.6
	3	360,797.7	374,278.1	380,621.8	389,344.3

	T (+)	COST $			
Tomato		0%	(-)10%	(-)20%	(-)30%
	0	9,850,317	10,097,502	10,097,502	10,097,502
	1	9,924,472	10,159,298	10,159,298	10,159,298
	2	9,998,628	10,221,094	10,221,094	10,221,094

	3	10,060,424	10,282,890	10,282,890	10,282,890
	T (+)	**COST $**			
Okra		0%	(-)10%	(-)20%	(-)30%
	0	1,504,143	1,537,856	1,537,856	1,537,856
	1	1,514,516	1,548,230	1,548,230	1,548,230
	2	1,524,890	1,556,010	1,556,010	1,556,010
	3	1,535,263	1,566,383	1,566,383	1,566,383
	T (+)	**COST $**			
Squash		0%	(-)10%	(-)20%	(-)30%
	0	1,944,005	2,061,824	2,089,315	2,116,806
	1	1,991,133	2,105,024	2,128,588	2,160,006
	2	2,030,406	2,144,297	2,171,788	2,203,206
	3	2,073,606	2,187,497	2,211,061	2,246,406
	T (+)	**COST $**			
Snake-Cucumber		0%	(-)10%	(-)20%	(-)30%
	0	448,388.9	462,401	462,401	462,401
	1	453,262.7	466,056.4	466,056.4	466,056.4
	2	457,527.2	470,320.9	470,320.9	470,320.9
	3	461,182.6	473,976.3	473,976.3	473,976.3

Table (A.6.2):Economical losses for the year (1993/1994)

Main Crops	T (+)	COST $			
Chick-peas		0%	(-)10%	(-)20%	(-)30%
	0	639,852.3	666,477.1	666,477.1	666,477.1
	1	648,441	674,206.8	674,206.8	674,206.8
	2	655,311.9	681,077.7	681,077.7	681,077.7
	3	663,041.6	687,948.6	687,948.6	687,948.6
	T (+)	**COST $**			
Wheat		0%	(-)10%	(-)20%	(-)30%
	0	227,766.1	242,776.5	249,302.8	255,829
	1	232,987.1	247,997.5	254,523.8	261,702.6
	2	238,860.8	249,955.4	259,744.8	266,923.6
	3	243,429.1	258,439.5	264,965.8	272,144.6
	T (+)	**COST $**			
Barely		0%	(-)10%	(-)20%	(-)30%
	0	47,575.04	63,004.79	69,862.45	77,148.72
	1	53,146.9	69,005.24	75,862.91	83,149.18
	2	59,147.35	74,577.1	81,434.76	89,149.63
	3	64,719.2	80,148.95	87,006.61	94,721.48
	T (+)	**COST $**			
Lentil		0%	(-)10%	(-)20%	(-)30%
	0	535.74	1741.14	3080.48	4821.62
	1	937.54	2410.81	4018.01	6027.02
	2	1741.14	3214.41	4955.55	7232.43
	3	2410.81	4151.95	6027.02	8437.83
	T (+)	**COST $**			
Sesame		0%	(-)10%	(-)20%	(-)30%
	0	269,547.6	269,547.6	269,547.6	269,547.6
	1	271,801.8	271,801.8	271,801.8	271,801.8
	2	274,056.1	274,056.1	274,056.1	274,056.1
	3	276,310.4	276,310.4	276,310.4	276,310.4
	T (+)	**COST $**			
Onion		0%	(-)10%	(-)20%	(-)30%
	0	610,589.9	719,070.4	768,661.4	827,550,8
	1	638,484.9	746,965.4	796,556.4	855,445.8

	2	666,379.9	774,860.3	827,550.8	883,340.8
	3	694,274.9	802,755.3	855,445.8	914,335.2

	T (+)	COST $			
Olive		0%	(-)10%	(-)20%	(-)30%
	0	9,995,478	10,293,851	10,293,851	10,554,927
	1	10,144,665	10,443,037	10,573,575	10,704,113
	2	10,293,851	10,592,223	10,722,761	10,853,299
	3	10,443,037	10,741,410	10,871,947	11,002,485

	T (+)	COST $			
Almond		0%	(-)10%	(-)20%	(-)30%
	0	563,755.4	591,577.1	600,362.9	609,148.7
	1	576,934.1	603,291.5	612,077.3	620,863.1
	2	588,648.5	615,005.9	623,791.7	632,577.5
	3	600,362.9	626,720.3	635,506.1	644,291.9

	T (+)	COST $			
Plums		0%	(-)10%	(-)20%	(-)30%
	0	17,410.87	19,258.32	19,930.13	20,769.88
	1	18,082.67	19,874.14	20,601.93	21,385.70
	2	18,754.47	20,545.94	21,273.73	22,057.50
	3	19,370.29	21,105.78	21,889.55	22,673.32

	T (+)	COST $			
Grape		0%	(-)10%	(-)20%	(-)30%
	0	460,522.6	479,622.6	487,050.4	497,661.5
	1	467,950.4	487,050.4	494,478.2	505,089.3
	2	475,378.2	493,417.1	501,906	512,517.1
	3	482,806	500,844.9	509,333.8	521,006

	T (+)	COST $			
Tomato		0%	(-)10%	(-)20%	(-)30%
	0	1,224,735	1,255,468	1,255,468	1,255,468
	1	1,233,955	1,263,152	1,263,152	1,263,152
	2	1,243,175	1,270,835	1,270,835	1,270,835
	3	1,250,858	1,278,519	1,278,519	1,278,519

	T (+)	COST $			
Okra		0%	(-)10%	(-)20%	(-)30%

	0	3,106,492	3,176,120	3,176,120	3,176,120
	1	3,127,916	3,197,544	3,197,544	3,197,544
	2	3,149,340	3,213,612	3,213,612	3,213,612
	3	3,170,764	3,235,036	3,235,036	3,235,036
	T (+)	**COST $**			
Squash		0%	(-)10%	(-)20%	(-)30%
	0	588,547.1	624,216.6	632,539.5	640,862.4
	1	602,814.9	637,295.4	644,429.3	653,941.2
	2	614,704.7	649,185.3	657,508.2	667,020
	3	627,783.6	662,264.1	669,398	680,098.8
	T (+)	**COST $**			
Snake-Cucumber		0%	(-)10%	(-)20%	(-)30%
	0	227,017.7	234,112	234,112	234,112
	1	229,485.3	235,962.7	235,962.7	235,962.7
	2	231,644.4	238,121.9	238,121.9	238,121.9
	3	233,495.1	239,972.5	239,972.5	239,972.5

The End…

الملخص

أجري الكثير من الدراسات في جميع أنحاء العالم؛ لتحليل ودراسة اثر تغير الطقس على القطاع الزراعي خاصة الزراعة البعلية ، كما تم دراسة التأثيرات المحتملة لتغير الطقس والتي لم تعطى الاهتمام الكافي حتى الآن. وفق هذه الحقائق، تهدف هذه الدراسة لتقييم ودراسة الآثار المحتملة لتغير الطقس على الزراعة البعلية في منطقة جنين .

واختيرت جنين؛ لأنها تعتبر واحدة من أكبر المناطق الزراعية في الضفة الغربية، ولها أنشطة زراعية كبيرة؛ حيث تساهم المنطقة بحوالي 16.2 ٪ من الإنتاج الزراعي في السوق الفلسطينية.

وأجري التحليل باستخدام برنامج الحاسوب (CropWat)؛ لتقدير التغيير في نقص الإنتاج، مع زيادة درجة الحرارة (1 و 2 و 3 درجات مئوية) وتناقص هطول الأمطار (10 و 20 و 30 ٪).

تظهر النتائج أنه مع زيادة درجة الحرارة بمقدار درجة مئوية واحدة للقمح مثلا، فإن التغيرات في قلة العائد تكون بنسبة (35.7 ٪) ، وبازدياد درجة الحرارة بمقدار درجتين مئويتين و ثلاث درجات مئوية يكون معدل التغييرات (36.6 ٪) و (37.3 ٪) على التوالي مع الأخذ بعين الاعتبار عدم وجود أية تغييرات في هطول الأمطار.

ولكن إذا غيرت جميع معالم المناخ، فان التغييرات سوف تكون أكثر أهمية،(41.7 ٪) ستكون التغييرات إذا اقترنت الزيادة في درجة الحرارة (+3 درجة مئوية) وانخفاض في هطول الأمطار (−30 ٪).

كذلك، فحص تأثير زيادة درجة الحرارة على متطلبات الري، و تحليل النتائج اظهر أن الدافع الرئيس لزيادة متطلبات الري هو الزيادة في درجة الحرارة. تحليل الحساسية على القمح (على سبيل المثال) أظهر زيادة درجة الحرارة بنسبة (+1 و +2 و +3 درجة مئوية)، ويستند التحليل إلى النتيجة التي تم الحصول عليها خلال السنوات العشر الماضية، وكانت النتيجة ؛ (499.41 مم) ، (514.61 ملم) و (530.13 ملم) وهي كمية المياه اللازمة لمحاصيل القمح من اجل الحصول على العائد الأمثل للإنتاجية، ولكن بانخفاض هطول الأمطار بنسبة (10 ٪ و 20 ٪ و 30 ٪) فإن كمية المياه المطلوبة هي (506.54 مم) ، (517.38 مم) ، (531.74 ملم) على التوالي. وأظهرت النتائج بوضوح أن سيناريو ارتفاع

درجة الحرارة يزداد سوءا عندما يقترن بسيناريو انخفاض هطول الأمطار ، حيث يمثل ازدياد درجة الحرارة بمقدار ثلاث درجات مئوية ونقصان الأمطار30 ٪ السيناريو الأسوأ.

هناك تغييرات كبيرة في نمط هطول الأمطار في محافظة جنين خلال السنوات العشر الماضية، هذه التغيرات الناجمة عن تغير المناخ تؤثر على توزيع الأمطار، وقد حللت جميع البيانات المتاحة على مدى السنوات العشر الماضية. أظهرت النتائج أن هناك اختلافات في معدل هطول الأمطار في الأشهر الآتية: كانون أول: حيث يظهر زيادة قليلة جدا؛ شباط، ازدياد ملحوظ ؛ فبراير، يظهر زيادة كبيرة؛ أبريل/نيسان، الذي يظهر زيادة؛ تشرين الثاني/ نوفمبر، حيث يظهر زيادة كبيرة. والأشهر الآتية تظهر اختلافات في كمية سقوط الأمطار: آذار / مارس، يحتوي على انخفاض كبير ، أيار / مايو، انخفاض قليلا ؛ وأيلول / سبتمبر وأكتوبر، يظهران انخفاضا قليلا و ديسمبر/كانون أول ، يظهر انخفاضا ملحوظا، وخلال أشهر حزيران وتموز وآب لم يسجل أي هطول للأمطار في المنطقة.
ومن الواضح أن موسم الشتاء تحول قليلا نحو تشرين ثاني في بداية الموسم ونحو نيسان في نهاية الموسم.

وأخيرا، الخسائر الاقتصادية تزداد وفقا للزيادة في درجة الحرارة وانخفاض هطول الأمطار، على سبيل المثال؛ الخسائر التي حصلت في محصول القمح خلال العشر سنوات الماضية تقدر بحوالي 1,461,606 وفي حال ازدياد درجة الحرارة بمقدار درجة مئوية واحدة مع عدم تغير كمية الأمطار تكون الخسارة حوالي 1,495,110 دولار، فضلا على أن انخفاض هطول الأمطار يزيد من الخسائر الاقتصادية المتوقعة. وإذا لم تتغير درجة الحرارة مع نقصان الأمطار بنسبة 10٪ فان الخسائر ستكون 1,557,930 دولار ، لذلك سيكون هناك مضاعفة للتأثيرات إذا كان هناك دمج في التغيرات التي طرأت على درجات الحرارة وهطول الأمطار.