

The Impact of Climate Change on Rain-Fed Agriculture of Field Crops in Ajloun Governorate

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Abstract

The study aimed to study the impact of climate change on rain-fed agriculture of field crops in Ajloun Governorate, which numbered approximately (6554) farmers, and the study population included all farmers of different demographic characteristics, areas and crops, and the researcher followed the random sample method in distribution, where she distributed (362) copy of the questionnaire to the study sample. The researcher used the statistical analysis program, 25SPSS, to analyze the data collected from the study tool, and used descriptive statistics represented by arithmetic mean, standard deviation, percentages, frequency, relative importance, analysis of Cronbach alpha coefficients, and simple linear regression analysis.

The results showed that there is knowledge and awareness among the sample members of climate change and its phenomena. The vast majority had yes answers to a change in some weather phenomena. There has been a change at the beginning and end of winter over the past years. There is also a change in temperatures. The results showed from the point of view of the sample members. The level of climate

change impact has a role on the productivity of rain-fed field crops is high, as it achieved an arithmetic average of (3.80), which is within the high relative importance, and in the year (2015) it achieved the highest rainfall rate, while the lowest rainfall rate was in the year 2000, and the highest temperature was recorded in the year (2016) where it reached (18.2) degrees Celsius, while the lowest temperature was in the year (2000), when it reached (12.7) degrees Celsius. The study recommended the creation of a flexible plan to manage the production of rain-fed field crops according to the emerging conditions of climate change.

Keywords: Climate Change, Field Crops, Rain-Fed Agriculture, Ajloun.

1. The General Framework of the Study

1.1 Introduction:

Climate change is considered one of the most pressing issues of our time due to its harmful effects on all areas of development, most notably water scarcity, drought, severe fluctuations in sea levels, plant life, and mass extinction. Human activities often cause climate change by increasing the amount of greenhouse gases in the atmosphere, which trap more heat (Jordanian Ministry of Environment, 2022).

The Jordanian agricultural sector is characterized by the diversity of its production methods and techniques, playing a vital role in enhancing economic performance and promoting food security in the kingdom. It contributes directly and indirectly to various productive and service sectors, increasing production and employment, and improving levels of self-sufficiency. Additionally, it boosts investments, supports exports, and reduces imports. However, despite its significance, the agricultural sector's contribution to the GDP and its performance indicators are noticeably affected by weather conditions and some internal factors related to the nature of agricultural production. The sector contributes approximately 5.6% of the GDP at current market prices. In 2022, the value of agricultural exports was around 15.2%

of total exports, amounting to 711 million Jordanian dinars (Jordanian Ministry of Agriculture, 2022).

Jordan, like other countries in the world, is affected by the ongoing wave of climate change. Evidence of this includes the drying up of the Azraq Oasis due to a lack of water, and the decreasing levels of the Dead Sea caused by the drying up of the tributaries that supply it with water (National Center for Agricultural Research, 2022).

1.2 The Study Problem and Questions:

The areas cultivated with rainfed crops fluctuate from year to year, suggesting varying temporal and spatial relationships between the cultivated areas of these crops and the influence of different geographical factors. Moreover, agricultural policies have contributed to the decline in the cultivation of field crops.

The latest statistics from the Jordanian Ministry of Agriculture (2022) show a significant decrease in rainfall and a rise in temperatures, affecting rainfed crops due to water shortages and drought. As a result, rainfed agriculture is greatly impacted, as it relies entirely on climate conditions.

Based on the study problem, this research aims to answer the following main question: What is the effect of climate change on rainfed agriculture in Ajloun Governorate? The main question is further divided into the following sub-questions:

- What is the level of awareness of farmers in Ajloun Governorate about climate change?
- What is the extent of climate change in Ajloun Governorate?
- What are the main climate impacts on rainfed agriculture in Ajloun Governorate?
- What is the rainfall and temperature trend in Ajloun Governorate from 2000 to 2023?

1.3 Study Objectives:

The primary objective of this study is to demonstrate the impact of climate change on rainfed field crop agriculture in Ajloun Governorate. To achieve this goal, the study will address the following secondary objectives:

- Determine the level of awareness among farmers in Ajloun Governorate about climate change.
- Analyze the extent of climate change in Ajloun Governorate.
- Identify the trends of rainfall and temperatures in Ajloun Governorate during the period from 2000 to 2023.
- Understand the demographic characteristics of the study sample.

1.4 The Importance of the Study:

A- Scientific Importance:

The scientific importance of this study stems from the critical role the agricultural sector plays in the national economy and the significance of field crops.

The study focuses on understanding the reasons why farmers are reluctant to cultivate strategic crops such as wheat and barley, which are key to food security. Despite the state's efforts to increase self-sufficiency in these crops, local production has dropped to just 3%. Currently, the total annual production of wheat and barley stands at 20,000 and 35,000 tons, respectively, while the country consumes 1 million tons of wheat and 750,000 tons of barley each year. Comparing the quantities of imported barley, it is noticeable that imports have risen from 120,000 tons annually in the mid-1980s to more than 750,000 tons today. Additionally, about 1 million tons of wheat are imported annually.

B- Practical Importance:

The study is vital as it addresses the significant negative impacts of climate change, particularly the pressures it exerts on food security.

The results and recommendations of this study could open avenues for researchers to conduct similar studies in other regions of Jordan.

This study will contribute to improving national agricultural strategies to mitigate the effects of climate change on agricultural productivity in general and field crops in particular in Jordan.

1.5 Study Boundaries:

- **Subject Boundaries:** The study addresses climate changes and their effects on rainfed agriculture of field crops in Ajloun Governorate.
- **Human Boundaries:** The study is applied to a sample of farmers cultivating rainfed field crops in Ajloun Governorate.
- **Temporal Boundaries:** The study relies on primary data collected between mid-February and the end of March 2024.

2. Previous Studies and Theoretical Framework

2.1 Theoretical Framework:

This chapter aims to define the concepts related to the impact of climate change on rainfed agriculture of field crops in Ajloun Governorate. It seeks to establish a coherent theoretical framework that serves as the foundation for the field study. This chapter is divided into two sections: the first addresses the theoretical framework, including concepts and knowledge related to climate change, rainfed agriculture, and field crops, while the second reviews the most important previous studies on the topic of the research.

2.1.1 Climate Change:

Climate change is one of the most important environmental issues due to the increasing human activities and the growing consumption of traditional energy sources. Climate change has become a phenomenon that cannot be ignored due to the negative environmental impacts associated with the exploitation of natural resources (Al-Jubouri et al., 2020).

Therefore, climate change represents one of the major challenges of our time, as it has adverse effects on various developmental sectors. The most significant impacts include water scarcity, drought, dangerous fluctuations in sea levels, plant life, and the mass extinction of animal and plant species, in addition to affecting human societies. Climate change, in general, occurs due to human activities that increase the concentration of greenhouse gases in the atmosphere, which traps more heat (Yang et al., 2022).

2.1.2 Concept of Climate Change:

Climate change refers to long-term shifts in temperature and weather patterns. These shifts may be natural, such as changes in the solar cycle. However, since the 19th century, human activities have been the primary driver of climate change, primarily due to the burning of fossil fuels like coal, oil, and gas. The burning of these fuels releases greenhouse gases, which act like a blanket around the Earth, trapping the sun's heat and raising temperatures.

Examples of greenhouse gas emissions that cause climate change include carbon dioxide and methane. These gases are produced, for example, from the use of gasoline to power cars or coal to heat buildings. (Oliver, 2021).

Thus, climate change refers to a long-term alteration in the climate that can be identified by changes in the average or variability of climate elements. This change

can last for a long period, and over time, refers to any shift in climate, whether resulting from human activities or natural changes.

2.1.3 Climate Change Indicators:

Climate change, accompanied by changes in various environmental phenomena, has always been a topic of debate and discussion among scientists. Observational records show significant recent changes in key climate elements such as temperature, precipitation, atmospheric humidity, air pressure, and wind, as well as ice cover, both continental and maritime, and rising sea levels. Data also indicate that the solar radiation entering the Earth's atmosphere is not constant but rather fluctuates. These fluctuations may be due to changes in the tidal forces exerted on the sun by planets, which can lead to variations in the amount and characteristics of the solar radiation reaching the Earth's surface (Aziz & Abdullah, 2015).

- First: Indicators of Temperature Changes:

Statistical analyses of meteorological station data indicate that the rise in temperature during the 20th century is the greatest among centuries in the past millennium. The 1990s and the beginning of the new millennium represent the most extreme periods of heat on Earth's surface, with 1998 being one of the hottest years. The third report of the Intergovernmental Panel on Climate Change (IPCC) for the year 2001 indicated that the global average temperature increased by about 0.74°C from 1906 to 2005. Analyses have shown that the increase in the frequency of these changes leads to significant changes in temperature extremes, with research indicating a major reduction in the number of cold days by about 75% in mid-latitudes, compared to a 10% increase in hot days during the period from 1951 to 2003. It is noteworthy that the increase in land temperature is more than that over water bodies. The rise in ocean temperature from 1950 to 1990 was half the average air temperature on Earth's surface. On average, the daily minimum temperatures over land increased at twice the rate of the daily maximum

temperatures between 1950 and 1993, leading to changes in the timing of seasons with no frost occurring in many mid-latitude and high-latitude areas. These changes, which result in many extremes in climate elements, are expected to have a significant negative impact on human health and comfort.

- **Second: Indicators of Changes in Precipitation:**

Climatic studies have indicated that changes in precipitation amounts, if they occur in a region, will be more significant than changes in temperature, which rise within a limited range, possibly by a fraction of a degree or more from the general average. In contrast, precipitation amounts may increase or decrease by tens or hundreds of millimeters, and its occurrence is usually more variable compared to temperature. (Al-Zoubi, 2022).

- **Third: Indicators of Changes in Extreme Weather Events:**

Extreme weather events, such as hurricanes and tropical storms, are linked to global warming. The IPCC has given significant attention to these phenomena due to the large harmful effects caused by such hurricanes and storms. The third report of the IPCC for the year 2011 mentioned the difficulty of tracking hurricanes and tropical storms over long periods due to their occurrence in various parts of the world and their irregular timing, as well as the lack of scientific documentation of these phenomena compared to other climate elements (air temperature and precipitation), where records and measurements are available for several climate cycles. Long-term information on hurricanes and storms provided by historians in their writings cannot be relied upon to track and develop these phenomena and reach results that document the link between global warming and the increase or decrease in the frequency of hurricanes and tropical storms. The National Oceanic and Atmospheric Administration (NOAA) has developed a measure for hurricane energy, known as the "Accumulated Cyclone Energy" (ACE), which essentially measures the sustained wind power over a period of six

hours in a specific location. It is a broad spectrum that combines the temporal extent and intensity of the phenomenon and is based on satellite data to calculate this measure. (Rwashdeh, 2022).

2.1.4 Climate Changes in Jordan:

Jordan has participated in many international agreements aimed at adapting to and mitigating the impacts of climate change both within the kingdom and globally. According to the 2020 IPCC report, Jordan is one of the countries most vulnerable to drought due to climate change.

Jordan is experiencing unusual rainfall and changes in temperature. An increase in the annual average temperature and a decrease in precipitation rates have been observed over the past fifty years in the capital, Amman. In the coming decades, it is expected that the intensity of climate disruptions in Jordan will increase, posing a threat to economic and social gains. These transformations will have severe and widespread impacts on Jordan's natural and human systems, affecting not only water supplies and crop productivity but every aspect of life (Assaf, 2020).

The negative impacts of climate change, along with recurrent droughts, will lead to climate migration toward the capital, Amman, where safer water sources are available. It is expected that the country's farmers will either leave their lands or shift from agriculture to other uses.

According to Jarrar (2022), Jordan has witnessed significant climate changes over the years that have greatly affected natural resources, agriculture, food security, and various aspects of life. Key indicators of these changes over the past sixty years include:

- Annual rainfall rates have decreased by 30%, while drought has tripled.
- Minimum temperatures have increased by 0.4–2.8°C, and maximum temperatures by 0.3–1.8°C.

- The number of rainy days has decreased by 3–10%, averaging 30 days in recent years.
- Per capita water availability has decreased from 3500 m³ in 1950 to 130 m³ in 2023.
- Water production has decreased from 205 million cubic meters in 1975 to about half in 2021.
- Environmental violations, such as illegal logging, grazing, forest fires, and increased pressure on wildlife, have been recorded.
- Jordan experiences unprecedented heatwaves annually, with temperatures rising up to 12°C above the annual average for up to seven days a year at best.
- Crop productivity has declined in quantity and quality, accompanied by seasonal shifts and increased pest infestations and plant diseases.
- Climate change has led to more than 103 vertebrate species being threatened with extinction, with 25 species listed in the International Union for Conservation of Nature's Red List.
- Livestock production has decreased, and the cost of raising animals, especially cattle and sheep, has increased, resulting in very low economic returns. There is insufficient information on the impact of climate change on camels and goats in Jordan.

All indicators suggest that climate change in Jordan affects all aspects of life, and there is an urgent need for a national strategy to address it. (<http://www.jpu.edu.jo/newsletter/?p=324875>)

2.2 The Agricultural Sector in Jordan and Its Impact on Field Crop Production:

2.2.1 Introduction:

The agricultural sector in Jordan is considered a productive sector, with agriculture playing a significant role in economic and social development. It is closely linked to the system of life and its sustainability. The agricultural sector is fundamental in

determining the way of life and the income level of individuals, and it is a source of food and social security (Al-Qurashi & Al-Zamli, 2020). This sector contributes approximately 5.1% to the GDP in 2019. It is particularly important in rural areas, representing a source of income for about 80,000 households in both rural and urban areas (Department of Statistics, 2020).

The Hashemite Kingdom of Jordan has an area of approximately 89,000 km², characterized by a Mediterranean climate that is dry and semi-dry. Average rainfall does not exceed 150 mm over 90% of its area, with about 5.5% of Jordan being arid land where rainfall does not exceed 300 mm annually. In northern highlands, rainfall can exceed 300 mm, reaching up to 600 mm. Rainfall is characterized by variability from year to year and uneven distribution across regions (Al-Warsan, 2021).

2.2.2 Dryland Farming:

The significance of dryland farming, with water as a major constraint worldwide, lies in the fact that more than 80% of the cultivated area depends solely on rainfall. The importance of dryland farming varies from region to region; in Latin America, about 87% of the cultivated land is dryland, while in the Middle East and North Africa, it is 67%, in East Asia, it is 65%, and in South Asia, it is 58%. Dryland farming is most prominent in sub-Saharan Africa, where 96% of the cultivated land is used for dryland farming. Dryland farming can be highly productive across almost all water and climatic regions. (FAO, 2022).

On the other hand, the current challenges in managing water in dryland production systems, which suffer from water scarcity along with other changing factors like population growth, are expected to increase. Climate change is anticipated to heighten the need for improved water management in these areas. Climate forecasts suggest that water resources could be severely affected by climate change. Potential impacts include changes in precipitation patterns and intensity, extreme weather

events, reduced snow cover, widespread glacier melt, and changes in soil moisture and surface runoff. Agricultural productivity in dryland areas critically depends on the temporal and spatial dynamics of rainfall, which must be sufficient to meet evapotranspiration requirements and associated soil moisture distribution. (FAO, 2022).

2.2.3 Dryland Farming in Jordan:

In Jordan, cultivated land for dryland farming occupies 87% of the total area. The main goal of dryland farming research is to achieve the highest economic yield for such lands by optimizing rainwater use and improving its efficiency. (<http://www.ncare.gov.jo>).

According to the General Statistics Department (2017), the cultivated area varies from year to year due to fluctuations in dryland areas planted with field crops. The cultivated area with field crops ranged between 7,367.315 thousand dunams in 2017, of which 76.8418 thousand dunams were irrigated and 65.9887 thousand dunams were dryland, with the harvested area being 520.0523 thousand dunams. In comparison, the area in 2016 was 1,345.8603 thousand dunams, including 89.1783 thousand dunams irrigated and 1,240,663.9 thousand dunams dryland, with the harvested area being 655.6116 thousand dunams. This fluctuation in cultivated areas is due to dependence on rainfall, as more than 90% of field crop areas are dryland, due to the economic or financial viability of these crops under limited water resources.

To achieve the best results, the Dryland Farming Research Program has developed an action plan aligned with the National Center for Agricultural Research and Extension's strategy. This plan includes achieving overall agricultural development goals in Jordan and specific objectives for dryland farming. Key elements of this plan are natural resource conservation and management, development of genetic plant resources, management and development of agricultural production, and

conducting socio-economic studies. This action plan is implemented in two main phases: the first phase (short-term) involves developing new high-yielding, drought-resistant strains that are adapted to local climatic conditions, introducing modern and appropriate agricultural techniques, and educating farmers through observations and extension programs. It also involves collaborating with local, regional, and international scientific institutions and exchanging information and expertise to identify the best agricultural practices to increase and improve agricultural production. (Ministry of Agriculture, 2023).

The second phase (long-term) includes increasing the cultivated area in Jordan for agricultural crops, striving for self-sufficiency in some crops, reducing trade deficits, and using modern technologies to improve plant production.

Field Crops in Ajloun Governorate:

Ajloun is considered an important agricultural area in Jordan due to its topography and climate diversity. The land in Ajloun ranges from mountainous areas more than 1500 meters above sea level to lowlands 400 meters below sea level. Water availability is a significant factor for agriculture, with abundant rainfall in the winter on the highlands and numerous flowing wadis and springs in Ajloun.

Important crops in Ajloun include various cereals, some vegetables, olives, figs, grapes, apples, lemons, and pomegranates. (Ajloun Agriculture Directorate, 2023).

Agriculture in Ajloun mainly relies on rainfall, with an average of more than 522.2 mm of precipitation. Rainfall is crucial for replenishing water sources such as dams, groundwater, and springs. Ajloun has four dams, all dependent on seasonal rainfall. These dams collect water from rivers, rainfall, and springs.

Groundwater sources in Ajloun include:

- Spring and spring water, with 61 springs surrounding which fruit trees, especially olives, pomegranates, figs, and grapes, are cultivated.

- Artesian wells, with 49 wells surrounding which vegetables and a few trees are cultivated. (Ajloun Agriculture Directorate, 2023).

2.2.4 Distinctiveness of This Study:

Compared to previous studies, this research focuses on one of the most important sectors in Jordan, namely agriculture, and its environmental impacts. It highlights the effects of climate change on dryland crops in Ajloun Governorate. Previous studies have addressed isolated relationships between one or two variables, while this study aims to explore the correlational and causal relationships between independent and dependent variables to reach new scientific results. It seeks to provide a comprehensive framework for understanding climate change impacts on dryland farming, exploring new aspects not covered in previous literature, and applying them to crop cultivation. This represents a comprehensive model presented by this study.



Figure (1): illustrates the map of Ajloun Governorate.

(Source: /https://moi.gov.jo/AR/Pages)

3. Discussion of Recommendations and Results

3.1 Discussion of Results:

The study reached several conclusions after analyzing the data and testing hypotheses as follows:

- The results showed differences in gender among the sample of farmers. Male farmers were predominant with a count of 233 individuals, accounting for 65.4%, while female farmers numbered 129, making up 35.6%. This is attributed to a higher reliance on male farmers in agriculture, although recent years have seen increased attention to training and involving women in field farming.
- The age group 25 to less than 35 years had the highest representation among the sample, with 131 individuals, or 36.2%. This was followed by the 35 to less than 45 years age group, with 93 individuals, or 25.7%. The lowest count was for those aged 55 years and above, comprising only 67 farmers or 18.5%. This indicates that most farmers are young, reflecting their investment of energy and expertise in field farming.
- Those with a bachelor's degree had the highest percentage, at 36.2%, with 131 individuals. This was followed by those with a high school diploma, who numbered 120, or 33.1%. This result is logical given that Jordan is an educated society that values academic qualifications, with bachelor's degrees being most prevalent.
- Farmers specializing in agriculture had the highest percentage, with 271 individuals, or 74.9%. This indicates that most farmers have scientific and practical expertise, contributing to the development and flourishing of field farming.
- Those with 5 to 10 years of experience had the highest percentage, with 151 individuals, or 41.7%. This was followed by those with 11 to less than 15 years of

experience, totaling 118 individuals or 32.6%. The lowest count was for those with 16 years or more of experience, with only 64 farmers or 17.7%. This shows that most farmers have sufficient experience to handle field crops.

- Those working solely in agriculture had the highest percentage, with 221 individuals, or 61%. The lower percentage was for those who rely on agriculture and other sources, comprising 141 individuals or 39%. This indicates that most farmers in Ajloun depend solely on their agricultural income, while a smaller percentage relies on additional sources.
- Results showed that 98.3% had heard of climate change. Of these, 98% observed changes in the beginning and end of winter and summer over recent years, 97% noted changes in temperatures during the season, 92% reported changes in rainfall rates in recent years, and 91% noticed changes in rainfall intensity and distribution. This indicates significant awareness and monitoring of climate change.
- The results showed that the level of climate change impact in Ajloun Governorate was high, affecting field crops. The study found a statistically significant effect of climate change on dryland crops in Ajloun, suggesting that increasing climate change impacts are clearly visible on dryland crops in the governorate.
- The average rainfall in Ajloun from 2000 to 2023 was consistent, as Ajloun is a mountainous area with higher rainfall than other regions. However, temperature averages varied, with the highest being 18.2°C. This indicates the impact of climate change on field crops in Ajloun.

The researcher notes that climate change significantly affects future agricultural production patterns, including:

- Decreased soil moisture available for crops in dryland areas.
- Increased water requirements for crops.

- Increased competition between crops and weeds.
- Reduced stream flow.
- Changes in rainfall intensity with potential for more flooding.
- Shortened growing seasons.
- Decreased yields of dryland crops.

These results align with studies by Younis (2022) and Anbar (2021).

3.2 Recommendations:

The study recommends the following actions:

1. Develop an awareness plan for dryland crop farmers in the study area about the significant impacts of climate change and increase their knowledge about climate changes.
2. Create a flexible plan for managing the production of dryland crops according to the evolving climate change conditions.
3. Empower farmers by increasing learning and training opportunities and seeking advice and guidance on dryland crop farming.
4. Disseminate agricultural innovations and updated methods from scientific research through the Ministry of Agriculture and enhance the role of agricultural extension by organizing seminars and training programs to help farmers quickly adopt these innovations to address and adapt to climate change impacts on agricultural production.
5. Consider the financial risks associated with agricultural production activities under climate change, while maintaining necessary records to document the economic aspects of dryland crop cultivation (output, revenue, costs, profits).
6. Enhance the implementation of government regulations and laws aimed at mitigating climate change impacts on dryland crops.

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