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Effect of Climate Change on Agriculture in Nimruz Province and its Relationship with the Development of Rural Areas

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ABSTRACT

Climate change poses a critical challenge to Afghanistan's agriculture by reducing water resources, increasing temperatures, and altering rainfall patterns, all of which threaten food security and rural development. Despite the vulnerability of Afghanistan's agricultural sector, there is limited empirical research assessing how climate change explicitly affects agriculture in Nimruz Province and its implications for rural development, leaving a critical gap in localized evidence. This study investigates the impact of climate change on agriculture in Nimruz Province. The statistical population included employees of the Department of Agriculture, the Agricultural High School, the Faculty of Agriculture at Nimruz Institute of Higher Education, and local farmers (N=100), from which 80 participants were selected using Cochran's formula and convenience sampling. Data were collected through a 35-item questionnaire validated by agricultural experts, with a Cronbach's alpha coefficient of 0.8 confirming strong reliability. As an applied, descriptive-analytical, and survey-based study, data were analyzed in SPSS using descriptive statistical methods. The results show that climate change has a considerable impact on agriculture in Nimruz Province, with the most potent effects observed in agricultural production and the weakest in cultivation methods. The study concludes that climate change has a significant impact on agriculture in the region, and it recommends implementing sustainable resource management, promoting modern agricultural technologies, and raising farmers' awareness to mitigate adverse effects and enhance resilience.

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INTRODUCTION

Climate change is one of the significant global challenges that directly and indirectly affects agriculture and agricultural production. Increasing temperatures, changes in the rainy season, successive droughts, and the occurrence of natural disasters threaten food security and pose many challenges to the livelihoods of farmers (Mendelsohn, R., 2009). The main problems that climate change has created for agriculture are reduced soil fertility and reduced crop yields (Aydinalp & Cresser, 2008). The Food and Agriculture Organization of the

United Nations (FAO) has reported that "climate change is reducing crop and horticultural production by an average of 10 to 25 percent in some regions of the world" (FAO, 2021). This has had a particularly profound impact on developing countries, whose economies are heavily dependent on agriculture (Mendelsohn, 2014).

Climate change has not only reduced crop yields but also increased production costs, reduced farmers' income, threatened food security, and raised food prices in global markets (Calzadilla et al., 2013). The spread of pests and diseases due to temperature changes has created greater risks for agricultural production (Adams et al., 1998). These challenges have led to the migration of farmers, the emergence of social tensions, and an increase in poverty in rural communities (Kalra et al., 2007).

In recent years, various studies have been conducted on the impact of climate change on agriculture. Many countries have implemented programs to increase the resilience of crops to climate change (Venables, 2016). The use of drought-resistant varieties, optimization of irrigation systems, and the development of innovative agricultural technologies have been implemented in some countries. Despite these efforts, significant challenges remain in combating climate change in the agricultural sector (Parry, 1989). Many of the proposed methods require further improvement and development. Moreover, sufficient programs to raise awareness among farmers and effective policies to reduce the effects of climate change have not been fully implemented (Carter et al., 2018).

Climate change represents one of the most pressing global challenges facing the agricultural sector today. It exerts both direct and indirect impacts on agricultural productivity, soil fertility, water resources, and ultimately, food security. Rising global temperatures, irregular and reduced rainfall, prolonged droughts, and an increasing frequency of natural disasters, such as floods and storms, threaten the sustainability of agricultural systems and rural livelihoods (Calzadilla et al., 2013). These environmental stressors disrupt crop growth cycles, reduce photosynthetic efficiency, and hinder traditional farming practices, particularly in vulnerable regions such as Nimruz Province in southwestern Afghanistan.

Numerous studies have confirmed that climate change significantly affects crop yields and agricultural productivity worldwide (Iglesias et al., 2009). Increased temperatures and heat stress lead to rapid plant development, grain shrinkage, and a reduction in crop quality. These factors, coupled with declining soil fertility and water scarcity, result in the degradation of farmland (Karimi et al., 2018). In many regions, including arid zones such as Nimruz, a persistent decline in rainfall has led to decreased photosynthesis and stunted plant growth, making it difficult or impossible to cultivate traditional crops (Ahmad & Hassen, 2011).

In addition to affecting crop growth directly, climate change intensifies the presence of pests, diseases, and invasive species. Increased atmospheric carbon dioxide levels, along with rising temperatures, create favorable conditions for pest outbreaks, wind and soil erosion, and the degradation of grasslands (Adams et al., 1998). Irregular rainfall patterns, flash

floods, and storms disrupt planting and harvesting schedules, reducing farmers' ability to bring produce to market in time (Kouchaki & Nasiri Mahallati, 2016). These issues are particularly relevant to regions like Nimruz, where agriculture is the primary source of livelihood (Ahmad et al., 2011).

Further evidence shows that rising temperatures and decreased precipitation severely limit agricultural output by diminishing soil moisture, microbial activity, and access to surface water resources (Mahato, 2014; Arora, 2019). Increased evapotranspiration rates accelerate the drying of soil and plant surfaces, thereby exacerbating water scarcity. Rivers and dams that provide critical irrigation are drying up due to prolonged droughts, leading to a water crisis that jeopardizes farming operations (Mehtab et al., 2022). These environmental challenges are compounded by changes in crop phenology, including disruptions to the flowering and ripening stages in crops such as wheat, barley, and rice. Insect infestations like desert locusts, intensified by warmer climates, have devastated large areas of farmland and contributed to food shortages (FAO, 2021).

The economic consequences are equally severe. As agricultural yields decline, the resulting rise in market prices can increase consumers' financial burden, while in some cases providing farmers with higher revenues from their products. In rural economies heavily reliant on agriculture, shocks such as declining yields, water scarcity, and reduced farm income exacerbate poverty, compelling farmers to migrate to urban centers in search of alternative livelihoods (Ameri, 2024). Climate change also brings broader environmental and socio-economic consequences. If greenhouse gas emissions remain unchecked, scientists estimate that nearly one-third of global cropland and pastureland could be rendered unproductive (Abdullah Zada, 2018).

Marine ecosystems are also affected. Ocean acidification, marine heatwaves, and saltwater intrusion are threatening fish stocks and seafood security in coastal regions (Kucheki & Mohalati, 2016). Prolonged droughts, melting glaciers, rising sea levels, and frequent natural disasters such as forest fires and hurricanes have intensified, inflicting damage on agricultural infrastructure and compromising human health and safety (Rezwani, 2025; Ahmadi et al., 2017). These changes significantly reduce the fertility and resilience of agricultural lands, intensify food insecurity, and increase the migration of rural populations (Habiburahman et al., 2022).

In response, farmers globally have begun implementing various adaptive strategies to mitigate the adverse effects of climate change. These include more efficient water resource management, adjustments to crop calendars, the adoption of drought-resistant crop varieties, and the integration of climate-smart agricultural technologies. Understanding these adaptive responses and their applicability in local contexts such as Nimruz is essential for developing targeted strategies that enhance agricultural resilience and ensure rural sustainability.

This research will examine the impact of climate change on agriculture, the challenges faced by farmers, and practical solutions to mitigate its negative impacts. It will also examine strategies for adapting to these changes and the role of new technologies in managing agricultural crises.

1. What are the perceptions of local farmers and agricultural experts regarding the effects of climate change on the growth and yield of crops in Nimruz Province?
2. In what ways do farmers and agricultural experts describe the impacts of decreased rainfall and increased temperature on crop production in Nimruz Province?
3. What problems caused by climate change have most affected the farmers of Nimruz Province?
4. What measures have been taken so far by farmers and related institutions to combat climate change in this region?

METHODS AND MATERIALS

The present study is applied in terms of its purpose, employing a descriptive-analytical and survey method. The statistical population in this study includes employees of the Department of Agriculture, Agricultural Vocational High School, Faculty of Agriculture of Nimruz Institute of Higher Education, and several farmers (N=100). A sample of 80 people was selected using the Cochran sample, which was chosen through the convenience sampling method. This approach allowed for easy access to respondents within the study area, given the time and resource constraints, and data were collected through a questionnaire.

The research questionnaire consisted of 35 questions, and the opinions of agricultural experts were used to measure the validity of the questionnaire. The reliability of the questionnaire was assessed using the Cronbach's alpha coefficient, which indicated strong reliability of the research tool. Data collected through the questionnaire were analyzed using the SPSS program. Descriptive statistics (average) methods were used to determine the effectiveness of the impact of climate change on agriculture in Nimruz province.

Table 1*. Cronbach's alpha coefficient (n = 80)*

No	Number of Questions	Cronbach's alpha coefficient
1	29	0.857

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

FINDING

Descriptive findings include age, education level, work experience in the agricultural sector, area of agricultural land, primary source of agricultural water, and occupations of family members in agricultural matters, which are listed in the table below:

***Table 2**. Characteristics of research participants (n = 80)*

Variable		Number	Percentage
Age	Under 20 years	0	0.0
	21-30 years	43	53.8
	31-40 years	14	17.5
	41-50 years	20	25.0
	More has been done in 50 years	3	3.8
	Total	80	100
Education	Illiterate	15	18.8
	Elementary	13	16.3
	Intermediate	6	7.5
	Baccalaureate	18	22.5
	Bachelor	28	35.0
	Total	80	100
Work experience in the agricultural sector	Less than one year	23	28.7
	1-2 years	11	13.8
	3-4 years	13	16.3
	5-6 years	15	18.8
	More than 6 years	18	22.5
	Total	80	100
Area of agricultural land	One Acre	18	22.5
	1-5 Acre	4	5.0
	3-5 Acre	22	27.5
	5-8 Acre	11	13.8
	More than 8 acres	25	31.3
	Total	80	100
The primary source of agricultural water	Ground water	18	22.5
	Well	27	33.8
	Sea	29	36.3
	Aqueduct	0	0
	Others	6	7.5
	Total	80	100
Other family members are busy with Agriculture	Yes	63	78.8
	No	17	21.3
	Total	80	100

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

The demographic profile of the respondents indicates that the majority were young adults, primarily within the 21–30 age range. Educationally, most participants held at least a baccalaureate or bachelor's degree, though a portion of the sample also included individuals with lower educational attainment or no formal education. In terms of professional experience in the agricultural sector, many respondents were relatively new to farming, with a notable proportion having less than one year of experience. However, there was also a substantial presence of individuals with extended experience.

Land ownership among participants was diverse, with many owning medium to large-scale agricultural land. Rivers were identified as the most common source of irrigation, followed by wells and groundwater. Additionally, most respondents reported that other family members were also actively involved in agricultural work, indicating a household-level engagement in farming activities.

Table 3*. Mean values of variables for the impact of climate change on agriculture and rural development in Nimruz Province (n = 80)*

No	Question	Totally agree	Agree	Natural	Disagree	Completely disagree	Average
1	Air temperatures have increased in recent years	56	22	0	2	0	4.65
2	Annual rainfall in Nimruz has decreased	69	11	0	0	0	4.86
3	Droughts have become more frequent and severe in recent years	62	16	2	0	0	4.75
4	Sandstorms and strong winds have increased in Nimruz Province	56	20	4	0	0	4.65
5	The rate of water evaporation from the earth's surface has increased more than in the past	49	29	2	0	0	4.59
	Overall average: 4.7						

Source: Research findings, The impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year (1403).

Analysis of the variable impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas: According to the findings of Table (3), based on the results obtained on the variable impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas, which is equal to 4.7, which is higher than the average (3), it can be concluded that the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas is at a high level. Accordingly, the results show that its most tremendous impact is the reduction in annual rainfall (4.86), and its least impact is the increase in the rate of water evaporation from the surface of the earth in Nimruz province (4.59).

Table 4*. Mean values of variables for the impact of climate change on agricultural production and rural development in Nimruz Province (n = 80)*

No	Question	Totally agree	Agree	Natural	Disagree	Completely disagree	Average
1	Climate change has caused a decrease in the area under cultivation	50	27	3	0	0	4.59
2	Drought has reduced soil fertility	40	40	0	0	0	4.50
3	Increasing air temperatures have reduced the quality of agricultural products	60	20	0	0	0	4.75
4	The lack of water resources has reduced the yield of crops	52	28	0	0	0	4.65
	Strong winds have caused damage to crops	62	16	2	0	0	4.75
	Overall average: 4.648						

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

Analysis of the variable of the impact of climate change on agricultural production in Nimruz province and its relationship with the development of rural areas: According to the findings of Table (4) and based on the total average obtained for the variable of the impact of climate change on agricultural production in Nimruz province and its relationship with the development of rural areas, it shows that 4.648, which is higher than the average (3), it can be concluded that the impact of climate change on agricultural production in Nimruz province and its relationship with the development of rural areas is at a high level. Based on the findings of the research results, it is determined that its most tremendous impact is due to the increase in temperature and strong winds, which reduce the quality of agricultural products and damage to products (4.75), and its least impact is due to drought, which reduces soil fertility (4.50).

Table 5. *Mean values of variables for the impact of climate change on soil and water resources and rural development in Nimruz Province (n = 80)*

No	Question	Totally agree	Agree	Natural	Disagree	Completely disagree	Average
1	Reduced rainfall has led to a shortage of water for irrigation	59	21	0	0	0	4.74
2	Floods and erratic rainfall have caused soil erosion	46	28	0	4	2	4.40
3	The reduction in vegetation cover has increased soil erosion	65	15	0	0	0	4.81
4	There is a shortage of water resources in Nimruz Province	54	19	7	0	0	4.59
5	Farmers in Nimruz Province do not have sufficient water resources to irrigate their agricultural crops	57	20	3	0	0	4.68
	Overall average: 4.644						

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

Analysis of the variable impact of climate change on soil and water resources in Nimruz province and its relationship with the development of rural areas: According to the findings of Table (5), and based on the total average obtained for the variable impact of climate change on soil and water resources in Nimruz province and its relationship with the development of rural areas, which is equal to 4.644, which is higher than the average (3), it can be concluded that the impact of climate change on soil and water resources in Nimruz province and its relationship with the development of rural areas is at a high level. Based on the findings of the study, it is determined that the most tremendous impact is in the area of increased soil erosion due to reduced vegetation cover (4.81), and the least impact is in the area of increased soil erosion due to floods and irregular rainfall (4.40).

Table 6. *Mean values of variables for the impact of climate change on agricultural crop planting methods and rural development in Nimruz Province (n = 80)*

No	Question	Totally agree	Agree	Natural	Disagree	Completely disagree	Average
1	Farmers in Nimruz Province have been forced to turn to growing drought-resistant crops	59	16	0	5	0	4.61
2	Climate change has increased irrigation costs	49	27	4	0	0	4.56
3	Some farmers have abandoned their lands due to the climate crisis	67	13	0	0	0	4.84
4	Farmers' use of modern irrigation methods (such as drip irrigation) has decreased	54	17	7	2	0	4.54
5	In Nimruz Province, recent droughts have harmed agricultural production	60	20	0	0	0	4.75
	Farmers in Nimruz Province are planning to manage water resources	49	19	7	5	0	4.40
	The soils of Nimruz Province are fully utilized for agriculture	52	12	0	9	7	4.16
	Overall average: 4.551						

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

Variable analysis of the impact of climate change on changes in agricultural crop cultivation methods in Nimruz province and its relationship with the development of rural areas: According to the findings of Table (6), and based on the total average obtained for the variable of the impact of climate change on changes in agricultural crop cultivation methods in Nimruz province and its relationship with the development of rural areas, which is equal to 4.551, which is higher than the average (3), it can be concluded that the impact of climate change on changes in agricultural crop cultivation methods in Nimruz province and its relationship with the development of rural areas is at a high level. Based on the findings of the study, it was determined that the most significant impact was in the area of abandonment of agricultural lands by farmers due to climate crises (4.84) , and the least impact was in the area of full use of lands for agriculture (4.16).

Table 7. *Mean values of variables for the impact of climate change on social and economic conditions and rural development in Nimruz Province (n = 80)*

No	Question	Totally agree	Agree	Natural	Disagree	Completely disagree	Average
1	The decline in agricultural production has led to an increase in the prices of agricultural products	61	19	0	0	0	4.76
2	Climate change has reduced farmers' incomes	52	28	0	0	0	4.65
3	Farmers have increasingly turned to non-agricultural jobs	52	24	4	0	0	4.60
4	Climate change has caused some farmers to migrate from Nimruz province	51	29	0	0	0	4.64
5	Farmers in Nimruz Province mostly use traditional farming methods	55	19	6	0	0	4.61
6	The agricultural products of farmers in Nimruz Province enjoy a good market	44	32	0	2	2	4.43
7	Diseases and pests have reduced sales of agricultural products	68	10	0	2	0	4.80
	Overall average: 4.641						

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

Variable analysis of the impact of climate change on social and economic conditions in Nimruz province and its relationship with the development of rural areas: According to the findings of Table (7), and based on the total average obtained for the variable of the impact of climate change on social and economic conditions in Nimruz province and its relationship with the development of rural areas, which is equal to 4.641, which is higher than the average (3), it can be concluded that the impact of climate change on social and economic conditions in Nimruz province and its relationship with the development of rural areas is at a high level. The research findings show that the most significant impact was in the sector of reducing the sale of agricultural products due to the presence of diseases and pests (4.80), and the least impact was in the sector of the existence of a market for agricultural products (4.43).

Table 8. *Perceived Impacts of Climate Change in Nimruz Province*

No	Variable	Average
1	Climate change in Nimruz province	4.7
2	The impact of climate change on agricultural production in Nimruz Province	4.648
3	The impact of climate change on soil and water resources in Nimruz Province	4.644
4	The impact of climate change on changes in agricultural crop cultivation methods in Nimruz Province	4.551
5	The impact of climate change on social and economic conditions in Nimruz Province	4.641
	Total	**4.636**

Source: Research findings on the impact of climate change on agriculture in Nimruz province and its relationship with the development of rural areas in the year 1403.

DISCUSSION

The findings of this study reveal a significant and multifaceted impact of climate change on agriculture in Nimruz province, with direct implications for rural development. The high overall mean score (4.636) indicates that respondents overwhelmingly perceive climate change as a serious challenge affecting various aspects of the agricultural system, including crop production, soil and water resources, cultivation methods, and the socio-economic stability of rural communities.

In response to the first research question regarding the overall impact of climate change on agriculture, the results show a substantial adverse effect. Climate variability, including rising temperatures, irregular rainfall patterns, and prolonged droughts, has disrupted traditional farming practices, reduced crop yields, and compromised agricultural productivity in the region.

These findings are consistent with previous studies. For instance, Calzadilla et al. (2013) and Iglesias et al. (2009) reported that climate change significantly alters rainfall patterns and affects global food production. Similarly, Karimi et al. (2018) and Ahmad and Hassen (2011) documented how heat stress leads to soil degradation and poor crop quality—issues also

observed in Nimruz.
The study reveals that decreased rainfall and increased temperatures have a direct impact on crop growth and yield. Farmers reported water shortages, reduced soil fertility, and increased incidence of crop diseases. Changes in cultivation methods, such as shifting planting dates or adopting drought-resistant varieties, were noted as coping strategies.

These results align with Mahato (2014) and Arora (2019), who emphasized the adverse effects of reduced rainfall and higher temperatures on agricultural productivity. Conversely, a few studies, if any conflicting studies exist, suggest that specific modern irrigation methods can mitigate temperature impacts, showing a partial divergence from our findings. Analysis indicates that water availability, soil fertility, and crop adaptability are under the most significant strain. Farmers highlighted prolonged droughts and irregular water supply as the main challenges. Loss of traditional crop varieties and the need to adopt new farming techniques were also emphasized.
These findings are corroborated by Mehtab et al. (2022), who analyzed drought-related challenges in arid regions. Ahmad and Hassen (2011) also reported soil degradation and low crop quality as primary climate-induced problems, which aligns closely with our observations. The study found that farmers have employed several adaptive measures, including adjusting crop calendars, utilizing drought-resistant varieties, and implementing water conservation techniques. Institutional support is limited, although some governmental programs provide technical guidance and irrigation assistance.
Rezvani (2025) and Habibur Ahman et al. (2022) also highlighted the role of adaptation strategies and institutional interventions in mitigating climate change impacts. However, our findings suggest that, in Nimruz, these measures are not yet sufficient to fully offset the adverse effects, indicating a gap between policy and practical implementation. Overall, the results of this study support the consensus in the literature that climate change severely impacts agriculture, especially in arid regions. The findings largely align with previous studies in terms of reduced rainfall, increased temperatures, soil degradation, and socio-economic consequences, including migration and poverty. Minor divergences exist concerning the effectiveness of adaptation strategies, highlighting the need for more targeted interventions in Nimruz.

CONCLUSION

The primary objective of this study was to examine the impact of climate change on agriculture in Nimruz Province and its relationship with rural development. Findings, based on a high overall mean score of 4.636, indicate that climate change exerts a significant influence across multiple dimensions, particularly agricultural production (mean = 4.648), followed by soil and water resources, cultivation practices, and socio-economic conditions. These results confirm that climate change has become a critical challenge for agriculture in the region, with profound implications for food security, rural livelihoods, and economic resilience.

To address these challenges, policymakers and development agencies should prioritize strategies such as introducing drought-resistant crop varieties, investing in irrigation infrastructure, providing farmer training on climate adaptation, and integrating modern agricultural technologies into traditional practices. Strengthening local institutions through subsidies, technical assistance, and knowledge dissemination is also crucial for enhancing resilience. This study is not without limitations. First, its focus on a single province may limit the generalizability of findings to other regions of Afghanistan. Second, reliance on self-reported perceptions could be influenced by temporary climatic fluctuations or individual biases. Finally, the absence of gender-specific analysis and limited exploration of institutional roles suggests important areas for future research.

AUTHORS CONTRIBUTIONS

- Naseer Mukhlis and Reza Joia conceptualized and conducted the study and collected the data.
- Naseer Mukhlis and Nasrullah Baluch wrote the manuscript with input from the third author.
- All authors reviewed and approved the final version.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

All data generated and analyzed during this study are included in this published article and its supplementary information files (Tables 1-8).

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