

An Empirical Evaluation of Climate Change Effects on Food Insecurity: Evidence from Zaranj, Nimruz, Afghanistan

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ABSTRACT

This study examines the impact of climate change on food insecurity among residents of Zaranj City, Nimruz Province, Afghanistan, using a descriptive-analytical approach. Data were collected through a structured questionnaire administered to 150 knowledgeable government employees in Nimruz Province. The questionnaire used in this study consists of three sections. The first section gathers personal information, the second includes Likert-scale questions, and the third contains open-ended questions that allow respondents to express their opinions. The quantitative data were analyzed using E-Views 9. The results reveal that climate change has a positive and statistically significant effect on food insecurity ($\beta = 0.2575$, $p = 0.0001$), indicating that increasing climate-related pressures contribute to higher levels of food insecurity. In contrast, political factors significantly reduce food insecurity ($\beta = -0.1574$, $p = 0.0199$), while economic factors show a marginally significant negative relationship ($\beta = -0.1139$, $p = 0.0542$). Qualitative findings highlight key adaptation and mitigation strategies, including improved water management, greenhouse expansion, afforestation, farmer training and support, regulation of food markets, and strengthened storage infrastructure. Overall, the findings emphasize the importance of integrated climate adaptation, agricultural support, and governance strategies in reducing food insecurity in climate-vulnerable regions. This study contributes to the growing body of evidence on climate-induced food insecurity in fragile settings and provides policy-relevant insights for improving food resilience in arid regions such as Nimruz Province.

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INTRODUCTION

Although substantial efforts have been made in recent years to reduce hunger worldwide, but food insecurity remains one of the most significant global challenges, particularly in less developed countries such as Afghanistan. According to the Food and Agriculture

Organization (FAO), approximately 925 million people worldwide faced difficulties in meeting their basic energy requirements in 2020. climate changes which has direct effect on food insecurity; moved beyond a purely environmental debate to become one of the most pressing developmental and humanitarian challenges (Fanzo et al., 2018; Gregory et al., 2005; Mirón et al., 2023; Parry & Swaminathan, 1992; Wheeler & Von Braun, 2013). Rising temperatures, irregular precipitation patterns, persistent droughts, dust storms, and flash floods disrupt the production, distribution, and accessibility of food, eroding households' resilience to price and livelihood shocks (Bedeke, 2023; Cramer et al., 2018; Hoffmann et al., 2022; Nyantakyi-Frimpong & Bezner-Kerr, 2015; von Braun et al., 2023; Yeleliere et al., 2023). In Afghanistan, particularly across the arid and semi-arid southwest, this vulnerability is more severe. Nimruz Province faces chronic water scarcity, recurrent droughts (Mukamana, 2024; Safi & Safi, 2024), and the 120-day winds (Alizadeh-Choobari et al., 2014; Darvishi Bolorani et al., 2022); which together pose among the most serious threats to resident's food security (Alami & Tayfur, 2022).

Food security is a key determinant of economic development, human development, productivity growth, and public health. Therefore, countries around the world strive to achieve and maintain an adequate level of food security to ensure sustainable development and improve the well-being of their populations. Food security is a multidimensional concept encompassing four pillars: the physical availability of food, economic and physical access, effective utilization/consumption with adequate nutrition, and stability over time (Peng & Berry, 2018). Climate change can undermine all four: by reducing agricultural and livestock productivity it diminishes supply (Mottet et al., 2017); through price shocks and income losses it weakens purchasing power (Ziervogel & Ericksen, 2010); by degrading water quality and increasing water-borne diseases it endangers safe utilization (Xia et al., 2015); and By increasing the frequency and intensity of extreme events, climate change undermines the stability pillar of food security (Mirzabaev et al., 2023). Beyond environmental stressors, governance quality, supportive policies, and household economic conditions can amplify or attenuate these pathways (Fanzo et al., 2021).

In Nimruz, prolonged drought and wind erosion, high rainfall variability and extreme events, combined with limited water-management infrastructure, households' economic vulnerability, and unequal access to services, have created fertile ground for food insecurity (Hamidianpour et al., 2021). Local accounts point to the 120-day winds, floods, and shortages of potable water, alongside unemployment and weak waste management, as major threats (Alizadeh-Choobari et al., 2014). Yet systematic, city-scale evidence that separates the relative contributions of climate change versus political and economic factors to food insecurity remains scarce an evidence gap this study seeks to address.

The expected findings can guide local and provincial policymakers in designing climate-adaptation strategies, livelihood-support programs, improved water and soil management, and targeted protective interventions such as subsidies, storage and reserve systems, and drought-resilient agronomic training. At the knowledge frontier, the study provides urban-

scale empirical evidence that considers the interacting influences of climatic, political, and economic drivers in Afghanistan's food security literature.

Within this framework, the overarching objective is to measure the effect of climate change on food insecurity in Zaranj and to explain the relative contributions of political and economic factors to that relationship. Specific objectives include:

- Estimating the direction and magnitude of the impact of the Climate Change Index on the Food Insecurity Index;
- Assessing the influence of political factors on food insecurity;
- Evaluating the effect of economic factors on food insecurity;
- Providing evidence-based policy recommendations tailored to local conditions to mitigate food insecurity.

Several studies have examined the relationship between climate change and food security. Among the most important is a study entitled "Assessing the Effects of Climate Change on Food Security in Selected Member Countries of the Organization of Islamic Cooperation (OIC)." In this study, OIC member countries were classified into three groups: middle-income countries, least developed countries, and oil-exporting countries. The findings indicated that middle-income countries experienced the lowest growth in food security in the absence of climate change and the greatest decline in food security resulting from climate change compared to the other two groups (Ahadzadeh et al., 2024). Another study entitled "Climate Change and Its Consequences for Food Security in the Khorasan Region" found that variables such as high temperature, low temperature, and precipitation had significant effects on crop productivity (Shayanmehr et al., 2021). Similarly, Lobell et al. (2011) reported that rising temperatures, together with changes in precipitation patterns, have diverse impacts on agricultural production worldwide (Lobell et al., 2011). Furthermore, Von Braun (2007) projected that global warming by 2080 would lead to substantial declines in cereal yields and production in several South Asian countries (Von Braun, 2007)

METHODS AND MATERIALS

This section outlines the research design, data sources, and analytical procedures employed in the study. It provides a detailed description of the methodological approach used to examine the relationship between climate change and food insecurity. Specifically, it explains the applied research design, the descriptive-analytical approach, the development of the conceptual framework based on existing literature, and the procedures for primary data collection using a structured questionnaire. In addition, it describes the sampling process, data collection period, and the statistical techniques used for data analysis in order to ensure transparency, reliability of the study.

Research Design

This study adopts an applied research design using a descriptive–analytical approach. The study integrates a literature review and empirical field investigation to examine the relationship between climate change and food insecurity. The conceptual framework was developed from existing scholarly literature, while primary data were collected through a structured questionnaire.

The descriptive–analytical design was selected because it enables the systematic examination of respondents’ perceptions and experiences regarding climate change and food insecurity while also facilitating the analysis of relationships among the study variables. This design is particularly appropriate for identifying patterns, assessing the magnitude of observed phenomena, and generating evidence-based insights relevant to policy and practice. Furthermore, the applied nature of the study allows the findings to contribute directly to the development of strategies aimed at improving food security and strengthening climate resilience in Nimruz Province.

The questionnaire was developed in April 2025 and, after being reviewed and approved by academic experts, was distributed among the target population. Data collection for this study was completed in May 2025, after which the collected data were entered into EViews software for analysis.

Study Area

The study was conducted in Zaranj, the capital of Nimruz Province, shown by a red circle in Figure 1. The region is characterized by arid and semi-arid climatic conditions, chronic water scarcity, frequent droughts, dust storms (including the 120-day winds), and limited agricultural productivity. These environmental and socio-economic constraints make the region highly vulnerable to food insecurity.

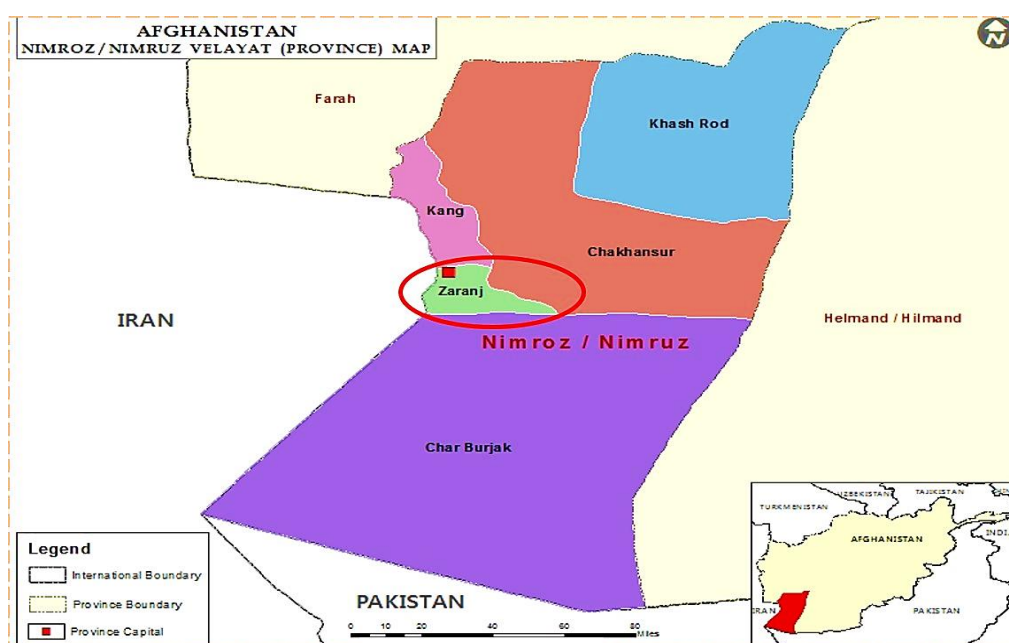


Figure 1. Map of Nimruz Province showing its provincial capital, Zaranj, highlighted in red color

Population and Sampling Technique

The target population comprised all residents of Zaranj, estimated at 63,992 individuals (NSIA, 2025). Due to the technical nature of the study, a non-probability purposive sampling approach was adopted. A structured questionnaire was used, and respondents were selected based on their ability to understand and complete it accurately. Accordingly, employees were chosen as participants because they were more likely to have adequate literacy and relevant knowledge. In contrast, most members of the general public were unable to read or respond to the questionnaire effectively. In total, 150 respondents from government institutions in Nimruz Province were selected as key informants. These participants were considered well-informed about local climatic, institutional, and socio-economic conditions.

Data Collection Instrument

The questionnaire used in this study consists of three sections. The first section collects respondents' demographic and personal information. The second section contains structured closed-ended questions based on a five-point Likert scale ranging from very low to very high, allowing respondents to indicate their level of agreement or disagreement with each statement. The third section includes open-ended questions that provide respondents with the opportunity to freely express their views and opinions. The questionnaire items were developed based on the key components of the study, with each variable measured through several related items. Responses were coded numerically from 1 to 5, and after data collection, the data were processed and averaged in Excel to generate standardized scores for each component.

The questionnaire items were grouped into four composite indices: The Climate Change Index (CE), including climatic variability, drought, temperature change, and dust storms; the Political Factors Index (PE), covering governance quality, institutional support, and policy effectiveness; the Economic Factors Index (EE), including income, employment, and market conditions; and the Food Insecurity Index (FIS), reflecting availability, access, utilization, and stability of food. Composite indices were calculated by taking the mean scores of their corresponding items.

Reliability

Research reliability indicates whether a measurement tool or method yields the same results when used multiple times under similar conditions. In other words, reliability indicates whether the obtained results are trustworthy (Takona, 2024). In this study, Cronbach's alpha was used to assess reliability. Whenever the value of Cronbach's alpha exceeds 0.7, it indicates acceptable reliability. (Table 2) presents the Cronbach's alpha coefficient for this study's questionnaire.

Table 2. Cronbach's Alpha Coefficient for the Questionnaire

Number of Questionnaires	Cronbach's Alpha Coefficient
30	0.731

The results of the reliability analysis indicate that the measurement instrument has satisfactory internal consistency, as evidenced by a Cronbach's alpha coefficient of 0.731. Given that this value is above the commonly accepted threshold of 0.70, the questionnaire is deemed reliable and appropriate for subsequent econometric analysis.

Data Analysis

Data were analyzed in EViews 9 in two stages: descriptive and inferential.

Descriptive Analysis

The descriptive stage summarized the sample's demographic characteristics, including age, job position, education level, and employing department.

Table 1. Demographic Characteristics (Descriptive Summary)

Variable	Category	Frequency	Relative Frequency
Age	20–25 years	17	0.11
	25–30 years	33	0.22
	30–35 years	35	0.23
	35–40 years	38	0.26
	Above 40 years	27	0.18
	Total	150	100%
Job Position	Medical Doctor	19	0.13
	University Lecturer/Professor	26	0.17
	Director/Head	6	0.04
	Supervisor/ Department Head	24	0.16
	General Manager	33	0.22
	Administrative Officer	31	0.21
	Service Staff	11	0.07
	Total	150	100%
Education Level	Doctorate (PhD)	9	0.06
	Master's	31	0.21
	Bachelor's	62	0.41
	14th-grade graduate	35	0.23
	12th-grade graduate (High School)	13	0.09
	Total	150	100%
Workplace/ Organizational Distribution	Nimruz University	26	0.17
	Chaharburjak Health Clinic	10	0.07

Directorate of Labor and Social Affairs	22	0.15
Municipality Directorate	17	0.11
Directorate of of Education	27	0.18
Breshna (Electricity) Directorate	15	0.10
Directorate of Agriculture and Livestock	21	0.14
Central Public Hospital	12	0.08
Total	150	100%

Inferential Analysis of Data

The inferential stage examined relationships among variables and tested the research model. It included diagnostic tests for heteroscedasticity (Breusch–Pagan) and normality (Jarque–Bera), and the model estimation was used to estimate the effects of the Climate Change Index, Political Factors Index, and Economic Factors Index on the Food Insecurity Index.

Heteroscedasticity Test of the Study

This test is used in statistical and econometric analyses to determine whether the variance of the model's errors or residuals is constant or not (Rani et al., 2025). In this study, the Breusch–Pagan test was used to examine variance non-constancy (Heteroscedasticity). If the obtained significance level is less than 0.05, it indicates heteroscedasticity in the data.

Table 3. *Heteroscedasticity (Variance Non-Constancy)*

Test statistic (label)	Significance level (p-value)
F-Statistic	0.3702
Obs*R-Squared	0.3653

Since the significance levels obtained in this study are greater than 0.05, specifically 0.3702 and 0.3653, the test indicates that the collected data exhibit homoscedasticity (constant variance).

Normality Test of the Study's Error Distribution

Since the normal distribution curve is drawn in a bell shape, it is sometimes called the "bell-shaped distribution." In a normal distribution, the data on the right and left sides of the curve are symmetric, and the mean, mode, and median are equal. Gauss was the first to use the normal distribution as the probability distribution of measurement errors, and today this test

is used to examine a dataset to determine whether it follows a normal distribution com(Gauss, 2011; Stigler, 1986).

To examine the distribution of the errors in this study, the Jarque–Bera test was used. If the Jarque–Bera test yields a significance level less than 0.05, the error distribution is non-normal; if it is greater than 0.05, the errors follow a normal distribution. The following table presents the Jarque–Bera test.

Table 4: Distribution of Errors

Test name/significance level	Value
Jarque–Bera	21.33531
Significance level (p-value)	0.000023

As shown in the table above, the significance level is less than 0.05 (specifically, 0.000023), which indicates that the error distribution is non-normal. Consistent with this interpretation, Figure 2 also indicates non-normality of the error distribution.

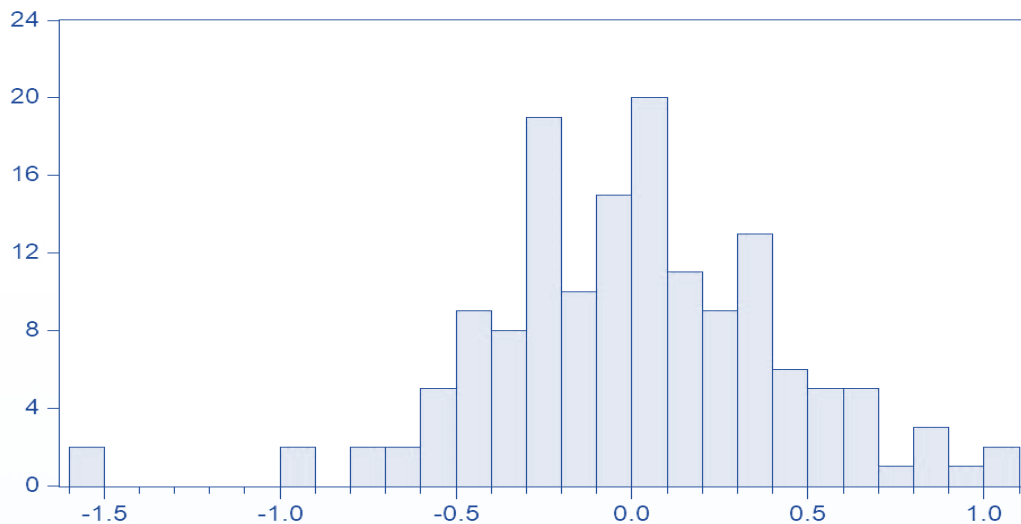


Figure 2. shows the error distribution

The right-skewed distribution of residuals indicates asymmetry and departures from normality; accordingly, estimation should proceed via a robust regression estimator rather than ordinary least squares (OLS), which is comparatively sensitive to dispersion (see Figure 2).

Model Estimation of the Study

To estimate the research model, information was first collected through a questionnaire consisting of 47 items in the form of a five-choice Likert scale and (3) descriptive questions. Components categorized the items, and several components formed a variable. A numerical value of 1 to 5 was considered for the options "very little" to "very much". After converting the qualitative data to quantitative data, the average of the items for each component and then the average of the components for each variable were calculated using Excel. After the prices of the final variables were obtained, the prepared information was entered into the

Eviews 9 software to estimate its regression equation, the results of which are listed in Table 5.

Table 5. Regression Model Estimation

Variable	Coefficient	Z - Statistic	Prob.
C	1.4829	6.2781	0.0000***
C-E	0.2575	3.7954	0.0001***
p-E	-0.1574	-2.3278	0.0199**
E-E	-0.1139	-1.9252	0.0542*

In the significance column of the above table, the stars indicate confidence levels: three stars denote a 99–100% confidence level, two stars denote 95–99%, and one star denotes 90–95%.

FINDINGS

For Better findings; the questionnaire used in this study consists of three sections. The first section collects respondents' demographic and personal information. The second section contains closed-ended questions measured using a Likert scale, enabling respondents to express their level of agreement or disagreement with each statement. The third section includes open-ended questions that provide respondents with the opportunity to freely express their views and opinions.

The descriptive statistics show that the sample consisted of respondents from different government sectors. The majority of participants had at least a bachelor's degree, indicating a relatively educated and institutionally embedded sample.

Diagnostic test results revealed that the Breusch–Pagan test found no evidence of heteroscedasticity ($p > 0.05$), confirming constant variance of residuals. However, the Jarque–Bera test indicated that residuals were not normally distributed ($p = 0.000023$), which justified the use of a robust regression estimator.

Based on the results of the estimated model presented in Table 5, the effect of climate change on food insecurity in the country is positive and significant. If climate change in the country increases by one unit, that is, if the natural balance of weather and climate is disrupted due to human activities, then, with 99.99% confidence, the level of food insecurity in the country increases by 0.2575 units.

Political factors, included as a control variable in the model, have a negative and significant effect on food insecurity. If political factors in the country improve by one unit, then, with 98.01% confidence, the level of food insecurity decreases by 0.1574 units.

Another important factor that strongly affects food insecurity is economic factors, also included in this study as a control variable. If economic factors in the country increase by one unit, then, with 94.58% confidence, the level of food insecurity decreases by 0.1139 units.

Given the coefficients and significance levels of all variables, the regression equation can be written as follows:

$$FIS = 1.4829 + 0.2575CE - 0.1574PE - 0.1139EE.... \text{ (Equation 1)}$$

The above regression equation shows the relationship between food insecurity and three main groups of factors. Here, FIS stands for Food Insecurity Score (or Food Insecurity Status), which is the dependent variable. The term CE stands for Climate Change Effect, referring to how climatic stresses such as drought, dust storms, or irregular rainfall influence food insecurity. The term PE refers to the Political (or Policy) Effect, capturing the role of governance quality, public policies, and institutional support in reducing vulnerability. Finally, EE represents the Economic Effect, which reflects how households' income, employment, and market conditions affect their level of food security.

QUALITATIVE ANALYSIS OF OPEN-ENDED RESPONSES

In addition to the closed-ended Likert-scale items, the questionnaire included three open-ended questions to capture respondents' contextual perceptions of food security challenges and potential solutions in Zaranj City. A thematic analysis of the responses identified three main overarching themes. (1) environmental and climate-related pressures, (2) The Role of the Government in Ensuring Food Safety and Public Access to Healthy and Safe Food, and (3) socioeconomic vulnerability and livelihood constraints. These themes reflect interconnected dimensions influencing food security in the study area.

Theme 1: Environmental and Climate-Related Pressure

Respondents consistently highlighted environmental degradation and climate-related factors as major constraints to food security. These responses are included: *drought, floods, water scarcity, and strong seasonal winds (locally known as the "120-day winds")* in Nimruz Province, which were perceived as directly damaging agricultural productivity and food availability.

Participants emphasized the need for: *environmental protection measures, including afforestation, deforestation prevention, improved water management, and better control of surface water resources. The repeated mention of greenhouse construction and climate-resilient farming practices indicates that respondents are aware of adaptation strategies.* These responses suggest that food insecurity in Zaranj is strongly perceived as environmentally driven, where climate variability and ecological degradation reduce agricultural stability. The emphasis on environmental interventions reflects a recognition that long-term food security requires adaptation to increasingly harsh climatic conditions in the region.

Theme 2: The Role of the Government in Ensuring Food Safety and Public Access to Healthy and Safe Food

A second dominant theme concerns the perceived role of government institutions in ensuring food security and safety. Respondents emphasized: *the government's responsibility for regulating food markets, controlling food prices, ensuring quality standards for imported goods, and enforcing food safety regulations.* In addition, participants highlighted: *the importance of state support for agriculture through subsidies, vocational training for farmers, investment in cold storage facilities, and improved food distribution systems. Strengthening oversight*

mechanisms for food producers and retailers was also frequently mentioned. These findings indicate a strong expectation of state-led intervention in both agricultural development and food regulation. Respondents perceive governance not only as a regulatory mechanism but also as a key driver of agricultural modernization and economic stabilization. This reflects a dependency-oriented institutional perspective, in which food security is closely linked to effective public-sector performance.

Theme 3: Socioeconomic Constraints and Livelihood Insecurity

The third theme centers on socioeconomic factors, including unemployment, poverty, and income inequality. Respondents identified these issues as: *underlying drivers of food insecurity, limiting households' ability to access sufficient and safe food*. Unemployment was repeatedly cited as a critical concern, alongside calls for job creation and more equitable economic policies. In addition, *inadequate waste management and weak urban infrastructure* were identified as indirect contributors to poor food safety and environmental health. These responses highlight that food insecurity is not only a supply-side agricultural issue but also a demand-side economic problem. Limited livelihood opportunities reduce household purchasing power, thereby increasing vulnerability to food insecurity even when food is available in markets.

DISCUSSION

This study shows that climate change has a significant positive effect on food insecurity ($\beta \approx 0.26$). This result is consistent with evidence from Afghanistan and other arid and semi-arid regions. In these areas, climate variability, especially droughts, irregular rainfall, and flooding, reduces agricultural productivity, disrupts supply chains, and increases food prices (Ahmadzai & Morrissey, 2025). The World Bank (2025) and the World Food Program (WFP, 2025) also report that climate-induced droughts in Afghanistan are reducing both food availability and affordability. Overall, the findings confirm that climate change is not only a background factor but a direct driver of food insecurity in vulnerable regions such as Nimruz Province.

The governance variable ($\beta \approx -0.16$) shows a clear mitigating effect on food insecurity. This aligns with studies emphasizing the role of institutional capacity in reducing climate vulnerability. Research in similar dry land contexts shows that effective local institutions can reduce food stress by improving water distribution, agricultural support, and early warning systems (Mubaya & Mafongoya, 2017). Regional studies from West and South Asia also confirm that food insecurity depends not only on climate hazards but also on governance quality in managing resources and delivering social protection (Dzvene et al., 2025). In Nimruz Province, this is especially important due to frequent droughts, dust storms, and the "120-day winds." These risks can be partly reduced through stronger institutions and better resource management (Jahantigh & Jahantigh, 2021).

The relationships can be explained through linked mechanisms. Climate variability reduces crop yield, increases production costs, and raises food prices. It also worsens water

scarcity and quality. National studies in Afghanistan show the same pattern, linking climate stress to weak water governance and rising food insecurity. Reports further highlight that limited investment in water infrastructure has worsened these impacts. This supports the need for stronger water governance and storage systems as a key policy response (Farida et al., 2024).

The economic variable ($\beta \approx -0.11$) shows a weaker but still relevant effect on food insecurity. This differs slightly from national studies that identify income and price changes as the main drivers of food insecurity in Afghanistan (WFP, 2025). In Nimruz Province, however, economic effects are partly shaped by environmental constraints. Dust storms, poor transport systems, and limited storage reduce physical access to food markets. Studies on the Sistan–Nimruz wind system confirm that these conditions disrupt food transport and water access, reducing the impact of income alone (Jahantigh & Jahantigh, 2021). Therefore, the weaker economic effect reflects the specific environmental context rather than a contradiction of national findings.

CONCLUSION

This study demonstrates that climate change significantly increases food insecurity among Zaranj residents, while stronger governance and improved economic conditions help reduce its severity. The findings highlight that food insecurity in drought-prone regions is shaped not only by environmental pressures but also by institutional and economic resilience. In particular, effective governance, better market regulation, and support for agricultural livelihoods can partially mitigate climate-related risks to household food security. The study contributes empirical evidence from the under-researched context of Nimruz Province, offering a practical basis for local planning and policy interventions. The findings support the adoption of climate-smart agriculture, improved water management and storage systems, stronger oversight of food markets, and targeted support for farmers through training and financial assistance. Despite these contributions, the study is limited to a single city and relies on questionnaire responses, which may limit the generalizability of the findings. Future research should expand to other regions of Afghanistan, incorporate longitudinal or comparative approaches, and further explore how social, institutional, and environmental factors interact to influence food insecurity under changing climatic conditions.

Authors Contributions

- Reza Joia conceptualized and supervised the study.
- Rohullah Rasa distributed the questionnaires and collected the raw data.
- Mohammad Reza Shujaie and Reza Joia investigated and analyzed data.
- Reza Joia and Naseer Mukhlis wrote the manuscript with input from all authors.
- 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

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request and subject to ethical approval. All key summarized data presented in the study are included in this article and its supplementary materials (Tables 1–5).

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