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Designing a conceptual model for the climate change impact on agricultural performance and food security: a study based on farmers and policymakers' experiences in the agricultural sector

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Introduction: The present study aimed to design a conceptual model of the climate change impact on agricultural performance and food security, which focused on experiences of farmers and policymakers in the agricultural sector.
Methods: In terms of its purpose, it was an applied research and in terms of nature, it was a qualitative study using grounded theory technique. The statistical population consisted of all farmers in Kermanshah city, experts, university professors and policymakers. In this study, totally 18 individuals were investigated using a non-probability purposive sampling and snowball method until reaching theoretical saturation. An in-depth semi-structured individual interview was carried out for data collection and then MAXQDA 2018 software was applied for data coding. Thereafter, 18 major categories were identified in six grounded theory groups.
Results: According to the results, agricultural instability and food security threats were influenced by the causal factors as a result of climate change. These causal factors included severe climate change, reduced production capacity, economic instability of farmers, and dependence on natural resources. This issue is formed in a context of background conditions including climatic characteristics, agricultural infrastructure, prevailing policies, economic and social conditions, which is influenced with economic, social, technological, environmental, policy-making, and international constraints as the intervening factors. To address this challenge, strategies such as water resource management, crop optimization, support policies, education and extension, and social measures should be adopted to alleviate economic collapse, food security crisis, natural resource degradation, migration, social instability, and governance inefficiency.
Discussion: In conclusion, to reduce agricultural instability and food security threats, increasing agricultural system resilience to the climate change is suggested through developing new technologies, strengthening support policies, optimizing resource management, and educating farmers.

KEYWORDS

agricultural instability, food security, climate change, farmers, grounded theory

1 Introduction

Climate change is a matter of worldwide concern, with alarming repercussions for human societies, economies, and ecosystems (Adnan et al., 2023). The Earth's climate has been evolving for nearly a million years, but the current rate of change is much faster than can be attributed solely to natural processes. The prevailing consensus among scientists is that human activities are the primary cause behind the escalating speed of climate change (Brempong et al., 2023). Climate change, as one of the most important challenges of the current century, has widespread consequences on various aspects of human life, particularly in the field of agriculture and food security. Increasing global temperature and extreme climatic events such as floods and droughts, changing precipitation patterns, and changes in the soil moisture are among the key factors affecting agricultural production. These changes not only reduce agricultural yields, but also disrupt the food supply chain (Amani et al., 2024).

Multiple studies have demonstrated that the world is currently facing the impacts of climate change. Rising temperatures have led to more frequent and severe heatwaves, significantly affecting human health and productivity (Chen et al., 2023). Climate change has also caused intense storms and droughts, impacting water supplies and food security in various nations (Dawood et al., 2024). Climate change may naturally occur over periods of several thousand years; nonetheless, sudden and severe climate fluctuations have become a fundamental challenge of various societies and important environmental issue in recent years. This phenomenon has brought about wide-ranging consequences such as increasing global temperatures, melting polar ice caps, rising sea levels, and climate thresholds' changes (Asadi and Rostami, 2025). In less developed regions, farmers are more vulnerable to climate change due to their economic and social capital shortages, including modern irrigation systems and drought-resistant crops' cultivation. Climate change is widely recognized as a significant risk for the agricultural sector, since it can have substantial negative impacts on agricultural production, food industries, and added value in this area (Hajirahimi et al., 2025).

Climate change has a significant impact on agriculture, which plays a crucial role in sustainable development and food production. The various effects of climate change on agriculture include changes in temperature, precipitation, and extreme weather events (Bradshaw et al., 2024). These harmful effects are particularly concerning for developing nations, where agriculture is essential for both economic growth and food security (Dmuchowski et al., 2024). Hence, it is essential to identify the climate change consequences and develop appropriate policies to deal with this phenomenon. One of the vital consequences of these changes is their effect on food security, as the food security is directly connected to climate conditions. Any change in climatic factors can affect all aspects of the food chain (Yuan et al., 2024). Food supply is influenced by the climate change, both directly and indirectly, as this change would significantly affect the yield and production of agricultural products (Fahad et al., 2024). From a theoretical perspective, climate change can affect agricultural production in various ways. Factors such as rainfall patterns, air temperature, extreme weather conditions, soil moisture, and carbon dioxide accumulation are among the key variables that play chief roles in agricultural development. This relationship is especially evident in African countries where national economies are heavily dependent on the agricultural sector (Asadi and Rostami, 2025).

Widespread changes in rainfall patterns, such as droughts or floods, can damage agricultural crops and reduce production in this sector. Temperature drops, lack of rainfall, and other adverse climate changes also have negative effects on agricultural production. Conversely, improving these conditions can lead to increased agricultural production and development (Blanz, 2023). Therefore, climate change may have positive or negative effects on agriculture and consequently food security, depending on its nature and severity. Since, most of the food consumed is provided by the agricultural sector, any change in production level of this sector will directly affect food security (Gasparini et al., 2024). Agricultural performance is strongly influenced by weather conditions, and climate change can directly and indirectly alter this performance. Decreased soil moisture, increased plant pests and diseases, and reduced quality and quantity of water resources are among these negative and undesirable changes. Although, in some regions, temperature changes and increased carbon dioxide levels may improve the growth of some crops in the short term, climate instability will be a serious threat to sustainable agriculture in the long term (Hajirahimi et al., 2025). Food security depends on four main dimensions, including access, attainment, utilization, and sustainability; while, the climate change can affect any of these dimensions. Reduced agricultural production increases food prices and reduces the purchasing power of vulnerable groups. The climate change could affect nutritional value of the food products and, as a result, change the diet quality of different societies (Ortiz-Bobea et al., 2021). The experiences of farmers and agricultural policymakers can be used as a valuable source for developing a conceptual model. Farmers are directly involved in climate change and can provide valuable information about the impact of these changes on their production, coping methods, and adaptation. Besides, policymakers can provide insights into the implementation challenges and existing policies addressing climate change in the agricultural sector (Lee et al., 2023). In many countries, several policies have been employed to mitigate negative impacts of climate change on agriculture and food security (Gbadeyan et al., 2024). These policies could be stated as: promoting climate-smart agriculture, developing drought and heat resistant seeds, optimizing water resource management, and implementing strategies to reduce greenhouse gas emissions in the agricultural sector. Adopting policies that are compatible with climate conditions in each region can reduce the damage caused by climate change in the agricultural sector (Amani et al., 2024).

Several studies have already examined the impact of climate change on agriculture and food security. The impact of climate change on agriculture poses significant challenges to global food security and sustainable development goals (Lodhi et al., 2024). Decreased agricultural productivity due to climate variability is a leading factor contributing to food insecurity and malnutrition. According to Rehman et al. (2024), South Asian regions are particularly vulnerable to soil and land degradation, which can be attributed to their limited land area, accounting for only about 3.4% of the world's total, and high population density, representing roughly 25% of the estimated 1.75 billion people worldwide. Hence, the adverse impacts within this region could

TABLE 1 Open coding, axial coding, and selective coding stages.

Row	Primary open codes	Subcategories	Main category	Category type
1	Increase in average annual temperature, decrease in seasonal rainfall, change in rainfall timing, increase in the length of warm periods, decrease in frosting days, change in cropping pattern	Noticeable climate change		
2	Frequent droughts, increased intensity and duration of heat waves, increased flash floods, increased frequency of dust storms, unexpected frost, occurrence of hail in unusual seasons	Occurrence of extreme climatic phenomena		
3	Groundwater depletion, aquifer depletion, increased soil salinity, decreased irrigation water quality, decreased soil organic matter, increased surface runoff, decreased vegetation cover, deforestation and rangeland degradation	Destruction of natural resources	Severe climate change	
4	Decreased soil nutrients, increased wind and water erosion, decreased water retention capacity in soil, increased pest and disease resistance, increased need for chemical fertilizers	Decrease in the quality of agricultural land		
5	Decrease in crop production per hectare, decrease in quality and marketability of crops, decrease in crop diversity, increase in crop waste, decrease in grain yield of crops, change in seasonal crop yield	Declining agricultural productivity	Reduced production capacity	
6	Increasing water supply costs, increasing the cost of purchasing agricultural inputs, increasing farmers' debts, reducing crop profitability, increasing crop insurance costs, reducing farmers' purchasing power	Economic pressure on farmers		
7	Inadequate insurance support, lack of allocation of support subsidies, ineffective climate change adaptation policies, lack of compensation programs for affected farmers, lack of participation of farmers in climate decision-making	Weak climate policymaking		
8	Lack of access to smart irrigation systems, high cost of installing modern equipment, lack of knowledge of using modern technologies, lack of access to drought and salinity resistant varieties, lack of appropriate mechanization to reduce climate damage	Limitations in technology use	Economic instability of farmers	Causal factors
9	Fluctuations in agricultural input prices, increased production costs, fluctuation of agricultural product prices, reduced economic power of farmers, dependence on foreign markets, lack of sustainable financial support	Economic instability and market fluctuations		
10	Weak bank credit, lack of support loans, lack of sufficient budget allocation for agricultural infrastructure development, weak investment in climate change-resistant technologies	Lack of investment in the agricultural sector	Economic constraints	
11	Aging of the farming population, decreasing motivation of young people to enter agriculture, lack of training of new agricultural skills, reduction of the rural labor force due to migration, increasing dependence on unskilled seasonal workers	Reduction of skilled labor force in agriculture		
12	Resistance to modern agricultural methods, negative attitude towards sustainable agriculture, traditional beliefs about resource management, weak and unreasonable culture of optimal use of water and soil, strong dependence on agricultural methods of previous generations	Cultural and attitudinal effects on acceptance of changes		
13	Farmers' reluctance to change traditional methods, distrust in government policies, weak education and promotion of sustainable agriculture, dependence on intensive farming methods, migration of young farmers to cities	Social and cultural barriers	Social constraints	
14	Lack of appropriate mechanized equipment, weakness in modern irrigation systems, high cost of drought and salinity resistant technologies, lack of supplying improved seeds, lack of proper distribution network for the new technologies	Lack of access to modern agricultural technologies	Technological constraints	

(Continued on following page)

TABLE 1 (*Continued*) Open coding, axial coding, and selective coding stages.

Row	Primary open codes	Subcategories	Main category	Category type
15	Shortage of renewable water resources, reduction of dam and aquifer reserves, increased competition for water resources, weakness in water allocation policies, high wastage in traditional irrigation networks	Challenges in water resource management		
16	Extinction of some resistant native species, reduction of natural pollination, degradation of rangelands and reduction of sustainable livestock farming, spread of invasive species, reduction of soil quality and crop diversity	Reduction of biodiversity and agricultural ecosystems	Environmental constraints	
17	Lack of incentive programs for sustainable agriculture, weak implementation of laws to combat climate change, ineffective agricultural insurance, delays in paying farmers' damages, weak coordination among institutions related to agriculture	Weakness in the government support policies		
18	Frequent changes in support policies, lack of coordination among government departments, affected policies by management changes, lack of long-term planning for the development of climate-resilient agriculture	Instability of decision-making in agriculture	Policy Challenges	
19	Impact of sanctions on importing improved equipment and seeds, dependence on agricultural exports, impact of climate change on domestic food security in other countries, increased cost of importing agricultural raw materials	Global impacts and dependence on international trade	International constraints	Intervening factors
20	Decrease in annual rainfall, irregular distribution of rainfall, increased occurrence of floods	Instability of precipitation patterns		
21	Increase in average annual temperature, lengthening of heat periods, reduction of cold nights	Temperature changes		
22	Increased evaporation intensity, decreased soil moisture, decreased surface water resources	Increased evaporation and drought	Climatic and geographical features	
23	Lack of modern irrigation technologies, deterioration of water transmission networks, high wastage of water resources	Inefficiency of irrigation systems		
24	Decreased soil fertility, increased wind and water erosion, decreased water storage capacity in the soil	Soil degradation and erosion		
25	Declining groundwater levels, over-extraction of groundwater resources, salinization of water resources	Reduction of groundwater reserves	Agricultural Infrastructure and Water Resources	
26	Lack of comprehensive plans to adapt with climate change, lack of financial supports of vulnerable farmers	Weakness in support policies		
27	Lack of integrated agricultural management, lack of cooperation between executive and administrative agencies, conflict of interest in policymaking	Incoherence among government institutions		
28	Lack of suitable laws restricting water withdrawal, weak supervision of agricultural land use	Legal gap in natural resources' protection	Policies and Governance in the Agricultural Sector	
29	Rising prices of seeds, fertilizers and pesticides, shortage of seeds resistant to environmental stresses	Weakness of agricultural inputs' provision		
30	Lack of access to mechanized equipment, high cost of new technologies, lack of farmers' sufficient training to use new technology	Low technology level	Access to new inputs and technologies	
31	Sudden changes in agricultural product prices, reduced farmers' profitability, market instability	Fluctuations in product prices		
32	Increasing energy costs, rising transportation costs, high prices of agricultural equipment	High cost of production		
33	Lack of efficient marketing systems, dependence on intermediaries, farmers' lack of direct access to the consumer market	Weakness in distribution and sales' networks	Economic and market conditions for agricultural products	
34	Inefficiency of agricultural cooperatives, lack of required support for local groups, weak participation of farmers in decision-making	Weaknesses of agricultural organizations		

(Continued on following page)

TABLE 1 (*Continued*) Open coding, axial coding, and selective coding stages.

Row	Primary open codes	Subcategories	Main category	Category type
35	Farmers' distrust from the government supports, concerning about instability of policies, past negative experiences of farmers in receiving governmental supports	Decreased trust in the government policies		
36	Individual competition instead of group cooperation, lack of cooperative working culture, unwillingness to participate in the joint projects	Lack of team working	Social Structures and Group Interactions	Contextual factors
37	Expanding drip and pressurized irrigation, using smart technologies in water consumption, reducing water waste in farms	Development of new irrigation methods		
38	Artificial recharge of aquifers, managing water withdrawals, preventing unauthorized well drilling	Revitalization of groundwater resources		
39	Recycling and reusing wastewater for agricultural purposes, collecting and storing rainwater, developing small storage dams	Recycling and reusing of water	Water Resources Management	
40	Developing the crop varieties resistant to environmental stress promoting the cultivation of resistant native plants, increasing the production of improved seeds	Using drought and heat resistant seeds		
41	Replacing current crops with low-water consumption crops, cultivating plants adapted to the region's climate, reducing the dependence on vulnerable crops	Changing the cropping patterns		
42	Improving soil organic matter' management, using mulch to reduce evaporation, applying biotechnology to improve the soil	Soil improvement and increasing productivity	Strategies for optimizing cultivation and production	
43	Supporting and managing direct sales to farmers, developing local brands, creating fair and beneficial markets for agricultural products	Strengthening local markets and supply chains		
44	Reducing interest rates on agricultural loans, allocating subsidies to producers, financing the adaptation plans of climate change	Providing facilities and Financial credits for farmers		
45	Creating strategic reserves of products, implementing price stabilization policies, supporting farmers against economic crises	Controlling the price fluctuations of agricultural products	Economics and Market	
46	Creating incentive laws for sustainable cultivation, imposing penalties for improper use of natural resources, strengthening agricultural insurance policies	Developing climate-friendly policies		
47	Creating joint working groups among relevant agencies, increasing interaction between government and farmers, implementing coordinated intersectional policies	Improving inter-sectoral coordination		
48	Continuously evaluating support policies' performance, reducing administrative corruption in agricultural resources' allocation, providing public reports on climate policies	Increasing transparency and monitoring of agricultural policies	Policy and Governance	
49	Holding Training courses related to climate change, promotion of new agricultural practices, access to meteorological and climate information	Increasing farmers' awareness		
50	Supporting agricultural research in climate change, cooperation with scientific centers, expansion of technologies related to sustainable agriculture	Developing applied research concerning climate-friendly agriculture		
51	Disseminating information about sustainable agriculture in local media, producing related educational content, using social networks to disseminate required information among farmers	Strengthening the role of media in raising farmers' awareness	Education and outreach	
52	Supporting agricultural organizations, creating incentives for farmers to cooperate with each other, increasing the role of local groups in agricultural decision-making	Strengthening agricultural cooperatives		

(Continued on following page)

TABLE 1 (*Continued*) Open coding, axial coding, and selective coding stages.

Row	Primary open codes	Subcategories	Main category	Category type
53	Developing alternative business methods in agriculture, supporting complementary jobs for farmers, encouraging multi-purpose farming	Promoting sustainable livelihood models		
54	Holding consultative meetings with farmers, involving local communities in macro-decision-making, using local experiences in policy formulation	Increasing farmers' participation in policymaking	Social and participatory	Strategies
55	Decreasing crop yields, increasing production costs, severe fluctuations in agricultural product prices	lessening profitability of agricultural production		
56	Increasing agricultural loans, dependence on government subsidies, growing agricultural land sales	Increasing debt and financial dependence		
57	Decreasing incentives for long-term investment, changing farmers' jobs, increasing farmers' migration from agriculture to service and industrial jobs	Retreating investment in agriculture	Economic Collapse	
58	Increasing food prices, reducing the diversity of household food baskets, greater dependence on imports	Reducing access to healthy and sufficient food		
59	Increasing living costs, reducing purchasing power of food and medicine, declining social welfare	Fall in purchasing power of the farming households		
60	Access unequal access to healthy food products, spread of malnutrition in rural areas, dependence on government aids	Increasing food inequality and malnutrition	Food Security Crisis	
61	Drying up of wells and aqueducts, reduction of groundwater reserves, increase in the salinity and water pollution	Reducing the quality and quantity of water resources		
62	Decrease in vegetation cover, destruction of agricultural lands, increasing fine dust and decreasing land productivity	Accelerating desertification and soil erosion		
63	Spreading new pests and diseases, changing in plant growth cycles, decreasing biodiversity in agricultural products	Increasing biological threats to crops	Natural Resource Destruction	
64	Decrease in rural income, losing job opportunities, growth of marginalization and informal settlements	Forced migration of villagers to the outskirts of cities		
65	Conflict over water and land, intensification of local disputes, mass migrations of farmers to more water-rich areas	Increasing social conflicts over natural resources		
66	Decrease in the young generation's interest in agriculture, decline of traditional skills, greater dependence on costly technologies	Decline of rural lifestyle and agricultural culture	Migration and Social Instability	
67	Lack of preventive policies, late governmental responses, lack of budget to support farmers	Lack of strategic plans in managing climate changes		
68	Decrease in domestic production, increasing price fluctuations of agricultural products, threats to national food security	Country's growing dependence on food imports		
69	Growth of social protests, public demands for agricultural policies' reform, pressure on the government to provide financial and insurance support	Increasing pressure on decision-makers for climate reform	Inefficient governance	Consequences

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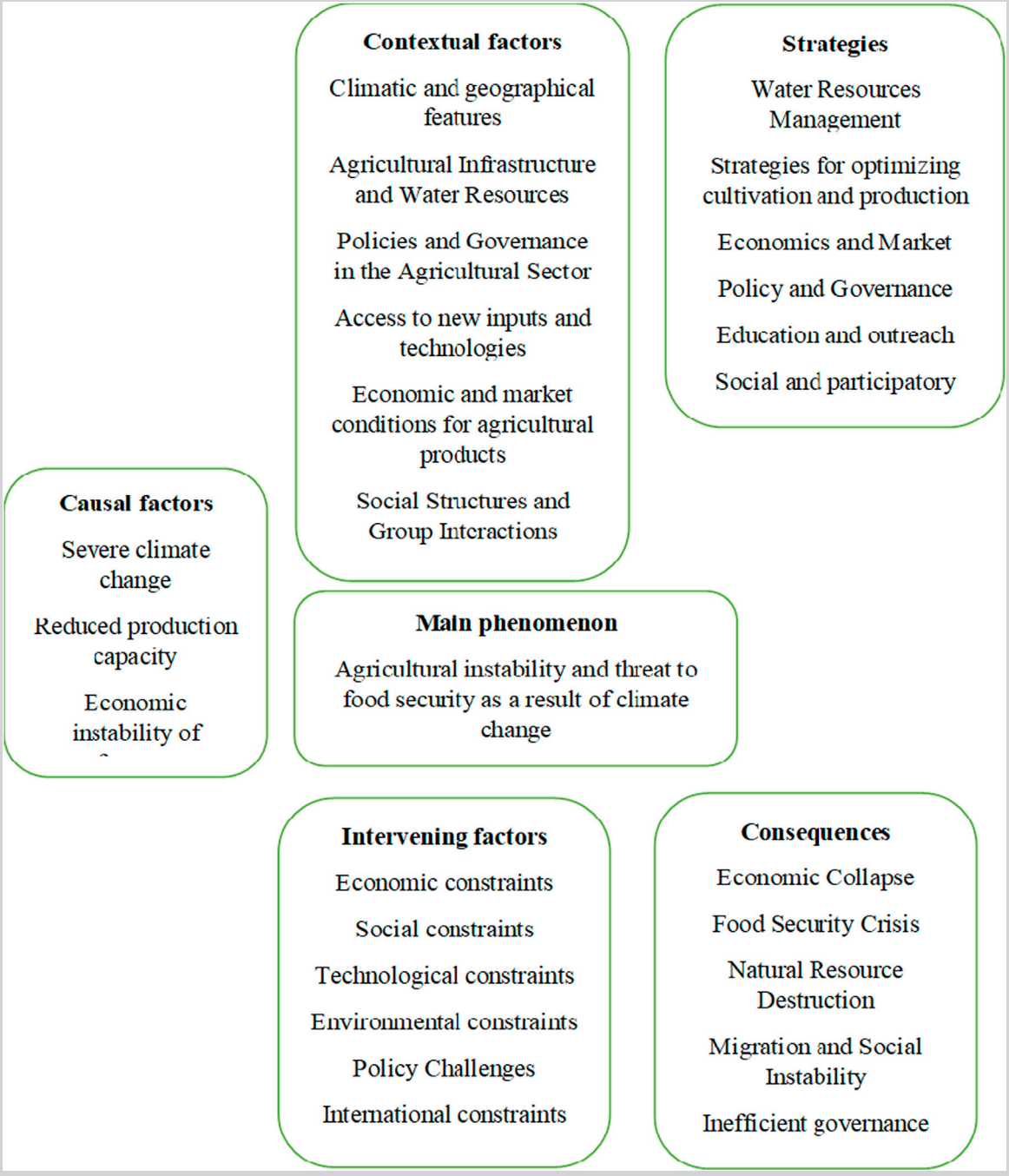
impede agricultural productivity (Nawaz et al., 2024). Diminished agricultural productivity could consequently lead to poverty, worsening preexisting social and economic disparities (Sheikh et al., 2024). Climate change might bring about changes in land suitability for farming, with high-altitude regions experiencing increased crop production, while low-altitude areas may witness a decrease in crop yields (Sun et al., 2024). In conjunction with the rising concern of food insecurity, the uneven growth patterns of these vital crops can not only reduce domestic income and employment but also hinder the performance of associated production industries (Timsina, 2024). Furthermore, climate change can result in conflict, migration, and social instability, intensifying its impact on food security (Yanagi, 2024). The changing climate has substantial implications for achieving the sustainable development goals, such as reducing poverty, fostering sustainable agriculture, and addressing climate change (Yu et al., 2024). Sustainable agriculture is crucial for ensuring food security and alleviating poverty (Zheng et al., 2024), yet the negative effects of climate change, especially on biodiversity and natural resources, pose significant obstacles to reaching these objectives.

TABLE 1 (*Continued*) Open coding, axial coding, and selective coding stages.

Row	Primary open codes	Subcategories	Main category	Category type
Researchers' findings, 2025				



Sharifi and Rezaei (2020) examined the climate change effect on wheat production in Iran. Also, Mohammadi and Ahmadi (2021) used the SSM-iCrop2 model to predict the impact of climate change on strategic crops. Similarly, Akbari and Nouri (2018) analyzed the adaptation strategies of date growers in the face of climate change and their impact on production in southeastern of Iran. Given the increasing trend of climate change, it is essential to adopt long-term strategies to increase the agricultural sector resilience and to ensure food security. Investing in the research related to new agricultural technologies, developing early warning systems for managing climate crises, and encouraging changes in cropping patterns and optimal use of resources are among some applicable solutions for diminishing negative effects of climate change. Designing an appropriate

TABLE 2 Participant demographic characteristics.

Participant demographic characteristics	Frequency	Percentage
Age levels		
Less than 30 years	4	22.22
31–35	3	16.67
36–40	3	16.67
40 years and older	8	44.44
Gender		
Women	8	44.44
Man	10	55.56
Marital status		
Single	0	0
Married	18	100
Education		
Bachelor's degree	5	27.78
Master's degree	4	22.22
PhD students	2	11.12
PhD	7	38.88
Job		
Farmers	6	33.33
Experts	6	33.33
University Professors	3	16.67
Policymakers	3	16.67

Researchers' findings, 2025.

conceptual model can enforce scientific and policy decisions and pave the way of achieving sustainable agricultural development. However, a remarkable gap in the related research is clearly visible. In fact, most of the existing studies have focused on quantitative analyses and model-based predictions or have only examined farmers' experiences, without considering the perspectives of policymakers and decision-makers in the agricultural sector. In other words, no research has been yet conducted with a comprehensive conceptual model based on a data-driven method, which simultaneously assess the experiences of farmers and policymakers. Therefore, this research aims to design and afford a conceptual model from the impact of climate change on agricultural performance and food security through a data-driven method, which could be assumed as an attempt to fulfill this scientific gap.

2 Research methodology

The present research used a qualitative approach and its strategy was based on grounded theory. At the heart of this method, a systematic approach was used to achieve a paradigmatic model. The statistical population of this research included all farmers in Kermanshah city, experts, university professors, and policymakers. In order to do sampling, non-probability purposive and snowball sampling method was used. The sample population consisted of experts who were more knowledgeable about the research topic and could give richer answers to the research questions. Semi-structured interviews were conducted with 18 experts; while, theoretical saturation was achieved after the 15th interview. The interview protocol also included seven general questions that were designed based on the results of observing documents, research history, and consulting with experts in the field. The validity of questions was confirmed based on the opinions of experts. It should be noted that before starting the interview, the research objectives and questions were sent to the interviewees via email to have initial preparation, a brief explanation was given at the beginning of the meeting, and then the interview questions were asked. In order to have better and cordial communication with interviewees during the interview process and to gain participants' satisfaction, the interviews were recorded using tape recorder, and the notes were also written down from the key points of each interview. The average time of each interview was 35 min.

Data analysis was conducted using a systematic approach that included three stages of open, axial, and selective coding according the Strauss and Corbin model. For this purpose, at the open coding stage, initial codes or concepts were identified after reviewing and organizing the interview texts, and similar codes were put in specific categories. Then, for each category, a title was selected that represented all codes of that category. At the axial coding stage, the relationships between the axial phenomenon and other categories and concepts were identified and presented. Finally, these categories were represented as a paradigm and placed at selected coding through considering the relationship among their categories in

the grounded theory paradigm model and its six classes. Because the research nature required a detailed analysis of participants' perspectives on the study subject, the interviews' coding and analysis process were carried out using MAXQDA 2018 software. Eventually, the findings' validity of the qualitative analyses was ensured using the criteria provided by Creswell and Miller (2000). This criteria, consisted of the review by three interviewees and peer review of two professors as well as two doctoral students who were experts in document and interview coding.

It is important to mention that this article has been approved by the Ethics Committee of Razi University, in the Kermanshah Province, in the Ethics Audit Department. Informed consent was secured from all participants, with detailed explanations provided regarding the study's purpose, procedures, risks, benefits, and the voluntary nature of their participation. Participant information was kept confidential, utilizing anonymous transcripts and secure data storage protocols.

3 Research findings

As was stated earlier, semi-structured interviews were conducted with 18 farmers, experts, university professors, and policymakers in Kermanshah city. Descriptive analysis of the study population showed that in terms of education, out of a total of 18 respondents, seven (38.88%) had a PhD, two (11.12%) were PhD students, four (22.22%) had a Master's degree, and five (27.78%) had a Bachelor's degree. This distribution indicates respondents' educational diversity and the importance of having different educational degrees in the research. Accordingly, 18 interviews were analyzed. At the open coding stage, after reviewing the data and merging similar concepts, 170 initial concepts were reduced to 66 subcategories. At the second stage of axial coding, secondary codes were classified based on their relationship with similar topics and were placed into 18 main categories. At the last stage of the open coding, main categories that were previously obtained were put into more generalized categories or the categories with similarities, conceptual connections, and common features between open codes and concepts. At the axial coding stage, the components obtained from the open coding stage were linked together and transferred into 18 subcategories in a paradigmatic pattern. The findings of the open, axial, and selective coding stages are presented in Table 1. Due to the length of the open coding stages, only the secondary open codes are mentioned for each category.

Table 2 contains the concepts identified in the transcribed interview text categorized into sub and main categories.

3.1 Causal factors

In this study, the causal factors of climate change impact on agricultural performance and food security were identified. They included severe climate change, reduced production capacity, and economic instability of farmers. Climate change, with the occurrence of extreme climate phenomena (such as flash floods and prolonged droughts) `, has caused natural resources' destruction and agricultural sustainability alleviation. As a result, the decline in the quality of agricultural land and crop productivity has resulted in reduced production capacity and has threatened food security. On the other hand, economic pressure on farmers, inappropriate climate policymaking, and restrictions in using new technologies have reduced the ability of farmers to adapt to new conditions and exposed them to greater vulnerability. In sum, these factors have challenged food security and sustainable agricultural development, and have necessitated the development of supportive and climate-adapted policies.

3.1.1 Quote from contributors

Contributor 1: I believe that flash floods and extended droughts pose a significant threat to our food security.

Contributor 5: The more we destroy our natural resources, both individually and through government actions, the farther we drift from achieving development and sustainable agriculture.

Contributor 8: Our agricultural lands have deteriorated in quality due to water shortages, insufficient basic knowledge and technology, and the absence of proper industrial wastewater treatment.

Contributor 9: Because of the limited use of technology and poor communication with agricultural promoters, agricultural production efficiency has decreased.

Contributor 10: Farmers are facing economic challenges and struggling.

Contributor 12: The government's climate policies have proven ineffective, leading us to confront a climate crisis and severe air pollution.

Contributor 17: We are facing issues because of a lack of fundamental training in utilizing modern technology.

Contributor 18: Floods and acid rain result in the extinction of natural resources, ultimately leading to a decline in food availability.

3.2 Contextual factors

In this study, contextual factors that provide conditions for the emergence and intensification of climate change impacts on agriculture and food security were identified. They consisted of climatic and geographical characteristics, agricultural infrastructure, policies and governance, access to inputs, economic status, and social structures. The instability of precipitation patterns, temperature changes, and increased evaporation and drought have decreased water resources and increased soil erosion, which both threaten agricultural productivity. In addition, the inefficiency of irrigation systems, soil degradation, and reduced groundwater reserves have diminished the ability to reach sustainably. Weaknesses in support policies, incoherence among government institutions, and a legal vacuum in the protection of natural resources, have challenged climate crises' management. Limitations in the supplying agricultural inputs and low technology level have undermined the possibility of using modern methods to deal with climate change. Economically, volatile crop prices, high production costs, and weak distribution and sales' networks have lessened farmers' income security. Generally, weak agricultural organizations, low trust in

government policies, and a lack of collective action, have hindered collaborative approaches in addressing climate challenges. Altogether, these factors have created complex circumstances of the barriers that make it difficult to manage climate change and improve food security.

3.2.1 Quote from contributors

Contributor 2: The unpredictable rainfall patterns are depleting our water sources, posing a threat to our agricultural sector.

Contributor 6: The inefficiency of our country's irrigation systems is hindering our ability to achieve sustainable development, ensure food security, and promote sustainable agriculture.

Contributor 7: The government's failure to protect the environment and natural resources is leading to irreversible climate crises.

Contributor 11: In my view, fluctuating agricultural prices have diminished farmers' financial stability.

3.3 Confounding factors

In this research, confounding factors were identified as variables affecting the intensity and manner of climate change impacts on agriculture and food security. Economic constraints such as economic instability, market unpredictability, and lack of investment in the agricultural sector, have reduced farmers' financial capacity to benefit from climate change adaptation' strategies. Besides, social constraints such lack of skilled labor, cultural influences on change acceptance, as well as social and cultural barriers have challenged farmers' adaptation processes. Technological constraints including lack of access to modern agricultural technologies have hindered the development of innovative methods, which are compulsory to increase productivity and reduce negative impacts of climate change. Environmental constraints like challenges in water resource management and reduction of biodiversity in agricultural ecosystems have made environmental conditions more difficult for achieving sustainable agriculture. Policy challenges, including weak governmental support policies and unstable decision-making in the agricultural sector, have also contributed to confusion and lack of coordination in coping strategies' accomplishment. Finally, international constraints such as global impacts and dependence on international trade have made domestic agriculture more vulnerable to global economic and political crises. These intervening factors have limited the ability of farmers and policymakers to cope with climate change consequences and have contributed to fundamental challenges in managing food security and sustainable development in the agricultural sector.

3.3.1 Quote from contributors

Contributor 3: Economic challenges, like instability and a lack of investment in the agricultural sector, have diminished farmers' financial ability to take advantage of climate change adaptation strategies.

Contributor 4: Social barriers, including the shortage of skilled and specialized labor, along with social and cultural obstacles, have hindered farmers' adaptation processes.

Contributor 13: Technological constraints and barriers, including lack of access to modern agricultural technologies, hinder the development of innovative methods.

Contributor 15: I believe that environmental challenges, such as managing water resources, loss of biodiversity, and endangerment of species in agricultural ecosystems, have made it more difficult to achieve sustainable agriculture.

Contributor 16: The government's misguided policies have hindered us from implementing and executing a sound strategy.

Contributor 17: Many argue that our reliance on foreign countries for agriculture and the excessive amount of imports have negatively impacted our agricultural sector.

3.4 Main phenomenon

In this experiment, the pivotal phenomenon was recognized as the central concept in which other causal factors (intervening, contextual, strategies, and consequences) are formed around it and was called: "agricultural instability and threat to food security as a result of climate change". This phenomenon reflects the widespread impacts of climate change, including increased extreme weather events, reduced agricultural productivity, degradation of natural resources, and economic fluctuations in agriculture and food security. Temperature changes, decreasing water resources, unstable agricultural product markets, and ineffective support policies have caused farmers to face with increasing challenges to secure their livelihoods and continue their activities. Meanwhile, farmers' inability to properly use new technologies and inappropriate infrastructure have reduced their resilience to these changes, leading to production instability and increased vulnerability of the food supply chain. These conditions not only threaten farmers' livelihoods, but also have widespread consequences on food security of the society.

3.5 Strategies

In order to deal with climate change consequences on agriculture and food security, a set of key strategies were identified that can help reduce negative effects of climate change and intensify the agricultural sector resilience. In terms of water resource management, development of new irrigation methods, restoration of groundwater resources and water reuse can facilitate water stress reduction. Furthermore, in terms of crops' production optimization, using drought and heat-resistant seeds, changing crop patterns, and soil improvement are assumed as effective measures for increasing agricultural productivity. Considering economic and market strategies, strengthening local markets, providing financial facilities to farmers, and controlling product price' fluctuations can play effective role in farmers' economic sustainable improvement.

At the policy and governance level, it is essential to formulate climate-friendly policies, improve coordination among different institutions, and increase transparency in monitoring agricultural policies. Implementing educational and extension strategies through raising farmers' awareness, developing applied research, and strengthening the role of media can accelerate farmers'

acceptance upon the occurrence of changes and easier adaptation to new conditions. Finally, social and participatory strategies, such as strengthening agricultural cooperatives, promoting sustainable livelihood models, and increasing farmers' participation in policy-making procedure, are of particular importance in increasing resilience and social cohesion upon facing climate change.

3.5.1 Quote from contributors

Contributor 1: Using drought-resistant seeds and improving soil quality can enhance agricultural productivity.

Contributor 5: I believe that implementing environmentally and climate-friendly policies can be effective.

Contributor 8: I believe that enhancing agricultural cooperatives, promoting sustainable livelihood models, and involving farmers more in policy-making are crucial for improving resilience and social cohesion in response to climate change.

Contributor 9: Improving local markets, offering financial support to farmers, and managing fluctuations in product prices can effectively contribute to the sustainable economic development of farmers.

Contributor 12: I believe that educating farmers is a crucial step towards achieving sustainable agriculture and ensuring food security.

Contributor 14: Restoring groundwater resources can help prevent water stress.

Contributor 17: I believe that implementing water resource management is a beneficial strategy.

3.6 Implications

Economic collapse caused by climate change is distinguished as one of the main challenges of agriculture. Lack of agricultural production profitability as a result of reduced productivity and increased production costs, has increased debt and financial dependence of farmers, and has led to investment withdrawal and undermining development potential of the agricultural sector and ultimately has jeopardized its sustainability. The food security crisis has been also intensified due to decreasing access to healthy and sufficient food, leading to a decline in the purchasing power of farming households, increase in food inequality, and malnutrition in the society. Moreover, the destruction of natural resources through a decrease in the quality and quantity of water resources, expedites desertification and soil erosion rate, increases biological threats to crops, limits the capacity of agricultural production and threatens food security even more than before. In addition to these issues, farmers' migration to the cities and social instability are also serious consequences of the climate change on rural communities. Forced migration of villagers to the outskirts of cities, increased social conflicts over natural resources, rural lifestyles decline, and agricultural culture deterioration have led to fundamental changes in the social structure of rural areas and have generated new crises. Eventually, ineffective governance with a lack of strategic plans for managing climate change, the country's increased dependence on food imports, and increased pressure on decision-makers for climate reforms, weaken the competency of governments to deal with this crisis and accordingly complicate future challenges.

3.6.1 Quote from contributors

Contributor 2: The economic downfall is the foremost challenge and repercussion of climate change.

Contributor 4: The lack of profitability in our agriculture industry is causing a decline in sustainability.

Contributor 7: In my view, the food security crisis has worsened due to limited access to safe and adequate food, which has resulted in reduced purchasing power for farming households. This has led to heightened food inequality and malnutrition within society.

Contributor 10: I believe that the migration of farmers to cities and social instability are significant consequences of climate change affecting rural communities.

Contributor 13: In my view, ineffective governance, coupled with a lack of strategic plans to address climate change, heightens the country's reliance on food imports and places added pressure on policymakers to enact reforms to combat climate change. This weakens governments' capacity to confront the crisis and, consequently, complicates handling future challenges.

4 Discussion and conclusion

The climate change, as a fundamental challenge of the current century, has had profound effects on agriculture and food security. The findings of this study exhibited that increasing temperature, changing precipitation patterns, and the occurrence of numbers of extreme phenomena such as drought and flood, has led to a decrease in agricultural production and economic instability in this sector. These results are consistent with a great deal of previous studies. For example, the study carried out by Nehbandani et al. (2021) revealed that climate change scenarios could reduce the production of basic crops such as wheat and barley by 5% and 8%, respectively. Eslami (2020) also emphasized that temperature fluctuations have reduced production efficiency in arid and semi-arid regions of the country and have increased the need for compensatory policies.

On the other hand, underlying factors including inefficient agricultural infrastructure and weak support policies exacerbate negative effects of climate change. Studies have displayed that insufficient investment in the agricultural sector, lack of appropriate equipment for storing and utilizing water, and lack of government support have made farmers more vulnerable to climate crises. The research accomplished by Asadi & Rostami. (2025) underlined that the weakness in macro-policies and incoordination among different sectors of natural resource management, have exacerbated environmental and economic crises in the rural areas of Iran.

Intervening factors such as economic and social constraints have also worsened the agricultural crisis. The reduction of farmers' financial capacity and forced migration of villagers to cities are among the consequences of these constraints. The findings of this study indicated that lack of investment in agricultural infrastructure and market fluctuations have resulted in a decrease in farmers' motivation to continue production activities. These results are consistent with the studies implemented by Amani et al. (2024),

which reported that increasing production costs and lack of government financial supports have gradually caused farmers to withdraw from the production cycle.

To address these challenges, it is indispensable to adopt effective strategies. The findings of the present study highlighted the fact that using modern irrigation systems, optimizing the cropping pattern, and providing economic support to farmers play significant role in reducing negative effects of climate change. The study executed by Hajirahimi et al. (2025) showed that using drip irrigation systems and development of water resources' management technologies have significantly increased production efficiency and facilitated the reduction of drought effects. In terms of policy-making and governance, our results uncovered that improving inter-sectoral coordination, increasing transparency, and monitoring agricultural policies can lead to more sustainable development of this sector. In line with this finding, the study of Yuan et al. (2024) disclosed that the countries with coherent and supportive policies for natural resource management and climate change are more resilient to environmental crises and are able to maintain their food security.

Social and participatory strategies also play a chief role in increasing farmers' resilience to climate change. According to the current study, strengthening agricultural cooperatives, promoting sustainable livelihood patterns, and increasing farmers' participation in policymaking could reinforce agricultural sustainability. The study of Lee et al. (2023) also reported that participatory programs in water resource management and increasing farmers' awareness have positive influence on their adaptability to climate change.

The consequences of not managing properly the climate change in agriculture are very widespread. The findings accentuated that if appropriate measures are not taken, agricultural economic collapse, food security crisis, destruction of natural resources, and increased migration from rural areas to the cities would certainly occur. These findings are consistent with the study of Asadi & Rostami. (2025), when they pinpoint that reducing in water resources' quality and quantity is regarded as a central intervening factor of rural migration.

Another important consequence of the climate crisis is biodiversity reduction and biological threats' increase in crops. Sharifi and Rezaei (2020) discovered that increasing temperatures and decreasing rainfall have led to a reduction in vegetation cover, reduced soil yield, and increased risk of agricultural pests and diseases. In present study, this issue was also identified as one of the key consequences of the climate change.

Overall, our findings confirmed that climate change has pervasive impacts on agriculture and food security, and to deal with this crisis, it is compulsory to formulate comprehensive policies to be able to improve agricultural infrastructure, sustainably manage natural resources, and provide financial support for farmers. Future research are expected to examine the effects of mitigation policies of climate change on agriculture and food security in more detail. Correspondingly, using new technologies in agriculture, including smart agricultural systems and drought-resistant crops, can be regarded as an effective solution to deal with the challenges caused by the climate change. This research detected that climate change, whether in the form of normal change, variability, or a combination of both, has severe negative effects on food security and economic wellbeing of farmers in Iran. The most significant negative consequences of these changes could be listed as farmers' income deterioration, raising the price of basic agricultural products such as wheat, rice, and potatoes, and decreasing in economic well-being surplus. It was identified that the climate change not only affects agricultural production, but also causes instability in food supply and increases the consumer costs. Therefore, ignoring this issue can lead to serious crises in the agricultural sector and food security of the country in the long term. To diminish negative effects of climate change on food security, the policymakers and program planners in the agricultural sector, are recommended to put following measures on the agenda: changing the cultivation pattern towards drought-resistant crops, using modern irrigation methods, implementing desertification programs, and developing sustainable agricultural technologies. Also, increasing farmers' awareness of the soil and water resource management methods and supporting applied research in the field of climate change could be suggested to mitigate its adverse impacts. Adopting these sustainable approaches not only improves food security, but also increases the country's agricultural resilience to climate change.

Despite offering valuable results, this research faced some restrictions during its implementation. One of the fundamental challenges researchers confronted was the lack of access to recent and accurate data on agricultural production and climate change, which definitely affected the accuracy of data analyses. Also, the research focus was solely on three basic crops (wheat, rice, and potatoes) and other important crops were neglected. Besides, the effects of government support policies such as subsidies, agricultural insurance, and modern irrigation methods were not independently examined; while, these factors can have a significant impact on food security and farmers' income and should be separately assessed.

It is suggested that in future studies the research scope is extended to other agricultural products and sectors, including livestock and water resources. Investigating the role of supportive policies and government adaptation programs in reducing climate change effects, can also afford solutions that are more practical. Applying advanced simulation and machine learning models can increase the accuracy of predictions as well. Finally yet importantly, conducting comparative studies with the countries under similar climatic conditions such as Turkey and the Persian Gulf countries is suggested to identify successful and applicable solutions for Iran and even other neighborhood countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Razi University Kermanshah, Iran. The studies were conducted in accordance with the local legislation and institutional requirements. Written

informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MS: Conceptualization, Data curation, Formal Analysis, Methodology, Resources, Software, Validation, Writing – original draft. PS: Data curation, Formal Analysis, Methodology, Resources, Software, Writing – review and editing.

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Supplementary material

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