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Assessment of the Economic, Social, and Environmental Impacts of Drought on the Stakeholders of the Karganeh Watershed in Iran

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Abstract

Drought is a creeping phenomenon characterized by a gradual reduction in precipitation and increased temperatures, whose cumulative effects often manifest over extended periods. This study employs a quantitative approach to analyze the economic, social, and environmental impacts of drought on stakeholders in the Karganeh Watershed, Iran. A sample of 130 stakeholders (including farmers, pastoralists, nomads, and local council members) was selected via simple random sampling from a total population of N = 197, using Cochran's formula for precision. Data were collected through a researcher-administered questionnaire, validated by an expert panel, and demonstrating high reliability (Cronbach's α = 0.829). Data analysis using the Friedman test revealed the following ranked impacts: Socio-Economic Impacts: The most severe consequences were a significant decrease in agricultural and horticultural income (mean rank = 16.13), a reduction in crop yield (mean rank = 16.01), and a decrease in orchard yield (mean rank = 16.09). Environmental Impacts: The most critical impact was the destruction of springs and drying of wells (mean rank = 9.36), followed by the reduction of groundwater and surface water resources (mean rank = 7.51) and an increase in pests and diseases affecting orchard trees (mean rank = 6.74).The findings quantitatively demonstrate that water resource depletion constitutes the primary environmental challenge, while severe reductions in income and agricultural productivity are the foremost socio-economic concerns. These results underscore the critical need for integrated water resource management and economic diversification strategies to enhance resilience in the watershed.

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Introduction

Drought is a complex and multifaceted phenomenon. Its definition and interpretation vary depending on the specific field of expertise (Belayneh et al., 2016; Di Paola et al, 2025). Although this phenomenon impacts nearly all sectors of the economy, the methods used to measure and evaluate it differ across these sectors and are tailored to their particular characteristics. For instance, a period of hot and dry weather may be disastrous for a cereal farmer, while the same conditions could be desirable for the ripening of certain fruits (Anyamba et al., 2005; Bonaldo et al, 2023). This highlights the subjective nature of drought, as its interpretation can vary within different disciplinary frameworks. To date, over 150 definitions of drought have been proposed. Most of these definitions consider a reduction in water availability relative to demand as the fundamental criterion for drought (Wilhite and Glantz, 1985; Van Loon et al., 2024).

Drought, recognized as a significant environmental hazard, refers to a period of notably severe and temporary water scarcity impacting surface and underground water reserves. This issue causes extensive disruptions across ecosystems, agriculture, water provision, and economic activities. It generally results from an extended and substantial decrease in regional rainfall, with manifestations that can be either temporary or prolonged (Wilhite and Glantz, 1985; Mishra and Singh, 2010; Savari and Moradi, 2022). As a recurring climatic event, drought influences all facets of natural and human systems. Due to its intricate nature, the concept and interpretation of drought vary among individuals and disciplines (Hang et al., 2015; Morote et al., 2020). Nonetheless, a fundamental and conventional definition relies on decreased rainfall or deviations from the typical precipitation levels. The second half of the twentieth century saw a rise in drought incidents, often leading to agricultural losses and crises such as extensive famines. Drought is classified as a natural catastrophe with multifaceted consequences spanning economic, social, and environmental domains (Ahmadi et al., 2019, Veettil and Mishra, 2023). Iran's geographic location in one of the most arid zones globally exacerbates water scarcity issues, significantly hindering agricultural progress (Raziei et al., 2008; Karimi Sangchini et al., 2015; Karimi Sangchini et al., 2020; Bozorg Hadad et al., 2020). In recent years, Iran has experienced increased drought severity, particularly affecting rural regions where the economy heavily depends on agriculture. This situation raises significant concern for rural communities, which suffer the most, becoming particularly vulnerable. Vulnerability here refers to households losing the capacity to withstand adverse conditions, resulting in issues like hunger, unemployment, social disconnection, and health problems (Morid et al., 2006; Nouri, 2023). As a result, implementing drought mitigation measures has grown in importance; many developed nations have adopted strategic policies to address drought risks effectively (Roman, 2017; Boelens and Vos, 2014). In Iran, this issue is well recognized, and national policies emphasize drought risk management within the broader agricultural framework (Raziei et al., 2008; Keshavarz et al., 2013; Shahangian et al, 2022).

Extensive research has been conducted on drought crisis management, some of which are summarized below. Villarreal et al. (2016) employed multi-index time series analysis to monitor the effects of drought and fire on desert grasslands. Engstr et al. (2020) performed an assessment of drought vulnerability in the United States, while Hoque et al. (2020) evaluated drought susceptibility using geospatial methods in northwestern Bangladesh. Damian et al. (2022) focused on an index-based evaluation of social-ecological drought vulnerability in Romania's Danube Delta. Stephan et al. (2023) studied agricultural vulnerability to drought in pre-Alpine European regions, integrating expert insights with data analysis to identify regional risk factors. Similarly, Shin et al. (2023) analyzed vulnerability in high-altitude farming systems, emphasizing management strategies, and Koley & Jeganathan (2023) examined climatic and socio-economic influences on drought vulnerability in Jharkhand, highlighting the role of various variables. Based on these studies, the Analytic Hierarchy Process (AHP) method is frequently regarded as an effective tool for drought assessment. This research also applies AHP to evaluate conditions in Karganeh, within Khorramabad County in Iran. Recently, drought conditions in Khorramabad, especially in Karganeh, have worsened due to declining rainfall and rising temperatures, resulting in lower agricultural yields and migration toward urban centers. Since most local livelihoods depend on farming, studying drought mitigation in this region is critical. The current study aims to analyze drought coping approaches from the perspective of local village officials, using AHP as a decision-making framework.

The Karganeh Watershed in Lorestan Province represents a critical case study of these challenges. Agriculture here, encompassing both rainfed and irrigated systems for cereals, legumes, and livestock, is highly vulnerable. Recent years have seen drought-related damages disproportionately impact smallholder rainfed farmers (Karimi Sangchini et al., 2024). While farmers have developed indigenous adaptation strategies—such as water channel lining, constructing reservoirs, and cultivating drought-tolerant crops—these practices and their efficacy, along with the full spectrum of drought impacts, have not been systematically quantified from the stakeholders' perspective. This study aims to fill this critical gap. Its primary innovation lies in its integrated, bottom-up approach to assessing drought impacts. Unlike previous studies in Iran that often rely on remote sensing or purely environmental indices, this research employs a robust mixed-methodology: combining qualitative interviews to identify context-specific indicators with a quantitative survey (based on a validated and highly reliable questionnaire, α=0.829) to rank socio-economic and environmental impacts through statistical analysis (Friedman Test). This method directly prioritizes impacts based on the lived experiences and perceptions of the stakeholders themselves—farmers, pastoralists and local elders production (Safdary et al., 2025).

The significance of this research is threefold: First, it provides a empirically-grounded hierarchy of the most severe drought impacts specific to the Karganeh Watershed, offering clear priorities for policymakers and disaster management agencies. Second, by documenting and validating indigenous coping strategies, it helps to integrate local knowledge into formal adaptation planning, increasing the likelihood of community adoption and policy success. Finally, the methodological framework developed is transferable, providing a model for conducting similar stakeholder-centric vulnerability assessments in other arid and semi-arid regions globally. Therefore, this study offers not just a diagnosis of a local problem, but a replicable tool for building resilience in drought-prone agricultural communities (Karimi Sangchini et al., 2021).

Materials and Methods

This study employed a quantitative, cross-sectional research design to assess the perceived impacts of drought on stakeholders in the Karganeh Watershed. The methodology consisted of four main phases: (1) identification of drought impact indicators through a literature review and expert consultation, (2) selection of a representative sample of stakeholders using probabilistic sampling, (3) data collection via a structured questionnaire assessing the perceived importance of various impacts, and (4) statistical analysis of the data using descriptive and non-parametric inferential methods to rank and prioritize the identified impacts.

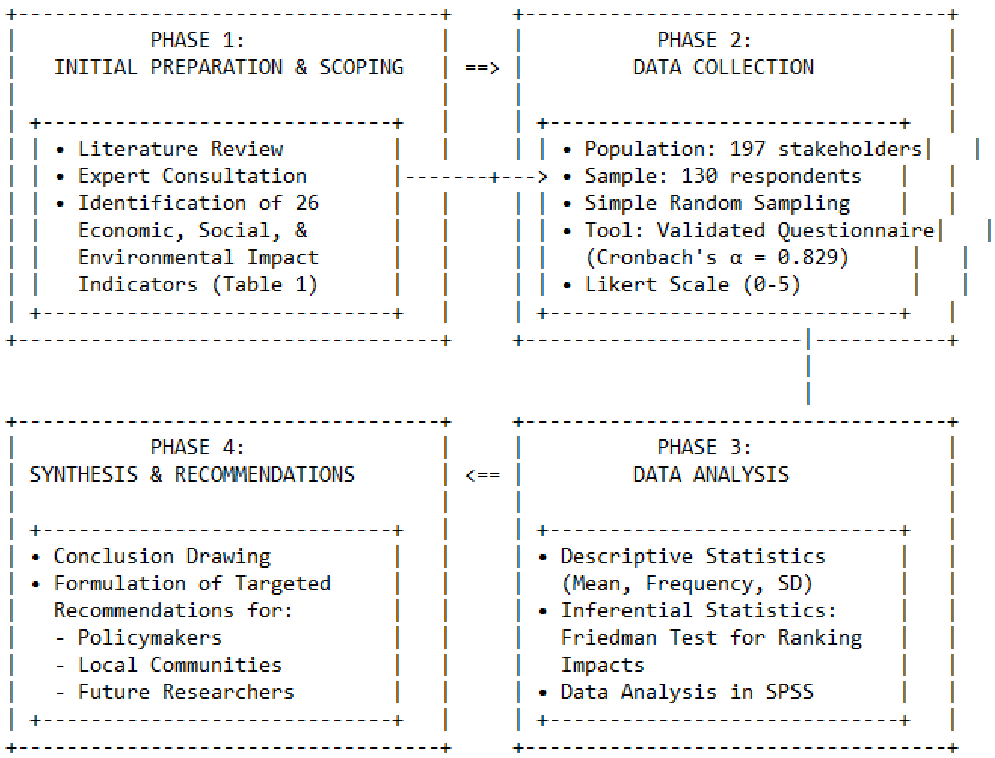

Figure 1. Research Workflow Diagram

A flowchart illustrating the sequential mixed-methods research design, from initial scoping based on literature and expert input to data collection and analysis, culminating in the development of evidence-based conclusions and recommendations.

Study area

The Karganeh Watershed is one of the large sub-watersheds of the Khorramabad Watershed, located in Iran. It covers an area of 294.2 square kilometers. A review of the watershed's slope and elevation map indicated that the minimum elevation of the Karganeh Watershed is 1300 meters and the maximum is 2700 meters. Additionally, 60% of the watershed's area has a slope of over 12% (relatively high slope). The study area is situated between longitudes 48°44'24" to 48°23'59" East and latitudes 33°37'12" to 33°25'12" North. Its average rainfall is 469 millimeters. Based on the current land-use map prepared for the watershed (total area of 15,477 hectares), the land use distribution is as follows: 12,036 hectares (40.9%) are rangelands, 1,813 hectares (6.2%) are forests (mostly degraded), 7,805 hectares (26.5%) are rain-fed agriculture, 360 hectares (2.1%) are rain-fed agriculture under forest canopy, 3,871 hectares (13.2%) are irrigated agriculture, and 2,445 hectares (8.3%) are rocky areas and rock outcrops. The Karganeh Watershed has 61 villages, with 56 of them being permanently inhabited. According to the 2016 census, the watershed's population is 12,186 people, with 3,285 households and an average household size of 4 people. Of this population, 6,441 are male (52.9%) and 5,745 are female (47.1%). The most populated village in the watershed is Malekabad with 1,037 people, and the least populated is Hadiabad with 21 people (Karimi Sangchini et al., 2024).

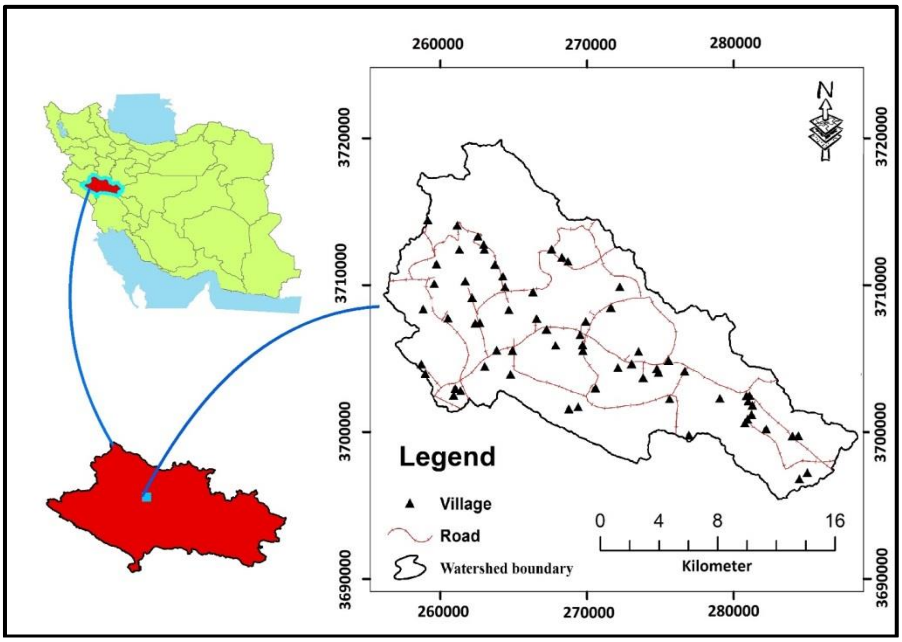

Figure 2. Geographical location of the Karganeh Watershed in Lorestan Province, Iran.

Statistical Population and Sample

The target population for this research comprised key local stakeholders whose livelihoods are directly dependent on natural resources and are most affected by drought. This included agricultural and livestock farmers, members of village councils, village heads (dehyars), and nomadic groups within the Karganeh Watershed.

To determine the sample size from this finite population, Cochran's formula for categorical data was applied. The total population of the watershed is 12,186 people. There are 61 villages in this watershed, of which 56 are inhabited. The statistical population is determined to be 197 people, and a sample size of 130 people is determined using Cochran's formula (Karimi Sangchini and Arami, 2024).

Research Methodology and Data Collection

This study is classified as field research based on its data collection methodology. The variables examined—specifically the effects of drought—were identified and refined through an iterative process. This process involved in-person site visits and face-to-face interviews with stakeholders in the Karganeh Watershed to ground the research in local context. Additionally, a comprehensive review of theoretical literature related to the research topics, including studies conducted both domestically and internationally, was undertaken. Furthermore, semi-structured interviews with key experts and informants were conducted for the purpose of identifying and extracting relevant information. A total of 26 economic, social, and environmental impacts were documented and are presented in Table 1.

Table 1. Effects of Economic-Social and Environmental Impacts of Drought Extracted for the Karganeh Watershed

Row	Economic and Social Effects of Drought	Row	Environmental Effects of Drought
1	Decrease in income from agricultural and horticultural production	1	Destruction of springs and drying of wells
2	Decrease in crop yield	2	Severe reduction of groundwater and surface water resources
3	Decrease in orchard yield	3	Increase in pests and diseases of orchard trees
4	Increase in agricultural input prices	4	Decrease in water quality
5	Increase in agricultural production costs	5	Rising temperatures and increased water demand of orchards
6	Increase in non-agricultural incomes	6	Reduction in forage plant diversity
7	Increase in non-agricultural employment	7	Soil erosion and degradation

Row	Economic and Social Effects of Drought	Row	Environmental Effects of Drought
	opportunities		
8	Decrease in investment motivation in the agricultural sector	8	Decrease in herbal medicinal plant production
9	Increase in natural hazards and higher investment risks	9	Loss of wildlife habitats in the region
10	Increase in debts to banks and government organizations	10	Increase in invasive plants in rangelands
11	Decrease in supply of production inputs		
12	Change in production and farming systems		
13	Migration from rural to urban areas		
14	Increase in social tensions among villagers		
15	Decrease in local participation		
16	Increase in mental and psychological issues		
17	Migration from rural to urban areas (repeat)		

The sample selection was conducted using a simple random sampling technique to ensure each member of the population had an equal chance of being selected, thereby enhancing the representativeness of the sample. The data collection instrument was a researcher-designed questionnaire, which consisted of two sections: the personal and professional characteristics of the respondents and the stakeholders' perspectives regarding the importance of each of the drought impacts in the studied basin. To measure the second section, a five-point Likert scale (ranging from 0, representing the least importance, to 5, representing the highest importance) was employed.

Validity and Reliability

The content validity of the questionnaire was established through review by a panel of experts in the fields of watershed management, drought, and sociology. Its reliability was assessed for internal consistency using Cronbach's alpha coefficient. The Cronbach's alpha was calculated based on the relationship formula (1) using SPSS software (Karimi Sangchihi et al., 2022)

$$\propto = \frac{k}{k-1}\left[1 - \frac{\sum_{i=1}^{k} S_i^2}{S_T^2}\right] \quad (1)$$

K: The number of items *Sj*: The standard deviation of the scores for item number j. *Stotal*: The standard deviation of the total scores across all respondents (overall variability of all items).

For this study, the reliability coefficient was found to be 0.829, indicating a high level of internal consistency among the questionnaire items.

Data Analysis

Both descriptive and inferential statistics were employed for data analysis using the SPSS software package. In the descriptive statistics section, data were characterized using measures such as frequency, mean, standard deviation, and percentage.For the inferential analysis, the Friedman non-parametric test was selected as the primary statistical method. This test is appropriate for this research as it is used for the analysis of two-way rank dispersion, involving ranking and comparing the mean ranks of different related groups (in this case, the different drought impact indicators) within the SPSS software (Mosaffaei and Salehpour Jom, 2018). The Friedman test examines the hypothesis that k related samples (the ranked impact items) are drawn from the same population.

$$X^2 = \frac{12}{Nk(k+1)} \sum_{i=1}^{k} R_j^2 - 3N(k+1) \quad (2)$$

K: The number of columns or questions, N: The number of rows, Rj: The sum of ranks in column j, In this case, the degrees of freedom are k−1.

Research Findings

Descriptive Results

Based on the obtained results, the characteristics of the respondents can be summarized as follows (Table 2): Most respondents were between 31 and 50 years old, and a significant proportion had earned qualifications below a diploma level. Approximately 60 percent of the respondents reported an agricultural experience ranging from 11 to 30 years. The vast majority, around 90 percent, were employed. The primary activities among the respondents were agriculture, horticulture, and animal husbandry, each with a prevalence rate of approximately 94 percent. A considerable portion of the respondents were small landowners, possessing less than 5 hectares of land, with respective rates of 74 and 63 percent. In terms of livestock, most respondents did not raise small livestock such as sheep and goats (42 percent), while a large proportion, about 80 percent, owned large livestock such as cattle. Furthermore, the data indicates that most respondents had no history of loan receipt (91 percent) and were not members of any cooperatives or social organizations (60 percent).

Table 2. Descriptive Statistics of Respondents in the Karganeh Watershed

Variable	**Class (Year)**	**Count**	**Percentage**	**Variable**	**Class**	**Count**	**Percentage**
Age	20-29	0	0	Education Level	Illiterate	0	0
	30-40	49	37.7%		Under Diploma	36	27.7%
	41-50	42	32.3%		Diploma	66	50.8%
	Over 50	39	30%		Bachelor's Degree	21	16.1%
	Total	130	100%		Above Bachelor's	7	4.5%
					Total	130	100%
Variable	Class (Year)	Count	Percentage	Variable	Class	Count	Percentage
Farming Experience	0-10	17	13.1%	Employment Status	Employed	89	68.5%
	11-20	50	38.5%		Semi-employed	20	15.4%
	21-30	28	21.5%		Unemployed	4	3.1%
	Over 30	35	26.9%		Incapacitated	17	13.1%
	Total	130	100%		Total	130	100%
Variable	Class	Count	Percentage	Variable	Class	Count	Percentage
Type of Activity	Agriculture and Horticulture	94	72.3%	Land Condition	No Land	8	6.2%
	Livestock Farming	29	22.3%		Less than 5 hectares	97	74.6%
	Laborer	3	2.3%		5-10 hectares	18	13.8%
	Employee	4	3.1%		More than 10 hectares	7	5.4%
	Total	130	100%		Total	130	100%
Variable	Class	Count	Percentage	Variable	Class	Count	Percentage
Orchard Status				Livestock Status (Cattle)	No Cattle	105	80.8%
	Less than 5 hectares	83	63.8%		1-5 heads	18	13.8%
	5-10 hectares	9	6.9%		6-10 heads	6	4.6%
	Over 10 hectares	0	0%		More than 10 heads	1	0.8%
	Total	130	100%		Total	130	100%
Variable	Class	Count	Percentage	Variable	Class	Count	Percentage
Livestock Status (Sheep and Goats)	No Sheep	55	42.3%	Loan History	Yes	11	8.5%
	Less than 10 heads	31	23.8%		No	119	91.5%
	11-30 heads	13	10%		Total	130	100%
	More than 30 heads	31	23.8%	Membership in Cooperatives & Associations	Yes	51	39.2%
	Total	130	100%		No	79	60.8%
					Total	130	100%

A majority of the respondents expressed low or very low satisfaction with the organization of educational and extension classes, accounting for 72.3%. Additionally, 60 percent of them were not familiar with drought adaptation strategies. Most respondents did not have access to low-interest bank loans, with a percentage of 91.5%. Furthermore, 93 percent did not utilize agricultural insurance for their products, and 87.7 percent lacked access to agricultural machinery (Table 3).

Table 3. Ontinuation of the Descriptive Statistics of Respondents in the Karganeh Watershed

Variable	**Satisfaction Level**	**Count**	**Percentage**	**Variable**	**Awareness Level**	**Count**	**Percentage**
Satisfaction with Educational and Extension Classes	1	40	30.8%	Familiarity with Drought Adaptation Strategies	1	19	14.6%
	2	54	41.5%		2	59	45.4%
	3	27	20.8%		3	35	26.9%
	4	7	5.4%		4	16	12.3%
	5	2	1.5%		5	1	0.8%
	Total	130	100%		Total	130	100%
Variable	Satisfaction Level	Count	Percentage	Variable	Response	Count	Percentage
Access to Low-Interest Bank Loans	1	71	54.6%	Use of Agricultural Insurance	Yes	9	6.9%
	2	48	36.9%		No	121	93.1%
	3	8	6.2%		Total	130	100%
	4	3	2.3%	Access to Agricultural Machinery	Yes	16	12.3%
	5	0	0%		No	114	87.7%
	Total	130	100%		Total	130	100%

Analysis of the Ranking Results

Table 4 demonstrates how the economic and social impacts of drought have been evaluated among farmers and residents in the studied areas. These evaluations are based on the mean scores, standard deviations, as well as the minimum and maximum values for each component. The decrease in income and production: The highest score relates to the reduction in income derived from agricultural and horticultural outputs (mean of 4.31), indicating a significant negative impact on farmers' earnings. Similarly, the reductions in crop and orchard yields (means of 4.19 and 4.15, respectively) demonstrate the considerable effect of drought on decreasing agricultural productivity. Increase in costs and prices: The rise in the prices of agricultural inputs (mean of 3.89) and production costs (mean of 3.67) also reflect economic pressure on farmers, although these are perceived as less severe compared to the loss of income. Role of non-agricultural income and employment: The increase in non-agricultural incomes and employment opportunities, with scores below 4 (means of 3.29 and 1.96 respectively), suggests that the negative impacts in these sectors are less pronounced. It appears that these indicators are less directly affected by drought conditions. Other factors: The decrease in investment motivation (mean of 4.03) and the increase in natural hazards and investment risks (mean of 3.99) highlight the serious challenges drought poses to investment and risk management. Changes in farming and production systems and rural-to-urban migration (means of 3.32 and 3.66) also signify notable social impacts, though they are rated at a moderate level. Social and psychological changes: The increase in social tensions (mean of 3.08) and the decline in local participation (mean of 3.13) indicate that drought can amplify social conflicts and reduce community engagement in rural areas. Additionally, the rise in mental health and psychological issues (mean of 2.84) is at a lower level but still suggests the presence of adverse effects. Overall, the results emphasize that the economic impacts of drought-particularly the reduction in income and agricultural productivity—are highly evident, while social consequences such as increased tensions, migration, and mental health issues are also present but to a lesser extent. These findings underscore that the impacts of drought extend beyond the economic sphere and highlight the necessity for comprehensive planning across various sectors to address these challenges.

Table 4. Descriptive Statistics of the Economic and Social Effects of Drought on Beneficiaries of the Karganeh Watershed

Economic-Social Effects of Drought	Mean	Standard Deviation	Minimum	Maximum
Decrease in income from agricultural and horticultural production	4.31	0.79	3	5
Decrease in crop yield	4.19	0.68	3	5
Decrease in orchard yield	4.15	0.85	2	5
Increase in agricultural input prices	3.89	0.92	2	5
Increase in agricultural production costs	3.67	0.81	1	5
Increase in non-agricultural incomes	3.29	0.75	1	5
Increase in non-agricultural employment opportunities	1.96	0.71	1	3
Decrease in investment motivation in the agricultural sector	4.03	0.86	2	5
Increase in natural hazards and investment risks	3. 99	0.96	2	5
Increase in debt to banks and government organizations	3.61	0.69	1	5
Decrease in the supply of production inputs	3.82	0.8	2	5
Change in farming and production systems	3.32	0.76	1	5
Increase in migration from rural to urban areas	3.66	0.81	1	5
Increase in social tensions among villagers	3.08	0.65	1	4
Decrease in local participation	3.13	0.80	1	5
Increase in psychological and mental health issues	2.84	0.73	1	4

Table 5 presents an assessment of the environmental impacts of drought, as perceived by respondents. The evaluation incorporates the mean scores, standard deviations, and the minimum and maximum values for each environmental variable. The destruction of springs and the drying up of wells received a high mean score of 4.14, indicating that respondents perceive this as a significant consequence of drought. Similarly, the decline in water quality is also considered highly impactful, with a mean of 4.07, reflecting substantial concerns about water-related issues. The reduction of groundwater and surface water resources is also notably significant, with a mean score of 3.97 and a high standard deviation of 1.06, suggesting some variability in responses. The increase in pests and diseases affecting orchard trees and the rise in water demand due to elevated temperatures are perceived as moderate to high effects, with mean scores of 3.72 and 3.71 respectively, along with considerable variability indicated by the standard deviations. Other environmental effects such as reduction in forage plant diversity (mean 3.81), soil erosion and degradation (mean 3.67), and decline in herbal medicinal plant production (mean 3.45) further highlight the broad spectrum of ecological impacts attributed to drought conditions. The loss of wildlife habitats (mean 3.01) and the invasion of non-native plants in rangelands (mean 3.74) are also recognized, though with somewhat lower mean scores, indicating moderate concern. Overall, the findings suggest that drought-related environmental degradation is perceived to be severe, with significant impacts on water resources, biodiversity, and ecological stability, underscoring the urgent need for sustainable management and mitigation strategies.

The economic, social, and environmental impacts of drought on stakeholders in the Karganeh Watershed were evaluated using the Friedman ranking test. The statistical difference identified by the Friedman test was significant at the 1% level for both assessments. table 6 presents a comparative ranking of the socio-economic and environmental effects of drought, based on their perceived importance or impact as evaluated by respondents. The ranking is indicated by the mean rank scores for each effect. The decrease in income from agricultural and horticultural production was ranked as the most significant socio-economic impact of drought, with a mean rank of 16.13, closely followed by the decrease in crop yield (16.01), and the decrease in orchard yield (16.09).

Table 5. Descriptive Statistics of the Environmental Impacts of Drought on the Land Use Practitioners in the Karganeh Watershed

Environmental Effects of Drought	Mean	Standard Deviation	Minimum	Maximum
Destruction of springs and drying of wells	4.14	0.61	2	5
Severe reduction of groundwater and surface water resources	3.97	1.06	1	5
Increase in pests and diseases of orchard trees	3.72	1.68	1	5
Decrease in water quality	4.07	0.88	2	5
Rising temperatures and increased water demand of orchards	3.71	1.02	2	5
Reduction in forage plant diversity	3.81	1.3	1	5
Soil erosion and degradation	3.67	1.41	1	5
Decrease in herbal medicinal plant production	3.45	1.09	1	5
Loss of wildlife habitats in the area	3.01	1.14	1	5
Increase in invasive plants in rangelands	3.74	1.11	1	4

These high rankings demonstrate that the primary concern among respondents is the direct impact on farmers' income and productivity. Other notable effects include the reduction in investment motivation within the agricultural sector (15.37), increases in debts owed to banks and government organizations (12.6), and the rise in agricultural input prices and production costs (14.25 and 14.06). Migration from rural to urban areas (13.54) and increased social tensions and decreased local participation (12.29 and 11.97) also feature prominently, indicating significant social disruptions owing to drought. From an environmental perspective, the destruction of springs and drying of wells was rated as the most severe impact, with a mean rank of 9.36. This underscores the critical importance of water resources in the ecological health of the region. The reduction of groundwater and surface water resources follows (7.51), alongside increased pests and diseases affecting orchard trees (6.74). Water quality issues and rising temperatures with increased water demand received mean ranks of 8.63 and 6.81, respectively, reflecting significant concerns about water sustainability and climatic changes. Other notable environmental impacts include reduction in forage plant diversity (7.93), soil erosion and degradation (5.39), and invasion of non-native plants in rangelands (7.48). The ranking indicates that both economic and environmental effects of drought are of high concern, with water resource depletion (destruction of springs and groundwater reduction) being perceived as the most critical environmental issue. Socio-economic impacts such as decreased income, crop yields, and investment motivation are prioritized as the most pressing social and economic challenges. These findings highlight the interconnectedness of ecological health and socio-economic stability in drought-affected regions, emphasizing the need for integrated management strategies that address both environmental restoration and economic resilience.

Table 6. Ranking of the Effects of Economic-Social and Environmental Impacts of Drought on Beneficiaries Using the Friedman Test in the Karganeh Watershed

Row	Economic and Social Effects of Drought	Mean rank	Row	Environmental Effects of Drought	Mean rank
1	Decrease in income from agricultural and horticultural production	16.13	1	Destruction of springs and drying of wells	9.36
2	Decrease in crop yield	16.01	2	Severe reduction of groundwater and surface water resources	7.51
3	Decrease in orchard yield	16.09	3	Increase in pests and diseases of orchard trees	6.74
4	Increase in agricultural input prices	14.25	4	Decrease in water quality	8.63
5	Increase in agricultural production costs	14.06	5	Rising temperatures and increased water demand of orchards	6.81
6	Increase in non-agricultural incomes	11.2	6	Reduction in forage plant diversity	7.93
7	Increase in non-agricultural employment opportunities	7.51	7	Soil erosion and degradation	5.39
8	Decrease in investment motivation in the agricultural sector	15.37	8	Decrease in herbal medicinal plant production	4.82
9	Increase in natural hazards and higher investment risks	15.1	9	Loss of wildlife habitats in the region	4.33
10	Increase in debts to banks and government organizations	12.6	10	Increase in invasive plants in rangelands	7.48
11	Decrease in supply of production inputs	15.3			
12	Change in production and farming systems	10.44			
13	Migration from rural to urban areas	13.54			
14	Increase in social tensions among villagers	12.29			
15	Decrease in local participation	11.97			
16	Increase in mental and psychological issues	8.13			

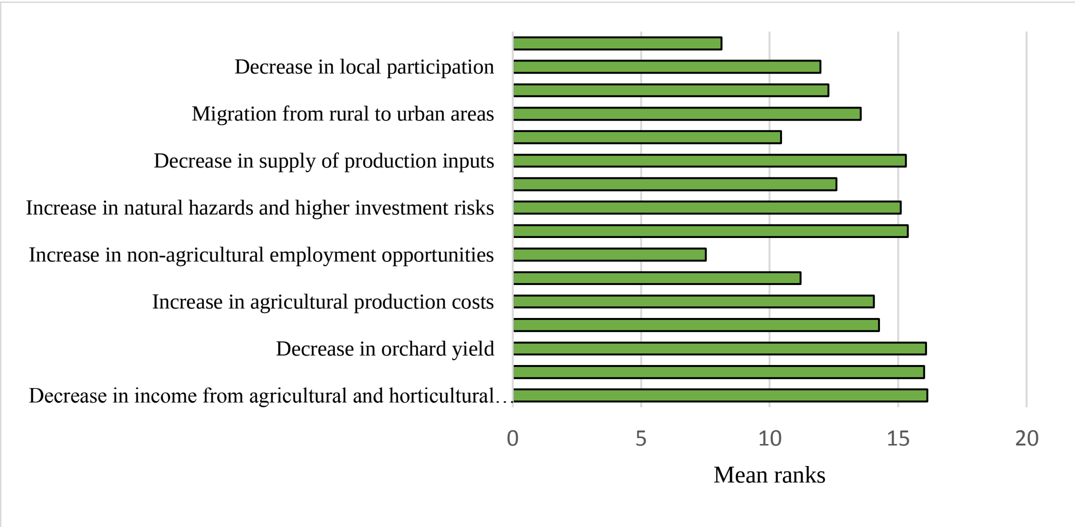

Figure 3. A bar chart ranking the top socio-economic impacts of drought based on their mean rank from the Friedman test.

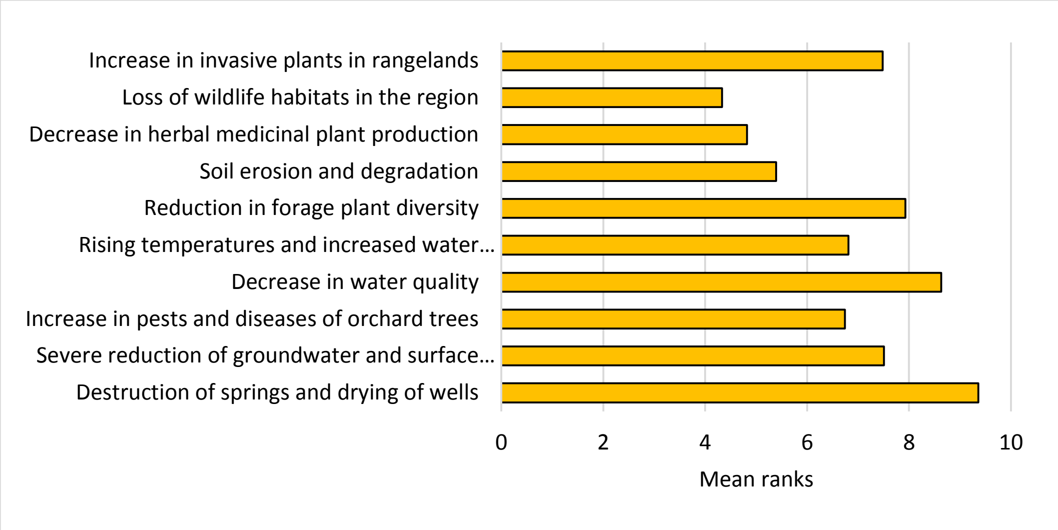

Figure 4. A bar chart ranking the environmental impacts of drought based on their mean rank from the Friedman test.

Discussion

Descriptive statistics indicated that most respondents were between 30 and 50 years of age. This suggests that most of the sample population was relatively young to middle-aged. Additionally, approximately 50% of the respondents held a diploma, reflecting a moderate level of education among the sample. Most respondents (about 94%) were engaged in agriculture, horticulture, and livestock farming. Around 67% had extensive experience in farming and livestock management, exceeding 10 years. This indicates that the sample population is familiar with the effects of drought and potential adaptation strategies. Most of the stakeholders in the watershed were small landowners, with their agricultural or orchard lands below 5 hectares, representing about 75% of the sample. This highlights their vulnerability to drought impacts. Overall, the survey revealed that 58% of the respondents possessed sheep and goats, and 19% owned approximately 83 cattle, which could pose a risk of exacerbating drought conditions in the watershed. The descriptive statistics from this study highlight key demographic and socio-economic characteristics of the respondents within the watershed. The concentration of age between 30 to 50 years aligns with findings from similar studies, such as Shang et al. (2012), which identified the middle-aged demographic as predominant in agricultural communities and crucial for implementing adaptive measures against climate variability. This age group is often experienced but still actively engaged in farming activities, making them vital stakeholders in drought mitigation strategies. The educational profile, with nearly 50% holding a diploma, indicates a moderate level of educational attainment, which is consistent with findings from Ghonji et al. (2015) in comparable agricultural regions. Education level influences the capacity to adopt innovative practices and access extension services, emphasizing the importance of targeted awareness programs. The high engagement (94%) in agriculture, horticulture, and livestock farming underscores the dependency of the community on natural resource-based livelihoods, similar to observations by Khan et al (2020) in semi-arid regions. Notably, the extensive experience exceeding 10 years among 67% of respondents suggests a deep understanding of local environmental challenges, including drought impacts. Small landholdings (below 5 hectares), which constituted about 75% of the sample, reveal a vulnerability profile consistent with other studies, such as those by Jamshidi et al (2019), highlighting that small-scale farmers are more susceptible to climate-induced stresses due to limited resource buffers and access to adaptive options. The prevalence of small landowners exacerbates their vulnerability and calls for targeted interventions to improve resilience. The livestock ownership pattern—58% possessing sheep and goats and 19% owning approximately 83 cattle—raises concerns regarding resource pressures on water and pasture, which could intensify drought conditions, similar to findings in pastoral systems documented by Swanepoel et al. (2010). Livestock management practices directly influence drought vulnerability, and overgrazing often accelerates land degradation, further compounding the drought risk. In conclusion, the study reveals a community characterized by moderate education, extensive agricultural experience, reliance on small landholdings, and significant livestock ownership, placing them at heightened risk of drought impacts. These findings align with prior research emphasizing the need for integrated drought management policies tailored to small-scale farmers and pastoralists. Future strategies should incorporate community capacity building, sustainable resource management, and climate-resilient agricultural practices to enhance adaptive capacity.

Descriptive statistical analyses showed that the profound economic and social impacts of drought on farmers and local residents in the studied region. The high mean scores associated with reductions in income (4.31) and crop and orchard yields (4.19 and 4.15) reveal that drought significantly diminishes agricultural productivity and livelihoods, which are critical to rural economies. The increased costs of inputs and production (means of 3.89 and 3.67), although perceived as less severe than income loss, still impose notable economic pressures on farmers. These findings align with previous research indicating that drought exacerbates financial vulnerabilities in agricultural communities, ultimately threatening their sustainability (Sepehr, 2014). Furthermore, the social ramifications—such as increased social tensions (mean of 3.08), reduced community participation (mean of 3.13), and mental health issues (mean of 2.84)—although rated at moderate levels, point to broader sociocultural disruptions caused by prolonged drought conditions. These social consequences can undermine social cohesion and community resilience, making recovery more challenging once drought conditions improve (Falkenmark and Widstrand, 1992). The results highlight the importance of adopting integrated management strategies that address both economic and social vulnerabilities. Policymakers should prioritize support for agricultural income stability and social cohesion, alongside measures to enhance drought resilience and mitigate its adverse impacts on mental health and community participation. Drought exerts a significant negative influence on agricultural productivity and farmers' income, with secondary effects observed in social cohesion and mental well-being. These findings emphasize the necessity for comprehensive, multi-sectoral planning and intervention strategies that bolster economic resilience, promote social stability, and enhance adaptive capacity in drought-prone regions. Nevertheless, there are also some differences between the findings of this study and those of other research. For example, a study conducted by Savari et al (2024) in Iran reported a greater impact of drought on mental health, which may be attributed to variations in cultural, economic, and social conditions across regions. These differences highlight that, although drought is a global challenge, the severity and nature of its effects can vary significantly depending on local circumstances and specific regional contexts.

The findings presented the extensive environmental consequences of drought as perceived by respondents in the study area. The high mean scores associated with the destruction of springs and the drying up of wells (4.14) underscore the severe depletion of water sources, which is a critical issue in arid and semi-arid regions. Similarly, the decline in water quality (mean of 4.07) and the reduction of groundwater and surface water resources (mean of 3.97 with a high standard deviation of 1.06) reflect substantial concerns about water scarcity and variability, which threaten both ecological and human systems (Motamed and Devisti, 2012). Environmental effects such as the increase in pests and diseases affecting orchard trees (mean of 3.72) and the rise in water demand due to higher temperatures (mean of 3.71) further demonstrate how drought exacerbates ecological imbalances and stresses agricultural productivity. The reduction in forage plant diversity (mean 3.81), soil erosion, and degradation (mean 3.67), as well as the decline in herbal medicinal plant production (mean 3.45), reveal significant impacts on biodiversity and ecosystem services, which are vital for sustainability. Moreover, concerns about habitat loss (mean 3.01) and the invasion of non-native plants in rangelands (mean 3.74) suggest that drought contributes to ecological disruption, threatening native species and overall ecosystem resilience. The variability in responses, indicated by standard deviations, points to differing perceptions or intensities of environmental impacts among respondents. Overall, the survey indicates that drought-induced environmental degradation is perceived as severe, especially regarding water resource depletion, biodiversity loss, and ecological stability. These findings emphasize the pressing need for sustainable water management, conservation efforts, and ecological restoration strategies aimed at mitigating these impacts and enhancing resilience against future droughts in vulnerable regions.

The application of the Friedman ranking test to assess the economic, social, and environmental impacts of drought in the Karganeh watershed reveals statistically significant differences at the 1% level, underscoring the profound influence of drought on different facets of regional sustainability. The ranking results highlight that the most critical socio-economic impacts, such as the reduction in farmers' income (mean rank 16.13), crop yields (16.01), and orchard productivity (16.09), are primarily related to direct agricultural losses. These findings underscore the vulnerability of farming communities to drought-induced productivity declines, which threaten livelihoods and economic stability. Other socio-economic concerns, including decreased investment motivation (15.37), rising debts (12.6), increased input prices, and costs (14.25 and 14.06), along with migration to urban areas (13.54), reveal the broader social upheaval caused by water scarcity. Moreover, social tensions and reduced community participation (ranked around 12) point to potential social cohesion challenges, directly linked to environmental stresses. From an environmental perspective, the destruction of springs and dried wells (mean rank 9.36) was perceived as the most severe impact, emphasizing the critical role of water resources for ecological health. The subsequent decline in groundwater and surface water (7.51), increased pest and disease prevalence (6.74), and water quality issues (8.63) reflect escalating environmental degradation and climatic stressors. The reduction in forage diversity (7.93), soil erosion (5.39), and invasive plant species in rangelands (7.48) further illustrate the wide-ranging ecological impacts, threatening biodiversity and ecosystem stability. The findings of this study align closely with prior research highlighting the profound environmental consequences of drought in arid and semi-arid regions. For instance, Shaikh and Birajdar (2024) also emphasized the critical depletion of water sources, including groundwater and surface water, along with the resultant ecological stresses. Their work similarly underscored concerns about water quality deterioration and biodiversity loss, which corroborate the current results indicating the significant decline in water resources, biodiversity, and ecosystem services. Furthermore, the observed environmental impacts such as increased pest infestations and disease prevalence are consistent with findings by Zhou et al. (2024), who reported that drought conditions often lead to ecological imbalances fostering pest outbreaks and diseases affecting both natural vegetation and agricultural systems. Regarding socio-economic impacts, the ranking of critical issues such as decreased income, crop yields, and orchard productivity aligns with previous studies by Timsina et al (2025), which identified direct crop and livestock productivity losses as primary vulnerabilities for farming communities in drought-prone areas. Their research also highlighted the broader social ramifications, including migration and reduced community participation, as mechanisms by which communities cope with water scarcity and economic hardship. Overall, the findings demonstrate that both economic and environmental impacts of drought are perceived as highly significant, with water resource depletion being especially critical. These interconnected challenges call for integrated management approaches that combine ecological restoration with economic resilience strategies. Addressing water scarcity through sustainable resource management, enhancing agricultural adaptation practices, and improving social cohesion are essential to mitigate the adverse impacts of drought on vulnerable communities and ecosystems in the Karganeh Watershed.

Conclusions and Recommendations

Conclusions

This study employed a integrated, bottom-up methodology to systematically quantify and prioritize the perceived impacts of drought on stakeholders in the Karganeh Watershed, Iran. The research unequivocally demonstrates that drought acts as a catalyst for a interconnected socio-ecological crisis, with effects permeating every aspect of livelihood and environmental health.The key findings reveal that the most severe impacts are profoundly economic and hydrological in nature. The paramount concern for stakeholders is the direct loss of income and agricultural productivity, driven by significant reductions in crop and orchard yields. Concurrently, the depletion and degradation of water resources, particularly the destruction of springs and the drying of wells, emerged as the most critical environmental threat. These core impacts trigger a cascade of secondary consequences, including diminished investment motivation, increased social tensions, and out-migration, thereby threatening the long-term resilience and stability of the entire community.

The primary innovation of this research lies in its methodological approach, which directly integrates stakeholder perception into impact assessment. By moving beyond purely biophysical indices, this study provides a hierarchically-ordered list of priorities that reflects the lived realities of the affected population. This offers a crucial evidence-base for designing targeted and socially-accepted intervention strategies. The practical implications of this work are significant. The findings provide policymakers and watershed managers with a clear mandate to:

- Prioritize interventions that safeguard and enhance water resources (e.g., spring rehabilitation, managed aquifer recharge).
- Develop and promote drought-resilient agricultural practices and drought-tolerant crops to directly address yield losses.
- Implement financial safety nets, such as accessible insurance schemes and low-interest loans, to buffer against income shocks and maintain investment capacity.

Despite its contributions, this study has limitations. The findings are specific to the socio-ecological context of the Karganeh Watershed, though the methodology is transferable. Furthermore, the study captures perceptions at a single point in time; longitudinal research would be valuable to understand how these impacts evolve. Therefore, future research should:

- Apply this stakeholder - driven methodology in other arid and semi-arid regions to enable comparative analysis.
- Investigate the direct causal pathways between water resource depletion and socio-economic outcomes in greater depth.
- Focus on co-developing and evaluating specific adaptation strategies with local communities, based on the priority impacts identified here.

In conclusion, this research provides a robust, empirical foundation for moving from crisis response to proactive resilience building. It argues that effective drought management must be rooted in a deep understanding of local priorities, ensuring that interventions are not only technically sound but also socially relevant and sustainable.

Recommendations

Based on these conclusions, the following actionable recommendations are proposed:

A. For Policy and Decision-Makers:

1. **Promote Drought-Resilient Agriculture:** Subsidize and support the transition to drought-tolerant crop varieties and water-efficient irrigation systems (e.g., drip irrigation) to directly address the key issue of yield loss.
2. **Develop Financial Safety Nets:** Design and implement accessible crop insurance schemes and low-interest emergency loan programs to buffer farmers against income shocks and stabilize investment motivation.
3. **Launch Targeted Educational Programs:** Establish ongoing extension services and training workshops focused on practical drought adaptation and water conservation techniques, addressing the identified knowledge gap among stakeholders.
4. **Implement Integrated Water Resource Management (IWRM):** Enforce policies for the sustainable management of groundwater, including the protection and rehabilitation of springs, and explore options for small-scale water harvesting structures.

B. For Local Farmers and Community Members:

1. **Diversify Livelihoods:** Reduce reliance on purely agricultural income by exploring alternative livelihoods such as agro-tourism, beekeeping, or the processing of agricultural products to enhance economic resilience.
2. **Adopt Water Conservation Practices:** Form water user associations to collectively manage local water resources and adopt practices like mulching and rainwater harvesting at the farm level.
3. **Engage in Knowledge Sharing:** Actively participate in government or NGO-led training programs and share indigenous knowledge and successful adaptation strategies within the community.

C. For Future Research:

1. **Conduct Vulnerability Mapping:** Future studies should employ spatial analysis to map the specific vulnerability of different parts of the watershed to prioritize intervention efforts.
2. **Evaluate Indigenous Strategies:** Research should systematically document and evaluate the efficacy of indigenous drought coping mechanisms (e.g., traditional water storage methods) for potential scaling up.
3. **Investigate Mental Health Links:** A deeper qualitative investigation into the links between drought, livelihood loss, and the psychological well-being of farmers is recommended to inform community support programs.

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