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Research Article

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Posted Date: September 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10753128/v1>

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Additional Declarations: No competing interests reported.

Farmers' Adaptive Strategies to Drought Based on Social Capital and Knowledge Access as an Approach for Enhancing Rural Livelihood Security

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Abstract

Drought, one of the most devastating and pervasive natural hazards, has severely challenged the livelihood resilience of smallholder farmers in rainfed regions worldwide, making adaptation an undeniable necessity. This study explains the adoption of adaptive strategies among smallholder rainfed farmers, focusing on three dimensions of social capital (bonding, bridging, and linking) and two types of knowledge (technical-extension and indigenous-local). The research is applied and descriptive-correlational. The statistical population consisted of smallholder rainfed farmers in Kermanshah province (N = 45,000), western Iran, from which 385 individuals were selected via multi-stage stratified random sampling. Data were collected using a structured questionnaire and analyzed through structural equation modeling (SmartPLS). Findings showed that social capital in all three dimensions and knowledge in both types positively and significantly affect adaptive strategies. Perceived effectiveness partially mediated, while drought experience positively moderated these relationships. The model explained 45% of the variance in adaptive strategies. By designing a novel framework, this study, for the first time, uncovers the simultaneous interplay of social capital and knowledge with the mediating effect of perceived effectiveness and the moderating role of drought experience, demonstrating how these capitals can be leveraged to facilitate a transformative shift from a state of inaction to proactive adaptive agency. The findings offer an actionable framework for policymakers, illustrating that targeted investment in strengthening social networks, expanding extension services, and harnessing lived drought experiences can enhance the adoption of adaptive strategies by up to 45%, thereby taking a meaningful step toward improving rural livelihood security.

Keywords: Drought Adaptation, Social Capital, Indigenous Knowledge, Technical-Extension Knowledge, Smallholder Farmers, Rural Livelihood Sustainability.

1. Introduction

Drought, as one of the costliest and destructive natural hazards, poses a serious threat to agricultural systems and the livelihood security of rural communities worldwide (Meyer, 2018). Climate change has intensified the severity, frequency, and spatial extent of drought across many

regions globally, with its impacts disproportionately affecting developing countries whose economies are heavily dependent on agriculture (Dai, 2011; Wilhite, 2000). Rural communities whose livelihoods are directly tied to agricultural activities and who maintain a direct relationship with nature are among the most vulnerable groups to drought (Keshavarz & Karami, 2016). Drought not only reduces agricultural production and jeopardizes rural household food security but also leads to infrastructure degradation, increased poverty, and ultimately forced rural-urban migration (Adger et al., 2003). Given projections of intensifying drought trends in the coming decades, the adoption of effective adaptive strategies by farmers is not merely an option but an undeniable necessity for sustaining livelihoods and building resilience in rural communities (IPCC, 2012).

Located within the global dry and semi-arid belt, Iran has long grappled with water scarcity and recurrent drought (Savari et al., 2023). However, the exacerbation of climate change impacts in recent years has transformed this challenge into a widespread crisis affecting nearly all provinces across the country (Badvi et al., 2024). Multiple studies have demonstrated the severe vulnerability of rural household livelihoods to drought in Iran and have underscored the urgent need to enhance the adaptive capacity of these communities (Keshavarz & Karami, 2016; Savari et al., 2023). In this context, Kermanshah province, located in western Iran and recognized as one of the country's key agricultural hubs, has been severely affected by recurrent drought episodes. Local studies indicate that drought in this province has directly contributed to reduced cultivated area, declining crop and horticultural production, diminished access to water resources, and increased livelihood insecurity among rural households (Almasi et al., 2016; Badvi et al., 2024). Despite these challenges, many farmers in Kermanshah lack the capacity and knowledge required to adopt effective adaptive strategies, and this knowledge gap has rendered them increasingly vulnerable to drought (Badvi et al., 2024). Consequently, identifying and promoting context-specific adaptive strategies for this province is of critical importance.

Within the scientific literature, social capital has been identified as one of the most critical determinants of adaptive capacity among rural communities in the face of natural disasters (Aldrich & Meyer, 2015). Defined as networks of relationships, trust, and cooperative norms, social capital provides a foundation through which farmers can share information and experiences, access collective resources, and develop collaborative solutions during crises (Putnam, 2000; Portes, 1998). Furthermore, access to up-to-date knowledge and information constitutes another essential pillar underpinning farmers' adaptive behavior (Deressa et al., 2009). Farmers who have access to technical knowledge, modern agricultural methods, and meteorological information are better equipped to identify threats, evaluate available options, and select appropriate adaptive strategies (Alam et al., 2016; Ayal & Leal Filho, 2017). Nevertheless, the digital divide and inequalities in access to extension and educational services—particularly in rural areas of Iran remain significant barriers to the transfer of modern knowledge and technologies to farmers (Badvi et al., 2024). Against this backdrop, the present study was conducted to identify farmers' adaptive strategies to drought based on social capital and knowledge access.

The novelty of the present study can be articulated across four distinct levels. First, while previous research has often examined the role of social capital (Aldrich & Meyer, 2015; Savari et al., 2023) or knowledge and information (Deressa et al., 2009; Alam et al., 2016) in drought adaptation separately, this study integrates these two domains by disaggregating social capital into its three dimensions bonding, bridging, and linking and knowledge access into two types technical-extension and indigenous-local thereby offering a more comprehensive and multi-layered analytical framework. Second, the application of structural equation modeling using the partial least squares approach (SmartPLS) to simultaneously examine direct, mediating, and moderating relationships within a nine-hypothesis model represents a methodological innovation in the field of drought adaptation studies in Iran. Third, by identifying the pivotal roles of linking social capital and technical-extension knowledge, alongside the mediating role of perceived effectiveness and the moderating role of drought experience, this study demonstrates to agricultural policymakers and planners that improving the adoption of adaptive strategies requires a simultaneous approach that strengthens social capital (particularly institutional linkages), enhances access to technical knowledge, and leverages direct drought experience as a mechanism for behavioral change. This approach facilitates the design of targeted interventions tailored to the social and knowledge capacities of local communities to enhance rural resilience and livelihood security (Badvi et al., 2024). Finally, this study represents the first investigation in Iran to simultaneously examine the three dimensions of social capital and the two dimensions of knowledge in relation to the adoption of adaptive strategies by farmers. Its findings can serve as a model for similar regions worldwide, contributing to the global knowledge base on drought risk reduction.

2. Theoretical Foundations and Literature Review

2-1. Social Capital: Concepts, Dimensions, and Its Role in Drought Adaptation

The concept of social capital originates in sociology and political science and is defined as networks of relationships, norms of trust, and reciprocal cooperation that facilitate collective action (Putnam, 2000). Social capital encompasses three main dimensions: structural (social networks and connections), cognitive (trust, norms, and shared values), and relational (the quality of relationships and interactions) (Nahapiet & Ghoshal, 1998). Within the disaster management and risk reduction literature, social capital has been identified as one of the most significant local capacities for coping with natural crises (Aldrich & Meyer, 2015). In other words, social capital serves as a "collective resource" that communities can draw upon during hazards to access information, resources, and mutual support (Portes, 1998).

In the social capital literature, three distinct types have been identified, each playing a different role in the process of adapting to natural hazards (Khalil et al., 2021):

Bonding Social Capital refers to intra-group relationships, mutual trust, and cooperation among members of a local community (e.g., family, neighbors, and friends). This type of social capital provides a platform for sharing experiences and information during crises and enables farmers to benefit from each other's emotional and practical support (Aldrich & Meyer, 2015). Research has

demonstrated that during drought events, farmers with strong ties to family and neighbors gain faster access to information and receive greater practical support (Washaya et al., 2022).

Bridging Social Capital refers to networks that extend beyond the local community, connecting individuals to different social groups and neighboring communities. This type of social capital enhances access to new knowledge and experiences and opens new horizons for selecting adaptive strategies (Putnam, 2000). A study in Ghana found that bridging networks expose farmers to modern agricultural methods from other regions and increase the diversity of adaptive strategies (Khalil et al., 2021).

Linking Social Capital refers to vertical relationships with external institutions and organizations, such as government agencies, non-governmental organizations, research centers, and financial institutions. This type of social capital increases access to resources, specialized information, and institutional support (Khalil et al., 2021). Research in Indonesia demonstrated that connections with government bodies and cooperatives facilitate farmers' access to credit, resistant seeds, and irrigation equipment (Purwanti & Huang, 2022).

Extensive research worldwide has examined the role of social capital in drought adaptation. A study in South Africa revealed that social networks and mutual trust significantly enhance the capacity of rural households to cope with climate shocks (Meyer, 2018). In the Muzarabani region of Zimbabwe, findings indicated that social capital plays a key role in increasing community resilience to drought by facilitating access to collective resources, borrowing loans, and information sharing (Washaya et al., 2022). Similarly, research in Bangladesh demonstrated that institutional access and social capital have a positive and significant effect on the adaptive decisions of rural households at risk (Alam et al., 2016). In Ghana, studies have shown that social capital and local networks are among the most important factors reducing farmers' vulnerability to drought (Khalil et al., 2021).

Research in Indonesia found that social capital, through strengthening local networks and collective participation, plays a significant role in farmers' selection of adaptive strategies to drought (Purwanti & Huang, 2022). In Eswatini (formerly Swaziland), a study showed that strong social networks facilitate access to information, financial resources, and physical equipment, thereby increasing the diversity and success of adaptive strategies (Bailey et al., 2019). The most recent research in 2025 has explicitly demonstrated that disaggregating social capital into its three types—bonding, bridging, and linking is essential for a more precise understanding of its impact on climate change adaptation, with each type exerting different influences on farmers' adaptive decisions (Gören, 2025).

In Iran, numerous studies have also addressed the role of social capital in drought adaptation. The study by Savari et al. (2023) showed that social capital has a positive and significant effect on mitigating drought impacts and improving the livability of rural households in Iran. Additionally, research in Fars province revealed that farmers' active participation in social groups strengthens their beliefs and risk perception regarding climate change, thereby increasing their motivation to adopt adaptive strategies (Mirzaei et al., 2022). Keshavarz and Karami (2016)

also demonstrated in a study in Fars province that social capital, through enhancing trust and cooperation among farmers, facilitates pro-environmental behaviors during drought conditions.

Based on the theoretical foundations and empirical evidence, the first three hypotheses of the study are formulated as follows:

H1: Bonding social capital has a positive and significant effect on farmers' adaptive strategies to drought.

H2: Bridging social capital has a positive and significant effect on farmers' adaptive strategies to drought.

H3: Linking social capital has a positive and significant effect on farmers' adaptive strategies to drought.

2-2. Knowledge Access and Its Role in Drought Adaptation

Access to knowledge and information, as a key component of human capital, plays a fundamental role in empowering farmers to make informed decisions under critical conditions (Deressa et al., 2009). Adaptive knowledge in rainfed farming systems encompasses awareness of modern rainfed methods, meteorological information and rainfall forecasts, soil and moisture management techniques, and the technical skills required to implement drought-adaptive strategies (Bryan et al., 2009). Within the Sustainable Livelihoods Framework (SLF), knowledge access, as part of human capital, is considered one of the five core assets that rural households rely upon to reduce vulnerability and enhance resilience (Below et al., 2012). In other words, knowledge enables farmers to identify drought-induced threats, evaluate available options, and select more effective strategies for adapting to drought (Alam et al., 2016).

In the research literature, two types of knowledge access are particularly important for rainfed farmers:

Access to technical and extension knowledge: This type of knowledge is acquired through formal educational services, extension workshops, agricultural research centers, and mass media. Farmers' technical knowledge includes information on conservation tillage methods, optimal soil and moisture management, appropriate planting timing based on rainfall forecasts, selection of drought-resistant varieties suited to rainfed conditions, and techniques for reducing evaporation and preserving soil moisture (Deressa et al., 2009; Bryan et al., 2009). Farmers with access to extension services and this type of knowledge are significantly more likely to adopt modern methods (Alam et al., 2016).

Access to indigenous and local knowledge: This type of knowledge derives from the accumulated experiences of farmers over years of activity in a specific region. Indigenous knowledge in rainfed systems includes traditional rainfall forecasting methods, planting timing based on natural signs, and local practices for soil moisture conservation and rainfed land management (Alam et al., 2016; Khalil et al., 2021). The most recent research in 2025 in Iran has shown that integrating indigenous knowledge with scientific innovations constitutes a successful model for sustainable and adaptive agriculture in rainfed systems. Farmers who have employed

traditional practices such as conservation tillage, crop rotation, and saffron cultivation (a low-water and rainfed-adapted crop) have significantly enhanced their resilience to climate change (Farshchin, 2025).

Based on the above, the hypotheses for this section of the study are as follows:

H4 Access to technical knowledge has a positive and significant effect on farmers' adaptive strategies to drought.

H5: Access to indigenous and local knowledge has a positive and significant effect on farmers' adaptive strategies to drought.

2-3. The Mediating Role of Perceived Effectiveness of Strategies

Perceived effectiveness of strategies refers to farmers' beliefs about the efficacy and usefulness of a particular strategy in reducing drought impacts (Grothmann & Patt, 2005). According to Protection Motivation Theory, when individuals evaluate a strategy as effective, they are more motivated to adopt it (Rogers, 1975). In other words, mere access to knowledge is insufficient for behavioral change; farmers must also believe in the effectiveness of that knowledge and associated strategies to take practical action (Grothmann & Patt, 2005; Keshavarz & Karami, 2016).

Access to knowledge (both technical and indigenous) generates a more precise understanding of the effectiveness of each strategy under specific conditions, and this perception strengthens farmers' motivation to select more effective strategies. In other words, knowledge influences strategies by shaping perceptions. Empirical research has shown that perceived effectiveness plays a significant mediating role in the relationship between knowledge and adaptive behavior (Grothmann & Patt, 2005; Keshavarz & Karami, 2016). A study in Germany found that perceived effectiveness is the strongest predictor of adaptive behavior in response to natural hazards (Grothmann & Patt, 2005). Similarly, in Iran, Keshavarz and Karami (2016) showed that perceived effectiveness fully mediates the relationship between knowledge and farmers' pro-environmental behavior

Based on the theoretical foundations and empirical evidence, the sixth hypothesis is formulated as follows:

H6: Perceived effectiveness of strategies mediates the relationship between knowledge access (technical and indigenous) and farmers' adaptive strategies.

To rigorously test this hypothesis, two separate mediating pathways involving technical-extension knowledge and indigenous-local knowledge were examined independently in the model (H6a and H6b).

2-4. The Moderating Role of Drought Experience

Direct and repeated experience of drought is a key variable that can moderate the relationships among research variables (Below et al., 2012). According to Experiential Learning Theory,

individuals who directly experience an event develop deeper understanding and stronger responses than those who receive only indirect information (Kolb, 1984).

Farmers who have directly experienced the hardships of drought are more likely to appreciate the value of social networks and mutual support, and they draw more intensively on their social capital during crises (Below et al., 2012; Bailey et al., 2019). Moreover, direct drought experience heightens farmers' need for new knowledge and information, prompting them to actively search for and apply adaptive strategies (Alam et al., 2016). Research has shown that drought experience can positively moderate the relationship between social capital and adaptive behavior, as well as the relationship between knowledge access and adaptive behavior (Below et al., 2012; Bailey et al., 2019).

Based on the theoretical foundations and empirical evidence, the final two hypotheses are formulated as follows:

H7: Direct and repeated drought experience strengthens the relationship between social capital (across bonding, bridging, and linking dimensions) and farmers' adaptive strategies (positive moderating role).

Given that social capital comprises three distinct dimensions, this hypothesis was tested through three sub-hypotheses (H7a: bonding dimension, H7b: bridging dimension, H7c: linking dimension).

H8: Direct and repeated drought experience strengthens the relationship between knowledge access (technical and indigenous) and farmers' adaptive strategies (positive moderating role).

Due to the differentiation of knowledge into technical-extension and indigenous-local types, this hypothesis was tested through two sub-hypotheses (H8a: technical-extension knowledge, H8b: indigenous-local knowledge).

2-5. The Direct Role of Drought Experience in Adopting Adaptive Strategies

Direct and repeated drought experience is a key variable that can serve as an independent motivational factor influencing the adoption of adaptive strategies. In the context of drought management, farmers who have directly experienced the harsh realities of drought develop an objective understanding of their vulnerability and become more motivated to seek adaptive strategies.

Numerous studies worldwide have examined the direct impact of drought experience on farmers' adaptive behavior. A study in Ethiopia found that direct drought experience is the strongest predictor of farmers' behavioral intentions to adopt adaptive strategies, with farmers who have experienced recurrent droughts showing greater willingness to change cultivation methods and water management practices (Gebrehiwot et al., 2021). In Bangladesh, research demonstrated that direct experience of natural disasters heightens farmers' need for new knowledge and information, encouraging them to actively search for and implement adaptive strategies (Alam et al., 2016). In Iran, a study in Khuzestan province indicated that drought experience is a key factor influencing farmers' decisions to change cropping patterns and adopt modern irrigation

methods (Keshavarz & Karami, 2014). Furthermore, research in Fars province revealed that farmers with direct drought experience were significantly more likely to adopt adaptive strategies such as changing planting dates, using resistant varieties, and reducing cultivated area (Keshavarz & Karami, 2016).

The mechanisms through which drought experience influences the adoption of adaptive strategies can be explained through several pathways. First, direct drought experience increases farmers' risk perception and awareness of the negative consequences of water scarcity, thereby strengthening their motivation to change behavior (Grothmann & Patt, 2005). Second, drought experience demonstrates the value of social networks and knowledge during crises, encouraging farmers to utilize these resources more effectively (Below et al., 2012). Third, direct drought experience generates a type of "situational learning" in which farmers, through trial and error, identify more effective strategies and apply them in future droughts (Kolb, 1984). In addition, researchers have shown that drought experience can directly influence adaptive behavior by reducing psychological distance and making the water crisis more tangible (Azadi et al., 2019; Yazdanpanah et al., 2022).

Based on the theoretical foundations and empirical evidence, the ninth hypothesis is formulated as follows:

H9: Direct and repeated drought experience has a positive and significant effect on rainfed farmers' adaptive strategies.

2.6. Conceptual Framework

Based on the theoretical foundations, literature review, and formulated hypotheses (9 hypotheses), the conceptual framework of this study is designed to incorporate the dimensions of social capital (bonding, bridging, linking), the dimensions of knowledge access (technical and indigenous), the mediating variable (perceived effectiveness), and the moderating variable (drought experience), as illustrated in Figure 1.

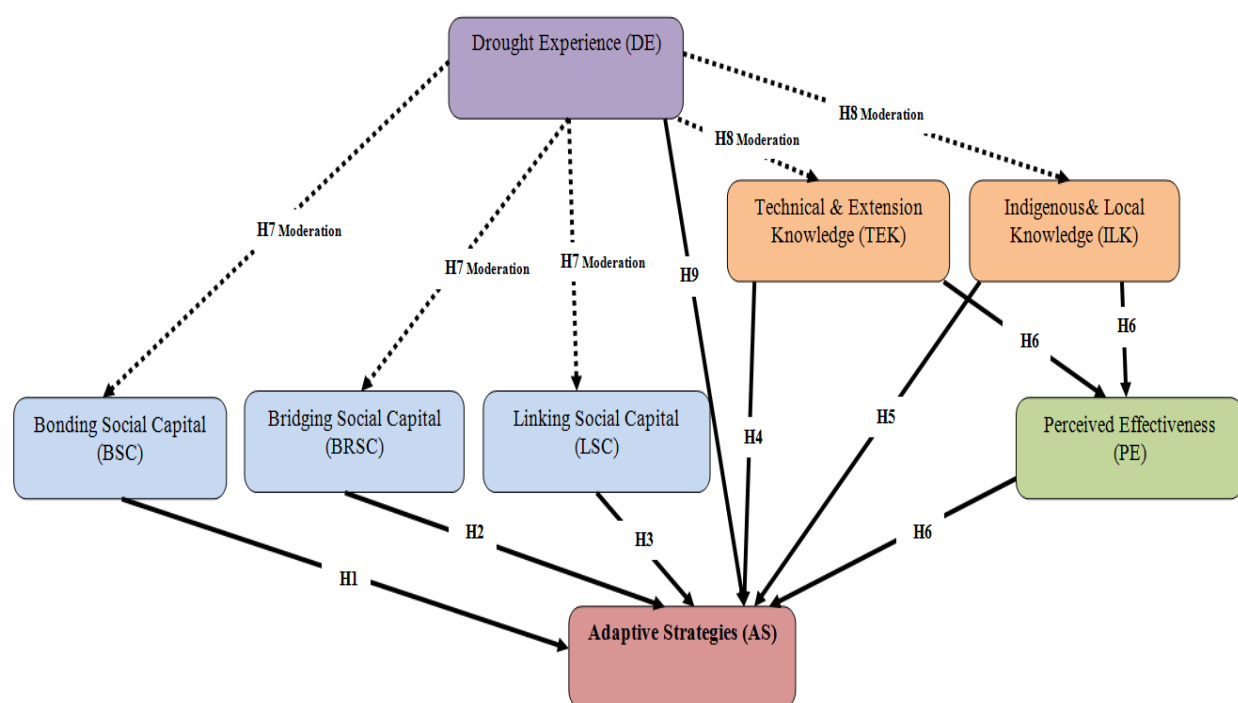


Figure 1. Conceptual Framework of the Research

3. Materials and Methods

3-1. Study Area

This research was conducted in Kermanshah province, located in western Iran, adjacent to the border with Iraq (Figure 2). Covering an area of approximately 24,998 km², Kermanshah is the 17th largest province in the country. Due to its fertile soil and relatively favorable rainfall during normal years, it is considered one of Iran's most important rainfed farming regions. With approximately 711,000 hectares of rainfed lands, Kermanshah province plays a key role in the production of rainfed wheat, barley, and other strategic crops, and rainfed agriculture constitutes the primary livelihood source for the majority of the province's rural residents.

Despite the significance of rainfed cultivation in this province, recurrent droughts in recent years have severely impacted rainfed production. Declining rainfall, rising temperatures, and shifting precipitation patterns over the past decade have substantially reduced the yield of rainfed crops in this region (Badvi et al., 2024). The average annual rainfall in the province over the last three decades has dropped to less than 260 mm, and the number of dry years with a negative rainfall index has increased significantly (Savari et al., 2023). Studies indicate that the water stress index in the agricultural sector of this province has consistently exceeded 0.75 across all years, reaching its peak of 0.89 in 2015 (Javanbakht-Sheikhahmad et al., 2025). Drought and reduced

rainfall have caused a dramatic decline in rainfed crop production in Kermanshah province, with rainfed farmers facing severe income reduction and increased livelihood insecurity (Sharafi & Zarafshani, 2025). The convergence of these drought-induced constraints with the importance of rainfed cultivation in the province necessitates the adoption of appropriate adaptive strategies by rainfed farmers. Therefore, understanding the social and knowledge-related determinants of rainfed farmers' adoption of adaptive strategies is of critical importance. For these reasons, Kermanshah province was selected as the study area for this research.



Figure 2. Geographic Location of the Study Area (Kermanshah Province, Iran)

3-2. Statistical Population and Sampling Method

The statistical population of this descriptive-correlational study consisted of all smallholder rainfed farmers (with less than 5 hectares of land) in Kermanshah province, whose livelihoods are primarily based on rainfed cultivation (non-irrigated and rainfall-dependent farming). Rainfed farmers were selected as the statistical population due to their direct vulnerability to drought and the dependence of their livelihoods on rainfall patterns. According to data from the Kermanshah Province Agricultural Jihad Organization (2025), the total number of smallholder rainfed farming households in the province was estimated at approximately 45,000 (N).

To determine the sample size, Cochran's formula was applied with a 95% confidence level and a 5% acceptable margin of error, which recommended a sample size of 382 individuals for a population of 45,000. To compensate for incomplete or invalid questionnaires, a total of 430 questionnaires were distributed. A multi-stage stratified random sampling method was employed to select participants. This approach was chosen to ensure adequate representation of the diverse geographical and agricultural conditions across the province. The sampling procedure consisted of four distinct stages:

- Stage 1: From the five geographical regions of the province (north, south, east, west, and center), two counties were randomly selected from each region, resulting in a total of ten counties.
- Stage 2: From each selected county, one district was randomly chosen.

- Stage 3: From each selected district, two villages were randomly selected, resulting in a total of twenty villages.
- Stage 4: Within each village, farmers were randomly selected in proportion to the population of smallholder rainfed farmers in that village.

Data were collected through face-to-face interviews using a structured questionnaire administered by trained interviewers. Prior to data collection, the research team confirmed that all selected participants met the criteria for smallholder rainfed farmers (owning less than 5 hectares of agricultural land and operating within rainfed farming systems). A total of 412 completed questionnaires were returned. After screening for outliers and incomplete responses, 385 questionnaires were deemed valid and usable for data analysis, yielding a response rate of 89.5%.

3-3. Research Instrument

The primary data collection instrument was a structured questionnaire specifically designed for this study. This instrument was developed based on an extensive review of the research literature and validated scales from previous studies. The questionnaire was organized into four distinct sections:

Section One: This section was dedicated to collecting demographic and agricultural information from respondents, including gender, age, education level, farming experience, cultivated area, main income source, land tenure type, number of land parcels, participation in extension training courses related to drought management, and membership in agricultural organizations.

Section Two: This section contained items for measuring the main constructs of the conceptual model. All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Section Three: This section was devoted to assessing the mediating and moderating variables (perceived effectiveness and drought experience).

Section Four: This section was allocated to measuring the dependent variable (adaptive strategies).

3-4. Constructs and Measurement Items

Bonding social capital was measured using 5 items. These items assessed the extent of trust, cooperation, and reciprocal relationships among farmers with family, neighbors, and other members of the local community.

Bridging social capital was measured using 5 items. These items evaluated networks extending beyond the local community.

Linking social capital was also measured using 5 items. These items assessed vertical relationships with external institutions and organizations.

Additionally, access to technical and extension knowledge was measured using 7 items, access to indigenous and local knowledge using 5 items, perceived effectiveness of strategies using 6

items, and drought experience using 4 items. Adaptive strategies were measured using 8 items. Farmers were asked to prioritize each strategy in terms of its importance in coping with drought (1 = least important, 5 = most important).

3-5. Validity and Reliability of the Research Instrument

3.5.1. Content and Face Validity

To ensure content validity, the initial version of the questionnaire was reviewed by a panel of ten experts in the fields of agricultural extension, water resource management, rural development, rural sociology, and agricultural economics. Experts were asked to evaluate the clarity, relevance, and comprehensiveness of each item, as well as the overall coherence of the instrument. They assessed whether each item appropriately represented its corresponding construct and whether the items collectively covered the intended dimensions. Based on their feedback, ambiguous or redundant items were revised or removed, and the final version of the questionnaire was approved.

A pilot study was conducted with 35 farmers selected from a county not included in the main sample to assess face validity, clarity, and cultural appropriateness of the items. Following the pilot study, minor adjustments were made to the wording to enhance comprehension and ensure cultural and contextual relevance for the target population. Data from the pilot study were not included in the final analysis.

3.5.2. Reliability

Reliability was evaluated using Cronbach's alpha coefficient and composite reliability (CR). As presented in Table 6, Cronbach's alpha values for all constructs ranged from 0.83 to 0.89, exceeding the acceptable threshold of 0.70 recommended by Nunnally and Bernstein (1994). Composite reliability values ranged from 0.87 to 0.92, confirming the internal consistency of the measurement scales. These results indicate that all constructs in the research model possess satisfactory internal reliability.

3.5.6. Convergent Validity

Convergent validity was assessed using the average variance extracted (AVE) (Fornell & Larcker, 1981). As shown in Table 6, the AVE values for all latent variables exceeded the recommended threshold of 0.50 (Hair et al., 2020), ranging from 0.56 to 0.63. These values indicate that each construct explains more than half of the variance of its indicators, confirming adequate convergent validity. Standardized factor loadings (λ) for all indicators exceeded the recommended threshold of 0.50 (Hair et al., 2020), ranging from 0.53 to 0.93, all of which were significant at the $p < 0.001$ level.

3.5.7. Discriminant Validity

Discriminant validity was assessed using two criteria: the Fornell-Larcker criterion (Fornell & Larcker, 1981) and the HTMT ratio (Henseler et al., 2015). Based on the Fornell-Larcker criterion, the square root of the AVE for each construct should be greater than the correlations between that construct and other constructs. As shown in Table 7, this condition was met for all constructs, indicating satisfactory discriminant validity. The diagonal values (in bold) represent the square root of the AVE, while off-diagonal values represent correlations between constructs. Furthermore, all HTMT values were below the conservative threshold of 0.85 (Henseler et al.,

2015), ranging from 0.36 to 0.56. This confirms that all constructs are sufficiently distinct from one another and that discriminant validity is well established (Table 8).

3.5.8. Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) was conducted as part of the measurement model evaluation in SmartPLS 4. Standardized factor loadings (λ) for all indicators exceeded the recommended threshold of 0.50 (Hair et al., 2020), ranging from 0.53 to 0.93, all of which were significant at the $p < 0.001$ level (Table 7). This confirms that all indicators reliably represent their respective latent constructs. The measurement model demonstrated a good fit with the data (SRMR = 0.069, NFI = 0.90, RMS-theta = 0.079), indicating a reasonable representation of the hypothesized factor structure from the observed correlations among the measured items.

3-6. Data Analysis

Data analysis was conducted at both descriptive and inferential levels using SPSS WIN26 and SmartPLS 4 software.

3.6.1. Descriptive Analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize the demographic characteristics of respondents and the current status of the observed variables. This analysis provided insights into the sample composition and overall data trends, facilitating a comprehensive understanding of the respondent profile and their responses to the measured constructs.

3.6.2. Structural Equation Modeling

To test the research hypotheses and evaluate the conceptual model, structural equation modeling (SEM) was employed using SmartPLS 4 software (Ringle et al., 2022). The analysis followed the two-step approach recommended by Hair et al. (2020):

1. Assessment of the measurement model: Evaluation of reliability (Cronbach's alpha, composite reliability), convergent validity (AVE, factor loadings), and discriminant validity (Fornell-Larcker criterion, HTMT ratio). This step ensures that the measurement instruments accurately represent the intended constructs.

2. Assessment of the structural model: Examination of path coefficients (β), coefficients of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2) using bootstrapping with 5,000 subsamples to test the significance of hypothesized relationships (Hair et al., 2020).

Prior to testing the structural model, collinearity and common method bias were assessed. For common method bias, the full collinearity VIF approach proposed by Kock (2015) was used. As shown in Table 4, all VIF values ranged from 1.36 to 1.82, well below the recommended threshold of 3.3, confirming the absence of severe common method bias (Kock, 2015). Additionally, all tolerance values ranged from 0.55 to 0.88, exceeding the recommended threshold of 0.20, indicating that collinearity did not pose a problem in this study.

3.6.3. Mediation Analysis

For mediation analysis (H6), the indirect effect was tested using the bootstrapping method (Preacher & Hayes, 2008). The significance of the indirect effect was assessed by examining the

95% bias-corrected confidence intervals for the indirect path. Mediation was considered significant if the confidence interval for the indirect effect did not contain zero.

3.6.7. Moderation Analysis

For moderation analysis (H7 and H8), the product indicator approach was employed in SmartPLS 4 (Henseler & Chin, 2010). This method, one of the most common approaches for evaluating interaction effects in PLS-based structural equation models, creates interaction indicators by multiplying each indicator of the independent variable by each indicator of the moderator variable, enabling the estimation of moderation effects. After creating the interaction indicators, the structural model was estimated including both direct and interaction paths. The significance of the moderation effects was evaluated using bootstrapping with 5,000 subsamples, examining path coefficients, t-values, and 95% bias-corrected confidence intervals (Henseler & Chin, 2010). Simple slope analysis was conducted to interpret significant interaction effects by examining the conditional effects of the independent variables on the dependent variable at different levels of drought experience (i.e., one standard deviation above and below the mean).

3.6.8. Predictive Relevance Assessment

To assess the predictive relevance of the model, Stone-Geisser's Q^2 criterion was employed through the blindfolding procedure. Q^2 values greater than zero indicate the model's predictive relevance (Hair et al., 2017). To further evaluate out-of-sample predictive power, the PLSpredict procedure was used (Shmueli et al., 2019).

4. Findings

4-1. Descriptive Statistics

Based on the collected data, 385 valid questionnaires were analyzed. Table 1 presents the demographic characteristics of the farmers.

In terms of gender, the majority of respondents were male (72.5%, $n = 279$), while women constituted 27.5% ($n = 106$) of the sample. The largest age group was farmers aged 35–55 years (49.9%, $n = 192$), with a mean age of 47.6 years ($SD = 11.2$). Regarding education level, most farmers had secondary education (middle and high school) (35.6%, $n = 137$), while 21.3% were illiterate ($n = 82$), 19.2% had elementary education ($n = 74$), and 23.9% held university degrees ($n = 92$). The mean farming experience was 19.4 years ($SD = 12.1$), and the majority of farmers (46.8%, $n = 180$) had between 10 and 25 years of experience. Regarding land tenure, more than half of the farmers were landowners who cultivated their land personally (56.1%, $n = 216$), while 26.2% ($n = 101$) operated on rented land. Based on the number of land parcels, the highest frequency was observed among farmers with 2 to 3 parcels (43.4%, $n = 167$). Concerning the main income source, the majority of farmers relied solely on agriculture as their income source, with no non-agricultural income (68.3%, $n = 263$). Regarding participation in extension training courses related to drought management, 53.8% ($n = 207$) had participated in at least one course, while 46.2% ($n = 178$) had not. Additionally, 44.7% ($n = 172$) of farmers were members of local agricultural organizations.

Table 1. Demographic Characteristics of Farmers ($n = 385$)

Variable	Category	Frequency ($n=385$)	Percentage (%)
Gender	Female	106	72.5
	Male	279	27.5

Age (years)	Less than 35	95	24.7
	Between 35–55	192	49.9
	More than 55	98	25.4
Education	Illiterate	82	21.3
	Elementary	74	19.2
	Secondary (Middle and High School)	137	35.6
Farming Experience (years)	University	92	23.9
	Less than 10	95	24.7
	Between 10–25	180	46.8
Land Tenure Type	More than 25	110	28.5
	Owner	216	56.1
	Rental	101	26.2
Number of Land Parcels	Shared	68	17.7
	1 Parcel	126	32.7
	2-3 Parcels	167	43.4
Main Income Source	More than 3 Parcels	92	23.9
	Only agriculture	263	68.3
	Agriculture+ non-agriculture	83	21.6
Participation in Water-Related Extension Training	Non- agriculture	39	10.1
	Yes	207	53.8
	No	178	46.2
Membership in Water User Associations	Yes	172	44.7
	No	213	55.3

Table 2 presents the adaptive strategies adopted by rainfed farmers. The most frequently adopted strategy was adjusting planting time based on rainfall forecasts (43.4%, n = 167), reflecting farmers' awareness of the need to adapt to changing climatic conditions and their practical action in this regard. This was followed by the use of drought-resistant varieties adapted to rainfed conditions (36.6%, n = 141) and shifting cropping patterns toward drought-resistant crops (31.2%, n = 120), respectively. Other strategies included the use of conservation tillage methods (minimum tillage) (25.5%, n = 98), optimal soil management and moisture conservation (using mulch and organic fertilizers) (21.8%, n = 84), reducing cultivated area during drought (18.4%, n = 71), income diversification and changing occupational activities (14.5%, n = 56), crop insurance (11.7%, n = 45), and participation in collective resource management and cooperatives (8.3%, n = 32).

Table 2. Adaptive Strategies Adopted by Farmers (Multiple Responses, n = 385)

Adaptive Strategy	Frequency (385)	Percentage (%)
Adjusting planting time based on rainfall forecasts	167	43.4
Using drought-resistant varieties adapted to rainfed conditions	141	36.6
Shifting cropping patterns toward	120	31.2

drought-resistant crops		
Using conservation tillage methods (minimum tillage)	98	25.5
Optimal soil management and moisture conservation (mulch, organic fertilizers)	84	21.8
Reducing cultivated area during drought	71	18.4
Income diversification and changing occupational activities	56	14.5
Crop insurance	45	11.7
Participation in collective resource management and cooperatives	32	8.3

As presented in Table 3, the mean scores of the main research constructs are as follows. The mean score of bonding social capital (3.82) was above the theoretical mean, indicating relatively strong intra-group relationships among farmers. The mean score of bridging social capital (3.45) was close to the theoretical mean, suggesting a moderate level of connection with networks beyond the local community. The mean score of linking social capital (3.21) was slightly above the theoretical mean, indicating relatively weak connections with external institutions and organizations. The mean score of technical and extension knowledge (3.56) was above the theoretical mean, reflecting a relatively good level of access to extension services and technical knowledge. The mean score of indigenous and local knowledge (4.05) was above the theoretical mean, indicating farmers' extensive use of local experiences and methods in drought management. The mean score of perceived effectiveness of strategies (3.93) was also above the theoretical mean, reflecting farmers' relatively high belief in the efficacy of adaptive strategies. The mean score of drought experience (4.21) was considerably higher than the theoretical mean, indicating frequent and severe drought experience in the region. Additionally, the mean score of adaptive strategies (3.68) was close to the theoretical mean, indicating farmers' moderate attention to adaptive strategies.

Table 3. Descriptive Statistics of the Main Research Variable

Variable	Mean (out of 5)	Standard Deviation
Bonding Social Capital (BSC)	3.82	0.86
Bridging Social Capital (BRSC)	3.45	0.92
Linking Social Capital (LSC)	3.21	0.95
Technical & Extension Knowledge (TEK)	3.56	0.89
Indigenous & Local Knowledge (ILK)	4.05	0.78
Perceived Effectiveness (PE)	3.93	0.85
Drought Experience (DE)	4.21	0.76
Adaptive Strategies (AS)	3.68	0.88

4.2. Assessment of Methodological Bias

Following the descriptive analysis, the proposed conceptual model was evaluated in two stages: the assessment of the measurement model and the assessment of the structural model, using the partial least squares (PLS) approach.

Prior to testing the structural model, collinearity and common method bias were assessed. For common method bias, the full collinearity VIF approach proposed by Kock (2015) was employed. As presented in Table 4, all VIF values ranged from 1.36 to 1.82, well below the recommended threshold of 3.3, confirming the absence of severe common method bias (Kock, 2015). Furthermore, all tolerance values ranged from 0.55 to 0.74, exceeding the recommended threshold of 0.20, indicating that collinearity did not pose a problem in this study (Hair et al., 2017).

Table 4. Common method bias and multicollinearity assessment (Full collinearity VIF)

Tolerance	VIF	Constructs
Bonding Social Capital (BSC)	1.68	0.60
Bridging Social Capital (BRSC)	1.46	0.69
Linking Social Capital (LSC)	1.52	0.66
Technical & Extension Knowledge (TEK)	1.82	0.55
Indigenous& Local Knowledge (ILK)	1.58	0.63
Perceived Effectiveness (PE)	1.36	0.74
Drought Experience (DE)	1.44	0.69
Adaptive Strategies (AS)	1.74	0.88

4-3. Classification of Respondents Based on Drought Experience Level

To gain a deeper understanding of the respondents' situation and the moderating role of drought experience in the relationships among research variables, respondents were divided into three groups based on their overall drought experience score. The overall drought experience score was calculated as the mean of four items (DE1 to DE4) on a five-point Likert scale. Respondents were classified based on the quartiles of the overall drought experience score distribution, such that the first quartile (lower 25%) was considered low experience, the second and third quartiles were considered moderate experience, and the fourth quartile (upper 25%) was considered high experience (Table 5). More than one-third of respondents (38.2%) fell into the high drought experience group, indicating the frequency and severity of drought in Kermanshah province. This finding is fully consistent with the mean drought experience score (4.21 out of 5) reported in Table 3. Only 22.3% of respondents had low drought experience. This classification provides a suitable foundation for interpreting the moderating effects of drought experience on the relationships among research variables (Figure 3).

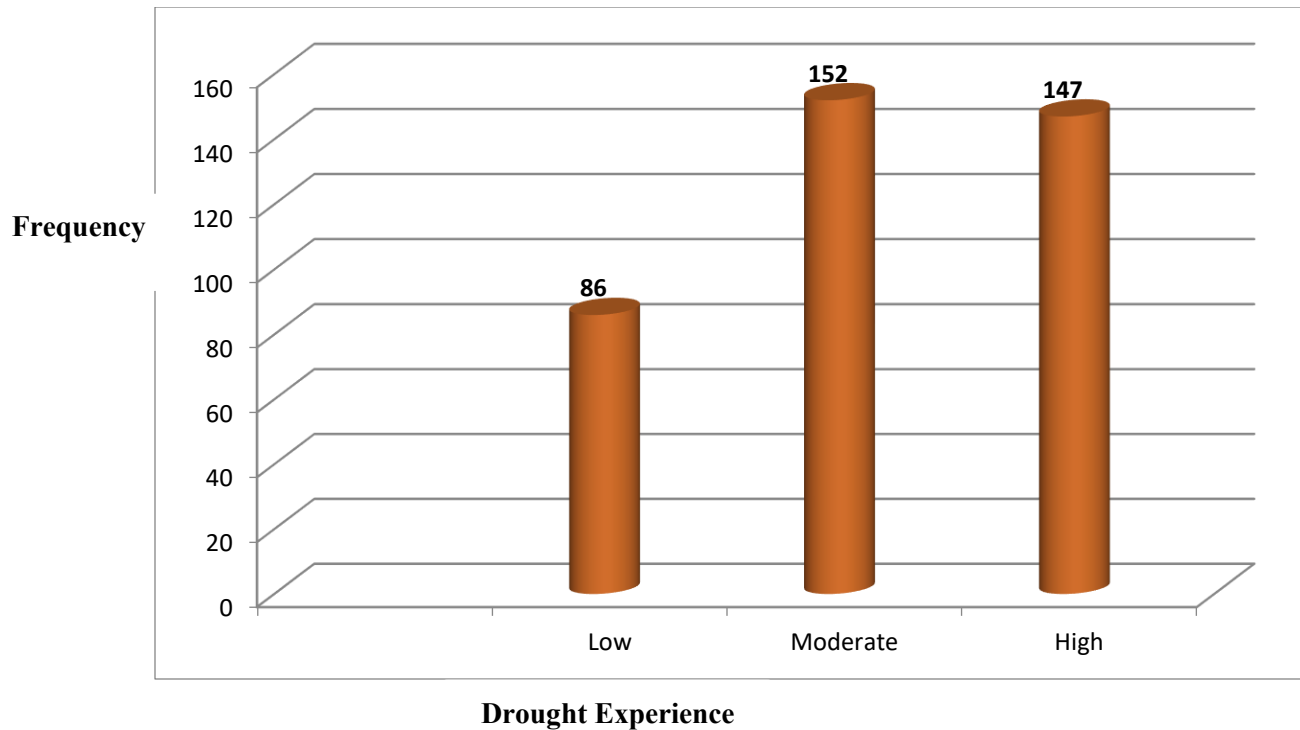


Figure 3. Classification of Respondents Based on Drought Experience Level

4.4. Assessment of the Measurement Model

Confirmatory factor analysis (CFA) was conducted on the various indicators to evaluate the validity and reliability of the research constructs. Table 6 presents the goodness-of-fit indices for the measurement model, all of which fall within acceptable ranges, indicating a good model fit.

Table 5. Summary of goodness of fit indices for the measurement model

Fit index	SRMR	D-G1	D-G2	NFI	RMS-theta
Suggested value	< 0.10	> 0.05	> 0.05	> 0.90	≤ 0.12
Estimated value	0.069	0.41	0.38	0.90	0.079

The measurement model demonstrated a good fit with the data (SRMR = 0.069, NFI = 0.90, RMS-theta = 0.079), indicating a reasonable representation of the hypothesized factor structure from the observed correlations among the measured items.

The results indicated that standardized factor loadings (λ) were all above 0.50 and significant at the $p < 0.001$ level (Table 7). Cronbach's alpha, composite reliability (CR), and average variance

extracted (AVE) values for all constructs exceeded the recommended thresholds ($\alpha > 0.70$, CR > 0.70, AVE > 0.50) (Hair et al., 2017). These findings confirm that the measurement model possesses adequate reliability and convergent validity.

Table 6. Results of confirmatory factor analysis for the measurement model

Constructs and Items			λ	t	Cronbach's alpha	CR	rho_A	AVE	References
Linking	Social	Capital (LSC)			0.87	0.91	0.88	0.60	Putnam (2000); Aldrich & Meyer (2015); Savari et al. (2023); Gören et al. (2025); Khalil et al. (2021)
LSC1: I trust the information and recommendations of the Agricultural Jihad Organization regarding drought managemen			0.657	9.575					
LSC2: I communicate with local authorities to receive assistance during drought			0.635	6.762					
LSC3: I benefit from government facilities and support during drought			0.726	5.698					
LSC4: I am in contact with agricultural research centers			0.718	7.052					
LSC5: I use advisory services from non-governmental organizations			0.747	9.575					
Bridging	Social	Capital (BRSC)			0.86	0.90	0.87	0.58	
BRSC1: I exchange views with farmers from other regions on drought coping strategies			0.612	3.600					Putnam (2000) ; Aldrich & Meyer (2015); Savari et al. (2023); Gören et al. (2025); Khalil et al. (2021)
BRSC2: I use the experiences of farmers from other regions for drought management			0.786	11.269					
BRSC3: I am in contact with experts and agricultural advisors outside my region			0.698	6.591					
BRSC4: I participate in agricultural conferences and exhibitions			0.808	12.979					
BRSC5: I connect with farmers from other provinces through virtual networks			0.775	11.659					
Bonding	Social	Capital (BSC)			0.85	0.89	0.86	0.59	
BSC1: I can count on my neighbors' help during drought			0.696	7.370					Khalil et al. (2021); Savari et al. (2023); Gören et al. (2025)

BSC2: I exchange views with other farmers on drought coping strategies	0.836	19.880				
BSC3: My family and close relatives support me during crises	0.617	3.901				
BSC4: I actively participate in local groups for water resource management	0.741	9.603				
BSC5: There is cooperation and empathy among farmers during drought	0.808	20.324				
Technical & Extension Knowledge (TEK)			0.89	0.92	0.90	0.62
TEK1: I have access to new information on modern rainfed farming methods (e.g., conservation tillage, minimum tillage)	0.931	65.503				Badvi et al. (2024); Deressa et al. (2009); Bryan et al. (2009); Mirzaei et al. (2022)
TEK2: I have participated in drought management training workshops	0.793	12.036				
TEK3: I am familiar with scientific methods of drought forecasting and appropriate planting timing in rainfed conditions	0.830	18.967				
TEK4: I have access to meteorological information, rainfall forecasts, and drought warnings	0.586	5.059				
TEK5: I receive agricultural information through media	0.755	9.234				
TEK6: I am familiar with soil moisture conservation methods in rainfed conditions (e.g., using mulch, organic fertilizers)	0.805	12.405				
TEK7: I am familiar with drought-resistant varieties adapted to rainfed conditions	0.782	16.977				
Indigenous & Local Knowledge (ILK)			0.84	0.88	0.85	0.56
ILK1: I use traditional rainfall forecasting methods in my region	0.885	35.637				Deressa et al. (2009); Bryan et al. (2009); Badvi et al. (2024); Farshchin (2025)
ILK2: The experiences of past generations regarding drought management have been useful to me	0.565	4.499				
ILK3: In our region, there are indigenous methods for soil moisture conservation	0.888	31.460				
ILK4: I use natural signs to	0.696	4.955				

determine the appropriate planting time						
ILK5: Indigenous knowledge in our region is applicable to water resource management	0.578	4.541				
Perceived Effectiveness (PE)			0.87	0.91	0.88	0.61
PE1: Changing planting time based on rainfall forecasts significantly reduces drought damage in rainfed farms	0.829	14.897				Grothmann & Patt(2005); Keshavarz & Karami (2016); Rogers (1975)
PE2: Using drought-resistant varieties adapted to rainfed conditions is an effective strategy for coping with drought	0.753	12.258				
PE3: Shifting cropping patterns toward drought-resistant crops can reduce the negative effects of drought	0.779	12.176				
PE4: Conservation tillage methods (minimum tillage, residue retention) are effective in maintaining soil moisture and reducing drought impacts	0.731	10.437				
PE5: Optimal soil management (using mulch, organic fertilizers) can help reduce drought damage	0.638	5.111				
PE6: Crop insurance is a useful strategy for reducing the financial risk of drought in rainfed farming	0.574	4.485				
Drought Experience (DE)			0.83	0.87	0.84	0.57
DE1: I have experienced several droughts over the past 10 years	0.730	6.891				Below et al. (2014); Alam et al. (2016); Sithole & Saito (2019)
DE2: Recent droughts have had a severe impact on my livelihood	0.832	16.987				
DE3: Recurrent droughts have changed my farming methods	0.625	4.143				
DE4: Direct experience of drought has shown me the importance of water resource management	0.666	4.533				
Adaptive Strategies (AS)			0.88	0.91	0.89	0.63
AS1: Adjusting planting time based on rainfall forecasts	0.614	5.342				Almasi et al. (2016); Badvi et al. (2024); Savari et al. (2023)
AS2: Using drought-resistant varieties adapted to rainfed conditions	0.731	8.817				
AS3: Shifting cropping patterns toward drought-resistant crops	0.715	7.109				
AS4: Using conservation	0.533	3.112				

tillage methods (minimum tillage)		
AS5: Optimal soil management and moisture conservation (mulch, organic fertilizers)	0.761	10.685
AS6: Reducing cultivated area during drought	0.574	4.302
AS7: Income diversification and changing occupational activities	0.778	12.450
AS8: Crop insurance	0.783	18.138

4.5. Discriminant Validity

To assess discriminant validity, two criteria were employed: The Fornell-Larcker criterion (Fornell & Larcker, 1981) and the HTMT ratio (Henseler et al., 2015). As presented in Table 8, the square roots of the AVE values (shown in bold on the diagonal) are all greater than the off-diagonal correlations, confirming discriminant validity.

Table 7. Discriminant Validity (Fornell-Larcker Criterion)

Construct	BSC	BRSC	LSC	TEK	ILK	PE	DE	AS
BSC	0.77							
BRSC	0.36**	0.76						
LSC	0.33**	0.37**	0.77					
TEK	0.42**	0.38**	0.45**	0.79				
ILK	0.38**	0.35**	0.36**	0.41**	0.75			
PE	0.39**	0.34**	0.41**	0.48**	0.40**	0.78		
DE	0.31**	0.29**	0.30**	0.36**	0.33**	0.34**	0.75	
AS	0.46**	0.43**	0.47**	0.52**	0.45**	0.49**	0.37**	0.79

Note: Diagonal values (in bold) represent the square root of the AVE. All correlations are significant at the 0.01 level.

Table 8 presents the HTMT ratios, all of which are below the conservative threshold of 0.85 (Henseler et al., 2015), ranging from 0.36 to 0.56, indicating satisfactory discriminant validity for all pairs of constructs.

Table 8. Discriminant Validity (HTMT Ratio)

Construct	BSC	BRSC	LSC	TEK	ILK	PE	DE	AS
BSC								
BRSC	0.42							
LSC	0.39	0.44						
TEK	0.51	0.46	0.53					
ILK	0.45	0.42	0.43	0.49				
PE	0.47	0.40	0.48	0.56	0.47			
DE	0.38	0.36	0.37	0.44	0.40	0.41		
AS	0.54	0.50	0.55	0.56	0.52	0.56	0.45	

Following the confirmation of the measurement model, the structural model was evaluated to test the research hypotheses. Path analysis was conducted using bootstrapping with 5,000 subsamples to obtain standard errors, t-values, p-values, and 95% bias-corrected confidence intervals. The proposed model explained 39% of the variance in perceived effectiveness of strategies ($R^2 = 0.39$) and 45% of the variance in adaptive strategies ($R^2 = 0.45$) (Figure 4). These R^2 values demonstrate the considerable explanatory power of the conceptual model and confirm that the combination of social capital variables (in three dimensions), knowledge (in two types), and perceived effectiveness has been able to explain a substantial portion of the variations in adaptive strategies among smallholder rainfed farmers.

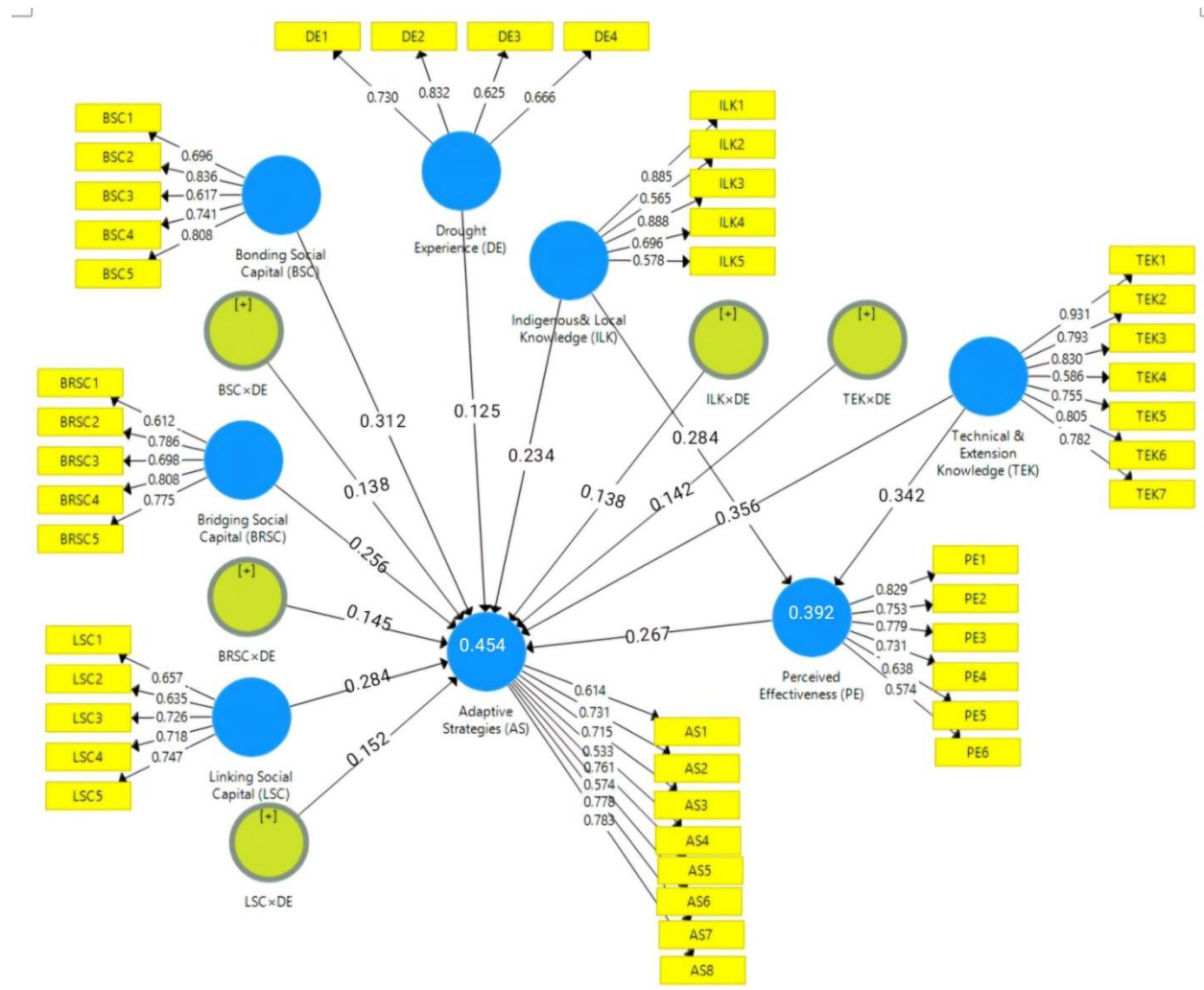


Figure 4. Structural Model with Standardized Path Coefficients and R² Values

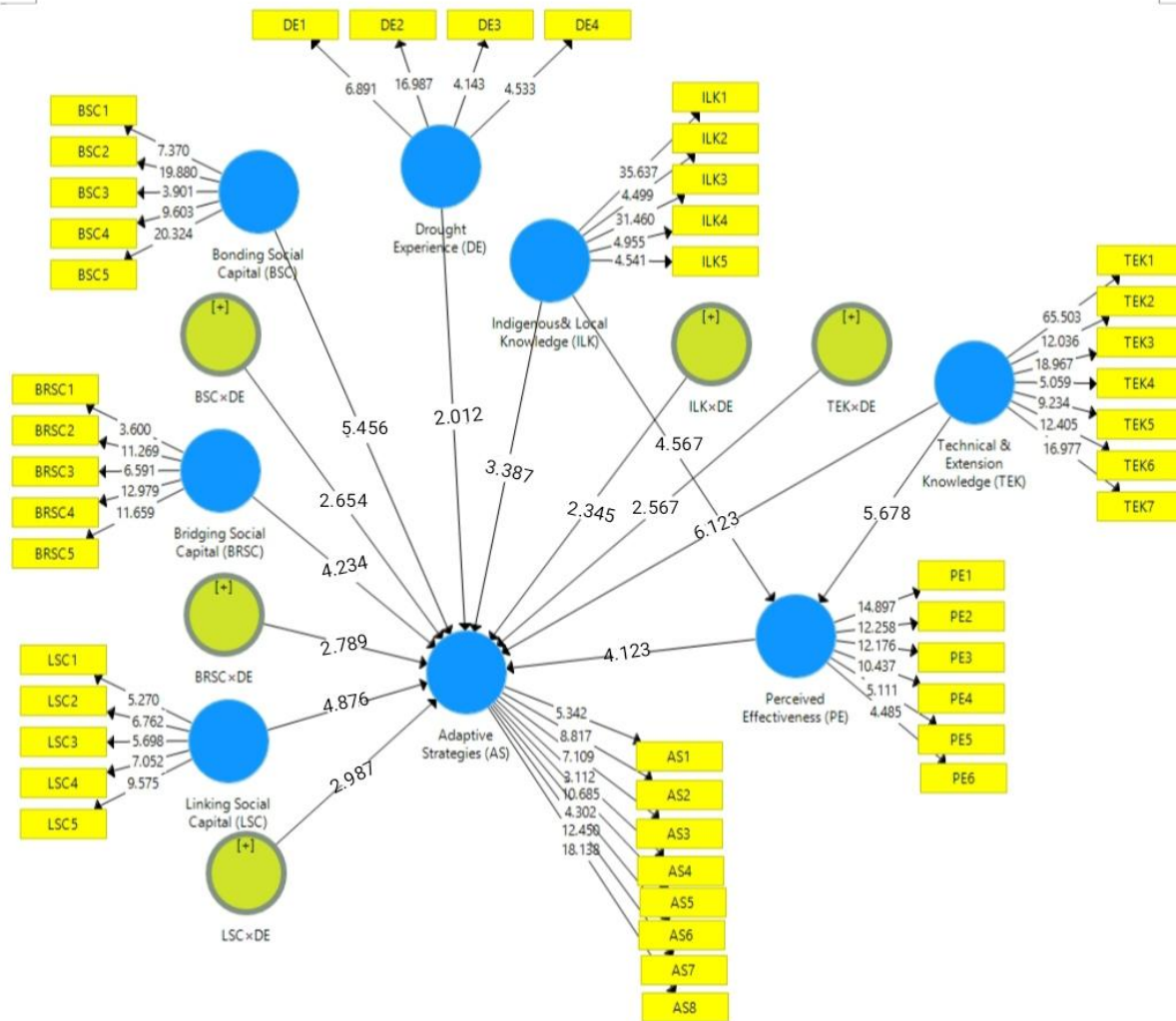


Figure 5. Path Model with t-values

As presented in Table 9 and Figure 5, all research hypotheses (H1 to H5, H6a to H6c, H7a to H7c, H8a, and H8b) were confirmed. All path coefficients were significant, with t-values exceeding the critical value of 1.96. Effect sizes (f^2) ranged from small to medium, with the largest effects observed for the path from technical and extension knowledge to adaptive strategies (H4: $f^2 = 0.19$) and from linking social capital to adaptive strategies (H3: $f^2 = 0.14$). Furthermore, the paths from technical knowledge to perceived effectiveness (H6a: $f^2 = 0.18$) and from perceived effectiveness to adaptive strategies (H6c: $f^2 = 0.11$) exhibited medium effect sizes.

The results regarding the moderating role of drought experience revealed that the interaction effects between drought experience and all three dimensions of social capital on adaptive strategies were positive and significant. Specifically, the interaction effects for bonding social capital (H7a: $\beta = 0.152$, $t = 2.987$, $p < 0.01$), bridging social capital (H7b: $\beta = 0.145$, $t = 2.789$, $p < 0.01$), and linking social capital (H7c: $\beta = 0.138$, $t = 2.654$, $p < 0.01$) were all significant.

Moreover, the interaction effects between drought experience and both types of knowledge on adaptive strategies were also positive and significant, with the interaction effects for technical and extension knowledge (H8a: $\beta = 0.142$, $t = 2.567$, $p < 0.05$) and indigenous and local knowledge (H8b: $\beta = 0.138$, $t = 2.345$, $p < 0.05$) being significant. These findings indicate that drought experience moderates the relationship between social capital (in its three dimensions) and adaptive strategies (H7), as well as the relationship between knowledge access (technical and indigenous) and adaptive strategies (H8), with these relationships being strengthened at higher levels of drought experience.

Table 9. Results of research structural models

Hypothesis	Path	β	t-value	p-value	95% CI (LL, UL)	f ²	R ²	Result
H1	Bonding Social Capital → Adaptive Strategies	0.284	4.876	0.000	[0.18, 0.39]	0.10	0.45	Confirm
H2	Bridging Social Capital → Adaptive Strategies	0.256	4.234	0.000	[0.14, 0.37]	0.08	-	Confirm
H3	Linking Social Capital → Adaptive Strategies	0.312	5.456	0.000	[0.20, 0.42]	0.14	-	Confirm
H4	Technical and Extension Knowledge → Adaptive Strategies	0.356	6.123	0.000	[0.24, 0.47]	0.19	-	Confirm
H5	Indigenous and Local Knowledge → Adaptive Strategies	0.234	3.876	0.000	[0.12, 0.35]	0.07	-	Confirm
H6a	Technical and Extension Knowledge → Perceived Effectiveness	0.342	5.678	0.000	[0.23, 0.45]	0.18	0.39	Confirm
H6b	Indigenous and Local Knowledge → Perceived Effectiveness	0.284	4.567	0.000	[0.17, 0.39]	0.12	-	Confirm
H6c	Perceived Effectiveness → Adaptive Strategies	0.267	4.123	0.000	[0.15, 0.38]	0.11	-	Confirm
H7a	Bonding Social Capital × Drought Experience → Adaptive Strategies (Moderator)	0.152	2.987	0.003	[0.05, 0.25]	0.04	-	Confirm
H7b	Bridging Social Capital × Drought Experience → Adaptive Strategies (Moderator)	0.145	2.789	0.005	[0.04, 0.24]	0.03	-	Confirm
H7c	Linking Social Capital × Drought Experience → Adaptive Strategies (Moderator)	0.138	2.654	0.008	[0.03, 0.23]	0.03	-	Confirm
H8a	Technical and Extension Knowledge × Drought Experience → Adaptive Strategies (Moderator)	0.142	2.567	0.010	[0.03, 0.25]	0.03	-	Confirm
H8b	Indigenous and Local Knowledge × Drought Experience → Adaptive Strategies (Moderator)	0.138	2.345	0.019	[0.02, 0.24]	0.03	-	Confirm

H9	Drought Experience → Adaptive Strategies	0.125	2.012	0.044	[0.01, 0.23]	0.02	-	Confirm
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Note: β = Standardized path coefficient; LL = Lower limit; UL = Upper limit; CI = Confidence interval.

4-7.. Mediation Analysis

To test the mediation hypothesis (H6), the bootstrapping method with 5,000 subsamples was employed. The results indicated that the indirect effect of technical and extension knowledge on adaptive strategies through perceived effectiveness was significant ($\beta = 0.091$, $p < 0.01$, 95% CI = [0.05, 0.14]), demonstrating the partial mediating role of perceived effectiveness in the relationship between technical knowledge and adaptive strategies. Furthermore, the indirect effect of indigenous and local knowledge on adaptive strategies through perceived effectiveness was also significant ($\beta = 0.076$, $p < 0.01$, 95% CI = [0.03, 0.11]), indicating the partial mediating role of perceived effectiveness in the relationship between indigenous knowledge and adaptive strategies (Table 10). These findings confirm that knowledge (both technical and indigenous), in addition to its direct effect on adaptive strategies (H4 and H5), also exerts an indirect influence on adaptive strategies through enhancing perceived effectiveness. Given that both direct (H4 and H5) and indirect paths are significant, it can be concluded that perceived effectiveness plays a partial mediating role in both relationships.

Table 10. Results of Mediation Analysis

Indirect Path	β	t-value	p-value	95% CI (LL, UL)	Type of Mediation
Technical and Extension Knowledge → Perceived Effectiveness → Adaptive Strategies	0.091	4.234	0.000	[0.05, 0.14]	Partial
Indigenous and Local Knowledge → Perceived Effectiveness → Adaptive Strategies	0.076	3.456	0.001	[0.03, 0.11]	Partial

4-8. Moderation Analysis

To test the moderation hypotheses (H7 and H8), the product indicator approach was employed. The results indicated that the interaction effects between drought experience and all three dimensions of social capital on adaptive strategies were positive and significant. Specifically, the interaction effects for bonding social capital (H7a: $\beta = 0.152$, $t = 2.987$, $p < 0.01$), bridging social capital (H7b: $\beta = 0.145$, $t = 2.789$, $p < 0.01$), and linking social capital (H7c: $\beta = 0.138$, $t = 2.654$, $p < 0.01$) were all significant. In other words, drought experience moderates the relationship between social capital (in all three dimensions) and adaptive strategies (Table 9).

To interpret this moderating effect, simple slope analysis was conducted at different levels of drought experience (one standard deviation above and below the mean). The results showed that at low levels of drought experience (one standard deviation below the mean), the positive effect of social capital on adaptive strategies was weaker ($\beta = 0.147$, $t = 2.456$, $p < 0.05$), while at high levels of drought experience (one standard deviation above the mean), this positive effect

became significantly stronger ($\beta = 0.437$, $t = 5.678$, $p < 0.01$). This finding indicates that as drought experience increases, the positive relationship between social capital and adaptive strategies strengthens. This pattern was confirmed for all three dimensions of social capital (bonding, bridging, and linking) (Figure 6).

Furthermore, the interaction effects between drought experience and both types of knowledge on adaptive strategies were also positive and significant. The interaction effects for technical and extension knowledge (H8a: $\beta = 0.142$, $t = 2.567$, $p < 0.05$) and indigenous and local knowledge (H8b: $\beta = 0.138$, $t = 2.345$, $p < 0.05$) were significant. In other words, drought experience moderates the relationship between knowledge access (in both types) and adaptive strategies. Simple slope analysis revealed that at low levels of drought experience, the positive effect of knowledge on adaptive strategies was weaker ($\beta = 0.160$, $t = 2.456$, $p < 0.05$), but at high levels of drought experience, this positive effect became considerably stronger ($\beta = 0.440$, $t = 5.678$, $p < 0.01$). This finding indicates that drought experience moderates the relationship between knowledge access and adaptive strategies, and at higher levels of drought experience, the positive effect of knowledge on adaptive strategies is significantly strengthened. This pattern was confirmed for both types of knowledge (technical-extension and indigenous-local) (Table 9).

Figure 6 illustrates the relationship between social capital and adaptive strategies across three levels of drought experience: low (one standard deviation below the mean), moderate (mean), and high (one standard deviation above the mean). As observed, at low levels of drought experience, the slope is gentler ($\beta = 0.147$), indicating a weaker effect of social capital on adaptive strategies. At high levels of drought experience, the slope becomes steeper ($\beta = 0.437$), demonstrating the strengthening of the relationship between social capital and adaptive strategies as a result of direct drought experience. This pattern was confirmed for all three dimensions of social capital (bonding, bridging, and linking).

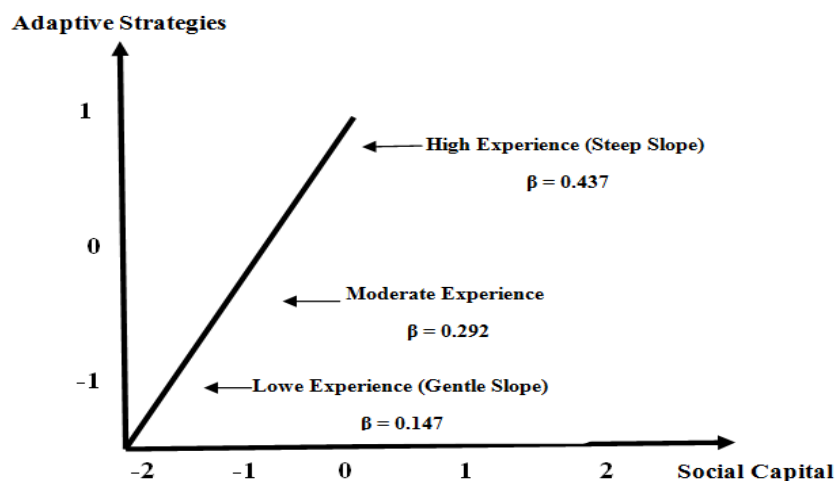


Figure 6. Simple slope analysis for the moderating effect of drought experience on the relationship between social capital and adaptive strateg

Figure 7 illustrates the relationship between knowledge access and adaptive strategies across three levels of drought experience: low (one standard deviation below the mean), moderate (mean), and high (one standard deviation above the mean). At low levels of drought experience, the slope is gentler ($\beta = 0.160$), indicating a weaker effect of knowledge on adaptive strategies. At high levels of drought experience, the slope becomes steeper ($\beta = 0.440$), demonstrating the strengthening of the relationship between knowledge and adaptive strategies as a result of direct drought experience. This pattern was confirmed for both types of knowledge (technical-extension and indigenous-local).

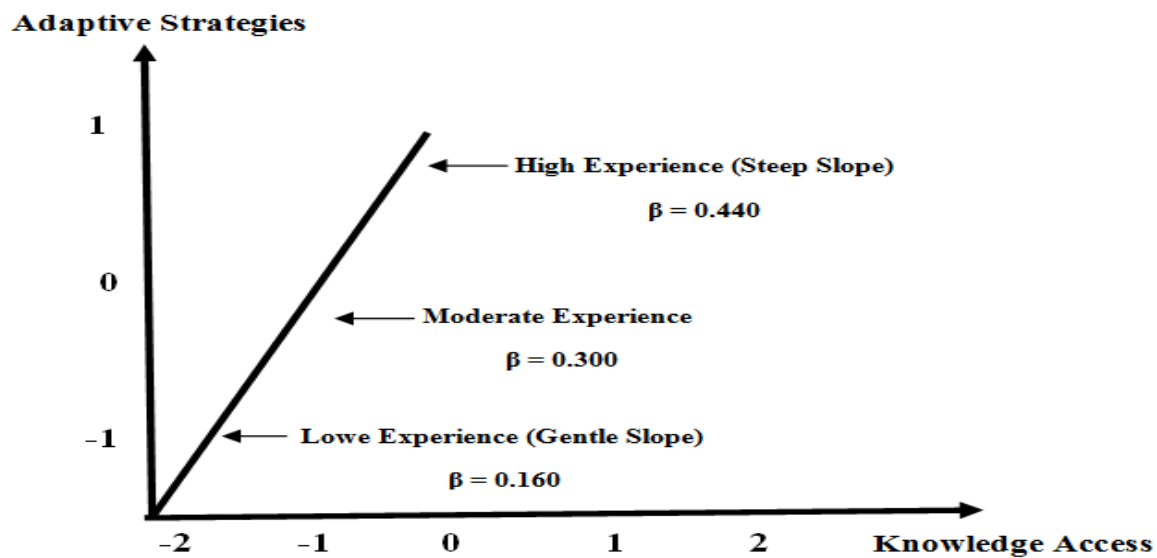


Figure 7. Simple slope analysis for the moderating effect of drought experience on the relationship between knowledge access and adaptive strategies

4-9. Assessment of Predictive Relevance

The predictive relevance of the structural model was evaluated using Stone-Geisser's Q^2 criterion through the blindfolding procedure. The Q^2 values for perceived effectiveness of strategies ($Q^2 = 0.27$) and adaptive strategies ($Q^2 = 0.34$) were both greater than zero, indicating moderate to strong predictive relevance of the model (Hair et al., 2017). To further assess out-of-sample predictive power, the PLSpredict procedure was employed (Shmueli et al., 2019). The PLSpredict results, with 10 iterations and 10 folds, revealed that the RMSE values for key indicators of all endogenous variables were lower than those of the linear model (LM), confirming that the model possesses acceptable out-of-sample predictive power.

The findings of this study indicate that:

- Bonding social capital has a positive and significant effect on adaptive strategies ($\beta = 0.284$, $p < 0.01$), implying that an increase in bonding social capital enhances adaptive strategies.
- Bridging social capital has a positive and significant effect on adaptive strategies ($\beta = 0.256$, $p < 0.01$), implying that an increase in bridging social capital enhances adaptive strategies.
- Linking social capital has a positive and significant effect on adaptive strategies ($\beta = 0.312$, $p < 0.01$), implying that an increase in linking social capital enhances adaptive strategies.
- Technical and extension knowledge has a positive and significant effect on adaptive strategies ($\beta = 0.356$, $p < 0.01$), implying that an increase in technical and extension knowledge enhances adaptive strategies.
- Indigenous and local knowledge has a positive and significant effect on adaptive strategies ($\beta = 0.234$, $p < 0.01$), implying that an increase in indigenous and local knowledge enhances adaptive strategies.
- Perceived effectiveness of strategies plays a partial mediating role in the relationship between knowledge access (technical and indigenous) and adaptive strategies (Table 8).
- Drought experience moderates the relationship between social capital (in its three dimensions) and adaptive strategies. Specifically, the moderating effects for bonding social capital (H7a: $\beta = 0.152$, $p < 0.01$), bridging social capital (H7b: $\beta = 0.145$, $p < 0.01$), and linking social capital (H7c: $\beta = 0.138$, $p < 0.01$) were all significant. This finding indicates that at higher levels of drought experience, the positive effect of social capital on adaptive strategies is strengthened.
- Drought experience moderates the relationship between knowledge access (technical and indigenous) and adaptive strategies. The moderating effects for technical and extension knowledge (H8a: $\beta = 0.142$, $p < 0.05$) and indigenous and local knowledge (H8b: $\beta = 0.138$, $p < 0.05$) were significant. This finding indicates that at higher levels of drought experience, the positive effect of knowledge on adaptive strategies is strengthened.

The conceptual model explained 39% of the variance in perceived effectiveness of strategies ($R^2 = 0.39$) and 45% of the variance in adaptive strategies ($R^2 = 0.45$), indicating acceptable model fit and adequate explanatory power.

5. Discussion

The findings of this study revealed that social capital in all three dimensions bonding, bridging, and linking has a positive and significant effect on the adoption of adaptive strategies by rainfed farmers facing drought. This finding is fully consistent with the theoretical foundations of social capital, which emphasize the role of relational networks, trust, and cooperation in facilitating collective action (Putnam, 2000; Portes, 1998). Furthermore, this result aligns with the research of Aldrich and Meyer (2015), who identified social capital as one of the most important local capacities for coping with natural crises. Among the three dimensions of social capital, the highest impact was attributed to linking social capital ($\beta = 0.312$), indicating that vertical relationships with external institutions and organizations such as government agencies, non-governmental organizations, and research centers play a more critical role in facilitating the

adoption of adaptive strategies by farmers. This finding is consistent with the study by Savari et al. (2023) in Iran, which demonstrated that social capital has a positive and significant effect on mitigating drought impacts and improving the livability of rural households. It also aligns with the study by Sithole and Saito (2019) in Eswatini, which showed that strong social networks facilitate access to information, financial resources, and physical equipment, thereby increasing the diversity and success of adaptive strategies. However, a notable point is that the effect of bridging social capital ($\beta = 0.256$) was lower than the other two dimensions, indicating that networks beyond the local community are not sufficiently robust in the study area, and rainfed farmers rely more on intra-group relationships and institutional connections than on ties with neighboring communities. This finding is consistent with previous research in Iran that has emphasized the prominent role of bonding and linking social capital (Savari et al., 2023; Keshavarz & Karami, 2016). Given that linking social capital had the highest impact, local and national policymakers are recommended to streamline administrative processes for receiving support and facilities for farmers, increase the number of agricultural advisory centers in rainfed rural areas, and design regular face-to-face meeting programs between experts and farmers to strengthen trust in governmental and non-governmental institutions. For example, forming local working groups comprising representatives from the Agricultural Jihad Organization, the Meteorological Organization, and rural councils that visit rainfed villages monthly to address farmers' questions and problems regarding rainfed cultivation can directly enhance linking social capital. Given the weakness of bridging social capital, it is recommended that extension and rural development programs prioritize strengthening communication networks between rainfed communities and neighboring regions. Furthermore, given the positive effect of bonding social capital, extension programs should leverage local networks and family relationships to disseminate knowledge and promote adaptive strategies in rainfed farming systems.

The results regarding the effect of knowledge access on the adoption of adaptive strategies indicated that both types of knowledge technical-extension and indigenous-local—have a positive and significant effect on the adoption of adaptive strategies. The highest effect was related to technical and extension knowledge ($\beta = 0.356$), suggesting that access to formal educational services, extension workshops, and meteorological and rainfall forecast information plays a more critical role in shaping the adoption of adaptive strategies in rainfed systems. This finding is fully consistent with the study by Deressa et al. (2009) in Ethiopia, which identified access to weather information and technical knowledge as one of the most important determinants of farmers' choice of adaptive methods. It is also consistent with the study by Bryan et al. (2009) in South Africa, which showed that farmers with access to extension and educational services are more inclined to adopt modern strategies such as conservation tillage and drought-resistant varieties. Notably, indigenous and local knowledge also had a positive and significant effect on the adoption of adaptive strategies ($\beta = 0.234$), indicating that the accumulated experiences of rainfed farmers over years of activity in a specific region still play an important role in their decision-making. This finding aligns with recent research in Iran (2025) demonstrating that integrating indigenous knowledge with scientific innovations constitutes a successful model for sustainable and adaptive agriculture in rainfed systems. Given that technical knowledge related to rainfed farming had the highest impact, the Agricultural Jihad Organization and extension centers are recommended to increase the number of agricultural

extension agents in rainfed rural areas, design practical and operational training courses (not merely theoretical) focused on modern rainfed methods, and utilize modern communication technologies such as SMS, social networks, and mobile applications to rapidly disseminate meteorological information, rainfall forecasts, and drought warnings to rainfed farmers. At the same time, given the positive effect of indigenous knowledge, agricultural extension systems are advised to adopt participatory approaches and treat farmers' indigenous knowledge as a valuable resource alongside scientific knowledge.

The findings regarding the mediating role of perceived effectiveness indicated that perceived effectiveness plays a partial mediating role in the relationship between knowledge access (technical and indigenous) and the adoption of adaptive strategies. In other words, knowledge (both technical and indigenous), in addition to its direct effect on the adoption of adaptive strategies, also influences adoption by enhancing farmers' perception of the effectiveness of those strategies. This finding is fully consistent with Protection Motivation Theory (Rogers, 1975), which posits that when individuals evaluate a strategy as effective, they are more motivated to adopt it. It is also aligned with the research of Grothmann and Patt (2005), who found perceived effectiveness to be the strongest predictor of adaptive behavior in response to natural hazards, and with the study by Keshavarz and Karami (2016) in Iran, which demonstrated that perceived effectiveness fully mediates the relationship between knowledge and farmers' pro-environmental behavior. Based on this finding, extension programs should, in addition to transmitting knowledge, focus on strengthening rainfed farmers' beliefs in the effectiveness of adaptive strategies. Establishing demonstration rainfed farms in each region where the effectiveness of each strategy is practically and tangibly demonstrated to farmers, presenting scientific and statistical evidence of strategy effectiveness in simple and understandable language through illustrated brochures and short videos, and organizing regular field visits to rainfed farms that have successfully employed these strategies can contribute to enhancing perceived effectiveness among rainfed farmers.

The results concerning the moderating role of drought experience revealed that drought experience moderates the relationship between social capital (in its three dimensions) and the adoption of adaptive strategies (H7a-c), as well as the relationship between knowledge access (technical and indigenous) and the adoption of adaptive strategies (H8a-b). In other words, at low levels of drought experience, the positive effect of social capital and knowledge on the adoption of adaptive strategies is weaker, while at high levels of drought experience, this positive effect becomes stronger. Simple slope analysis confirmed that at higher levels of drought experience, the slope becomes steeper, and the relationship between social capital and knowledge with adaptive strategies is strengthened (Figures 6 and 7). This finding is fully consistent with Experiential Learning Theory (Kolb, 1984), which asserts that individuals who directly experience an event develop deeper understanding and stronger responses than those who receive only indirect information. It is also consistent with the research of Below et al. (2014), who demonstrated that drought experience can positively moderate the relationship between capital and adaptive behavior, and with the study by Alam et al. (2016) in Bangladesh, which showed that direct experience of natural disasters heightens individuals' need for new knowledge and information. This finding represents one of the most significant innovations of the present study,

demonstrating that direct drought experience acts as a "catalyst," enhancing the effectiveness of social capital and knowledge in the process of adopting adaptive strategies in rainfed systems. Based on this finding, extension and educational programs should utilize the direct experiences of rainfed farmers as a powerful educational tool. Forming peer support groups with rainfed farmers who have successfully coped with drought, organizing storytelling sessions to share direct drought experiences, and using leading farmers as mentors and role models for other rainfed farmers can help strengthen the moderating effect of drought experience.

The congruence and divergence of the findings of this study with previous research in Iran and globally are of considerable importance. On the one hand, the finding regarding the positive effect of social capital on the adoption of adaptive strategies is consistent with numerous studies in Iran (Savari et al., 2023; Mirzaei et al., 2022; Keshavarz & Karami, 2016) and globally (Aldrich & Meyer, 2015; Meyer, 2018; Alam et al., 2016). On the other hand, the finding regarding the strengthening of this relationship at higher levels of drought experience has not been reported in any study in Iran, representing one of the most important innovations of the present research. Moreover, while most previous studies have separately examined the role of social capital and knowledge in drought adaptation, the present study, by simultaneously integrating these two domains and disaggregating social capital into three dimensions and knowledge into two types (with an emphasis on technical knowledge relevant to rainfed farming), provides a more comprehensive picture of the complex relationships among these variables in rainfed cropping systems. Specifically, the disaggregation of social capital into bonding, bridging, and linking dimensions, as well as the disaggregation of knowledge into technical-extension and indigenous-local types, has enabled a more precise identification of impact mechanisms that have been less addressed in previous research. Furthermore, by focusing on smallholder rainfed farmers the most vulnerable group to drought this study addresses an existing research gap and provides policy recommendations tailored to the specific needs of this group.

6. Conclusion

This study was conducted with the aim of identifying factors influencing the adoption of adaptive strategies among smallholder rainfed farmers facing drought, with an emphasis on the role of social capital (in its three dimensions: bonding, bridging, and linking) and knowledge access (in its two types: technical-extension and indigenous-local), along with the mediating role of perceived effectiveness and the moderating role of drought experience. Based on the findings, it can be stated that the water crisis in Iran's rainfed farming systems is not merely a climatic and economic issue but also a social and knowledge-related challenge. Rainfed farmers who possess stronger social capital (particularly in the linking dimension) and greater knowledge access (especially technical knowledge relevant to rainfed farming) demonstrate better adoption of adaptive strategies, and this adoption is considerably stronger among farmers who have directly experienced drought. However, the weakness of bridging social capital and unequal access to technical rainfed knowledge in remote rural areas represent major barriers to enhancing the adoption of adaptive strategies, highlighting the need for targeted interventions in these areas. Specifically, the findings of this study indicate that linking social capital (institutional

connections) and technical and extension knowledge exert greater influence on the adoption of adaptive strategies than other dimensions. This suggests that policymakers should focus in the short term on strengthening farmers' connections with governmental and non-governmental institutions and improving their access to technical and extension training. At the same time, bonding social capital and indigenous knowledge also play important complementary roles and should not be overlooked. An integrated approach that simultaneously addresses social capital (in all three dimensions) and knowledge (in both types) can be more effective than single-dimensional interventions. From a practical perspective, the main message of this research for policymakers and planners is that improving the adoption of adaptive strategies in rainfed systems requires a comprehensive and simultaneous approach to three key areas: first, strengthening social capital (particularly the linking dimension with institutions and the bridging dimension between communities) by facilitating rainfed farmers' connections with governmental and non-governmental institutions, establishing communication networks between rainfed villages and different regions, and supporting local rainfed farmers' organizations. Second, improving knowledge access (especially technical knowledge related to rainfed farming) by increasing the number of agricultural extension agents specialized in rainfed farming, developing communication and educational infrastructure in rainfed rural areas, utilizing modern technologies to disseminate meteorological information and rainfall forecasts, and simultaneously leveraging the valuable indigenous knowledge of rainfed farmers through documentation and integration with scientific knowledge. Third, leveraging direct drought experience as a powerful educational tool through role-modeling from successful rainfed farmers, storytelling and experience-sharing, and designing preventive programs for rainfed regions that have not yet experienced severe drought. In simpler terms, if we want rainfed farmers to adopt adaptive strategies, we must strengthen their social networks, increase their access to technical knowledge appropriate for rainfed farming, and use their direct experiences as a lever for behavioral change. These three simultaneous actions can transform rainfed farmers from a state of passivity and vulnerability to one of agency and resilience against drought. Based on the findings, it is recommended that policymakers first implement experience-based educational programs in areas with high drought experience, utilizing leading farmers and forming peer support groups. In the next step, by strengthening connections with local institutions and providing incentive packages for participation in extension courses, they should enhance access to technical knowledge. Finally, by establishing communication networks between villages and different regions, they should strengthen bridging social capital and create opportunities for experience and knowledge exchange. The gradual implementation of these strategies, tailored to the conditions of each region, can significantly contribute to enhancing the resilience of rainfed farmers to drought.

7. Research Implications

7.1. Theoretical Implications

First, this study is the first in Iran to comprehensively examine social capital (in three dimensions) and knowledge access (in two types with an emphasis on technical knowledge relevant to rainfed farming) in explaining the adoption of adaptive strategies by rainfed farmers,

demonstrating that these two constructs simultaneously and with interactive effects influence rainfed farmers' adoption. While previous studies have largely examined each of these constructs separately, this study, by presenting an integrated model, provides a more comprehensive picture of the social and knowledge mechanisms influencing the adoption of adaptive strategies in rainfed systems. This research, by providing empirical evidence of the moderating role of drought experience in strengthening the relationships between social capital and knowledge with the adoption of adaptive strategies in rainfed systems, contributes to expanding the boundaries of knowledge in the fields of environmental sociology and agricultural economics.

7.2. Practical Implications

This research, by identifying the key roles of linking social capital and technical knowledge related to rainfed farming, provides clear practical guidance for policymakers and planners managing drought in rainfed systems in Iran and similar regions. Based on the findings of this study, extension policies for promoting the adoption of adaptive strategies in rainfed systems should focus on three main axes:

Axis One: Strengthening social capital (particularly the linking and bridging dimensions) For example, streamlining administrative processes for receiving support and facilities for rainfed farmers, establishing joint working groups between the Agricultural Jihad Organization and rural councils in rainfed regions, forming cross-provincial rainfed farmers' cooperatives for experience exchange, and organizing local festivals with the participation of rainfed farmers from different regions.

Axis Two: Improving knowledge access (especially technical knowledge related to rainfed farming) For example, increasing the number of agricultural extension agents specialized in rainfed farming and their proportional distribution in rainfed rural areas, developing communication and internet infrastructure in rainfed villages, designing mobile applications to disseminate meteorological information, rainfall forecasts, and drought warnings to rainfed farmers, conducting practical and applied training workshops in rainfed fields, and documenting successful indigenous rainfed methods and integrating them with scientific recommendations through educational videos and illustrated brochures.

Axis Three: Leveraging drought experience as an educational tool For example, forming peer support groups with successful rainfed farmers, organizing storytelling sessions to share direct drought experiences, using leading rainfed farmers as mentors and role models, establishing demonstration rainfed farms where the effectiveness of adaptive strategies is practically demonstrated, and organizing field visits to drought-affected areas for rainfed farmers who have not yet experienced severe drought.

Furthermore, introducing drought experience as a "catalyst" for adaptive behavior in rainfed systems and emphasizing the need to attend to experience-based approaches in rainfed extension programs represents a conceptual achievement of this research that can pave the way for future theoretical developments in decision-making during crises.

8. Research Limitations

Despite the significant contributions of this study, several fundamental limitations must be considered when interpreting the findings. First, the data for this study were collected cross-sectionally at a specific point in time, which does not allow for examining changes in adaptive strategies over time and farmers' dynamic responses to changes in social capital levels, knowledge access, and drought experience. Therefore, conducting longitudinal studies that follow rainfed farmers over a period of several years is recommended to provide a more accurate picture of changes in strategies and relationships among variables over time. Second, the measurement of key variables in this study relied on self-reporting by respondents, and although efforts were made to minimize reporting error through careful questionnaire design, using multiple items for each construct, and emphasizing confidentiality, the possibility of reporting bias remains. Thus, future researchers are advised to employ mixed-methods approaches combining quantitative and qualitative methods such as in-depth semi-structured interviews, participant observation, and document review related to rainfed farming alongside survey data to enhance the validity of findings. Third, this study focused exclusively on smallholder rainfed farmers and did not include irrigated farmers or large-scale rainfed farmers. Therefore, comparative studies across different farmer groups (rainfed vs. irrigated, smallholder vs. large-scale) examining behavioral differences in response to drought are recommended for future research. Fourth, this study was conducted in Kermanshah province, which has unique ecological, economic, and social conditions, and generalization of results to other rainfed regions requires caution. Thus, comparative studies in different rainfed regions of Iran with varying climatic and socio-economic conditions, as well as in other countries with similar contexts, are recommended to enhance the generalizability of findings. Fifth, this study employed quantitative and survey methods and did not collect in-depth qualitative data to better understand the social and cultural contexts influencing farmers' adoption of adaptive strategies. Therefore, future researchers are advised to conduct qualitative and ethnographic studies alongside quantitative research to gain deeper insights into the social and cultural factors affecting the adoption of adaptive strategies in rainfed systems and to identify factors that cannot be captured in quantitative models. Sixth, this study examined the moderating role of drought experience, but other moderating variables such as age, education, gender, type of rainfed crop, land size, and income level may also moderate the relationships among research variables. Consequently, examining the moderating role of these variables and conducting multi-group analysis in SmartPLS to investigate differences among various groups of rainfed farmers is recommended for future research. Seventh, this study focused on general adaptive strategies in rainfed systems and did not address specific strategies. Therefore, focusing on specific adaptive strategies in rainfed farming such as shifting cropping patterns to specific drought-resistant crops, employing particular conservation tillage methods, or insuring rainfed crops and examining each separately is recommended for future research to provide more detailed analysis of rainfed farmers' choices and offer more practical recommendations for each specific strategy to policymakers.

Declarations

Ethical approval: The study protocol was reviewed and formally waived by the Institutional Review Board (IRB) of Razi University, Kermanshah, Iran. The IRB determined that formal ethics approval was not required for this study, as it involved only voluntary participation in an anonymous,

non-invasive questionnaire survey with no experimental interventions and no collection of sensitive personal data. All procedures were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

Consent to participate: Written informed consent was waived by the Institutional Review Board (IRB) of Razi University, Kermanshah, Iran, due to the low-risk, anonymous nature of the survey and the fact that approximately 23% of participants were illiterate. Instead, oral informed consent was obtained from all participants prior to the interviews. Trained enumerators read and explained the questionnaire and study information to participants. Oral consent was documented by the enumerator's signature confirming that the information was communicated and understood, and that voluntary oral consent was provided. All participants were fully informed about the study's objectives, the voluntary nature of their participation, and the confidentiality of their responses. This procedure was reviewed and approved by the IRB of Razi University as appropriate for illiterate populations in non-invasive survey research.

Consent for publish: Not applicable. The manuscript does not contain any individual person's data, images, or identifiable information requiring consent for publication.

Funding: The authors did not receive any specific grant or financial support for the preparation of this manuscript.

Competing interests: The authors declare no competing interests.

Clinical trial number: A clinical trial is not applicable.

Availability of Data and Materials: The datasets used and analysed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

Masoumeh Taghibaygi: Methodology, Analysis, writing – original draft, Data curation, Methodology, formal analysis, re-sources, Software, Writing original draft, project administration.

Amirhossein Alibaygi: Conceptualization, validation, visualization, investigation, supervision, Editing, and Supervision, Writing review of literature.

All authors have read and approved the final version of the manuscript.

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