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Risk Aversion Mediates the Impact of Environmental Change Perceptions on Farmers' Livelihood Strategies: A PLS-SEM Study

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Abstract

Farmers' perceptions of environmental change are a key trigger for livelihood behaviors. However, it remains unclear how these perceptions become specific livelihood strategies through internal psychological processes. To address this, this study constructs an analytical framework. It integrates multidimensional environmental perceptions, risk aversion, and livelihood strategies. Particular focus is given to the mediating role of risk aversion in the link between perception of environmental change and livelihood strategy. The proposed mechanism is tested using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate that farmers pursue both adaptive and defensive livelihood strategies. They balance security with development opportunities. Perceptions of ecological transition and market volatility significantly affect both adaptive and defensive strategies. Perception of social dynamics mainly influences adaptive strategies. The perception of policy adjustment has no significant effect. Risk aversion mediates these relationships. It strengthens defensive behaviors while promoting adaptive actions, showing its dual function in risk management and proactive adaptation. These findings underscore the complexity of decision-making in rural areas. They elucidate how environmental perceptions shape risk awareness and responses to livelihoods. This offers insights for policies aimed at enhancing rural resilience.

Keywords: perception of environmental change; risk aversion; livelihood strategies; PLS-SEM

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1. Introduction

Global climate change and socioeconomic shifts make agricultural management more complex [1]. Unlike other industries, agriculture depends on natural resources and ecosystem services. It is also shaped by production, markets, and policies in a global context, making it unique [2,3]. The reliance on biology and specific locations makes it difficult and costly for smallholder farmers to adjust to risk [4]. Multiple factors—markets, policies, local ecologies—interact and create complex influences on farming households. Farmers' choices are shaped by both opportunity and constraint [5,6]. Agricultural decisions usually have long-term or irreversible effects. When households stop cultivating or switch to alternative production methods, they face lasting social, ecological, and economic consequences [7]. This makes how farmers adjust their strategies a key issue. It affects both household welfare and sustainable development, as well as national food security, rural stability, and ecological resilience.

Emerging research challenges the traditional focus on capital endowments—such as natural, human, and financial capital—as the primary determinants of livelihood strategies [8]. Instead, it highlights that farmers' subjective perceptions of environmental change play a critical and often decisive role in shaping their coping behaviors and livelihood decisions [9,10]. These perceptions, rather than objective environmental data, frequently trigger behavioral responses, as noted by Fierros-González and López-Feldman [11]. Therefore, understanding how farmers perceive and respond to environmental changes is crucial [12]. In contexts marked by ecological and social transformation, analyzing the influence of such perceptions on livelihood strategies is both theoretically and practically significant.

Existing research provides growing evidence that farmers' perceptions of environmental change directly influence their livelihood strategies. Continuous shifts in the ecological environment force farmers to adjust their livelihood pathways. These shifts include declining resource availability [13], heightened production uncertainty [14], and an increase in more frequent extreme weather events [5]. Such changes compel farmers to mitigate risks, stabilize incomes, and explore new development opportunities. Transformations in the social and cultural environment also reshape values, norms, and social networks. This alters resource allocation preferences and strategic orientations, encouraging adaptive adjustments in livelihood decisions [15,16]. Changes in the policy environment further redefine opportunities and institutional constraints. As a result, farmers' expected returns and behavioral boundaries shift, prompting the re-selection and optimization of strategies under policy incentives [17,18]. Perceptions of market fluctuations—covering price volatility and unstable sales channels—also play a critical role. These perceptions often lead farmers to modify cropping patterns, adopt lower-risk production approaches, or reduce agricultural inputs to avoid potential losses [19,20].

While prior studies have examined the independent effects of environmental perception on farmers' behavior, such perception is multidimensional. It encompasses ecological, social, policy, and market domains. Different dimensions may exert influences on livelihood strategies that diverge or even oppose one another. For instance, perception of ecological transition often promotes adaptive behaviors. In contrast, perceptions of policy uncertainty may lead to defensive responses [21,22]. Yet a key question remains insufficiently addressed: through what internal psychological mechanisms do these perceptions translate into concrete actions for livelihoods? In other words, is there a mediating variable bridging "perception" and "action"? To address this gap, the present study introduces "risk aversion" as a mediating construct. Risk aversion reflects farmers' proactive or reactive tendencies to reduce exposure to environmental threats [23]. When facing signals of climate change, resource depletion, ecological imbalance, or market instability, farmers first develop a psychological motivation to avoid risks. Next, they evaluate losses and gains under anticipated adverse scenarios, which strengthens their risk-averse behavior [24]. This orientation—regarding economic, health, or social risks—shapes their livelihood strategies. It often results in defensive actions, such as abandoning high-risk farming or shifting to non-agricultural activities [25,26]. Previous studies have mentioned similar ideas, but few have explicitly treated risk aversion as a formal mediating variable. Therefore, constructing a comprehensive framework linking multidimensional perception of environmental change, risk aversion, and livelihood strategies is essential. This enables a systematic understanding of the mechanisms and impacts underlying farmers' adaptive and defensive responses.

The Dabie Mountains are in central China. They comprise a distinct region characterized by mountainous terrain, widespread poverty, and severe soil erosion. The area is rich in ecological resources. It serves as both an important ecological function zone in central China and as a protective barrier for the middle and lower Yangtze River. However, the environment is fragile. Ecological degradation and poverty are closely linked, and

the tension between socioeconomic development and conservation is growing [27]. Agricultural production relies on small-scale, fragmented farming. The economic base is also weak. In recent years, the Dabie Mountains have faced several pressures. These include land-use changes resulting from ecological restoration and the Grain-for-Green program, demographic shifts due to labor out-migration and aging, and market uncertainties caused by price fluctuations and unstable demand. These pressures result from agricultural industrialization and marketization. These dynamics have reshaped farmers' perceptions of environmental change, risk assessments, and livelihood decisions. As a result, the Dabie Mountains provide an ideal setting for studying the link between environmental perceptions and livelihood strategies.

To address this research gap, the present study constructs a theoretical framework that incorporates risk aversion as a mediating variable. It employs partial least squares structural equation modeling (PLS-SEM) to empirically test how environmental perceptions influence farmers' livelihood strategies. The study focuses on the mechanism of risk aversion. Specifically, it seeks to answer two core questions: How do farmers' multidimensional perceptions of environmental change shape their livelihood strategy choices in the Dabie Mountains? What mediating role does risk aversion play in this process?

Compared to existing studies, this research makes three key contributions. Theoretically, it is the first to unify multidimensional environmental perceptions and risk aversion within a single analytical framework, elucidating farmers' livelihood strategies through a cognition–psychology–behavior chain. Practically, using the Dabie Mountains as a case, it delivers empirical insights into how ecologically fragile regions facing socioeconomic transition address environmental uncertainties. Methodologically, it employs structural equation modeling to reveal both direct and indirect effects, thereby surpassing single-path regression in its ability to expose underlying mechanisms.

The remainder of this paper is structured as follows. Section 2 outlines the theoretical analysis and research hypotheses. Section 3 introduces the data and methodology. Section 4 presents the results and tests the hypotheses. Section 5 discusses the findings. Section 6 concludes the paper.

2. Theoretical Analysis and Research Hypotheses

2.1. Farmers' Livelihood Strategies

Livelihood strategies refer to farmers' choices and resource allocation within specific social and ecological contexts. Their aim is to achieve goals such as income growth, stability, and risk resilience [28,29]. To cope with environmental uncertainty, farmers adjust their livelihood strategies and optimize resources. This enhances adaptability and system resilience. This study, based on the Sustainable Livelihood Framework and existing behavioral classifications, divides livelihood strategies into two dimensions: adaptive and defensive. Adaptive strategies are proactive adjustments and innovations, such as changing crops, expanding off-farm work, or adopting new technologies. Defensive strategies involve risk-averse practices such as reducing investment, taking off-farm jobs, or relying on social networks. Adaptive strategies focus on opportunity and flexibility, while defensive ones emphasize risk avoidance and maintaining the status quo, exhibiting different behavioral responses to uncertainty.

2.2. Effects of Environmental Change Perception on Livelihood Strategies

Perception of environmental change refers to farmers' subjective awareness and evaluation of environmental changes, as well as their potential impacts. This awareness is shaped by life experiences, farming practices, and access to information [30]. In complex rural social–ecological systems, a single-dimensional perspective is insufficient to capture farm-

ers' cognition. This study employs a four-dimensional framework: ecological transition, social dynamics, policy adjustment, and perceptions of market volatility. This approach systematically characterizes farmers' understanding of their environment. Perception of ecological transition reflects farmers' experiences of natural changes, such as climate anomalies, land degradation, and water scarcity. It indicates their sensitivity to variations in natural capital [31]. Perception of social dynamics addresses views on community social relations, cultural traditions, collective actions, and mutual support networks. This represents their comprehension of social capital [32]. Perception of policy adjustment concerns knowledge, implementation, and subjective evaluation of agricultural policies. It illustrates farmers' perception of institutional change [17]. Perception of market volatility captures responsiveness to price fluctuations, input costs, labor opportunities, and market access. This serves as the foundation for economic expectations [33]. These perceptions not only indicate farmers' understanding and awareness but also play a critical role in shaping their livelihood strategies.

Farmers' sensitivity to environmental change is both a prerequisite and a trigger for adjusting and innovating their livelihood strategies. When farmers notice ecological shifts—such as droughts, floods, or other pressures—they often take action to secure harvests and support long-term sustainability [34]. These actions may include introducing resistant crop varieties, investing in water-saving technologies, or using ecological farming methods. When they observe limited participation in public affairs or changes in community networks, farmers seek new opportunities. They may engage in skill training, expand non-farm work, or pursue entrepreneurship to improve household well-being. This helps them diversify and upgrade their livelihoods [15]. If farmers perceive supportive policies—such as subsidies, technology promotion, credit, or ecological compensation—they may adopt new technologies, expand production, or shift to higher-value ecological agriculture, expecting better returns [17]. Market-related perceptions, such as price volatility, growing consumer demand for healthy products, and the emergence of new sales channels like e-commerce, prompt farmers to adjust their production, improve quality, and innovate in marketing [35,36]. Together, these factors show how farmers' perceptions of environmental change encourage them to make opportunity-oriented adjustments. These adjustments enable farmers to choose adaptive strategies and cope with uncertainty in sustainable ways. Accordingly, the following hypothesis is proposed:

Hypothesis H1. *Different dimensions of farmers' perception of environmental change—including perception of ecological transition (H1a), perception of social dynamics (H1b), perception of policy adjustment (H1c), and perception of market volatility (H1d)—are hypothesized to have significant and positive effects on their adaptive livelihood strategies.*

When farmers see proactive adjustments as ineffective or too costly, they adopt defensive strategies to ensure survival and protect household welfare. For example, if they view ecological threats as uncontrollable and highly destructive, they reduce the use of fertilizers and pesticides or partially abandon farmland. This minimizes losses instead of prompting high-risk investments or innovations [37]. If social trust is declining or social support is insufficient, farmers tend to turn to kinship networks, increase precautionary savings, or reduce non-essential expenses. This reflects a contractionary, defensive stance [16]. Similarly, if policies seem inaccessible, inconsistent, or restrictive, farmers reinforce their defensive approach [18]. When market price fluctuations are perceived as unpredictable and risky, especially by those with limited capital or resilience, they lead to reduced cash crop cultivation, a focus on subsistence, or avoidance of the market. This helps prevent potential bankruptcy [20]. The following hypothesis is proposed:

Hypothesis H2. *Different dimensions of farmers' perception of environmental change—including perception of ecological transition (H2a), perception of social dynamics (H2b), perception of policy adjustment (H2c), and perception of market volatility (H2d)—are hypothesized to have significant and positive effects on their defensive livelihood strategies.*

2.3. Mediating Role of Risk Aversion

Risk aversion means that farmers prefer safe and steady strategies. They strive to avoid losses and maintain their livelihoods when facing uncertainty in production, markets, health, or social settings [23,38]. This study examines risk aversion in response to income changes, health threats, and social exclusion, highlighting how external shocks and farmers' own vulnerabilities interact. When farmers feel uncertain about earnings from farming or outside jobs, they act cautiously. Expected Utility Theory suggests that the more concerned individuals are about future changes, the more cautious they become [39]. Health concerns, especially in poorer rural areas, demonstrate the value of health. Poor health can reduce work productivity and disrupt income, prompting people to take steps to protect themselves [40,41]. Social exclusion refers to farmers feeling left out, having weak networks, or not receiving policy help. Social Exclusion Theory suggests that being left out makes it more difficult to obtain support. This encourages farmers to use their resources wisely to avoid further isolation [42,43].

Perception of environmental change can make farmers aware of potential uncertainties and threats. This awareness influences their risk perception, making them more likely to avoid risk. Risk aversion then serves as a key psychological factor in their decision on how to maintain their livelihoods. When farmers perceive more environmental change, they become more sensitive to risks and show stronger risk aversion [24]. Farmers with high risk aversion who notice environmental risks may attempt to mitigate losses by employing defensive strategies, such as reducing agricultural inputs or taking on non-farm work [44]. They may also adapt their farming practices by choosing stress-resistant crops, optimizing patterns, or adopting new technologies while aiming to protect their livelihoods. These changes help move their strategies toward adaptive development [45,46]. Based on this, the following hypotheses are proposed:

Hypothesis H3. *Risk aversion mediates the relationship between farmers' perception of environmental change—including perception of ecological transition (H3a), perception of social dynamics (H3b), perception of policy adjustment (H3c), and perception of market volatility (H3d)—and their adaptive livelihood strategies.*

Hypothesis H4. *Risk aversion mediates the relationship between farmers' perception of environmental change—including perception of ecological transition (H4a), perception of social dynamics (H4b), perception of policy adjustment (H4c), and perception of market volatility (H4d)—and their defensive livelihood strategies.*

2.4. Theoretical Model

This study developed a theoretical model of livelihood strategy choices based on the research hypotheses. The model aims to examine how farmers' perceptions of environmental changes influence their livelihood strategies. It also examines the mediating effect of risk aversion on the relationship between perception of environmental change and livelihood strategies. Figure 1 illustrates the detailed construction of the theoretical model.

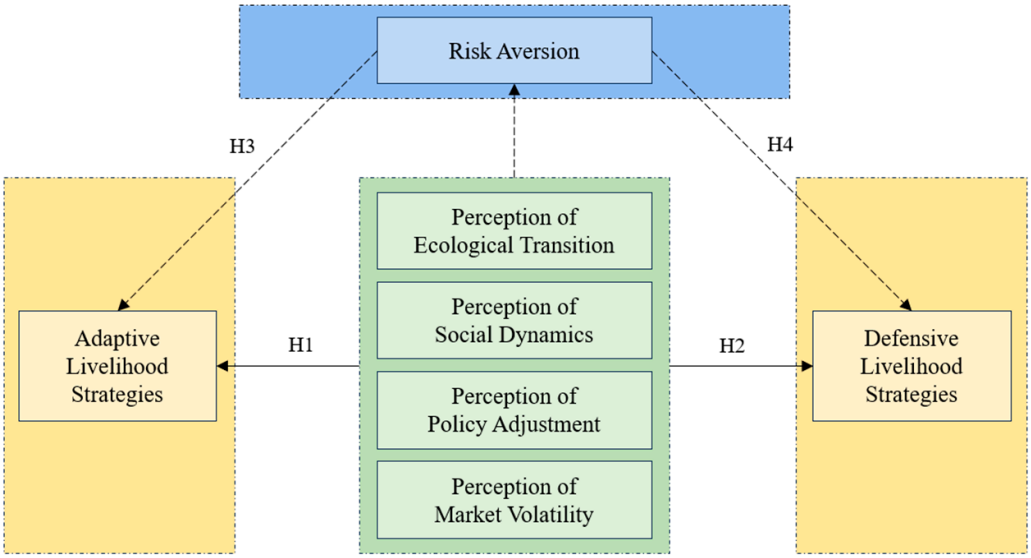


Figure 1. Conceptual framework and hypothesized pathways of this study. Note: - - - mediation relationship.

In this study, the perception of farmers on environmental change are the primary focus. These perceptions encompass four key areas: ecological transition, social dynamics, policy adjustment, and market volatility. These cover how farmers notice and understand the various changes happening around them. Risk aversion is the middle factor, indicating how farmers perceive uncertainty and their willingness to avoid risk. It is the main way that perceptions of environment change influence the types of livelihood strategies farmers use. Livelihood strategies are the outcome. They fall into two types: adaptive and defensive. Adaptive strategies involve making adjustments, such as utilizing new technology, modifying their products, or exploring additional revenue streams, to address changes and achieve long-term success. Defensive strategies focus on saving money and careful planning to keep a basic level of safety and avoid loss.

3. Data Sources and Methodology

3.1. Research Area

The Dabie Mountains were once a nationally designated contiguous poverty-stricken area. They are characterized by a monsoon mountain climate and complex terrain. These factors exacerbate the environmental vulnerability of agricultural production and heighten farmers' sensitivity to climate change and ecological degradation. Although poverty has been largely alleviated, the region continues to experience lagging industrialization, slow development, and an agriculture-dominated economy [47]. As a result, farmers' livelihoods remain highly dependent on natural resources. Their capacity to cope with risks is relatively weak. Focusing on the Dabie Mountains enables us to examine how farmers' perceptions of environmental changes impact their livelihood strategies. This not only reveals the mechanisms of livelihood adjustment under ecological fragility and developmental constraints but also provides important insights for advancing sustainable transformation in other post-poverty mountain regions.

3.2. Data Source

The data for this study were collected through a field survey conducted by the research team between April and July 2024. The study took place in Fushan Township, Shangcheng County, Henan Province, and covered three administrative villages. Farmers were randomly selected from these villages as survey respondents. The team administered detailed

questionnaires through household interviews. The questionnaires included farmers' basic characteristics (gender, age, education, household income), perceptions of environmental change (ecological transition, social dynamics, policy adjustment, and market volatility dimensions), risk aversion, and their livelihood strategies. A total of 348 questionnaires were collected. After excluding incomplete responses, 322 questionnaires were valid, yielding an effective response rate of 92.52%.

We interviewed 182 female and 140 male respondents, aged 17 to 72 years. The sample tended to be older, consistent with the demographic of villagers remaining in the area. Education levels were generally below seven years, mirroring the age structure. Most households (26.7%) had a per capita net income of 12,000–27,000 yuan (Table 1). Overall, the sample reasonably represents the study population.

Table 1. Socio-demographic characteristics.

Feature	Frequency (N = 322)	Proportion (%)
Gender		
Male	140	43.48
Famale	182	56.52
Age (years)		
Less than 30	11	3.42
From 30 to less than 45	37	11.49
From 45 to less than 60	166	51.55
60 and over	108	33.54
Education (years)		
Less than 7	183	56.83
From 7 to less than 10	87	27.02
From 10 to less than 13	33	10.25
13 and over	19	5.90
Income (Yuan)		
Less than 12,000	17	5.28
From 12,000 to less than 27,000	192	59.63
From 27,000 to less than 50,000	88	27.33
50,000 and over	25	7.76

3.3. Methodology and Measures of Variables

To investigate how multidimensional perceptions of environmental change influence farmers' livelihood strategies, this study employs Partial Least Squares Structural Equation Modeling (PLS-SEM). This empirical approach is well-suited for identifying causal relationships and complex pathways among variables. This study proposes an exploratory theoretical model: "multidimensional perception of environmental change → risk aversion → livelihood strategy." The aim is to develop and test an emerging theoretical framework. PLS-SEM is particularly suitable for early-stage theory development, as it focuses on prediction and the identification of key driving relationships among variables. It does not focus on verifying the absolute validity of an established theory [48]. Widely applied in management, social sciences, and rural studies, PLS-SEM integrates the strengths of factor analysis and regression analysis. It enables the estimation of models with multiple endogenous variables and accommodates measurement errors in exogenous constructs. This ensures robust identification and validation of the overall path structure [48,49]. Compared with covariance-based SEM (CB-SEM), PLS-SEM requires fewer assumptions regarding sample size and data normality. It generally produces more robust estimates [50]. Additionally, PLS-SEM allows for the simultaneous testing of both direct and mediating effects. It provides multiple evaluation criteria, including path coefficients, effect size (f^2), explained

variance (R^2), and predictive relevance (Q^2). In this research, the latest version of SmartPLS 4.1 was used to construct and evaluate the PLS-SEM path model.

This study measured perceptions of ecological transition, social dynamics, policy adjustment, and market volatility. It also examined risk aversion and both adaptive and defensive livelihood strategies. Table 2 lists the constructs and their corresponding items. All latent variables used multi-item scales. Unless specified, items were rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Higher scores reflect stronger agreement. The questionnaire was pre-tested among a small group of farmers. Minor wording adjustments were made for clarity and contextual relevance.

Table 2. Description of the construct and its variables used in the present research model.

Index	Latent Variable	Observed Indicators	Statements	Measures
Perception of Environmental Change	Perception of Ecological Transition	PET1	Soil fertility in your area has gradually declined.	Values 1–5, the higher the value, the higher the level of agreement with the statement
		PET2	The quality of rural water sources (wells, rivers, etc.) is worse than in the past.	
		PET3	The variety and number of wild plants and animals have significantly decreased.	
		PET4	Extreme weather events (e.g., heavy rain, droughts, strong winds) occur more frequently.	
	Perception of Social Dynamics	PSD1	Communication and visits among villagers have decreased compared with the past.	
		PSD2	Participation in village public affairs has declined.	
		PSD3	Mutual help among villagers has decreased compared with the past.	
		PSD4	Villagers are less willing to entrust private matters to their neighbors.	
	Perception of Policy Adjustment	PPA1	Agricultural subsidies provide limited support for your farming activities.	
		PPA2	Ecological protection policies impose more restrictions on your agricultural production than in the past.	
		PPA3	The coverage of medical and pension insurance is limited.	
	Perception of Market Volatility	PMV1	The price volatility of major agricultural products has increased significantly.	
		PMV2	It has become more difficult to obtain reliable sales information.	
		PMV3	The competition for agricultural products in local markets has become more intense.	
		PMV4	The costs of agricultural inputs have increased operational pressure.	
Risk Aversion	Risk Aversion	RA1	Household income is highly uncertain and difficult to maintain consistently.	
		RA2	Health problems or medical expenses may weaken household labor capacity and create a heavy financial burden.	
		RA3	The household is easily overlooked or marginalized in accessing resources and participating in village affairs.	

Table 2. *Cont.*

Index	Latent Variable	Observed Indicators	Statements	Measures
Livelihood Strategies	Adaptive Livelihood Strategies	ALS1	Have you adjusted your crop structure in recent years?	Yes = 1, No = 0
		ALS2	Have you adopted new agricultural technologies?	
		ALS3	Have you purchased agricultural insurance?	
		ALS4	Have you engaged in livestock raising or other non-crop activities?	
	Defensive Livelihood Strategies	DLS1	Have you reduced your agricultural investment?	
		DLS2	Have you relocated household labor to non-farm employment or migrant work?	
		DLS3	Have you relied on social support (such as assistance from relatives, government, or the village collective)?	

Descriptive analyses show that most farmers have already perceived ecological shifts. In particular, they have noted a decline in soil fertility and a worsening of water quality. When it comes to social transformation, farmers report fewer interactions and fewer visits from villagers. They also mention lower engagement in village affairs and greater reluctance to entrust personal matters to neighbors. Market fluctuations are keenly felt, especially through price volatility and rising production costs. However, farmers have weaker perceptions of policy adjustments and limited awareness of agricultural subsidies or ecological protection initiatives. For risk aversion, concerns about income instability and health risks are particularly notable. When facing environmental changes, farmers usually adopt both adaptive and defensive strategies. Adjusting crop structure and utilizing new agricultural technologies are the primary adaptive strategies. Reallocating labor to non-farm employment or migrating out are the most common defensive responses.

4. Empirical Results and Analysis

4.1. Measurement Model Assessment

To evaluate the reliability of the measurement scale, we applied the thresholds recommended by Hair et al.: outer loading (>0.70), Cronbach's alpha (>0.70), composite reliability (>0.70), and average variance extracted (AVE > 0.50) [49]. Table 3 shows that all outer loadings surpassed 0.70, verifying the accuracy of the measurement items. Furthermore, Cronbach's alpha and CR values for all latent variables exceeded 0.70, demonstrating strong internal consistency.

Table 3. Reliability, discriminant, and convergent validity of the scales.

Variables	Observed Indicators	Outer Loadings	Cronbach's Alpha	Composite Reliability (rho_c)	AVE	VIF
Recommended values		>0.7	>0.7	>0.6	>0.5	<3.0
Perception of Ecological Transition			0.875	0.787	0.649	
	PET1	0.818				1.840
	PET2	0.855				2.737
	PET3	0.779				1.835
	PET4	0.814				1.699
Perception of Social Dynamics			0.787	0.684	0.712	
	PSD1	0.773				1.805
	PSD2	0.911				1.948
	PSD3	0.883				1.663
	PSD4	0.828				1.791

Table 3. *Cont.*

Variables	Observed Indicators	Outer Loadings	Cronbach's Alpha	Composite Reliability (rho_c)	AVE	VIF
Perception of Policy Adjustment			0.804	0.722	0.594	
	PPA1	0.755				2.028
	PPA2	0.797				1.844
	PPA3	0.843				1.830
Perception of Market Volatility			0.759	0.728	0.716	
	PMV1	0.854				1.743
	PMV2	0.811				1.679
	PMV3	0.851				2.530
	PMV4	0.795				1.955
Risk Aversion			0.819	0.826	0.745	
	RA1	0.833				1.946
	RA2	0.901				1.849
	RA3	0.874				1.804
Adaptive Livelihood Strategies			0.796	0.871	0.694	
	ALS1	0.853				2.488
	ALS2	0.835				2.016
	ALS3	0.802				1.768
	ALS4	0.757				1.887
Defensive Livelihood Strategies			0.866	0.735	0.661	
	DLS1	0.766				1.694
	DLS2	0.793				1.845
	DLS3	0.837				1.837

We further evaluated potential multicollinearity and common method bias. We performed Harman's single-factor test using SPSS 21, subjecting all study variables to an exploratory factor analysis without rotation. The first unrotated factor accounted for 37.23% of the total variance, which is below the 50% threshold [51]. This suggests that common method bias is not a serious issue. Therefore, the data is reliable. We also examined the variance inflation factor (VIF) values. Following Hair et al.'s criterion, VIF values below 3.0 show that there is no multicollinearity or common method bias [49]. In our model, VIF values ranged from 1.679 to 2.737 (Table 3), well within the acceptable range. This confirms that multicollinearity and methodological bias were not concerns.

For validity assessment, SmartPLS 3 was used to calculate factor loadings and the average variance extracted (AVE). Details are presented in Table 3. All standardized loadings exceeded the recommended cutoff of 0.70, indicating satisfactory convergent validity.

Discriminant validity was evaluated using the heterotrait–monotrait (HTMT) ratio of correlations. The maximum acceptable HTMT value is 0.85 [52]. Table 4 shows that all HTMT values for latent variables range from 0.185 to 0.644. This confirms solid discriminant validity, ensuring that each construct is distinct and providing a sound basis for the structural model analysis.

Table 4. The HTMT criterion.

	PET	PSD	PPA	PMV	RA	ALS	DSL
PET							
PSD	0.366						
PPA	0.195	0.291					
PMV	0.278	0.296	0.421				
RA	0.428	0.185	0.358	0.622			
ALS	0.365	0.433	0.644	0.447	0.370		
DLS	0.280	0.377	0.506	0.288	0.259	0.588	

Note: PET: Perception of Ecological Transition; PSD: Perception of Social Dynamics; PPA: Perception of Policy Adjustment; PMV: Perception of Market Volatility; RA: Risk Aversion; ALS: Adaptive Livelihood Strategy; DLS: Defensive Livelihood Strategy.

4.2. Structural Model Assessment

After confirming the reliability and validity of the measurement model, the structural model was evaluated. Following Hair et al. [53], we assessed the coefficient of determination (R^2), cross-validated redundancy (Q^2), effect size (f^2), and path coefficients to examine model fit. R^2 reflects the explanatory power of the model. It ranges from 0 to 1, with higher values indicating greater predictive accuracy [54]. Q^2 evaluates predictive relevance. Values above 0 indicate sufficient predictive validity [52]. The f^2 quantifies the incremental contribution of each exogenous latent variable to the variance of endogenous latent variables. Values of 0.02, 0.15, and 0.35 are considered small, medium, and large effects, respectively [55].

In this study, R^2 values for all endogenous latent variables ranged from 0.346 to 0.691. This demonstrates moderate to strong explanatory power. All Q^2 values exceeded 0, confirming the model's predictive relevance (Table 5). f^2 values ranged from 0.007 to 0.334, indicating differences in the explanatory contributions of exogenous variables (Table 6). The path coefficients for most paths were statistically significant. Exceptions include "perception of social dynamics → adaptive livelihood strategy," "perception of policy adjustment → risk aversion," and "perception of policy adjustment → defensive livelihood strategy." Overall, based on R^2, Q^2, f^2, and path coefficients, the structural model is well-specified, shows good fit, and demonstrates robust statistical performance.

Table 5. Structural model test.

	R^2	Q^2
PET	0.691	0.457
PSD	0.474	0.322
PPA	0.346	0.195
PMV	0.454	0.310
RA	0.399	0.202
ALS	0.423	0.278
DLS	0.538	0.325

Table 6. Estimated indices of the path analysis.

Hypothesis	Paths	Standardized Coefficient β	T Statistics	*p* Value	95% Confidence Interval		f^2	VAF%	Decision
					2.5	95%			
				Direct effect					
H1a	PET→ALS	0.422	7.335	<0.001	0.292	0.517	0.041	N/A	Supported
H1b	PSD→ALS	0.188	0.189	>0.05	−0.106	0.385	0.028	N/A	Not supported
H1c	PPA→ALS	0.271	2.326	<0.05	0.074	0.319	0.206	N/A	Supported
H1d	PMV→ALS	0.266	4.837	<0.001	0.167	0.394	0.133	N/A	Supported
H2a	PET→DLS	0.257	5.479	<0.001	0.162	0.381	0.107	N/A	Supported
H2b	PSD→DLS	0.206	3.611	<0.001	0.007	0.278	0.119	N/A	Supported
H2c	PPA→DLS	0.112	1.038	>0.05	−0.128	0.326	0.074	N/A	Not supported
H2d	PMV→DLS	0.104	2.961	<0.05	0.075	0.329	0.066	N/A	Supported
	RA→ALS	0.506	5.855	<0.001	0.399	0.553	0.273	N/A	
	RA→DLS	0.337	3.726	<0.001	0.188	0.445	0.177	N/A	
	PET→RA	0.384	5.011	<0.001	0.326	0.499	0.025	N/A	
	PSD→RA	0.264	2.863	<0.001	0.155	0.372	0.155	N/A	
	PPA→RA	0.078	0.781	>0.05	−0.173	0.246	0.238	N/A	
	PMV→RA	0.252	3.531	<0.001	0.112	0.358	0.113	N/A	
				Indirect effect					
H3a	PET→RA→ALS	0.194	7.635	<0.001	0.028	0.251	N/A	31.494	Supported
H3b	PSD→RA→ALS	0.134	1.602	>0.05	−0.117	0.379	N/A	N/A	Not supported
H3c	PPA→RA→ALS	0.039	0.973	>0.05	−0.135	0.228	N/A	N/A	Not supported
H3d	PMV→RA→ALS	0.128	3.287	<0.001	0.024	0.244	N/A	32.487	Supported
H4a	PET→RA→DLS	0.129	5.907	<0.001	0.090	0.285	N/A	33.420	Supported
H4b	PSD→RA→DLS	0.089	3.136	<0.05	0.009	0.205	N/A	30.169	Supported
H4c	PPA→RA→DLS	0.026	1.455	>0.05	−0.273	0.124	N/A	N/A	Not supported
H4d	PMV→RA→DLS	0.085	5.894	<0.001	0.012	0.155	N/A	44.974	Supported

Bootstrapping with 3000 resamples was used to evaluate the significance of the hypotheses and test model integrity. In the PLS-SEM model (Figure 2), path coefficients with

t-values above 1.96 were deemed significant at the 5% level or higher. Detailed SEM results appear in Table 6.

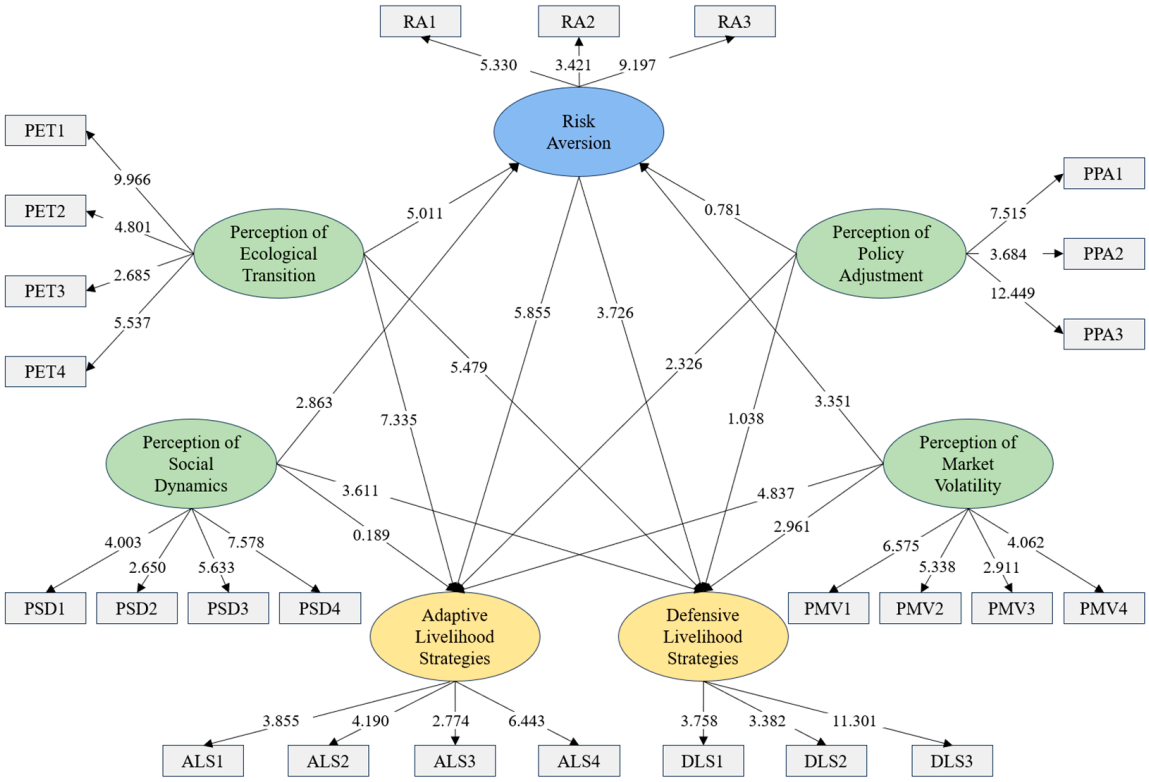


Figure 2. PLS-SEM path model.

As shown in Table 6 and Figure 2, most hypothesized relationships received empirical support. Perception of ecological transition had a strong and significant effect on both adaptive livelihood strategies (β = 0.422, $p < 0.001$) and defensive livelihood strategies (β = 0.257, $p < 0.001$). This supports H1a and H2a. When farmers perceive ecological transition, they tend to adopt both proactive adjustments and conservative coping behaviors. Perception of market volatility also had significant positive effects on adaptive livelihood strategies (β = 0.266, $p < 0.001$) and defensive livelihood strategies (β = 0.104, $p < 0.05$), supporting H1d and H2d. This suggests that market volatility can simultaneously drive diversification and mitigate risk. Perception of social dynamics, however, was only significantly associated with defensive livelihood strategies (β = 0.206, $p < 0.001$), supporting H2b. This suggests that uncertainty in the social environment primarily encourages conservative behavior. In contrast, perception of policy adjustment was only significantly related to adaptive strategies (β = 0.271, $p < 0.05$), supporting H1c. This suggests that policy adjustments effectively empower farmers to take proactive action for transformation.

Turning to risk aversion, it robustly predicted both adaptive livelihood strategies (β = 0.506, $p < 0.001$) and defensive livelihood strategies (β = 0.337, $p < 0.001$), underscoring its role as a key driver of livelihood behavior. Notably, risk aversion exerted a considerably stronger influence on adaptive livelihood strategies than on defensive ones, implying that increased risk sensitivity promotes proactive, adaptive behaviors among farmers more effectively.

Additionally, perceptions of ecological transition (β = 0.384, $p < 0.001$), social dynamics (β = 0.264, $p < 0.001$), and market volatility (β = 0.252, $p < 0.001$) significantly heightened risk aversion, whereas perception of policy adjustment had no significant effect (β = 0.078, $p > 0.05$). These results indicate that uncertainty in ecological, social, and market

contexts directly amplifies farmers' risk awareness, while policy adjustments have not been meaningfully integrated into their risk perception.

Regarding mediating effects, PLS-SEM results show that perception of ecological transition has significant indirect effects on adaptive livelihood strategies (β = 0.194, $p < 0.001$) and defensive livelihood strategies (β = 0.129, $p < 0.001$) through risk aversion. This supports H3a and H4a. Similarly, the perception of market volatility positively influences adaptive (β = 0.128, $p < 0.001$) and defensive livelihood strategies (β = 0.085, $p < 0.001$) via the same mediating pathway, supporting H3d and H4d. Perception of social dynamics also shows a significant indirect effect on defensive livelihood strategies (β = 0.089, $p < 0.05$), supporting H4b. In contrast, the perception of policy adjustment does not show a significant indirect effect, indicating that its impact is not transmitted through farmers' risk aversion.

Mediation was further evaluated using the variance accounted for (VAF) approach. Following Hair et al., VAF values are interpreted as follows: less than 20% indicates no mediation, 20–80% reflects partial mediation, and greater than 80% indicates full mediation [53]. The results show that risk aversion partially mediates the most significant paths between perceptions of environmental change and livelihood strategies. VAF values range from 30% to 45%. Exceptions occur in the paths from perception of social dynamics to adaptive livelihood strategies and from perception of policy adjustment to both adaptive and defensive livelihood strategies, where no mediation is found (Table 6).

In summary, the findings confirm a distinct "cognition–psychology–behavior" chain mechanism in farmers' responses to environmental changes. Farmers' perception of environmental change first triggers a risk aversion mindset. This, in turn, shapes their livelihood strategy choices. The most effective pathway identified is "perception of ecological evolution → risk aversion → adaptive livelihood strategy" (total effect = 0.422 + 0.194 = 0.616). This pathway, with the highest path coefficient, suggests that, under current conditions, farmers are more likely to select adaptive livelihood strategies through the mediation of risk aversion.

5. Discussion

5.1. Perception of Environmental Change as a Key Driver of Farmers' Livelihood Strategies

The study finds that farmers' perceptions of environmental changes significantly shape their livelihood strategies, consistent with the "perception–behavior" framework in existing literature [56,57]. Ecological transitions are widely perceived. As a result, farmers adopt proactive adaptive strategies, such as adjusting crop structures and applying green technologies. This aligns with Zhao et al.'s findings in the Qinghai–Tibet Plateau: perceived ecological degradation enhances farmers' proactive transformation [58]. At the same time, the perception of ecological transition leads some low-income farmers to adopt conservative defensive strategies. These include reduced agricultural inputs or shifts to non-farm activities. This echoes Baffoe and Matsuda's observations that a strong ecological perception often leads to conservative strategies [59]. Perception of social dynamics has a limited impact on adaptive livelihood strategies but a positive effect on defensive ones. When farmers sense instability in social structure, village cohesion, or their social networks, they tend to pursue more conservative livelihoods, such as transitioning to off-farm work or relying more heavily on social ties. This aligns with Yuan and Pu's finding that social trust and institutions shape farmers' non-agricultural employment choices [60]. Perception of market volatility has a dual effect: anticipated shifts in prices or demand lead farmers to adjust their production in the short term and take steps to mitigate market risk; this aligns with prior research on adaptation to market and climate change [14]. Perception of policy adjustment has minimal influence, likely due to delays, unclear communication, or

weak incentives, echoing earlier findings that policy perceptions rarely drive short-term defensive actions [61,62].

5.2. Risk Aversion as a Mediator in the Impact of Environmental Perception on Livelihood Strategies

The findings of this study indicate that risk aversion significantly influences both adaptive and defensive livelihood strategies. The effect is stronger on adaptive strategies. This suggests that risk aversion not only promotes traditional conservative behaviors but also motivates farmers to proactively adjust cropping patterns, diversify operations, and enhance their capacity to cope with risks. These results support the perspective that risk aversion has evolved from a conventional "avoidance logic" to a "multidimensional strategic adjustment mechanism" [63,64].

Moreover, several dimensions of environmental change perception—including perceptions of ecological transition, social dynamics, and market volatility—exert significant indirect effects through risk aversion. This highlights the critical pathway of "perception of environmental change—risk aversion-strategic response" in farmers' decision-making. In other words, risk aversion acts as a psychological mediator that translates farmers' perceptions of environmental changes into both adaptive and defensive livelihood strategies.

5.3. Structural Differences Among Perception Dimensions Reveal Policy Bottlenecks

The findings suggest that perceptions of ecological transition and market volatility operate through risk aversion. They form a partial mediating pathway. In contrast, the perception of policy adjustment shows no significant effect on risk aversion or defensive livelihood strategies. This suggests that policy information has not been effectively integrated into farmers' risk awareness or decision-making. Even when farmers are aware of policy changes and may be willing to respond, this awareness does not become part of their risk management thinking. As a result, it fails to translate into behavioral intentions through the risk-adjustment mechanism. These results reveal a gap between policy perception and risk judgment, highlighting a phenomenon of "policy insensitivity".

In this context, relying only on policy dissemination and information provision is unlikely to change farmer behavior. Policy design and promotion should embed policy information within farmers' risk perception. For example, policies can be presented as risk-mitigation tools for coping with environmental and market uncertainties. This approach can help turn policy initiatives into real behavior changes. These observations are consistent with earlier studies. Prior research notes a persistent "cognition–action gap," where awareness of policy does not automatically lead to action [26,65].

5.4. Coexistence of Adaptive and Defensive Livelihood Strategies: Mixed Behavioral Choices

It is noteworthy that farmers' livelihood behaviors are not simply binary but reflect a hybrid or mixed strategy. When faced with environmental uncertainty, farmers employ both defensive strategies to mitigate risks and adaptive strategies to capitalize on new opportunities. This tendency toward dual strategies is documented in previous studies [66–68] and, together, forms a composite livelihood pattern that enables farmers to navigate uncertainty effectively. The hybrid nature of these behaviors underscores the diversity and complexity of rural livelihood decision-making, yielding key insights into the drivers of ongoing rural livelihood transformations.

6. Conclusions and Policy Implications

6.1. Conclusions

This study examines farmers in the Dabie Mountains by constructing an analytical framework that connects perceptions of environmental change, risk aversion tendencies,

and specific livelihood strategies. Drawing on sustainable livelihood theory and behavioral response models, the study employs PLS-SEM to empirically analyze how detailed perceptions of environmental change shape farmers' livelihood strategy selection and the mediating influence of risk aversion.

The findings reveal three major insights. First, the study confirms that perception of environmental change is multidimensional and heterogeneous, addressing a critical gap in existing research. It moves beyond single-dimensional analysis to show that different perception dimensions influence livelihood strategies through distinct pathways and at varying intensity levels. Perceptions of ecological transition are the strongest driver of dual responses. These prompt farmers to adopt both adaptive and defensive strategies, reflecting a coexistence of "active adaptation" and "protective caution" under ecological stress. Perception of market volatility also drives both adaptive and defensive strategies. This highlights how farmers see markets as sources of both opportunity and risk. In contrast, perception of social dynamics significantly influences only defensive strategies. This suggests that factors such as migration and weakening community ties primarily trigger insecurity and conservative behavior. The perception of policy adjustment shows no significant effect. This reveals an overlooked challenge: even with ample policy support, gaps in communication, limited understanding, or distrust can block the translation of policy signals into concrete action. This provides a cognition-centered explanation for why policy may be ineffective.

Second, the mediating role of risk aversion sheds light on the "psychological black box" of livelihood decision-making. This is the core theoretical contribution of this study. The results show that risk aversion not only produces defensive behavior, as conventional theory claims. It can also lead to proactive adaptive actions. This challenges the linear view that risk aversion always results in conservatism. Risk aversion serves a dual role as a risk management mechanism. On the one hand, it encourages farmers to limit potential losses through contractionary strategies. On the other hand, it motivates them to adopt new technologies and diversify production to manage future uncertainty. This dual function addresses the central research question and clarifies the psychological link between environmental perception and livelihood behavior.

Third, farmers' livelihood strategies show a hybrid pattern that combines defense and adaptation, enriching our understanding of livelihood complexity. Rather than picking one approach, farmers strive to balance stability with opportunity for progress. Defensive strategies act as a buffer for household subsistence. Meanwhile, adaptive strategies open pathways for development. This mixed approach reflects farmers' dual identity as rational decision-makers and risk managers. It offers strong evidence of the complexity and resilience seen in smallholder livelihoods.

6.2. Policy Implications

Based on these conclusions, this study suggests several policy actions to bridge the gap between what policies aim for and what farmers perceive and to help build stronger mechanisms for them to make a living.

To begin, it is crucial to enhance localized policy communication and empowerment in order to overcome "policy perception failure." Current policy dissemination often relies on one-way, top-down communication using abstract or bureaucratic language. This approach mismatches farmers' cognitive habits and access to information. Local governments should use dialects, region-specific examples, and demonstration households. These measures improve policy accessibility, comprehension, and applicability by turning macro-level policies into clear, actionable guidance for farmers.

In addition, the local government should develop differentiated policy packages to support hybrid livelihood strategies. For adaptive strategies, policies should provide positive incentives that align with ecological and market perceptions. Examples include green technology subsidies, e-commerce training, and microcredit for entrepreneurial efforts. For defensive strategies, policy should recognize their legitimacy and include them in social safety nets. These nets may cover rural education, healthcare, and pension systems, reducing unproductive spending and supporting household stability.

6.3. Limitations and Future Scope of Study

This study has certain limitations. To focus on core theoretical relationships and maintain a simple and interpretable structural equation model, we excluded moderating variables, such as respondents' individual characteristics and value orientations. These factors are crucial for understanding the relationship between perceptions of environmental change and livelihood strategies. They also point to valuable directions for future research. The hilly areas of the Dabie Mountains studied here are ecologically fragile, are characterized by a mono-industrial economy, and have limited capacity for policy dissemination. These factors likely amplify perceptions of ecological transition, social dynamics, and market volatility while helping explain the nonsignificant impact on perception of policy adjustment. Study contexts may vary, for example, in plains, eastern coastal, or peri-urban areas. In these places, risk aversion mechanisms, livelihood response patterns, and perceptions of environmental change intensity may differ. Future research should include regional comparative analyses. This will demonstrate how contextual conditions influence farmers' risk aversion and livelihood strategies, thereby enhancing the generalizability and applicability of this theoretical framework.

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Institutional Review Board Statement: Ethical review and approval were waived for this study by the Xinyang Normal University Ethics Committee because it involved an anonymous survey analysis that did not collect any personally identifiable or sensitive information. The research posed no risks to the participants.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The research will exclusively rely on primary survey, and the provision of providing the primary data will be based solely on specific requests.

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