

Determinants of adopting sustainable agricultural livelihoods among ethnic minority households in a Luoi 4, Hue City, Vietnam

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ABSTRACT

This study aims to identify the determinants influencing households' adoption of sustainable agricultural livelihood models in A Luoi 4 commune, Hue City, Vietnam. Based on a household survey of 212 respondents and using a binary logistic regression model, the research examines the effects of 28 independent variables representing human, natural, physical, financial, and social capitals. The model identifies nine significant factors shaping the likelihood of adopting sustainable livelihood practices: ethnicity, access to local financial support, access to output markets, stability of current livelihood, participation in farmer groups or cooperatives, exposure to climate change impacts, perception of climate change, access to agricultural information, and educational attainment. These results highlight that a single factor does not drive livelihood adoption but emerges from the interaction of socio-economic conditions, institutional connections, and environmental stressors. Households with stronger cognitive awareness, better market and institutional access, or higher disaster exposure are more likely to shift toward sustainable livelihood practices. The findings underscore the need for targeted interventions that enhance education, strengthen local cooperatives, improve financial support schemes, and expand market linkages for ethnic minority communities. By providing empirical evidence on livelihood decision-making in upland areas, the study contributes to the design of inclusive, climate-adaptive development policies that support resilient livelihood transitions in mountainous regions.

Contribution/Originality: This study contributes to the existing literature by empirically identifying the key determinants of sustainable agricultural livelihood adoption among ethnic minority households in Vietnam. It is one of the few studies that apply binary logistic regression to analyze livelihood transitions in mountainous contexts. The paper's primary contribution is to document nine significant factors influencing the adoption of sustainable livelihoods.

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1. INTRODUCTION

Climate change has profoundly impacted the environment and socio-economic systems worldwide (Tan & Thanh, 2013). As an inherently cross-sectoral and cross-regional phenomenon, climate change manifests through more frequent extreme weather events and the degradation of natural resources, which are among the fundamental sources of livelihood for rural farmers (Ahmad et al., 2023).

Vietnam is consistently ranked among the six countries most severely affected by climate change (Tuyet et al., 2020; Vo & Tran, 2022). Despite its relatively small territorial size, the country's greenhouse gas (GHG) emission intensity is nearly three times the global average and has risen sharply in recent years. Within this context, agriculture is the second-largest contributor to GHG emissions, accounting for almost 20%, only after the energy sector (Hai Van, Oanh, & Yen, 2025; Yamamoto, Huynh, Saito, & Matsuishi, 2022). This dual role as both a vulnerable sector and a major emitter underscores the urgency of transforming agricultural livelihoods.

For rural and mountainous communities, where dependence on natural resources is high and adaptive capacity is limited, transitioning to sustainable livelihoods has become both a development priority and a necessity for long-term resilience. Consequently, understanding the determinants of household decision-making in this context is critical for designing effective policies and interventions.

A Luoi 4 commune lies in the western part of Hue City, within a mountainous area along the Vietnam–Laos border. Steep terrain and limited infrastructure restrict socio-economic development in the commune. Most residents belong to ethnic minority groups, which face high vulnerability to the impacts of climate change (Le et al., 2024). This geo-cultural context presents opportunities, such as a rich indigenous cultural heritage and high biological diversity, as well as significant challenges for designing and scaling up appropriate sustainable livelihood models.

Livelihoods are the means through which people secure their living, typically analyzed at multiple levels, with the household being the most common unit of assessment (Bao et al., 2023; Nong, Gan, & Hu, 2022). The sustainable livelihoods framework developed by the UK Department for International Development (DFID) identifies five types of capital that underpin livelihoods: human, natural, physical, financial, and social. A livelihood is considered “sustainable” when it enhances resilience against risks, adapts flexibly to shocks, and supports long-term development.

Previous studies have largely focused on facilitating factors such as access to credit, improved farming techniques, and training. However, fewer have examined the deeper motivations behind household decisions. Some persist with traditional practices, while others adopt more climate-resilient strategies, such as indigenous crop cultivation. This gap remains critical in the literature. The central issue concerns how the livelihoods of ethnic minority and mountainous communities, whose survival largely depends on agriculture, will transform in the context of profound changes in livelihood capitals, particularly natural capitals. Furthermore, under increasingly extreme and unpredictable climate conditions, the factors that most decisively shape households' choices of sustainable livelihood models remain unclear. Although several studies have examined livelihoods and sustainable agricultural practices in Hue City and the A Luoi mountainous region, precise answers are still lacking.

This study aims to address this gap by examining how individual, socio-economic, institutional, and environmental factors influence household behavior. In doing so, it contributes to understanding livelihood transitions in climate-vulnerable mountainous areas. It informs evidence-based policymaking for multi-ethnic, resource-constrained communities.

Accordingly, this study pursues two main objectives: (i) to identify the key determinants influencing the adoption of sustainable agricultural livelihood models among ethnic minority households in A Luoi 4 commune; and (ii) to provide policy-oriented insights for strengthening resilience and promoting inclusive rural development in climate-vulnerable mountainous regions of Vietnam.

Drawing on the sustainable livelihood framework and prior research, the study proposes the following hypotheses:

- Educational attainment and awareness of climate change positively affect the adoption of sustainable livelihood models.
- Access to agricultural information, participation in farmer groups, and the availability of financial and market support increase the likelihood of adoption.
- Households with unstable livelihoods or high exposure to extreme weather events tend to shift toward more adaptive livelihood models.

These hypotheses guide the empirical analysis of the determinants shaping livelihood choices in mountainous areas vulnerable to climate change.

2. MATERIALS AND METHODS

2.1. Study Area Overview

A Luoi 4 commune is predominantly an agricultural community, with the majority of its population belonging to ethnic minority groups and living under modest socio-economic conditions. On July 1, 2025, the commune was officially established through the administrative merger of four former communes: Huong Phong, A Roang, Dong Son, and Lam Dot, covering a total natural area of 233.7 km². Geographically, A Luoi 4 is bordered to the north and east by A Luoi 3 and A Luoi 5 communes, and to the south and west by the Lao People's Democratic Republic (Figure 1).

As of 2024, the commune had a population of 10,752, with the majority of the labor force employed in agriculture. Crop cultivation is the dominant livelihood activity; however, it is also one of the most vulnerable sectors to climate change impacts, while contributing significantly to greenhouse gas emissions. Given that more than half of the population belongs to small ethnic minority groups, agricultural practices and production capacity in A Luoi 4 remain relatively limited.

Local households primarily rely on paddy rice cultivation, complemented by upland vegetables, forestry, livestock husbandry (including buffalo and cattle), and certain forms of agroforestry (Vu & Son, 2013). Farmers continue to practice traditional methods, though they have gradually adopted some mechanization. The government's new rural development program directs investments toward rural infrastructure to support agricultural activities.

In-depth interviews with 10 local stakeholders, including farmers, village leaders, and commune officials, suggest that A Luoi 4 is highly vulnerable to the impacts of climate change. Stakeholders frequently mention extreme weather events, including heavy rainfall, landslides, flash floods, and droughts. Respondents also emphasize pressing environmental concerns, particularly land degradation and increasing unseasonal heavy rainfall in recent years.

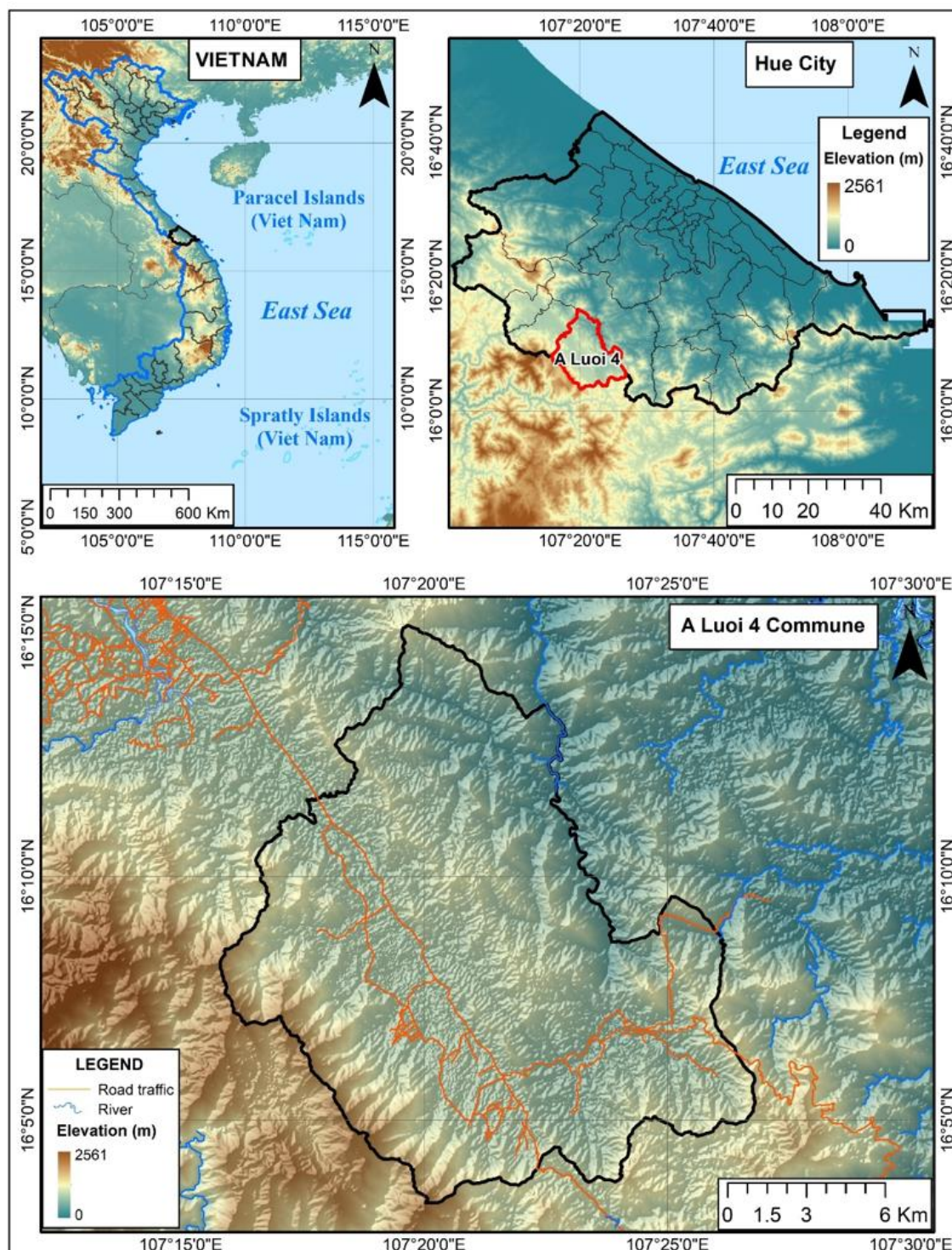


Figure 1. Map of the Study Area.

2.2. Research Methods

This study employed a mixed-methods approach, integrating both qualitative and quantitative techniques, with an emphasis on quantitative analysis using a binary logistic regression model to identify the factors influencing household

decisions regarding the adoption of a livelihood model. Unlike previous studies that primarily describe enabling conditions for sustainable livelihoods, this research focuses on the decision-making process itself, examining the factors that drive or deter farm households from adopting sustainable agricultural livelihood models.

2.2.1. Data Collection

This study relies on both secondary and primary data sources. The research team collected secondary data on household livelihoods from statistical yearbooks, socio-economic development reports of former communes and A Luoi District in 2024, as well as scientific publications, monographs, and policy documents. This data enabled the team to analyze the status of livelihood models, identify emerging trends toward sustainability, and examine the contextual factors that influence households' adoption of sustainable livelihood practices. By compiling and synthesizing secondary sources, the researchers developed the analytical framework, designed survey instruments, and selected appropriate methods, thereby enhancing the validity and scientific rigor of the study.

The team also generated primary data through a structured household survey in the commune. The questionnaire covered three major sections:

- i. Demographic and livelihood characteristics of respondents (e.g., age, ethnicity, gender, educational attainment, household size, and current livelihood activities).
- ii. Questions on potential factors influencing households' decisions to adopt sustainable livelihood models.
- iii. Respondents' suggestions and recommendations for promoting sustainable agricultural practices.

The final survey instrument included 28 independent variables and one dependent variable, as summarized in Table 1. The team selected independent variables based on prior empirical studies in both international and Vietnamese contexts, while ensuring their relevance to the study area. The dependent variable captured whether a household adopted sustainable agricultural practices, coded as one if the household implemented at least one adaptation measure and zero otherwise. Table 1 presents the operationalization of variables, measurement scales, and hypothesized relationships.

2.2.2. Sampling Design

The study employed a non-probability convenience sampling approach. The research team selected respondents based on household lists provided by local authorities and the accessibility of households within the study area. To minimize bias, the team ensured balance across key characteristics such as gender and livelihood type (Andrade, 2020). The survey was conducted in four former communes: Huong Phong, A Roang, Dong Son, and Lam Dot, which the government officially merged into A Luoi 4 commune on July 1, 2025.

The researchers designed the questionnaire to capture 28 independent variables related to potential factors influencing households' adoption of sustainable agricultural livelihood models. Following Hair, Black, Babin, and Anderson (2010) guidelines, the number of variables required a minimum sample size of $28 \times 5 = 140$ observations (Hair et al., 2010). In practice, the team surveyed 230 households and retained 212 valid responses after data cleaning, resulting in a response rate of 92.2%. This sample size exceeded the minimum requirement and provided sufficient statistical power for the subsequent regression analysis.

2.2.3. Sociological Survey Method

Recent studies emphasize that a wide range of household- and individual-level factors influence farmers' decisions to adopt sustainable livelihood models, with individual-level factors having varying degrees of impact on these decisions. For instance, gender has been highlighted as a significant determinant, as men and women often display different livelihood strategies. Marie, Yirga, Haile, and Tquabo (2020); Mersha and Van Laerhoven (2016), and Dang, Li, Nuberg, and Bruwer (2019) all found that gender roles and responsibilities strongly affect the choice of livelihood models in rural and mountainous communities (Dang et al., 2019; Marie et al., 2020; Mersha & Van Laerhoven, 2016).

Similarly, researchers identify the household dependency ratio as a critical driver of livelihood decisions. Belay, Recha, Woldeamanuel, and Morton (2017) and Gbetibouo (2009) demonstrated that households with more dependents face stronger livelihood pressures, which in turn shape their decision-making processes regarding agricultural practices (Belay et al., 2017; Gbetibouo, 2009).

Factors such as the age of household heads and their farming experience also play a significant role in adopting sustainable livelihoods (Alwedyan & Taani, 2021). The total landholding size and awareness of climate change have a significant influence on livelihood decisions. Farmers who cultivate larger areas and are more aware of climate change are more readily adopting sustainable livelihood models (Belay et al., 2017; Maddison, 2007; Marie et al., 2020). Income and educational attainment further enhance households' capacity to access and adopt new models (Dasmani, Darfor, & Karakara, 2020; Dehghani, Barati, Azadi, & Scheffran, 2018; Kuang, Jin, He, Ning, & Wan, 2020).

In addition, numerous studies have shown that collaboration with research institutes and enterprises, along with supportive policies for agricultural transition and access to production credit, are key drivers of farmers' adoption of sustainable livelihoods (Dang et al., 2019; Ndamani & Watanabe, 2016; Yang, Gao, Yang, & Zhang, 2022). Based on the survey results in A Luoi 4 commune, we further note that the impact of extreme weather events, instability in current livelihoods, and market accessibility are additional factors that may influence farmers' decisions. Table 1 presents these factors together with their corresponding scales and coded values.

The field survey was conducted in three phases, from March 2024 to July 2025, with the target respondents being residents of A Luoi 4 commune. After collecting the data, the research team processed the dataset in SPSS version 27 and applied analytical techniques, including descriptive statistics, Cronbach's Alpha, and binary logistic regression.

The findings provide scientific evidence to assess the determinants of sustainable agricultural livelihood choices in A Luoi 4 commune, Hue City (Figure 2).

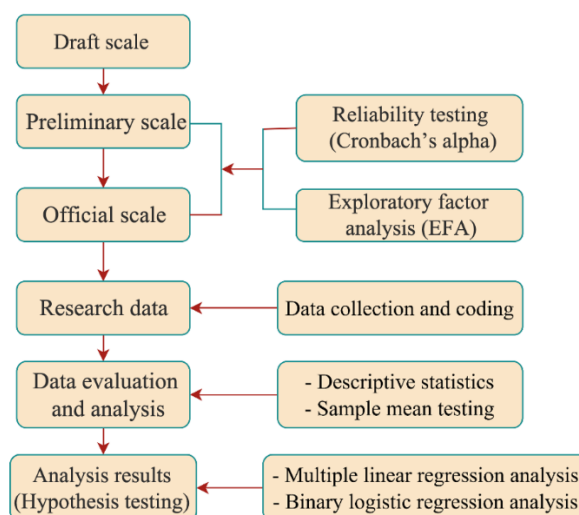


Figure 2. Research process and data analysis framework.

2.2.4. Data Analysis Methods

A binary logistic regression model was employed to empirically examine the determinants influencing the adoption of sustainable agricultural livelihood models. The model incorporated 28 independent variables representing the five livelihood capital groups: human, natural, physical, financial, and social (Figure 3) and one dependent variable reflecting whether a household adopted sustainable livelihood practices. A non-probability sampling approach was applied, as the study area's mountainous terrain and dispersed ethnic settlements made it infeasible to conduct a random household survey. This approach is widely used in similar livelihood and rural adaptation studies where population frames are unavailable or accessibility is limited. While the sampling design may restrict the statistical generalizability of findings beyond A Luoi 4 commune, it nonetheless provides robust empirical insights into the internal dynamics of livelihood adoption within comparable socio-ecological contexts.

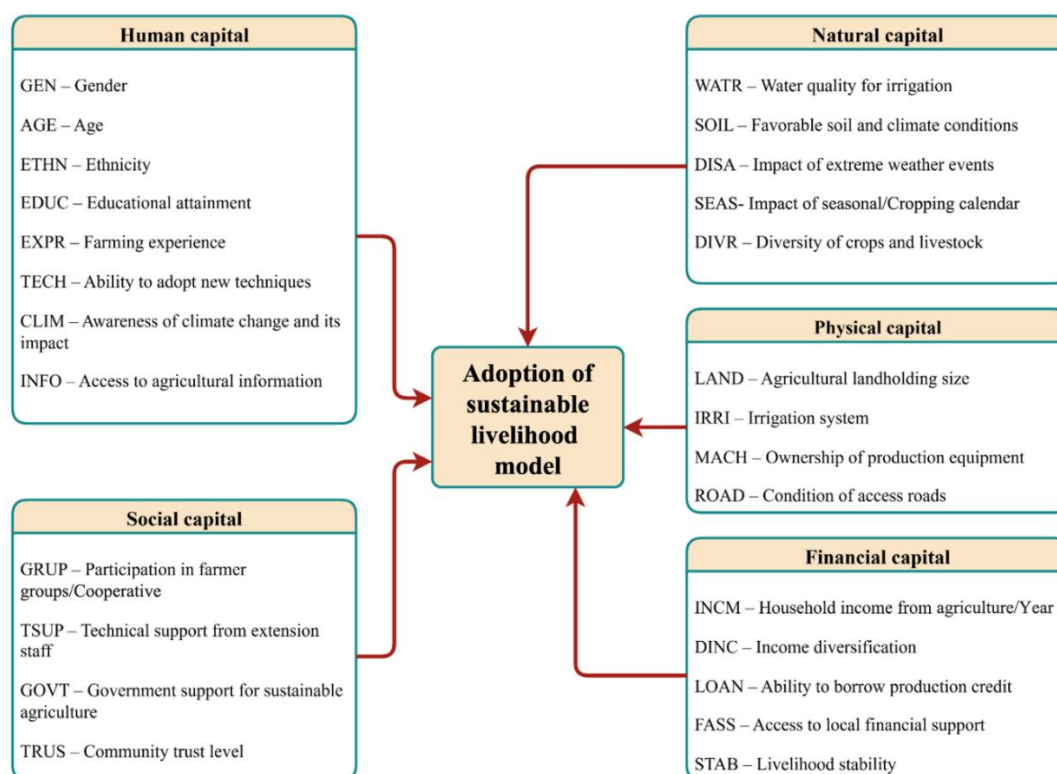


Figure 3. Conceptual framework of factors influencing the adoption of sustainable agricultural livelihood models in A Luoi 4 commune, Hue City.

Prior to conducting the regression analysis, the study employed multicollinearity diagnostics to verify the model's validity. The Pearson correlation coefficients among all independent variables remained below the 0.7 threshold, reflecting acceptable inter-variable relationships (Hair et al., 2010). The Variance Inflation Factor (VIF) values, ranging from 1.105 to 1.865, further confirmed that the model maintained adequate independence among predictors.

The analysis utilized SPSS version 27, integrating descriptive statistics, Cronbach's Alpha reliability tests, and logistic regression estimation to quantify both the direction and magnitude of relationships between variables. In contrast to prior livelihood adoption studies that primarily relied on qualitative approaches or linear regressions, this research enhances methodological robustness by employing a multivariate logistic framework. This approach enables a more precise identification of probability-based effects of individual determinants, while simultaneously accounting for interrelated household characteristics within complex livelihood systems.

Table 1. Factors Influencing the Adoption of Sustainable Livelihood Models

Influencing factors	Variable code	Coded value	Research hypothesis
Gender	GEN	1 = Male, 2 = Female	+ or -
Age	AGE	Number of years	+ or -
Ethnicity	ETHN	1 = Kinh; 2 = Ta Oi; 3 = Pa Co; 4 = Bru Van Kieu; 5 = Others	+ or -
Educational attainment	EDUC	1 = No schooling; 2 = Primary; 3 = Lower secondary; 4 = Upper secondary; 5 = College/University; 6 = Postgraduate	+ or -
Farming experience	EXPR	Number of years	+ or -
Ability to adopt new techniques	TECH	1 = Very poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very good	+ or -
Awareness of climate change and its impact	CLIM	1 = No impact; 2 = Minor; 3 = Moderate; 4 = High; 5 = Very high	+ or -
Access to agricultural information	INFO	1 = Very poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very good	+ or -
Agricultural landholding size	LAND	ha	+ or -
Irrigation system	IRRI	1 = None; 2 = Rain-fed; 3 = Manual; 4 = Pump; 5 = Automatic irrigation system	+ or -
Ownership of production equipment	MACH	0 = No, 1 = Yes	+ or -
Condition of access roads	ROAD	1 = Very difficult; 2 = Difficult; 3 = Average; 4 = Easy; 5 = Very easy	+ or -
Participation in farmer groups and cooperatives.	GRUP	0 = No, 1 = Yes	+ or -
Technical support from extension staff	TSUP	1 = Very low; 2 = Low; 3 = Average; 4 = High; 5 = Very high	+ or -
Government support for sustainable agriculture	GOVT	1 = Very low; 2 = Low; 3 = Average; 4 = High; 5 = Very high	+ or -
Community trust level	TRUS	1 = Very low; 2 = Low; 3 = Average; 4 = High; 5 = Very high	+ or -
Market accessibility	MRKT	0 = No, 1 = Yes	+ or -
Household income from agriculture per year	INCM	VND Million	+ or -
Income diversification	DINC	1 = Agriculture only; 2 = Mainly agriculture + side income; 3 = Balanced agriculture & non-agriculture; 4 = Mainly non-agriculture	+ or -
Ability to borrow production credit	LOAN	0 = No, 1 = Yes	+ or -
Access to local financial support	FASS	0 = No, 1 = Yes	+ or -
Livelihood stability	STAB	0 = No, 1 = Yes	+ or -
Household savings ability	SAVE	0 = No, 1 = Yes	+ or -
Water quality for irrigation	WATR	1 = Very poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very good	+ or -
Impact of extreme weather events	DISA	1 = No impact; 2 = Minor; 3 = Moderate; 4 = High; 5 = Very high	+ or -
Diversity of crops and livestock	DIVR	1 = Very low; 2 = Low; 3 = Average; 4 = High; 5 = Very high	+ or -
Favorable soil and climate conditions	SOIL	1 = Very unfavorable; 2 = Unfavorable; 3 = Average; 4 = Favorable; 5 = Very favorable	+ or -
Impact of seasonal/Cropping calendar	SEAS	1 = No impact; 2 = Minor; 3 = Moderate; 4 = High; 5 = Very high	+ or -
Adoption of the sustainable livelihood model	SLMH	0 = No, 1 = Yes	+ or -

2.2.5. Expert Evaluation Method

Given the limitations in research resources and the challenges of collecting detailed household-level data on livelihood practices, the study also used an expert evaluation method. Researchers often apply this approach in contexts

where primary data are insufficient or difficult to obtain (Alberini, Chiabai, & Muehlenbachs, 2006; Colson & Cooke, 2018).

Two groups of experts were consulted. The first group consisted of local government officials who provided an overview of the research context, identified manifestations and impacts of climate change in the study area, and offered insights into the socio-economic factors influencing livelihood decisions. The second group comprised community representatives, village heads, elders, and experienced farmers with in-depth knowledge of local practices, livelihood strategies, and coping mechanisms against environmental shocks.

The research team consulted five commune-level officials, five village leaders, and five academic experts from Hue University and the Institute of Earth Sciences. These academics possessed research experience in sustainable livelihoods and climate-related issues in the A Luoi region. The team conducted consultations and in-depth interviews from March 2024 to July 2025. The discussions focused on issues directly relevant to this study, including:

- The sustainability of current livelihood practices in A Luoi 4.
- Environmental conditions and observed climate change impacts.
- Barriers to adopting sustainable agricultural models.
- Key factors that either prevent or enable farmers to adopt advanced production strategies.

This expert-based assessment served as an important triangulation tool, complementing household survey data and providing a more comprehensive understanding of the determinants of sustainable livelihood adoption in mountainous ethnic minority communities.

3. RESULTS AND DISCUSSION

3.1. *Livelihood Characteristics and Livelihood Capitals*

The household survey conducted among 212 respondents in A Luoi 4 commune revealed a relatively balanced gender distribution, with 50.9% male and 49.1% female participants. This indicates that men and women are equally engaged in local agricultural activities, reflecting the shared responsibilities of farming households in the study area.

The average age of respondents was 41.3 years (ranging from 16 to 64 years, with a standard deviation of 13.82). This suggests that most respondents were of economically active age, possessing both physical capacity and accumulated experience to serve as the primary labor force in their households. This age profile also reflects a stage of life characterized by increasing responsibility for sustaining and improving household livelihoods. In terms of ethnic composition, the community is notably diverse. The Bru Van Kieu accounted for the largest share (30.2%), followed by the Kinh (27.8%), Ta Oi (20.8%), and Pa Co (15.1%) groups. Other minority groups represented only 6.1% of the sample. This ethnic mosaic is typical of the A Luoi mountainous region, where cultural diversity enriches the local identity but presents unique challenges for development interventions, particularly in promoting sustainable agricultural practices.

Respondents generally reported low levels of educational attainment. About 10.4% had never attended school, 28.3% had completed only primary education, and 31.6% had stopped at the lower secondary school level. Only 6.1% held a university degree. This limited educational background restricts residents' access to new knowledge and innovations, thereby limiting opportunities for advancing sustainable agricultural practices.

The average farming experience of respondents was 13.72 years ($SD = 10.78$), suggesting a considerable depth of practical knowledge accumulated over time. Nonetheless, there was significant variation across households, with some possessing extensive farming expertise. In contrast, others had only recently entered the agricultural production sector.

In terms of technological adoption capacity, the majority of respondents rated themselves as having limited capacity. Specifically, 18.9% reported their technical application ability as very poor, 39.6% as poor, and only 8.5% considered themselves proficient. Awareness of climate change impacts, however, showed signs of improvement. About 31.6% of households acknowledged that weather variability had a strong impact on agricultural production, and 8.5% perceived the impacts as severe. Nevertheless, a substantial proportion (35%) had not yet clearly recognized the extent to which climate change impacts their livelihoods.

The average agricultural landholding per household was 0.618 hectares, with a maximum of 1.37 hectares and a minimum of 0.1 hectares ($SD = 0.276$). Farming plots remain highly fragmented and small in scale, posing significant constraints to adopting sustainable agricultural models, particularly those that require larger production areas, such as high-tech farming or commercial-oriented agriculture.

Respondents also reported limited access to agricultural information. Only 37.2% indicated having good access to relevant knowledge, such as techniques, cropping seasons, or market conditions, while nearly 30% described persistent difficulties in obtaining such information. This gap highlights the vulnerability of local farmers in terms of knowledge diffusion and capacity building.

Production infrastructure was generally underdeveloped. Approximately 30.2% of households relied primarily on natural rainfall for irrigation, 27.8% depended on manual methods, only 8% used motorized pumps, and only 4.2% had access to automated irrigation systems. Mechanization in irrigation practices is therefore extremely limited. Furthermore, more than half of the households surveyed (54.7%) reported they did not own basic production equipment, such as plows or water pumps, which further restricts their ability to improve productivity and transition toward sustainable agricultural systems.

Transport infrastructure was identified as a major barrier to sustainable livelihood development. More than half of respondents (55.6%) reported that access roads to their production areas were "difficult to travel." In comparison, only 17.4% considered them convenient. Poor-quality transportation infrastructure hinders the timely delivery of agricultural inputs and services, restricting market access and undermining the sustainability of household livelihoods.

Participation in collective organizations such as farmer groups or cooperatives remained relatively limited, with only 40.6% of households engaged. This is considerably low given the well-documented role of such organizations in enhancing production capacity, facilitating knowledge sharing, and strengthening market linkages.

Support from technical staff and local authorities was also perceived as inadequate. Only about 20% of respondents reported receiving high or very high levels of support, whereas nearly 55% rated support as low. This lack of institutional assistance diminishes farmers' confidence in implementing sustainable practices. Similarly, levels of community trust were not robust: while 26.9% of households described community relations as highly trustworthy, almost 29.7% considered them weak, reflecting constraints on social capital.

Market access was another significant challenge. A substantial proportion (64.2%) of households reported lacking stable buyers or reliable product outlets. This dependency on fluctuating and informal market channels reduces income stability and discourages long-term investment in sustainable agricultural models.

Average annual income from agricultural activities was approximately 30.2 VND million (ranging from 5 VND million to 58.7 VND million, SD = 10.5). This relatively modest income level, coupled with rising input prices, high production costs, and increasing climate-related risks, has resulted in low financial accumulation capacity, constraining households' ability to reinvest in more efficient or sustainable production models. More than half of households surveyed (52.4%) relied exclusively on agricultural income. In comparison, only 12.7% reported a balanced combination of agricultural and non-agricultural earnings. This income structure highlights the high vulnerability of households whose livelihoods remain heavily dependent on agriculture and, therefore, are more susceptible to production risks.

Regarding financial capacity, only 41.5% of households reported access to production credit, 29.7% could benefit from local support schemes, and 33% indicated the ability to accumulate financial savings. These figures highlight the limited financial resilience of households and the critical role of external support in sustaining agricultural production. The lack of diversified income sources and constrained access to financial resources represent major barriers to scaling up and maintaining sustainable livelihood models in the commune.

Most households perceived the quality of water resources for agricultural production as poor, with 65.1% reporting irrigation water conditions as weak or very weak. Farmers face greater vulnerability to climate variability because of this unreliable water supply. Respondents also emphasized the severe impacts of natural disasters, with 29.7% reporting that extreme weather events had a "very high" impact on production. In comparison, 29.2% rated the impact as "high." These assessments underscore the significant exposure of local livelihoods to climate risks.

In contrast, perceptions of opportunities for diversifying crops and livestock were somewhat more positive. About 31.1% of households believed the potential for diversification was high or very high. However, soil quality remains a critical constraint, with 51.9% of respondents rating the land conditions as unfavorable or highly unfavorable for production. Additionally, the unique cropping calendar of mountainous areas posed further challenges: 37.8% of respondents reported that seasonal timing significantly reduced productivity and overall production efficiency.

3.2. Determinants of Sustainable Livelihood Adoption in A Luoi 4 Commune, Hue City

A binary logistic regression analysis was conducted to empirically examine the determinants of households' adoption of sustainable agricultural livelihood models in A Luoi 4 commune. The results are presented in Table 2, providing insights into the relative influence and statistical significance of demographic, socio-economic, institutional, and environmental factors.

Table 2. Results of binary logistic regression analysis.

Variable code	Logistic regression coefficient estimates and test statistics						
	B (Unstandardized coefficient)	S.E. (Standard error)	Wald statistic	Sig. (Significance)	OR (Odds ratio)	CI (Confidence interval) lower	CI upper
GEN	-0.392	0.433	0.818	0.366	0.676	0.289	1.579
AGE	0.013	0.022	0.344	0.557	1.013	0.97	1.058
ETHN			20.46	0.000***			
ETHN (1)	1.276	0.884	2.085	0.149	3.583	0.633	20.26
ETHN (2)	-1.121	0.939	1.424	0.233	0.326	0.052	2.053
ETHN (3)	-0.989	1.027	0.927	0.336	0.372	0.05	2.784
ETHN (4)	-0.977	0.868	1.265	0.261	0.377	0.069	2.063
EDUC	0.341	0.165	4.285	0.038*	1.407	1.018	1.943
EXPR	-0.021	0.027	0.596	0.44	0.979	0.929	1.032
TECH	0.064	0.212	0.092	0.762	1.066	0.704	1.615
CLIM	0.515	0.205	6.287	0.012*	1.674	1.12	2.501
INFO	0.455	0.197	5.354	0.021*	1.576	1.071	2.319
LAND	1.23	0.914	1.811	0.178	3.422	0.57	20.521
IRRI			2.177	0.703			
IRRI (1)	0.903	1.179	0.587	0.444	2.468	0.245	24.874
IRRI (2)	0.74	1.216	0.37	0.543	2.095	0.193	22.723
IRRI (3)	0.339	1.209	0.079	0.779	1.403	0.131	15.009
IRRI (4)	1.461	1.394	1.099	0.294	4.312	0.28	66.237

Variable code	Logistic regression coefficient estimates and test statistics						
	B (Unstandardized coefficient)	S.E. (Standard error)	Wald statistic	Sig. (Significance)	OR (Odds ratio)	CI (Confidence interval) lower	CI upper
MACH	0.423	0.444	0.908	0.341	1.527	0.639	3.645
ROAD	-0.05	0.19	0.068	0.795	0.952	0.655	1.38
GRUP	0.891	0.448	3.952	0.047*	2.439	1.013	5.865
TSUP	-0.232	0.212	1.2	0.273	0.793	0.523	1.201
GOVT	0.068	0.22	0.096	0.757	1.07	0.695	1.647
TRUS	0.024	0.214	0.013	0.911	1.024	0.673	1.558
MRKT	1.065	0.459	5.392	0.020*	2.901	1.18	7.132
INCM	0.011	0.021	0.301	0.583	1.011	0.97	1.054
DINC			3.696	0.296			
DINC (1)	1.562	1.091	2.049	0.152	4.77	0.562	40.462
DINC (2)	1.509	1.134	1.77	0.183	4.523	0.49	41.748
DINC (3)	0.59	1.215	0.236	0.627	1.804	0.167	19.519
LOAN	-0.276	0.461	0.359	0.549	0.759	0.307	1.873
FASS	1.073	0.505	4.506	0.034*	2.924	1.087	7.868
STAB	1.038	0.479	4.693	0.030*	2.824	1.104	7.22
SAVE	0.218	0.473	0.212	0.645	1.243	0.492	3.143
WATR	0.122	0.169	0.517	0.472	1.13	0.811	1.573
DISA	0.74	0.23	10.396	0.001**	2.096	1.335	3.29
DIVR	0.199	0.208	0.919	0.338	1.22	0.812	1.834
SOIL	-0.119	0.202	0.349	0.555	0.888	0.598	1.319
SEAS	-0.206	0.188	1.206	0.272	0.814	0.563	1.176
Constant	-11.267	3.063	13.532	0	0	0	0.005

Note: *. p<0.05; **. p<0.01; ***. p<0.001.

Binary logistic regression was employed to identify the factors influencing households' adoption of sustainable agricultural livelihood models in A Luoi 4 commune. In the model, categorical variables were encoded as dummy variables, with the last category set as the reference group. Specifically, the "Other ethnic groups" category was selected as the baseline for the ethnicity variable (ETHN), "Automatic irrigation system" served as the baseline for the irrigation system variable (IRRI), and "Mainly non-agriculture" was designated as the baseline for the income diversification variable (DINC). The regression coefficients (B) and odds ratios (OR) of the remaining groups were interpreted relative to these reference categories.

The model achieved a high level of statistical significance (Chi-square = 114.053; df = 36; $p < 0.001$), with a Nagelkerke R^2 value of 0.569, indicating that the model explained more than 56% of the variance in livelihood choice behavior. Additionally, the McFadden (1974) R^2 was calculated at approximately 0.398, which falls within the acceptable range of 0.2–0.4 suggested by McFadden (1974), indicating a good model fit. This further confirms that the logistic regression model demonstrates reliable and stable explanatory power (McFadden, 1974). The overall classification accuracy reached 81.1%, correctly predicting 88.1% of households that did not adopt sustainable models and 69.2% of households that did adopt sustainable models.

The analysis identified nine independent variables that significantly influenced the probability of adopting sustainable livelihood models ($p < 0.05$), reflecting the multidimensional effects of education, awareness, production resources, social connections, and environmental factors. Ethnicity (ETHN) emerged as a statistically significant determinant ($p = 0.000$; OR = 3.583). The results revealed that, compared to the Kinh majority, ethnic minority groups such as the Ta Oi, Pa Co, Bru Van Kieu, and others were less likely to adopt sustainable agricultural practices, with regression coefficients showing negative values; for example, ETHN (2) = -1.221, ETHN (3) = -0.989, and ETHN (4) = -0.977.

This finding highlights the structural disadvantages faced by ethnic minority households, who often have lower levels of education, limited access to agricultural information, financial capital, and technical support—essential prerequisites for adopting advanced livelihood models. In A Luoi, most ethnic minority communities reside in remote areas with poor transportation, weak market access, and heightened vulnerability to climate change. Consequently, implementing sustainable agricultural livelihood models is often constrained by cognitive barriers, reliance on traditional farming practices, and insufficient institutional support.

In addition to ethnicity, educational attainment ($B = 0.341$, $p = 0.038$, OR = 1.407) and climate change awareness ($B = 0.515$, $p = 0.012$, OR = 1.674) also exhibited positive and significant effects on livelihood adoption behavior. Specifically, a one-unit increase in educational attainment increases the likelihood of a household adopting sustainable livelihood models by approximately 40.7%. Similarly, a one-level increase in climate change awareness raises the probability of adoption by about 67.4%. Households with higher levels of education and stronger awareness of climate-related risks were more likely to adopt adaptive livelihood strategies to proactively reduce their vulnerability.

Similarly, access to agricultural information (INFO) was identified as a significant determinant ($B = 0.455$; $p = 0.021$; OR = 1.576). Households with greater access to information, including farming techniques, climate change

information, cropping calendars, market outlets, and support policies, were 1.576 times more likely to adopt sustainable livelihood models than those facing difficulties in obtaining such information.

Several socio-financial factors also played prominent roles. Households participating in farmer groups or cooperatives ($B = 0.891$; $p = 0.047$; $OR = 2.439$) were nearly 143.9% more likely to adopt sustainable livelihood models compared with those not participating. Involvement in collective organizations enhanced farmers' awareness, access to information, technical capacity, and market connections, facilitating the transition toward more sustainable production models.

Furthermore, market accessibility ($B = 1.065$; $p = 0.020$; $OR = 2.901$) was found to be a fundamental condition enabling households to invest in and transition toward new production models. Households with better market access were about 190% more likely to adopt sustainable agricultural livelihood models than those facing difficulties in product marketing. Many households in A Luoi 4 remain dependent on small-scale traders, characterized by weak value chain links and limited access to current market prices and demand information. This situation has led to spontaneous production decisions, trend-following behavior, and unstable market outlets. The absence of reliable buyers discourages farmers from investing in innovative cultivation models due to concerns over price volatility and unsold produce.

Similarly, access to local financial support schemes ($B = 1.073$; $p = 0.034$; $OR = 2.924$) was identified as another critical determinant of sustainable livelihood adoption. A Luoi 4 has a high proportion of poor and near-poor households, and access to traditional commercial credit is often constrained by barriers such as a lack of collateral and complex application procedures. In this context, financial support programs from local budgets, preferential credit policies, and funding from rural development projects are essential in enabling households to shift toward sustainable production models.

Notably, the stability of current livelihoods and the extent of disaster impacts emerged as two decisive environmental factors. Households perceiving their livelihoods as unstable were nearly three times more likely to adopt alternative models ($B = 1.038$; $OR = 2.824$), while those directly affected by extreme weather events were also significantly more inclined to shift toward adaptive livelihood strategies ($p = 0.013$). This finding is particularly relevant in the mountainous context of A Luoi, where households frequently face flash floods, droughts, and irregular cropping seasons.

Figure 4 illustrates the odds ratios with 95% confidence intervals for the significant predictors. The vertical red line at $OR = 1$ denotes the neutral threshold. Predictors with confidence intervals lying entirely to the right of this line demonstrate a robust positive effect on the likelihood of adoption. As shown, access to markets, financial support, livelihood stability, participation in cooperatives, and exposure to disasters exert the most decisive influence, followed by education and access to information.

It is important to note that ethnicity (ETHN), although statistically significant at the omnibus level, is not included in the figure (Figure 4). This decision reflects the categorical nature of the variable, where individual dummy coefficients for minority groups (e.g., Ta Oi, Pa Co, Bru–Van Kieu) were not statistically significant and displayed wide confidence intervals overlapping unity. In other words, while ethnicity influences adoption behavior, the category-specific effects show imprecise estimates and high uncertainty. For this reason, Figure 4 visualizes only variables with robust and interpretable odds ratios.

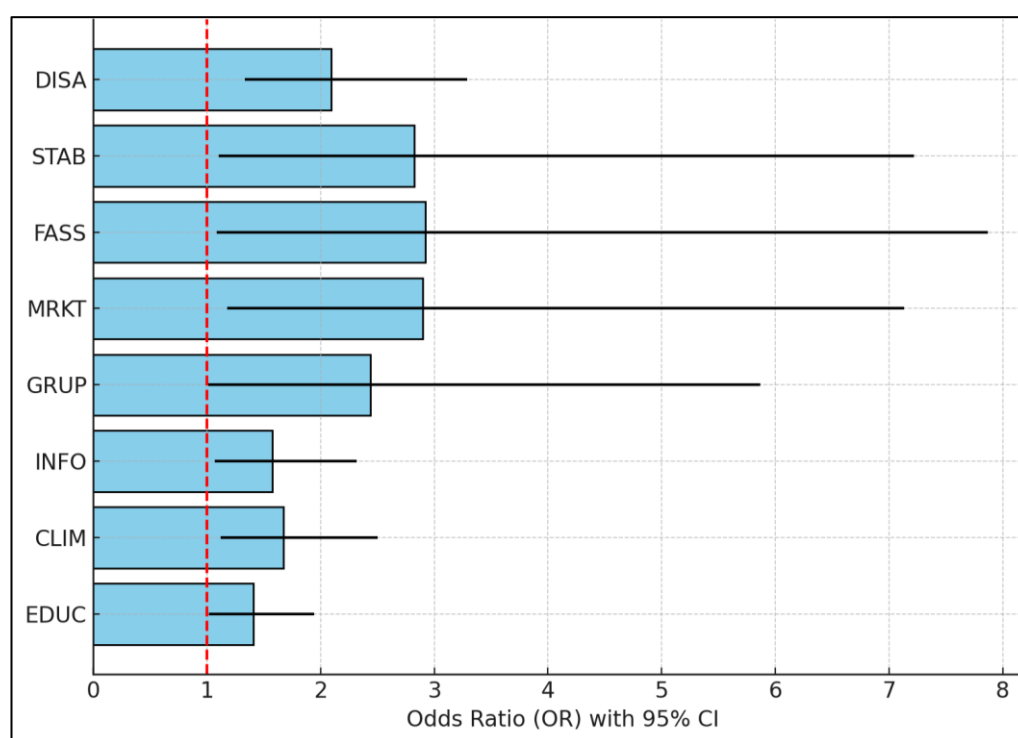


Figure 4. Significant Predictors of Sustainable Livelihood Adoption.

The inclusion of confidence emphasizes the reliability of the estimated effects. None of the significant predictors' confidence intervals cross the $OR = 1$ threshold, confirming the robustness of their association with livelihood adoption. These findings suggest that sustainable livelihood adoption in A Luoi is shaped not by a single factor but by the interplay of human capital, institutional links, financial resources, and environmental risk exposure.

Several variables that were expected to have a positive effect on the probability of adopting sustainable livelihood models, such as income (INCM), landholding size (LAND), farming experience (EXPR), mechanization level (MACH), and technical support (TECH), were not found to be statistically significant ($p > 0.05$). This may be attributed to the relative homogeneity in living standards, production scale, and natural conditions among households, which reduces the model's ability to capture variation. Furthermore, financial and institutional variables such as credit access (LOAN), savings (SAVE), and government support (GOVT), although theoretically important, may not exert a strong measurable influence in practice due to limited accessibility among local farmers. These findings reflect the specific characteristics of mountainous regions, where environmental and social factors tend to exert stronger influences on livelihood decisions than purely economic ones.

Overall, the regression results and graphical presentation jointly highlight that adopting sustainable livelihood models in the study area is a multidimensional process. Strengthening education, enhancing market access, improving financial support schemes, and fostering cooperative participation are pivotal for facilitating household transitions toward sustainable agricultural practices, particularly in climate-vulnerable rural and ethnic minority contexts.

3.3. Discussion

3.3.1. Influence of Ethnicity on Adoption Behavior

The adoption of sustainable agricultural livelihood models can vary significantly across ethnic groups. Recent studies echo our findings of ethnic differences in adoption. For example, research in Vietnam's uplands noted that farmers from different ethnic communities perceive the benefits of agroforestry practices differently, which in turn shapes their aspirations and decisions to adopt those practices (Do et al., 2025). A study in India compared tribal and non-tribal farming households and revealed distinct differences in crop adoption patterns that stemmed from prevailing cultural norms. Tribal farmers tended to stick with subsistence crops. They showed greater resistance to changing traditional methods, whereas non-tribal farmers more readily embraced cash crops and new varieties (Voorhaar, Kumra, Kholová, & Garin, 2025). These differences were associated with distinct cultural values; tribal communities exhibited more collectivist attitudes and a greater degree of caution toward innovation. Such evidence underscores that ethnicity and culture are not just background variables but active influences on adoption behavior. Interventions, therefore, should be culturally tailored; as Voorhaar et al. (2025) suggest, understanding an ethnic group's values and preferences can help in designing technologies and support programs that farmers are actually willing to adopt (Voorhaar et al., 2025). In sum, the influence of ethnicity observed in our study aligns with global findings that cultural context matters for technology adoption, highlighting the need for culturally sensitive approaches in promoting sustainable practices.

3.3.2. Role of Social Capital and Group Participation

The discussion highlights how social capital, particularly membership in farmer groups or cooperatives, facilitates the adoption of sustainable practices, a conclusion strongly supported by recent empirical findings. In China, for instance, Yu, Nilsson, Li, and Guo (2023) found that participation in an agricultural cooperative significantly increased farmers' willingness to adopt environmentally friendly and "green" farming techniques (Yu et al., 2023). Cooperative members had better access to information, peer support, and credit, all of which lowered barriers to trying new practices. Similarly, a scoping review of rice farmers in Vietnam highlighted that peer learning through farmer groups enhances the adoption of practices. Farmers exchanging knowledge in informal groups or participating in collective trainings were more likely to implement crop rotations and organic methods (Ogut, Mockshell, Minh, & Remans, 2025). These findings substantiate the conclusion that social capital fosters adoption: group participation builds trust and disseminates practical knowledge, thereby addressing information asymmetries. Notably, no major recent study contradicts this trend. The consensus is that strong social networks and farmer organizations serve as catalysts for the uptake of innovation in rural communities. To leverage this, development programs should strengthen farmer associations and local networks as a means to diffuse sustainable agriculture knowledge.

3.3.3. Impact of Climate-Related Disasters on Livelihood Decisions

Climate-related shocks and disasters have emerged as a critical influence on households' livelihood decisions, as evidenced by recent studies worldwide. A systematic review conducted in 2025, which analyzed 50 studies across sub-Saharan Africa, found that farmers who have experienced frequent climate shocks, such as droughts or floods, demonstrate significantly higher adoption rates of climate-smart practices. These practices include drought-tolerant crop varieties and water-saving techniques (Mnukwa, Mdoda, & Mudhara, 2025). This evidence suggests that direct exposure to climatic disasters can serve as a catalyst for adaptation and innovation, effectively 'shocking' farmers into adopting more resilient practices.

On the other hand, disasters can also adversely impact livelihoods in ways that constrain options, a nuance highlighted by case studies in Asia. For instance, research on upland communities in Inner Mongolia (China) showed that recurrent natural disasters, especially drought, significantly undermined livelihood resilience among farmers (Dongdong, Xi, & Weihong, 2022). Households facing year-after-year climate stress saw their asset bases and capacity to adapt eroded, which can trap them in poverty or force undesired livelihood changes. Meanwhile, in Southeast Asia, we see evidence of both pressure and adaptive responses: in Vietnam's northwest mountains, extreme weather events

(e.g., unseasonal rains causing crop failures) have prompted ethnic minority farmers to diversify their livelihoods by integrating more cash crops and fruit trees into their farming systems. This diversification is a deliberate strategy to sustain income and soil stability in the face of climate volatility (Do et al., 2025). Thus, recent studies both support our finding that climate disasters significantly influence livelihood decisions and provide additional nuance. Disasters can spur proactive adaptations (greater uptake of sustainable practices or new livelihood activities). However, without adequate support, they can also reduce the capacity of vulnerable groups to adapt. This dual reality underlines the importance of strengthening resilience through climate-adaptive livelihood models before severe shocks occur, as well as providing timely support after disasters so that affected households can rebuild and pivot toward sustainable strategies rather than slide backward.

3.3.4. Financial and Policy Support Access Barriers

We noted in our discussion that financial and policy support (such as credit schemes, subsidies, or government programs) had limited influence on adoption in our study area, mainly due to access barriers faced by ethnic minority households. Recent evidence corroborates this interpretation: even when support programs exist, marginalized farmers often struggle to access them, blunting their effectiveness. A clear example is agricultural extension services. A synthesis of African studies found that only about 34% of farmers had adequate access to extension advice, and those without regular extension contact were far less likely to adopt new practices. In fact, farmers who received frequent extension guidance had nearly 2.8 times higher odds of adoption, highlighting how a lack of information and technical support is a significant barrier (Mnukwa et al., 2025). Similarly, access to credit is a decisive factor in enabling or constraining adoption. Mnukwa et al. (2025) report that smallholders with formal credit access were approximately 45% more likely to implement resource-intensive innovations (like irrigation or improved seed varieties) compared to those without credit (Mnukwa et al., 2025). This statistic illustrates that when financial support is available and accessible, it can drive uptake; conversely, farmers who cannot access affordable loans or grants are often unable to invest in sustainability transitions.

Barriers to access are especially acute for minority and remote communities. Language, literacy, bureaucratic complexity, and physical distance to service centers all contribute to the low uptake of support programs among these groups. For instance, a study on underserved farmers in the United States (though in a different context) revealed that many did not participate in government assistance programs simply due to a lack of awareness and cumbersome application processes (Guynn, Player, & Burns, 2024). Researchers in Southeast Asia have documented comparable governance challenges in implementing policies for upland development. Governments often design such programs to support ethnic minority communities. Yet, district and commune administrations frequently channel the resources in ways that enable elite capture. Consequently, well-connected or higher-status households often secure the primary benefits, while poorer ethnic minority farmers remain marginalized from development gains (Anh, Kim, & Ubukata, 2016; Ironside, 2017; Thomas et al., 2008). These institutional asymmetries illustrate how governance structures and unequal access to information constrain the effectiveness of pro-poor interventions and hinder the equitable promotion of sustainable livelihoods in upland areas. Recent studies emphasize that financial and policy support alone cannot generate a meaningful impact unless researchers and policymakers address underlying access barriers. Our finding that such support had limited influence is therefore consistent with global observations that structural barriers, whether socio-economic, informational, or institutional can prevent well-intended programs from reaching the people who need them most. Overcoming these hurdles (for example, through mobile banking, decentralized extension agents, linguistically appropriate materials, and inclusive policy design) is crucial if financial and policy supports are to truly enable sustainable livelihood transitions among ethnic minorities and other vulnerable rural households.

4. CONCLUSIONS

This study examined the determinants influencing the adoption of sustainable agricultural livelihood models among ethnic minority households in A Luoi 4 Commune, Hue City, Vietnam. Using a mixed-method approach and binary logistic regression analysis on 212 surveyed households, nine variables were found to significantly shape adoption behavior: ethnicity, access to local financial support, access to output markets, stability of current livelihood, participation in farmer groups or cooperatives, exposure to climate change impacts, perception of climate change, access to agricultural information, and educational attainment. The findings highlight that livelihood adoption decisions are multidimensional outcomes resulting from the combined effects of human, social, financial, and environmental capitals rather than isolated factors. In this context, social inclusion, cognitive awareness, and institutional connectivity jointly determine whether rural households transition toward sustainable agricultural practices.

The empirical results hold several policy implications for strengthening livelihood resilience in climate-vulnerable mountainous regions. First, improving educational opportunities and climate literacy among ethnic minority communities can enhance farmers' adaptive capacity and willingness to innovate. Second, promoting farmer organizations and local cooperatives serves as an effective means of disseminating knowledge, building trust, and facilitating collective action. Third, expanding local financial assistance programs and market linkages is critical for overcoming credit barriers and encouraging long-term investments in sustainable production. Policymakers should adopt integrated interventions that simultaneously address social, economic, and environmental dimensions, linking awareness raising, institutional support, and risk management to ensure inclusive and climate-resilient rural development.

Despite its contributions, this study has several limitations. The sample was limited to one commune of modest size, which constrains the generalizability of the findings to other ethnic and ecological settings. The reliance on

quantitative data may also overlook deeper behavioral and cultural dynamics underlying livelihood decisions. Future research should therefore employ mixed or longitudinal designs that combine household surveys with qualitative interviews, focus group discussions, and participatory rural appraisal to capture temporal changes and local narratives. Comparative studies across multiple mountainous regions or ethnic groups are recommended to validate and refine the proposed analytical framework. Further integration of institutional, policy, and environmental indicators will also enhance understanding of how multi-level governance can promote the adoption of sustainable livelihoods in the context of climate change.

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Institutional Review Board Statement: The study involved minimal risk and adhered to the ethical guidelines for social science fieldwork. Formal approval from an Institutional Review Board was not required under the research ethics policy of Hue University, Vietnam. Informed verbal consent was obtained from all participants after a clear explanation of the study's purpose. All data were anonymized to ensure participant confidentiality.

Transparency: The authors declare that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any deviations from the study as planned have been clearly explained. This study followed all writing ethics.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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