

Community-based climate change adaptation in upland tropical communities of the Philippines based on a cross-sectional household survey

BRENT JOSEPH D. BANGAO[✉]

Mountain Province State University. Poblacion, Bontoc, Mountain Province 2616, Philippines. Tel.: +63-926-096-4782, ✉email: attandew@gmail.com

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Abstract. Bangao BJD. 2026. *Community-based climate change adaptation in upland tropical communities of the Philippines based on a cross-sectional household survey.* *Intl J Trop Drylands* 10 (1): t100102. <https://doi.org/10.13057/tropdrylands/t100102>. Climate change increasingly threatens ecosystems, livelihoods, and human well-being, particularly in vulnerable tropical dryland and upland communities. This study examined climate change knowledge, vulnerabilities, impacts, and adaptive responses using a descriptive cross-sectional research design. Data were collected from 240 purposively selected respondents through a validated questionnaire and structured interviews. While the sample size met statistical requirements, the cross-sectional design and convenience sampling may limit temporal analysis and broader generalizability. Findings revealed a high knowledge of climate change among respondents with overall weighted mean of 4.09, particularly on extreme climatic events such as typhoons, droughts, and landslides. Yet, 29.17% of respondents remain highly vulnerable to water shortage, 26.25% vulnerable to reduction of crop yields, soil infertility is 21.25%, and climate-induced diseases shows 19.16% vulnerability. The overall mean of 2.97 on the magnitude of climate change indicates a moderate effect on economic, environment and social domain but with major effect on economic and environmental effects and relatively minor effect on social domain. The computed Pearson correlation yielded an r-value of 0.62, indicating a moderate positive correlation between climate change knowledge and adaptation practices among the respondents. The relationship was found to be statistically significant at the 0.05. Limited institutional support was reported by 89.17% of respondents that has led respondents to rely primarily on locally driven adaptation strategies, including planting drought-resistant crops, diversified farming, and reforestation. Only 3.33% of respondents reported receiving government assistance. Moreover, the study highlights that awareness alone does not reduce vulnerability, as adaptation in tropical dryland is largely sustained through community-based initiatives.

Keywords: Adaptive practices, climate change, impact, knowledge, vulnerability

INTRODUCTION

Climate change poses growing challenges to many aspects in upland and dryland communities. Livelihoods such as agriculture, fisheries, ecosystems, and health are increasingly at risk (Kifunda 2023). As climate change shift the biogeochemical cycles that support life in upland communities, they gradually lose their capacity to sustain their livelihood. Moreover, many biological organisms associated with the spread of infectious diseases are highly influenced by fluctuations in climate variables. Climate change creates favorable breeding conditions for mosquito-borne diseases, which are closely associated with extreme temperature changes. Children and the elderly who generally have weaker resistance, are the most vulnerable, while upland communities with limited health infrastructure are least able to adapt.

In the upland communities, climate change has contributed in the reduction of crop yields. Communities that heavily rely on agriculture are adversely affected by reduced rainfall and the increasing frequency of droughts (Busthanul et al. 2023). According to Wheeler and von Braun (2013), climate change eventually hinder progress toward achieving adequate food supply. The stability of food systems is increasingly compromised, exacerbating

food insecurity in areas already vulnerable to hunger and undernutrition (Rozaki et al. 2026).

Annual food crops sensitive to drought, is reflected in the decline of their agricultural yields. Hacıbrahimoglu (2025) explained that food security challenges require adaptive strategies that involve reflection and modification. Changes in upland and dryland landscapes have also been observed as a result of climate change. Furthermore, World Bank Group (2024) reported a growing evidence that climate change is projected to increase health risks, morbidity, and mortality in many upland areas.

Climate change is inevitable, thus, upland communities must adapt and strengthen their adaptive capacities to vulnerabilities. The development and climate research communities have much to learn from each other in supporting these adaptation processes (Intergovernmental Panel on Climate Change (IPCC) 2007). Fortunately, countries worldwide are increasingly taking action by implementing resilience plans. Resilience gained prominence in discussions during the Rio+20 Conference on Sustainable Development in 2012, reflecting a new wave of thinking on sustainability amid economic and political instability driven by climate change vulnerabilities (Walsh 2010; Santiago 2015).

The Philippines, along with other tropical and archipelagic nations, is highly susceptible and vulnerable to climate change impact. Extreme weather events such as tropical cyclones, monsoon rains, and prolonged dry spells have triggered floods and landslides that often escalate into disasters (Basia and Mero 2016). Philippine Agricultural and Fisheries Strategic Plan (2017-2022) identified upland and dryland areas as among the most due to long-term exposure and frequent extreme events. Typhoon Yolanda, the strongest typhoons on record to strike the Philippines, displaced approximately 750,000 people and disrupted power and communication systems across several regions (Philippine Daily Inquirer 2013). Similarly, Israel and Briones (2013) indicated that extreme weather events led to significant declines in overall agricultural production and food security.

Existing studies on climate change adaptation in Philippine predominantly focus on coping strategies and agricultural responses, with limited attention to community-based adaptive systems integrating social, institutional, and ecological dimensions. Consequently, there is insufficient understanding of how collective community mechanisms shape sustainable climate adaptation in tropical upland settings, thereby necessitating a community-based analysis of adaptive responses.

This study provides quantitative evidence how upland households perceive climate change, vulnerability and household-level adaptive responses. It identifies key socio-economic and institutional factors influencing adaptation measures. By focusing on upland environments, which face distinct challenges related to water availability, crop suitability, and land degradation, the study contributes context-specific adaptation strategies for an understudied agro-ecological areas. Given these circumstances, this study is undertaken to establish baseline information on community vulnerability and adaptation status, and policy development and planning that are appropriate, responsive to community needs.

Specifically, this study examines climate change adaptation within a social-ecological systems framework. It seeks to answer the following: (i) To what extent do respondents demonstrate climate change knowledge across the domains of causes, impacts, adaptation, and mitigation? (ii) What vulnerability exemplify the direct and indirect effects of climate change on respondents. (iii) What is the magnitude of climate change impacts on the respondents across the economic, environmental, and social domains? (iv) What support mechanisms contribute to the adaptation practices of communities affected by climate change? (v) Is there a correlation between knowledge and adaptation practices on climate change among the respondents in the upland tropical communities? (vi) What are climate change community-based adaptive responses to address climate-related risks and impacts?

MATERIALS AND METHODS

Framework of the study

The foregoing study is guided by a conceptual framework illustrated in Figure 1. The framework explains how the intensity of climate change impacts on upland communities is manifested through the people's level of knowledge, lived experiences, vulnerability and adaptive responses of the community. These impacts include drought, extreme climatic variability, water scarcity, and other climate-induced conditions that continuously affect the livelihood systems of upland communities.

The consequences of climate change are examined across three interrelated dimensions: economic, social, and environmental impacts. Economically, climate change disrupts agricultural productivity, income stability, and food security. Socially, it affects household well-being, community resilience, health, and social cohesion. Environmentally, climate change accelerates land degradation, biodiversity loss, and depletion of natural resources, which further intensify community vulnerability.

Despite these challenges, the adverse impacts of climate change can be mitigated through the community-based adaptive response. Such mechanisms influence economic stability, strengthen social capacity, and promote environmental sustainability. When an appropriate balance exists between the intensity of climate change impacts and the effectiveness of community-based adaptive responses across the economic, social, and environmental dimensions, the outcome is the attainment of a sustainable upland community.

Research design

This study employed a cross-sectional descriptive research design to systematically document the climate change knowledge, vulnerabilities, and community-based adaptive practices of upland households. Survey data and descriptive observations were used to assess experienced impacts and corresponding mitigation responses. The design was appropriate because it describe knowledge, experiences, vulnerability and community based adaptive response rather than determine cause and effect and it does not attempt to establish relationship.

Sources of data

The study covered residents from selected upland communities. Although 15 communities were initially identified with a target of 800 households, the sample was limited to six communities to ensure manageable and consistent data collection. Households were chosen through convenience sampling due to the dispersed and difficult-to-access settlement pattern, while respondents were drawn from different clusters within each community to maintain variation. Because participants are chosen based on accessibility rather than random selection, so some groups may be over- or under-represented.

Originally, 50 household respondents per community were planned. The first two communities each completed 50 respondents with total 100 respondents. Because responses showed strong consistency, the researcher

reduced the sample to 35 respondents in each of the remaining four communities. This resulted in a final sample of 240 household respondents across six upland communities.

The decision to adjust and reduce the sample size was based on preliminary data monitoring, which revealed strong consistency and homogeneity in respondents' answers across the key study variables. This uniformity indicated that additional data collection was unlikely to produce significant changes in the statistical patterns already observed. In the survey, such consistency is comparable to statistical saturation, where increasing the number of respondents contributes minimal additional variance and only marginal improvements in explanatory power. The stability of the mean responses further suggested that parameter estimates had already stabilized; thus, expanding the sample would have mainly reduced standard errors without meaningfully affecting the interpretation of results. Moreover, post-hoc power analysis confirmed that the adjusted sample size still acceptable with statistical power levels of commonly 0.80, thereby maintaining analytical rigor. The adjustment also aligns with responsible research practice, promoting efficient use of time and resources while minimizing unnecessary respondent burden, particularly among climate-vulnerable upland communities.

Locale of the study

Location map of Mountain Province in the Cordillera Administrative Region, Northern Luzon, Philippines, showing the municipalities of Sabangan, Bauko, and Tadian and the selected upland barangays included in the study. The area represents mountainous upland environments characterized by steep agricultural landscapes and seasonal dryland conditions influenced by rain shadow effects, limited water retention, and dependence on rain-fed farming systems.

Figure 2 presents the geographic location of the study area in Mountain Province, Cordillera Administrative Region (CAR), Northern Luzon, Philippines, specifically highlighting the municipalities of Sabangan, Bauko, and Tadian where the selected upland barangays are situated. The province is characterized by rugged mountainous terrain with elevations generally above 1,000 meters above sea level and landscapes dominated by agricultural and forest ecosystems distributed along steep slopes. Spatial analysis indicates that, despite the region's humid tropical climate classification, portions of the study sites exhibit tropical dryland characteristics during extended dry periods. These conditions are associated with seasonal water scarcity, rainfall variability, soil moisture deficits, and reliance on rain-fed agriculture. The occurrence of localized dryland conditions is influenced by rain shadow effects, steep terrain limiting surface water retention, and reduced watershed storage capacity, contributing to increased vulnerability of upland farming systems to drought, soil erosion, and climate variability.

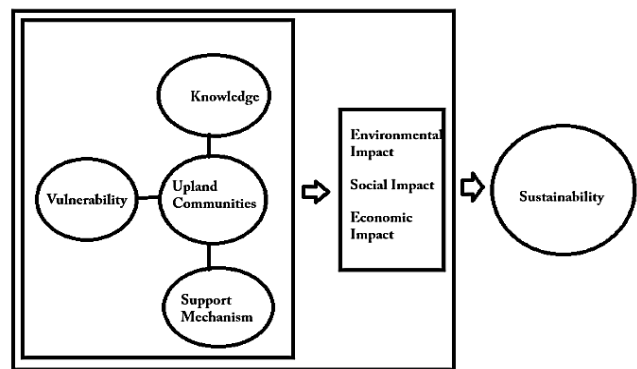


Figure 1. Conceptual framework

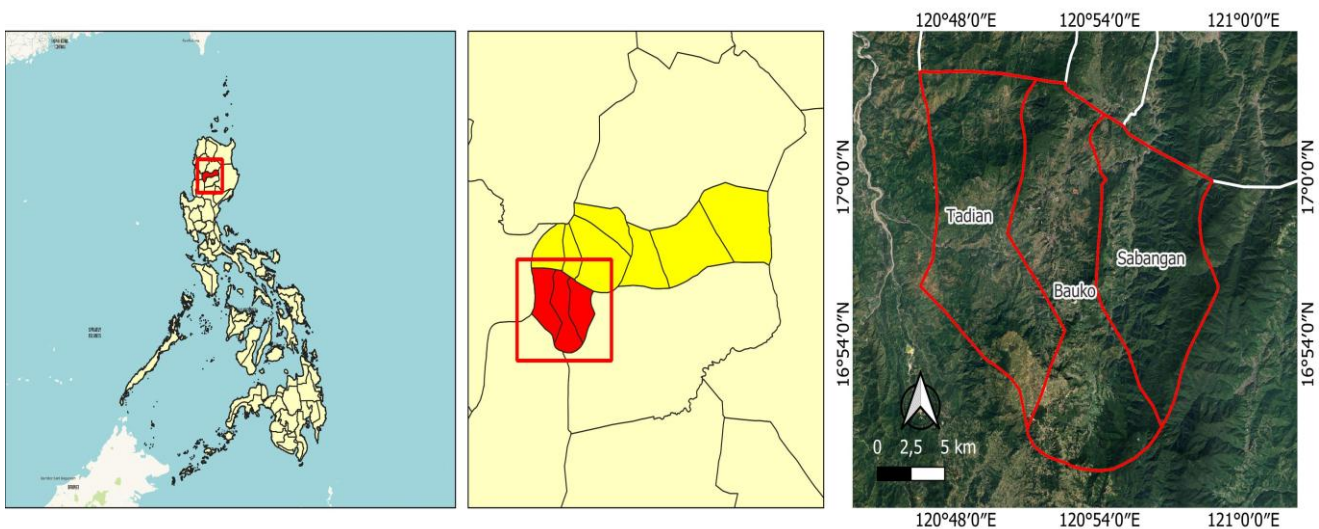


Figure 2. Location of the study in Mountain Province, Cordillera Administrative Region (CAR), Northern Luzon, Philippines

Instrumentation and data collection

A researcher-made questionnaire was used for data collection. The instrument was adapted from Fontanilla (2015) and modified to fit the objectives of the study. Prior to final administration, the questionnaire was pilot-tested with 15 respondents, and the results were used to refine and improve the items. The content validity was established through expert evaluation using a 5-point scale such as: 1.00-1.79 (Very low validity); 1.80-2.59 (Low validity); 2.60-3.39 (Moderate validity); 3.40-4.19 (Valid) and 4.20-5.00 (Highly valid). The instrument obtained a mean rating of 4.45, interpreted as Highly valid.

Reliability was assessed using Cronbach’s alpha to determine internal consistency. The instrument obtained a coefficient of 0.82, indicating good reliability for knowledge, community-bases adaptive response, and vulnerability.

Data were collected based on the validated questionnaire. The researcher asked each question and recorded the respondents’ answers, with follow-up questions used to clarify responses. Participants were allowed to express their ideas in their native language, and the questionnaire was translated into the language most understandable to them. To further support respondents’ claims regarding their experiences related to climate change, observational notes were also documented during the interviews.

Data analysis

The data were analyzed using descriptive statistics, specifically frequency counts, weighted mean, and percentages. Frequency counts and percentages were used to describe the farmers’ experiences of climate change and their coping strategies. The weighted mean was used to determine the level of knowledge of respondents across different aspects of climate change, the degree of its effects on the economic, environmental, and social conditions of the household, and the extent of use of community-based adaptive responses.

Descriptive statistics were appropriate because the study aimed to provide a systematic description of existing conditions within the selected communities. The research did not intend to test hypotheses, compare groups, or establish causal relationships; therefore, inferential statistics were unnecessary since the findings were not meant to be generalized beyond the specific respondents included in the study. The data gathered were tallied and categorized using the following scales (Table 1)

Table 1. Likert scale of responses with its descriptive equivalent

Score range	Degree of knowledge of the respondents on climate change	Effects of climate change
	Descriptive equivalent	Descriptive equivalent
4.50-5.00	Very Highly Knowledgeable	Extreme effect
3.50-4.49	Highly knowledgeable	Major Effect
2.50-3.49	Knowledgeable	Moderate Effect
1.50-2.49	Fairly Knowledgeable	Minor effect
1.00-1.49	Not Knowledgeable	No Effect

RESULTS AND DISCUSSION

Extent to demonstrate climate change knowledge among the respondents

One of the objectives of this study was to determine the extent of climate change knowledge among the respondents. Climate change knowledge in this study refers to the respondents’ awareness and understanding of extreme climatic variability and unpredictable weather patterns that affect daily livelihoods, such as drought, El Niño, floods, heat waves, La Niña, landslides, monsoons, mudslides, typhoons, and wildfires.

Table 2 presents the level of climate change knowledge of the respondents. The results revealed that respondents possess a High Knowledge (HK) on climate change, as indicated by an overall mean rating of 4.09. Among the identified climatic events, typhoons obtained the highest mean score of 4.54, interpreted as Very High Knowledge, followed by drought (M=4.40). On the other hand, mudslide recorded the lowest mean score of 3.81 but falls within the high knowledge category.

The findings indicate that respondents demonstrate strong awareness of climate change, particularly in recognizing climate-related hazards as natural and recurring environmental phenomena affecting their communities. This result contrasts with the findings of Whitmarsh et al. (2011), who reported limited public understanding of climate change among their participants. However, the present findings support the study of Ogallo et al. (2022), which revealed that household respondents were highly aware of climate variability, identifying strong winds and excessive rainfall as major destructive climatic factors.

Table 2. Climate change knowledge of respondents

Aspects	M	Descriptive equivalent
Typhoons	4.54	VHK
Drought	4.40	HK
Landslide	4.22	HK
Flood	4.10	HK
Heat Wave	4.11	HK
Monsoon	4.08	HK
La Nina	4.06	HK
Mudslide	3.81	HK
Overall Mean	4.09	HK

Note: 4.50-5.00: Very High Knowledge (VHK), 3.50-4.49: High Knowledge (HK), 2.50-3.49: Average Knowledge (AK), 1.50-2.49: Fair knowledge (FK), 1.00-1.49: Zero Knowledge (NK)

Similarly, Berman et al. (2015) emphasized that increased exposure to climatic variability enhances people's understanding and perception of climate change impacts. The high level of knowledge observed among respondents may be attributed to their frequent exposure to climate-related disasters, which strengthens experiential learning and environmental awareness.

Furthermore, exposure to various forms of mass media may have significantly contributed to the respondents' climate change knowledge. Ho et al. (2014) emphasized that mass media serves as an essential channel in disseminating information about global climate issues and environmental risks. Information campaigns, disaster preparedness programs, and community orientations likewise play vital roles in improving public understanding of climate-related concerns. Supporting this view, Vo (2015) highlighted the contribution of educational institution extension services in disseminating climate change information, particularly among farming communities. The findings concluded that institutional support, media exposure, and direct experiences with natural calamities collectively enhance respondents' awareness and understanding of climate change phenomena.

Vulnerability that exemplifies the direct and indirect effects of climate change on respondents

Table 3 revealed the major climate change-related vulnerabilities that exemplify the direct and indirect effects of climate change, particularly among upland farming communities. The findings revealed that water shortage emerged as the most frequently reported vulnerability, affecting 29.17% of the respondents followed by low crop yield (26.25%), soil infertility (21.25%), and climate-related human diseases (19.16%). Other reported vulnerabilities included plant diseases, animal diseases, destruction of properties, landslides, severe heat, and difficulties in farming operations.

The results indicate that climate change significantly affects both the environmental and socio-economic conditions of upland communities. Respondents reported that prolonged high temperatures beginning in late February caused deep wells and natural springs to dry up, compelling households to obtain water from distant sources. Some water sources were also observed to be contaminated, further aggravating household vulnerability. In agricultural areas, drying streams and irrigation systems intensified water scarcity, forcing farmers to construct temporary reservoirs along riverbanks or temporarily suspend farming activities until the rainy season begins. These findings corroborate the study of Shams et al. (2015), which documented that climate change-induced drought and rainfall variability negatively affect water availability and agricultural productivity.

Water scarcity directly contributes to declining agricultural production. Approximately 29.17% of respondents associated with water shortages and 26.25% reduced crop yields. Although Ye et al. (2013) and Francisco et al. (2022) suggested that climate change may sometimes produce moderate positive agricultural

outcomes, the present findings support Akram and Hamid (2015), who emphasized that increasing temperatures generally reduce agricultural productivity. Respondents reported a decline in rice production to approximately 10-15 cavans per hectare due to extreme temperature variability, consistent with the findings of Java (2025), which linked rising temperatures to reduced crop yields.

Declining soil fertility further compounds agricultural vulnerability. Respondents noted that acceptable harvests were previously attained without fertilizer application; however, the changing climate now necessitates the use of external inputs to maintain productivity. Heavy rainfall and prolonged drought contribute to nutrient leaching, soil degradation, and loss of organic matter essential for plant growth. Consequently, farming costs have increased due to dependence on fertilizers. This observation supports the assertion of Francisco et al. (2022) that soil systems are strongly interconnected with climatic processes through carbon, nitrogen, and hydrological cycles, making them highly susceptible to climate variability.

In addition to direct effect of climate change to livelihood of the respondents, it also poses risks to human health. About 15.05% of respondents reported increased occurrences of colds and coughs, particularly among children and elderly household members, which they attributed to fluctuating weather conditions. This finding aligns with Miller et al. (2016), who emphasized that climate change heightens health risks among vulnerable populations, especially children. Likewise, Elias et al. (2026) reported that extreme temperatures and excessive monsoon rainfall increase the prevalence of respiratory illnesses. The findings demonstrate that climate change creates interconnected vulnerabilities affecting water resources, agricultural productivity, soil quality, and human health, thereby intensifying the adaptive challenges faced by upland communities.

Magnitude of climate change impacts on the respondents across the economic, environmental, and social domains

The findings in Table 4 revealed that climate change exerted a moderate effect as shown in overall mean score of 2.97. Among the three domains, the economic (M=3.72) and environmental (M=3.65) domain interpreted as major effects but the social domain interpreted as minor effect as evidenced in the computed Mean of 1.53.

The economic condition of respondents was found to be significantly affected by climate change. Participants reported that deteriorating farm conditions caused by water scarcity, landslides, and irregular weather patterns reduced agricultural productivity and household income. Despite these challenges, farmers continued cultivating crops to sustain their families' economic needs. Their persistence demonstrates the resilience and livelihood adaptation strategies employed by upland communities in coping with declining yields and climate-induced crop damage.

Environmental impacts were likewise perceived as severe. Respondents observed reduced water availability, increasing occurrences of forest fires, and unpredictable weather conditions that disrupt traditional farming

schedules. Water shortages were reported as early as December due to minimal discharge from springs, streams, and rivers. In addition, farmers noted an increase in crop-damaging pests such as worms and insects affecting plant leaves, roots, and fruits, further threatening agricultural productivity. These observations highlight the compounded effects of climate variability on ecosystem stability and farm management practices in upland communities. The findings indicate that although upland households possess considerable climate change knowledge and adaptive capacity, environmental degradation and livelihood instability remain significant concerns. This result supports the findings of Duba (2022), who emphasized that rural households located in climate-vulnerable regions experience heightened economic risks and environmental pressures resulting from climate variability.

Although climate change generated substantial economic and environmental consequences among respondents, its perceived social impact remained comparatively minor. This finding reflects a complex interaction between risk perception, adaptive response, and the gradual nature of social transformation rather than the absence of social vulnerability. Social impacts assessed in the study included climate-related illnesses, access to external assistance, community participation, educational disruption, and migration or displacement. The relatively low impact may be attributed to strong social cohesion within communities, established coping mechanisms, and collective adaptation practices that help mitigate social disruptions. Furthermore, the presence of external support systems and diversified livelihood opportunities may have reduced community vulnerability to social stressors associated with climate change.

Intergovernmental Panel on Climate Change (IPCC 2022) explains that climate change impacts are often first manifested through observable environmental degradation such as declining agricultural productivity, water scarcity, and ecosystem disruption. These environmental changes translate directly into measurable economic outcomes including reduced household income, livelihood instability, and increased production costs. Economic and environmental effects are therefore easily recognized because they produce immediate and tangible consequences but ultimately becomes a social problem making them less visible at the community level.

Weber (2016) argued that social consequences of climate change typically emerge through mediated pathways involving well-being, social relationships, migration decisions, and community cohesion rather than sudden disruption. According to the Intergovernmental Panel on Climate Change (IPCC 2022), climate risks increasingly exacerbate poverty, inequality, and social vulnerability; however, these effects often unfold gradually and are embedded within everyday coping practices. As a result, communities may experience significant social strain without explicitly identifying it as a climate-related outcome.

Another explanation lies in adaptive normalization of Erikson (1976), Oliver-Smith (1996), and Adger (2006). Rural and climate-exposed populations continuously

employ local adaptive responses such as livelihood diversification and indigenous adaptive practices. These responses enable households to maintain social functioning despite worsening environmental stress. While adaptation enhances short-term resilience, it may simultaneously mask deeper social costs, including education disruption, and psychological stress. Consequently, climate impacts become normalized as part of routine survival rather than perceived as social crises.

Risk perception theory that was primarily advanced by Slovic (1987) further explains why respondents report limited social impacts. Individuals tend to interpret climate change primarily as an environmental or economic concern rather than a social one. Moreover, social impacts are inherently more difficult to quantify compared with economic losses. Indicators such as income decline or crop failure can be statistically measured, whereas social dimensions like community cohesion, gender inequality, mental stress, and cultural disruption are intangible and evolve slowly over time. This measurement limitation often leads to an underestimation of climate-induced social assessments. However, it is important to note that the cross-sectional nature of the study may not fully capture the long-term social consequences of climate change, which may emerge gradually over time.

Moreover, the findings suggest that climate change primarily threatens the economic and environmental stability of upland communities, while social impacts of climate change are not minor but rather socially mediated. Climate change initially manifests as environmental stress, progresses into economic hardship, and ultimately reshapes social systems over extended periods.

Table 3. Vulnerability of respondents

Vulnerabilities	f (N=240)	%
Water Shortage	70	29.17
Low Crop Yield	63	26.25
Soil Infertility	51	21.25
Human Diseases	46	19.16
Plant Diseases	37	15.41
Animal Diseases	23	9.58
Destruction of Properties	16	6.66
Landslide	11	4.52
Severe heat	4	1.51
Difficulty of Planting Process	4	1.51

Note: Multiple response. Percentage exceeds to 100% because respondents were allowed to select more than one answer

Table 4. Magnitude of climate change

Magnitude of climate change on the respondents	M	Descriptive equivalent
Economic	3.72	Major Effect
Environment	3.65	Major Effect
Social	1.53	Minor effect
Overall Mean	2.97	Moderate Effect

Note: 4.50-5.00: Extreme Effect, 1.50-2.49: Minor Effect, 3.50-4.49: Major Effect, 1.00-1.49: No Effect, 2.50-3.49: Moderate Effect

Support mechanisms contribute to the adaptation practices of communities affected by climate change

Table 5 presents the external support received by respondents from government and non-government organizations. External support mechanisms are widely recognized as critical components of adaptive capacity, particularly in communities exposed to climate-related risks. However, the findings reveal that 89.17% of respondents reported receiving no form of external assistance, highlighting a heavy reliance on self-initiated coping and community-based adaptation strategies.

The limited access to institutional support suggests that respondents primarily address climate change impacts through endogenous resources and locally developed adaptation practices. This situation may be attributed to the geographical isolation of upland communities, which constrains program outreach, service delivery, and sustained engagement by both government and non-government agencies (Virola et al. 2008). Such spatial marginalization has been associated with increased vulnerability and limited adaptive capacity among climate-exposed populations.

A small proportion of respondents (7.50%) reported receiving assistance from government institutions, particularly through the Department of Social Welfare and Development (DSWD) under the *Pantawid Pamilyang Pilipino Program* (4Ps). The conditional cash transfer program serves as a short-term safety net by providing financial assistance that enables households to meet basic needs during periods of climate-induced economic stress. Some beneficiaries also reported receiving livelihood assets, such as goats, which contribute to income diversification and strengthen household resilience. However, within Adaptive Capacity Theory, Santiago (2015) said such financial safety nets enhance absorptive capacity by enabling households to maintain consumption and livelihood stability during shocks.

Support from non-government organizations was reported by 3.33% of respondents and was primarily delivered through livelihood training and agricultural input promotion programs facilitated by agricultural agencies. Although these initiatives aim to enhance farm productivity and adaptive capacity, respondents indicated that the high cost of recommended technologies—such as organic fertilizers and improved seed varieties—limits their adoption. This finding highlights a mismatch between capacity-building interventions and the economic realities faced by upland farmers (Veron et al. 2015). From a social-ecological resilience perspective of Morecroft and Cowan (2010) and Vo (2015), insufficient institutional support weakens transformative adaptive capacity, the ability of

communities to transition toward more climate-resilient livelihood systems. Consequently, upland households continue to rely primarily on autonomous adaptation strategies rather than integrated, policy-supported climate adaptation pathways.

In addition, some respondents participated in programs involving the distribution of crop seeds, particularly string beans, under production agreements wherein organizations purchase harvested outputs for seed production. While such arrangements provide market access and supplemental income opportunities, their limited coverage suggests that these initiatives have not yet substantially strengthened resilience at the broader community level.

Furthermore, the findings reveal a significant gap in institutional and external support available to upland communities confronting climate change impacts. Israel and Briones (2013) said that strengthening the accessibility, affordability, and inclusiveness of government and non-government interventions is essential to complement existing local coping strategies. Sustained livelihood assistance, improved program outreach, and multisectoral collaboration are therefore critical in enhancing adaptive capacity and reducing long-term vulnerability among geographically marginalized upland communities.

Correlation between climate change knowledge and adaptation practices among upland communities

Table 6 presents the correlation analysis between climate change knowledge and adaptation practices among the respondents. The results revealed that upland communities demonstrated a high level of climate change knowledge, with a mean score of 4.09, while adaptation practices obtained a mean score of 3.13, interpreted as sometimes adapted.

The computed Pearson correlation coefficient yielded an *r*-value of 0.62, indicating a moderate positive correlation between climate change knowledge and adaptation practices. The relationship was found to be statistically significant at the 0.05 level ($p=0.000$), leading to the rejection of the null hypothesis. This result suggests that respondents with higher levels of climate change knowledge tend to adopt more adaptive practices in responding to climate-related risks and impacts.

Table 5. Support mechanism

Source of support	f (N=240)	%
Government	18	7.50
None- Government	8	3.33
None	214	89.17

Table 6. Correlation between knowledge on climate change and adaptation practices

Variables	Mean	Interpretation	r-value	p-value	Degree of relationship	Decision
Knowledge on Climate Change	4.09	High Knowledge	0.62	0.000	Strong Positive Correlation	Significant
Adaptation Practices	3.13	Sometimes Adapted				

Note: *r*-value: 0.00-0.19: Very Weak, 0.20-0.39: Weak, 0.40-0.59: Moderate, 0.60-0.79: Strong, 0.80-1.00: Very Strong

Similar to the study of Nguyen et al. (2013), the findings imply that awareness and understanding of climate change contribute positively to the adoption of adaptive strategies within upland communities. Increased knowledge enables farmers to recognize climate risks, anticipate environmental changes, and implement appropriate coping mechanisms such as diversified farming, drought-resistant crop cultivation, and resource conservation practices.

However, the observed difference between high climate change knowledge ($M=4.09$) and only moderate implementation of adaptation practices ($M=3.13$) indicates that knowledge alone does not automatically translate into consistent adaptive action. According to Furoc-Paelmo et al. (2018) adaptation behavior is influenced not only by cognitive awareness but also by socio-economic capacity, access to technology, institutional support, and availability of financial and material resources. Thus, while communities are well-informed about climate change, practical implementation remains partially constrained by external and structural limitations.

This finding supports the broader perspective that adaptive capacity extends beyond knowledge acquisition and depends on enabling conditions such as supportive policies, extension services, accessible technologies, and community-based support mechanisms. The positive yet not fully realized relationship between knowledge and adaptation practices highlights the need to strengthen institutional interventions that can bridge the gap between awareness and action.

Therefore, enhancing agricultural extension services, improving access to financial assistance and climate-resilient technologies, and providing sustained technical training programs are essential strategies to translate climate change knowledge into effective and sustained community adaptation practices.

Climate change community-based adaptation responses to address climate-related risks and impacts

Another objective of the study was to determine the community-based adaptation responses employed by respondents to address climate-related risks and impacts. Understanding local adaptation responses is essential in assessing how upland communities sustain their livelihoods amid increasing climate variability.

Table 7 presents the extent to which respondents adopt various climate change adaptation responses. The results revealed an overall mean of 3.13, interpreted as Sometimes Adopted, indicating that respondents actively employ multiple adaptation strategies, although adoption levels vary depending on available resources and environmental conditions. Among the identified practices, planting drought-resistant crops ($WM=3.99$), diversified farming systems ($WM=3.94$), and reforestation activities ($WM=3.81$) were often adopted, making them the most common adaptive responses among respondents. These practices demonstrate a strong reliance on ecosystem-based adaptation and livelihood diversification strategies widely

recognized for strengthening resilience in climate-sensitive agricultural systems.

The respondents' ability to adopt diverse adaptive responses appears to be strongly influenced by their continuous exposure to climate-related hazards. Recurrent droughts, erratic rainfall, and extreme weather events have fostered adaptive traits such as resilience, prudence, and resourcefulness among community members. Experiential learning derived from repeated climate stress has enabled households to adjust farming practices and sustain livelihoods under uncertain environmental conditions, supporting evidence that prolonged exposure enhances local adaptive capacity.

The adaptation strategies identified in this study are consistent with findings from agricultural adaptation research across different regions. Olesen et al. (2011) reported that farmers respond to climate variability by adjusting cultivation timing and selecting alternative crop species and cultivars. Similarly, Okonya et al. (2013) found that smallholder farmers adopt tree planting, early-maturing and drought-tolerant crop varieties, and climate-responsive planting practices to minimize production risks. Furoc-Paelmo et al. (2018) further emphasized that crop selection, cropping systems, and sowing schedules are central components of climate adaptation planning in vulnerable agricultural landscapes.

The adoption of diversified farming systems and drought-resistant crops also supports the findings of Basia and Mero (2016), who highlighted diversification, rotational cultivation, and modification of crop and livestock production as essential farmer responses to climate stress. Beyond farm-based measures, engagement in off-farm activities emerged as an additional adaptive strategy, reflecting the multidimensional nature of household adaptation where livelihood diversification reduces dependence on climate-sensitive agriculture.

Table 7. Climate change adaptive responses by respondents

Practices	WM	DR
Planting Drought Resistant Crop	3.99	OA
Diversified Farming system	3.94	OA
Reforestation	3.81	OA
Applying Off-farm Activities	3.30	SA
Increasing Irrigation System	3.28	SA
Following Period of Farming	3.27	SA
Conserving Soil and Water	3.26	SA
Mulching	3.04	SA
Improving Postharvest Technology	3.00	SA
Modifying of Planting Schedule	2.44	A
Reducing Land Area Cultivated	2.14	A
Increasing Land Area Cultivated	1.97	A
Overall Mean	3.13	SA

Note: 4.50-5.00: Always Adopted (AA), 3.50-4.49: Often Adopted (OA), 2.50-3.49: Sometimes Adopted (SA), 1.50-2.49: Adopted (A), 1.00-1.49: Not Adopted (NA)

Soil and water conservation practices observed among respondents parallel the conclusions of Wato et al. (2022), who demonstrated that conservation measures enhance both climate adaptation and environmental sustainability. Likewise, reforestation and agroforestry initiatives align with Nguyen et al. (2013), emphasizing that locally evolved agroforestry systems contribute to ecological stability while providing livelihood and climate resilience benefits.

Additional community-based responses include fertilizer application, improvement of local irrigation systems, modification of planting schedules, and continued crop cultivation despite declining yields. While these strategies help buffer households from economic instability, increased reliance on chemical fertilizers and pesticides raises production costs and reduces net income. This situation underscores the need for institutional support in soil testing, appropriate input use, and improved access to affordable organic farming technologies.

Labor diversification and migration also function as adaptive responses, consistent with Yaouba et al. (2024), who identified wage employment as an important coping strategy for households experiencing climate-induced livelihood constraints. Access to credit through cooperatives and lending institutions further enables households to manage short-term climate shocks, although long-term dependence on loans may increase financial vulnerability without sustainable income opportunities.

Adjustments in planting schedules represent another critical climate-responsive practice shaped by farmers' long-term observations of shifting rainfall patterns. Respondents noted that traditional planting calendars synchronized with rainfall onset in May have become unreliable due to delayed and erratic precipitation. Consequently, farmers modify planting decisions based on experiential climate knowledge, consistent with the findings of Worku et al. (2022), who identified seasonal calendar adjustment as a key adaptation strategy.

Finally, the adoption of drought-resistant and hybrid rice varieties reflects efforts to enhance crop resilience under changing climatic conditions. However, challenges related to disease susceptibility, seed viability, and dependence on costly agricultural inputs persist. In response, farmers increasingly rely on community seed exchange systems, highlighting the continued importance of indigenous and locally managed seed networks as cost-effective adaptation mechanisms.

Based from the study, the findings demonstrate that upland communities employ a combination of ecosystem-based, livelihood diversification, and knowledge-driven adaptation strategies to mitigate climate change impacts. Strengthening institutional support and improving access to climate-appropriate technologies remain essential to sustain and scale these community-based adaptation practices.

In conclusion, climate change exerts a profound impact on both economic stability and environmental sustainability, directly affecting household income, food security, and the overall livelihoods of respondents. Despite these growing risks, the study reveals that respondents reported minimal access to government

assistance and climate-responsive agricultural support in tropical dryland areas. This underscores that knowledge alone is insufficient to reduce climate vulnerability. Adaptation in tropical drylands is largely driven by local initiative rather than structured policy intervention.

Moreover, policy frameworks should actively integrate indigenous and community-based adaptation strategies into formal climate governance mechanisms and ensuring resource allocation. Finally, stronger inter-agency collaboration among agriculture, environment, and disaster risk reduction sectors is essential to mainstream tropical dryland resilience. Without sustained institutional support and ecosystem-based policy interventions, the adaptive capacity of tropical dryland farmers will remain constrained, despite their high level of climate change knowledge and proactive resilience effort.

Based on the conclusions drawn from this study, the following recommendations are provided: (i) Local governments and partner agencies should prioritize rainwater harvesting systems, small farm reservoirs, communal irrigation, and spring protection projects to directly address chronic water shortage in tropical drylands. (ii) Agricultural offices should supply drought-resistant seeds, soil improvement inputs like organic fertilizers, composting materials, and technical training on conservation farming, mulching, and moisture-retention practices to reduce crop failure and soil infertility. (iii) Because government assistance is minimal, regular extension visits, demonstration farms, and farmer field schools should be established to strengthen adaptive capacity and ensure continuity of programs. (iv) Existing practices such as diversified farming systems and reforestation should be expanded through organized farmer groups, seed banks, and community nurseries, with incentives for participation. (v) Introduce alternative income opportunities such as agroforestry products, small livestock to reduce dependence on climate-sensitive crops and stabilize household income

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