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Adaptive Capacity and Climate Resilience of Smallholder Farmers in Mankayan, Benguet: Strategies, Constraints, and Policy Recommendations

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Abstract

Purpose: This study aims to assess how smallholder farmers in Mankayan, Benguet adapt to climate change, the challenges they face, and the support they need to strengthen their resilience and sustain their livelihoods.

Methodology: The study employed a mixed-method descriptive design to examine the adaptation strategies, challenges, and support needs of smallholder farmers in Mankayan, Benguet. Data were collected from July to September, 2025, using a standardized questionnaire with both closed- and open-ended items. The sample of 397 farmers was determined using Yamane's (1967) formula for sample size computation. Quantitative data were analyzed using frequency counts, percentages, and mean rankings, while qualitative responses were processed through thematic analysis to identify recurring patterns and insights.

Findings: The study finds that smallholder farmers in Mankayan primarily use low-cost, accessible strategies such as crop rotation, scheduling, traditional methods, agrochemicals, and simple water storage. Adoption of advanced technologies remains low due to financial limitations, weak institutional support, and inadequate infrastructure. Farmers emphasized needs such as financial aid, market stability, and modern tools. They showed strong willingness to adopt sustainable practices if support improved. Key barriers include unpredictable climate hazards, price volatility, high input costs, poor irrigation, and delayed institutional assistance.

Unique Contribution to Theory, Practice, and Policy: The study integrates multiple theoretical frameworks to explain farmer resilience and offers practical and policy recommendations for climate-resilient agricultural development. Practically, it highlights feasible, farmer-preferred adaptation strategies that are low-cost and knowledge-driven. For policy, it offers clear recommendations such as market stabilization, climate-resilient infrastructure, stronger extension services, financial inclusion, and valuing indigenous knowledge to guide local governments in developing targeted, context-specific programs that strengthen the climate resilience of highland farming communities.

Keywords: *Climate Change Adaptation, Smallholder Farmers, Sustainable Agriculture, Adaptive Capacity, Benguet, Philippines*

1. Introduction

Smallholder farmers in Mankayan, Benguet, face significant challenges due to climate change, impacting their agricultural productivity and livelihoods. This research focuses on understanding how these farmers currently adapt, the obstacles they encounter, and the support necessary to enhance their resilience and ensure sustainable livelihoods.

Globally, smallholder farmers, particularly those cultivating limited land and operating with constrained resources, are among the most vulnerable to climate variability and change (Mapfumo et al., 2015). In the Philippines, as in many developing nations, smallholder farmers depend heavily on natural resources for their survival, making them highly susceptible to shifts in weather patterns, climate extremes, and environmental degradation (Peria, 2016). Similar vulnerabilities have been observed across rural communities in Africa and Indonesia, where smallholder farming dominates and agricultural production is directly affected by changing climatic conditions (Kurniawati and Luvhengo, 2021). Empirical evidence from upland regions of Indonesia and the Philippines shows that farmers are already experiencing irregular rainfall and temperature fluctuations, resulting in increased pest and disease incidence, stunted crop growth, lower yields, delayed planting schedules, and rising production costs.

Although existing literature broadly documents the vulnerability of smallholder farmers and highlights various adaptation practices, there remains a need for localized and in-depth assessments of specific farming communities. Awinda et al. (2021) emphasize the crucial role of indigenous knowledge in climate adaptation, noting that farmers frequently draw on local knowledge systems to cope with environmental stress. However, they also stress the need to integrate indigenous knowledge with scientific knowledge in climate policies to ensure more effective adaptation outcomes. Meanwhile, studies in the Philippines, such as those conducted in Bulacan and among agroforestry farmers, show that while farmers are aware of climate impacts, their adaptive capacity remains limited, often due to financial constraints and lack of institutional support (Peñalba, 2019). Despite these insights, a comprehensive understanding of the specific adaptation strategies, challenges, and support needs of smallholder farmers in Mankayan, Benguet remains absent. This gap is critical, as insufficient knowledge of local adaptation behaviors and barriers hinders the formulation of targeted interventions that can strengthen resilience in vulnerable agricultural communities.

In response, this study aims to assess how smallholder farmers in Mankayan adapt to climate change, the challenges they face, and the support they require to enhance resilience and sustain their livelihoods. Specifically, the study pursues three objectives: (1) to identify and evaluate farmers' existing adaptation and coping strategies, including both indigenous and modern approaches; (2) to determine the socio-economic, technical, and institutional factors that influence their capacity to adapt to climate change; and (3) to examine the barriers and opportunities associated with adopting sustainable and climate-resilient farming practices in the community.

This research holds substantial value by contributing both local and broader insights to the field of climate change adaptation in agriculture. By focusing on Mankayan, Benguet, the study provides context-specific evidence that can guide local policymakers and agricultural extension services in designing tailored support programs. The findings will illuminate the specific needs and perceptions of farmers regarding climate change, as well as their constraints related to unpredictable weather, limited farm size, labor shortages, water scarcity, high input costs, and inadequate information. By identifying successful indigenous and modern adaptation strategies, the study enriches academic understanding of resilience-building practices among smallholder farmers. Moreover, the insights generated can inform policy frameworks and interventions that address key determinants of farmers' adaptive capacity, ultimately enhancing their ability and willingness to adopt effective adaptation measures. The study's outcomes will also help farmers themselves by clarifying viable pathways for strengthening climate resilience and securing more sustainable livelihoods in an increasingly variable climate.

2. Literature Review

2.1 Global and Regional Context of Smallholder Vulnerability

Smallholder farmers form a crucial component of global food systems. More than 500 million smallholder farms in sub-Saharan Africa and Asia alone provide food for over 80 percent of the population, an estimated two billion people in the developing world (Awazi et al., 2021). Despite their central role in food security, these farmers are increasingly vulnerable to climate change, which exacerbates existing pressures such as population growth, urbanization, income inequality, land degradation, and declining farm size and productivity (Chen et al., 2018).

The impacts of climate change on smallholder agriculture are already evident across multiple regions. In Asia, farmers report higher temperatures and altered rainfall patterns, with meteorological data confirming these observations (Nguyen et al., 2021; Karki et al., 2020; Juana et al., 2013). Similar disruptions have intensified in sub-Saharan Africa, where droughts and extreme rainfall events have become more frequent and severe (Chen et al., 2018). Southeast Asian countries, including the Philippines, Indonesia, and Malaysia, face additional challenges due to projected increases in precipitation, prolonged dry seasons, and the declining suitability of major crop areas such as coconut and oil palm (Appelt et al., 2023).

Global projections further highlight the heightened risks confronting smallholder agriculture. Staple crop yields in sub-Saharan Africa are expected to fall by 10 to 20 percent by 2050 under current climate trends, while rice and wheat production in South Asia may decline by 10 to 15 percent due to intensifying heat stress and changing monsoon patterns. In drought-prone areas across Africa and South Asia, crop production could decline by up to 25 percent by 2080 (Abebaw, 2025). These outcomes underscore the vulnerability of smallholder farmers, who often depend on rain-fed agriculture, have limited adaptive capacity, and face multiple socio-economic constraints. In Central America, similar patterns emerge, particularly in municipalities dominated by subsistence crops with limited capacity for innovation and adaptation (Bouroncle et al., 2017). Collectively, these findings emphasize the urgent need to strengthen smallholder resilience, given their central role in global food security (Awazi et al., 2021).

2.2 Documented Adaptation Strategies and Approaches

Farmers across climate-vulnerable regions employ a wide range of adaptation strategies. At the farm level, common actions include modifying cropping calendars, shifting planting dates by several weeks, adopting climate-resilient crop varieties, adjusting machinery and cultivation practices, and reallocating cultivation areas. Water management strategies have gained prominence, particularly the use of the System of Rice Intensification, water pumping, and the selection of heat-tolerant rice varieties to manage water scarcity and unpredictable rainfall (Shrestha et al., 2018).

Soil management is also a key adaptation domain. Farmers frequently apply manure, prepare compost, rotate crops, and retain crop residues to address declining soil fertility. The adoption of organic fertilizers has expanded as farmers seek to sustain soil health under fluctuating climatic conditions (Baraka, 2023). Crop diversification is widely recognized as one of the most effective resilience-building strategies. Diversifying crops reduces production risks while improving household income, nutrition, and food security (Makate et al., 2016). Agroforestry systems, which integrate crops and trees, further enhance resilience by moderating microclimates, improving soil structure, and increasing moisture retention when combined with conservation agriculture (Kamuti, 2021).

Indigenous and traditional knowledge also plays an essential role in climate adaptation. Indigenous agroforestry systems, which integrate trees and shrubs into agricultural landscapes, provide benefits such as erosion control, carbon sequestration, and access to non-timber forest products (Pirasteh et al., 2025). Traditional techniques, including the use of leguminous trees to enrich soil fertility and provide livestock feed, help mitigate climatic challenges (Assani et al., 2023). Home gardens represent another indigenous strategy, combining food production with biodiversity conservation while buffering households against economic and climatic risks (Pirasteh et al., 2025).

Community-based and cooperative strategies are increasingly important as many smallholders lack the resources to implement individual adaptation measures. Farmer cooperatives improve access to shared resources, technologies, and labor, enabling practices that would otherwise be financially or technically unfeasible (Shrestha et al., 2018). Local resilience mechanisms typically rely on multiple livelihood assets, including natural capital, social capital through social networks and cooperatives, financial capital from remittances, human capital derived from experiential learning, and physical capital such as irrigation infrastructure. Effective resilience-building requires complementing these local efforts with external support from government and development organizations (Kalidou et al., 2024).

2.3 Barriers and Challenges to Effective Adaptation

While adaptation strategies exist, substantial barriers prevent smallholder farmers from effectively implementing climate change responses. Techno-informational, economic, and environmental barriers are strongly and inversely correlated with adoption of adaptation measures, with these barriers varying significantly across different agroecosystems (Lamichhane et al., 2022). Research reveals that most farmers across Africa and Indonesia are not capacitated and willing to practice climate adaptive strategies suggested by researchers, though deeper analysis is still required to understand why smallholder farmers lack both capacity and willingness to adopt these strategies (Kurniawati et al., 2021).

Access to information and institutional support emerges as a critical constraint. Results show that smallholder farmers' level of adaptation to climate change is conditioned by access to extension services, access to remittances, family labor, household education, and linking capital with external organizations (Zamasiya et al., 2021). Studies reveal a lack of public and private institutional support to farmers, resulting in insufficient awareness of climate change among these farming communities (Tesfuhuney et al., 2021).

Structural constraints create fundamental limitations that go beyond simple technology adoption. In many regions, poverty is endemic and inequitable land distribution means that farmers have access to extremely small plots, sometimes as little as 0.06 hectares per person. For many farmers, agriculture itself does not represent a pathway out of poverty, and they are increasingly reliant on non-agricultural income sources. This reality challenges the assumption that climate-smart agriculture automatically provides an escape from poverty, as ineffective targeting of adaptation strategies ignores smallholder farming households' different capacities for livelihood transformation (Hellin et al., 2019).

The severity of predicted climate changes may be beyond many farmers' current ability to adapt and improve their livelihoods, even though farmers have long adapted to climate variability (Hellin et al., 2019). The scaling of climate-smart approaches has been limited partly because it focuses primarily on identifying adaptation options and financial mechanisms while giving less attention to local context and the diverse constraints farmers (Aggarwal et al., 2018).

2.4 Support Systems and Interventions for Enhanced Resilience

Building resilience among smallholder farmers requires comprehensive support systems that address multiple dimensions of vulnerability simultaneously. Agricultural and forestry extension services need to be strengthened to provide local support for adaptation measures to farmers, with improved access to insurance, technical support and markets for sustainable products serving as key ingredients for smallholders. However, knowledge production and diffusion remain rather scattered, making it difficult to prepare independent smallholders for climate change (Verburg et al., 2019).

The urgent nature of climate change impacts calls for targeted interventions that address specific adaptation needs. Future interventions that increase agricultural production, productivity and quality while reducing farmers' risk exposure should consider the provision of irrigation facilities, improved agricultural technologies, and access to off-farm work opportunities (Belay et al., 2017). Agricultural research systems should assist smallholder farmers in identifying improved crop varieties suitable for intercropping and irrigation use, with adaptation strategy choices prioritized based on sociodemographic factors (Lemessa et al., 2019).

Extension services play a crucial role in promoting climate-smart agricultural practices that enhance resilience. By leveraging advancements in technology, participatory learning, and climate adaptation strategies, extension services can improve farmers' capacity to manage resources sustainably, reduce risks, and boost productivity (Chourad et al., 2024). Effective support approaches include engaging local governments as partners, considering broader landscape issues such as markets, providing farmers with support to facilitate adoption of climate-smart agriculture practices, fostering community capacity building, and promoting adaptive management and scenario planning to deal with uncertainty (Halbherr et al., 2021).

Silici et al. (2021) mentioned that knowledge management emerges as a fundamental component of successful interventions. Access to knowledge remains one of the most important determinants of smallholders' decisions to respond to climate risk and a critical element in building adaptive capacity. Learning platforms through participatory action research, farmer field schools and community-based initiatives prove particularly effective, though knowledge based on local practices alone may be insufficient to prompt transformative action. Bridging local and external knowledge is critical because it widens smallholders' knowledge base and encourages proactive adaptation alongside more typical reactive strategies. Development programs should incorporate robust strategies for knowledge management at the outset in the design phase, rather than viewing knowledge management as part of communication and outreach in later stages of project implementation. Successful scaling up is characterized by interventions that adopt genuinely integrated, multisectoral and participatory approaches to planning, implementation, and dissemination, and foster co-creation of knowledge.

2.5 Indigenous Knowledge and Local Context in Adaptation

Indigenous and local people have possessed the capacity to adapt to environmental change within their ecological environments for centuries. This Indigenous and Local Ecological Knowledge (IEK) has progressively evolved from being viewed as a static body of knowledge to one of dynamism, becoming hybridized through accommodation of new forms of information and exposure to external socio-economic drivers. The relevance and role that indigenous knowledge plays in disaster risk management, natural resource conservation, and climate change adaptation must be clearly understood and acknowledged if we are to fully address the impacts of a warming climate (Sakapaji, 2022).

However, contemporary climate change presents unprecedented challenges for traditional knowledge systems. Research reveals that climate change is occurring at rates faster than indigenous knowledge can meaningfully adjust and adapt, resulting in greatly reduced agricultural productivity and forcing men to seek off-farm employment to supplement lost income. This rapid pace of change has led to increased agrochemical use, declines in local population health, and shifted village gender dynamics with women taking on extra farming burdens (Son et al., 2021).

The conservation and transmission of indigenous knowledge faces additional threats from social and demographic changes. In some regions, there is risk of losing traditional knowledge due to youth migration, which reduces the potential to improve community resilience. This creates challenges in incorporating local knowledge into adaptation planning, necessitating studies to rescue local knowledge and incorporate it into adaptation planning according to each rural community's specific needs (Ruiz-Garcia et al., 2021).

Effective integration of indigenous knowledge requires collaborative, community-based approaches that address root causes of vulnerability. In the Philippines, the Magsasaka at Siyentipiko para sa Pag-Unlad ng Agrikultura (Farmer-Scientist Partnership for Development) has organized a polycentric network over 30 years to implement food sovereignty initiatives, directly addressing root causes of vulnerability by working to reclaim

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farmer rights and control over resources while revitalizing agrobiodiversity and place-based knowledge (Heckelman et al., 2022).

Climate change adaptation must recognize that effects are largely location-specific, making targeted, context-specific, community-based strategies and processes critical. Social learning in climate-smart villages helps nurture farmers' capacities as communities-of-practice to find solutions, test and improve adaptation options, and critically engage in broader research for development and policy processes. Through iterative processes, smallholder farmers, research facilitators, and community members collectively improve their understanding of both generic and location-specific climate change, vulnerability drivers, and existing coping activities, then identify diverse adaptation options using a "portfolio approach" rather than seeking silver-bullet technologies (Chaurasiya et al., 2025)(Barbon et al., 2021).

The integration of indigenous knowledge with modern approaches offers practical solutions when blended forms of knowledge are developed to address the rapid pace of contemporary climate change (Son et al., 2021). However, more information is needed on the adaptive potential of nature-based actions rooted in traditional practices, such as shade trees, live fences, and live barriers, which could help farmers improve farm sustainability and resilience (Ruiz-Garcia et al., 2021).

3. Methodology

This study employed a descriptive research design using a mixed-method approach that combined quantitative and qualita tive techniques. The descriptive method was chosen because it allows for an accurate portrayal of existing conditions, behaviors, and perceptions of smallholder farmers regarding their adaptation to climate change. Through this approach, the study aimed to describe and analyze the adaptation strategies, challenges, and support needs of farmers in Mankayan, Benguet, in order to generate insights that could inform climate-resilient and sustainable agricultural development. The combination of quantitative and qualitative data provided a comprehensive understanding of farmers' climate adaptation practices and the factors influencing their resilience.

The research was conducted in Mankayan, Benguet, the northernmost municipality of the province, located at approximately 16°52′ north latitude and 120°47′ east longitude, about 104 kilometers by road from Baguio City and roughly 98 kilometers from the Benguet Provincial Capitol in La Trinidad, based on data from the Municipal Planning and Development Office (MPDO). Data collection was carried out from July 1, 2025 to September 30, 2025, using a combination of face-to-face interviews and online survey administration through Google Forms, enabling participation from farmers with varying levels of accessibility and ensuring comprehensive coverage during the rainy season when climate-related challenges are most pronounced.

The respondents of the study were smallholder farmers actively engaged in agricultural production in Mankayan, Benguet. The sample size was determined using Yamane's (1967) formula, $n = N / (1 + N(e)^2)$, which provides a simplified method for calculating sample size from a known population. Based on data from the Municipal Agriculture Office (2023), there are 9,248 registered smallholder farmers in Mankayan. Using a 5% margin of error at a 95% confidence level, the computed sample size was 383. To ensure adequate representation across

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barangays and farming types, and to account for potential non-responses, the sample was increased to 397 farmers, which served as the final sample size for the study.

Data were collected using a structured questionnaire developed by the researcher, comprising both closed- and open-ended items designed to capture information on farmers' demographic characteristics, adaptation and coping strategies, support requirements, and perceived challenges associated with climate change. The inclusion of open-ended questions enabled respondents to share personal experiences and recommendations, thereby enriching the qualitative insights of the study. Data collection was conducted over a two-month period through face-to-face interviews and survey administration by trained enumerators to ensure comprehension across varying literacy levels. Participation was voluntary, informed consent was obtained prior to data collection, and all responses were treated with strict confidentiality.

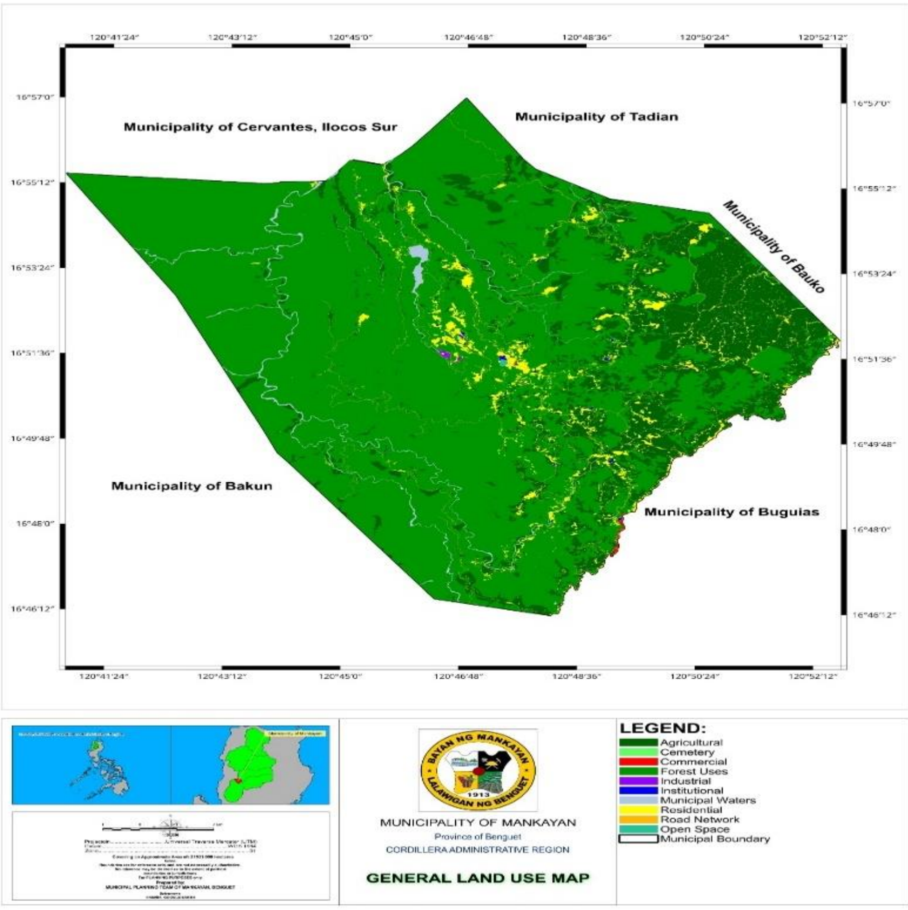

Figure 1. Mankayan Existing Resource Map Use (Location of the Study)(Source: Mankayan MPDO)

Quantitative data collected from the survey were analyzed using descriptive statistical tools, including frequency counts, percentages, and mean rankings, to identify the most common adaptation strategies, challenges, and types of support needed by farmers. These methods allowed the researcher to summarize and interpret numerical data effectively. In addition, qualitative data from open-ended responses were analyzed using thematic analysis to identify recurring themes, insights, and contextual explanations related to farmers' experiences and perceptions. The integration of both quantitative and qualitative findings strengthened the overall analysis and provided a holistic view of the farmers' climate resilience.

The theoretical framework for this study is be grounded in a synthesized approach, primarily drawing upon the Sustainable Livelihoods Framework (SLF), the Adaptive Capacity Framework, and the Knowledge Systems Framework, to comprehensively analyze the challenges and adaptation strategies of smallholder farmers in Mankayan, Benguet. The SLF provided a holistic lens to understand the various capital assets (human, social, natural, physical, and financial) that shape farmers' vulnerabilities and choices, allowing for an in-depth examination of how these assets are affected by climate change and how they influence livelihood strategies and outcomes in the context of Mankayan. Complementing this, the Adaptive Capacity Framework focused on evaluating the determinants that enable or hinder farmers' ability to adjust to climate change impacts, dissecting the socio-economic, technical, and institutional factors influencing their adaptive potential and identifying critical barriers such as limited financial resources, inadequate information, and structural constraints. Finally, the Knowledge Systems Framework is employed to investigate the crucial role of both indigenous knowledge (IK) and modern scientific knowledge in farmers' adaptation practices, emphasizing how their integration, dissemination, and utilization can enhance resilience, while also addressing the challenges posed by the rapid pace of climate change and the need for collaborative, context-specific learning platforms to bridge knowledge gaps and inform effective interventions.

4. Discussion

This study examines the climate change adaptation strategies, challenges, and support needs of smallholder farmers in Mankayan, aiming to enhance their climate resilience and promote sustainable agricultural livelihoods. The analysis begins by documenting the range of adaptation and coping practices that farmers currently employ practices that blend indigenous knowledge, experience-based wisdom, and emerging innovations shaped by necessity and resource limitations.

Beyond the practices themselves, the study explores the type of support that influence farmers' capacity to adapt particularly the support they prefer most and the constraints that hinder their progress to other studies, this research seeks to propose practical, evidence-based policy directions and community-driven interventions to build a farming system in Mankayan that honors the farmers' ingenuity, strengthens their collective capacity, and supports the long-term sustainability of rural life in the highlands.

4.1 Climate Change Adaptation and Coping Strategies of Smallholder Farmers in Mankayan

Table 1 summarizes the demographic profile of 397 farmer-participants in Mankayan particularly their age, gender, educational attainment and years of farming experience together with their associated category, frequency and percentage. When it comes to age distribution, most participants (64.74%) belong to the 25–54 age group, indicating that farming in the community is largely driven by individuals in their economically productive years.

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Meanwhile, the smaller 15–24 cohort (8.56%) reflects the growing concern that younger generations are shifting away from agriculture- an issue widely documented in Asian agriculture, where youth involvement remains low (Ahearn & Newton, 2020). This age trend may indicate potential future labor shortages and the need for youth-focused agricultural programs.

Table 1. Demographic Profile of Farmer-Participants in Mankayan

Profile	Category	Frequency (f)	(%)
Age	15–24 years old	34	8.56
	25–54 years old	257	64.74
	55–64 years old	86	21.66
	65 and above	20	5.04
Gender	Male	154	38.79
	Female	243	61.21
Educational Attainment	No Formal Education	15	3.78
	Elementary	99	24.94
	High School	141	35.52
	Vocational	65	16.37
	Tertiary/College	71	17.88
	Postgraduate	6	1.51
Years Engaged in Farming	0–5 years	72	18.14
	6–10 years	110	27.71
	11–15 years	84	21.16
	16–20 years	54	13.61
	Above 20 years	77	19.40
		397	100

With regard to gender distribution, women represent 61.21% of the respondents, showing a clear feminization of agricultural labor. This is consistent with research highlighting that in many rural communities, women increasingly take on farm-related roles due to male out-migration and diversification of income sources (De Schutter, 2013). This implies that agricultural programs must integrate gender-responsive support, acknowledging women's expanded role in production, management, and decision-making.

In terms of educational attainment, most farmers have High School education (35.52%) or Elementary education (24.94%), while a notable segment (17.88%) attained Tertiary education and only 1.51% reached postgraduate studies. Lower educational attainment among a majority may limit the adoption of technologically advance farming (Feder et al., 2010). This trend mirrors nation-wide statistics showing that rural farmers often have limited formal education but possess substantial experiential knowledge. Moreover, the modest presence of college-educated farmers could serve as catalysts for innovation adoption and community training adoption and community training initiatives.

Lastly, years engaged in farming reveals a significant number of farmers (81.86%) with long-term experience (6–20 years and above). This underscores deep-rooted agricultural heritage. Meanwhile, the sizeable proportion of new entrants (0–5 years; 18.14%) indicates sustained interest in farming despite climate-related challenges.

Hence, support services must be varied to cater to both beginner farmers and long-established practitioners. Experienced farmers may require advanced agri-tech training, while new farmers benefit more from foundational capacity-building. Knowler and Bradshaw (2007) emphasize that years of farming experience strongly influence technology preference, risk management, and adaptation strategies, supporting the patterns seen in this dataset.

Overall, the demographic structure of the 397 farmers shows a farming population that is generally middle-aged and female-dominated mostly with basic to secondary education composed of both new and experienced farmers. These demographic characteristics shape how farmers adopt climate adaptation strategies, technologies, and extension programs. They also determine opportunities and barriers in achieving sustainable agricultural resilience especially in the context of changing climate.

On the other hand, Table 2 summarizes ten distinct adaptation and coping strategies reported by 397 smallholder farmers in Mankayan to enhance resilience against climate variability. It presents the number and proportion of respondents who reported each strategy and ranks strategies by prevalence. At the top of the distribution are crop rotation (377, 94.96%) and use of pesticides or fertilizers (367, 92.44%) that are nearly widespread among respondents while protected cultivation (greenhouse or tunnels; 3, 0.8%) and income diversification (1, 0.3%) are scarcely reported.

The pattern of results implies that farmers prioritize accessible, low-cost measures that directly buffer productivity and risk (rotation, multi-cropping, scheduling), while also relying heavily on agrochemical inputs to maintain yields under stress. Water security ranks highly, consistent with an experiential priority to manage rainfall unreliability. Less capital-intensive, locally transmitted practices (traditional practices, GAP) are reasonably well adopted, whereas interventions with higher up-front costs, such as greenhouse production or formal livelihood diversification, show minimal uptake.

Table 2. Smallholder Mankayan Farmers' Climate Change Adaptation & Coping Strategies

Adaptation and Coping Strategy	Frequency	Percentage	Rank
Crop Rotation	377	94.96	1
Use of Pesticides/ Fertilizers	367	92.44	2
Crop Scheduling/ Programming	232	58.44	3
Water Storage/ Irrigation	230	57.93	4
Traditional Practices	225	56.68	5
Multi-cropping/ Mixed Cropping	220	55.42	6
Good Agricultural Practices	200	50.38	7
Organic Farming	147	37.03	8
Greenhouse/ Tunnels	3	0.76	9
Diversify Income Sources	1	0.25	10

**Multiple responses were recorded per respondent; thus, total percentages exceed 100%.*

The predominance of crop rotation and multi-cropping can be attributed to their affordability, ease of implementation, and proven agronomic benefits. These practices interrupt pest and disease cycles, maintain soil fertility, and stabilize yields across seasons. The Intergovernmental Panel on Climate Change (IPCC, 2022) recognizes such cropping system adjustments as primary adaptation measures among smallholder farmers globally. Crop rotation is especially effective because it simultaneously addresses multiple climate-related challenges. For example, farmers in other areas replace water-intensive crops like rice with drought-tolerant varieties such as maize or root crops during dry seasons (Johnson et al., 2023), thereby ensuring continued productivity despite rainfall irregularities.

Moreover, crop rotation serves as a cornerstone of integrated farming systems that combine multiple adaptation strategies. Traditional approaches often integrate rotation with mixed cropping and crop-livestock systems, creating synergistic effects that enhance resilience to climate variability (Okoronkwo et al., 2024). These integrated systems diversify production, improve soil structure, and reduce pest and disease outbreaks intensified by climate stress. The global relevance of crop rotation is evident in studies from Southeast Asia and Africa, where it consistently forms part of comprehensive adaptation portfolios that include soil conservation and water harvesting practices (Hein et al., 2019; Shrestha et al., 2018; Mwalusepo et al., 2015).

Parallel to the adoption of crop-based strategies, the high prevalence of pesticide and fertilizer use reflects farmers' immediate response to livelihood pressures and environmental stress. When unpredictable weather threatens yields, farmers tend to intensify input use to secure production and meet household and market demands (Acevedo et al., 2020). Studies consistently show that chemical input adjustments rank among the most common adaptation strategies globally, with adoption rates exceeding 60% in many regions (He et al., 2019; Mamun et al., 2021). This trend underscores the reliance on agrochemical inputs as a coping mechanism against declining soil fertility, pest infestations, and disease outbreaks exacerbated by climate change (Hein et al., 2019; Shrestha et al., 2018).

While input intensification provides short-term yield protection, its adoption also represents a broader risk management strategy. Farmers often combine increased fertilizer and pesticide applications with complementary measures such as crop rotation, improved seed varieties, and diversified planting patterns (Yeleliere et al., 2023). Such combinations create adaptive farming systems capable of mitigating multiple risks simultaneously. Furthermore, research indicates that socio-demographic factors such as age, education, and experience significantly influence the likelihood of adopting these practices, with more experienced and better-educated farmers demonstrating greater responsiveness to climate variability (Mamun et al., 2021).

In addition to these input-based adaptations, crop scheduling and planting date adjustments have emerged as another central strategy among smallholder farmers in Mankayan. These measures allow farmers to align crop growth stages with shifting rainfall and temperature patterns. Empirical evidence from diverse agricultural regions indicates that over 90% of farmers adjust their planting calendars in response to climate variability (Sekaranom et al., 2021; Kommu, 2022). Although calendar shifts may range from two weeks to a month, their

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successful implementation requires accurate weather forecasting and adaptive planning based on local environmental conditions. When integrated with other practices such as crop diversification, soil conservation, and improved irrigation, crop scheduling becomes a powerful component of climate-resilient farming systems (Jiao et al., 2020).

On the other hand, despite the proven benefits of advanced and infrastructure-based adaptation methods, the data reveal that Mankayan's smallholder farmers rarely adopt them. Protected cultivation technologies, such as greenhouses or tunnels, are used by less than 1% of respondents, and income diversification strategies are even rarer at 0.3%. These approaches can significantly reduce exposure to weather extremes and enhance income stability, yet their limited adoption underscores persistent socio-economic and institutional barriers.

The low uptake of capital-intensive strategies stems primarily from financial constraints. Many smallholder farmers lack access to credit, agricultural insurance, or government subsidies that could support investment in modern technologies (Chourad et al., 2024). Beyond economic challenges, farmers also face structural barriers including inadequate infrastructure, limited access to markets, and insufficient extension services. These constraints create a dependence on low-cost traditional practices, perpetuating a cycle where resource limitations hinder the transition toward more sustainable and technologically advanced forms of adaptation. Comparable findings in other rural contexts confirm that infrastructure-dependent strategies, such as irrigation and greenhouse systems, remain inaccessible to the majority of smallholders (Olabanji et al., 2021).

The adaptation landscape of smallholder farmers in Mankayan reflects a practical balance between traditional knowledge and the necessity of immediate survival under changing climatic conditions. Farmers predominantly rely on low-cost, experience-based strategies that offer short-term protection and gradual resilience building. Yet, the minimal adoption of advanced, investment-driven methods highlights a critical adaptation gap, one rooted not in lack of awareness, but in systemic financial and institutional constraints. Addressing these barriers through improved access to capital, infrastructure, and extension services is therefore essential to empower Mankayan's farming communities to move from coping to sustainable climate resilience.

4.2. Type of Support and Support Needs that Influence Farmers' Capacity to Adapt to Climate Change

The next tables discuss the type of support (Table 3) that smallholder farmers need and their preferred needs (Table 4) should the prevailing type of support made accessible. Both present the indicators with their associated mean ranks as perceived by the respondents (1 being the most essential or preferred).

Table 3 presents the mean ranks of various types of support that farmers in Mankayan identified as most needed to enhance their capacity to adapt to climate change. As gleaned from the table, financial support or loans (2.37) rank as the most needed type of assistance among smallholder farmers in Mankayan. This highlights the significant socio-economic constraints that limit farmers' ability to invest in climate-resilient practices. Without adequate capital, even technically capable farmers remain vulnerable to losses caused by erratic rainfall and temperature fluctuations.

Market access (2.62) follows closely, suggesting that farmers recognize the importance of fair and stable pricing systems to sustain adaptive investments. Improved market linkages, value-chain integration, and buyer relationships can incentivize farmers to maintain productivity despite climate-induced risks.

Government or NGO programs (3.60) rank lowest, suggesting either insufficient awareness of existing programs or perceived inefficiency in their implementation. While institutional support exists, its impact is limited if not paired with direct financial and technical interventions.

Table 3. Types of Support Needed to Enhance Farmers' Adaptive Capacity

Type of Support Needed	Mean Rank	Rank
Financial Support / Loans	2.37	1
Market Access (buyers, fair prices)	2.62	2
Access to Modern Farming Tools / Technology	3.01	3
Training and Education	3.41	4
Government or NGO Programs	3.60	5

The prominence of financial support in the rankings reflects the economic realities of smallholder farming in mountainous Benguet, where farmers operate under limited landholdings, irregular rainfall patterns, and volatile vegetable markets. These challenging conditions require sufficient liquidity to purchase inputs, maintain equipment, and diversify crops. This aligns with the findings of Maziya et al. (2024), who reported that access to financial and market-related support directly enhances household food security and resilience among smallholder farmers.

The result also corresponds with Yeleliere et al. (2023), who found that access to credit and farm insurance significantly improves farmers' capacity to purchase essential inputs such as drought-tolerant seeds, fertilizers, and pesticides, thereby enhancing climate resilience. Similarly, Chourad et al. (2024) emphasize that financial capital is a critical determinant of climate adaptation, as it enables investment in irrigation systems, protective infrastructure, and other adaptive technologies. The Mankayan data thus reinforce the broader empirical consensus that financial access serves as the cornerstone of agricultural adaptation, a finding echoed by Mustapha et al. (2020) and Abraham and Fonta (2018).

However, consistent with Omokaro (2025), the results also suggest that farmers in Mankayan face systemic barriers to accessing credit or insurance, owing to the absence of suitable financial products and policy gaps in formal institutions. These constraints mirror global challenges where smallholder farmers, despite their central role in food production, remain disproportionately affected by limited access to credit, weak subsidy programs, and poor financial inclusion. The findings affirm that poverty and limited capital are among the most significant determinants of adaptive capacity, preventing smallholders from investing in climate-smart technologies.

Beyond enabling input purchases, financial access empowers farmers to implement comprehensive adaptation strategies. As supported by Yeleliere et al. (2023), financially capable farmers are more likely to diversify their livelihood activities—through mixed farming, petty trading, and agribusiness ventures—thereby reducing vulnerability to climate shocks. These findings illustrate that increased financial capital does not merely buffer risk; it also stimulates innovation and diversification, both essential for sustainable adaptation.

Following financial assistance, market access (mean rank = 2.62) ranked as the second most important form of support. This result suggests that farmers recognize the role of fair and stable markets in sustaining long-term adaptive practices. Improved market linkages enable farmers to recover investments made in resilient production systems and motivate continued innovation despite climatic uncertainty.

This observation is consistent with findings from Omokaro (2025) and Solomon et al. (2018), who reported that farmers with better market connections are more likely to adopt high-value crops and diversify income sources, thus reducing their vulnerability to climate-induced risks. Conversely, as noted by Akintonde et al. (2016), poor infrastructure and limited market integration often restrict smallholders from accessing profitable markets. In the Mankayan context, volatile vegetable prices and limited transport infrastructure exacerbate these barriers, underscoring the necessity of market-based interventions alongside financial support.

These findings collectively reveal that financial and market access are mutually reinforcing: credit enables production, while market access ensures profitability and sustainability. Together, they form the economic foundation for effective climate adaptation among smallholder farmers.

Government or NGO programs (mean rank = 3.60) ranked lowest among the identified support types. This result indicates that while institutional support exists, it is either not effectively reaching the intended beneficiaries or is perceived as insufficiently responsive to farmers' immediate needs. Similar findings were reported by Myeni et al. (2020), who observed that limited awareness and inefficiencies in program implementation hinder the effectiveness of institutional adaptation initiatives. This aligns with Kommu (2022), who identified policy gaps in formal institutional systems, such as weak pricing policies, limited subsidies, and inadequate extension services, as key barriers to climate adaptation. The Mankayan results reflect these structural deficiencies, suggesting that institutional efforts have yet to translate into tangible benefits for smallholder farmers. Extension services, however, emerge as a potentially transformative mechanism for bridging these gaps. As emphasized by Myeni et al. (2020) and Chourad et al. (2024), extension services play a critical role in disseminating climate information, facilitating access to microfinance institutions, linking farmers with government subsidies or climate funds, and promoting sustainable agricultural practices. Through these functions, extension agents can help farmers overcome both informational and financial barriers to adaptation.

Despite these potential benefits, Omokaro (2025) and Abraham et al. (2018) report that approximately 96% of farmers seeking credit are unable to access it, largely due to financial exclusion and weak institutional linkages. This underscores the urgent need for integrated policy reforms that strengthen financial inclusion, improve extension delivery, and align government and NGO efforts with localized needs. Government support, therefore, should prioritize the creation of an enabling policy environment incentivizing the development and adoption of climate-resilient crop varieties, funding agricultural research, and streamlining the approval of new technologies (Lopes, 2023). As Ceccarelli et al. (2022) suggest, the development and dissemination of climate-resilient crop varieties tailored to smallholder needs can significantly improve food security and adaptive capacity, particularly when coupled with supportive credit and market systems.

On the other hand, Table 4 presents the mean ranks of nine adaptation and mitigation practices that smallholder farmers in Mankayan identified as priorities should institutional and financial support become available.

Table 4. Prioritized Practices to be Adopted if Support Becomes Available

Practices	Mean Rank	Overall Rank
Organic or Sustainable Farming	3.43	1
Good Agricultural Practices (GAP)	3.85	2
Water Harvesting and Efficient Irrigation	4.57	3
Soil Conservation (Contour Farming, Composting)	4.64	4
Improved Post-Harvest Handling and Storage	5.03	5
Climate-Smart Technologies (e.g., Drought-Resistant Seeds, Precision Farming)	5.07	6
Digital Tools for Farming (Apps, Online Markets)	5.50	7
Agroforestry (Trees with Crops and Livestock)	5.65	8
Renewable Energy (Solar Drying, Solar Pumps)	6.09	9

The findings revealed that organic and sustainable farming (mean rank = 3.43) emerged as the most preferred practice, followed by Good Agricultural Practices (GAP) (3.85). Farmers recognize the benefits of reducing chemical dependence, improving soil structure, and increasing long-term productivity through composting and natural pest control. This practice also aligns with local cultural values of stewardship and ecological balance, particularly in Benguet's highland communities where traditional organic methods have persisted alongside modern interventions. Meanwhile, water harvesting and efficient irrigation ranked third (4.57), underscoring water management as a continuing adaptation priority.

The use of digital tools for farming (5.50) and agroforestry (5.65) ranks lower, suggesting that while farmers acknowledge their benefits, digital literacy and long-term returns from agroforestry may make these less immediately attractive. Renewable energy technologies (6.09) are ranked lowest, likely because they require substantial investment and infrastructure support. The preference for organic and sustainable farming reflects farmers' experiential knowledge and adaptation to resource constraints. This aligns with empirical evidence from the Food and Agriculture Organization (FAO, 2013), which highlights that resource-conserving practices allow smallholders to maintain yields and reduce vulnerability. Good Agricultural Practices (GAP) also emerged as top priorities, demonstrating that farmers tend to value approaches that are both practical and affordable. Similarly, the emphasis on water and soil management is consistent with studies in upland regions showing that erosion control and irrigation efficiency are critical to building agricultural resilience (Lasco et al., 2015). These patterns suggest that farmers gravitate toward practices that rely more on ecological processes and local knowledge than on external inputs.

Connecting to this, the lower ranking of renewable energy and digital tools may be attributed to technological and financial barriers. Smallholder farmers often lack access to credit and technical assistance necessary for adopting innovations such as solar irrigation or mobile-based marketing. This mirrors findings by Khatri-Chhetri et al. (2017), who emphasize that farmers adopt climate-smart technologies only when extension support, financing mechanisms, and enabling infrastructure are accessible. Thus, the contrast between highly preferred ecological practices and less-preferred capital-intensive technologies reveals a clear pattern: farmers prioritize adaptation options that fit within their existing constraints.

Building on these insights, the results suggest that enhancing climate change adaptation capacity among smallholder farmers requires support programs to focus first on accessible, low-cost, and knowledge-intensive practices before introducing capital-intensive technologies. Policymakers and development agencies can therefore expand training and demonstration farms for organic and sustainable farming; support community-based irrigation and soil conservation efforts; strengthen post-harvest and value chain management to reduce losses; and only then gradually introduce digital and renewable innovations through cooperative-based pilots. Such a phased, farmer-centered approach ensures both immediate adaptation and longer-term transformation toward climate-resilient agriculture.

This prioritization is further supported by extensive evidence on the effectiveness of resource-conserving agricultural practices. These methods help smallholder farmers sustain yields and reduce susceptibility to climate- and market-related challenges, while also enabling developing countries to increase food production without depleting soil and water resources. Practices such as organic fertilization, minimal soil disturbance, residue incorporation, terracing, water harvesting, and agroforestry not only improve yields but also reduce greenhouse gas emissions and increase carbon storage. A review of 160 studies on sustainable land management (SLM) practices found generally positive yield effects, although outcomes vary by practice and agro-climatic conditions (Branca, 2013). For example, cover crops, organic fertilizer, mulching, and water harvesting consistently perform well, whereas improved fallows, terraces, minimum tillage, and live fences show more mixed results. These findings reinforce why farmers often adopt such practices in integrated "packages" rather than individually.

The importance of soil and water conservation is especially pronounced in upland regions, creating a direct link to the earlier emphasis on GAP and sustainable land management.

Upland farms, located on steep and erosion-prone terrains, require interventions that stabilize soils and improve water availability. Systems like the System of Rice Intensification (SRI), an agroecological approach that optimizes water, soil, nutrient, and plant management have demonstrated large yield gains while reducing dependence on agrochemicals and lowering production costs (Uphoff, 2007). In addition to increasing productivity, such systems decrease household vulnerability by reducing reliance on purchased inputs. Moreover, improved soil and water conservation also prevents land degradation and enhances resilience to climate change. In the Philippines and other upland areas, farmers consistently identify reliable irrigation as a top adaptation priority, underscoring again the central role of resource-conserving strategies. These adaptation challenges and priorities take on even greater urgency when considering the broader vulnerability of smallholder farmers globally. Numbering 450–500 million and representing 85% of the world's farms, smallholders make up about half of the global hungry population. Their livelihoods are highly exposed to risks such as pest outbreaks, extreme weather, and market shocks all of which are expected to intensify under climate change. The case of Madagascar illustrates these vulnerabilities starkly, with farmers constituting 70% of the population, 81% living below the poverty line, and most households facing chronic food insecurity. This broader global context reinforces why cost-effective, locally grounded adaptation strategies are essential.

Given these challenges, support programs must prioritize accessible, low-cost, and knowledge-intensive practices echoing the earlier discussion on farmer preferences and constraints. Strengthening extension services becomes essential for disseminating technical information and promoting best practices related to planting, harvesting, and crop storage. Such services also encourage the uptake of improved crop management strategies and diversification, adaptation options that are both inexpensive and scalable through farmer-to-farmer learning. In parallel, investments in smallholder infrastructure, such as localized irrigation systems and storage facilities, can significantly improve production and reduce post-harvest losses. Moreover, establishing and reinforcing both formal and informal safety nets is crucial for helping farmers withstand climate and market shocks. Mobile payment systems, for instance, offer secure and affordable financial access, while village savings and loan groups help households manage lean seasons and extreme events. Protecting natural ecosystems like forests, wetlands, and rivers also provides essential safety buffers and livelihood resources, especially during post-disaster recovery.

These interconnected findings underscore the need for a phased, farmer-centered approach to climate-resilient agriculture, one that begins with knowledge-based, resource-conserving practices and gradually integrates more advanced technologies as capacities strengthen. This integrated strategy not only addresses farmers' immediate adaptation needs but also lays the foundation for long-term agricultural transformation.

4.3 Barriers Affecting Smallholder Farmers and Opportunities for the Adoption of Sustainable and Climate-Resilient Agricultural Practices

Table 5 presents the major themes of barriers that emerged from farmers' responses regarding the primary challenges they face in agricultural production. It enumerates the common challenges met by respondents together with their associated rank, sample responses of challenges encountered, and perceived solutions. The 397 smallholder farmers of Mankayan consistently reported challenges that reflect both climatic and socio-economic vulnerabilities typical of highland vegetable-producing communities.

Table 5. Challenges Encountered and Proposed Solutions by Smallholder Farmers

Themes	Frequency (n)	Percentage (%)	Sample Response of Challenges Encountered	Sample Response of Perceived Solution
1.Climatic Hazards and Weather Extremes	355	89.4	The changing climate has led to irregular rainfall, prolonged droughts, and unexpected floods, which make it difficult to plan crops and manage resources	Reliable irrigation systems to mitigate the impacts of drought and ensure consistent crop production through financial assistance, modern farming and training
2.Market Instability and Low Vegetable Prices	331	83.4	Fluctuating market prices, dominance of middlemen, poor market access, and price manipulation	Market fixed prices that will not go below production cost, a win-win prices for farmers and consumers
3.High Cost of Farm Inputs and Limited Capital	309	77.8	Rising prices of fertilizers, pesticides, and seeds; difficulty in accessing production loans	Financial support, farming materials and low interest loans
4.Lack of Irrigation and Farm Infrastructure	241	60.7	Water scarcity during dry season, poor drainage and inaccessible farm-to-market roads	Provision of tank for irrigation and farm machineries for sustainable water source
5.Soil Problems and Degradation	173	43.6	Soil-borne diseases (clubroot, kuyos), erosion, and fertility loss from chemical overuse	Trainings and modern farm facilities and machineries
6.Inadequate Institutional Support and Delayed Assistance	118	29.7	Delayed insurance claims, limited access to interventions and extension services	Creation of laws that will protect and support farmers especially smallholder; Participatory planning

**Multiple responses were recorded per respondent; thus, total percentages exceed 100%.*

The top-ranked challenge, climatic hazards (355, 89.4 percent), underscores the direct and intensifying impact of climate change on highland farming systems. Farmers frequently cited typhoons, prolonged rains, frost, and pest and disease outbreaks, all of which result in crop destruction, delayed planting schedules, and income loss. The steep and erosion-prone mountain topography of Mankayan further amplifies these hazards, leading to landslides, soil nutrient loss, and reduced arable land. These findings align with the IPCC (2022), which emphasizes that increased rainfall intensity and more frequent typhoons in Southeast Asia disproportionately affect smallholder farmers in upland agroecosystems. Similar observations were reported by Cinco et al. (2016), who found that Philippine highland agriculture is among the most vulnerable to extreme-weather-driven crop failures.

Market instability (331, 83.4%) emerged as the second most pressing challenge. Respondents described "unfair prices" and "middlemen control" as persistent sources of financial vulnerability. These price distortions weaken farmers' bargaining power and create dependency on traders who dominate the supply chain. This aligns with the findings of Dawe (2020), who reported that smallholder vegetable farmers in the Cordillera region often receive less than half of the retail price due to market intermediaries. The implications are significant: unstable markets not only reduce profitability but also discourage farmers from investing in climate-resilient technologies or adopting long-term sustainable practices.

The high cost of farm inputs (309, 77.8%) ranked third. Many farmers expressed those fertilizers, pesticides, and seeds were "too expensive," making sustainable farming difficult without financial backing or cooperatives. According to World Bank (2019), reducing input costs and addressing market inefficiencies are essential to enabling smallholders to adopt climate-resilient and resource-efficient practices. Rising global fertilizer prices, driven by supply-chain disruptions and geopolitical factors, further intensify this burden on remote farming communities.

Compounding these constraints are limited irrigation and poor infrastructure (241, 60.7%), which hinder year-round production and reduce the capacity of farmers to adapt to seasonal climate variations. Without sufficient water storage, irrigation facilities, or access roads, farmers remain vulnerable to both droughts and excessive rainfall. Numerous Philippine studies (e.g., David, 2021) confirm that inadequate rural infrastructure remains a critical bottleneck to productivity and market access in upland agriculture.

Finally, soil degradation (173, 43.6%) and weak institutional support (118, 29.7%) reflect deeper structural and governance-related barriers. Farmers pointed to chemical dependence, declining soil fertility, delayed insurance payouts, and limited responsiveness from local government units (LGUs) as persistent challenges. These issues resonate with SEARCA (2020), which noted that fragmented extension services and bureaucratic delays significantly hinder the delivery of agricultural assistance in highland communities.

The dominance of climate-related challenges can be attributed to Mankayan's exposure to extreme weather and its high reliance on open-field vegetable production, making farmers acutely sensitive to climatic shocks. Economic barriers such as price volatility and rising input costs stem from systemic market dependency, lack of cooperative consolidation, and weak access to financial instruments. Institutional gaps, on the other hand, reveal a fragmented extension system, insufficient insurance mechanisms, and bureaucratic bottlenecks that delay the delivery of crucial support.

These findings reinforce a growing body of evidence that climate resilience, market reform, and institutional strengthening must be pursued simultaneously. For example, the Food and Agriculture Organization (FAO, 2021) highlights that farmers facing both climatic stress and market failures are less likely to adopt climate-smart practices, creating a cycle of vulnerability. Similarly, Philippine government reports (DA, 2023) emphasize that upland farmers' exposure to climate extremes is exacerbated by limited access to infrastructure and financial safety nets.

Hence, it is time to strengthen climate risk management by expanding crop insurance coverage, enhancing emergency recovery funds, and ensuring timely payout mechanisms. Local ordinances protecting farmers from predatory trading and establishing minimum pricing for highland crops need to be institutionalized. Moreover, intensified information campaigns on crop diversification, integrated pest management (IPM), and soil rehabilitation would help address both climatic and soil-related risks. The establishment of irrigation and drainage systems is likewise critical to enhancing water availability and reducing erosion.

At the community level, strengthening farmer cooperatives for collective marketing can counter middlemen's influence and improve price stability. Additionally, community-based disaster preparedness and recovery protocols tailored to specific farming zones can mitigate the impacts of extreme weather events. Implementing these strategies would not only address the immediate challenges identified by Mankayan farmers but also contribute to long-term agricultural resilience and rural development.

4.4 Proposed Policy Directions and Mankayan-Based Interventions to Improve Smallholder Farmers' Climate Change Resilience and Agricultural Sustainability

Table 6 displays the themes derived from the responses of 397 smallholder farmers in Mankayan concerning proposed policy directions and community-based interventions aimed at improving climate change resilience and agricultural sustainability. Farmers' responses were analyzed thematically, with frequencies converted into percentages and ranks to identify priority concerns. The results reveal a convergence between local experiences and broader development challenges documented in Philippine highland agriculture, demonstrating how both climatic and socio-economic factors shape farmers' preferred interventions.

The findings show that market stabilization and price regulation (122, 30.73%) emerged as the most urgent concern among Mankayan farmers. Respondents expressed ongoing frustrations over volatile vegetable prices, exploitative intermediaries, and the absence of fixed pricing mechanisms. Repeated calls for a "minimum price" for highland vegetables and "direct links to institutional buyers" reflect a demand for stronger market governance. This illustrates the structural vulnerability of the local agricultural economy, where farmgate prices are externally dictated, leaving producers with minimal profit margins. These sentiments are consistent with the findings of the Philippine Institute for Development Studies (PIDS, 2021), which identified trader dominance and weak farmer bargaining power as major constraints in the vegetable value chain in Northern Luzon. Similarly, FAO (2020) notes that price instability is one of the most persistent obstacles limiting smallholder resilience in developing countries.

Infrastructure development (98, 24.68%), particularly farm-to-market roads (FMRs), irrigation systems, and drainage facilities, ranked second. These investments are vital in Mankayan's steep and erosion-prone terrain, where flooding, landslides, and water scarcity significantly constrain agricultural productivity. Farmers' calls for "concreting of FMRs" and "construction of irrigation tanks for upland farms" reflect a recognition of how infrastructure deficits intensify climate risks. This aligns with observations by David (2021) and the Department of Agriculture (DA, 2023), which emphasize that upland infrastructure is a prerequisite for climate-resilient agriculture, enabling mobility during extreme weather events and reducing postharvest losses.

Capacity building and continuous training (83, 20.90%) ranked third, highlighting farmers' openness to adopting modern, smart, and sustainable agricultural practices. Enthusiasm for "seminars on pest management, GAP, and smart farming" indicates a broader shift toward knowledge-based adaptive strategies. This reflects a pattern reported in SEARCA (2020), which noted increasing farmer interest in climate-smart agriculture when training programs are locally contextualized and regularly delivered. The Mankayan farmers' responses imply a movement away from reactive decision-making toward proactive, information-driven adaptation.

Institutional and financial support (62, 15.62%) followed, revealing systemic governance gaps. Calls for "fair distribution of interventions," "accessible loans," and "machinery provision" point to long-standing issues such as bureaucratic delays, inequitable targeting, and insufficient formal credit access. These concerns mirror national-level analyses (e.g., World Bank, 2019; PIDS, 2022), which argue that the effectiveness of agricultural policies in the Philippines is undermined by fragmented implementation and limited rural financial inclusion. Meanwhile, environmental and waste management concerns (51, 12.85%) show increasing ecological awareness, particularly regarding pesticide container disposal and watershed protection. Studies by Rola et al. (2018) corroborate this finding, noting that highland farmers increasingly recognize the long-term impacts of agrochemical misuse and environmental degradation on soil productivity and water quality.

Other notable but lower-ranked themes include postharvest and processing facilities (38, 9.57%), promotion of GAP and organic practices (34, 8.56%), agri-tourism and livelihood diversification (23, 5.80%), and governance and policy implementation (20, 5.04%). Collectively, these indicate that farmers understand sustainability to be multi-dimensional, extending beyond production to value addition, environmental conservation, economic diversification, and participatory governance. These patterns can be attributed to Mankayan's unique agroecological and economic context: its mountainous terrain increases climate exposure; its dependence on commercial vegetable production heightens market vulnerability; limited credit and infrastructure constrain adaptability; and fragmented institutional support forces farmers to rely on their own coping mechanisms. The expressed preference for capacity building and ecological protection further suggests a cultural and generational shift toward collective, informed adaptation.

Table 6. Proposed Evidence-Based Policy and Community-Based Interventions to Strengthen Smallholder Farmers Resilience and Sustainability

Themes	Frequency (n)	Percentage (%)	Rank	Sample Responses
1.Market Stabilization and Price Regulation	122	30.73	1	Set fixed/minimum price for vegetables, eliminate middlemen, link to institutional buyers
2.Infrastructure Development (Farm-to-Market Roads, Irrigation, Drainage)	98	24.68	2	Build/concrete FMRs, improve irrigation systems, construct drainage canals
3.Capacity Building and Continuous Training on Modern/Smart/Organic Farming	83	20.90	3	Conduct seminars, GAP and organic farming, pest management, smart agriculture
4.Institutional and Financial Support	62	15.62	4	Provision of funds, loans, subsidies, and equal distribution of interventions
5.Waste Management and Environmental Protection	51	12.85	5	Proper disposal of pesticide containers, protect watersheds, enforce zoning
6.Postharvest and Processing Facilities	38	9.57	6	Build cold storage, processing centers, and postharvest facilities
7.Promotion of GAP, Organic, and Sustainable Agriculture	34	8.56	7	Apply GAP standards, adopt organic methods, promote sustainable farming
8.Promotion of Agri-Tourism and Livelihood Diversification	23	5.80	8	Promote agri-tourism, introduce livestock and non-vegetable livelihood
9.Governance and Policy Implementation	20	5.04	9	Monitoring, enforcement of solid waste ordinances, fair intervention access

**Multiple responses were recorded per respondent; thus, total percentages exceed 100%.*

The findings have significant implications for agricultural development planning and policy formulation in Mankayan. The prominence of market stabilization and price regulation underscores the urgent need for institutional mechanisms that protect farmers from price shocks and predatory trading practices. Establishing a municipal price monitoring and stabilization program, along with direct farmer–buyer linkages, would align with PIDS and FAO recommendations advocating for strengthened local market governance to ensure income stability for smallholders.

Infrastructure investments, particularly FMRs, irrigation systems, and drainage canals, must be prioritized, as they serve as foundational resilience assets. As corroborated by DA (2023) and ADB (2021), infrastructure quality directly influences farmers' capacity to withstand extreme weather events, maintain consistent production cycles, and reduce losses along the value chain.The strong preference for capacity building suggests the need to institutionalize farmer field schools, regular technology demonstrations, climate information services, and extension programs on organic, smart, and climate-resilient farming. This aligns with the recommendations of SEARCA (2020), which emphasize continuous learning as a core component of climate adaptation.

Moreover, enhancing financial and institutional support systems is essential. Simplified loan schemes, climate risk insurance, and transparent allocation of interventions can reduce the systemic barriers that limit farmers' adaptive capacities. Strengthening partnerships among LGUs, DA-CAR, LandBank, and local cooperatives would promote integrated and accountable program delivery.

Environmental priorities, such as proper pesticide disposal, watershed conservation, and soil rehabilitation, should be reinforced through LGU ordinances and community-led monitoring systems. These efforts complement physical and institutional interventions by ensuring ecological sustainability, a consideration increasingly recognized in global climate frameworks (IPCC, 2022). The emphasis on postharvest facilities, livelihood diversification, and governance reforms indicates that resilience building must extend beyond production. A comprehensive approach that integrates value chain development, cooperative strengthening, youth and women participation, and public–private partnerships can enhance both economic stability and community cohesion.

These findings point toward the need for a multi-sectoral, integrated strategy for agricultural development in Mankayan, one that aligns infrastructure, market systems, environmental management, and human capacity to create a climate-resilient and sustainable rural economy.

5. Conclusion

This study demonstrates that smallholder farmers in Mankayan primarily rely on low-cost, experience-based strategies such as crop rotation, agrochemical use, traditional practices, and basic water storage to manage climate-related risks. Despite their resourcefulness, farmers face substantial constraints including climatic hazards, volatile vegetable prices, high input costs, soil degradation, and inadequate irrigation infrastructure. The findings further reveal that limited financial access, weak institutional support, and delayed agricultural assistance significantly reduce farmers' adaptive capacity. Although adoption of advanced technologies remains low, farmers express strong willingness to transition toward organic farming, Good Agricultural Practices, soil conservation, and improved irrigation systems when adequate support is available. The study confirms that economic, structural, and institutional barriers rather than lack of awareness hinder the shift from coping strategies to long-term climate resilience. Strengthening market governance, investing in climate-resilient infrastructure, improving extension delivery, and integrating indigenous knowledge are essential to building adaptive capacity in the highlands. Climate-resilient agricultural development in Mankayan requires coordinated interventions that align financial support, technical services, and community-based approaches to enable sustainable and resilient livelihoods for smallholder farmers.

5.1 Future directions

The study emphasizes the need to strengthen market governance through price stabilization mechanisms and farmer–buyer linkages to reduce vulnerability to market volatility. Investments in climate-resilient infrastructure, particularly irrigation systems, drainage facilities, and farm-to-market roads, must be prioritized to support year-round production and mitigate the impacts of extreme weather. Agricultural extension services should be expanded and institutionalized to deliver continuous training on Good Agricultural Practices, organic farming, climate-smart technologies, and localized pest management. Improving access to credit, insurance, and subsidies is essential to enable farmers to adopt adaptive technologies and manage production risks more effectively. Local governments must ensure transparent and equitable distribution of interventions while enforcing environmental regulations related to watershed protection, waste disposal, and land-use management. Community organizations and cooperatives should be strengthened to promote collective marketing, shared resources, and community-led adaptation initiatives. Research institutions are encouraged to develop localized climate-resilient crop varieties and low-cost innovations, while documenting and integrating indigenous knowledge into extension programs to support long-term resilience in Mankayan's highland farming communities.

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