

Comparative Assessment of Climate Change Impacts and Farmers' Knowledge, Attitudes, and Practices in Tropical Crops Production Systems in Davao Oriental, Philippines

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Abstract

Climate change increasingly threatens tropical crop production through erratic rainfall, rising temperatures, and more frequent extreme weather events that reduce crop productivity and disrupt farm management. This study assessed climate change impacts and farmers' knowledge, attitudes, and practices (KAP) across banana, cassava, and mixed-cropping systems in Davao Oriental, Philippines. A total of 450 farmers were surveyed using a structured questionnaire, and data were analyzed using descriptive statistics and one-way analysis of variance (ANOVA). Banana farmers perceived the greatest climate change impacts (mean = 4.35), followed by cassava (4.05) and mixed-crop farmers (3.98). Across all systems, farmers demonstrated moderate to high knowledge (3.55–3.85) and positive attitudes (3.70–4.10) toward climate change adaptation, yet adaptation practices remained only moderate (3.50–3.75). Major climate-related challenges included erratic rainfall, prolonged drought, flooding, increasing pest and disease incidence, and declining crop yields. Common adaptation strategies included crop diversification, supplemental irrigation, drought-tolerant planting materials, soil conservation, and improved pest management. However, about 20% of banana farmers reported adopting no adaptation measures. Climate

change affected not only crop productivity but also planting schedules, water management, and crop protection. Production constraints also varied by landscape, with upland banana and cassava farms experiencing greater drought and soil erosion, while coastal mixed-cropping areas were more vulnerable to flooding and saltwater intrusion. These findings underscore the need for crop-specific climate adaptation strategies, strengthened climate-smart agricultural extension, and improved access to localized climate information to enhance the resilience and sustainability of tropical crop production systems in the Philippines.

Keywords: adaptation strategies, climate-smart agriculture, climate variability, farmers' knowledge, resilience, tropical crops

Introduction

Climate change is one of the major challenges for agricultural production worldwide, particularly in tropical developing countries where farming systems are highly dependent on seasonal rainfall and favorable climatic conditions (Habib-ur-Rahman et al., 2022; Intergovernmental Panel on Climate Change, 2022). Rising temperatures, more erratic rainfall, longer droughts, more intense typhoons, and more frequent extreme weather events have

destroyed agricultural production, lowered crop yields and put the livelihoods of millions of smallholder farmers at risk (Rhaman et al., 2022; Sahu, 2022). Apart from reducing productivity, climate variability also influences farm management decisions by changing planting schedules, altering irrigation needs, affecting pest and disease incidences, modifying fertilizer efficiency and changing harvesting operations. These production challenges are particularly pronounced in the Philippines because of the country's frequent exposure to typhoons, prolonged droughts, floods, and other climate-related hazards, while its predominantly rain-fed agricultural systems remain highly sensitive to climate variability. As one of the world's most climate-vulnerable countries, agriculture continues to play a vital role in food security, employment, and rural livelihoods (Eckstein et al., 2021; Pulhin & Tapia, 2021).

Tropical crops such as banana (*Musa* spp.), cassava (*Manihot esculenta*), coconut, corn and mango are significant contributors to the agricultural production and rural livelihoods of Mindanao. Davao Oriental is one of the key agricultural provinces producing these crops under different agroecological conditions from coastal lowlands to mountainous uplands (Bureau of Plant Industry, 2022; Pagulayan III et al., 2024). The tropical crop production systems, examined in this study, particularly banana, cassava, and mixed-cropping systems, differ in their physiological tolerance to environmental stresses and therefore exhibit contrasting responses to climate variability. Banana (*Musa* spp.) is particularly vulnerable to prolonged drought because its shallow root system limits water extraction from deeper soil layers, while its large leaf area and high transpiration demand increase susceptibility to water deficit. Excessive rainfall further impairs root function through temporary soil saturation, promotes nutrient leaching, and favors the development of major foliar and soil-borne diseases (Abdoussalami et al., 2023). In contrast, cassava (*Manihot esculenta*) exhibits greater tolerance to short-term drought because of its relatively deep rooting system and efficient water-use strategies,

although prolonged moisture deficits still reduce storage-root development and yield, whereas heavy rainfall accelerates soil erosion and increases nutrient losses, particularly on sloping lands (Vala et al., 2024).

Beyond their direct effects on crop growth, prolonged wet conditions and high relative humidity modify the microclimate within crop canopies and the soil environment, creating conditions that favor the survival, reproduction, and dispersal of many tropical plant pathogens. In banana, persistent soil moisture and humid conditions increase the likelihood of diseases caused by soil-borne and foliar pathogens, including *Fusarium* wilt and root rots, resulting in reduced plant vigor and productivity (Abdoussalami et al., 2023). Consequently, climate variability influences not only crop growth and yield but also pest and disease management, planting schedules, fertilizer application, irrigation, and harvesting operations (Hussain et al., 2024). Understanding these biological responses provides an important framework for interpreting farmers' adaptation practices under changing climatic conditions. These crop-specific physiological responses demonstrate that climate change affects not only crop growth and productivity but also farm management decisions, including land preparation, planting schedules, fertilizer application, irrigation, weed management, and harvesting (Hussain et al., 2024). Consequently, effective climate-smart agricultural interventions require an understanding of both the biological responses of crops to climatic stress and farmers' adaptation practices under changing environmental conditions.

Climate variability affects tropical crop production not only through direct effects on plant growth but also by altering soil physical and chemical processes. In the predominantly weathered tropical soils of the Philippines, including weathered upland soils commonly associated with upland landscapes in Mindanao, intense rainfall increases surface runoff, soil erosion, and the leaching of mobile nutrients such as nitrate beyond the effective rooting zone of many crops. Alternating periods of heavy

rainfall and high temperatures may also reduce nitrogen-use efficiency by increasing ammonia volatilization following surface application of urea fertilizers, particularly when fertilizer management is not synchronized with rainfall events. These plant-soil-climate interactions reduce nutrient availability, fertilizer-use efficiency, and soil water retention, ultimately affecting crop productivity and influencing farm management decisions, including fertilizer application, irrigation scheduling, soil conservation, and crop establishment (Hussain et al., 2024; Vala et al., 2024). Consequently, effective climate-smart agricultural interventions require an understanding of both the biophysical processes affecting crop production and farmers' adaptation practices under changing climatic conditions.

Farmers' adaptive capacity is strongly influenced by their knowledge, attitudes, and practices (KAP), which shape their perceptions of climate risks and appropriate adaptation measures (Yacob et al., 2026). Farmers who are more aware of climate change are more willing to adopt adaptive strategies but implementation is often a matter of access to extension services, financial resources, agricultural technologies and timely climate information (Belay et al., 2022). Previous literature showed that although a large number of farmers are aware of the impacts of climate change, the adoption of adaptation practices is intermittent due to socioeconomic and institutional constraints (Belay et al., 2022; Lamichhane et al., 2022). The adaptation responses also vary depending on local environmental conditions, available resources, and dominant cropping systems (Ghaffar et al., 2022). Site-specific assessments are important. The local government units provide assistance based on assessments of farmers' KAP.

Contrasting production environments are present in farming communities in Davao Oriental (Pagulayan III et al., 2024). The coastal agricultural areas are more vulnerable to flooding, storm surges and intrusion of salt water, while the upland farms are exposed to long dry spells, reduction in soil moisture, soil erosion, and landslides. These upland production areas are

predominantly characterized by highly weathered tropical soils that are susceptible to runoff, nutrient leaching, and declining soil fertility during periods of intense rainfall, whereas prolonged dry spells reduce soil moisture availability and nutrient uptake by crops. These differences affect the level of climate impacts and the adaptation strategies of farmers. For instance, crop production is gradually incorporating changes in planting dates, crop diversification, contour cultivation, soil conservation measures, supplemental irrigation, and integrated pest management to reduce climate-related risks. However, the extent to which these practices are adopted across different tropical crop production systems remains poorly documented.

The literature on farmers' perceptions of climate change is growing, but there is still little comparative information on how different tropical crop production systems respond to climate variability within a single province. Few studies have simultaneously addressed farmers' knowledge, attitude, adaptation practices and production management of multiple crops under different agroecological conditions. Bridging this knowledge gap is critical to the design of location-specific climate-smart agricultural programs that increase resilience while maintaining tropical crop productivity.

Thus, the study assessed the comparative impacts of climate change on selected tropical crop production systems in Davao Oriental and the farmers' knowledge, attitudes and practices on climate change adaptation. The study compared banana, cassava and mixed-cropping systems in contrasting agroecologies specifically and identified the adaptation strategies used by farmers to sustain crop production under changing climatic conditions. The results offer baseline information to guide agricultural extension programs, local government climate adaptation planning, and the promotion of climate-smart management practices for tropical crop production.

Materials and Methods

Study Area

The study was conducted in three (3) selected barangays (the smallest administrative units or villages) in Davao Oriental, Philippines. These are Barangay Limot, Municipality of Tarragona; Barangay San Ignacio, Municipality of Manay; and Barangay Lawigan, City of Mati. The sites were purposively selected because they represent contrasting agro-ecological and topographical conditions that influence tropical crop production and farmers' responses to climate variability. The three communities are primarily agricultural-based, with smallholder farmers cultivating banana, cassava, coconut, corn, mango and other food crops. The study sites grow similar crops; however, the predominant production systems are different due to local environmental conditions, so impacts of climate change and adaptation practices can be compared in different farming systems.

The three barangays have different landscape characteristics that influence agricultural productivity and climate-related risks. Barangay Lawigan is located in a low-lying coastal area susceptible to flooding, waterlogging and saltwater intrusion during

heavy rainfalls and storm surges. On the other hand, Barangays Limot and San Ignacio are located in rolling to mountainous areas where farms are commonly found in sloping lands. These production areas in the upland areas are more susceptible to soil erosion, fast surface drainage, water stress in long dry spells and falling soil fertility. Such environmental variations affect crop performance, management practices and farmers' ability to cope with changing climatic conditions.

The climate of the province is tropical with generally high temperatures throughout the year. Rainfall is generally evenly distributed throughout the year. During this past decade, farmers have reported that the weather patterns have become increasingly unpredictable. There have been occurrences of prolonged dry spells, delayed onset of rainfall, heavy precipitation events and stronger typhoons. The changing climatic conditions have affected crop establishment, planting schedules, irrigation needs, pest and disease incidence and harvesting operations at the study sites. Similar climate-induced agricultural problems have been reported in the Philippines and other tropical farming systems (Eckstein et al., 2021; Intergovernmental Panel on Climate Change, 2022; Pulhin & Tapia, 2021).

Table 1

General Climate Trends Affecting Tropical Crop Production in Davao Oriental During the Past Decade (2015–2025) Based on Farmers' Observations and Regional Climate Reports

Climate variable	General trend (2015–2025)	Implications for tropical crop production
Mean air temperature	Increasing	Increased heat stress, higher evapotranspiration, and greater irrigation demand
Rainfall distribution	More variable	Delayed planting, disrupted field operations, and unpredictable harvesting schedules
Dry spells	More frequent	Reduced soil moisture, moisture stress, and lower crop productivity
Heavy rainfall events	More frequent	Flooding, soil erosion, nutrient leaching, and waterlogging
Pest and disease incidence	Increasing	Greater occurrence of insect pests and fungal diseases, particularly in banana production
Extreme weather events	Increasing	Crop damage, reduced yields, and increased production risks

Research Design

This study employed a descriptive cross-sectional survey design to assess farmers' knowledge, attitudes, and practices (KAP) related to climate change and adaptation strategies across selected tropical crop production systems (Creswell & Creswell, 2017; Sirisilla, 2023). The design was appropriate because it enabled the systematic assessment and comparison of farmers' perceptions and management practices at a single point in time without manipulating the study environment. The survey also facilitated the identification of differences in climate change impacts and adaptation strategies among contrasting agroecological settings.

Sampling Procedure and Respondents

The target population consisted of active smallholder farmers engaged in the production of bananas, cassava, coconut, corn, mango, and mixed-cropping systems. A total of 450 respondents were included in the study, with 150 farmers were selected from each study site using proportionate allocation. This sampling approach ensured balanced representation among Barangay Limot (Tarragona), Barangay San Ignacio (Manay), and Barangay Lawigan (City of Mati), thereby improving the comparability of climate change perceptions and adaptation practices across different production systems.

Respondents were selected through stratified purposive sampling based on the dominant crop production systems within each barangay. Farmers were included if they (1) were at least 18 years old, (2) had a minimum of three years of farming experience, and (3) were actively engaged in tropical crop production during the survey period. These criteria ensured that respondents possessed sufficient farming experience to evaluate long-term changes in climate and agricultural production.

Entry Protocol and Ethical Considerations

Permission to conduct the study was obtained from the respective Barangay Captains

before coordinating with purok leaders and farmer representatives. Prior to each interview, the objectives of the study were explained to all respondents, and informed consent was obtained. Participation was entirely voluntary, and respondents were informed of their right to decline participation or withdraw at any stage of the interview without consequence. No personally identifiable information was collected, and all responses were treated with strict confidentiality in accordance with accepted ethical research practices (Babbie, 2020). Ethical clearance was secured before field implementation, and all research activities complied with institutional ethical standards.

Data Collection Instrument and Procedure

Data were collected using a structured questionnaire adapted from established studies on farmers' knowledge, attitudes, practices, and climate change adaptation (Abid et al., 2015; Acquah & Onumah, 2011; Villanueva et al., 2015). The questionnaire consisted of five sections: (1) sociodemographic characteristics, (2) knowledge of climate change, (3) attitudes toward climate change, (4) adaptation practices, and (5) perceived impacts of climate change on crop production together with adaptation strategies.

Responses to KAP statements were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Additional questions documented farmers' experiences regarding changes in rainfall patterns, temperature, pest and disease occurrence, crop productivity, and farm management practices, including crop diversification, irrigation, soil conservation, pest management, planting schedules, and other adaptation measures employed in response to climate variability.

The questionnaire was translated into Cebuano and subsequently back-translated to ensure linguistic consistency. Face-to-face interviews were conducted using KoboCollect (KoboToolbox), which enabled efficient offline and online data collection. Enumerators

received prior training on interview techniques, ethical considerations, and standardized administration procedures. Each interview required approximately 20–30 min, while field supervision, spot-checking, and validation were undertaken throughout the data collection period to ensure data accuracy and completeness.

Data Analysis

The collected data were coded, cleaned, and analyzed using SPSS and Microsoft Excel. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed to summarize farmers' socio-demographic characteristics, knowledge, attitudes, practices, perceived climate change impacts, and adaptation strategies.

Mean scores obtained from the Likert-scale responses were interpreted as follows: 4.21–5.00 (Strongly Agree), 3.41–4.20 (Agree), 2.61–3.40 (Neutral), 1.81–2.60 (Disagree), and 1.00–1.80 (Strongly Disagree). One-way analysis of variance (ANOVA) was performed to determine significant differences in KAP levels and adaptation practices among the three tropical crop production systems. These analytical procedures are widely applied in studies evaluating farmers' climate change perceptions and adaptation strategies (Bryan et al., 2013; Deressa et al., 2009).

Data Reliability and Validity

The survey instrument was pre-tested among approximately 20 farmers from a neighboring community that was not included in the actual study. Feedback from the pilot testing was used to improve the clarity, organization, and consistency of questionnaire items before full implementation. Internal consistency of the Likert-scale items was evaluated using Cronbach's alpha, with values of 0.70 or higher considered acceptable.

Because the study relied on self-reported perceptions and experiences, some degree of recall and response bias may have occurred. Nevertheless, these potential limitations were

minimized through the use of standardized questionnaires, trained enumerators, field validation, consistent interview procedures, and comparison of responses across multiple study sites. These quality assurance measures enhanced the reliability, validity, and reproducibility of the findings.

Results and Discussion

A total of 450 farmers were surveyed, with 150 respondents representing each production system. Across the three production systems, most respondents had attained elementary or high school education, while only a few had completed college, indicating that educational attainment may have contributed to variations in farmers' knowledge, attitudes, and practices (KAP) related to climate change adaptation.

Banana farmers from Barangay San Ignacio, Municipality of Manay ($n = 150$) reported the highest perceived impact of climate change (mean = 4.35), followed by cassava farmers from Barangay Limot, Municipality of Tarragona ($n = 150$) (mean = 4.05) and mixed-crop farmers from Barangay Lawigan, City of Mati ($n = 150$) (mean = 3.98). Across the three production systems, most respondents had completed elementary or high school education, while only a small proportion had attained college education. Among banana farmers, 63 (42.0%) had completed elementary education, 82 (54.7%) had completed high school, and 5 (3.3%) had attained college education. Similarly, cassava farmers comprised 68 (45.3%) elementary graduates, 77 (51.3%) high school graduates, and 5 (3.4%) college graduates, whereas mixed-crop farmers consisted of 61 (40.7%) elementary graduates, 84 (56.0%) high school graduates, and 5 (3.3%) college graduates. The predominance of respondents with elementary and secondary education reflects the educational profile commonly observed among smallholder farming communities in rural Philippines. Educational attainment may have influenced farmers' knowledge, attitudes, and adaptation practices (KAP), as previous studies have shown that higher educational levels improve access to climate

information, agricultural extension services, and climate-smart agricultural technologies, thereby enhancing adaptive capacity (Abid et al., 2015; Belay et al., 2022; Yacob et al., 2026).

Differences in perceived climate change impacts were associated with crop characteristics and local agroecological conditions. Banana farmers perceived the greatest vulnerability because banana production is highly sensitive to rainfall variability, prolonged drought, strong winds, and pest and disease outbreaks. Respondents reported disrupted planting schedules, delayed fertilizer application, reduced bunch development, increased foliar diseases, and harvesting delays caused by excessive rainfall, consistent with previous studies on banana production under climate variability (Abdoussalami et al., 2023; Department of Agriculture, 2021; Varma & Bebbber, 2019). Cassava farmers perceived relatively lower climate impacts because cassava is more tolerant of short-term water deficits, although prolonged drought reduced tuber development while heavy rainfall increased runoff, soil erosion, and nutrient leaching on sloping lands. Farmers responded by adjusting planting schedules, intercropping, applying mulch, and adopting

drought-tolerant varieties that have been shown to improve resilience under increasingly variable climatic conditions (Abbas & Ribeiro, 2023; Altieri et al., 2015; Department of Agriculture, 2020). Mixed-crop farmers reported the lowest perceived climate impacts, largely because crop diversification helped distribute production risks across multiple crop species with varying tolerance to climatic stresses. However, their coastal farms remained vulnerable to flooding, waterlogging, and saltwater intrusion, prompting farmers to adopt crop diversification, improved drainage, contour farming, soil conservation, and mulching to reduce production losses. These diversified farming practices have been recognized as effective strategies for strengthening agricultural resilience under changing climatic conditions (Mijatović et al., 2013; Sridhar et al., 2025).

A comparative assessment of climate change impacts and farmers' knowledge, attitudes, and practices (KAP) among tropical crop production systems in Davao Oriental is presented in Table 2. Although all respondents recognized that climate variability had affected agricultural production, the magnitude of these impacts differed among crop systems because

Table 2

Comparative Assessment of Climate Change Impacts and Farmers' Knowledge, Attitudes, and Practices (KAP) in Tropical Crop Production Systems in Davao Oriental, Philippines

Variable	Cassava farmers (Limot, Tarragona)	Banana farmers (San Ignacio, Manay)	Mixed crops farmers (Lawigan, Mati)
Perceived climate change impacts	Moderate–High (Mean = 4.05)	High (Mean = 4.35)	Moderate–High (Mean = 3.98)
Knowledge level	Moderate (Mean = 3.60)	Moderate–High (Mean = 3.85)	Moderate (Mean = 3.55)
Attitude toward Climate change	Positive (Mean = 3.90)	Positive (Mean = 4.10)	Neutral–Positive (Mean = 3.70)
Adaptation practices	Moderate (Mean = 3.50)	Moderate (Mean = 3.75)	Moderate (Mean = 3.50)
Common climate impacts identified	Drought, soil degradation	Drought, pests, yield decline	Rainfall variability, pests
Common adaptation strategies	Crop rotation, drought-tolerant varieties	Crop diversification, irrigation	Mixed cropping, soil conservation
Access to Climate Information	Low–Moderate	Moderate	Moderate

of variations in crop characteristics, topography, and management practices.

Banana farmers from Barangay San Ignacio reported the highest perceived impact of climate change (mean = 4.35), followed by cassava farmers from Barangay Limot (4.05) and mixed-crop farmers from Barangay Lawigan (3.98). The banana crop's sensitivity to rainfall variability, prolonged drought, strong winds and the increasing incidence of pests and disease may account for the increased vulnerability perceived by banana farmers. Erratic rainfall disrupted planting schedules, delayed fertilizer application, reduced bunch development and increased the incidence of foliar diseases. Farmers reported that these effects resulted in reduced marketable yields. Heavy rainfall also restricted field access, delaying pruning, weed management and harvesting activities. These findings are consistent with previous studies that demonstrate the significant impact of climate variability on the productivity of bananas and farm management (Abdoussalami et al., 2023; Department of Agriculture, 2021; Varma & Bebbber, 2019).

Cassava farmers reported relatively lower climate impacts (mean = 4.05), reflecting the crop's greater tolerance to intermittent water stress. Nevertheless, prolonged drought reduced storage-root development, whereas intense rainfall on sloping production areas likely accelerated runoff, soil erosion, and the downward movement of soluble nutrients, particularly nitrate, beyond the effective rooting zone. These processes decrease nutrient availability and fertilizer-use efficiency, resulting in reduced crop growth despite fertilizer application. Likewise, alternating wet and hot conditions following fertilizer application may increase nitrogen losses through ammonia volatilization when urea is surface-applied without adequate incorporation or rainfall synchronization. Farmers' reported adoption of mulching, contour cultivation, adjusted planting schedules, and intercropping, is therefore, consistent with practices that reduce runoff, improve soil moisture conservation, minimize nutrient losses, and enhance soil fertility under

increasingly variable climatic conditions (Abbas & Ribeiro, 2023; Altieri et al., 2015; Department of Agriculture, 2020).

Farmers consistently reported increasing incidence of pests and diseases incidence under changing climatic conditions, particularly during periods of prolonged rainfall and high humidity. These observations are consistent with established phytopathological evidence showing that warm and humid environments favor pathogen survival, reproduction, infection, and dispersal in tropical cropping systems. In banana, prolonged soil saturation and elevated canopy humidity create favorable conditions for the development and spread of important diseases such as Fusarium wilt and root rots, while frequent rainfall facilitates pathogen dissemination through contaminated soil, surface runoff, and infected plant materials (Abdoussalami et al., 2023). Excessive rainfall may also reduce root health through temporary oxygen deficiency, increasing plant susceptibility to infection and further reducing productivity. Thus, the reported increase in pest and disease incidence reflects biologically plausible responses of tropical production systems to changing microclimatic conditions rather than perception alone, supporting the observed need for improved crop monitoring, field sanitation, drainage management, and integrated pest and disease management as climate adaptation strategies.

Although coconut, corn and mango were not analyzed as separate farmer groups, respondents growing these crops consistently identified climate-related production constraints. During prolonged dry periods, coconut farmers reported reduced nut production, while during strong winds, they reported increased damage. This was consistent with the vulnerability of perennial crops to climate variability (Kumar & Aggarwal, 2013). Poor germination, uneven crop establishment and reduced grain filling for corn farmers were associated with delayed or erratic rainfall. Mango growers reported irregular flowering, less fruiting and more frequent pest attacks during the long spells of humidity. These observations indicate that climate change affects

crop growth, productivity, and routine crop management across a wide range of tropical crops (Rezaei et al., 2023).

Among the three production systems, Barangay Lawigan mixed-crop farmers reported the lowest perceived climate impacts. Crop diversification may have reduced the risk of production by distributing harvests over various crop species, which vary in their tolerance to climatic stress. But these farmers were still vulnerable to floods, waterlogging and saltwater intrusion because their farms were located in coastal areas. Respondents reduced production losses through a combination of crop diversification and improved field drainage, contour farming, soil conservation and mulching. Diversified farming systems have been recognized as important strategies to improve agricultural resilience under changing climatic conditions (Mijatović et al., 2013; Sridhar et al., 2025).

Results indicate that climate variability affects routine crop management activities as well as crop productivity. Farmers reported modifying land preparation, planting schedules, planting density, irrigation scheduling, fertilizer application, pest and disease management, and harvesting operations in response to increasingly

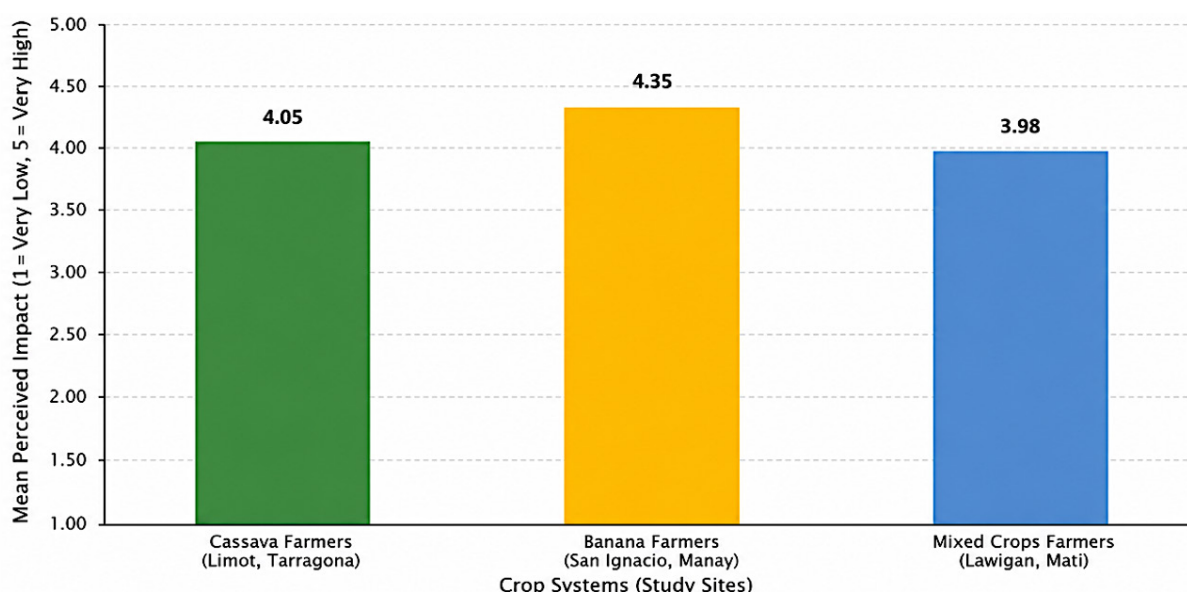
unpredictable rainfall and temperature conditions. These results suggest that climate adaptation is emerging as an important component of tropical crop production and should be incorporated into local agricultural development programs.

Figure 1 shows the perceived impacts of climate change on the three crop systems and varied significantly across the farmer groups. Banana farmers in Barangay San Ignacio, Manay had the highest mean score (4.35), which indicates that they perceived greater climate-related impacts more than other groups. Cassava farmers in Limot, Tarragona followed with a mean of 4.05 which shows a moderate to high level of perceived impact. Meanwhile, in Barangay Lawigan, City of Mati, mixed crop farmers had the lowest mean score (3.98) but was within the moderate to high range. Overall, the data suggest that banana production systems are more sensitive and vulnerable to climate variability, whereas cassava and mixed cropping systems exhibit relatively lower but still substantial levels of perceived climate impact.

Figure 2 presents a comparison of farmers' knowledge, attitudes and practices regarding climate change among the three production systems. In general, the respondents demonstrated moderate to moderately high

Figure 1

Perceived Climate Change Impacts Across Crop Systems in Davao Oriental, Philippines



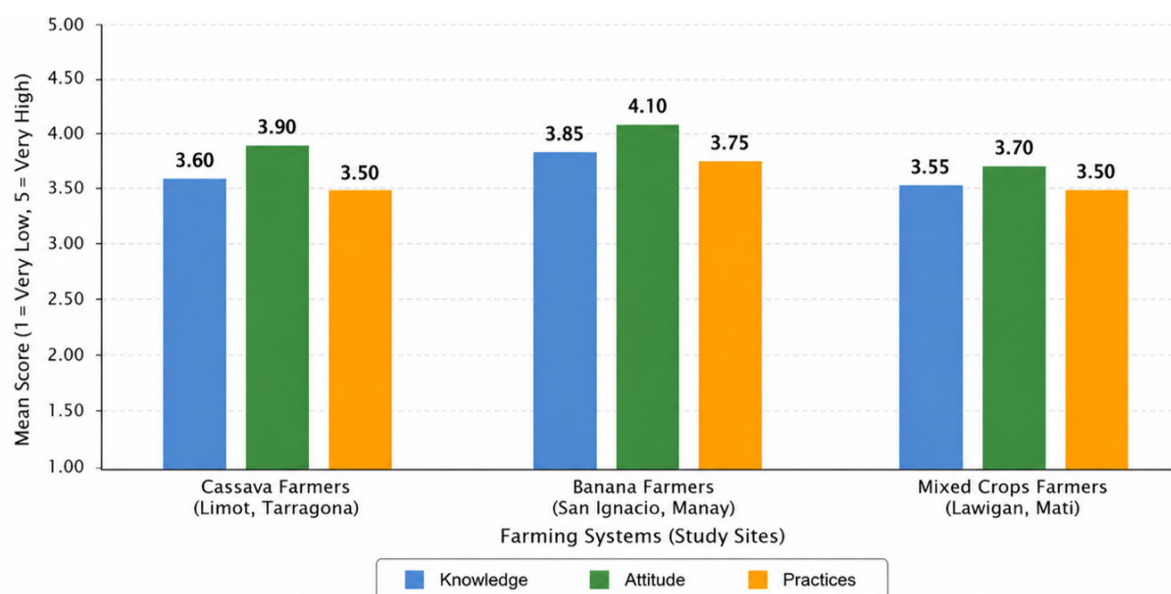
knowledge and positive attitudes to climate change. Banana farmers had the highest mean knowledge scores (3.85), attitudes (4.10) and adaptation practices (3.75) showing relatively higher awareness and implementation of adaptive management practices. Knowledge and practice scores were similar for cassava and mixed-crop farmers, but adaptation practices were generally lower than knowledge and attitudes in all study sites.

The results show a knowledge-practice gap. Farmers observed the impacts of warming temperatures, irregular rainfall, extended drought, floods and pest outbreaks. However, the uptake of climate-smart agricultural practices was only moderate. The main barriers to adoption of adaptation measures as perceived by the farmers included financial constraints, inadequate irrigation facilities, limited agricultural extension services and insufficient access to localized climate information. Comparable challenges have been reported among smallholder farmers in developing countries where institutional support and access to information greatly influence climate adaptation (Abid et al., 2015; Bryan et al., 2013; Deressa et al., 2009; Lasco et al., 2014; Salisu, 2022).

Survey responses also indicated that farmers had begun to change to change routine crop management practices to cope with changing climatic conditions. Banana farmers delayed planting until the onset of more reliable rainfall, increased planting density in poorly drained fields to increase air circulation, increased monitoring for Sigatoka disease with prolonged rainfall, and used supplemental irrigation with extended dry periods. Cassava farmers synchronized their planting to seasonal rains, rotated their crops, adopted drought-tolerant planting materials and mulched to reduce soil moisture loss. Farmers growing corn changed sowing times to achieve better crop establishment in uncertain rainfall conditions and mango growers increased pruning and pest monitoring after high rainfall periods. Mixed-crop farmers used staggered planting dates, different crop mixtures, contour farming, and improved drainage to reduce flood damage. Such adaptive production practices suggest that farmers are progressively incorporating climate resilience into farm management despite ongoing socioeconomic limitations (Altieri et al., 2015; Department of Agriculture, 2020; Rañola et al., 2019).

Figure 2

Farmers' Knowledge, Attitudes, and Practices (KAP) Comparison among Tropical Crops Farmers in Davao Oriental, Philippines



Adaptation Practices of Tropical Crop Farmers

The adaptation strategies adopted by banana farmers are summarized in Figure 3. The most frequently identified adaptation strategy was crop diversification (35%), followed by supplemental irrigation (25%) and improved pest management (20%). However, approximately one fifth of the respondents indicated that they have not implemented any adaptation measures.

Crop diversification allowed farmers to spread income and harvests over crops with differing tolerances to climatic stress, reducing production risks. Supplemental irrigation lessened moisture deficits during long dry spells and helped establish crops, and integrated pest management reduced crop losses from growing pest and disease outbreaks following irregular rainfall. Farmers also discussed changing planting dates according to rainfall forecasts, changing planting density in areas prone to flooding, using mulches to conserve soil moisture, building contour barriers to reduce erosion and improving drainage channels to avoid waterlogging. These practices are aligned with climate-smart agriculture practices designed to enhance resilience and maintain crop productivity under varying environmental conditions (Altieri et al., 2015; Department of Agriculture, 2020; World Bank, 2021).

However, about 20% of the banana farmers had not adopted any climate adaptation strategy despite these adaptive responses, leaving this group potentially vulnerable to future climatic shocks due to limited financial resources, inadequate technical assistance and limited access to weather information. Hence, strengthening agricultural extension services, promoting climate-smart technologies and increasing access to localized climate information could help increase farmers' adaptive capacity and promote sustainable production of tropical crops (Aduko et al., 2026; Lasco et al., 2014; Zhou et al., 2023).

The findings show that climate variability is already affecting tropical crop production in Davao Oriental through rising temperatures,

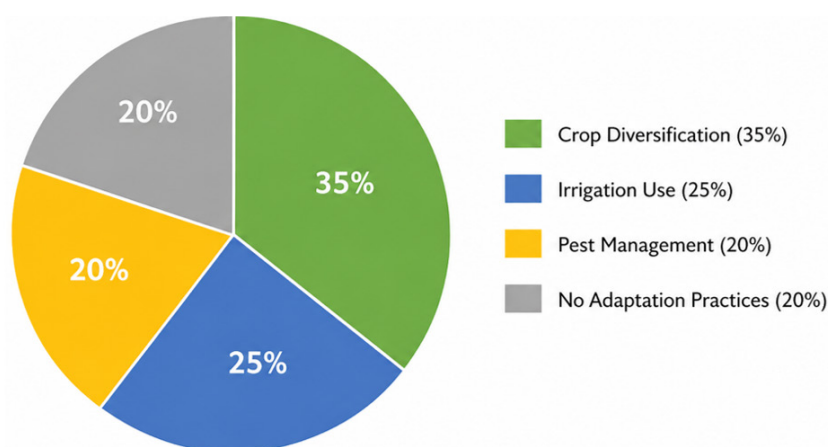
erratic rainfall distribution, longer dry spells, flooding and increasing pest and disease incidence. These climatic changes impact not only crop productivity but also routine farm management decisions including land preparation, planting schedule, planting density, fertilizer application, irrigation management, weed control, pest management and harvesting. It is not surprising that farmers consistently reported changing these production practices in response to changing weather conditions, indicating that climate adaptation has become an integral part of tropical crop management.

Differences between banana, cassava, coconut, corn, mango, and mixed cropping systems also show that crop responses depend on biological characteristics and local agro-ecological conditions. Banana production was the most susceptible, being particularly sensitive to droughts, too much rainfall, and disease outbreaks (Abdoussalami et al., 2023; Varma & Bebber, 2019). Cassava was relatively more tolerant to water stress but still was vulnerable to the decline in soil moisture and erosion on sloping land. Coconut and mango production were affected by irregular flowering, less fruit development and storm damage. Corn production was highly dependent on the timing and distribution of rainfall. Mixed-cropping systems were relatively resilient as crop diversification reduced the probability of total crop failure under adverse climatic conditions (Altieri et al., 2015; Mijatović et al., 2013).

The survey also shows that positive attitudes toward climate change adaptation do not automatically lead to wide adoption of adaptation practices. Although the respondents recognized the importance of climate adaptation, the limited irrigation infrastructure, financial resources, extension services, and access to climate information still hampered implementation. Similar findings have been reported in previous studies indicating that institutional support, farmer education, and access to agricultural technologies are essential for improving adaptive capacity (Abid et al., 2015; Arbuckle et al., 2013; Bryan et al., 2013; Deressa et al., 2009; Lasco et al., 2014).

Figure 3

Adaptation Practices among Tropical Crops Farmers in Davao Oriental, Philippines



Hence, the study highlights the importance of promoting location-specific climate-smart agricultural interventions that address the production requirements of different tropical crops. Strategies to strengthen farmers' resilience while sustaining tropical crop productivity under increasingly variable climatic conditions include adjusting planting calendars, appropriate planting density, supplemental irrigation, crop diversification, contour farming, mulching, integrated pest management and improved access to climate information (Department of Agriculture, 2020; United Nations Environment Programme, 2023; World Bank, 2021).

Conclusions

This study demonstrated that climate change is already affecting tropical crop production systems in Davao Oriental, with varying levels of perceived impact among farmers in Barangay Limot, Tarragona (cassava), Barangay San Ignacio, Manay (banana), and Barangay Lawigan, City of Mati (mixed-cropping systems). Banana production was perceived as the most vulnerable because of its sensitivity to irregular rainfall, drought, pest and disease outbreaks, and strong winds, while cassava, coconut, corn, mango, and mixed-cropping systems experienced crop-specific impacts associated with changes in rainfall patterns, soil moisture, flooding, and erosion. Although

farmers generally exhibited moderate to high knowledge and positive attitudes toward climate change, the adoption of adaptation practices remained moderate, indicating that awareness alone is insufficient to strengthen farm resilience.

The study further showed that farmers have begun integrating adaptive management into crop production through adjusted planting schedules, crop diversification, supplemental irrigation, crop rotation, contour farming, mulching, soil conservation, and integrated pest management. However, uptake of these practices is inconsistent as many farmers reported limited access to climate information, extension services, financial support, irrigation facilities and climate-smart agricultural technologies. Such constraints diminish the ability of farmers to respond to more variable climate conditions.

The findings have significant implications for agricultural policy and extension programs in Davao Oriental and similar tropical production systems. Because climate vulnerabilities differed among the production systems, climate adaptation initiatives should be commodity- and site-specific rather than using a single approach for all farming communities. For banana production, priority interventions include improved drainage, windbreak establishment, integrated pest and disease management, supplemental irrigation during prolonged dry periods, and the use of wider planting spacing where appropriate to improve air circulation and

reduce disease incidence. Cassava production would benefit from drought-tolerant varieties, contour planting on sloping lands, mulching, and intercropping with companion crops such as corn or legumes to improve soil moisture conservation and reduce erosion. For corn, recommended strategies include adjusting planting dates to coincide with reliable rainfall, planting drought-tolerant cultivars, and practicing crop rotation or intercropping to improve productivity under variable climatic conditions. Coconut and mango production systems require different approaches, including improved soil and water conservation, pruning, nutrient management, pest and disease monitoring, and the establishment of suitable companion crops or ground cover vegetation to minimize soil erosion and maintain soil moisture, as drought-tolerant planting materials for these perennial crops remain limited. In mixed-cropping systems, crop diversification, staggered planting, contour farming, cover cropping, and improved field drainage should continue to be promoted to enhance resilience against flooding and rainfall variability.

Strengthening localized weather advisory services, commodity-specific agricultural extension programs, and access to climate-smart technologies could further improve farmers' adaptive capacity. Collaborative efforts among local government units, the Department of Agriculture, agricultural extension workers, research institutions, and farming communities remain essential to develop and disseminate crop-specific adaptation strategies. Future studies should integrate long-term meteorological records with field evaluations of commodity-specific climate-smart interventions to provide stronger evidence for climate-resilient tropical crop production systems in the Philippines.

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