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The impacts of crop diversity and sustainable farming on food security, climate, and biodiversity in Dumanjug, Cebu, Philippines

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Abstract. *Lillo EP, Alcazar SMT, Malaki ABB, Chavez MLM, Cañarijo III DM, Redoblado BR, Margate MA, Diaz JL, Mago JE, Belanizo J, Beceril R, Revillas MJ, Abrigana M, Davirao C, Obando ME, Diaz GGG, Gonzaga CF, Cagara BN. 2025. The impacts of crop diversity and sustainable farming on food security, climate, and biodiversity in Dumanjug, Cebu, Philippines. Asian J Agric 9: 208-214.* The Philippines, an archipelagic Southeast Asian country, faces a complex and interconnected set of challenges involving food security, biodiversity conservation, and sustainable agricultural practices. The impacts of climate change, the loss of crop diversity, and the reduction in agricultural output brought on by unsustainable farming practices are some of the country's complex issues. This study examines crop diversity and sustainable farming practices in Dumanjug, Cebu, Philippines, and their implications for food security, climate change adaptation, and biodiversity conservation. The research evaluates the farmer's diverse cropping systems and sustainable agricultural techniques by employing participatory observation and a survey questionnaire. Results highlight the reliance on local seeds, adoption of sustainable practices such as intercropping and crop rotation, and the cultivation of indigenous food crops like *Cocos nucifera* L., *Moringa oleifera* Lam., and *Musa acuminata* × *balbisiana (ABB Group)*. Despite challenges such as typhoons, droughts, and limited resource access, these practices contribute to food security, economic stability, and ecosystem resilience. The study underscores the importance of promoting local seed systems, climate-resilient farming techniques, and supportive policies to address systemic vulnerabilities and enhance agricultural sustainability. The implementation of these recommendations is expected to bring about benefits such as increased crop diversity, improved food security, and enhanced resilience to climate change. Findings provide evidence-based recommendations for policymakers, agricultural extension workers, and local communities, contributing to regional and national efforts to achieve sustainable development goals.

Keywords: Agricultural resilience, Cebu, climate change adaptation, Dumanjug, local seeds, sustainable farming practices

INTRODUCTION

The Philippines is an archipelagic country in Southeast Asia facing significant problems with food security, biodiversity preservation, and sustainable agricultural practices. Among the critical concerns are the declining agrarian productivity caused by unsustainable farming methods, climate change impacts, and the erosion of crop diversity (Ortega-Espaldon and Medina 2024). As a nation deeply rooted in agriculture, these challenges are particularly felt in rural communities that depend on farming for their livelihoods, and the interconnected targets of both food security and environmental sustainability must be prioritized in these contexts. Addressing both food security and environmental sustainability is very important.

Through exploiting traditional knowledge and modern innovations, the Philippines can enhance food security, resilience to climate change, and biodiversity conservation. Recognizing that traditional knowledge and modern agricultural technologies are not mutually exclusive is essential. Traditional practices often reflect centuries of adaptation to local environments and can offer insights into sustainable farming methods. By integrating these practices with modern technology, farmers can create a synergistic approach that enhances productivity while respecting cultural heritage and local biodiversity. Engaging with local communities and understanding their knowledge can lead to innovative solutions that increase crop yields without disregarding the wisdom of traditional techniques. The combination of traditional and modern agricultural approaches has been proven effective and serves as a blueprint for other regions. These efforts will drive the country towards sustainable development in its agricultural communities, promoting a more resilient and self-sufficient future. Dumanjug in Cebu province is an important case where crop diversity meets sustainable farming practices. Dumanjug demonstrates how diverse cropping systems can enhance farming resilience by integrating traditional and modern

agricultural practices. Crop diversity is essential for agricultural biodiversity, protecting against pests, diseases, and climate change that threaten global food production (Chittapur and Umesh 2017; Altieri 2018). Research shows that diverse cropping systems help stabilize ecosystems, improve soil health, and increase nutrient availability, improving crop yields and long-term sustainability (Beillouin et al. 2021).

The approach towards eco-friendly activities such as organic farming, intercropping, crop rotation, and agroforestry has received attention as an efficient means of building soils, improving water quality, and decreasing reliance on chemicals (Edwards 2020; FAO 2020). In the Philippine context, these approaches have shown the potential to enhance biodiversity and ensure long-term food security (Parreño-de Guzman et al. 2015). Unfortunately, smallholder farmers continue to be hesitant to widely adopt these beneficial practices due to economic and technical barriers (e.g., limited access to resources and insufficient technical support) (Heckelman 2019; Touch et al. 2024). Environmental shocks, like abnormal trends in weather variability and pest outbreaks, also persist in damaging rural farming systems (Romeh 2019; Ortega-Espaldon and Medina 2024).

In order to tackle these challenges and establish resilient agricultural systems, it is crucial to comprehend the significance of crop diversity and sustainable farming practices. Studies show that diversifying crops enhances local food security and reinforces farming communities ability to adapt to climate change and other pressures (Vernooy 2022). In addition, diverse farming systems contribute to the preservation of local biodiversity, aligning with global strategies for accomplishing Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land) (United Nations 2015; Lee at al. 2016). This study assesses crop diversity and sustainable farming practices in Dumanjug, Cebu, while identifying farmers common challenges. Through field observations and interviews, it seeks to evaluate the contributions of diverse cropping systems and sustainable agricultural techniques to food security, climate resilience, and biodiversity conservation. These findings aim to inform policymakers, agricultural extension workers, and local communities, promoting informed decision-making and sustainable development in agricultural areas. Policymakers can develop supportive frameworks to provide economic incentives and technical help to smallholder farmers, encouraging the adopting of sustainable practices. Agricultural extension workers can spread the knowledge and skills necessary for eco-friendly farming, bridging the gap between research and real-world application. Local communities can also play a vital role in preserving agricultural biodiversity by adopting the knowledge acquired about diverse cropping systems and participating in sustainable initiatives. Additionally, this research will contribute to regional and national discussions on enhancing food sovereignty to achieve sustainable development in agricultural communities across the Philippines.

MATERIALS AND METHODS

Study area

The study was conducted in the Municipality of Dumanjug, a third-class municipality situated in the southwestern part of Cebu Province, Philippines (Figure 1). Dumanjug is composed of 37 barangays with Barangay Tubod-Duguan as the biggest (556.69 hectares) and Barangay Sima as the smallest (85.16 hectares). The municipality has eight coastal barangays namely: Kanyuko, Bitoon, Tangil, Tapon, Poblacion, Looc, Calaboon and Camboang. A total population of 57,823, as recorded in the 2020 census. The municipality features a diverse landscape, encompassing both upland and lowland agricultural zones. This geographical and ecological diversity provides an ideal setting to explore and assess crop diversity and the sustainability of farming practices across varied environmental conditions.

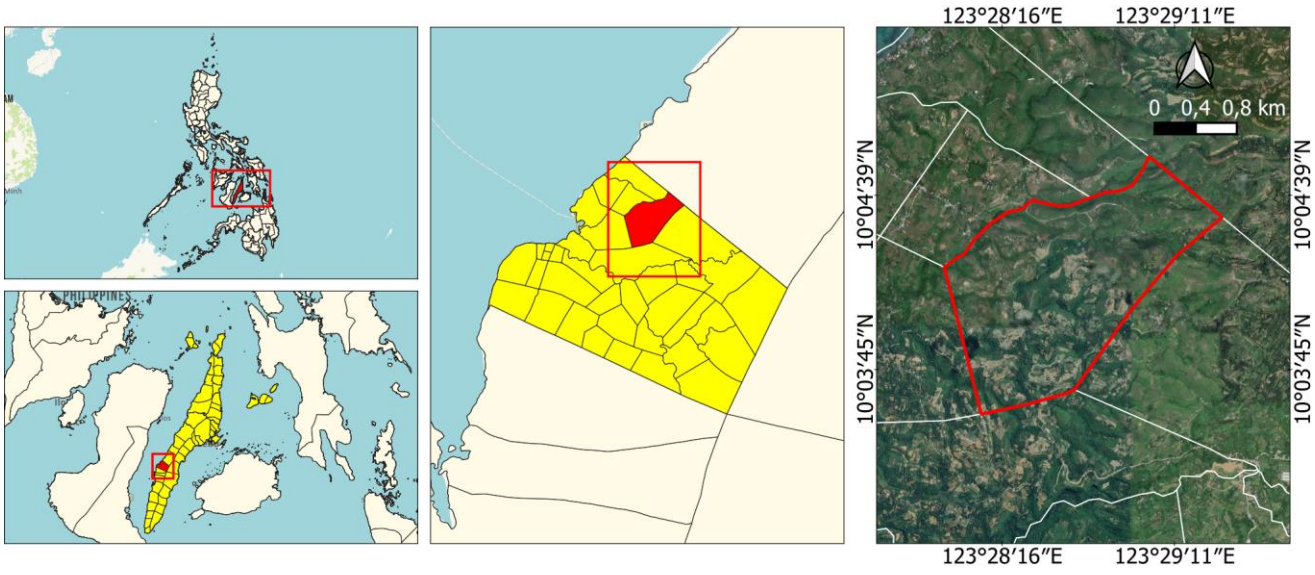

Figure 1. Map of Kanghumaod, Dumanjug, Cebu Province, Philippines

Barangay Kanghumaod, in particular, was selected as the focal area due to the active participation of the KAACWWA (Kanghumaod Association of Active Community Workers and Agriculturalists), a local People's Organization (PO) (Figure 1). The majority of farmers affiliated with KAACWWA manage landholdings of less than a hectare, with many operating as "sa-op" (tenant farmers). Under this traditional tenancy arrangement, farmers cultivate the land and share a portion of the harvest with the landowner. The prevalence of small-scale and tenant farming in the area underscores the importance of studying how agricultural practices in such settings can be optimized for sustainability and productivity.

Data collection

The study was conducted in the months of March-May, 2024 including the analysis of data. It conducted a courtesy call to the municipality of Dumanjug and asked for an available list of POs for farmers. From the list, POs whose goal is to produce food crops were selected, disregarding those POs producing timber, handicrafts, etc. Hence, the PO of KAACWWA was selected as the subject for the study. The goal is to conduct a 100% sampling from a total of 150 PO members, but unfortunately, only 28 farmers were readily available and accessible, and the rest were hesitant and other had worked in the city and other region.

This study utilized a mixed-methods approach consisting of participatory observation and survey questionnaires to collect qualitative and quantitative data. Kawulich (2005) describes that participatory observation is important during field visits to selected farms to observe farming practices first-hand and the context around agricultural activities. Also, this helped validate the data collected through the questionnaires, ensuring accuracy and a thorough understanding of the farming systems. A modified version of the survey questionnaire is used to fit the study's objectives in obtaining information on the types of crops planted, farming practices adopted, and challenges faced by the farmers.

Data analysis

The gathered data was recorded and arranged using Microsoft Excel. Data analysis was performed utilizing statistical tools in Excel, focusing on descriptive and inferential statistics to derive meaningful insights. The Shannon Diversity Index (*H'*) was calculated to evaluate crop diversity on the farms, as this index effectively measures species richness and evenness (Shannon 2001; Magurran 2013):

$$H' = -\sum(pi \cdot lnpi)$$

Where:
pi: Represents the proportion of each crop species

Descriptive statistics, such as means, percentages, and frequency distributions, were used to summarize farming practices and challenges data. Furthermore, qualitative data from observations were thematically analyzed to identify recurring patterns and contextual insights, following Braun and Clarke's (2006) thematic analysis framework.

RESULTS AND DISCUSSION

Source of seeds/planting stocks

The findings of this study emphasize the farmers' preference towards local sources as well as the sources of planting materials as opposed to commercial sources (Figure 2). It is not surprising in all cases since many of these people could identify benefits from local sources of seed use. Firstly, local seeds tend to better adapt to the local climate conditions and soil, which enhances crop resilience and yield (Liu et al. 2018). It becomes imperative in these climate-changing times where unpredictable weather conditions continue to bring about crop problems under the negative influence of soil degradation. Hence, by using local sources, farmers can reduce reliance on outside sources of inputs while adapting to varying environmental conditions. Secondly, local seeds are usually cheaper or even free an excellent bonus, especially for small-scale farmers with limited funds (Ahmed and Sarma 2022). Commercial seeds become too expensive and often become a barrier for many farmers. In terms of food security, this is a serious problem because small-scale farmers contribute significantly to the food production of localities. Thirdly, local seeds mirror traditional agricultural practices inherited through generations (Sharma et al. 2020). They have been used in many farmers lives and may appear natural or sustainable compared to commercial, generally associated with large-scale, industrialized agriculture. Local seeds are important for biodiversity conservation because they are often attached to specific crop varieties and agroecological practices that support ecosystem services. Lastly, in some rural areas, limited access to commercial seeds exists. However, local seeds, as demonstrated by Montalvo-Romero et al. (2023), are more practical in such cases. This reliability is particularly valuable in the face of infrastructural challenges or the absence of nearby suppliers. Therefore, local seeds are the best choice for farmers living in remote locations, providing a secure solution to their seed needs. This reliability is especially important in the context of climate change, where farmers may need to adapt to changing environmental conditions, and the availability of commercial seeds may not be guaranteed.

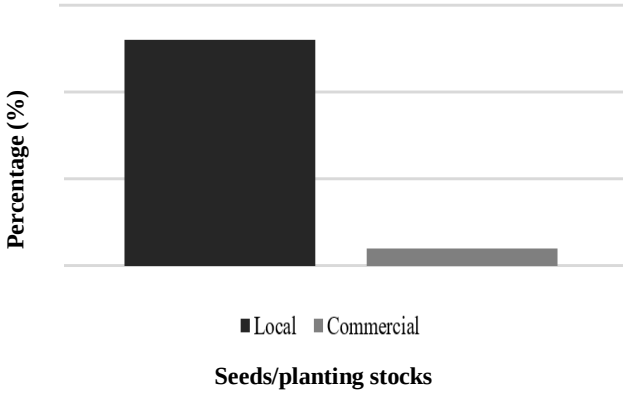

Figure 2. Source of seeds/planting stocks

This paper illustrated the importance of using local seeds among farmers in food security, biodiversity conservation, and climate change. Reviving local seeds encourages local seed production, which manages small farmers, advocates traditional agricultural practices, and increases the resiliency of crops and yields. Furthermore, using local seeds can help conserve biodiversity and promote ecosystem services, which are important and critical for maintaining ecosystem health and resilience. While hybrid seeds may offer higher productivity in certain contexts, local seeds are often better adapted to specific climatic and soil conditions, leading to resilience against pests and diseases. It is important to value the role of local seeds in promoting food sovereignty and biodiversity. Additionally, there can be long-term benefits associated with local seeds regarding sustainability and lower input costs. Educating farmers about both options advantages and potential trade-offs can empower them to make informed decisions that align with their unique circumstances.

Crop diversity and its role in food security, economic stability, and ecosystem resilience

The findings from the study highlight the relevance of indigenous food crops, namely *Cocos nucifera* L., *Moringa oleifera* Lam. and *Musa acuminata* × *balbisiana* (ABB Group), which is rooted deep in the local agriculture of the locality (Figure 3). These crops provide essential nutrition at a community level, but their impact goes beyond this to generate economic opportunities for farmers. *C. nucifera*, also known as the "tree of life," has a wide range of food and medicine uses and industrial applications, thus being a valuable asset to the community (Henrietta et al. 2022). *Moringa oleifera*, the so-called "superfood," has been characterized by its vitamin, mineral, and antioxidant content that, among others, offers numerous health benefits for humans and livestock (Henrietta et al. 2022). Additionally, *M. acuminata* × *balbisiana* is a crop that stimulates household nutrition and market demand. It forms a significant part of the local food system.

The integration of perennial crops like *C. nucifera* and *Theobroma cacao* L. into agroforestry systems further enhances biodiversity conservation, climate change mitigation and ecosystem services (Nair et al. 2021). Through sustainable farming practices, trees and shrubs associated with traditional crops are introduced to improve resilience and pursue environmental health (IPBES 2019). The variety among the crops, including staple crops such as *C. nucifera*, *M. oleifera*, *Musa acuminata* × *balbisiana*, *Zea mays* L., and *Ipomoea batatas* (L.) Poir. ensures food security. These crops have carbohydrates and nutrients needed by communities that are particularly vulnerable to food insecurity (FAO 2017). For farmers, continuous income from such crops motivates them to keep investing in their agricultural practices and their livelihoods (FAO 2017).

The cultivation of indigenous food plants also has broader ecological implications. The wide variety of crops planted, including underutilized species such as *Capsicum frutescens* L., *Cucurbita maxima* Duchesne, *Spondias purpurea* L., *Carica papaya* L., *Colocasia esculenta* (L.) Schott, *Abelmoschus esculentus* (L.) Moench, and *T. cacao* enrich the genetic diversity of farming systems. This genetic diversity reduces the risk of crop failures caused by pests, diseases, or climate variability, ensuring greater agricultural sustainability (IPBES 2019).

Agricultural operations can enhance the provision of specific ecosystem services and biodiversity (Bethwell et al. 2021), however, poor management often leads to biodiversity loss, degradation of ecosystem conditions, and deterioration of services (Huang et al. 2015). These crops support ecological resilience by fostering the adaptability of farming systems to climate change (IPBES 2019).

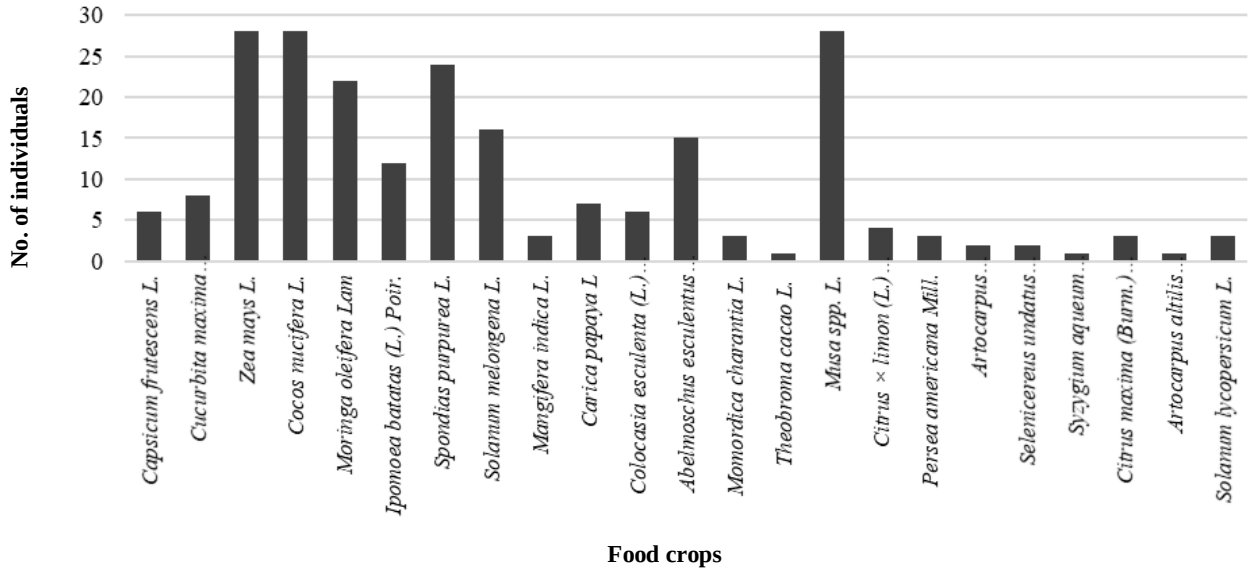

Figure 3. Food crops planted

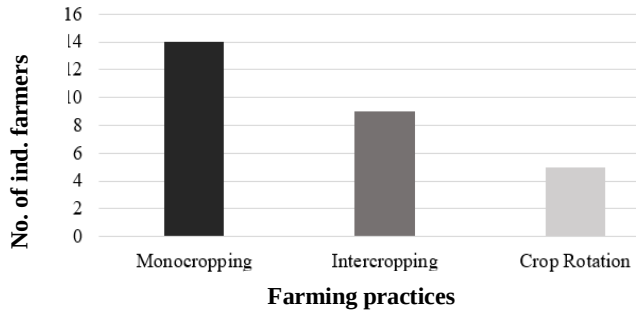

Figure 4. Farming techniques utilized by farmers

Farmers cultivating a diverse range of crops not only ensure food security and economic stability but also strengthen ecosystem resilience and biodiversity. This will encourage and promote the use of indigenous food plants as an advocacy measure against climate change and to improve farmers livelihoods, biodiversity, and long-term environmental sustainability.

A Shannon Diversity Index of 2.69 would indicate a relatively high level of species diversity within the community. The greater the value of the Shannon Diversity Index, the greater the diversity of species there. This index points towards the community's good combination of species, which supports a healthy and balanced ecosystem.

Although diverse cropping systems can present challenges in terms of logistics and management, they also offer significant advantages, such as improved soil health, pest control, and resilience to climate variability (Davis et al. 2012; Hufnagel et al. 2020). It is crucial to educate farmers about the long-term benefits of diversity, including increased ecosystem stability and reduced risk of total crop failure. Simplifying farming logistics through proper planning, education, and access to resources can help mitigate these challenges, allowing farmers to reap the rewards of diverse cropping systems while improving overall efficiency.

Farming techniques employed

In this study, the dominant farming practice is monocropping, which is characterized by the cultivation of a single crop species on a large scale (Figure 4). This approach is often favored due to its simplicity and short-term profitability (Jhariya et al. 2021). However, monocropping has several drawbacks, including soil degradation and depletion of specific nutrients, which can lead to increased reliance on fertilizers and pesticides (Tilman et al. 2002). This can have negative impacts on biodiversity, as well as contribute to climate change through the release of greenhouse gases. Despite these challenges, the potential for change is within our reach, offering hope for a more sustainable and resilient agricultural future.

Moreover, some farmers in the region are adopting more sustainable practices such as intercropping and crop rotation. Intercropping, combining different crops, has improved soil quality, increased biodiversity, and enhanced host plant resistance to pest attack (Perfecto and Vandermeer 2016). Also, such diverse crops would indirectly act as biological pest control as their life cycles are disrupted or they are attracted to beneficial insects (Altieri 2018). The fact that nine farmers in the area have intercropped indicates a growing awareness of the advantages of crop diversity and the willingness to adopt more sustainable practices.

Crop rotation, a method where various crops are planted in succession on the same plot of land, is a sustainable practice that enhances soil health while minimizing the accumulation of pests and diseases (Liu et al. 2022). This strategy can also interfere with the life cycles of pests and diseases, as those that harm one type of crop are less likely to persist when a different crop is sown in the next season (Mahato et al. 2021). While only 5 farmers in the area are currently practicing crop rotation, this method has the potential to improve long-term agricultural sustainability and resilience.

Disturbances and challenges faced by farmers

In this study the farmers in Dumanjug, Cebu, face various disturbances and challenges, impacting their livelihoods and agricultural productivity (Figure 5). Typhoons emerge as the most significant disturbance, with a notable proportion of respondents reporting varying levels of impact. Of the total, 10 respondents were extremely affected, seven were moderately affected, six were rarely affected, and five were unaffected. Typhoons are recurrent events in the Philippines, particularly in the Visayas Region, due to the country's geographical location in the typhoon belt. These extreme weather events can destroy crops, infrastructure, and homes, disrupting agricultural cycles and leading to economic losses (Yumul et al. 2011). The result of the study implied that farmers need disaster-resilient farming practices, such as the use of storm-resistant crops and sustainable soil management techniques, alongside government support through insurance and rapid response systems.

Drought is identified as another critical disturbance, with eight respondents extremely affected, 14 moderately affected, and six rarely affected. Unlike typhoons, no respondent reported being completely unaffected by drought. Prolonged dry spells can severely affect rain-fed agriculture, a common practice among smallholder farmers. Reduced water availability for irrigation leads to crop failure, food insecurity, and income loss (Quibria 2024). Addressing drought impacts requires long-term solutions such as implementing water-saving technologies, the promotion of drought-tolerant crop varieties, and investing in community-based water management systems.

While less impactful overall, landslides, flooding, earthquakes, fire, and pests/diseases affect specific groups within the community. Four respondents in each category reported being extremely affected, while the majority (24 respondents) reported no impact. These events, though localized, can disrupt farming activities, damage agricultural lands, and pose safety risks. For instance, landslides caused by heavy rains in sloped agricultural areas can lead to soil erosion and loss of arable land (Panda 2021). Pests and diseases, though not widespread, have the potential to escalate if not addressed promptly, emphasizing the urgent need for Integrated Pest Management (IPM) systems and proactive monitoring.

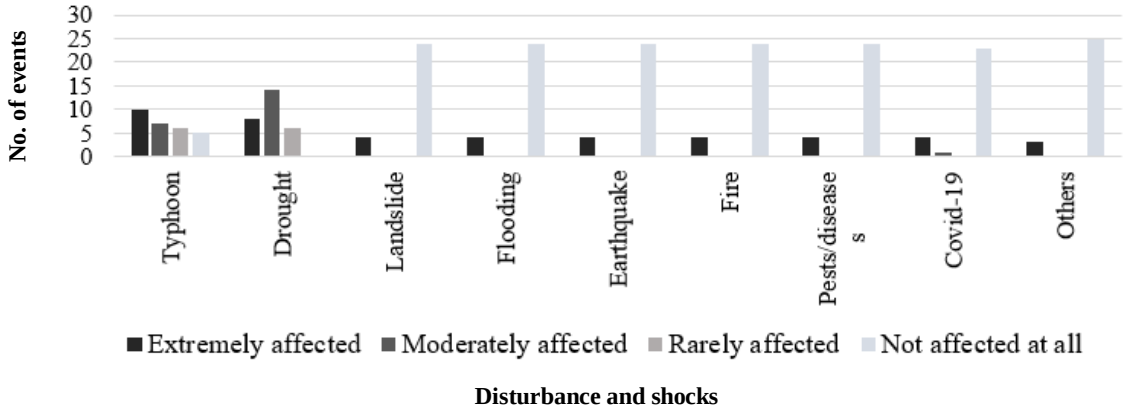

Figure 5. The disturbances and shocks encountered by farmers

The direct impact of the COVID-19 pandemic on the farming community would be minimal, with only four respondents saying that they were greatly affected and one moderately affected. However, there is a high likelihood of the indirect effects of the pandemic, especially the disrupted supply chains, limited access to markets, and fluctuating input prices, which worsened existing vulnerabilities (Somashekhar and Basavaraja 2021). For farmers, these disruptions highlight the need for diversification strategies and underscore the potential of digital tools for accessing markets, and policies that support local food systems to enhance resilience during future global disruptions.

Challenges classified under the "other" category consist of insufficient financial resources, small plots of land, lack of farming ordinances, and changes in market prices. These systemic problems arise from chronic structural inequities that restrict farmers from adapting to external shocks. The lack of affordable credit restricts investment into better farming practices. Small areas further restrict productivity and income generation (Quibria 2024). Additionally, the lack of binding regulations on sustainable farming methods leads to inconsistency in land use and agricultural policies. Therefore, this points to the need for stronger local governance. It will also be detrimental to farmers economic stability. Thus, cooperative marketing strategies and value chain improvements are needed.

The research emphasizes the importance of a cohesive and localized method for enhancing resilience among farmers in Dumanjug, Cebu. These interventions are designed through participatory methods and supported by evidence-based policies aimed at protecting farmers livelihoods while ensuring sustainable agricultural practices that are environmentally friendly.

Conclusion, this study highlights the vital role of crop diversity and sustainable farming practices in ensuring food security and ecological resilience in Dumanjug, Cebu. By prioritizing local seed systems, intercropping, and crop rotation, farmers can strengthen agricultural sustainability while preserving biodiversity. The study is relevant as it emphasizes the need for a two-pronged strategy, including self-consumption and income generation, in addressing food security. The impacts of typhoons and droughts highlight the need for targeted interventions to build community resilience. However, long-term success will require collaborative efforts involving policymakers, local organizations, and community leaders. Targeted interventions supporting smallholder farmers, improving disaster resilience, and promoting sustainable agriculture are essential for safeguarding the livelihoods and food security of local communities in Dumanjug.

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