Farmers' Response to Disasters: A Study in Three Municipalities of the Sierra Nevada of Puebla

Blanca-Bautista, Martina[1]; Ramírez-Valverde, Benito[1*]

[1] Colegio de Postgraduados Campus Puebla. Santiago Momoxpan, Municipio de San Pedro Cholula, Puebla, México. C.P. 72760.
* Correspondence: bramirez@colpos.mx

ABSTRACT
Objective: This study aimed to analyze the types of disasters affecting family agriculture and to understand the strategies implemented by producers to mitigate damage to crops and the economic well-being of farming families in three municipalities of the Sierra Nevada region in Puebla.
Design/Methodology/Approach: The information used in this research was derived from secondary sources and key informants from the municipalities of Calpan, Domingo Arenas, and San Nicolás de los Ranchos in Puebla.
Results: The Sierra Nevada region is characterized by family-based subsistence agriculture, practiced on smallholdings. In response to the frequent climatic disasters that occur throughout the year —such as frost, hail, drought, strong winds, and excessive rainfall— local farmers have developed various strategies. One such strategy is the introduction of new crops, such as berries and grapes, which are better adapted to the changing environmental conditions. These crops are easier to manage and have shown strong market demand, providing farmers with a viable alternative to traditional crops.
Study Limitations/Implications: Some key informants declined to provide information.
Findings/Conclusions: Family-based agriculture is highly vulnerable to a range of disasters with varying intensities, which negatively impact the living conditions of rural populations, especially those living in poverty. In response, rural communities have developed strategies to mitigate the effects of these disasters and adapt to the changing environmental conditions.

Keywords: Family agriculture, food security, climate change

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INTRODUCTION

Family agriculture refers to the managed cultivation of land, a practice that dates back over 10,000 years (Rosales, 2016). It involves the production of both plant-based and animal-based foods, relying predominantly on the labor of family members, including both men and women. Family farmers play a crucial role in providing healthy, diverse, and culturally appropriate food, producing the majority of the world's food supply in both developing and developed countries. They also create agricultural and non-agricultural

employment opportunities, contributing to the growth of rural economies. Furthermore, family agriculture helps preserve and restore biodiversity and ecosystems. Through sustainable production methods, family farmers are positioned to mitigate or prevent the risks associated with climate change (Obschatko, 2016). In addition, we are also facing climate change, which affects family agriculture and threatens the food security of farming families. This forces producers to confront increasingly atypical conditions year after year, dealing with various climatic disasters and developing strategies to mitigate these phenomena, as their agriculture is primarily rain-fed. Global warming is expected to lead to weather events that will negatively impact agricultural production (Altieri and Nicholls, 2009). On the other hand, the FAO estimates that by 2050, food production will need to increase by 70% compared to current levels to meet the demands of a growing population and its need for improved diets (FAO, 2014). This situation puts at risk the food security and quality of life of farming families, with quality of life understood as the state or sense of well-being derived from the assessment of a person's satisfaction in various dimensions of life (Urzua, 2008).

In the context of global warming, weather phenomena are expected to negatively impact agricultural production and, consequently, the populations that depend on this sector (Salazar & Godoy, 2018). Climatic disasters refer to natural events that occur as part of meteorological cycles and can cause physical, social, economic, and environmental damage in a given area. Examples of such disasters include hurricanes, droughts, wildfires, floods, strong winds, heatwaves, torrential rains, hailstorms, and frosts (WMO, 2021). The aim of this study was to analyze the types of disasters affecting family agriculture and to examine the strategies employed by producers to mitigate damage to crops and the economic well-being of farming families in three municipalities in the Sierra Nevada region of Puebla.

MATERIALS AND METHODS

Socioeconomic Characteristics of the Study Area

This research was conducted in the municipalities of Calpan, Domingo Arenas, and San Nicolás de los Ranchos, located in the central-western part of Puebla state (Figure 1). The majority of the arable land in this region is dedicated to rain-fed agriculture, with maize and beans being the predominant crops (INEGI, 2017). Maize is particularly significant, occupying 73% of the total cultivated area (INEGI, 2017). Additionally, the area is characterized by a diversified traditional agricultural production and marketing system, which includes the cultivation of indigenous fruit varieties (Mendoza *et al.*, 2010).

The population of the municipality of Calpan in 2020 was 15,271 inhabitants, according to the Population and Housing Census, with 48% being men and 42% women (INEGI, 2020). For San Nicolás de los Ranchos, the population was 11,780, comprised of 51.3% women and 48.7% men. Domingo Arenas has a total population of 7,982, with 52% women and 48% men. Among the residents, 1,847 speak an indigenous language (Nahuatl) [11] (INEGI, 2020). These municipalities are characterized by high poverty rates: 82.5% in Calpan, 86.3% in Domingo Arenas, and 83.5% in San Nicolás de los Ranchos (INEGI, 2020). Furthermore, crops in this region have suffered damage due to climatic disasters,

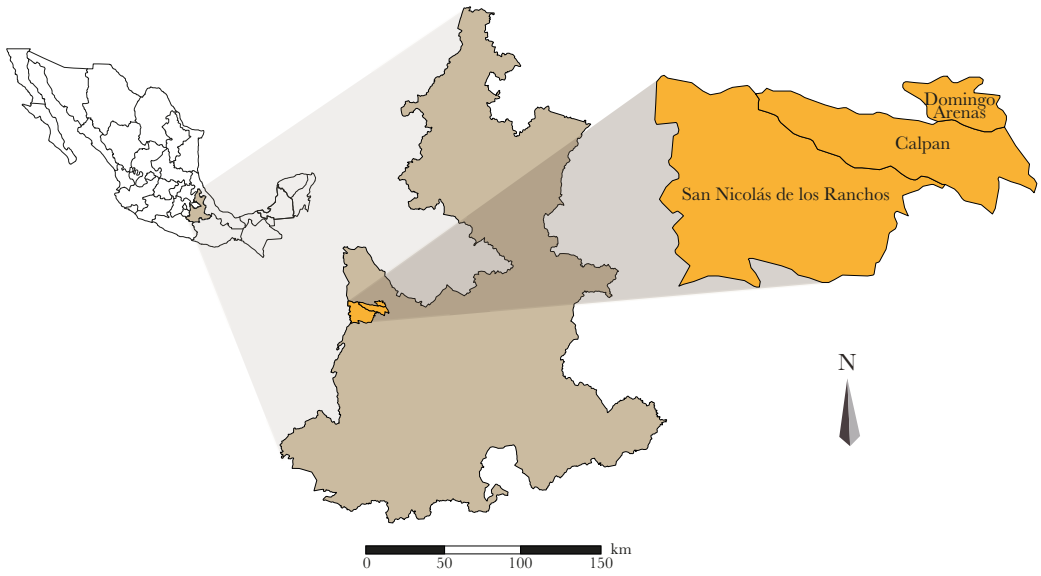

Figure 1. Geographic Location of the Municipalities of Calpan, San Nicolás de los Ranchos, and Domingo Arenas, Puebla, Mexico. Source: Created by the authors, based on: [10] INEGI, 2023. Municipal Political Division, Scale 1:250,000.

particularly maize and beans, resulting in losses of up to 800 tons in both crops (SIAP, 2022), which severely affects the living conditions of farming families.

Research Methods and Techniques

To gather information, 22 semi-structured interviews were conducted, along with direct observation using a non-probabilistic snowball sampling method. Prior to the interviews, a field survey was carried out in the municipalities to identify the families to be interviewed. The results obtained were recorded and analyzed using the ATLAS.ti software.

RESULTS AND DISCUSSION

Social Characteristics of Families

The Sierra Nevada region of Puebla is characterized by family-based rain-fed agriculture, with producers ranging in age from 18 to 98 years. They are often compelled to engage in multiple activities, with 35% working as merchants, 20% as drivers, 25% as construction workers, and 10% in professional occupations.

Due to their reliance on rain-fed agriculture, producers face various climatic disasters throughout the year. The most common are droughts (90%), frosts (51%), hailstorms (45%), strong winds (15%), and excessive rainfall (10%). López-González *et al*. (2020) report that the main disasters in the area are drought, hail, and frost, which aligns with our findings. However, our study also identifies two additional disasters that, although occurring at lower frequencies, are already causing damage to family farmers. Recently, producers have begun introducing new crops into their family units, particularly berries and grapes, due to their nutritional and economic benefits as well as their ease of management. Unfortunately, some producers in the region are now facing a new threat:

volcanic ash, due to the proximity of the municipalities to the Popocatépetl volcano. This has particularly affected berry producers, as their crops are often exposed in open fields or are grown in backyards, leading to losses of up to 45% in production, especially for blackberries.

Furthermore, the climatic disasters have necessitated changes in planting and harvesting schedules. Families that once planted in March are now delayed until May due to insufficient rainfall, resulting in harvests that were previously completed in November now occurring as late as January. This has led to food security issues for these families. Martínez-Corona (2020) notes that changes in planting calendars and production impacts are consequences of disasters such as frost and drought. Another significant impact has been the loss of varieties of pears, apples, and plums, with the *panochera* apple being at the highest risk of extinction, according to producer testimonies. This is particularly concerning as it is a key ingredient in the preparation of *chiles en nogada*, a signature dish of the region that serves as a vital source of income for families.

"*Previously, we had apple orchards, but due to rising temperatures, we have lost varieties of apples, plums, and pears, like San Juan pears and Reyna pears, which are now nearly extinct*," (Producer: Fredi Marcos, San Lucas Atzala, Calpan, 2024).

Finally, the overall production of crops such as wild cherry, peaches, apricots, blackberries, maize, and beans has declined due to the experienced disasters. These climatic events vary from year to year, preventing producers from being adequately prepared or taking preventive measures. "*We no longer know when it will frost or hail. We used to have a better understanding of the months, but now we can have frost in February and hail in October. Moreover, the rains have been significantly delayed, making it impossible to plant in March as we used to*," (producer: Alejandro Alonso from San Andrés Calpan, 2024).

According to Ulloa (2008), each culture has its own perceptions of nature, climate, and the environmental changes they experience, making it essential to understand their processes of perception and adaptation. In this context, the crops most affected by disasters have primarily been maize, beans, apples, plums, mexican hawthorn, peaches, pears, and wild cherry. This aligns with the findings of Pérez-Magaña *et al.* (2021), which identified maize, beans, apricots, plums, and peaches as the crops most impacted by such events. The increasing damage to fruit crops in recent years can be attributed to the intensification and lack of control over these disasters.

To identify the most important themes during the interviews, a word cloud was generated using the ATLAS.ti software (Figure 2). The most frequently mentioned words were "apple," "varieties," "cold," and "temperature," which is consistent with our findings. Apples were the fruit most affected by disasters, alongside significant losses of varieties of apples and other fruits due to rising temperatures in recent years. These conditions have led to prolonged droughts and a lack of chill hours, which are essential for the proper development of certain varieties.

Agroecological Practices

In response to these phenomena, producers have developed various strategies, including agroecological practices that help mitigate certain disasters. For instance, 53% of them

Figure 2. Word Cloud Created using Atlas.ti software.

routinely practice Amogotar with their maize (Figure 3). This technique involves cutting the grass and gathering it in different spots across the property to clear the land. The goal is to conserve soil moisture when the first rains come, as otherwise, the grass would block the rainwater from being absorbed. Additionally, this practice helps make the harvest process quicker and less physically demanding.

Another common practice is the formation of cajetes (42%) (Figure 4). This technique involves digging a circular depression around the base of fruit trees, approximately 30 cm deep, to capture rainwater for the trees. This method helps prevent landslides and soil erosion, ensuring better water retention for the fruit trees.

Figure 3. Amogote of Maize in San Andrés Calpan, Puebla.

Figure 4. Formation of Cajetes around Fruit Trees.

To mitigate damage caused by excessive rainfall and strong winds, 35% of producers build live barriers (Figure 5). These barriers are made using plants such as colorín, maguey, and carrizo, among others, to prevent soil erosion and crop loss.

Additionally, producers have opted to incorporate organic fertilizers (24%) instead of chemical products that harm the soil and biodiversity. In this regard, [9] López-González *et al.* (2020) highlight the importance of implementing agroecological practices across various management systems, as these practices support adaptation and mitigation in response to climate change.

Figure 5. Live Barriers

CONCLUSIONS

Smallholder family farming is increasingly exposed to various types of climatic disasters year after year, which adversely affect the living conditions of rural populations, particularly those living in poverty and extreme poverty. Disasters in the region jeopardize the food security of farming families due to the significant losses in their production. In response to this situation, rural populations have been forced to develop strategies to reduce the impact of these disasters, mainly by introducing new crops and agroecological practices.

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