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Characterization of Maize Producers in the Paso de Ovejas Micro-Watershed, Veracruz, Mexico

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ABSTRACT

Objective: The objective of this study was to determine the producer profile and the management of productive activities along the Xocotitla-Angostillo transect in Veracruz, Mexico.

Design/methodology/approach: A questionnaire consisting of n=49 items was administered, including socioeconomic and technical questions to assess the situation of producers in the study area.

Results: Rainfed agriculture was identified as the main production system, with yields of 3.4 t ha^{-1} and 3.1 t ha^{-1} in Xocotitla and Angostillo, respectively. Likewise, producers reported receiving no government support, low maize (*Zea mays*) prices, and limited commercialization opportunities. In addition, livestock production was used as a secondary activity.

Findings/conclusions: It is recommended to update knowledge on maize management by exploring new alternatives that reduce ecological impact, adopting new technologies for irrigation and grain storage, and promoting access to technical assistance and fair market prices for producers.

Keywords: Water, agriculture, backyard livestock farming, agronomic management, soil.

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INTRODUCTION

Land use and land occupation for agricultural development have been key aspects of socioeconomic development, transforming rural landscapes (Liu, 2018). These changes increase risk and vulnerability to natural and technological disasters in a context where poverty, although lower than in the twentieth century, remains significant and a large proportion of the population still lacks the minimum resources required for a dignified existence (Gligo *et al.*, 2020). Landscape change is driven by several complex drivers that involve feedbacks between human-ecosystem relationships (Fischer *et al.*, 2015).

Global production of food, fiber, and industrial crops continues to grow significantly in line with increasing demand (UNESCO, 2020). Furthermore, the need to reach urban markets exerts greater pressure on rural regions and drives rapid landscape changes. The extent of human transformation of the Earth's surface and ecosystem functions has led to the crossing of multiple planetary boundaries, particularly climate change, biodiversity loss, and nitrogen cycle alteration.

Human influence on ecosystem transformation is irreversible. Perhaps the most important driver of these changes is the conversion of ecosystems into agricultural systems dedicated to the production of food, fiber, and fuels necessary for human well-being (Andersen *et al.*, 2015).

These landscape changes affect community members, who must adapt the ways in which they use, manage, conserve, and interact with the agroecosystems and natural resources that belong to them.

In the state of Veracruz, Mexico, various productive activities modify the landscape, particularly agriculture and livestock production. According to data reported by INEGI (2022), there are 5.8 million hectares with agricultural or livestock use potential, of which 2.6 million hectares are used for agriculture, making Veracruz a state with significant landscape modification driven by productive activities.

Specifically, in the municipality of Paso de Ovejas, where a micro-watershed is formed, there is a highly marginalized area consisting of a transect that includes the communities of Angostillo and Xocotitla. Although productive activities are carried out in this area, the management practices and modifications implemented by farmers to develop these activities remain poorly documented. Over time, these activities change constantly due to seasonal variations, natural resource modifications, and social factors.

Due to the region's topographic diversity, access to water varies depending on location, creating different environmental conditions for the development of productive activities. Therefore, it is important to understand how producers manage the natural resources required for production, particularly water and soil. Accordingly, this study identified the profile of rural producers in the Xocotitla-Angostillo transect, Veracruz, in relation to productive activities and the management of natural resources (water and soil) they employ.

MATERIALS AND METHODS

The research was conducted from October to December 2022 in the central region of the state of Veracruz, where the Paso de Ovejas micro-watershed is located, specifically in the communities of Angostillo and Xocotitla along the transect situated near the Tecolutla River (Figure 1).

A survey was administered to n=180 producers from both communities using a structured questionnaire consisting of 49 items. Five aspects were considered: producer profile, crop management and productivity, production costs, commercialization, and livestock component.

The sampling method used to establish the study population was snowball sampling (linear sampling), which consists of interviewing one producer who then refers other producers known to them for subsequent interviews, and so on. Key contact agents were the presidents of the ejido commissariats in each community, who facilitated access to producers and the administration of the surveys (Mendieta-Izquierdo, 2015).

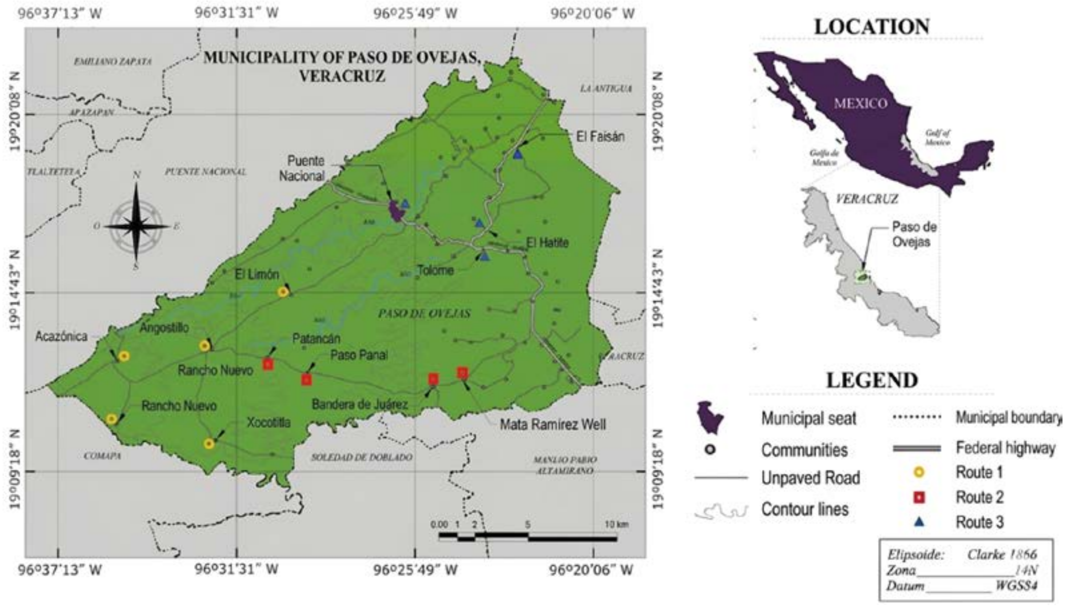

Figure 1. Geographic location map of the study site. Source: Cruz-Bautista *et al.* (2021).

RESULTS AND DISCUSSION

Producer profile

According to the data obtained, the average age of producers was 59.74 and 63 years in Angostillo and Xocotitla, respectively, showing a difference of 3.26 years between the two communities. This indicates that the majority of the population belongs to older age groups. This pattern is explained by the limited involvement of younger generations (adults under 30 years old) in these activities, as most of them tend to migrate.

Producers have an average schooling of 5.2 years, indicating that most of them only reached elementary primary education, and the majority did not complete this level.

Producers are evenly distributed between both communities. Most of them practice agriculture in areas where tomato and papaya were previously cultivated under irrigation; however, these crops were abandoned due to high production costs. Currently, producers focus on rainfed maize cultivation, as it involves lower production costs and requires less investment. Due to economic constraints and the need for a stable income, nearly half of the producers engage in livestock production or combine this activity with agriculture (40%).

100% of the producers reported operating as individual producers, and land tenure is ejidal. However, they own their plots through inheritance from their ancestors, where productive activities are carried out, and they do not pay land rent. Their properties have legal registration, which provides land tenure security and allows them greater autonomy in managing maize cultivation.

Regarding cultivated area, producers in Xocotitla and Angostillo cultivate an average of 5.8 and 5.9 ha, respectively (with some producers planting between 1 and 30 ha). This indicates that they are considered small-scale producers, as their land area is smaller than 13.5 ha (INEGI, 2017), and production is mainly oriented toward commercialization, while only a small portion (10-20%) is used for self-consumption. Producers also reported that they previously cultivated other crops such as tomato (*Solanum lycopersicum*) and squash (*Cucurbita* sp.); however, due to changing climatic conditions, such as prolonged droughts, they have shifted to maize cultivation, as its production requirements are lower than those of the aforementioned crops.

According to the findings from the producer profile, educational level is a key factor influencing human development and poverty reduction, as recognized by UNESCO (2020). According to INEGI (2022), the average years of schooling in Mexico is 9.84 years, while in the state of Veracruz it is 8.75 years. In contrast, the schooling level in the study area is below both the national and state averages, revealing significant educational gaps. Evidence has shown that education has gained increasing relevance in a world undergoing profound transformations driven by the rapid advancement of science and its applications (de la Rosa *et al.*, 2021). Completing at least 12 years of schooling (primary to upper secondary education) is considered by the population to be the minimum level required to obtain conventional employment that does not require a university degree or engineering training.

School dropout occurs across all educational levels (Hernández and Montes, 2020). The factors associated with school dropout in upper secondary education are diverse and vary in nature, including economic, academic, family-related, individual, and broader external factors (Vizcarra-Muro, 2024).

It is worth noting that in 2020 at least one million students at all educational levels dropped out of school nationwide (SEP, 2020). However, the level of education among producers allows them to understand processes that do not require specialized training and to make decisions regarding crop management, such as land preparation and input application for crop development. It should be emphasized that the educational level observed among producers is minimal (primary education). Furthermore, producers no longer pass on agricultural activities to their children, as previously mentioned, because younger generations migrate to pursue education and, after attaining higher levels of schooling, remain in urban areas to work, where they perceive higher wages compared to agricultural or livestock activities. Nevertheless, improving the educational level of the population or encouraging younger generations to return to work in rural communities could enhance overall development and well-being for children, youth, and adults by fostering new ways of living (Miranda-López, 2018).

Crop management and productivity

The maize cultivated in the communities is predominantly hybrid (DK-370) in most cases (65.6%), while the remaining portion corresponds to locally sourced maize obtained from a regional supplier, and a small minority of producers use seeds saved from the previous harvest. Rainfed agriculture is practiced, and therefore irrigation infrastructure is lacking; the sowing season varies from May to July, which consequently affects the harvest period.

Regarding agronomic crop management, activities include soil preparation, sowing, cultural practices, and the application of fertilizers and pesticides (Ávila *et al.*, 2024). In this regard, 100% of producers prepare the land mechanically, using a tractor to carry out harrowing. Likewise, all producers in both communities use tractors to establish planting furrows with a spacing of 0.8 m between rows.

All producers perform sowing and cultural practices manually and apply fertilizers at least once (before flowering) and pesticides (during the early growth stage) to control pests affecting the crop.

For seed preparation prior to sowing, 100% of producers apply a pre-treatment with thiodicarb to prevent pest attacks. The grain is sown in the field after the first three rains of the season to ensure adequate soil moisture. Three days after sowing, and once weeds reach approximately 20 cm in height, herbicide is applied to control weeds that could affect maize development.

During this phenological stage, producers apply glyphosate (50%) or a paraquat + diuron mixture (50%). Although glyphosate is currently banned, producers continue to apply it, stating that it is more effective than the alternative. For narrow-leaf weeds, nicosulfuron is applied, while for broadleaf weeds, Fito Amina is used. Approximately eight weeks after sowing, the flowering stage begins, at which point 100% of producers apply urea at a rate of 300 kg ha^{-1}. Regarding pests affecting the crop, the most common are fall armyworm and stem borer (*Diatraea* sp.). To control these pests, producers apply DENIM at 0.05% (4″-epi-methylamino-4″-deoxyavermectin B1 benzoate), using 200 L ha^{-1} (100 mL diluted in 200 L of water).

Regarding maize production parameters, the average yield was 3.1 t ha^{-1} and 3.4 t ha^{-1} in Angostillo and Xocotitla, respectively, while planting density was approximately 41,625 plants ha^{-1}.

These yields are slightly higher than those reported for communities in the Tierra Blanca region of Veracruz, where rainfed maize production shows yields of 1.26 t ha^{-1} (Jaramillo *et al.*, 2018).

In contrast, in areas where irrigation technology is used, yields are higher, reaching values of 8.13 t ha^{-1} and 9.77 t ha^{-1} in Sonora and Sinaloa, respectively (SAGARPA-SIAP, 2021). This variation in production yield may be due to different factors such as constant access to water, since nutrient distribution and uptake in crops improves in the presence of water, thereby optimizing plant development, whereas in the study site water is only available when rainfall occurs.

Another factor that affects production yields is plant density, as it has been reported that for improved varieties with short and intermediate plant height, around 62,500 plants ha^{-1} should be used under irrigation and fertilization conditions (Saltos, 2018). In other studies, such as that conducted by García-López and Hernández (2023), it is mentioned that plant populations of up to 90,000 plants ha^{-1} can be achieved.

In contrast, in studies where irrigation is not used (Medina-Méndez *et al.*, 2018), 70,000 plants ha^{-1} have been sown, which is higher compared to what was found in the study sites (41,625 plants ha^{-1}), with a difference of more than 20,000 plants. Planting density in maize has a strong influence on grain yield and agronomic characteristics, since grain yield increases with population density until reaching a maximum point and decreases when density increases beyond this point. León-Aguilar *et al.* (2018) mention that population density is one of the most important controllable factors in maize production available to producers to obtain higher grain yields. However, if population densities higher than the optimum are used, competition for light, water, and nutrients increases, causing a reduction in root volume, number of ears, grain quantity and quality per plant, and increasing the frequency of root and stem rot, which leads to lodging, whereas low population densities promote weed problems and underutilization of the soil (Moya-Cisneros, 2016).

Another factor to consider is ear size and weight. According to data obtained from producers, ear weight ranged from 150 to 220 g, while ear length was 18 cm and width was 5 cm. These values are higher than those reported by Sánchez-Hernández *et al.* (2019), where ears from Loma Bonita, Oaxaca, Mexico, had a length of 14 cm. Ramírez *et al.* (2020) found that ears from the same area had an average weight of 139.73 g, being slightly higher in the region of the present study. In addition, other factors such as climate, temperature, soil type, and crop management practices may affect yield, since high temperatures may prevent the plant from reaching the required cold hours for adequate production, and similarly, soil mineral deficiencies may lead to inadequate ear development.

Production costs

Production costs do not show considerable variations among producers. In the case of both communities, 100% of producers obtain their agricultural inputs from regional suppliers, since there are no stores in the communities that sell these products. In both communities, the purchased inputs are used to improve yields, grain quality, and based on recommendations among producers themselves. Production costs range from $12,000.00 Mexican pesos (USD $670.00) to $14,500.00 (USD $805.00) per hectare, with these differences due to the location where the inputs are obtained.

In addition to the required inputs, external labor used during the sowing and harvesting seasons must be included. During this period, 100% of producers hire external labor. Each producer hires an average of 5 to 10 laborers, with each laborer receiving an average payment of MN $300.00 per day (USD $17.00), which is higher than the current minimum wage (USD $11.50). These laborers work for the duration of the harvest period, which can last up to approximately five days, since ear harvesting is not difficult and therefore does not require much time (Morales-Ibarra, 2021). Production costs vary according to the amount of inputs used, such as the quantity of fertilizers and pesticides applied depending on the number of applications, the type of machinery used for land preparation, the number of laborers employed, among others. According to the data collected, production costs are higher compared to those reported by Medina-Méndez *et al.* (2018), who mention that maize production cost USD $590.00 per hectare, where 27% of the total amount is used for fertilization, 28% for seed and sowing, 19% for soil preparation, 10% for herbicides, 7% for pesticides, and the remaining 9% for harvesting. In contrast, in the present study approximately 40% of the total amount is used for pesticides and herbicides. The complete dependence on rainfed conditions in maize cultivation results in high risk, which limits resource investment, and under this scenario maize becomes a highly soil-extractive agroecosystem, as some producers, in order to save as much as possible, use inadequate fertilization formulas and some even reach the point of not applying fertilizers or pesticides.

Comercialization

After harvesting, the ears are dried in the sun and then shelled. The grain obtained is stored in sacks for commercialization. Although maize could also be stored in metal drums or storage facilities, producers do not have this type of technology (SADER, 2024).

The grain can be used as livestock feed or consumed by humans in the form of fresh maize (elote), or once nixtamalized, as tortillas and a wide variety of products (Sánchez-Rodríguez, 2016). Because several maize-based products are part of the basic food basket, most of the production is commercialized mainly to industries. In the case of producers, a small portion of production is kept for self-consumption (20%), while most is commercialized or sold (Figure 3).

In both localities, producers mentioned that the price at which the collector purchases the grain is low, receiving a payment of USD \$0.40 kg^{-1} and USD \$0.36 kg^{-1} in Xocotitla and Angostillo, respectively, while the collector sells this same maize at a price of approximately USD \$0.54 kg^{-1}. The difference between producer and trader, translated into tons of production, represents a considerable amount. However, between 70-80% of producers consider the crop to be profitable, as it generates some benefit.

In addition, it is important to mention that producers do not export the maize they produce nor sell it directly to companies, as the individual production volume is small and they do not have a producers' organization through which they could coordinate to gather the necessary production volume to meet the demand of a specific company, which could also provide them with higher profits by eliminating intermediaries in commercialization.

They also indicate that the government should support maize production in the region, as they do not receive any type of support, lack infrastructure (transport, packing facilities, storage containers), and their commercialization is limited due to being a marginalized area. In both localities, maize cultivation presents constraints such as low production yields, soil erosion, lack of irrigation technology or access to water, pests, lack of technical assistance, and commercialization limitations (IICA, 2018).

In the case of the study localities, maize production (approximately 2,737.80 tons) is sold or commercialized to an intermediary (collector), who sells the production to companies that require large volumes of maize, or in some cases to buyers who export the grain to other countries where there is demand.

Although it is mentioned that the payment they receive is not fair, mainly because production costs are high and therefore profits are reduced, producers consider that commercialization prices could be improved if a guaranteed price were established so that producers could obtain profits, as well as by establishing a collection center near the region to avoid selling to intermediaries. Likewise, the establishment of a producers' association could allow them to set their own guaranteed price or make agreements directly with companies and consequently obtain greater benefits from grain sales.

The reduced payment received by producers causes economic difficulties, motivating them, directly or indirectly, to seek alternatives to obtain income, and one of these is through livestock raising.

Livestock component

Animal husbandry in rural areas is used as an alternative subsistence activity (20-30% of income), which is related to rural activities and together contribute to the food sovereignty of producers. According to the surveys conducted, it was found that each maize producer had on average five head of cattle, in addition to some chickens and pigs.

In this sense, 100% of the producers raise chickens under backyard conditions. It was also found that producers had on average five cows, mainly raised in pastureland, and to a lesser extent an average of one pig per producer raised in backyard conditions.

Maize production together with backyard livestock farming constitutes a peasant production system in which agricultural and livestock activities converge with the purpose of providing families with basic foods such as meat, eggs, seeds, among others (Cuca *et al.*, 2015). The importance of livestock in rural families lies mainly in the fact that the products obtained are destined for self-consumption, as they represent family savings (Montero and Martínez, 2015). In addition, in case of emergency or under precarious conditions, these animals can be sold to generate income (García-Navarro *et al.*, 2022), which ensures family stability. Pig raising (*Sus scrofa* ssp.) generates income through live-animal sales, and most pigs are fed with waste or leftovers from the kitchen or harvest. Likewise, chickens (*Gallus gallus*) are part of the producers' diet and have great importance in the communities, being essential for the subsistence of many low-income farmers, as they are often the only asset they possess. They are also used as food during celebrations and gatherings, helping to build networks and relationships with other peasants in the community, as they are part of their uses and customs (Morales-Jiménez *et al.*, 2024).

Based on the aforementioned, it was determined that animal husbandry in the localities of Xocotitla and Angostillo constitutes a strategy that provides food for self-consumption and also becomes a means to meet certain needs, as these animals can be sold in case of financial emergencies and can therefore be considered a form of savings.

In addition, producers stated that when maize production is good, it helps sustain animal feeding, providing capital availability to improve animal husbandry and better control their diseases, which leads to better development and consequently greater profit for the producer.

The characterization of producers made it possible to determine that the main productive activity was agriculture, with rainfed maize as the principal crop, with an average of 5.8 ha cultivated and yields of 3.1 t ha^{-1} and 3.4 t ha^{-1} in Angostillo and Xocotitla, respectively. Producers in both localities could benefit from the implementation of new technologies or products to improve production yields and thus obtain greater benefits. Backyard animal husbandry, such as cows, pigs, and chickens, helps support family subsistence. The limiting factors affecting crop production are water availability, pests, lack of government support for infrastructure (machinery and storage), and technical assistance, and consequently poor crop management.

CONCLUSIONS

It is necessary to update producers on crop management and to consider more effective and economical alternatives to those currently used in the study localities in order to reduce ecological damage; likewise, it is essential to adopt irrigation technologies for crop production and grain storage. Similarly, it is important for the government to support producers in Xocotitla and Angostillo through governmental programs that provide technical assistance and infrastructure, in addition to guaranteeing a fair selling price for producers. It would also be important for the government to conduct periodic censuses in this type of locality in order to develop databases that would facilitate future research.

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