



Changes in the pattern of cultivated species and loss of sustainability in central Veracruz, Mexico

Cambios en patrón de especies cultivadas y pérdida de sostenibilidad en el centro de Veracruz, México

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Abstract

The economic, social, and technological conditions in agriculture have changed due to public policies implemented by the Mexican government. These changes have forced producers to make decisions to adapt to a complex agricultural reality. The objective of this research is to analyze the changes in cropping patterns over four decades and their impact on sustainability in a local context. A survey and in-depth interviews were conducted among producers in agricultural and rainfed areas in central Veracruz, Mexico. The findings suggest that the promotion and subsequent reduction of public spending in favor of agricultural production resulted in the gradual introduction and exclusion of crops, as well as the fundamental management practices underlying them, such as fertilization, weed, disease, and pest control. This led to a loss of sustainability as it promoted monoculture, the use of agrochemicals, and the commercialization of crops. This not only simplified the crop pattern but also affected the family's diet, created conditions for increased pest and disease presence, and degraded soil life and agrobiodiversity, including medicinal and food-plants subject to harvesting. These findings should be taken into account when defining medium and long-term strategies.

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Resumen

Los cambios en las condiciones económicas, sociales y tecnológicas en la agricultura derivadas de las políticas públicas del Gobierno Mexicano, han provocado que los productores tomen decisiones con el fin de adaptarse a una realidad agrícola compleja. En este sentido, el objetivo de la presente investigación, fue analizar los cambios en el patrón de cultivos por cuatro décadas, y su impacto en la sostenibilidad en un contexto local. Esto involucró la realización de una encuesta y entrevistas a profundidad entre productores de zonas agrícola, y de temporal en el centro de Veracruz, México. Los hallazgos indican, que tanto el fomento, como la posterior reducción del gasto público a favor de la producción agrícola, originó la introducción y exclusión gradual de cultivos y, por ende, las prácticas de manejo fundamentales que le subyacen como, la fertilización, control de malezas, enfermedades y plagas, entre otras. Esto generó, la pérdida de sostenibilidad, ya que se favoreció la existencia del monocultivo, el uso de agroquímicos y que primara el fin comercial de sus cosechas, con ello, no solo se simplificó el patrón de cultivos, sino también, la dieta familiar, se crearon condiciones para la mayor presencia de plagas y enfermedades, la degradación de la vida en el



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suelo y la agro-biodiversidad (plantas medicinales, plantas alimenticias incluidas aquellas sujetas a recolección). Estos hallazgos deben ser considerados en la definición de estrategias en el mediano y largo plazo.

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Introduction

The modifications to the economic, social, and technological conditions in agriculture resulting from the Mexican government's public policies have compelled producers to take action in order to adapt to the complex reality of contemporary agriculture¹. One decision that has been made is the alteration to the cropping pattern, which is accompanied by a change in the underlying management practices². Although this phenomenon has been previously studied, there is a lack of information on what has occurred in the local context and how the crop structure has been transformed (inclusion and exclusion of crop species)³.

This is particularly pertinent in areas where agriculture, in addition to being the primary productive activity, is also an integral part of the way of life and identity of those who live there⁴. Consequently, in Mexico, and particularly in the Centre of the state of Veracruz (where this study was carried out), the current cropping pattern can only be explained on the basis of its historical background, the result of decisions taken by producers over several decades, as a way of adapting to a series of agricultural policies that had as their axis the reduction of the role of the State, which limited the resources allocated to agricultural promotion. This situation mostly affected small producers and their families⁵.

However, these changes in the cropping pattern (previously made up of traditional species that also formed part of their culinary culture), while allowing producers to enter the market, also meant that local production was more exposed to fluctuating market

prices and to the adoption of certain management practices, including monoculture, which would lead to the loss of natural soil fertility and increase their dependence on external inputs, which would progressively increase their dependence on external inputs. The adoption of certain management practices, including monoculture, would result in the loss of the soil's natural fertility and an increasing reliance on more expensive external inputs. Consequently, income became dependent on a single crop, while the diversity of food in the diet of producers and their families was reduced⁶.

Consequently, this research is descriptive in nature, with the purpose of analysing the impact of changes in cropping patterns and their relationship with the loss of sustainability of agriculture in central Veracruz, Mexico. The concept of sustainability is employed as a useful meta-concept in the understanding and search for solutions to the socio-environmental problems of this productive activity, where environmental, social and technological factors converge⁷.

Materials and methods

The present research was carried out in the communities of El Mango, El Faisán, El Limón, Angostillo, Rancho Nuevo and Xocotitla in the municipality of Paso de Ovejas, Veracruz, Mexico. This municipality is located between the coordinates 19°17' - 19°22' north latitude and 96°20' - 96°38' west longitude, with an altitude between 10 and 400 m above sea

level⁸.

The survey included sugar cane producers from El Mago and El Faisán (irrigated agriculture) and maize producers (rainfed agriculture) from the remainder of the localities. This research forms part of a larger project, entitled 'Adaptation of agroecosystems in the Veracruz sub-humid tropics to climate change'

The probability sample was constructed using a stratified sampling methodology based on the sample frame of 302 producers. The sample size was calculated using the formula proposed by Scheaffer et al.⁹, resulting in a final sample size of 210 producers.

The targeted sample consisted of identifying some informants, who in turn helped to identify others using the 'snowballing' technique¹⁰. This type of sample was used to identify producers who participated as informants in the in-depth interviews (n=27). The number of interviewees was determined heuristically from the 'saturation point', at which point the information obtained became redundant¹¹. With regard to the guided in-depth interviews, the data obtained were systematized in an Excel database and subjected to thematic analysis¹².

The questionnaire was administered to participants from January to June 2014 in the 6 localities of the study area. The data obtained were systematized in a database. The survey, interviews and life histories were complementary techniques in this research process. In this sense, the changes made by the producers in their agro-ecosystem management practices were identified through the survey, while their causes were identified through the guided in-depth interviews and life histories. The statistical analysis was exploratory and employed the Statistica 7.1 software (Stat Soft Inc. 1984-2006, Tulsa, O.K., USA).

Results

The area of study is physiographically characterized by the prevalence of barrial or black earth (mollisols

or Vertisols) in the temporal zone, along with yellow earth (Entisols), gravelly earth (Inceptisols), and sandy earth. These soils are shallow, rocky, and have low organic matter (OM)¹³ content. In contrast, the soils in the irrigated zone are classified as Feozems, which have a sufficient amount of organic matter, nutrients, and Vertisols, which are characterized by their hardness, wide, deep fissures, and susceptibility to erosion¹⁴. Currently, the main crops grown in the temporal zone are maize, while in the irrigated zone, it is sugarcane.

The vegetation types observed in the study area include medium sub-evergreen forest, riparian vegetation, and secondary communities¹⁵. The predominant climate is Aw° (w), which is warm sub-humid with an annual precipitation between 1200 and 1000 mm¹⁶. In this study area, changes associated with climate change, as in other regions, show a trend towards less precipitation and higher temperatures¹⁷. This places maize in particular at risk, as sugar cane is cultivated in the irrigated area.

The majority of farmers in the study area are descendants of agricultural workers who were employed at large haciendas at the beginning of the 20th century. The agrarian movements of the 1920s and 1930s resulted in a series of presidential resolutions for the establishment of a series of ejido nuclei¹⁸.

The ejidal nucleus of El Mango was established in 1935 through a presidential resolution, with an initial endowment of 211 hectares, which were considered to be prime farmland. Each ejidatario was allocated a total of 6 hectares. However, the documentary review did not identify the land parceled, with infrastructure, or the area corresponding to rivers, streams, and bodies of water. In 1935, a decree was also issued for the El Faisán ejido, with an endowment of 524,084,746.2 ha, 28,637,993.2 ha was allocated for infrastructure, and the area with rivers, streams and bodies of water was 3,168,232.9 ha. Each producer was allotted 7.5 hectares. A 1990 research report on the ejido's utili-

zation of land indicates that that year, the ejido cultivated sugar cane, grass, papaya, corn, mango, and banana. Angostillo was constituted as an ejido in 1936, with a land area of 864,152.8 ha, comprising 140,698.9 ha of infrastructure and 175,741.5 ha of rivers, streams, and bodies of water. Each ejidatario was allotted 10 hectares. At the time of the presidential resolution, the hacienda subject to expropriation was identified as producing maize, beans, and rice as the primary crops, with tomato, sugar cane, chile, and fruit trees of lesser importance. This distinction was made on the basis of the cultivated area.

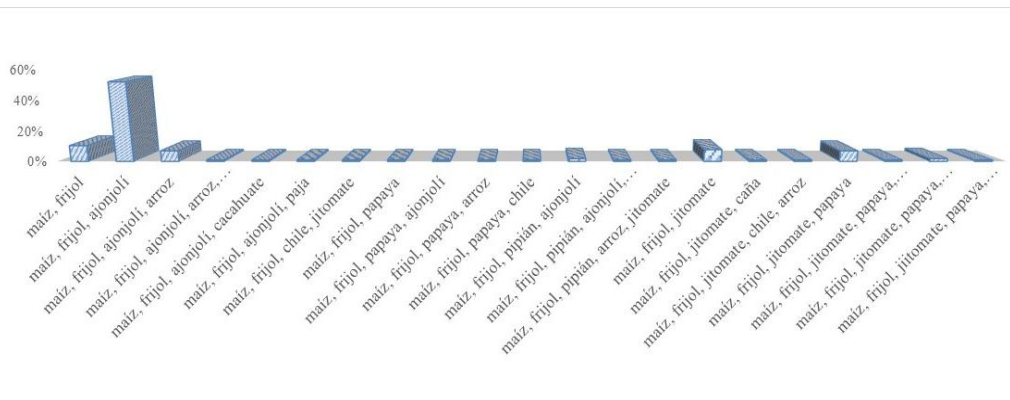
The presidential resolution for the creation of the El Limón ejido was issued on May 1, 1936, with the following specifications: 238-65-16,931 ha were for the parceled area, while 2-65-91.199 were for infrastructure. The total area endowed was 241-31-08,130 hectares. The area per ejidatario was 10 ha, and there is no mention of any area with rivers, streams, or bodies of water. Neither the resolution nor the land usufruct investigation reports mention the types of crops or livestock existing at the time of issuance.

In 1942, according to a presidential decree, Xocotitla was granted 611-76-15671 ha, of which 521-42-90,213 was the parceled area, 50-088-96,796 was

common use, 05-35-74,526 was infrastructure and 10-52-17,920 was water. Each ejidatario was granted 13 hectares. A general survey report of the usufruct parcel in 1996 indicates that the parcel was used for the production of corn, beans, mango, papaya, tomato, pasture, and some areas identified as acahual. Rancho Nuevo was established as an ejido in 1957, with an initial endowment of 630 ha. The area was initially parceled at 610-49-88.336 ha, of which 7-38-24.891 ha was designated for infrastructure and 0-07-90.817 ha corresponded to rivers, streams, and bodies of water. Each ejidatario was allotted 20 ha of rainfed land and 18 ha of irrigated land. A 1996 land usufruct investigation report identified corn, beans, tomato, papaya, and chile as the most important crops.

The results of the survey indicate that in the 1970s, the main crops in the study area were beans and corn. Fifty percent of those interviewed also planted sesame, a crop with the highest commercial value whose production was supported by the company Aceites Faro, which granted loans for production and paid crops in advance. This enabled the financing of not only sesame, but also other crops (Figure 1).

Figure 1 Predominant crop patterns in the 1970s in the study area (Source: field data)



However, this pattern changed a decade later, when public spending on sugarcane production was reduced (Azúcar, S.A. disappeared and so did subsidies

and credits to growers)¹⁹. In this context, producers began to introduce vegetables of high commercial

value, such as tomatoes, chile peppers, and in the 1980s, 50% of the producers had tomato and papaya

in their productive areas, while 20% had tomato, papaya and chile (Figures 2 and 3).

Figure 2 Predominant cropping pattern in the 80's in the study area

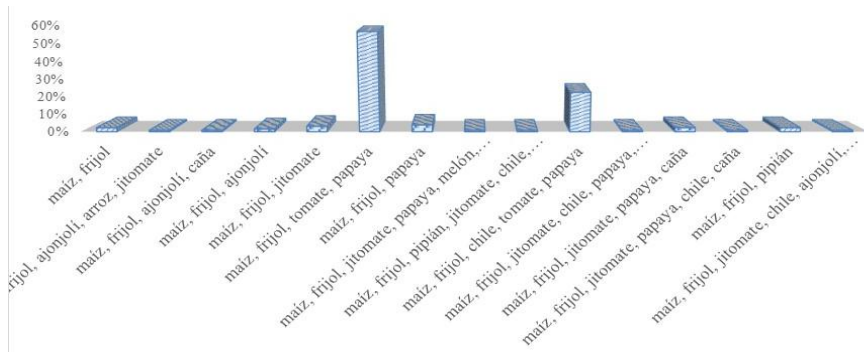
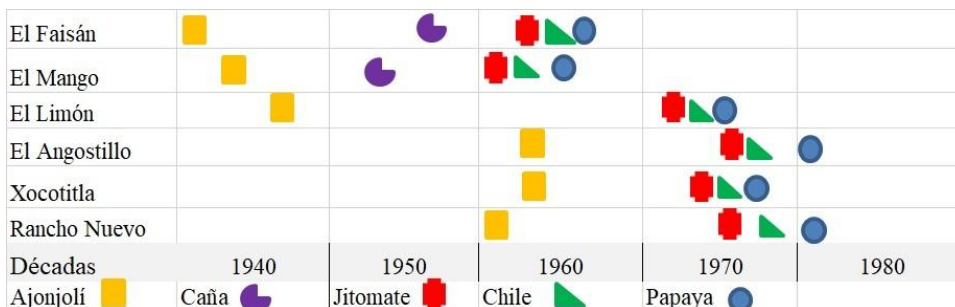


Figure 3 Introduction of cash crops in the study area (Source: in-depth interviews)



This change in the cropping pattern was gradual as evidenced by the information obtained in the in-depth interviews, where the sesame crop was succeeded by sugar cane, to be replaced by tomato in the first instance, chile and finally papaya maradol (Figure 3).

Discussion

The study area has undergone significant changes in its cropping pattern over time. Traditional crops such as maize and beans have been gradually replaced by cash crops, including sugar cane, tomato, chile, and papaya maradol. Although there are some coincidental aspects that led to the inclusion and subsequent exclusion of these crops in the agroecosystems, there are also aspects that can only be explained

through the historical background that was recovered from the participants in each of the interviews.

In the irrigated agriculture zone, particularly in El Mango and El Faisán, small areas were first cultivated with tomato crops in the 1930s and early 1940s. These crops were marketed in the port of Veracruz through the railroad. Subsequently, in consideration of the conditions made possible by the construction of Irrigation District 06 in 1950, which permitted producers to mitigate the risk associated with drought and drought, sugarcane was introduced. This crop began to exhibit favorable prices, and producers began to receive government support for the promotion of its production as part of a strategy to supply sugar to the domestic market. This support was provided in the form of incentives for the expansion of the culti-

vated area, financing, advisory services, and the granting of health insurance and pensions to growers¹⁹.

However, a decade later, in El Mango and El Faisán, the production of tomatoes, chiles and papayas resumed with greater intensity. According to the producers, the quantity and quality of the produce obtained were so attractive that buyers from the center of the country began to travel to this area to purchase the crops. In this period, the State could still be considered as an agglutinating system²⁰ that directed agricultural policies and favored the relative inclusion of a sector of the country's agricultural producers, including those in the study area. This period was a reflection at the local level of the so-called "Mexican miracle," a process derived from the positive effect of a set of policies aimed at agricultural development as a means of obtaining cheap food and raw materials as part of a national development plan, the ultimate goal of which was to boost national industry⁵.

Nevertheless, by the end of the 1970s, the producers of El Mango and El Faisán began to encounter difficulties associated with the presence of diseases in tomato, chile, and papaya crops. Lacking access to technical advice and the pesticides necessary for phytosanitary control, they opted to abandon these crops. In contrast, sugarcane cultivation expanded, especially with the establishment of the El Modelo and La Gloria sugar mills in the region, which facilitated the commercialization and processing of sugarcane. As a result, sugarcane became an almost unique component of the agroecosystems of El Mango and El Faisán, gradually becoming the most important monoculture.

"When the [ji] tomato, chile, papaya stopped giving, we started to grow more cane." I25, 69 years old, ejidatario, El Faisán.

In the rainfed zone, specifically in El Limón, Angostillo, Rancho Nuevo, and Xocotitla, agriculture was primarily oriented towards self-consumption

during the 1940s until the end of the 1950s. In the subsequent decade, some began to cultivate sesame on a small scale, approximately two decades later than in the irrigated agriculture zone. This was primarily done in El Limón and El Angostillo for at least a decade, between 1965 and 1975. The decline in sesame production can be attributed to the replacement of locally produced sesame with oilseeds acquired at lower international prices by the company that purchased their crops. Furthermore, the elimination of the sesame guarantee price by the State at the end of the 1980s served to discourage national production²¹. The cultivation of tomatoes and chiles in the rainfed agriculture zone commenced in the 1970s, and the commercialization of these crops was accompanied by the commercialization of corn. The area dedicated to the production of tomatoes, chiles, and papayas per producer ranged from several hectares to small areas of less than half a hectare. Consequently, the production of cash crops commenced at a later stage in the rainfed zone, within a more constrained production environment.

It is crucial to acknowledge that the primary constraint was the availability of financing for the agricultural cycle. Consequently, the ejidatarios and small landowners in this rainfed region utilized financing obtained through familial, social, and professional connections. Although some producers cultivated only small portions of their land with these crops, they were able to benefit to some extent from this dynamic activity that had an assured market. Despite the poor condition of the roads, which were made of dirt and in a state of disrepair, the transportation of crops to market was not impeded.

However, as with irrigated farmers, the emergence of certain diseases that could not be controlled due to the lack of technical assistance or resources for the acquisition of expensive agrochemicals led to a decrease in production and the farmers' subsequent exclusion from their agroecosystems. This resulted in

producers dedicating themselves to a greater extent to the production and marketing of corn and beans. However, there was a radical change in the objective of corn production. Whereas previously it had been a crop associated with self-sufficiency for millennia, it is now produced for commercial purposes (Figure 3). Consequently, the alterations in the crop pattern observed in the study area can be attributed to changes in public policies, a reduction in the budget allocated to agriculture, and the dissolution of development institutions. The necessity for producers to enter the regional and national market²² led them to prioritize the cultivation of corn and vegetable varieties based on the needs of suppliers, which simplified their crop pattern. This, in turn, impacted their family diet (food security) and initiated management practices that involved the use of agrochemicals. Over the decades, this has led to soil degradation and a decrease in agrobiodiversity (disappearance of species with different degrees of management, from cultivated to harvested).

In other words, production shifted from family consumption and exchange in relatively proximal markets to larger markets, favoring the idea of obtaining a monetary income and thus individual economic accumulation. Despite the abandonment of these cash crops (except sugarcane) by producers in this area decades later, the main purpose of the production of all their crops was essentially commercialization. Consequently, farmers ceased planting corn for their own consumption, and producers who planted corn in the rainfed zone ceased cultivating the native breeds that had previously constituted an essential component of their diet. Furthermore, the aforementioned factors resulted in a negative impact on the soil and agrobiodiversity, as the prevalence of monoculture, a more intensive form of cultivation, led to an increased incidence of pests and diseases, as well as the intensive and prolonged use of agrochemicals.

This phenomenon occurred in both irrigated and rainfed agricultural zones.

The aforementioned allows for the inference of a loss of sustainability, which is expressed in degraded soils and dependence on external inputs. A crop pattern where corn and sugarcane are the most important monocultures represents the basis of the producers' income. Price fluctuations in the market affect these producers, resulting in the loss of germplasm and traditional knowledge of medicinal plants, edible plants subject to collection or with a minimum degree of management (tolerated and encouraged species).

These findings should be taken into account when designing and implementing strategies for agricultural development in local and regional contexts. In particular, it is important to consider the management practices employed in agroecosystems and how these are carried out by farmers. Additionally, it is essential to assess how farmers respond to the information they receive from their environment, including the agricultural market, input and agrochemical market, agricultural policies, livestock policies, agrarian policies, and laws on natural resource management.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Ethical considerations

During the research process, the authors complied with the corresponding ethical standards.

Research limitations

This is a local study, however, it contributes to the understanding of specific situations in greater depth.

Authors' contribution

Lorena Casanova Pérez, project management, writing and editing of the manuscript. *Verónica Rosales Martínez*, *Patricia Cruz Bautista*, *Florencia García Alonso*, data analysis and discussion. *Emigdio de la Cruz* and *Alberta San Juan*, documentary review and systematization of field data.

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