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Urban-rural transition of agricultural production systems in Tocuila, Texcoco

Transición urbano-rural de los sistemas de producción agrícola en Tocuila, Texcoco

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ABSTRACT

Agricultural production in urban environments, especially in areas affected by urban growth, is essential for securing food supplies. This research aimed to identify and characterize urban agricultural systems by analyzing general and agricultural data from ejido landowners. To achieve this, surveys were conducted, supported by field notes and direct observation, followed by statistical analysis using the IBM Statistical Package for the IBM Social Sciences (SPSS) version 21. The results show the classification of three main agricultural systems based on their production purposes: subsistence, mixed, and commercial. Subsistence systems make up 48 % of the population, making them the most common type, while mixed systems account for 39 % and commercial systems 13 %. Despite urbanization, 50 % of elderly individuals remain interested in continuing to work their ejidos, even when their lands have been reduced to urban areas. These individuals have adapted their production methods to ejidos that have not been affected by urbanization or have been divided. These findings highlight the adaptability of ejidatarios to urban changes and emphasize the importance of finding solutions to conserve agriculture and ensure its sustainability.

KEY WORDS: Urban gardens, resilience, food security.

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RESUMEN

La producción agrícola en entornos urbanos de localidades afectadas por el crecimiento urbano es vital para garantizar el abasto de alimentos. Esta investigación tuvo como objetivo identificar y caracterizar los sistemas agrícolas de la zona urbana, analizando información general y agropecuaria de los ejidatarios. Para ello, se aplicaron encuestas, respaldadas con libro de campo y observación directa, seguidas de análisis estadístico mediante SPSS. Los resultados muestran la clasificación de sistemas agrícolas predominantes, son tres según el propósito de su producción: de subsistencia, mixtos y comerciales. Los sistemas de subsistencia representan el 48 %, siendo el tipo de sistema productivo más frecuente, mientras que los mixtos representan el 39 % y los comerciales el 13 %. A pesar de la urbanización, el 50 % de las personas de la tercera edad son las más interesadas en seguir trabajando su ejido, incluso cuando sus tierras han quedado dentro de la ciudad. Estas personas han adaptado sus métodos de producción en los ejidos que no han sido alcanzados por la urbanización o fraccionados. Estos hallazgos resaltan la capacidad de adaptación de ejidatarios ante cambios urbanos, además señalan la importancia de encontrar soluciones para la conservación de la agricultura y garantizar su sostenibilidad.

PALABRAS CLAVE: Huertos urbanos, resiliencia, seguridad alimentaria.

Introduction

Traditional agriculture relies on knowledge passed down through generations, built from empirical experience and experimentation by farming communities (Remmers, 1993). It is worth highlighting that this knowledge also connects to geographical, environmental, and ecological understanding, which helps ensure the survival of families in rural areas and is heavily influenced by traditional practices and natural resources (Pérez & Juan, 2022).

However, urbanization is changing traditional agricultural systems worldwide in ways that can only be understood from a perspective that considers the rural-urban continuum. These changes include the fragmentation of rural and urban landscapes, the growth in employment in the service and trade sectors, the disconnection of family and peasant forms of agricultural production, and the movement of production and markets (Salas & González-Fuente, 2017a; FAO, 2025).

In Mexico, 1992 marked a significant change in Article 27 of the Political Constitution by authorizing, for the first time, the sale of communal and ejido lands. It was argued that this measure would facilitate a progressive transition from clandestine land sales toward their regulated

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incorporation into legal urban development (Calva Téllez, 1993; Olivera, 2005). Nevertheless, rather than being primarily aimed at integrating ejidos into the market, this reform increased the availability of land for urban growth (Hernández, 2023). Furthermore, some authors contend that the true purpose was to reverse land fragmentation (minifundio) and encourage private capital investment in larger agricultural holdings.

This growth has made food scarcity more evident in developed regions of the world. Consequently, food systems are under increased pressure and are more vulnerable due to stress on natural ecosystems (Awasom, 2021).

In response to this issue, both globally and regionally, international organizations such as the Food and Agriculture Organization of the United Nations (FAO) have promoted productive alternatives in limited spaces. In this context, new agricultural systems designed for small areas have emerged, including backyards, orchards, terraces, and container crops, among others. These practices, aimed at self-consumption and, in some cases, local marketing, are encompassed under the term urban agriculture (UA) (FAO, 1999). Additionally, it has been observed that the size of UA varies depending on the available space in an urban environment and the specific purpose of the farm or garden. However, size is not a defining factor for its classification, as UA includes everything from edible gardening in private homes, ranging from small herb pots on a balcony to conventional farms exceeding 10 ha (Papanek *et al.,* 2023).

Given the diversity of practices and scales, there is a need to classify agricultural systems by considering several key factors, such as available resources, main agricultural activities, household subsistence strategies, their links to markets, and the intensity of productive actions (Dixon *et al.,* 2001; Escobar & Berdegué, 1990).

Within this framework, UA offers an alternative to enhance food security through sustainable food production methods, utilizing innovative techniques such as vertical farming, hydroponics, and community gardens. These techniques maximize yields in limited spaces by efficiently utilizing resources (Krishnappa et al*.,* 2024). Therefore, to address global food shortages, UA is being considered as a strategy to improve food access within communities and promote more sustainable cities. This agricultural approach enables localities to grow their own food, providing urban areas with a reliable food supply. It is important to note that UA does not replace traditional agriculture but rather complements it (Garrett & Ruel, 2000; FAO, 2023).

UA aims to make food sustainably accessible in communities aligned with the Sustainable Development Goals (SDGs) adopted by the United Nations (UN) in 2015. These goals provide a framework for countries and communities to pursue a new path focused on improving everyone's quality of life while ensuring no one is left behind. UA directly supports achieving Sustainable Development Goal (SDG) 2: Zero Hunger, established in the 2030 Agenda for Sustainable Development by the United Nations, which aims to end hunger, ensure food security, improve nutrition, and promote sustainable agriculture (UN, 2015).

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Although INEGI does not officially classify Tocuila as a mixed locality (INEGI, 2020), the Texcoco Municipal Development Plan (2022-2024) documents urbanization processes that have led to the loss of agricultural land and unplanned expansion of the urban area. These territorial dynamics characterize Tocuila as a place where rural and urban features coexist, with agricultural practices still active despite ongoing urbanization.

In light of the above, this study aims to identify and characterize the agricultural systems in Tocuila's urban area through the analysis of general and agricultural data provided by ejidatarios.

Materials and Methods

The Tocuila area belongs to the Lacustrine Zone of Texcoco municipality, in the State of Mexico, and is part of the region known as the Valley of Mexico or eastern zone of the State of Mexico (Figure 1). It is situated between parallels 19°24′ and 19°33′ N and meridians 98°38′ and 99°02′ W. Notably, Tocuila has a mixed character, with both urban and rural features, reflecting its transitional state within the study area (H. Ayuntamiento de Texcoco, 2022).

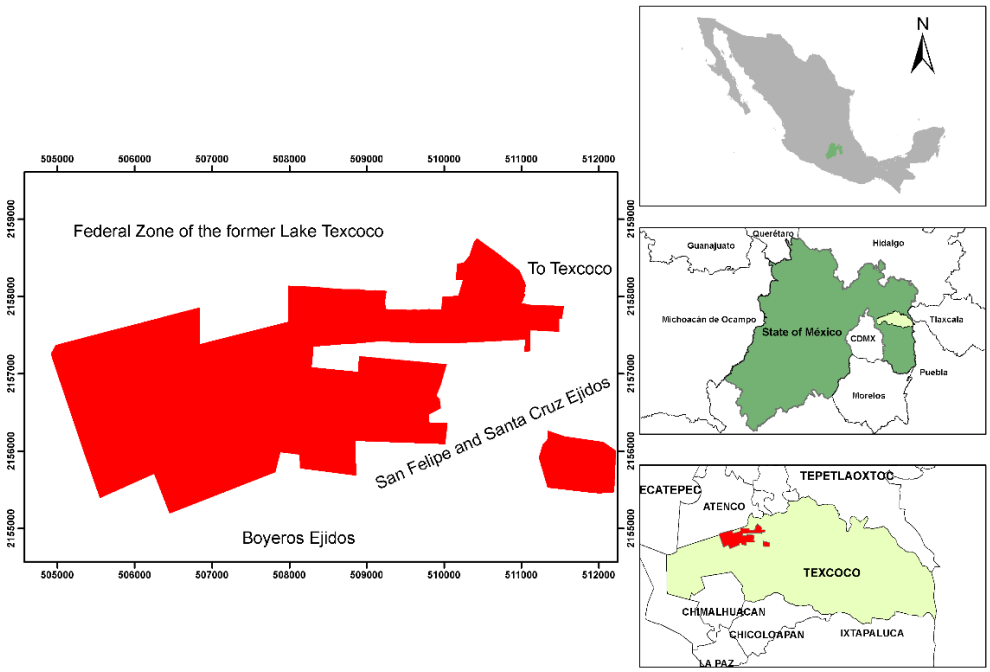

Figure 1. Location of ejido lands in Tocuila, Texcoco.

Source: INEGI (2024)

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Sample calculation

For this study, the sample was selected using the simple random sampling formula with finite population correction, as systematized and disseminated by Cochran (1977). The universe consisted of 215 active ejidatarios, chosen solely from those still involved in production, based on the census list provided by the President of the Ejidal Commissariat (totaling 499 ejidatarios). From this group, 50 surveys were conducted, resulting in an approximate margin of error of 12 % with a 95 % confidence level, calculated through Equation 1 (Boza et al., 2021), thereby ensuring the representativeness of the primary attributes of the ejido's productive population.

$$n = \frac{N * Z_{\alpha}^{2} * p * q}{d^{2} * (N-1) + Z_{\alpha}^{2} p * q}$$, equation.1

Where:

N = Total population.

Z_{α}^{2} = 1.96 (95 % confidence level).

p = Expected proportion (in this case 0.05).

q = $1-p$ (in this case 1−0.05 = 0.95).

d^{2} = precision 0.12 = 12 %

Survey application

To gather field information, surveys were conducted covering 18 quantitative variables and 64 qualitative variables, divided into five sections: (I) personal data of the ejidatario, (II) family details, (III) agricultural activities, (IV) production systems, and (V) impacts of urban growth. However, only modules I to IV were included in this study. A field notebook and direct observation supported the process. Data collection was initially done in 2013 and updated with information gathered between December 2023 and January-June 2024, which helped validate and supplement the original data. This update ensures that the results more accurately reflect the current situation of active ejidatarios.

Data analysis

The collected data were analyzed using IBM Statistical Package for the Social Sciences, Version 21 (SPSS). Frequencies and percentages were calculated for qualitative variables, while

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measures of central tendency and dispersion were obtained for quantitative variables. However, this study mainly reports percentages, as they best highlight the observed patterns.

Results and Discussion

I. General information on ejidatarios

According to the obtained data, 50 % of elderly ejidatarios (65-79 years old), despite urbanization processes, continue to work their lands actively. Likewise, in the oldest age group, which accounts for 8 % of ejidatarios aged 85 and over, activity mainly involves cattle raising with support from grandchildren, while participation in open-field agricultural work has decreased due to physical demands. On the other hand, the 35-64 age group comprises 42 % of respondents and is primarily involved in the service sector, with some individuals combining part-time farming with other jobs.

Ninety-four percent of families have between 2 and 7 children, with the most common household sizes having 6 or 7 children (38 %), followed by those with 4 or 5 children (26 %), and those with 2 or 3 children (22 %). In contrast, 8 % of families consist of a single child, while 6 % are single individuals.

Currently, women also play an important role in the agricultural sector. Among the active ejidatarios surveyed in this study, 34 % were women and 66 % men. Although food production has traditionally been linked mainly to men, women are increasingly taking on a vital role in this field.

II. Main economic activities of the locality

Based on the survey sample, the main economic activity in the area is construction work (36 %), followed by paid domestic work in other households (34 %). Fourteen percent are employed in government jobs or public transportation, while 12 % are unemployed. Only 4 % of active ejidatarios are engaged in full-time farming.

In terms of agricultural production, ejidatarios primarily contribute to household income through the sale of maize within the community. Seventy percent of their production is maize used for self-consumption and sale (seed, leaves), or processed into tortillas, tlacoyos, and pinole (roasted maize mixed with other ingredients and ground). Forage maize accounts for 6.8 %. The second most produced crop is alfalfa (19.6 %), valued for its high energy content for livestock feed, while the remaining 3.6 % includes oat and bean production.

Other agricultural activities reported by respondents include milk sales through small-scale distribution, considered a derivative activity of agriculture since it depends on forage production such as maize and alfalfa for cattle feed, accounting for 20 % of respondents. Pig raising, mainly for meat sales either on the hoof or as carcasses, makes up 15.7 %. Sheep rearing for sale on the hoof represents 23.6 %, cattle fattening 10.2 %, and rabbit production 5.6 %. Additionally, sales

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of poultry, including chickens, ducks, and turkeys, along with eggs sold exclusively to neighbors, were reported. Overall, these poultry activities total 24.9 %.

III. Backyard crops for self-consumption and distribution of family activities

In the area, it is common to find backyard spaces dedicated to vegetable gardening. Among the crops grown, lettuce appears in 18 % of households, spinach in 24 %, radish in 10 %, and cilantro in 14 %. Prickly pear cactus (nopal) is the most widespread backyard crop, reported by 34% of households. These percentages are not mutually exclusive, as a single ejidatario or family may cultivate multiple crops simultaneously. Responsibility for these crops mainly falls on women.

For backyard crop care, housewives account for 26 %, while children play a secondary role (18 %). The household head is responsible for more labor-intensive agricultural activities, contributing 56 %.

Additionally, residents of the ejido often use fruit trees to fence their plots and maintain some fruit species in their homes. Among these species, the most common are plums (31 %), apples (12 %), pears (12 %), capulín (wild cherry) (23 %), pomegranates (6 %), and lemons (16 %).

IV. Urban agricultural systems

In the urban area of the locality under study, three types of agricultural systems were identified, based on their purpose and current practice (Figure 2).

Although several studies have been conducted in Tocuila, many of them adopt a municipal perspective, addressing the area in broad terms. These studies emphasize the reduction of agricultural land or land use changes due to urban growth. Soto-Cortés (2015) and Moreno (2017) highlight issues linked to demographic growth over agricultural zones, discussing concerns such as speculation related to the construction of the New Mexico City Airport (NAICM), unemployment, saturation of basic services and infrastructure, food demand, and water scarcity, among others. Both emphasize soil conservation and the promotion of sustainable development. While their objectives differ from those of the present study, they agree on the importance of encouraging urban agriculture.

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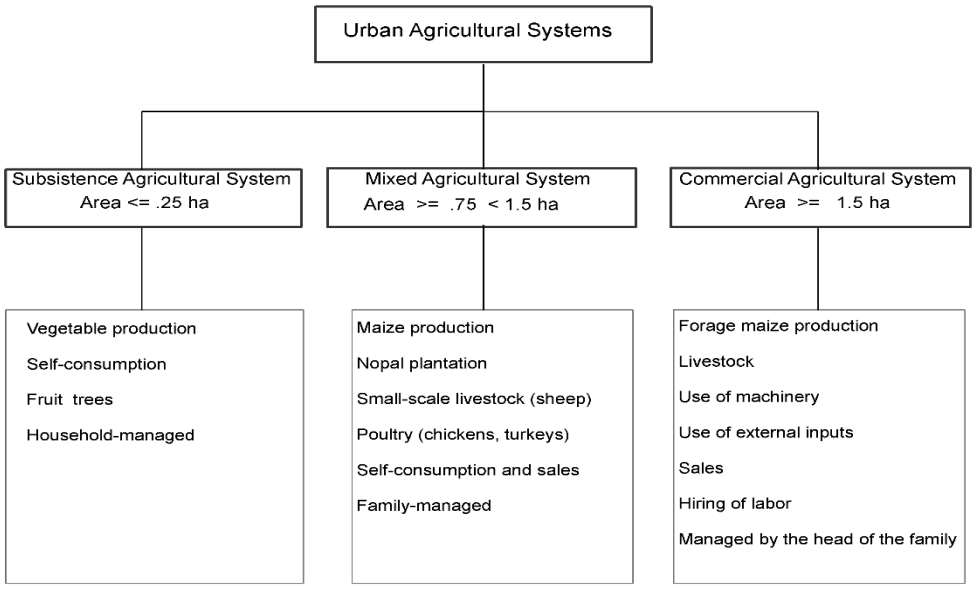

Figure 2. Graphical representation of agricultural systems located in Tocuila, Texcoco.

Source: Own elaboration.

In parallel, studies in Tocuila have documented the locality's transition due to urban growth and its effects on agricultural lands. Noriero (2006), for instance, describes changes in residents' lifestyles, showing transformations in clothing and diet caused by urbanization. These findings predicted a process of change that the current study confirms, revealing that the loss of agricultural land continues and is now reflected in the community's productive dynamics.

Flores-Sánchez *et al.* (2012) examined 11 production units across 47 plots in three localities of Texcoco municipality, describing various cropping systems, including monocultures, associations, and intercropping, and identifying the most common crops in each area. However, their primary goal was to determine types of production and the impacts they face due to urban growth, with a focus on urban agriculture.

In the present research, 50 ejidatarios were surveyed, which revealed that a large portion of the population is interested in continuing production, demonstrating both their adaptability and commitment to urban agriculture. The survey results show that the dominant agricultural systems in the area are mainly subsistence-based, reflecting the community's reliance on its own production to support local food security.

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Drawing on the approach of Escobar & Berdegué (1990) regarding the typification of agricultural systems, this study in Tocuila identified three main systems: subsistence (48 %), mixed (39 %), and commercial (13 %), adapted to the urban-peri-urban context, without directly applying their methodology.

The results of this study show that the dominant agricultural systems in Tocuila are primarily subsistence-based, followed by mixed and commercial systems, reflecting the ejidatarios' adaptation to a changing urban environment. These findings align with previous studies in the region, such as those by Salas & González-Fuentes (2017b), who highlight how urbanization reduces and fragments agricultural land and promotes diversification of productive activities. In Tocuila, subsistence systems are concentrated in small plots for self-consumption, while mixed systems combine crops and livestock, contributing to the availability of food and protein.

Description of urban agricultural systems in Tocuila according to their production purpose

I. Subsistence agricultural system: Primarily focused on growing food for their own use, this system usually covers areas smaller than 0.25 hectares within household plots. It involves cultivating vegetables such as Swiss chard, radish, cilantro, lettuce, and nopal in limited spaces, which restricts their productivity. Additionally, fruit trees like plums, pears, and apples are also present. This type of agriculture is mainly managed by housewives since it doesn't require heavy labor. This system makes up 48 % of the surveyed ejidatarios.

II. Mixed agricultural system: Covering areas of 0.75 hectares or more, typically as part of subdivided ejido lands, it combines various components, including cattle and poultry, with designated space for nopal cultivation. This system integrates crops such as maize and beans with livestock, providing access to vegetables and protein, and creates a multifunctional and sustainable setup. Usually, the entire family actively participates in this system. It accounts for 39 % of the ejidatarios surveyed.

III. Commercial agricultural system: Its main goal is marketing products either locally or outside the municipality. It emphasizes bull fattening, while maize production occurs on ejido lands. Even though their cultivation areas exceeding 1.5 hectares are situated within ejido zones outside Tocuila's urban area, the livestock stay within the locality, showing how farming combines with animal husbandry across different spaces. These producers also have the necessary machinery for land preparation. They depend on external inputs and sometimes hire labor for stable management and cattle feeding. Their agricultural activity focuses solely on forage maize cultivation. This system makes up 13 % of the surveyed ejidatarios.

Conclusions

Based on the information obtained, it can be concluded that the urban growth of Texcoco, especially in the locality of Tocuila, affects rural areas, particularly agriculture. This highlights

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the vital role of empirical knowledge and the resilience of ejidatarios in maintaining production. The adaptation of the three identified production systems is crucial for the conservation and sustainability of agriculture, aligning with the SDGs, particularly concerning food security, by encouraging sustainable farming practices and reducing poverty. The diversity of these systems enhances resilience to climate change. The results also show that ejidatarios continue to produce and adapt, not only to changes impacting agricultural soils but also by creating employment within the community. Preserving current agricultural systems is essential for maintaining food production locally. In this context, blending traditional knowledge with adaptations to urban environmental changes demonstrates the community's ability to meet challenges and sustain agricultural activity. Another key point observed in Tocuila was the increasing demand for land for urban expansion, which competes unevenly with agricultural land, influenced by the real estate market and local urban growth processes.

Authors' Contributions

Analysis, writing, and preparation of the work: APG; writing, review, and editing: MJJM; project administration: MJEM.

All authors of this manuscript have read and approved the published version of the manuscript.

Informed Consent Statement

Informed consent was obtained from all participants involved in the study. Participation was voluntary, the confidentiality of the information provided was ensured, and participants were informed that the data would be used exclusively for academic and research purposes

Conflict of interest

The authors declare no conflict of interest.

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