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Article

Sustainability of agricultural systems of farmers' markets. Case evaluation in Mexico City

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Abstract

Alternative marketing and consumption initiatives in urban food systems propose changes in the perception of the socioenvironmental environment, production practices, and the economic viability of local agriculture. Given the current visibility and importance of Mexico City's farmers' markets, the research objective was to evaluate the sustainability of their agricultural supply systems. To this end, the Food and Agriculture Organization's sustainability assessment framework for food and agriculture was used, with its environmental, social, economic, and governance dimensions. Interviews with producers and visits to farmers' markets and production units were conducted between July 2019 and August 2022. The main results found were that agricultural systems meet international sustainability compliance criteria, particularly in the dimensions of good governance and environmental integrity. On the other hand, the themes of unacceptable performance correspond to the dimensions of economic resilience and social well-being. It is identified to include the different spatial and temporal scales (agro-productive units and rural-urban landscapes) and institutional areas of action for a comprehensive agenda for the evaluation of agricultural systems. It is concluded that the agricultural systems that supply the farmers' markets have the potential to strengthen the knowledge co-production works, the levels of participation, and decision-making in the formulation of local development agendas that contribute to food security and sovereignty in Mexico City.

Keywords:

agriculture, local development, SAFA.

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Introduction

Urban contexts and urban-rural links have become central to agrarian issues, agroecological transitions, and food system transformations (Tornaghi and Dehaene, 2020). Since urban agriculture is highly dependent on local factors, studying the opportunities and challenges for ASs in various socioeconomic contexts and under different evaluation models can be beneficial in connecting agricultural practices in cities with urban planning.

Especially when it comes to analyzing agricultural systems (ASs), which are represented by material and food flows through various interactions between humans, the environment, and technology, whether from a holistic approach (Wadumestrige *et al*., 2021), food security approach (Charles *et al*., 2021), or under the framework of sustainability (Feola *et al*., 2020).

Farmers' markets (FMs) are urban spaces for marketing and meeting, where small-scale producers and food processors offer contaminant-free, healthy, fresh, and seasonal food that is in line with cultural identity, local production, and direct sales from the producer to the consumer at more stable prices, to consumers committed to their health, protecting the environment, and strengthening local economies (García *et al*., 2017).

These markets respond to the need to consume sustainably produced food to the extent that they are constituted as short agri-food chains (Zavaleta-González, 2022) and imply trust and strengthening of social capital since information related to the origin and production of food is transparently shared (Ranaboldo and Arosio, 2014). In Mexico, most of the studies reported in the literature focus on the markets themselves or consumers (Zavaleta-González, 2022), and information on who and how they produce the food offered in these markets is mostly found on their websites, social networks, and other electronic media.

In this context, there is a need to know the design and functioning of the ASs that sustain the FMs and that feed people while contributing to conserving the environment and biodiversity of agricultural and food interests. Although improving sustainability could be a common goal for the ASs in Mexico City, there is limited information on the systematic assessment of the sustainability of the ASs supplying the FMs in Mexico City.

An important precedent, especially when the discourse of sustainability was just emerging in Mexico, addressed a framework for evaluating the sustainability of the chinampa system from productive, economic, and social approaches (Torres-Lima *et al*., 1994). Nevertheless, there is still a need to know whether the ASs of FMs is sustainable in the environmental, social, economic, and governance dimensions since the definition of sustainability implies knowing the interactions between natural and social systems to meet the needs of present and future generations by substantially reducing poverty and conserving the systems that sustain life.

In the international literature, there are several conceptual and methodological advances of these frameworks, as well as different advantages and limitations in their application and comparison by different authors in different contexts (Schindler *et al*., 2015; Tonolli and Ferrer, 2018; Cruz *et al*., 2018; Lampridi *et al*., 2019). A recent key orientation is the co-design of an indicator framework for the assessment of ASs by integrating top-down (researchers) and bottom-up (stakeholder perspective) approaches (Locola *et al*., 2020).

In order to assess the performance of ASs under various agricultural scenarios, including self-consumption, commercial or mixed systems, the Food and Agriculture Organization of the United Nations (FAO, 2015) developed the Framework of Sustainability Assessment of Food and Agriculture (SAFA) for Smallholders (FAO, 2015). This global framework is holistic because it involves the assessment of sustainability along the food and agriculture value chains; however, it recognizes that there are various definitions of sustainability and aims to be an international reference tool.

One of SAFA's guidelines is offering a hierarchical structure of sustainability dimensions, themes, and subthemes contextualized in a postdiagnosis evaluation through indicators (Mili and Martínez-Vega, 2019; Soldi *et al*., 2019).

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This paper considered the definitions of: a) good governance, decision-making process and implementation in the environmental, economic, or social spheres; b) environmental integrity, conservation of life support systems essential for human survival by minimizing negative environmental impacts and fostering positive impacts; c) economic, system and local community resilience, ability to repay debts, generate positive cash flow, compensate for negative externalities that the system may generate and adequately remunerate workers and shareholders, it must also have cushioning mechanisms against economic recessions, adverse weather, or catastrophic accidents; and d) social well-being, the satisfaction of basic human needs and the provision of the right and freedom to meet one's aspirations for a better life (FAO, 2015).

This paper evaluates, using the SAFA framework, the sustainability trajectories of seven ASs that participate in the FMs of Mexico City. The assessment of the sustainability of ASs makes it possible to provide measurable and communicable information that delineates similar or diverse patterns in the same region, especially in terms of constraints and possibilities of integrating environmental processes with socioeconomic activities in local agriculture; in addition, it allows the identification of the critical points of the sustainability of ASs as a starting point to develop capacities and improve their performance (FAO, 2014).

Materials and methods

Study site

As case studies, Table 1 lists the FMs and the seven agricultural production units studied, which meet the criteria of 'local' due to their location in boroughs of the suburban and peri-urban areas of Mexico City, without exceeding a radius of 150 km (Torres-Lima *et al.*, 2019).

Table 1. Location of the seven case studies by borough of Mexico City.

Farmers' markets	Borough for the markets	Number of ASs studied	Borough for the ASs
Mercado el 100 (M100)	Cuauhtémoc (urban)	2 (cases 1 and 4)	Magdalena Contreras, Tláhuac (suburban)
Mercado alternativo de Tlalpan (MAT)	Tlalpan (suburban)	2 (cases 2 and 3)	Milpa Alta (peri-urban)
Mercado de las cosas verdes Tianquiskilitl (MCVT)	Xochimilco (suburban)	1 (case 7)	Xochimilco (suburban)
Capital verde (CV)	Azcapotzalco (urban)	2 (cases 5 and 6)	Xochimilco (suburban)

Methodological procedure

The research consisted of multiple descriptive and exploratory case studies for analytical purposes (Neiman and Quaranta, 2006), which integrate qualitative and quantitative data due to their agreement with the systemic approach that generates context-dependent knowledge and allows us to know both the general and the particular characteristics of each system. Thus, this paper aims to evaluate the sustainability of the ASs that supply the FMs, as systems that constitute a subsystem of the food system of Mexico City, which is congruent with the objective of presenting a phenomenon that has been little studied in its context (Yin, 2003).

The sample is not probabilistic but intentional since this type of study does not require the generalization of the results, but rather the need for the characteristics of the selected units of observation (ASs) to be appropriate to maximize the usefulness of the information from small samples or single cases (Flyvberg, 2006).

Seven agricultural production systems are included, selected from a total of 22, identified in 2019 based on fieldwork and according to their location within Mexico City, their constant participation for

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at least two consecutive years in an FM, their availability to answer the SAFA questionnaire, and to receive at least one visit to their production unit for data collation and verification purposes.

The SAFA questionnaire includes four dimensions: 1) environmental integrity, 2) social well-being, 3) economic resilience, and 4) good governance; it is made up of 21 sustainability themes and 44 indicators (FAO, 2014), with reliability and validity indices necessary to explore these dimensions with a single instrument. The authors conceptually and methodologically identified the a priori important criteria (themes and sub-themes between the pillars of sustainability and the nature of peri-urban and suburban agriculture) to articulate the analysis of the performance of the ASs.

In a second moment, these themes and indicators were integrated with the perspectives of the interested producers, through direct dialogue and ethnographic work, in various field visits throughout the five boroughs where the studied ASs are located. Based on the results obtained from the questionnaire, the performance scores of the 44 SAFA indicators are integrated into 21 themes for the four dimensions and are averaged under three main thresholds, which identify the degrees towards compliance or achievement of sustainability: good (2.6 to 3), limited (1.6 to 2.5), and unacceptable (0 to 1.5).

Participant observation was carried out during 2019 through repeated visits to M100, MAT, MCVT, and CV, and through direct questions to producers in the markets and to some consumers for the purpose of contextualization and data reference, for example, of the supply of agricultural products in the FMs. The SAFA questionnaire was applied to the heads of the production units of the seven case studies (two women and five men) from June to August 2019.

In the second half of 2021 and the first half of 2022, visits were made to the production units and MAT in order to consolidate the sustainability dimensions, themes, and sub-themes defined by SAFA, which served as a framework for the analysis of the results. This FM was selected because it is the one with the largest number of producers whose agricultural units are located in Mexico City. It should be clarified that since producers are not required to provide documentation or specific records of the work and management of their crops, the answers to the how and when of the ASs are subordinated to the perception of each of the interviewees and the timing of the interview.

Results and discussion

Socioeconomic, technological, and management determinants

The socioeconomic, technological, and management determinants of the total number of productive units correspond to those established in the Guide for the Development of Producers' Markets (García *et al*., 2017) since they are cultivated free of agrotoxic products by small producers, who are also interested in soil conservation and improvement (Tables 2 and 3).

Table 2. Technological and management determinants of agricultural systems.

Case	Type of species cultivated	Type of management	Pest and disease management	Fertilization	Soil conservation practices	Livestock production
1	Vegetable, fruits, medicinal and aromatic plants.	Organic	2	NFwk	CC, NF, IC, CR, HT	No
2	Cereals and fruits	Agroecological	2	IDEM	PC, HT	Apiculture
3	Vegetables and fruits	Traditional	2	IDEM	NF, IC, HT	No
4	Ornamentals, medicinal,	Organic	1, 2, 3.	IDEM	CR	No

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Case	Type of species cultivated	Type of management	Pest and disease management	Fertilization	Soil conservation practices	Livestock production
	aromatic plants and vegetables.					
5	Vegetables	Chinampa system	IDEM	IDEM	CR, PC	No
6	Ornamentals	Sustainable, reduction/ substitution of inputs	1, 2, 3 and 4.	CF	PC	No
7	Vegetables	Chinampa system	1, 2.	NFnk	NF, CR, IC, PC	Cattle

1= regular visual inspections; 2= use of traps, natural repellents and pesticides, and habitat for beneficial predators; 3= written records of pests or diseases suffered, indicated treatment, and results obtained; 4= occasional application of agrochemicals; NFwk= natural fertilizers with knowledge of soil and crops; CF= combination of natural and synthetic fertilizers; NFnk= natural fertilizers applied without knowledge of the crops or soil; CC= cover crops; NF= nitrogen fixation by annuals or perennials; IC= intercropping; CR= crop rotation; HT= use of hedges and terraces; PC= natural permanent soil cover with mulch or planted plants.

Table 3. Socioeconomic determinants of agricultural systems.

Cases	Land tenure	Farm size	Labor	Production objective	Places to market	Type of organization
1	Private	2 ha	Mixed	Sc, S	FM, LM, LC	Enterprise
2	Ejidal (common land)	3 ha	Mixed	Sc, S	FM, LC, C, SS	Cooperative
3	Private	0.2 ha	Family members	Sc, S	FM, DF	Family enterprise
4	Leasing	0.5 ha	Mixed	Sc, S	FM, LM, LC	Family enterprise
5	Private	0.3 ha	Mixed	Sc, S	FM, LM, LC	Family enterprise
6	Private	0.27 ha	Mixed	S	FM, LM, LC	Enterprise
7	Private	2 ha	Family members	Sc, S	FM, LM, LC	Cooperative

Sc= self-consumption; S= sale; FM= farmers' markets; LM= local markets; LC= local customers; C= cafés; SS= specialty stores; DF= local fairs and events. Enterprise= AS incorporated for commercial purposes; family enterprise= AS formed for commercial purposes only by members of a family; and cooperative= AS set up for commercial and community social cooperation purposes.

Sustainability diagnosis

Themes of good performance toward sustainability compliance

In relation to good governance, production units claim to keep records of their production processes, which are available to anyone interested, so that consumers can make informed decisions about what they are buying. There are links with educational institutions and other agroecological projects, but they are carried out without prior planning and any follow-up. Four productive units indicated that they participate in an organization focused on agriculture and the well-being of producers, with guidelines for participation towards sustainable agricultural production with benefits of greater profits, elimination of intermediaries, and direct contact with consumers.

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This has allowed them access to information, services, markets, and better prices, in addition to the fact that they can connect with other types of short agri-food chains, such as community baskets or direct sales to restaurants. Six ASs have a holistic management plan to ensure the long-term success of their production, which includes soil fertility management, reduction of negative impacts on the environment, increase in personnel, improvements in the health and safety of producers and consumers, the profitability of the ASs, and quality and marketing of their products.

Regarding the theme of environmental integrity, six productive units maintained or increased the tree cover area during the last year as a practice of mitigation of greenhouse gases and reforestation, with the leased farm being the only one that does not have a cover of this type. Composting manure as fertilizer is a common practice in all cases. Both actions, together with the predominant use of smokeless fuels and the non-burning of land in 6 out of 7 units, indicate their contribution to reducing greenhouse gases.

All systems implement some practices to reduce water consumption, mainly drip irrigation and water collection in aljibes or cisterns. In addition, agricultural production systems mainly cultivate locally adapted varieties; they use polycultures that reduce soil exposure to sun, rain, and wind, thus controlling erosion while optimizing nutrient cycling and reducing the incidence of pests and diseases.

In six of the seven production units, the application of natural fertilizers is based on a careful assessment of the soil and crops' needs, either through farmer observation, professional tests, or laboratory analysis. Additionally, producers recycle and/or reuse organic and inorganic waste regularly.

In terms of economic resilience, through productive diversification, economic and environmental risks are reduced by having various sources of income; in addition, value is added through the production of products such as jams, sweet and savory preserves, beverages, sauces, and other foods. Several of these units also offer guided tour services for tourism or educational purposes.

Producers feel secure in having stable points of sale through different buyers, with whom they establish relationships of trust, especially since the participatory certification of more than half of the products offered allows them to guarantee their quality and access to specialized markets and facilitates decision-making by consumers (Zavaleta-González, 2022). Finally, with regard to social well-being, all ASs provides regular employment that allows producers to work under conditions of equal pay and freedom of association.

At the same time, they are free to choose, according to their culture, the type of management for their crops, and the type of agrobiodiversity present in the ASs. This happens in parallel to the processes that drive the social construction of sustainability among the productive units and the social actors involved (Muñoz, 2021). Overall, general trends of good performance toward sustainability compliance are observed in the seven case studies (Figure 1).

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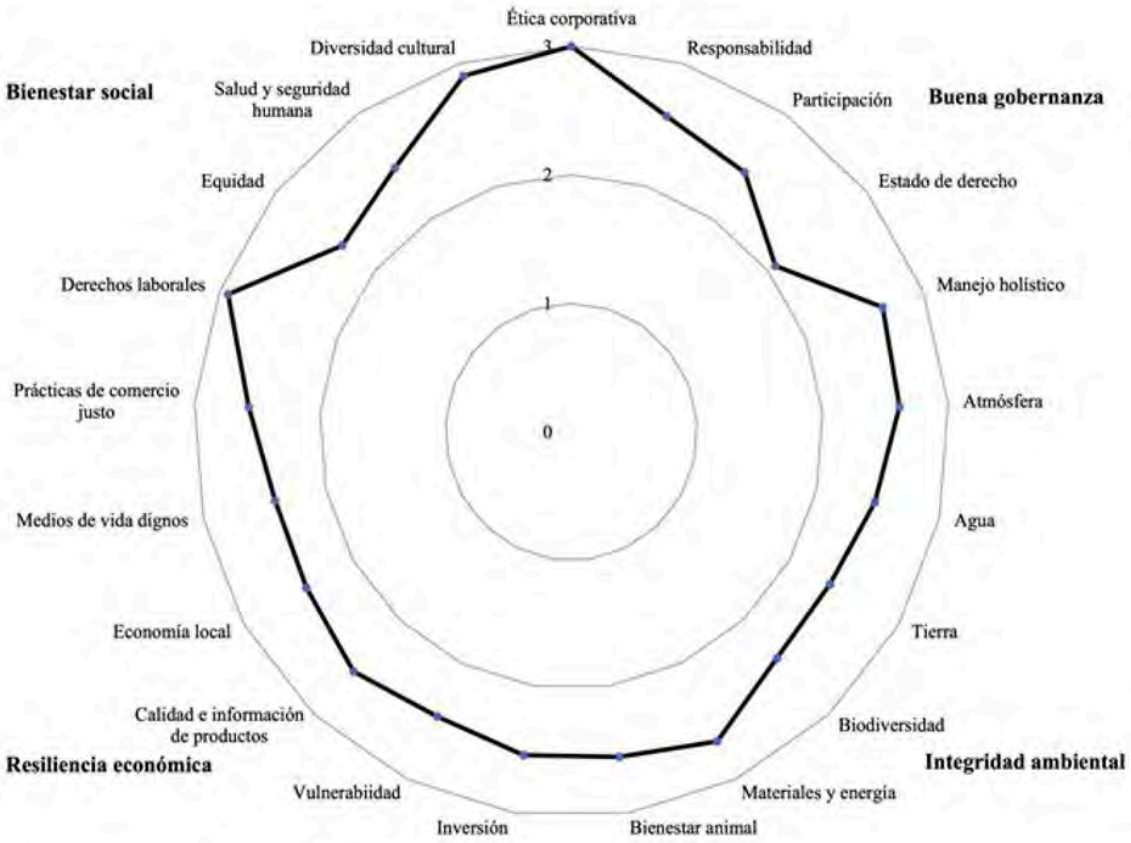
Figure 1. SAFA sustainability polygon for all cases.



Themes of limited performance toward sustainability compliance

Under the governance analysis framework, the owners or managers of all productive units stated that they had explicit objectives and values that all their members understood. Nonetheless, through the field visit to the ASs and with other confirmation questions in the SAFA questionnaire, it is concluded that the objectives do not contemplate the four dimensions of sustainability, nor do they do so in a comprehensive way. Producers with private farms (5 out of 7) have land tenure security and are not restricted from implementing practices or making investments to promote sustainability.

Nevertheless, SAFA catalogs this lack of restriction as an indicator of possible land-use changes that could affect the system's sustainability, so further monitoring is required (FAO, 2014). The legitimacy indicator shows that only one production unit guarantees its business's legal and regulatory compliance through the use of reports and minutes of meetings held, keeping the required licenses and permits in view, and regularly reporting on its administrative activity to the corresponding auditors.

Concerning environmental integrity, three production units carry out irrigation manually, and drip irrigation for better use of water resources is not contemplated. In four ASs, farmland is located directly next to natural watercourses, but even when fertilizers and pesticides are natural, the risk of contamination persists. Three production units practice reduced tillage, and three more carry out conventional tillage, which risks soil conservation. With regard to conserving and improving soil fertility, the systems evaluated apply only one or two strategies (Table 2).

To conserve biodiversity, four productive units implement only one of the following strategies: allocating an area of permanently resting soil, rehabilitating or restoring natural areas, or

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establishing hedgerows or buffer zones; two units employ at least two techniques simultaneously, and one does not practice any. Only a couple of production units implement four simultaneous strategies for managing pests and diseases in crops; the other five units carry out only one strategy.

All ASs uses locally adapted varieties; however, the main source of seed supply is external, and only in three cases are they obtained from local sources. During the visits to the markets, there was a lack of interest in those local varieties. Finally, all the units evaluated recycle various materials (ie. crop residues and plastics for mulching), and only two of them have implemented measures to improve energy efficiency (ie. solar lamps), while four Ass use solar, water, or wind energy.

Regarding economic resilience, only one productive unit regularly invests in a local well-being and sustainable development project, and another participates in it. In terms of profitability, even though all production systems reported knowing the costs of fertilizers, pesticides, seeds, and other materials, three units do not know their actual revenues for the last year. Positive revenues during the last five years are reported to be regular in three systems; two indicated that they were irregular, and two other units declared that the revenues were rarely positive.

Five agricultural production systems consider that they can only access a loan from a bank or a government institution; the other two productive units say they have access to credit from informal sources, such as friends or relatives, NGOs, cooperatives, microfinance groups, or producers' associations. Having more than one source of formal credit is the best way to ensure liquidity and thus reduce economic vulnerability (FAO, 2014).

Regarding social well-being, the producers in six units perceive their means and quality of life as decent compared to the previous year, and only one considers it fair. The wage level indicator shows that three of the seven units can comfortably cover the basic needs of their members (food, clothing, sustenance, education, etc.), depending on their income. Likewise, they have savings of at least 10% of their income for cultural or recreational activities.

Concerning local capacity building and specialized training, six production units received training on one or two topics, including improvement of agricultural or processing operations, improved record-keeping in the traceability of agricultural operations and accounting, marketing support, including information and education on pricing and market contacts, health and safety issues, environmental issues, adult literacy, business management, or the finances of the production unit.

Themes of unacceptable performance toward sustainability compliance

The first theme that indicates the unacceptable performance of the ASs is economic resilience. It is identified that, in terms of vulnerability, none of the systems have insurance for their crops, and only two of the seven have a risk management plan that includes the minimum costs or support required in cases of crop loss, such as community support strategies, agreements with cooperatives and other organizations.

The lack of safety nets increases vulnerability to economic, environmental, and social risks during emergencies, especially when the producer faces a lack of cash flow and is unable to pay inputs, salaries, loans, etc. The second relevant theme concerns the social well-being of members participating in the ASs. In particular, with regard to human health and safety, the working environment in production units is safe, hygienic, healthy, and adapted to the satisfaction of human needs, such as clean water, food, shelter, and sanitary facilities.

Nonetheless, to avoid risks in their unit and handle emergencies, it is not enough to occasionally warn employees about possible hazards within the unit and how they should handle them, it is necessary to have adequate storage of dangerous tools, good maintenance of the machinery, and a first aid kit inside the unit that is easy to access for its members.

Main challenges and areas of opportunity for the transition to sustainability

Given that urban contexts and urban-rural links have become central to agrarian issues, agroecological transitions, and the transformation of the food system (Tornaghi and Dehaene,

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2020), it can be said that among the main areas of opportunity to strengthen the sustainability of the ASs that supply the FMs of Mexico City are those related to consumers.

In the last decade, various food-related initiatives have emerged in cities around the world (multifunctional urban and peri-urban agriculture, solidarity purchasing groups, and FM) that engage citizens and revive the debate on sustainable, healthy, and local food (Minotti *et al*., 2022). In the FMs, consumers are provided with information on the production processes, the benefits they bring to the environment, and their health, with emphasis on the culture of prevention, as well as the risks they face as small producers in the city.

Additionally, it is of utmost importance to publicize farmers' markets as a meeting space between consumers and producers that strengthens urban-rural links, but above all that allows increasing the volume of production and supply in alternative markets of popular supply under the framework of social networks of sustainable local development (García *et al*., 2021).

Likewise, awareness must be raised about the externalities of conventional food production, its environmental costs, how the economy of scale works, and the drawbacks of long marketing chains, both for food and for any other product necessary in everyday life. Regarding the productivity of the ASs of Mexico City, the main area of opportunity is identified as the establishment of agroforestry systems since they maintain and improve soil fertility, and some species allow better nitrogen fixation, as well as the absorption of nutrients from deeper soil horizons, among other benefits.

Finally, the consolidation of work and research trajectories with an agroecological conceptual approach for ASs is highlighted as a pressing opportunity, as an essential element to achieve and strengthen sustainability in its four dimensions, in accordance with the SAFA framework (environmental integrity, social well-being, economic resilience, and governance), which would strengthen the regional food systems of Mexico City.

The agroecological approach continues to be highlighted as a relevant orientation for the restoration of chinampa agriculture in this city (Figueroa *et al*., 2022). That is to say, it is imperative that research, technical follow-up, and comprehensive evaluation of sustainable agricultural food production and FMs in Mexico City be part of the commitment of producers, associative figures and agricultural companies, key decision-makers in agricultural communities and in FMs and local and Mexico City governments.

Two priority actions are required: (1) to deepen the knowledge of the specific agroecological conditions of each region of Mexico City through the construction of a database with information on the ASs; and (2) to carry out a process of systematization and comprehensive meta-analysis of the information generated by the boroughs, government secretariats, higher education and research institutions, NGOs, and civil and producer associations, that identifies, spatially and temporally, the status of indicators, performance values, and correlations of the ASs and FMs, as well as of the comprehensive agri-food system of Mexico City (Torres-Lima *et al*., 2022).

This must be achieved from a socio-territorial and agrobiodiversity approach as key criteria (Locola *et al*., 2020; Scaramuzzi *et al*., 2021) because the different types of crops, agricultural landscapes and territorial units in Mexico City have different land uses and levels of local biodiversity; for example, the chinampa system.

To this end, despite the fact that the ASs has certain similar patterns based on a holistic model of food systems oriented to agrobiodiversity, the design and implementation of extension and cooperation programs for the promotion of local development must contemplate operational strategies based on territorial planning that conceive community and family participation as essential to improve the sustainable performance of the ASs that supply the FMs of the region Mexico City (Torres-Lima *et al*., 2019).

Conclusions

The agricultural systems (ASs) that participate in Mexico City's Farmers' Markets (FMs) do meet international criteria, such as those assessed by the Sustainability Assessment of Food and

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Agriculture (SAFA), towards sustainability compliance. In the dimension of good governance, for the themes of corporate ethics and holistic management, the commitment that producers and organizers of such markets have shown in order to maintain and reinforce sustainability trajectories; for example, of agroecological units, is considered fundamental.

Special importance for local development is achieved when the agro-productive units have guidelines for holistic sustainable management and participatory certification that direct, regulate, and hold the ASs responsible for the fulfillment of their own management plans under various areas of environmental integrity. Based on the application of the SAFA evaluation methodology for the ASs of the FMs of Mexico City, the need for greater involvement and commitment of producers is identified in order to obtain and measure the value chains, consumption patterns, rural-urban links, and agricultural product quantities and qualities that together validate the performance of the ASs themselves.

Participatory evaluation, monitoring, and rigorous iterative follow-up are required, with various actors, towards the achievement of local sustainability under different spatial and temporal scales, ASs, agro-productive units, rural-urban landscapes, and institutional areas of action. This is in order to strengthen the priority tasks of knowledge co-production, levels of participation, and decision-making in the formulation of local development agendas for the ASs of the FMs, which contribute to ensuring, under the framework of sustainability principles, the much-needed food security in Mexico City.

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