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Identifying Urban Agriculture Needs and Challenges for the Implementation of Green Labeling in Xochimilco, Mexico

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The current global situation with a dominant economic development model producing social inequality, increment and intensification of urbanization has generated severe environmental degradation and an associated increase in the likelihood of pandemics. New strategies that strengthen sustainable food production are urgent in highly unequal countries as Mexico. In Mexico City, the most populated city of the country, a wetland system, named Xochimilco, still holds *chinampas*, a unique and ingenious food system dating from pre-Hispanic times. These days *chinampas* are the best example of urban sustainable agriculture production. Unfortunately, this system is under threat due to urbanization and industrial land-use changes. Among the strategies to promote sustainable modes of production and consumption is eco or green labeling, consisting of a voluntary environmental certification approach, and marketing and advertising tool, that can change producers' and consumers' behavior toward long-term sustainability. Although widely used, the benefits of green labels for producers are not always realized. This study aimed to learn more about the agro-ecological production process and commercialization challenges in Xochimilco and San Gregorio Atlapulco in Southern Mexico City to understand *chinampa* producers' needs and determine whether a green label can offer solutions in this vulnerable socio-ecological system, particularly suffering the effects of the COVID-19 pandemics. For this, a literature review and producers' mental model analysis based on network theory, were developed. Results show that non-resolved issues such as commercialization problems, consumers' unwillingness to pay a fair price, loss of healthy soil, and degraded water quality used for irrigation persist and can affect the benefits of a green label including to improve *chinampa* production and farmers' income. Farmers' current necessities comprised increasing profits, receiving financial advice to set prices of agro-ecological vegetables and production costs, among others. Under the current production and commercialization scenarios complying with the assessment cost of certification will be difficult for most producers; then, implementing the green label would probably fail to fulfill the benefits. Attending to former and persistent conflicts and satisfying *chinampa* producers' neglected necessities are essential before implementing any program.

Keywords: agri-food systems, social-ecological system, agro-ecological systems, green labels, *chinampas*, COVID-19 pandemic, Xochimilco, Mexico City

INTRODUCTION

In the following decades we expect, considerable environmental degradation, including the effects of climate change (Di Marco et al., 2020). This degradation comes as a result of multi-dimensional processes linked to (1) the dominant model of economic development, with its associated forms of production and consumption, (2) the growing social inequality, and (3) the critical increment and intensification of urbanization as well as global population growth (Harvey, 1978; Galanakis, 2020; Di Clemente et al., 2021). Aspects such as urbanization, intensive exploitation of natural resources, and land-use change (Jones et al., 2008), among others, have increased the likelihood of pandemics over the past century (Pike et al., 2014). Emerging infectious diseases (EIDs), including HIV, Ebola, Influenza, SARS, MERS, and, currently Coronavirus (SARS-CoV-2), have caused mortality and morbidity at large scales, disruption in goods production, trade and travel networks, and rise in civil unrest as well as political insecurity worldwide (Pike et al., 2014; Kumar et al., 2020; GPI, 2021; Leach et al., 2021). Yet, lessons have been ignored, hardly applied, or perhaps not fully appreciated (Saqr and Wasson, 2020; Leach et al., 2021).

In March 2020, the COVID-19 pandemic was officially declared by the World Health Organization (WHO). Since then, cities and citizens have shown their vulnerability to unexpected complex global risks (Pulighe and Lupia, 2020). Urban food systems have been deeply affected, specifically the food production and distribution sectors, compromising citizens' food security (FAO, 2020a). The Mexico City metropolitan area is one of the most densely populated cities globally, in which an essential part of the population deals with food insecurity and food poverty. These have been persistent problems (Lemos Figueroa et al., 2018; Torres-Torres and Rojas-Martínez, 2021), even before the COVID-19 pandemic. For instance, in 2016, 11.5% of Mexico City's population had no access to food, whereas 7.5% suffered from food poverty (CONEVAL, 2018). For this and other megacities, generating and implementing strategies that strengthen resilient and sustainable food production and distribution systems, in the face of future pandemics and other disruptive phenomena (i.e., earthquakes) are critical. Xochimilco system contains the last remnant of the lake system that once occupied the Basin of Mexico (Cox et al., 2020). These remaining wetlands are critical ecosystems for the local hydrological cycle and the dynamic equilibrium between precipitation, run-off, evaporation, and infiltration of the metropolitan area (Romero Lankao, 2010). At the South of the Basin, Xochimilco's wetland system still holds *chinampas*, a unique and ingenious food system dating from pre-Hispanic times (Jiménez-Osornio, 1995; Eakin et al., 2019; Cox et al., 2020) and one of the most diverse and productive agroecosystems in the world (Armillas, 1971; Jiménez-Osornio, 1995). Nowadays, this traditional practice supports sustainable intensive cultivation (Merlín-Uribe et al., 2013).

*Chinampa*s are strip-shaped pieces of land surrounded by water, made of sediment from the bottom of the lake, supported by branches and decaying vegetation, which also give shape to a network of water canals (Armillas, 1971; Torres-Lima et al., 1994). This crop type has a particular irrigation system by capillarity (Contreras et al., 2009). *Chinampas* are bordered by "ahuejotes" (*Salix bonplandiana*, a native willow), which perform multiple functions, including live fences, wind, and insect barriers, and hold soil within the plots. The lakes and canals may reduce temperatures by as much as 2°C (Cox et al., 2020). This food production system reduces greenhouse gas emissions (e.g., Rakotovao et al., 2021). Its production tends to be commercialized locally, thus reducing its transportation of food to the city (e.g., from Xochimilco to the Central Market). Reports (Faber et al., 2012; Kulak et al., 2013; Pradhan et al., 2020) suggest that vegetables transported over long distances require more energy input in their life cycle than the commercialization of local production. Direct benefits for the people include ensuring local employment (by shortening chain supplies and promoting consumer-producer direct trade) and offering the consumers certainty about the origin and quality of the vegetables produced. Furthermore, promoting local consumption (vegetables from *chinampas*) favors practices such as crop diversification, agrobiodiversity conservation, and sustainable management of countless ecosystem benefits. Likewise, as the food production system in *chinampas* is high (Cox et al., 2020), it ensures food access in the short term for citizens in case of extreme events such as pandemics or earthquakes (FAO, 2020b; Gliessman, 2020; HLPE, 2020) and violent conflicts (Brück et al., 2019; FAO, 2021).

Although the peri-urban zone of Xochimilco and its agricultural landscapes have been resilient over centuries of urban management, today, they are under critical threat due to urban, industrial land-use changes. Other factors intervene, such as the water quality used for irrigation and over-pumping and reuse of treated wastewater for canal recharge (Mazari-Hiriart et al., 2008; Jiménez et al., 2020; Pérez-Belmont et al., 2021). Water is a crucial resource for this aquatic ecosystem functioning and has been affected in quantity (Crossley, 2004), as well as quality, both biologically (Espinosa et al., 2008, 2009; Mazari-Hiriart et al., 2008) and chemically (Solís et al., 2006; Díaz-Torres et al., 2013; Meza-González et al., 2021). *Chinampas* system has gone through several historical phases, which are explained by possible adaptive cycles from the resilience perspective (Jiménez et al., 2020). Despite the severe and diverse pressures, some key aspects such as the current market, social organization, and socio-cultural value of agriculture have been critical for the persistence and survival of such an agricultural system (more than 700 years) (Jiménez et al., 2020).

Market-based strategies, such as eco-labeling, have been applied worldwide to favor the sustainability of productive activities (UNOPS, 2009). Ecolabeling is a voluntary environmental certification and labeling approach that provides information to consumers about the environmental impact of production (GEN, 2022). As marketing and advertising tools, eco-labels seek to change producers' and consumers' behavior toward long-term sustainability goals. Through certification and labeling, consumers are guided to select products and services according to particular environmental and social criteria (UNOPS, 2009). Eco-labels are also known as ecological or green labels (Zhang et al., 2019), but some authors employ the latter specifically to depict labels regarding agricultural production (Wille and Lecaro, 1999). A green label provides information on the environmental impact of producing, cultivating, harvesting, processing, transporting, and using products. There are three main types of agricultural products certifications, characterized by different approaches and processes: organic, fair trade, and conservationist certification (Wille and Lecaro, 1999). Green labels are considered an ecological innovation process connecting consumers, private companies, institutions, and governments. These connections affect the others, leading to a circular dynamic that promotes sustainable development (Zhang et al., 2019). Even though eco or green labels are frequently used strategies, they also have drawbacks, such as the high costs of certification assessments that preclude the participation of small producers in developing countries (Pinto et al., 2014; Meemken et al., 2016).

A rejection of green labels and certifications are expected when they do not meet the producers' needs. Then, understanding the part of the system, which is the problems, and the expectancies of producers is critical for the implementation and success of any green label. Then, the use of mental models, represented as cognitive maps, have been powerful tools for the assessment of socio-ecological systems, the identification of conflicts, and the determination of the most relevant components of a system (Gray et al., 2013; Moon et al., 2019; Arroyo-Lambaer et al., 2021). Mental models are internal representations of the external world, depicting dynamic and context-dependent representations that people use to reason and make decisions (Jones et al., 2011). In complex socio-ecological systems, mental models have a critical role in driving the system behavior (Elsawah et al., 2013). They can be shared between many cultures or people due to everyday experiences (Holtrop et al., 2021). The analysis of mental models has several advantages in such complex systems; perhaps the most important is that understanding stakeholder views and mental models is critical for understanding decision-making (Elsawah et al., 2013). Its simplicity and parsimony allow for investigating complex phenomena and identifying significant components used to form judgments (Gray et al., 2014). The perceptions of farmers regarding organic certification have been analyzed using several methods that do not include mental model analysis (e.g., Leitner and Vogl, 2020). In Mexico, studies reporting the use of mental model analysis to assess agro-ecological producers' perceptions to evaluate the feasibility of green labels that certify vegetable quality have not been published yet.

Description of the Etiqueta Chinampera Label

Xochimilco, its communities, and its *chinampas* systems are unique, yet they are subject to diverse pressures. Thus, sound and efficient mechanisms for socio-environmental improvement are crucial to start conservation programs. These mechanisms should improve *chinampa* production and producers' income by enhancing their relationship with the larger city's agri-food market and biodiversity conservation. Therefore, the ECHI label (that stands for Etiqueta chinampera in Spanish) is promoted as an instrument to certify the quality of the *chinampa* products (mainly vegetables), the persistence of the ancestral agricultural system, and native biodiversity such as the Axolotl (*Ambystoma mexicanum*) and a market mechanism to influence producers' and consumers' attitudes, perceptions, and behavior.

The elements of the system under evaluation are soil, sludge and biosolids, water and vegetables. A third-party certification is planned, then, *chinampa* producers are expected to comply with specific soil, water and vegetables requirements to identify the presence of contaminants based on Mexican regulations and international legislation. This, for many of the farmers, imply additional *chinampas* operation.

The call for certification is open to those with active *chinampas*; however, some producers have already adopted the *Chinampa*-refuge model (Zambrano et al., 2020), an advantage for requirement fulfillment. The model seeks to combine efforts between the production system and Axolotl conservation. The refuge for Axolotls that also works for native species involves a filter to avoid the presence of exotics fishes (i.e., *Cyprinus carpio* and *Tilapia nilotica*) and increase water quality (Valiente et al., 2010; Zambrano et al., 2020). Nevertheless, the adoption of the Axolotl refuge program and *chinampa* conditioning are time-consuming and imply more expenses for the producers (Zambrano et al., 2020). A primary structure is proposed for implementing a label of this nature considering economic-financial, socio-ecosystemic, socio-cultural, and physicochemical and microbiological diagnosis components, which is part of an ongoing interdisciplinary research project.

The goal of this study is to learn about the small-scale agro-ecological production process and commercialization challenges in Xochimilco and San Gregorio Atlapulco in Southern Mexico City to understand the *chinampa* producers' needs and determine whether a green label can offer solutions in such a vulnerable socio-ecological system. For this, a literature review and mental model analysis were conducted. The *chinamp*a producers' mental models were elicited from interviews and assessed through cognitive mapping and network analysis to identify key aspects

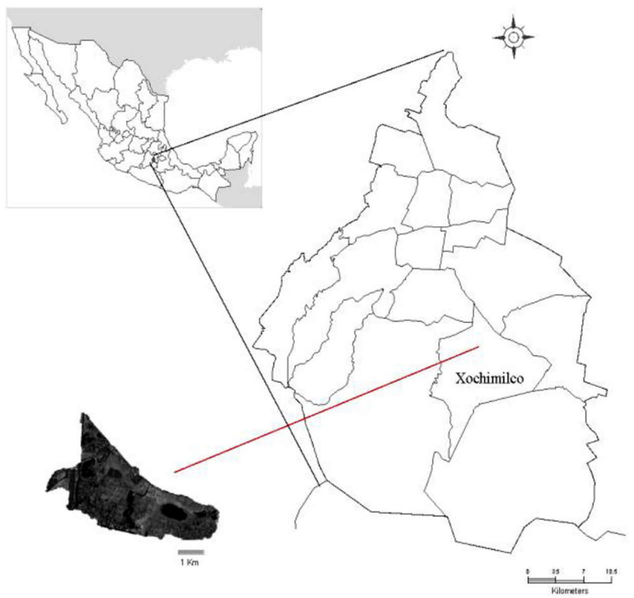

FIGURE 1 | Location of the study area.

of the system, that is, from production to commercialization of agro-ecological vegetables. Overall, these allow us to discern the actual *chinampa* farmers' needs to address the potential viability of a green label implementation on a vulnerable socio-ecosystem, particularly considering the effects of the sanitary restrictions derived from the COVID-19 pandemic on producers' activities.

METHODS

Study Area

Xochimilco is located to the south of México City (19°15' N, 99°06' W) (**Figure 1**) and is one of the 16 municipalities of the city. This municipality hosts 442,178 inhabitants (INEGI, 2020), and it comprises 17 original barrios. The lacustrine area has 2,240 m asl. The climate ranges from 13 to 25°C, and the average annual temperature is 16°C. The average yearly rainfall goes from 700 to 900 mm, abundant from June to September (Díaz-Torres et al., 2013).

The terrestrial vegetation and typical landscape comprise native willow (*Salis bonplandiana*) at the edge of the canals, Mexican cypress (*Taxodium mucronatum*), and mule's fat (*Baccharis salicifolia*). Regarding the aquatic vegetation, the more representative macrophytes are floating water hyacinth (*Eichhornia crassipes*), common waterweed (*Egeria densa*), American bulrush (*Schoenoplectus americanus*), swollen duckweed (*Lemna gibba*), Columbian watermeal (*Wolffia columbiana*), yellow waterlily (*Nymphaea mexicana*) y white waterlily (*Nymphaea odorata*) (Lot-Helgueras and Novelo, 2004). Some of this vegetation favors the habitat of fauna species, including an endemic crayfish (*Cambarellus montezumae*) and endangered amphibians (*Rana tlaloci* and *Ambystoma mexicanum*) (Valiente et al., 2010).

Because of its cultural and biodiversity importance, the Xochimilco wetland has been declared as a Human, Natural and Cultural Heritage for UNESCO (1987). Additionally, it is considered as a Natural Protected Area (1992) and Ramsar site (2004), and it is located within Mexico City's Conservation Zone (http://www.paot.org.mx/centro/programas/suelo-corena.pdf) (2012). Since 2017, the *chinampa* system has been recognized as "Globally Important Agricultural Heritage Systems" by FAO.

What Is Critical for the *Chinampa* Producers

Literature Review

A literature review was conducted considering sources in both scientific and gray literature such as thesis, scientific papers, book sections, etc., to identify needs and conflicts reported previously (see **Figure 2**). Also, we reviewed the collaboration and knowledge exchange between *chinampa* producers and academy members in the last decade in a series of workshops and non-structured encounters.

Analysis of Mental Models Through Cognitive Mapping

This section addresses the issues discussed with the *chinampas* producers about their needs, preferences, commercialization challenges, financial constraints, among other topics. For this, ten agro-ecological *chinampa* producers that have already adopted the *chinampa* refuge system and whose products can be certified were invited to participate in the interview. Five *chinampa* producers accepted, and the interviews were conducted during the first 2 weeks of December 2020 *via* video conference through the Zoom platform to reduce COVID-19 transmission risk. Three of the interviewed producers were women, and two of them represented two organizations/cooperatives of six and eight people, respectively. The interviews were designed to integrate knowledge about the problems and challenges the producers deal with during production and commercialization processes, for instance, those related to *chinampas* management, yield costs, trade issues, and whether they have participated in certification or labeling initiatives for organic or agro-ecological products (see the interview questions in **Supplementary Material 1**). To better understand the needs, conflicts, and perceptions, mental models were elicited from interviews (Carley and Palmquist, 1992), although audio files and notes taken during the interview sessions were also used. Then, a list of concepts was generated from the interview answers; next, using the specialized software Mental Modeler (Gray et al., 2013), the concepts from the most repeated or common responses were used first to start building the relations. Afterward, the result was as a collective cognitive map, visualized as a network comprising nodes or concepts and their relationships or connections representing direct and indirect causality (Özesmi and Özesmi, 2004; Gray et al., 2013) (see **Figure 2** for more details on the research framework). The software Mental Modeler and Cytoscape (Shannon et al., 2003) were employed to analyze the network. The properties and metrics of the network are crucial for understanding and identifying the system's critical elements. The network structure

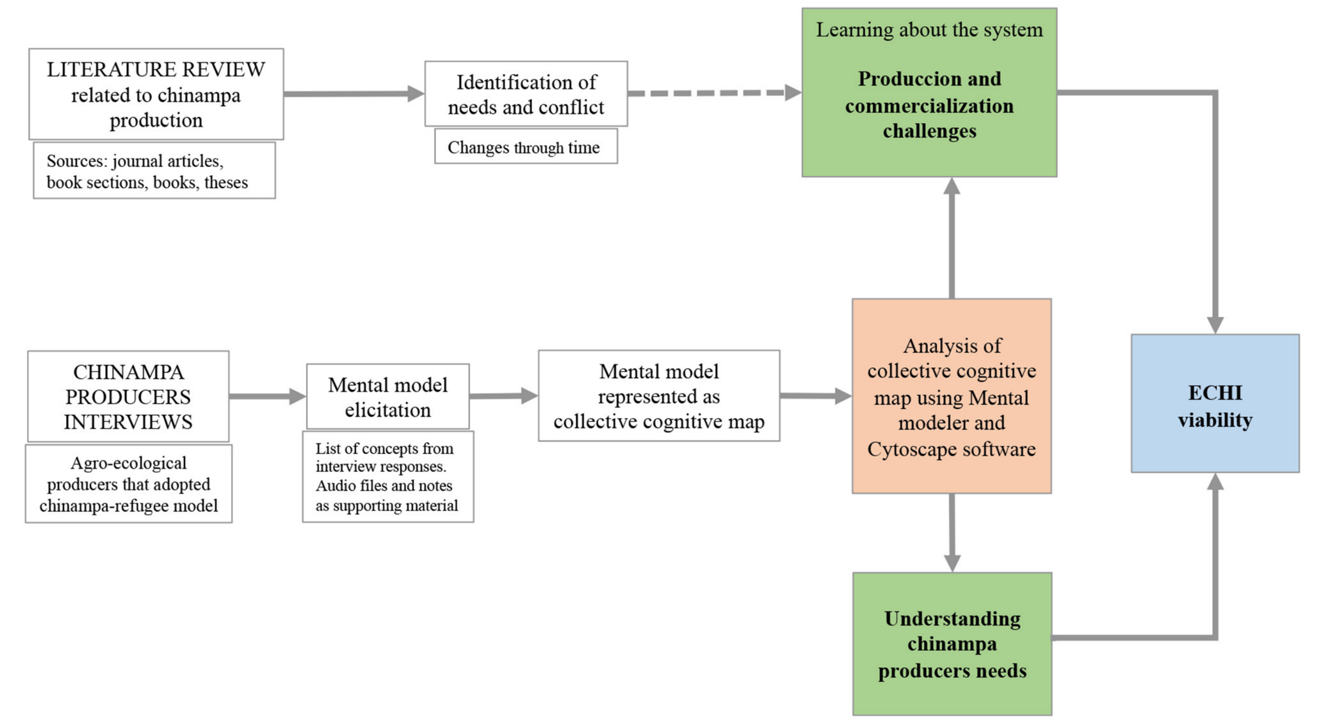

FIGURE 2 | Research framework depicting the flow of the research with applied methods.

was characterized by calculating the number of nodes and their type (driver, receiver, and ordinary nodes). In addition, the total number of connections, connections per node (determined as the number of links divided by the number of nodes), density calculated as the number of edges divided by the maximum number of possible connections, and complexity calculated as the ratio of the receiver to driver nodes (Hage and Harary, 1983; Özesmi and Özesmi, 2004). Once the network was generated, a hierarchical layout was applied in Cytoscape to visualize driver nodes at the bottom of the network, ordinary ones in the middle, and receiver nodes at the top of the network. In addition, two centrality measures were used: (1) degree centrality, or connectivity, that is used for finding highly connected nodes or those that are directly linked to many of the nodes of the network (Sharma and Surolia, 2013), and (2) betweenness centrality that is used for identifying the nodes that indirectly link many nodes of the network and have influence in the flow of information (Raghavan Unnithan et al., 2014). Then, to visualize the nodes with the highest centrality values, the CytoHubba application (Chin et al., 2014) implemented in Cytoscape was used with a centrality criterion to obtain the top 10 ranked nodes for connectivity and betweenness centrality.

RESULTS

Producers' Challenges Through Time

The review of previous research shed light on the needs, conflicts, and challenges faced by *chinampa* producers. These aspects were classified into Economic, Political, Socio-cultural, and Environmental categories. Previous research has provided essential knowledge for analyzing changes through time. Compared to our records, most producers' main concerns recorded by previous research have not changed over time, and many needs expressed in the past have been persistent through the years (**Table 1**). The literature review made evident that long-standing conflicts exist, which were also exacerbated during the first year of the COVID-19 pandemic and needed to be addressed straightaway. For instance, for the economic aspects, the lack of spaces to sell is the common aspect for almost all the studies. The government indifference and corruption were problems identified in all the reported studies. As for the socio-cultural aspects, the lack of organization among members of the community and irregular settlements were the most mentioned issues. Finally, the illegal discharge of water and low water quality were the most reported conflicts for the environmental aspects.

Collective Cognitive Map and Network Analysis

The network of the collective cognitive map had 54 nodes and 74 edges (**Figure 3**; **Table 2**). Thirty of the nodes were drivers, that is, to influence others but are not influenced. On the contrary, the 11 receiver nodes are affected but do not have an influence on other nodes. The rest of the nodes were ordinary, having influence and being affected by other nodes. Key aspects of the system (production and commercialization processes and challenges) were identified with the nodes highly

TABLE 1 | Needs and conflicts related to *chinampa* production identified in the literature are classified as economic, political, social, and environmental.

Economic	Political	Socio-cultural	Environmental	References
Lack of own financial resources to purchase inputs	Corruption	Low organization capacity No participation in organized groups or intervention in decision making within the community	Low water quality	Merlín-Uribe et al., 2013
	Inadequate governmental management Government indifference promoting only greenhouse production Corruption	Irregular settlements Abandonment of chinampas	Illegal discharge of wastewater Contamination Intentional damming of canals	Narchi and Canabal Cristiani, 2016
Lack of spaces to trade Trade intermediaries Competition with conventional products Discredited chinampa products Lack of economic support from government	Government lack of interest in identifying the primary needs of producers Corruption	Devaluation of chinampa work Abandonment of chinampas Irregular settlements	Use of chemical inputs Urbanization Illegal discharge of wastewater	Vázquez-Mendoza, 2018
Lack of markets	Inadequate governmental management Corruption	Young people show no interest in traditional productive activities The negative perception of agriculture Migration and professionalization	Low water quality of canals Deviation of spring water to provide potable water city Trash dumping into the canals Illegal discharge of wastewater	Rubio et al., 2020
Producers with no clear record of their economic balances High costs of farming inputs (i.e., gasoline and pumps for irrigation) Lack of places to sell	Government indifference and corruption Informal settlement expansion	Lack of organization among community members New generations are no longer interested in farming Competition with farmers from other states	Over-exploitation and suitable quality of water Discharges of untreated wastewater into the canals	Pérez-Belmont et al., 2021

connected and their relations. For instance, the *Marketing problems* concept (see **Figure 3**), at the top of the network seemed to be one of the major issues and challenges. It is caused by many factors such as the lack of *Governmental support* or aspects such as *Consumers unwillingness to pay a fair price.* Another critical concept was *Total profit* (located at the highest level of the network) that while affected negatively by *Highest spending in chinampa* or *Soil problems* led to low total profit, whereas *Direct marketing without intermediaries* or the *Producers have their own seeds* made the *chinampa* producers obtain a greater total.

Interestingly, none of the interviewed producers know exactly the *chinampas*' income and expenses of their property. For this, it is observed that *Lack of financial knowledge (investment, earnings, profitability are unknown),* located at the bottom of the network, increased *Boat expenses (not considered when planning process)* and led to problems such as the *Difficulty establishing economic value to vegetables and workforce* and. Moreover, the latter is also produced by needs like *Financial education and advice to producers* (see **Figure 3**) and an issue such as *Consumers unwillingness to pay a fair price*. Nevertheless, the *chinampa* producers recognized that the highest costs on the production process are the salary of workers and laborers (*Workers hired by the day*) and *Soil problems*.

The cognitive map also revealed that most producers had had the previous approach to green label proposals. The concept of *Green labels or certifications* is located at the top of the network (**Figure 3**), and it is directly related to *Governmental institutions*, *Civil Society Organizations*, *Private sector*, *Collective benefit* and *Academic sector nodes*, and indirectly (at least one-node-distance) related to *Financial education and advice to producers* and *Trust in chinampa products* through the *Academic sector* node and *Marketing problems* and *Conflicts with other producers* through the *Collective benefit* node. Regarding the direct relationship between *Green labels or certifications* and *Collective benefit* nodes, the COVID-19 pandemic now seems to presents an opportunity to reflect and ponder on the local production, supply chains, and the labor aspects, such as liaisons between producers (see **Figure 3**). Producers and families working at the *chinampas* deployed new ways of marketing vegetables and greens to cope with COVID-19, including alternative local markets within the closer municipalities and home delivery, handling the lack of spaces to sell without government support (as recorded in the review, see **Table 1**).

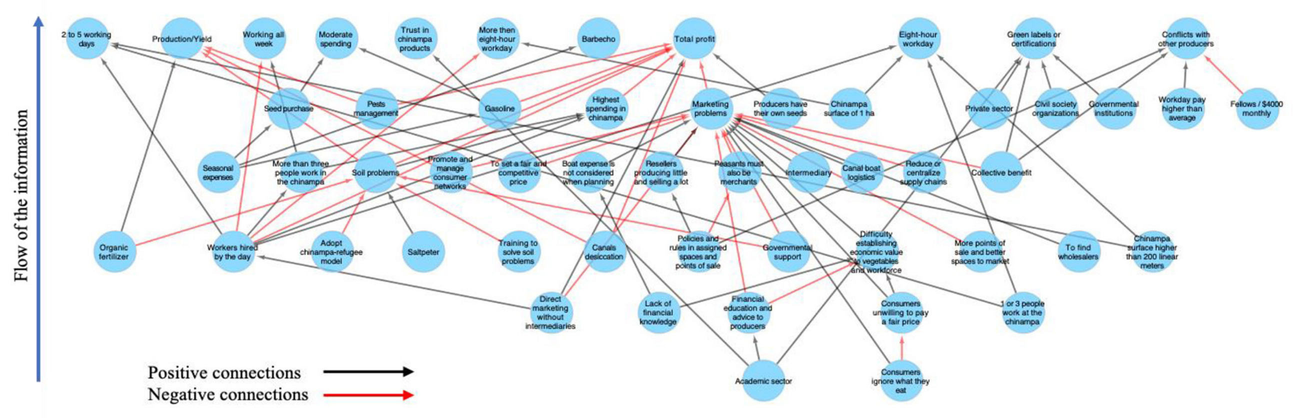

FIGURE 3 | Network of the collective cognitive map obtained from the interviews of the five *chinampa* producers.

TABLE 2 | Summary of network properties.

Properties	Value
Total nodes	54
Number of driver nodes	30
Number of receiver nodes	11
Number of ordinary nodes	13
Total edges	74
Density	0.0258
Connections per node	1.3703
Network complexity R/D	0.3666

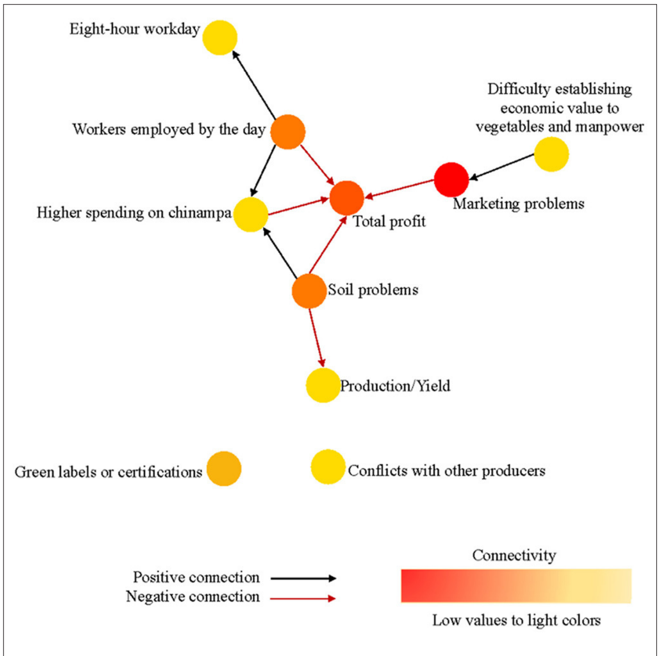

FIGURE 4 | Top 10 connectivity nodes network. Nodes with the highest connectivity are shown from red degrading to yellow. Two of the nodes are not connected with the others, although these are also highly connected nodes in the complete network.

The top 10 centrality nodes analysis showed the highest connectivity and betweenness centrality nodes (**Figures 4**, **5**). These concepts were *Marketing problems*, *Total profit*, *Soil problems*, *Workers hired by the day* and *Collective benefit*. In **Table 3** the complete list of the top 10 connectivity and betweenness centrality nodes are presented. The *Green labels or certifications* concept is also among the top ten centrality nodes (see **Figures 4**, **5**). The literature review showed that some aspects, such as *Marketing problems* are persistent concerns for producers and in part generated by the presence of *Resellers* and *Intermediaries*, the *Difficulty establishing economic value to vegetables and workforce* and the *Consumers unwillingness to pay a fair price*.

DISCUSSION

Under the current global situation in which the dominant model of economic development, the social inequality, the increment and intensification of urbanization and many others have generated severe environmental degradation (beyond planetary boundaries), many strategies have been proposed to promote sustainable modes of production and consumption. Eco-labeling has been proposed as one of the more efficient approaches. This paper aims to learn about agro-ecological production process and commercialization challenges in *chinampa*s of Xochimilco and San Gregorio Atlapulco to understand the producers' needs. This is critical to determine the viability of a green label and its implementation in a vulnerable social-ecological system like this urban wetland in Mexico City. The ECHI label was considered as an excellent opportunity for the megacity inhabitants in socio-cultural, socio-economic, and socio-ecological terms. Integrating the results of each of the components of the ECHI label should provide theoretical

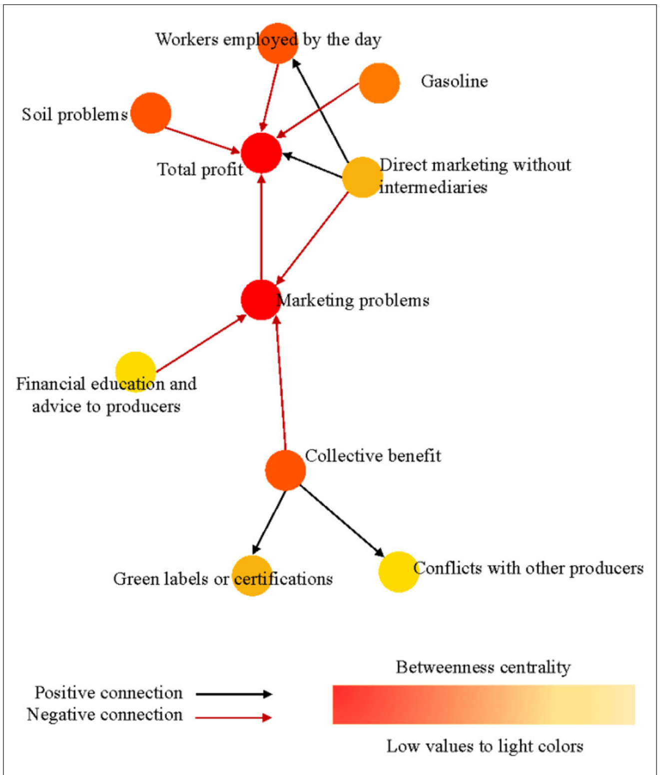

FIGURE 5 | Top 10 betweenness centrality nodes network. The nodes with the highest betweenness centrality values are shown from red degrading to yellow.

TABLE 3 | Top 10 centrality nodes ordered by value.

Connectivity	Betweenness
Marketing problems*	Marketing problems*
Total profit*	Total profit*
Soil problems*	Workers hired by the day*
Workers employed by the day*	Collective benefit
Green labels or certifications*	Soil problems*
Difficulty establishing economic value to vegetables and workforce	Gasoline
Production/Yield	Green labels or certifications*
Conflicts with other producers*	Direct marketing without intermediaries
Higher spending on chinampa	Conflicts with other producers*
Eight-hour workday	Financial education and advice to producers

**Nodes or concepts with the highest connectivity and betweenness centrality.*

and analytical solid bases for establishing and executing the certification. However, the outcomes from the network analysis provide valuable findings to suggest essential points: (i) if implemented now, the current ECHI label design will probably fail in fitting the needs of the *chinampa* producers, (ii) attending to former and persistent conflicts and satisfying urban agriculture producers neglected necessities are essential before implementing any program.

The network analysis showed that most nodes were drivers, offering a collective cognitive map with low complexity (ratio of receiver nodes to driver nodes). This indicates the degree of resolution and suggests top-down thinking and causal arguments poorly elaborated (Özesmi and Özesmi, 2004). On the other hand, many receiver variables might indicate that the producer's cognitive map considers countless effects or consequences, which are results of the system (Eden et al., 1992). The collective cognitive map provided the potential to visualize relationships between nodes that were not known with certainty (Özesmi and Özesmi, 2004). Likewise, the network analysis helped identify producers' current necessities that should be considered in the plans and procedures of the ECHI label implementation. For example, it is notable the difficulty expressed by each one of the interviewed producers to set the price of vegetables, due in part to the lack of knowledge about the production costs in *chinampas*', and the dilemma to give a fair value to continuing producing food through an ancient food production system. In this sense, the outcomes of the socio-ecosystem and socio-cultural components of the ECHI will be critical to have a complete picture of the factors that need to be addressed to reinforce aspects such as the meaning of being a peasant, the significance of food to the identity of a community and a nation, that are closely related to food sovereignty, social inclusion and cultural identity, and environmental sustainability (Appendini and Quijada, 2016; Guzmán Luna et al., 2019). Considering the relationship of socio-cultural values and food preferences, it has been recorded (Cantarero et al., 2013) that people reinforce the sense of belonging by consuming food symbolically associated with their own culture.

The *Green labels or certifications* concept is also part of the top ten connectivity and betweenness centrality networks. In **Figure 4**, it is evident it is disconnected from the rest of the nodes, suggesting that it is not part of the core issues which are currently of concern for the producers. However, hierarchical networks help visualize conflicts and prioritize actions (**Figure 3**). Following the prioritizing of first to attend to problems and needs located at the bottom of the network and then go through the top will ensure a steady improvement in the long run (Arroyo-Lambaer et al., 2021). Then, confronting problems such as *Lack of financial knowledge (investment earnings, profitability are unknown)*, *Consumer unwillingness to pay a fair price*, or *Direct marketing without intermediaries* (at the bottom of the network, **Figure 3**) will reduce *Conflicts with other producers* and increase the *Total profit*. Therefore, addressing essential needs increases the chances of farmers' acceptance of a green label foremost, it is closer to realizing the benefits of certification such as the improvement of production and income. For instance, significant challenges such as *Marketing problems* and *Total profit* (**Figure 3**) may be reduced and/or improved through a green label. This is possible if a producers' *Collective benefit* and the involvement of *Academic* and *Private sectors*, *Civil Society Organizations*, and *Governmental institutions* occur.

In addition, the presence of the node referring to green labels and certifications puts the ECHI label implementation in an advantageous position as many of the producers already have the idea of certifying their products. However, producers' acceptance of the certification process will largely depend on the degree of participation, information availability, and the certification's purposes and benefits. Moreover, as suggested above, the acceptance will also depend on the actions taken before implementing a green label. Addressing the urban agriculture producer's needs will increase probabilities to guarantee the quality of the *chinampa*'s products and access to a specialized market offering an allure over-price. It is also essential to note that green labels are potentially successful if technical assistance is provided, foremost if complementary public or private policies exist (UNEP, 2005). Likewise, certification costs and processes could represent significant barriers to getting an eco or green label (Veldstra et al., 2014). However, it also depends on interrelated factors like socio-economic and demographic aspects, risk preference, health, ecosystems, and knowledge (Veldstra et al., 2014; Praneetvatakul et al., 2022). Producers may evaluate certification if it increases production costs (Pinto et al., 2014; Praneetvatakul et al., 2022). Moreover, given that certification processes are expensive, they tend to be abandoned, as has been widely reported (Läpple, 2010; Leitner and Vogl, 2020). In the case presented here, the adoption of the *Chinampa* refuge program and *chinampa* conditioning which are expected preconditions to certify the products are time-consuming and imply additional expenses for the producers. Then, under the current ECHI label design, the costs of soil and water analyses (required for certification) must be covered by themselves, representing a production unaffordable extra cost, with an approximate cost *per sample* of $8,000 MN (∼$381 USD).

Furthermore, the consumers and the general public need to be reminded or informed of the cultural and biological relevance of the area, the *chinampas*, and their function as a food production system critical for the city and the influence on air temperature and water provision services. That is the provision of healthy food and the capacity to provide food to the city under normal circumstances and during global events such as pandemics. As recorded in several studies (see Bosseaux et al., 2019; Sobotko, 2019; Li and Kallas, 2021) potential consumers most probably accept to pay a higher amount if it is perceived that the value of a specific product feature differentiates it from conventional ones.

Moreover, consumption of healthy and sustainable diets presents significant opportunities to reduce greenhouse gas emissions from food systems and improve health outcomes (Mbow et al., 2019). According to FAO (2014), at least 20% of Mexico City's food is produced in Xochimilco, crucial during and after a pandemic. Then, it is paramount to give the consumers all the information on the certification process and labeling and the implications and benefits.

In terms of consumer behavior, sensory qualities such as appearance, taste, texture, and origin attributes as locally grown or nationally produced, labeling and even local cultural values are critical in driving consumer buying behavior (Lusk and Briggeman, 2009; Massaglia et al., 2019; Kilders et al., 2021; Ţigan et al., 2021). As visualized in the cognitive map, the concepts *Consumers ignore what they eat* and *Consumers unwilling to pay a fair price* (see **Figure 3**) are recognized by producers as negative aspects generating marketing issues and difficulty establishing economic value to vegetables and workforce. In this sense, several drawbacks and limitations are observed. The ancient food production system of *chinampas* seems to be forgotten, and it is not recognized among the consumers, general public, and citizens of Mexico City. This is partly due to the environmental conditions, water contamination, severe urbanization (Pérez-Belmont et al., 2021) that have stigmatized the food production system in these urban and peri-urban areas. As well as the lack of recognition of the fact that these conditions are reversed considerably in those areas incorporated in the *Chinampa*-refuge model (Zambrano et al., 2020). Therefore, there is an immediate necessity to look at strategies to overcome and strengthen the value (social, cultural, and economic) of this critical agri-food system and to disseminate the results among the potential consumers, public, and tourist visitors of Xochimilco, especially those related to water and vegetable safety analyses.

Among the potential strategies to make the public, visitors, and consumers aware of the *chinampa*'s social, cultural, and economic values are the integration of *chinampa* production system into the Mexico City urban planning to make food affordable and to improve access to nutritious food (Cabannes and Marocchino, 2018); urban agriculture products diffusion and promotion through direct sales, consumer cooperatives, alliances between producers and restaurateurs, and agro-ecological public purchases such as in school, community kitchens, hospitals or elderly nursing homes (Espluga-Trenc et al., 2021), and food festivals (Fontefrancesco and Zocchi, 2020). Another approach is urban agriculture education, at least in North America (Russ and Gaus, 2021), which has helped understand food systems and healthy eating, especially among the young population. While some countries are adopting pedagogical spaces as strategies to promote sustainable production (e.g., agro-ecological), provide education focused on social and environmental justice, encourage inclusive community and student leadership, and support student food security (Classens et al., 2021), others seem to work better with public communication campaigns (Buerke et al., 2017). These are potent tools to disseminate knowledge and help raise awareness among the general public and consumers (Sayers, 2006; Buerke et al., 2017). Here, it is essential to mention that farmers noted that the *Academic sector* would play an important role in increasing *Trust in chinampa products* (**Figure 3**). This certainly can be achieved through finding dissemination. Altogether, these measures will help to increase the capacity of the Xochimilco social-ecological system to maintain long-term resilience while coping with disturbances.

From the beginning of the COVID-19 pandemics, many affected countries have been forced to re-examine and transform their food and agriculture policies to maintain the availability and affordability of food supplies to the public (Ma et al., 2021); this is also true for Mexico. Then, it is paramount to propose strategies and modify public policies. It is undeniable that the business-as-usual scenario concerning food production systems in Mexico is unsustainable and must change. Moreover, the COVID-19 pandemic has triggered the urgent requirement of institutionalizing change to strengthen food production systems, foremost the *chinampas* in Mexico City, to implement food security and urban sustainability (Lugo-Morin, 2022). In this sense, the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2020) reports highlighting the crucial necessity of food system transformation worldwide. Food systems are frequently seen and treated as one isolated sectoral issue. Then, the successful implementation of the ECHI label will require more than governmental institutions, civil society organizations, or private sector support, but policies recognizing the interconnectedness of sectors and systems (e.g., agriculture, health, culture, and environment sectors and economic, social-cultural, energy, and health systems). Therefore, systems working synergistically and encouraging more regenerative, productive, and resilient food systems will be ensured through such policies (HLPE, 2020).

The limitations of the study, including the low number of interviewed producers, is recognized. The interview was focused on agro-ecological producers that have adopted the *Chinampa* refuge model and whose products can be certified. The universe of agro-ecological producers with such characteristics is low, and even lower the number of producers who accepted the invitation to participate. However, it is important to note that the number of interviews is not intended to reflect a significant sample but to learn about the system (see Prieto-Rodr?guez and March-Cerd?, 2002; Elsawah et al., 2015; Nyumba et al., 2018), that is, the challenges and issues faced by the agro-ecological producers during the production and commercialization processes. Thus, this analysis should be taken as a first step in learning about the system, then adding producers (as these adopt the *chinamp*a refuge approach) would strengthen further research. Finally, the contribution of this work relies on the use of mental models and their analysis through network theory to identify critical components and their relationships with each other and to understand urban agriculture needs to evaluate the feasibility of a green label in a vulnerable socio-ecological system, particularly considering the effects of sanitary restrictions derived from the COVID-19 pandemic.

CONCLUSIONS

In Mexico City, in the face of future pandemics and other disruptive phenomena it is imperative to generate and implement approaches that strengthen resilient and sustainable food production systems. This study aimed to learn about the small-scale agro-ecological production process and commercialization challenges in Xochimilco and San Gregorio Atlapulco in Southern Mexico City to understand the *chinampa* producers' needs and determine whether a green label can offer solutions in such a vulnerable socio-ecological system. A literature review was conducted to identify general aspects, challenges or issues the producers deal with. Then, *chinampa* producers were interviewed and from these mental models were elicited and analyzed through network theory. The literature review results indicated that needs and conflicts related to *chinampa* production are of Economic, Political, Social, and Environmental nature and most of them have not changed through time. Such persistent issues were also visualized in the collective cognitive map and its relations to one another were analyzed to better understand the *chinampa* producers' needs. From this, it is our believe that under the current production and commercialization circumstances/scenarios in Xochimilco and San Gregorio Atlapulco, the implementation of the proposed ECHI label will fail to fulfill the benefits including to improve *chinampa* production and producers' income strengthening the relationship with agri-food market and biodiversity conservation. Thus, attending to former and persistent conflicts and satisfying urban agriculture neglected necessities are essential before implementing any program. Nonetheless, an institutionalizing change is urgent to strengthen food production systems, to implement food security and urban sustainability.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

LZ, MM-H, and FF participated in the design of the project and coordinated the study. CS, MR, DV-M DA-L, MP-U, DR-F, MT-P, and AJ-S participated in the collection of data. Analysis of data was performed by DA-L, LZ, MR, DV-M, FF, MP-U, AE-G, MT-P, MM-H, DR-F, AJ-S, MC, and CS. DA-L designed, coordinated, and wrote the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2022.892341/full#supplementary-material

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