Review [Revisión]

SUSTAINABILITY IN RURAL AGRI-FOOD SYSTEMS BASED ON THE UNDERSTANDING OF THEIR STRUCTURAL AND FUNCTIONAL CHARACTERISTICS: A SYSTEMATIC REVIEW †

[SOSTENIBILIDAD DE SISTEMAS AGROALIMENTARIOS RURALES A PARTIR DE LA COMPRENSION DE SUS CARACTERISTICAS ESTRUCTURALES Y FUNCIONALES: UNA REVISIÓN SISTEMÁTICA]

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SUMMARY

Background. Rural agri-food systems are responsible for the production of most of the food products consumed in urban centers, however, despite the current importance they have in the food systems of populations worldwide, their structure and functioning, both key aspects for understanding its sustainability, have not been studied enough. **Objective.** This study was aimed at describing the conditions associated to agri-food systems sustainability in rural communities based on the understanding of their structural and functional elements, through a systematic review of scientific literature. **Methodology.** A comprehensive search for original papers in three different databases, ScienceDirect, Scopus and PubMed, was carried out, filtering the results based on inclusion and exclusion criteria, and subsequently adding grey literature. **Results.** Our findings indicate that sustainability in these agri-food systems relies on socioecological interrelations, whose environmental and sociocultural aspects are more relevant than the principles of the market economy, which become a menace for these systems. One of our most relevant findings is the essential role of distribution networks for ensuring sustainability. **Implications:** It is necessary to assess the different categories defined in agri-food systems in order to define in indigenous and rural communities the adjustments they require to achieve sustainability. **Conclusions.** Rural agri-food systems behave as complex, adaptive systems, conditioned by the multiple factors and dimensions of their biophysical, sociocultural, and political environment, as well as by the role of gender in their functioning.

Keywords: Agri-food system; smallholders; indigenous people; rural communities; sustainability.

RESUMEN

Antecedentes. Los sistemas agroalimentarios rurales, son los encargados de producir la gran mayoría de los productos alimenticios que se consumen en los centros urbanos, sin embargo, a pesar de la importancia actual de estos sistemas en la alimentación de las poblaciones del mundo, es poco lo que se ha estudiado sobre su estructura y funcionamiento, aspectos claves para comprender su sostenibilidad. **Objetivo**. Este estudio tuvo como objetivo describir las condiciones relacionadas con la sostenibilidad de los sistemas agroalimentarios de comunidades rurales a partir de la comprensión de sus elementos estructurales y funcionales por medio de la revisión sistemática de la literatura científica. **Metodología**. Se realizó una búsqueda exhaustiva de artículos originales en tres bases de datos diferentes; ScienceDirect, Scopus y PubMed, filtrando los resultados por criterios de inclusión y exclusión, y luego agregando literatura gris. **Resultados**. Los hallazgos indican que la sostenibilidad de estos sistemas agroalimentarios está soportada en interrelaciones socio ecológicas, en las que aspectos ambientales y socio culturales son más relevantes que las lógicas de la economía de mercado que se convierten en una amenaza. Un hallazgo relevante es el papel central de las redes de distribución para la garantía de la sostenibilidad. **Implicaciones**: Es necesario valorar

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las diferentes categorias definidas en los sistemas agroalimentarios para definir en comunidades indígenas y rurales las adecuaciones que requieren para alcanzar la sostenibilidad. **Conclusiones**. Los sistemas agroalimentarios rurales se comportan como sistemas complejos adaptativos, condicionados por múltiples factores y dimensiones del entorno biofísico, sociocultural y político, y el papel del género en el funcionamiento de los sistemas.
Palabras clave: Sistemas agroalimentarios; pequeños productores; pueblos indígenas; comunidades rurales; sostenibilidad.

INTRODUCTION

Rural agri-food systems (SAR, in Spanish) are integrated and comprehensive combinations of functions, agents, actors and socioeconomical relations, which influence, through different activities, in the transformation, transference and consumption of food products throughout the food chain (Schejtman, 1994; López, 2010; Hernández and Villaseñor, 2014). These systems work as an interdependent network of actors, located at a specific geographical space, who participate in the flow of goods and services that ensures the provision of nutritional and innocuous products for one or multiple consumer groups. (Rastoin and Ghersi, 2010).

The rise of SAR is considered throughout scientific literature to have taken place during the 20th century, as a part of a reordering of agriculture, originated by the formation of agro-industry enterprises which were subsequently consolidated into agri-food groups and complexes. This process led to a shift from the production of food products by smallholders to the provision of raw materials and input for the food industry (Delgado 2010).

The evolution of SARs transformed agricultural production (McMichael, 2009; Delgado, 2010), which evolved from an artisanal activity carried out by multiple economic actors at a small scale, to consolidate as a large-scale industry controlled by a few multinational food corporations. This is known as the Global Agri-food System (SAG, in Spanish) where the segmentation of production processes, and the competence based on food products differentiation and quality, production volume and price, as well as the power of large retailers over the rest of the economic agents in the market, the intensification of land ownership concentration processes and the privatization of natural resources, in addition to the control of agri-food systems by transnational companies, have all originated in order to respond to the demand of input by global manufacturing and distribution networks (Domínguez, 2015).

Trade liberalization and the strengthening of the world market (Hernández and Villaseñor, 2014), additional to the insertion of agri-food products in increasingly expanding production and distribution chains, which have a wide mobility around the world (Friemann and McNair, 2008; Friedland, 2004), have contributed to an increase in the availability of food products in global markets, in parallel to the development of SAGs. From the 1970s y 1980s, the term Localized Agri-Food Systems (SIALs, in Spanish) has been used to describe multiple industrial districts and regions in the north of Italy (Beccatini, 1979; Capecchi *et al*., 1987), highlighting the importance of social and trust networks among actors with a common territorial identity.

According to (Muchnik and Sautier, 1998), SIALs are made up by organizations that offer products and services, units of agricultural production, agri-food enterprises, and restaurants, among others, whose sociocultural, environmental and performance characteristics bind them to a specific territory.

The adoption of these systems has been steadily expanding, especially in rural communities; this is why it is possible to find studies in the scientific literature on small- and middle-sized agri-food enterprises in Africa (López and Muchnik, 1997), as well as agro-industrial corporations led by farmers in Latin America (Boucher and Muchnik,1998), which discuss the problematics of food provision to urban centers through the evaluation of local resources and family farming as an opportunity to generate added value.

Family farming (AF, in Spanish) plays an important role in reducing rural poverty, food insecurity, undernutrition, and in maintaining a sustainable food system (Soto *et al*., 2007; FAO, 2012). The agri-food industry does not have the capacity to provide enough innocuous food products to large urban centers, which obtain their provision mainly from the production of small farmers; this is how AF has proven to be the greatest provider of agricultural commodities consumed by the populations in Latin America and the Caribbean, where production is covered by the 80 % of agricultural holdings, represents a 30% to 40% of the agricultural GDP, provides between 27% to 67% of the total food production, uses a 12% to 67% of the agricultural soil and generates between 57% to 77% of the employment in the agricultural sector (Soto *et al*., 2007). All the above were the reasons why the General Assembly of the United Nations proclaimed year 2014 as the *International Year of Family Farming* (Arnalte, 2014).

AF has its roots in the ancestral agricultural practices of communities, such as indigenous groups (Rumrrill, 2008), whose agri-food systems have been studied from the perspective of various disciplines, such as agronomy and forestry, anthropology, archeology, biology and history, which have examined traditional technologies for a sustainable management of natural resources.

Authors as Vastola *et al*., (2017) claim that it is necessary to define and implement a model of sustainable agriculture, such as Conservational Agriculture (AC, in Spanish), which satisfies feeding needs and conserves the soil through the inclusion of a set of available best practices that preserve the agricultural soil and its biodiversity. However, it is not yet clear what are the conditions that such SARs should have to be sustainable.

Based on the situation described above, the aim of this study was describing the conditions related to the sustainability of agri-food systems in rural communities (SARs) based on the understanding of their structural and functional characteristics through the systematic review of the scientific literature published in the last ten years.

MATERIALS AND METHODS

Search Strategy

This study was conducted following the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Urrútia and Bonfill, 2010). A systematic review of scientific literature was carried out in the ScienceDirect, Scopus y PubMed databases in 2022 under the following criteria: a) sensitivity, using AGROVOC descriptors, b) specificity, using a combination of Boolean operators and terms defined according to the research problem, and c) completeness, using non-AGROVOC descriptors, and pooling the gray literature found in the Scholar Google database.

The general path used for the search was: [((Agri-food system) AND (structure OR functioning)) AND (agroecology OR sustainability)]. In the ScienceDirect, Scopus y Pub Med databases, time limits were used: “2009 to present” and “between 2009 and 2022”.

Citations found in databases were imported, along with their respective abstract, to the reference management software Mendeley, where duplicate citations among databases were eliminated.

A research protocol and inclusion and exclusion criteria were applied independently by two researchers to guarantee reproducibility in the review. All discrepancies were solved by consensus.

Inclusion and Exclusion Criteria

Only original articles reported in scientific literature in the last 13 years (2009 to 2022), which described a rural community and its agri-food system, alternative food networks, farmer markets or community agriculture were included. Additionally, only articles that provided a technical description of such systems or information on processes related to their maintenance, their use by the community and their future projection towards sustainability were considered.

Reproducibility

Reproducibility in this investigation was granted by the systematic use of preestablished search paths in the selected databases; inclusion and exclusion criteria were applied to the literature selected separately by two of the investigators, and any discrepancies arisen during the screening phase was solved by an external expert.

Data Analysis

The details of each publication were extracted and tabulated in an information collection form for later analysis, which contained general data about the articles (title, journal’s name, year of publication and country), the identification of elements related to Agri-food systems (structural and functional characteristics), sustainability related to each agri-food system within each analytic category.

RESULTS AND DISCUSSION

The implementation of the search protocol through the preestablished paths described above generated 185 articles published between 2009 and 2022 (ScienceDirect 76, Scopus 107 and PubMed 2). Subsequently, 23 references duplicated across databases were eliminated (Mendeley Reference Manager), 157 publications were evaluated based on the application of inclusion and exclusion criteria and 110 publications were excluded. Based on the previous process, the search protocol applied in the three databases included 47 articles for systematic review.

Additional to these 47 articles, we included the gray literature found through a search in Google Scholar, which included 4 doctoral theses, for a total of 51 articles that are to be analyzed in this study (Figure 1).

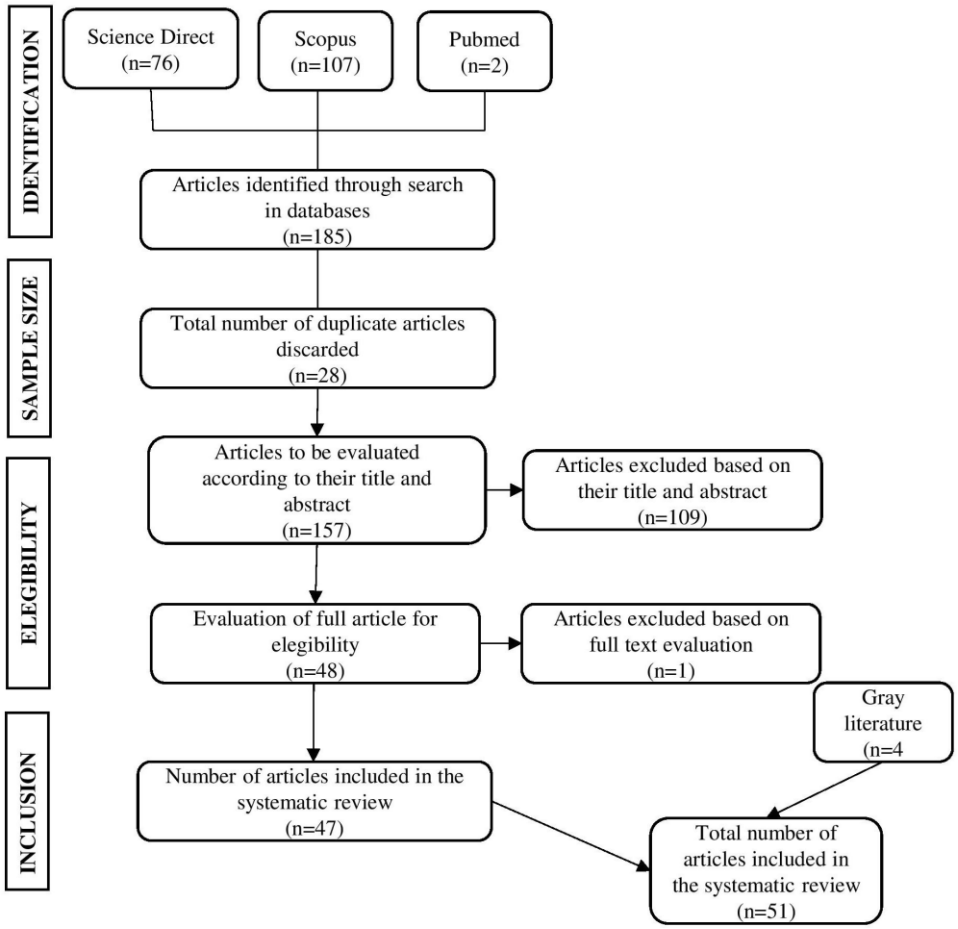

Figure 1. Flowchart of the search algorithm for articles included.

The systematic search of the scientific literature on this research topic published between 2009 and 2022 resulted in 51 scientific documents about studies conducted in 18 countries; 50% of the publications came from Belgium, Spain, Italy, Mexico, and Tanzania.

Structural and Functional Characteristics of Rural Agri-Food systems

According to the scientific literature included in this study, authors such as Shilomboleni *et al*., (2019) and Jagustović *et al*., (2019) agree that SARs are adaptive, complex systems influenced by socioeconomical, political, environmental and cultural factors which impact food production, distribution and consumption. Hubeau *et al*., (2019) consider that SARs have become increasingly complex, involving many interconnected structures and processes of production, transformation and supply, which are impacted by complex challenges that demand for sustainability solutions and collective actions, such as system innovation.

Vallejo *et al*. (2016) define SARs as socioecological systems where humans and the agro-environment integrate and interact. This allows studying the interactions between levels, the establishment of non-linear and crossed scales within and between the system's components and helps in a more systemic evaluation of policies such as the food sovereignty policy. They suggest that the most adequate framework for analyzing SARs in fragile and marginal environments, such as the Andean region in South America, should link the ideas and methodologies of studies focused on the knowledge and vulnerability of complex systems applied to SARs, in order to develop an integrated framework for evaluation that covers both the agroecological context and the social function of agriculture, and considers actors' agency and institutional processes, as well. Finally, they say that this framework also helps to understand how agri-food policies change the

configuration of SARs and determines whether these changes are consistent with the reproduction of communities' livelihood.

According to Iles and Montenegro (2015) communities organize their local production and distribution mainly by integrating rural producers and supporting the traditional markets and livelihoods. This is done to ensure food autonomy or sovereignty by seeking to take control over a wide variety of social and ecological assets, among them, cultural heritage, traditional knowledge and technologies, as well as natural resources such as water, biomass, minerals, and genetic resources, such as seeds (Davies *et al.,* 2022).

Swagemakers *et al*., (2019) state that the modernization of agriculture has generated an increasingly greater disconnection between agriculture, nature, and society, which translates into a series of social, economic, and ecological crises in the food chain. To solve this problematic, some food producers have adjusted their agricultural practices and their use of land to ensure sustainability for their rural enterprises. Such changes should be aligned to the specific characteristics of their local physical environment and the principles of the local political and economic environment. Ababio-Twi (2019) says that in Afadzato, Ghana, considerable variations are found in the strategies of small rice producers, whose preferences, interests and environmental evaluations transform into very different actions and, especially when the farm is transferred to the next generation, most of them opt for cost reduction as the predominant strategy. Sustainable rural development in different regions of the world is threatened by the exodus of young people who migrate from rural areas to urban centers in search of better economic opportunities than those offered by agricultural activity (Chen *et al*., 2022).

Dedeurwaerdere *et al.,* (2017), who studied the case of the Waals-Brabant province in the Wallonia region, Belgium, defines that SARs' governance should be characterized by inclusion and food systemic ethics in two ways: it must guide the strategies and activities carried out by most of the SARs actors and it has to be based on a systemic understanding of sustainability challenges and perspectives, considering social justice issues affecting both producers and consumers as key elements that contribute to the materialization of the transition to sustainability. For Bui *et al*., (2009), it is important to promote the social learning of a wide group of sustainability and experimentation values with lifestyle changes for ensuring sustainable food consumption and production practices (Table 1).

Table 1. Concepts discussed in the scientific literature on SAR.

Concept	Description	References
Sustainability	It is the capacity of resilience of the agri-food system to endure external pressures and conserve its structure to continue with food processing, distribution, and consumption through time.	Swagemakers *et al*., 2019; Ababio-Twi, 2019; Vallejo *et al*., 2016; Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Jagustović *et al*., 2019; Campbell *et al*., 2012; Godoy *et al*., 2017; Oñederra *et al*., 2018; Argüellesa *et al*., 2018; Vastola *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Bos and Owen, 2016; Miralles *et al*., 2017; Viccaro *et al*., 2018; Zirham and Palomba, 2016; Barzola, 2019; Hubeau *et al*., 2019; Rosin *et al*., 2017; Larroa, 2012; Vetter *et al*., 2019; Shilomboleni *et al*., 2019; Australian Centre for International Agricultural Research, 2019; Gil *et al*., 2022; Anastasiadis *et al*., 2022, Martens *et al*., 2022; (Zscheischler *et al*., 2022)
Food sovereignty or security	Food sovereignty is the right of peoples to autonomously decide on the use and control of their natural resources for maintaining their agri-food system, according to their own nutritional preferences and cultural traditions. Food security exists when all people have access, at all times, to sufficient, safe and nutritious foods in order to satisfy their nutritional needs for a healthy and active life.	Vallejo *et al*., 2016, Iles and Montenegro, Davies *et al*., 2022; 2015; Jagustović *et al*., 2019; Zimmerer and Rojas, 2016; Tolentino and del Valle, 2018; Vastola *et al*., 2017; Tedesco *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Enríquez *et al*., 2017; Barzola, 2019; Shilomboleni *et al*., 2019; Australian Centre for International Agricultural Research, 2019; (Zscheischler *et al*., 2022).

Concept	Description	References
Complex systems	Agri-food systems are a complex combination of various interdependent subsystems, they are adaptive, influenced by socioeconomical, political, cultural, and environmental factors which affect populations feeding.	Vallejo *et al*., 2016, Iles and Montenegro, 2015; Jagustović *et al*., 2019; Shilomboleni *et al*., 2019.
Socioecological systems	They are systems where the interaction and integration of a social system and its environment take place, their importance is rooted on the systemic relations, interactions, and feedbacks between their components.	Vallejo *et al*., 2016; Zimmerer and Rojas, 2016; Heckelman, 2019; Larroa, 2012;
Governance and governability	Governance refers to the process of interaction among crucial actors of the agri-food system. Governability refers to their self-strengthening and self-sustaining capacity.	Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Zimmerer and Rojas, 2016; Oñederra *et al*., 2018; Tolentino and del Valle, 2018; Argüellesa *et al*., 2018; Bos and Owen, 2016; Herrera *et al*., 2018; Kilelu *et al*., 2017; Kassis *et al*., 2021, Foti and Timpanaro, 2021.
Social justice	It refers to social equity, the equal distribution of resources, and equality of economic and political participation opportunities.	Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Argüellesa *et al*., 2018; Ochieng *et al*., 2017; Tedesco *et al*., 2017; Bos and Owen, 2016; Wegerif y Hebinck, 2016; Barzola, 2019; Hubeau *et al*., 2019; Vetter *et al*., 2019; Kilelu *et al*., 2017.
Gender	It refers to the roles that men and women play within the agri-food system, the sex division of labor, and the discrimination of women in the access to resources, political participation, and decision-taking activities. It also refers to the empowerment of women as a social-ecological resilience strategy before power structures to develop sustainable agri-food projects.	Vallejo *et al*., 2016; Jagustović *et al*., 2019; Zimmerer and Rojas, 2016; Tolentino and Del Valle, 2018; Argüellesa *et al*., 2018; Pambo *et al*., 2018; Bos y Owen, 2016; Wegerif and Hebinck, 2016; Zirham and Palomba, 2016; Larroa, 2012; Vetter *et al*., 2019; Kilelu *et al*., 2017; Shilomboleni *et al*., 2019; Australian Centre for International Agricultural Research, 2019, Sarapura and Hoddy, 2022; Kini, 2022.
Climate change	Global climate variability due to natural and anthropic causes with effects on the world's ecology, agriculture feeding and health.	Jagustović *et al*., 2019; Zimmerer and Rojas, 2016; Argüellesa *et al*., 2018; Vastola *et al*., 2017; Käyhkö *et al*., 2020; Heckelman, 2019; Barzola, 2019.
Social-ecological resilience	The adaptive capacity of social-ecological systems to deal with external pressure, conserving their essential features.	Zimmerer and Rojas, 2016; Heckelman, 2019; López *et al.*, 2021; Barzola, 2019; Zimmerer *et al.*, 2022, Sarapura and Hoddy, 2022.
Transition	A shift from conventional agri-food systems to sustainable agri-food systems	Swagemakers *et al*., 2019, Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Argüellesa *et al*., 2018; Vastola *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Miralles *et al*., 2017; Hubeau *et al*., 2019; Sgroi, 2022; Vetter *et al*., 2019.
Reconnection	Integration of food producers and consumers through local markets. It includes the reconnection of agriculture and environment through agroecological practices.	Argüellesa *et al*., 2018; Bos and Owen, 2016; Zirham and Palomba, 2016. Kassis *et al.*, 2021

Sustainability and Rural Agri-Food Systems

In our review of scientific literature on rural agri-food systems, we detected that sustainability is a common and recurrent concern, for which we propose measures and practices for adaptation to climate change that can lead to fundamental transformations in socio-ecological systems (Käyhkö *et al*., 2020) (Table 1); for instance, in Sub-Saharan Africa, the expansion of a Climate-Smart Agriculture (CSA) has been proposed as a solution that integrates the social, economic and environmental dimensions of food

production. Its objective is to grant food security through a combination of a sustainable increase in productivity and income, the adaptation to climate change, and the reduction of greenhouse gases. This Integrated Landscape Approach includes climate-smart practices at the farm, town, and landscape levels, directed towards establishing sustainable SARs (Jagustović *et al*., 2019) (Table 2).

Phenomena such as the COVID-19 pandemic highlighted the need to create an agri-food system that supplies quality food at fair prices and highlighted the role of small producers in the supply chain and their vulnerability to global changes (Stojcheska *et al*., 2021). In Italy, according to Mastronardi *et al.,* (2022), the COVID-19 pandemic unleashed an economic slowdown affecting the food supply chain, farms opted for the diversification of their farms accompanied by support for competitiveness, improving logistics through e-commerce and the exchange of knowledge and innovations among farmers to face the crisis through resilient political strategies with agroecological principles that allowed the sustainability of the agri-food system during and after the pandemic. Similarly, in Central America and Mexico, according to López *et al.,* (2021), the COVID-19 crisis affected all types of agricultural systems of large, medium, and small producers with the implementation of restrictive measures on mobility, access to public places, and border closures by governments. Subsistence or self-consumption agricultural systems with little use of external inputs were less affected and had greater adaptability thanks to the incorporation of resilient mechanisms such as value chains and alternative distribution systems for food and agricultural products, the use of digital technologies to communicate and make viable agri-food systems and the diversification of livelihoods in rural households, transforming these systems towards greater resilience that enabled them to be sustainable in the face of the COVID-19 phenomenon (Zscheischler *et al.*, 2022).

Table 2. Sustainability and typologies of food production systems in SARs.

Agricultural production system	Definition	Community	Country	References
Agroecological practices or organic farming	They promote natural resources conservation and agrobiodiversity in order to sustain the essential ecological processes required for food production.	Indigenous groups, Farmers, African origin groups	Peru, Netherlands, Spain, Italy, New Zealand, France, Kenya, Philippines, Indonesia, Tanzania, Colombia. Italy	Vallejo *et al*., 2016, Iles and Montenegro, 2015; Swagemakers *et al*., 2019; Campbell *et al*., 2012; Oñederra *et al*., 2018; Argüellesa *et al*., 2018; Tedesco *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Vetter *et al*., 2019; Shilomboleni *et al*., 2019; Herrera *et al*., 2018; Padró *et al*., 2020; Sgroi, 2022; Mastronardi *et al*., 2022
Conservation agriculture	Food necessities are satisfied by applying *Good Agricultural Practices*, i.e., minimum tillage, use of crops diversity and organic fertilizers, as well as by preserving biodiversity, preventing soil degradation, and regenerating eroded areas.	Indigenous groups, Farmers, African origin groups	Italy, Kenya, France	Vastola *et al*., 2017; Pambo *et al*., 2018; Kassis *et al*., 2021
Monoculture	The production of a single species at a large scale.	Indigenous groups, Farmers,	Italy, Bolivia	Zimmerer and Rojas, 2016; Vastola *et al*., 2017;
Climate-Smart Agriculture	Sustainable food production through time, resilient to	African origin groups	Ghana, Uganda	Jagustović *et al*., 2019; Barzola, 2019.

Agricultural production system	Definition	Community	Country	References
	climate changes and focused on the reduction and absorption of greenhouse gases.			
Smallholders and family farming	Biodiverse, small-scale productions, essential for feeding global populations; this includes family farming. They sustain sociocultural, political, economic, and environmental relations, which affect the structure and functioning of the agri-food system.	Indigenous groups, Farmers, African origin groups	Peru, Ecuador, Colombia, Bolivia, Mexico, Netherlands, Spain, Belgium, Italy, France, England, New Zealand, Kenya, Philippines, Tanzania, Uganda, Indonesia, China, North of Macedonia, Australia.	Iles and Montenegro, 2015; Davies *et al.*, 2022); Chen *et al.*, 2022; Stojcheska *et al.*, 2021; López *et al.*, 2021;Swagemakers *et al*., 2019; Ababio-Twi, 2019; Vallejo *et al*., 2016; Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Jagustović *et al*., 2019; Campbell *et al*., 2012; Zimmerer and Rojas, 2016; Godoy *et al*., 2017; Oñederra *et al*., 2018; Tolentino and Del Valle, 2018; Argüellesa *et al*., 2018; Ochieng *et al*., 2017; Vastola *et al*., 2017; Tedesco *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Bos and Owen, 2016; Miralles *et al*., 2017; Enríquez *et al*., 2017; Wegerif and Hebinck, 2016; Viccaro *et al*., 2018; Zirham and Palomba, 2016; Barzola, 2019; Hubeau *et al*., 2019; Rosin *et al*., 2017; Larroa, 2012; Vetter *et al*., 2019; Herrera *et al*., 2018; Kilelu *et al*., 2017; Shilomboleni *et al*., 2019; Australian Centre for International Agricultural Research, 2019.
Community agriculture	Groups of people who share common features, territories, customs, gender, and worldviews, are involved in the production, distribution, and consumption processes of agricultural products, and share the same risks and benefits.	Indigenous groups, Farmers, African origin groups	Mexico, Kenya, England, Spain.	Tolentino and Del Valle, 2018; Ochieng *et al*., 2017; Bos and Owen, 2016; Miralles *et al*., 2017; Enríquez *et al*., 2017; Davies *et al*., 2022.
Artisanal foods	They are manufactured using traditional agricultural products produced at family farms or small rural enterprises, they have a limited output. They have an identity linked to their region of origin.	Indigenous groups, Farmers	Belgium, Bolivia, Spain, Mexico, Italy, Indonesia.	Bui *et al*., 2009; Zimmerer and Rojas, 2016; Oñederra *et al*., 2018; Tolentino and Del Valle, 2018; Enríquez *et al*., 2017; Viccaro *et al*., 2018; Larroa, 2012; Vetter *et al*., 2019;

According to Campbell *et al*., (2012) and Padró *et al*., (2020), agroecology and organic agriculture are both social practices that are contributing to a more sustainable agricultural production; they allow for a connection between social practices and ecologic results in relation with food production. According to

Sgroi (2022), a task for sustainable development consists in the preservation of healthy rural ecosystems in efficient balance between social development and the functioning of natural ecosystems.

Regarding this, Zimmerer and Rojas (2016), who worked in the Bolivian Andes, found that the agricultural biodiversity of smallholders provides an alternative to increase their capacity for social and ecological recovery, as well as the reduction of their vulnerability within a context of wide global changes. They state that the contribution of biodiversity groups is relevant as a resilience strategy to respond to the current climate change, considering that creating crop groups improves the effective use of the scarce and marginal local water resources.

On the other hand, Godoy *et al*., (2017) state that family farms have created their own organizations and have built a close relationship with other stakeholders, such as the agri-food sector, where smallholders not only communicate their economic interests, but also their interests on the management and efficient use of resources such as water; thus highlighting the social character of the agricultural system. Oñederra *et al*., (2018) refer to family farms as small, diverse groups that lead a non-certified organic production in Gipuzkoa (Basque Country, Spain) by using a multichannel marketing model, where consumer families purchase products in local food markets, attracted by the quality of fresh, seasonal produce, locally grown.

Other type of adaptation towards sustainability, as described by Tolentino and Del Valle (2018) takes place in San Pedro Capula (Mexico), where economic globalization has originated an oligopolistic dairy products' market, where production is highly concentrated in large national enterprises and globalized international companies, leading to the marginalization of smallholders and family farms. Nevertheless, they have created an association to produce artisanal *Oaxaca* type cheese, registered under the trademark *N'a r'ay'o Hyat. S'I* (which means new dawn in Nahuatl); this association sells their cheese at their own facilities or at a nearby market, where the quality of the product is well-known. These actions have helped them to increase production and have proven to be beneficial for communities by increasing the number of milk providers and improving the income of residents.

In a peri-urban area of Barcelona (Argüellesa *et al*., 2018), *Quality Food Schemes* (QFSs) have been studied, where products, or certain characteristics in the production of food at a small scale, are classified as a superior level, which allows smallholders to obtain higher prices for their products. These policies promote the transition to more sustainable SARs, from both the environmental and social perspectives. However, the authors of this study reveal that these systems still face administrative challenges for food producers that have not been yet resolved: despite the new marketing and commercialization opportunities offered by these schemes, QFSs do not represent a long-term solution for sustainable agriculture, since they require to create a new organization for food producers, and entail for them new taxes, schemes and regulations that support the dynamics of power and surveillance, and favor the urban setting over the rural one.

An organization based on cooperatives has demonstrated to be essential for the development of trade, the access to services and the allocation of subsidies, as well as the training of food producers and the promotion of innovation and environmentally friendly practices. These organizations are highly relevant for smallholders in developing countries, such as Kenya. According to Ochieng *et al*., (2017), due to the modernization of global SARs, smallholders in this country are being forced to enter in contract farming, with supermarkets using contracts to obtain fresh produce directly from their preferred suppliers. Few studies have focused on the preferences and limitations food producers have for contracting, an aspect of major importance to promote more viable and beneficial transactions for food producer associations.

Kassis *et al.*, (2021) point out the problem that exists in the loss of agricultural land in peri-urban areas of France, where at the same time the local demand for food grows, in view of this situation the authorities promote processes of agricultural land conservation and encourage local food production. In this sense Zimmerer *et al.*, (2022), state that accelerated intensification/de-intensification and urbanization are changing agricultural systems and consider the importance of understanding the socioecological connectivity of environmental resources, resource users, and governance to strengthen the resilience and improve the sustainability of agricultural systems from spatial approaches. Zollet and Maharjan (2021) mention a growing concern about the sustainability of agri-food systems and the simultaneous decline in the number of people engaged in agriculture in the Global North and draw attention to new farmers in non-agricultural settings interested in sustainable agriculture, who do not find support from conventional agricultural institutions. The authors refer to farmer-to-farmer networks, but these networks are usually quite dispersed in the territories, making their interaction difficult. However, environmental, and social factors can facilitate the creation of organic clusters that facilitate cooperation between these new farmers with sustainable practices.

Conservation agriculture (CA) is a model that satisfactorily combines feeding needs and the preservation of agricultural soil and biodiversity, through a set of good practices, such as minimum tillage. Comparative studies on the economic development of CA compared to conventional agriculture in southern Italy (Basilicata region) conducted by Vastola *et al*., (2017) showed that CA can be a viable alternative to conventional systems, since it increases the water supply of the agricultural zones in the Mediterranean region and improves yield, especially during dry seasons. However, the authors state that government support is necessary, as these practices will not be widely accepted and disseminated without financial incentives; therefore, policy makers in Europe should acknowledge the benefits of CA and retribute food production as a service with an ecosystem approach.

According to Tedesco *et al*., (2017) this type of agriculture is aligned with the concepts and methods described above on territorial ecology and metabolism, and the relation between production and consumption should be analyzed through SARs. In the case of the peri-urban zone of Saclay, near Paris, it is made up of five subsystems: grasslands, croplands, breeding activities, local population, and green waste processing.

Another trend, restoration agriculture, was described by Swagemakers *et al*., (2019); it is focused on improving biodiversity by aligning modifications in agricultural practices with environmental regulations, public and market policies. This system adjusts its production mechanisms to improve an individual social and ecologic context.

It is possible to affirm that entomophagy is aligned with CA. Pambo *et al*., (2018) consider entomophagy as a sustainable food system; they think that the consumption of insects as a food practice may constitute a strategy to conserve the environment. Insects require less food and water to produce edible mass than any type of livestock, they may promote the use of local resources, the preservation of traditional knowledge and the diversity among the communities who include insects in their diet. Breeding edible insects constitutes a convenient practice and an idea to satisfy, in a sustainable way, the growing demand for food; entomophagy has been part of the diet of indigenous communities ever since the beginnings of humanity and has been culturally accepted in many societies across Africa an America.

Heckelman (2019), states that in conventional agriculture, whose interventions are focused on increasing yield, innovation and agricultural knowledge are specialized and centralized, and technologies are commercially available for food producers. In this scheme, only chemical inputs and genetically modified crops are valued, and it is highly dependent on external investment and agribusinesses. An example of this system and its effects is the case of agro-industry in the Mediterranean, which has generated serious ecological and social impacts that threaten sustainability at local, regional, and global levels (Gil *et al.*, 2022). On the other hand, organic agriculture and agroecology constitute an alternative paradigm in which interventions are oriented towards SARs, agricultural knowledge and innovation are decentralized, and technologies and resources are locally managed and freely exchanged, prohibiting the use of chemical inputs, additives, and genetically modified crops. It is a paradigm oriented towards self-sufficiency for food producers and their communities. Agroecology refers to integrated production systems at a small scale that are focused on maintaining agrobiodiversity to sustain ecologic processes, maintain a dependency on traditional crop varieties locally adapted and promote breeding and conservation practices *in situ* among food producers.

Rural Agri-Food Systems and Agri-Food Networks

Within the topic of SARs, the concept of Agri-Food Networks (AFN) has been widely used across scientific literature (Table 3); for instance, case studies on AFN at England and Valencia, Spain, carried out by Bos and Owen (2016), and Miralles *et al*., (2017), respectively, define AFNs as simple types of initiatives for the local economy, developed at a small scale and with a limited use of information technologies. Regarding leadership, bureaucracy, shared resources, and partners participation, they are also considered to be localized supply chains that are shorter and more transparent and are supported by a notion of reconnection. They are a group of biological, social, and moral processes that help stakeholders in the agri-food production chain to participate in ethical and transparent systems where they have a better connection among them and to the environment they belong to. These authors state that AFNs have become an interesting proposal to tackle the pressure of large retail supermarkets, since they provide benefits and integrate both producers and consumers; they may also promote more sustainable behaviors, for instance, food producers' markets, community agriculture schemes and agricultural supply shops, where food products are marketed using social and spatial information that differentiates them from conventional agri-food systems. Similarly, some authors refer to circular supply chains, which are oriented towards the sustainability of local agri-food systems by bringing local producers and consumers closer through relationships of mutual trust based on food quality and safety (Anastasiadis *et al.*, 2022). (Table 3).

Table 3. Food distribution methods in SARs.

Distribution systems	Concept	Communities	Countries	References
Local markets	Rural smallholders periodically commercialize products within their local communities. They include short supply chains and direct sales. They help to reduce food costs and create a direct relationship between food producers and consumers.	Indigenous groups, Farmers, African origin groups	Peru, Ecuador, Colombia, Bolivia, Mexico, Spain, Belgium, Italy, France, England, Kenya, Philippines, Tanzania, Uganda, Indonesia, Australia, Germany, Greece.	Vallejo *et al*., 2016, Iles and Montenegro, 2015; Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Zimmerer and Rojas, 2016; Oñederra *et al*., 2018; Tolentino and Del Valle, 2018; Argüellesa *et al*., 2018; Ochieng *et al*., 2017; Tedesco *et al*., 2017; Pambo *et al*., 2018; Heckelman, 2019; Bos and Owen, 2016; Miralles *et al*., 2017; Enríquez *et al*., 2017; Wegerif and Hebinck, 2016; Viccaro *et al*., 2018; Zirham and Palomba, 2016; Barzola, 2019; Hubeau *et al*., 2019; Vetter *et al*., 2019; Kilelu *et al*., 2017; Shilomboleni *et al*., 2019; Australian Centre for International Agricultural Research, 2019; Anastasiadis *et al*., 2022; Martens *et al.*, 2022.
Supermarkets, Hipermarket and large shops	Large retail stores with a self-service scheme and large assortments of fresh, high quality food products.	Indigenous groups, Farmers, African origin groups	Belgium, Spain, Kenya, Indonesia, Australia, and Philippines.	Dedeurwaerdere *et al*., 2017; Bui *et al*., 2009; Oñederra *et al*., 2018; Ochieng *et al*., 2017; Pambo *et al*., 2018; Miralles *et al*., 2017; Vetter *et al*., 2019; Australian Centre for International Agricultural Research, 2019.
Alternative Agri-Food Networks (AFNs)	Sustainable food production, distribution and consumption alternatives, led by smallholders and local consumers, they include food producers' markets, family farms and community agriculture, as well as agricultural supply shops that market products using social and spatial identification information.	Indigenous groups, Farmers, African origin groups	Ecuador, Belgium, Bolivia, Spain, Mexico, England, Tanzania, New Zealand, Italy, Uganda, Indonesia	Vallejo *et al*., 2016; Dedeurwaerdere *et al*., 2017; Zimmerer and Rojas, 2016; Oñederra *et al*., 2018; Argüellesa *et al*., 2018; Bos and Owen, 2016; Miralles *et al*., 2017; Enríquez *et al*., 2017; Wegerif and Hebinck, 2016; Viccaro *et al*., 2018; Zirham and Palomba, 2016; Barzola, 2019; Hubeau *et al*., 2019; Rosin *et al*., 2017; Larroa, 2012; Vetter *et al*., 2019; Zollet and Maharjan, 2021, Zollet *et al*., 2021, Foti and Timpanaro, 2021
Cooperatives, Associations	Autonomous groups of small producers who voluntarily partner to satisfy common economic and social necessities.	Indigenous groups, Farmers, African origin groups	Ecuador, Peru, Netherlands, Spain, Italy, Ghana, Belgium, England, Mexico, Tanzania, Indonesia, Australia,	Vallejo *et al*., 2016; Bui *et al*., 2009; Swagemakers *et al*., 2019; Ababio-Twi, 2019; Godoy *et al*., 2017; Argüellesa *et al*., 2018; Bos and Owen, 2016; Miralles *et al*., 2017; Enríquez *et al*., 2017; Wegerif and Hebinck, 2016; Viccaro *et al*., 2018; Zirham and Palomba, 2016; Vetter *et al*., 2019; Herrera *et al*., 2018; Australian Centre for International Agricultural Research, 2019.

Distribution systems	Concept	Communities	Countries	References
			Philippines.	
Export	The transport of goods, products, or services from a producer country to an importer or consumer country.	Indigenous groups, Farmers, African origin groups	New Zealand, Kenia, Italy, France, Tanzania, Uganda, Indonesia, Australia, Philippines.	Campbell *et al*., 2012; Ochieng *et al*., 2017; Tedesco *et al*., 2017; Pambo *et al*., 2018; Vastola *et al*., 2017; Wegerif and Hebinck, 2016; Viccaro *et al*., 2018; Barzola, 2019; Larroa, 2012; Vetter *et al*., 2019; Australian Centre for International Agricultural Research, 2019.

Cooperation AFNs among cheese producers in Chiapas, Mexico, which have been studied by Enríquez *et al*., (2017) have shown that their tacit value is solidarity, which involves the joint manipulation of inputs (milk, curdling agents, salt, etc.), consolidated purchase processes and cheese sales. Additionally, the strong and frequent ties between families and compadres have helped in know-how conservation, as well as its transmission from generation to generation. Likewise, studies on AFNs conducted by Miralles *et al*., (2017) in urban and peri-urban zones of Valencia, Spain, confirm that the participants of these networks share heterogeneous resources across different steps of the incorporation process of production and consumption activities. Some AFNs concentrate resources exchanges only at specific steps of food value chains; but commercial community gardens show a wider range of exchange activities, since they share all types of resources, i.e., natural, human, physical, financial and social, opposed to consumer groups, which only share human and physical capital.

SARs, commonly integrated by smallholders, are crucial for feeding populations worldwide (Table 1). In Tanzania, according to Wegerif y Hebinck (2016), SARs are one of the main producers of food staples demanded nationwide, and almost half of this production is carried out by smallholders at six million families dedicated to food production, who possess an average of 1.3 ha of land each. According to Ochieng *et al*., (2017) smallholders are the main food suppliers of population centers in Africa, Asia, and Latin America. However, it is too expensive for food producers to deliver their produce to supermarkets, which additionally request an important premium for exit price, make late payments to smallholders and create uncertainty, due to their high rates in product rejection at supermarket procurement channels.

In order to reduce tensions between smallholders and supermarkets, short food supply chains have been created, which are integrated by a small number of brokers between food producers and consumers. In some cases, such as the peri-urban zone of Saclay, near Paris, which is dedicated to animal agriculture, consumers who live outside the territory travel and directly buy food products to local producers (Tedesco *et al*., 2017). According to Viccaro *et al*., (2018), these local agri-food products are also regarded as a form of cultural capital, in alignment with the endogenous growth theory; they are considered as potentially valuable resources for local growth, since they have the capacity to incorporate and add value to many local resources with the particular characteristics of a specific territory.

In recent years, short food supply chains have re-emerged, accompanied by hybrid models of cooperation involving actors and institutions in the urban-rural context of industrialized countries. These initiatives have led to a sustainable agri-food system transformation in response to the negative effects of the dominant agricultural system (Martens *et al*., 2022).

Zirham and Palomba (2016) state that short food supply chains may offer an opportunity to commercialize food products, since it is possible to reduce food costs and create a direct relationship between food producers and consumers. They can be considered a social innovation, one of the main components of rural and agricultural growth, as they promote economic development through social connections at a local level.

Barzola (2019) indicates that in Uganda's SARs, networks provide greater opportunities for smallholders to innovate in their products, processes, and markets, as compared with smallholders in other places.

In northern Belgium, AFNs were created by agents of short food supply chains as a strategy aimed at identifying shared transformation pathways and developing a strategic plan to start a transition towards agri-food sustainability and to end natural and human resources depletion. Most of or all the

members of the agri-food network share the same cultural characteristics (Hubeau *et al*., 2019).

Other authors, such as Rosin *et al*., (2017), based on their investigation of the kiwi and wine production sectors in New Zealand, and the development of an indigenous trademark for promoting sustainable practices, agree that some features of the development of new economic practices may work as material agents in the reorganization of economic activities and social networks. According to Oñederra *et al*., (2018), although some changes in SARs at Gipuzkoa province (Basque Country, Spain) have reduced their positioning in supply chains, food producer markets have slowly recovered their appeal as distribution channels within AFNs, which highly value *local purchasing* and/or the *quality* of food as variables that help in the creation of a mutual trust relation.

Agri-food producers have organized themselves in the Localized Agri-Food Systems (SIAL). Larroa (2012) refers to these systems, that have been established to provide a means for sustainable development in rural communities around the world. These systems included strategies aimed at raising the esteem for their territory and culture and motivating the appreciation of their own differences and their contribution to the global society. One of their marketing tactics was starting to promote products with an *appellation of origin*, whose features are closely related to the culture of the region they come from, this motivated consumers' appreciation and preference for this type of distinction over industrially manufactured food products.

Culture plays an important role in AFNs sustainability; Hubeau *et al*., (2019) state that although AFNs have become a frequent research topic in transition studies, the understanding of the role that culture plays in these systems could be improved. Based on a comparative study of eight cases in the Flandes region (Belgium), they concluded that those networks with the strongest cultural ties had the greatest probabilities to continue, while those with the weakest cultural ties had the smallest possibilities to survive. On the other hand, the intention of multiple agri-food networks is transforming SARs by reproducing this model, generating incremental rather than radical changes. They observed that the level of such changes was associated with cultural differences between AFNs and SARs.

Interestingly, the dynamics of local products in Belgian supermarkets was not triggered by an initiative of food producers, baseline movements or local authorities; according to Bui *et al.*, (2009), such activity was initiated by Carrefour, one of the main corporative retail markets in Europe, with the purpose of generating a more positive image over their growing competitors and facing the reduction of their market share. Contrary to Belgium, Vetter *et al*., (2019) observed that in Indonesia, the increasing number of supermarkets results in high-impact socio-environmental issues, in view of the extreme dependence on water for irrigation and the use of excessive agrochemicals to comply with quality requirements for food products. Additionally, despite the *supermarket revolution* and the unyielding resistance of traditional supermarkets, family horticulture has been increasingly impacted by the rise of imports coming from other developing countries, which include chili, plantain, and mango, affecting seriously their local production.

In view of the challenges that the agri-food sector faces nowadays, framed within the social and environmental problematics, a need for increasing the production of food without compromising environmental conservation and human health has arisen. This requires a shift from conventional to ecologic agriculture, and a change in the biodynamics within a context of a growing awareness of social responsibility and sustainability (Herrera *et al*., 2018).

In Italy, in the face of the crisis unleashed by the Covid-19 pandemic, according to Zollet *et al.*, 2021, the AFNs played an important role, where local agri-food systems based on agroecology were the ones that guaranteed the production, distribution, and consumption of food in the region of the city of Rome, as a solution to the inopportune action of the main actors and institutions of the global food system. A study conducted by Foti and Timpanaro (2021) on two farmers' markets in Sicily, has shown that they can represent an environmental, social, and governance reference model for modern agri-food systems facing reconstruction after the Covid-19 pandemic. In addition, these markets meet the expectations of consumers in terms of health, safety, and wholesomeness of agri-food products.

Gender and Rural Agri-Food Systems

It is interesting to note, after the review, that scientific literature systematically addresses the topic of gender (Table 1). In 17 of the 51 articles selected in the search, issues related to gender roles were examined, particularly the role of women within SARs' function and structure, according to Sarapura and Hoddy (2022), in order to achieve equitable resilience in these systems it is important to consider multiple social locations, relationships, and power structures where categories such as gender, age, and ethnicity may have an impact.

According to Vallejo *et al*., (2016) some families at the heart of indigenous communities in Ecuador show

a marked division of work between sexes, with a higher participation of men in agricultural activities. Zimmerer and Rojas (2016) mention that in the Bolivian Andes, most men have emigrated abroad, and women have been forced to combine agricultural labor and multiple activities for subsistence (e.g., corn beer or 'chicha' manufacturing and commercialization).

Jagustović *et al*., (2019) when discussing the role of gender in SARs, indicate that the lack of understanding of the complete dynamics of these systems, may lead to undesirable changes, such as the increase in workload for women. Kilelu *et al*., (2017) and Shilomboleni *et al*., (2019) who examined cases in Tanzania and Colombia, respectively, observed cultural gender violence in rural and indigenous communities, manifested in an extremely limited access for women to resources and participation in decision-taking at home and the community.

Gender inequalities have a negative impact on women's actions within the system; Kilelu *et al*., (2017) state that power inequalities influence women's participation in value chains. Kini (2022) states that women are not equally included in agri-food value chains as men, where women are involved in less lucrative informal activities.

Shilomboleni *et al*., (2019) suggest that, to change power structures, it is necessary to integrate an education on gender topics oriented towards empowering and justness as a complement in the implementation of production projects for the agricultural setting, often focused only on the transfer of food production technologies. Bos and Owen, 2016, have observed that contexts where women who participate in agricultural production projects have a higher level of education, also integrate a highly committed community, not only with regards to the access to healthy and high-quality food products, but also with regards to solving critical issues related to social inequalities and unjustness, which have a wide impact, especially in periods of scarcity.

Recent studies on the phenomenon of female undertakings by Zirham and Palomba (2016) focused on examining its dynamics, structural capacities and sustainability empowerment framed within the context of the fruits and vegetables' supply chain, have demonstrated that Italian agriculture is characterized by an increasingly higher presence of women in farms leadership and management, showing to be more capable to bring new life to the agricultural system, as they are more open to innovation and often have a better capacity to quickly adapt to changes and demands from the market and the territory. They state that women can respond consistently in terms of welfare, sustainability, and empowering as main strategic objectives, which may generate better practices, allowing for an increase in female undertakings and an improvement in their competitiveness, thus contributing to global welfare and sustainability. According to Eckman, 2019, most of the research groups and students in Philippines that started post-harvest projects were comprised in a 90% by women, and, more than a 50% of the participants in workshops were female; this situation increased women's empowerment, helping them to leverage their potential for improving their small mango enterprises.

CONCLUSIONS

We found in scientific literature some elements that reafirm the complex nature of agri-food systems in rural communities and in smallholder or family farming systems. They show that in food production systems, not only the production, distribution and consumption relations are relevant, but also other systemic relations of a sociocultural, political, and environmental nature, which influence the structure and function of systems.

In general, a special emphasis is made on production, distribution and consumption relations, as well as in the function of alternative food networks articulating smallholders and family farms' systems linked to local consumers as an economic and social strategy to overcome the pressures of large retail supermarkets and brokers through the management of food producers' local and community markets. Also, the literature mentions small food supply chains, community agriculture, and sustainable production systems involving more sustainable agri-food models, such as conservation agriculture, entomophagy, restoration agriculture, agroecology and schemes for producing high-quality food.

The topic of gender is an emerging category, observed as a recurrent subject in many of the texts analyzed. It refers to the levels of participation of women in agri-food systems, which have been shown to have restrictions and inequalities in terms of decision-taking and access to resources. The literature consulted also mentions the empowerment of women driven by training programs, which open for them more spaces for equitable participation within agri-food systems.

Finally, it is necessary to highlight the lack of scientific data on the structural and functional elements that characterize agri-food systems at indigenous and farmers rural communities, which may provide clear information to formulate sustainable agri-food system models for these communities.

Further scientific research on agri-food systems at indigenous communities is needed, which may focus on describing the high complexity of systems in terms of their structural and functional characteristics. Investigators should consider the problematics of food self-reliance within the context of ancestral territories dispossession. This has a great impact in the lives of indigenous communities, who are negatively affected by the external pressures generated by the plant and animal agriculture expansion and the proliferation of illicit crops, which are often promoted by armed groups who generate violence and the forced displacement of entire communities. These situations deteriorate indigenous agri-food systems and result in the erosion of their traditional sustainable agricultural knowledge and practices.

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