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Contribution of periurban farming systems to local food systems: a systemic innovation perspective

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Abstract. The debate on food security has highlighted the connection between periurban farming systems (PFS) and local food systems (LFS) for academic research. Several researchers have called for in-depth analysis of the participation and impact of farmers in LFS, and the systemic innovation perspective can provide relevant analysis of the sustainability of this agro-food system. The objective of the current study is to investigate the integration of PFS into LFS from the systemic innovation perspective, by analysing systemic failures and merits that hinder or promote the contribution of PFS to LFS for farmers and commercial actors. The case study is the LFS of the urban Pisa region in central Italy. Results show that farmers there are adapting to urban pressure, which improves the sustainability of their farming practices. At the same time, commercial actors have a commercial opportunity to include local farmers in their economic strategy. Nevertheless, individual initiatives must be coordinated to support the sustainability of both LFS and PFS. This study thus developed an innovative method to identify systemic failures and merits for farmers and commercial actors to address sustainability strategies at the territorial level.

Keywords: adaptation, urban sprawl, local food network, systemic failures, Italy.

1. INTRODUCTION

Agriculture currently faces several systemic challenges, such as volatility in commodity prices, climate change, obstacles in generational turnover, and increasing labour costs, all of which influence how agriculture produces food. The population growth expected in urban areas has raised serious concerns about the ability of agro-food systems to feed people in the near future (Fraser et al., 2005; Godfray and Garnett, 2014). According to the FAO (2010), periurban farming systems (PFS) throughout the world need to be involved directly in relocating food systems to respond to the new challenges of food security. Local food systems (LFS) thus appear central in addressing periurban farms' contribution to local food security, even in the Global North (Opitz et al., 2015).

The literature defines PFS in several ways: geographically, PFS are simply agriculture performed near urban areas (Filippini et al., 2018), while relationally, PFS are agriculture which has a functional relationship with an urban area (Nahmías and Le Caro, 2012). Several definitions lie between these two extremes. In this study, PFS are defined as farming systems near the main urban area of the case study, including territorial, production, social, and institutional factors.

LFS also appear as a systemic phenomenon, in which different actors at different territorial levels integrate themselves in a sustainable way (Kneafsey et al., 2013). Analysis of LFS is complicated by the lack of a single definition of LFS (Eriksen, 2013). In literature it has been defined as the emergence of high-quality and typical food (Arfini et al., 2019), social and organisational relationships among actors (Renting et al., 2003), a specific geographic area near consumers (Horst and Gaolach, 2015), or food supply that provides food to urban dwellers (Morgan, 2015; Wiskerke, 2009). This study defined a LFS as the food system by which periurban farmers can provide food to consumers of the periurban and urban area.

The systemic innovation (SI) perspective may help to identify innovation mechanisms in farming systems, since "systems approaches to innovation are essentially an attempt to think through and analyse the nature and implications of the collective character of innovation" (Edquist, 2002). Farms that follow this approach do not normally innovate in isolation, but in interaction with other organisations, which involves different sectors and different types of know-how, from production to consumption, from policy and institutions to firms and private agents, and from technical to social skills. Therefore, the SI perspective is relevant in this context. Some studies indicate that integrating PFS into LFS is a source of innovation in farming and food systems (Houdart et al., 2012; Paül and McKenzie, 2013). Other studies highlight the need for further analysis of the actors of these innovations, their relations, and the infrastructure in which they act (Bloom and Hinrichs, 2011; Filippini et al., 2016a, 2018; Venn et al., 2006; Watts et al., 2005).

From a farming system perspective, the literature has called for in-depth analysis of the participation of periurban farmers in LFS. Urban sprawl may influence farming practices and output (e.g. intensity, crop rotations) and thus farmers' ability to change or expand their local commercial strategies. According to the literature, understanding the PFS state "is a first step towards aligning agricultural and nutritional goals" (Morrison et al., 2011 p. 498) in the development of a more sustainable agro-food food system (Galli et al, 2020).

From a food-chain perspective, LFS studies have focused more on analysing individual initiatives than on adopting a systemic understanding of LFS at the territorial level (Bui et al., 2016; Lamine et al., 2019). Sonnino (2014) highlighted a lack of understanding of the "exchange nodes" in LFS networks, such as processors, wholesale markets, retailers, and others.

From a territorial perspective, LFS studies have not adequately captured the "inherent complexity of the place" (Duram and Oberholtzer, 2010). According to several researchers (Duram and Oberholtzer, 2010; Ilbery and Maye, 2006; Venn et al., 2006), LFS studies have focused mainly on relationships among actors who already participate in LFS, and less on the wider spatial and social dynamics of the place. This could be an obstacle for PFS studies, given the particular context in which periurban farmers work (Filippini et al, 2020).

The innovative process involved in integrating PFS and LFS thus requires further study to improve the sustainability of the innovation for both PFS and LFS. The aim of the study is to analyse the integration of PFS into LFS from an SI perspective, which identifies systemic merits and failures of the innovation for both systems. This is essential to develop scenarios of transition to new forms of sustainability for LFS and PFS. To our knowledge, this is the first time that SI has been applied at the territorial level to agro-food-system analysis. Adopting a systemic perspective of territorial innovation processes makes it possible to apply an interdisciplinary, multilevel, and multi-actor approach, which is necessary to respond to claims made in the literature.

The article is organised as follows. Section 2 explains the theoretical background of PFS adaptation and issues related to the connection with LFS. Section 3 describes the case study, the source of information and how SI was applied in the present study. Section 4 shows results of applying the SI perspective to periurban farmers' participation in LFS. Section 5 discusses insights of the study and the methodology in light of the current literature. Finally, the last section provides concluding remarks and offers ideas for future studies.

2. THEORETICAL BACKGROUND

2.1 Contribution of periurban farming systems to local food systems

PFS are characterized by specific environmental, economic, and social pressures (Tolron, 2001). In areas of urban sprawl, land-use change is rapid and results in agriculture competing for natural resources, such as water and land. Several land issues influence PFS crop-

ping systems, such as degradation of fertile land (EEA, 2006), fragmentation of agricultural areas, and the lack of access to land. Urban pressure increases the price of land, which results in land insecurity, for which the solution is shorter leases in anticipation of more profitable urbanisation, and in land abandonment and reforestation (Tolron, 2001). Several positive externalities of farming practices, such as flood control or ecosystem services, are limited, while negative externalities are exacerbated, such as production of noise or odours (Heimlich and Anderson, 2001). The agricultural economy and political representation become marginal in areas where agriculture's position traditionally predominated. New social conflicts result from the coexistence of different community interests and activities in the same area, and at the same time farmers face new expectations for farming systems and new and varied demands from the urban system (Darly and Torre, 2013; Heimlich and Barnard, 1992; Henderson, 2005).

In this situation, farming systems may adapt to a particular territorial context that is characterised by continuous change. The literature mentions adaptability as one of the attributes of sustainable farming systems (López-Ridaura et al., 2005). Adaptability is also identified as a main characteristic of PFS (Clark et al., 2007; Soulard et al., 2017; Tolron, 2001). Clark et al. (2007) described the "pattern of adaptation" of PFS as changes in the cropping system as well as on-farm diversification. Periurban farmers must adapt their cropping systems to spaces into which a complex urban environment encroaches. Adaptation requires changing the intensity of production, as well as increasing or decreasing certain types of production (Diaz-Ambrona and Maletta, 2014; Filippini et al., 2016b; Wortman and Lovell, 2013). All of this occurs in a context that includes an uncertain future threatened by climate change and land insecurity (Diaz-Ambrona and Maletta, 2014; Wortman and Lovell, 2013). On-farm diversification entails changing a farm's structure to an urban-oriented context to meet urban expectations and demands for food production and services, as well as to minimise conflicts with urban neighbours. This adaptation helps to maintain agriculture in periurban areas. Based on the literature, recognising the multi-functional character of PFS has promoted several agriculture services, such as the development of short food-supply chains and/or social and educational farming, as a way to maintain agriculture in periurban areas (Filippini et al., 2020; Zasada, 2011). By definition, PFS are adaptive farming systems which tend to be heterogeneous: different farming strategies are implemented, which reflects that agriculture has multiple responses to the demands of nearby urban areas (Soulard et al., 2017). Moreover, heterogeneity occurs within each PFS: empirical analysis has observed that farms tend to combine the commercial strategies of local and non-local food chains (Filippini et al., 2016a). In addition, farms may adapt their practices to urban pressure, but not their commercial strategies (Filippini et al., 2016a), especially when conventional markets are more convenient (Brunori et al., 2016; Touzard et al., 2016).

According to the literature, PFS should be more prone to participate in LFS, as proximity increases access to local urban markets and market niches (Jarosz, 2008), decreases transaction costs due to more direct social contact between producers and consumers, and decreases distribution and transportation costs (Holloway et al., 2007). More generally, periurban agriculture is perceived as an innovative context that promotes the development of LFS (RUAF, 2008). Participating in LFS is seen as a form of innovation and "smart agriculture" (Corsi et al., 2021) Empirical studies have shown that commercialisation is one of the few factors involved in adapting to urban pressure in French periurban areas (Houdart et al., 2012). However, few researchers temper the positive role of periurbanisation in the emergence and development of LFS. The locally grown high-quality food that consumers demand requires more labour and investment in diversification, which increases production costs, and requires more available land, which is hindered by the same process of periurbanisation (Jarosz, 2008). Paül and McKenzie (2013: 94) even argue that short food supply chains in periurban areas "are only possible if farmland preservation is guaranteed, and that the former does not come as a direct consequence of the latter". Farmers may experience issues when adapting to urban pressure and demands, such as discovering that adaptation is not attractive or that they do not adapt effectively. One potential response is to simply move their agricultural activities, given the income that selling periurban land guarantees, and stop farming in periurban areas (Pascucci, 2007). Thus, the adaptability of PFS to LFS should be not taken for granted.

Similarly, if farmers do not produce locally, the economic actors who contribute to the value chain, such as small butcheries, slaughterhouses, and groceries, may also face a crisis, which could decrease the sustainability of LFS (Filippini et al., 2020). To date, few studies have focused on the processors and commercial actors who interact with farmers in LFS. According to Bloom and Hinrichs (2011), studies underestimate the contribution of local actors in the traditional conventional value chain to the development of a reliable LFS. Their analysis criticised the frustration of urban retailers and distributors when making direct commercial agreements with farmers

who participate in LFS, even though the participation of these actors can help scale up the LFS and thus improve the local food economy, which is the ultimate purpose of the LFS movement. According to Sonnino (2014), a more effective connection between urban and rural areas in LFS requires understanding the role of distributors in the value chain, who connect farmers to consumers, as well as the role of coordination and governance of LFS.

2.2 Application of the systemic innovation perspective to the contribution of farming systems to LFS

According to Knickel et al. (2009), the gap between the need for change and farmers' willingness to adapt exists because innovation policies and research have applied a linear approach from innovators to farming and thus have failed to address the relevant issues in farming systems that influence sustainable innovation. Doing so requires a more systemic approach to innovation that extends beyond the farmer who applies the innovation, to involve many interrelated actors for whom innovation has a performative character: "supermarkets that introduce self-service tools for fruit and vegetables reconfigure the roles between consumers and retailers' personnel, and imply learning processes of all the involved actors. Retailers also play a key role in shaping production systems, as they are able to impose their standards on national production systems" (Knickel et al., 2009: 138). Researchers define the inclusive character of systemic approaches as a "co-evolutionary process", as it requires "combined technological, social, economic and institutional change" (Klerkx et al., 2012). In this approach, innovation is perceived as a process characterised by continuous feedback mechanisms and interactive relations among the actors within the framework of specific institutional rules. Consequently, innovation is an evolutionary process that always changes and adapts itself, and is not based on the concept of optimality (Edquist, 2002). Innovation implies a complex system of strategies, organisation, and hybrid networks that extends beyond the use of new technology or the definition of a new process (Knickel et al., 2009).

When applying a systemic perspective, those who research farming systems recommend a multi-actor, multi-level, and inter-/trans-disciplinary approach, due to its inclusive characteristics (Klerkx et al., 2012). Multi-level implies including different elements at the same scale, while multi-scale considers them at different scales (Cash et al., 2006). Inter-/trans-disciplinary is the progressive integration of different disciplines and sectors, such as academia and actor experts (Vandermeulen and Van Huylenbroeck, 2008).

In farming systems analysis, Lamprinopoulou et al. (2014) and Kebebe et al. (2015) applied a specific SI perspective that identifies SI structures and functions, based on contributions of Woolthuis et al. (2005), Wieczorek and Hekkert (2012), Edquist (2001), and Weber and Roharacher (2012). The objective was to evaluate the policies that sustain technological innovation to identify the specific failures that hinder innovation.

Wieczorek and Hekkert (2012) used an SI structural-functional analysis to determine SI structures and functions. SI structures are the elements that drive the innovation: actors, interactions, infrastructure, and institutions. The actors are the agents of the innovation, and the innovation process emerges from their interactions. They move in a particular infrastructure which includes physical (e.g. roads and territorial elements), financial, and knowledge infrastructures. The institutions are the written or unwritten rules which the actors should respect. SI functions are the processes that enable the innovation to perform well. Weber and Rohracher (2012) define systemic functions as the "basic 'activities' or key processes required for successful system growth and performance of the innovation system". Researchers have identified several types of functions, depending on the case study and purpose of the study: knowledge diffusion, market creation, network exchanges which function at the micro-level, reflexivity, directionality, and policy coordination at the macro-level to effect transformations (Lamprinopoulou et al., 2014). Analysis of systemic functions complements a structural focus as it is process-oriented: structures make functions meaningful and vice versa, which supports the concept that a structural element must always be changed for policies to enable or strengthen functions. According to Lamprinopoulou et al. (2014) "an integrated structural-functional analysis provides a much more comprehensive overview of the operation of systems and the determinants that shape innovation trajectories". In this framework, "systemic failures" – also called systemic problems or blocking mechanisms (Wieczorek and Hekkert, 2012) – are obstacles that hinder development of innovation. According to Lamprinopoulou et al. (2014), identifying failures helps to identify "systemic merits" and thus instances when SI functions are working well and driving effective innovation processes.

The literature has focused especially on mapping structures and functions and identifying systemic failures in order to provide policymakers with a list of measures to fix problems and highlight positive aspects of the system (Wieczorek and Hekkert, 2012). To date, this approach has rarely been applied to farming systems or the agricultural sector. For example, Kebebe et

al. (2015) applied structural-functional analysis to small dairy farmers and concluded that systemic failures in developing innovation were related mainly to missing actors, limited capacity of existing actors, inadequate infrastructure, limited interactions between actors, infrastructure failures related to property rights, and bureaucratic processes and corruption, which hinder the development of innovation among smallholders. Lamprinopoulou et al. (2014) developed a comprehensive structural-functional systemic framework of analysis to compare national agro-food systems in Europe and identified differences in actors' skills and in infrastructure, which identified policies to support the agricultural sector. Thus, analysing application of this framework to a specific case study should provide new insights into the approach and help to develop effective policies at the territorial level.

3. MATERIALS AND METHODS: HOW TO UNDERSTAND THE CONNECTION BETWEEN PERIURBAN FARMING SYSTEM AND LOCAL FOOD SYSTEM PFS AND LFS FROM AN SI PERSPECTIVE

3.1 Case study

The case study is the periurban region of Pisa, a medium-sized city of 86,000 inhabitants in Tuscany, central Italy (Fig. 1). The area consists of six municipalities that were associated until 2020 in the Area Pisana inter-municipality. The area includes the coastal plain of the Arno River and a hilly area known as Monte Pisano (917 m a.s.l.). Thus, it is geographically defined by the sea to the west and the hills and mountain to the north and north-east. The area includes a regional natural park that contains privately owned agricultural land. The area is also representative of urban sprawl: the population in

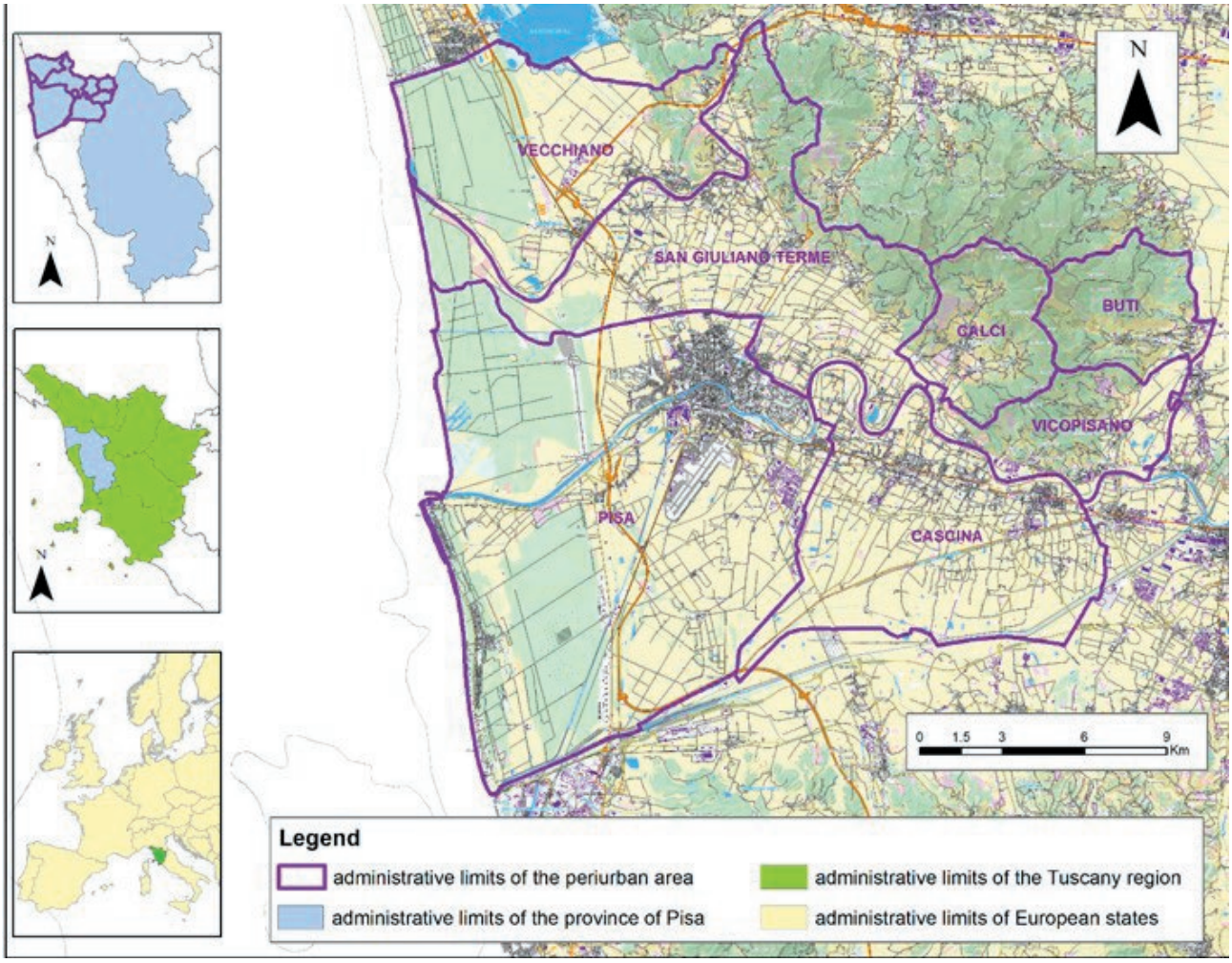

Figure 1. Case study: the periurban area of Pisa (Source: Filippini et al., 2020).

the main urban centre of Pisa has decreased since the 1980s but has increased in the nearby small towns. The geographic borders have created a unique social identity unlike those of nearby areas. Farming systems in the area seem to differ from others in the Province of Pisa: agriculture is not specialised or specific to one food chain, mixed farming systems still persist, and farmers rely on several types of commercial organisation (Filippini et al., 2016a). These characteristics have helped researchers consider different types of primary production. Previous research has shown that LFS management is one of the most challenging issues in the area, as acknowledged by farmers and institutional actors (Marraccini et al., 2013). Farming systems in the area have followed the main trend of Mediterranean agriculture: the number of farms decreased from 1990-2010 (-56%), especially for vegetables (-92%), while mean farm size increased slightly (Marraccini et al., 2012).

3.2 Interdisciplinary, multi-level, and multi-actor approach: selection and analysis of the sample

The method is based on an interdisciplinary, multi-actor, and multi-level approach (Vandermeulen and Van Huylenbroeck, 2008; Klerkx et al., 2012; Cash et al., 2006) (Fig. 2). The study is based on integrating multiple disciplines, especially agronomy, economics, and geography. As it is focused on understanding the integration of PFS into LFS, it is first based on analysing farms and farming systems, given the production and commercialisation conditions of farms in the periurban area. Then, the study analyses the relationships between the PFS and the rest of the local agro-food system (i.e. the LFS) by interviewing commercial actors. A multi-level approach is applied in the study, first by analysing farming systems and then by extending it to a more territorial basis, especially the value-chain actors in the LFS. Analysing relationships between PFS and LFS provides a multi-actor perspective that considered both farmers and the first buyers of local agricultural products, such as processors and retailers, as well as the intermediate actors who aim to help organise the LFS.

The analysis is based mainly on interviews with farmers and then with the LFS's first buyers in 2014-2015. As the analysis did not include perspectives from consumers or institutions, the overall LFS was not considered (Fig. 2). Farms were selected to represent the territorial farming system of the periurban area of Pisa as described in ISTAT (2010). Three criteria were used to select the farms: the main types of production, farm size, and the distance from the farmstead to the urban centre. The initial sample contained 58 farms oriented to types of production that represented the territorial farming system: extensive crops (65%), livestock (14%), vegetables (13%), and olive groves (8%). Farmers were contacted directly in order to conduct semi-structured face-to-face interviews in their farm's head office. Interviews focused on the farming territory, crop management, farm management, land-use intensity, commercialisation, the farmer's individual characteristics, the main type of production, and commercialisation constraints.

Based on these interviews, 19 commercial and intermediate actors were selected, the first buyers of farmers' products (e.g. processors, groceries, supermarkets, farmers' markets) and the intermediate actors who interacted with farmers. The processors included two cheese factories, one slaughterhouse, one butchery, three olive mills,

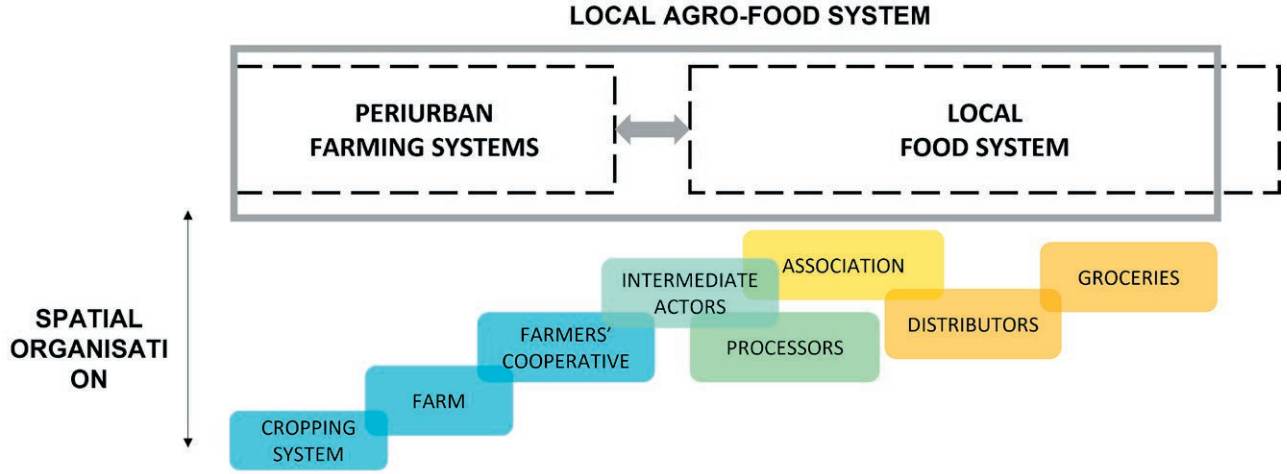

Figure 2. Multi-level and multi-actor approach: elements of the local agro-food system.

one wheat mill, and one general processor (mainly vegetables). The interviews also included three supermarkets, four groceries, and the coordinator of a farmers' market. One farmers' cooperative and a local livestock association were included as intermediate actors. Interviews with the commercial actors included questions about their practices, the importance of local farming systems for their income and stock of products, and limitations of and opportunities for interacting with local farming systems.

Previous studies have observed that only 26 of the 58 farms in the sample participated in the LFS: 19% of them sold all production to the LFS, 65% maintained hybrid commercialisation between those of the LFS and non-LFS, and 15% sold less than 10% of their products to the LFS (Filippini et al., 2016a). Qualitative textual analysis of the interviews was performed to compare the actors' viewpoints.

3.3 Application of the SI perspective

To define the contribution of PFS to LFS in the context of SI, SI structures and functions must be defined according to the literature. First, components of SI structure in the connection between PFS and LFS were identified: actors, interactions, infrastructure, and institutions (Table 1). The actors were the farmers and other actors, and their interactions took place in the LFS. The infrastructure was the periurban area, which was defined according to geography (i.e. physical proximity to the urban area) and relations and organisations (i.e. a common background of action for actors). Farmers were related because they shared the same production constraints. Farmers and commercial actors were related because they shared the same interest in developing a LFS based on proximal relationships. Political actors shared similar concerns as the other actors about territorial management and the creation of an urban food system. The institutions were the municipal, regional, and national rules which govern food production and the participation of farmers in the LFS.

Table 1. The structures of systemic innovation in this study.

Actors	Farmers, processors, supermarkets, groceries, intermediate actors
Interactions	Commercial relationships in local food systems
Infrastructure	Periurban area
Institutions	Municipal, regional, and national rules

SI functions are the dynamics that enabled innovation to perform well. Among the functions identified in the literature, the market, networks, directionality, and policy coordination were selected to be evaluated in this study. The literature provides several lists of systemic failures. Wieczorek and Hekkert (2012) developed a list of "systemic problems" related to the four structures as a function of their presence and quality/effectiveness. Lamprinopoulou et al. (2014) and Weber and Rohracher (2012) identified several failures in the literature and adapted them to the characteristics of their case studies. Based on the literature, a variety of systemic failures was thus chosen (Table 2). According to Lamprinopoulou et al. (2014), systemic merits are identified directly by identifying specific opportunities and qualities of the same categories of the structures and functions identified. In other words, identifying the failures makes it possible to identify merits. Thus, merits were also identified for each systemic failure.

Table 2. Description of the systemic failures selected from the literature.

Systemic Failure	Definition	References
Actor problems	Absence of actors and/or lack of skills	Wieczorek and Hekkert, (2012)
Institutional failures	Missing or malfunctioning of written or unwritten rules, which hinders innovation	Lamprinopoulou et al., (2014)
Infrastructural failures	Absence of physical, financial, and/or knowledge infrastructure	Lamprinopoulou et al., (2014); Wieczorek and Hekkert, (2012)
Interactions or network failures	Networks of actors are too dense; actors do not interact enough	Lamprinopoulou et al., (2014); Weber and Rohracher, (2012)
Market structure failures	Imperfections in the markets or monopolies; unbalanced market power; information asymmetries	Lamprinopoulou et al., (2014); Weber and Rohracher, (2012)
Directionality failures	Lack of shared vision, and inability for collective coordination of fragmented agents of change	Lamprinopoulou et al., (2014)
Policy coordination failures	Lack of consistency among policies at different institutional levels (national vs. local) and among different sectors	Lamprinopoulou et al., (2014)

4. RESULTS: A STRUCTURAL-FUNCTIONAL ANALYSIS TO UNDERSTAND SYSTEM INNOVATION

Based on the interviews, the farmers' and commercial actors' opinions on systemic failures and merits of their participation in the LFS were summarised (Table 3).

4.1 Actor problems/failures and merits

According to farmers, the blocking mechanisms of the systems were related to whether participation in LFS requires them to develop specific know-how, such as the ability to sell directly to consumers and other small businesses, while most farmers usually sold their products to cooperatives or wholesale markets. Some farmers indicated that another failure of integrating PFS into LFS was the need to address conflicts with urban residents who do not understand the daily work on farms, which produces noise, smell, etc. From the farmers' perspective, it seemed contradictory that consumers want local food but seem to have difficulty understanding how agriculture works.

Among the actors' merits, farmers considered that the presence of other people in the farm structure, who can help with sales or processing, was a driver for

Table 3. The most important systemic failures and merits of systemic structures and functions according to farmers and commercial actors in the periurban region of Pisa (Italy).

Systemic structure and function	According to	Failures/Problems/Blocking mechanism	Merits/Opportunities
Actor	Farmers	Need for specific know-how and manpower; conflicts with neighbours	Presence of family and structure
	Commercial actors	Not enough farmers; problems with the quality of the product: season, diversification, packaging; lack of awareness of local agriculture and farmers	Local food supply meets consumers' demands for local products
Institution	Farmers	Rules for diversifying the product; manpower; territorial management; lack of dialogue	
	Commercial actors	The same rules for small and large businesses	
Infrastructure	Farmers	Fragmentation of areas; production constraints; funding; knowledge	Proximity to urban consumers, proximity to crop storage
	Commercial actors		Greater potential to reach and contact farmers in order to control and trace production
Interactions, networks	Farmers	Individual efforts to participate in local food systems; no network among farmers	Multiple diversified networks that diversify the risk; flexibility in responding to commercial actors' demands
	Commercial actors	Strategy of contacting the same farmers already involved in other networks; short-term organisation	
Market structure	Farmers	Difficulty in being paid by small business; no markets for certain products	Market power; high demand for local food; paid immediately by final consumers; not always possible to predict and manage final consumers' demands
	Commercial actors	Information asymmetries; difficulties in negotiating the supply with farmers and with supermarkets for processors; consumer preferences for certain products change and do not reflect local traditional products	High demand for local food
Directionality	Farmers	Short-term participation in commercial actors' businesses; lack of shared and territorial vision	
	Commercial actors	Differing private visions that may compete with each other	Organising long-term food-chain projects to maintain shared visions
Policy coordination	Farmers	Different interpretations of rules among institutions	
	Commercial actors	No coordination of private initiatives; lack of policies that promote local products	

developing a LFS. The LFS was also considered a way to increase family income. In this case, the LFS was seen as a way to diversify farm income by processing the primary products and/or developing space to sell. Here, the farm family had great relevance: employing family members provides more flexibility in organising activities and costs less than hiring people. This was especially relevant when farmers perceived the LFS as a risky and unsure market.

According to processors, groceries, and supermarkets, the greatest system failure was the lack of local farms, but it has different meanings for each of them. According to groceries and supermarkets, few farmers from whom to purchase products were available. In particular, they expressed a lack of knowledge about new farmers who could be included in the LFS and an inability to contact farmers. During the interviews, some retailers even asked researchers to provide the names of farmers who could sell their products. Their usual strategy was to contact farmers who already participated in other LFS initiatives. Some of these retailers did not seem to know about characteristics of the farming systems in the area. They were surprised when researchers showed them data on the decrease in horticulture production, which they considered as a typical farming system in the area.

This was not the case for processors, who seemed familiar with local farming systems and their potential production, to the extent that they recognised the production capacity of each farmer. This was likely because such small-to-medium processors had worked in the area for a long time and had seen the farming system change, while some retailers were younger and less experienced. To processors, the lack of available local farms was due to the crisis of local farming and the decreased amount of agriculture, and thus primary production in the area, which influenced the economy.

Retailers, especially small businesses, highlighted the lack of diversified products offered, since most farmers provided the same seasonal fresh food, but few processed products. Processors of fresh vegetables complained about the difficulty in verifying the quality of products, as vegetables may arrive without being properly cleaned or packaged. Nevertheless, for both types of actors, the presence of local farms that participated in the LFS was a merit of the system. Consumers today increasingly want local food, and local farming systems are a source, which generates more business.

4.2 Institutional failures and merits

Institutional failures included the presence or absence of regulations that hinder the contribution of PFS to LFS. Most farmers experienced limitations related to regulations for processing primary products and the on-farm direct sale, including cheese from dairy production and jam and juices from fruits. According to farmers, the obstacles were related to meeting health regulations, as a large amount of money is necessary to convert the working environment. Several farmers mentioned the lack of rules adapted to small farming businesses. Other rules were related to the natural park in the production area: although it protects the use of land for agriculture, it also imposes strict environmental rules, which limits farm diversification. For example, to process sheep milk on the farm for direct sales, a farmer had to obtain permission from the local municipality, the local health authority, and the regional natural park, and each one imposed different and contrasting rules. The local health authority imposed strict health requirements for farm buildings according to European Union (EU) regulations, while the regional natural park, whose main interest is to preserve nature in the territory, had refused permission for several years because on-farm processing could impact the natural equilibrium of the area. Rules that influence diversification also influenced the involvement of seasonal workers. Regulatory constraints included a large amount of bureaucracy and the time required for such investments. Regulation failures for the small processors and retailers were related to the lack of regulations that are flexible and adapted to small businesses, because the same rules were applied to small and large businesses.

4.3 Infrastructure failures and merits

The infrastructure of the periurban area has both failures and merits for the contribution of PFS to LFS for farmers (Table 2). The infrastructure failures included both physical and knowledge failures. Physical infrastructure failures were related to urbanisation, which fragments the land and may influence crop rotations. Increased transportation costs and the use of infrastructure caused farmers to stop growing irrigated crops far from the farmstead. The presence of infrastructure and fragmented agricultural area influenced the ability to graze land and rotate the grazing due to the difficulty in moving animals. Knowledge failures were related in particular to information about financial opportunities that was fragmented among the many levels of institutions, from the region to the farmers' union that helps farmers to request funds from the EU. Another blocking mechanism was related to combining Common Agricultural Policy (CAP) funds and bank loans, for example to invest in innovation of the farm's structure and process-

es. The guarantee of obtaining CAP funds is not always sufficient for banks to loan money to farmers, which further slows the innovation process.

Among the merits, farming in a periurban area was one of the most important factors that allowed farmers to develop short food-supply chains. As stated in the interviews, the proximity to urban consumers drove innovation for several farmers, even those who sold less than 10% to the LFS. The innovation passed through the diversification of production and/or farming functions to sustain the farm economy. Despite the uncertainties, which prompted farmers to maintain global food chains, the proximity to the urban area encouraged farmers to try some initiatives for specific products that were easier to sell to the LFS. Proximity to an urban area also means proximity to crop storage for crops that are not sold locally. Crops are usually stored near urban or periurban areas, as these areas are better connected to regional and national roads.

Commercial actors also mentioned the merits of the infrastructure. For both processors and retailers, the proximity to farmers decreased transportation costs because the farmers were nearby, and because periurban farmers were usually better connected to roads than farmers in marginal rural areas. When farmers are closer and more reachable, it is easier to remain in contact with them and monitor their products for final consumers, which provides an advantage for marketing and thus income.

4.4 Interaction or Network failures and merits

The first network failure for farmers was that each farmer organised individual networks without coordinating his/her actions with other farmers or commercial actors. Farmers thus invested much individual effort in developing each network. Few farmers had established a farmers' network in the area. One farmer, in addition to processing grain and selling bakery products on the farm, opened a shop in the city to sell products from other periurban farmers. In the interview, he explicitly affirmed his intention to establish a famers' network initiative to promote the individual efforts of farmers. Farmers in the sample did not even mention other farmers' initiatives. Another farmer organised direct on-farm sales of vegetables with another farmer, who provided what he did not produce himself, and vice versa. This mutual exchange of goods diversified the products offered to consumers.

Conversely, a merit of this individual-based LFS network was that it enabled farmers to be more flexible in organising networks and adapting their commercial strategies to the variety of opportunities and demands of processors and commercial actors. For example, one dairy producer mainly in conventional food networks sold some of his milk to the local sheep milk processor when shortages of sheep milk occurred in winter. Another merit was that these individual networks allowed farms to diversify the economic risk of the LFS that they still perceived, as they can rely on several actors. From the viewpoint of commercial actors, especially retailers, however, this was a huge network failure. Since farmers were in contact with other commercial actors, they had less interest in investing in a relationship with a specific grocery and provided products only with short-term perspective. Moreover, the difficulty in including other farmers made the LFS a closed network.

4.5 Market structure failures and merits

One main market failure for farmers was that certain products, such as meat from dairy farming, fodder, other crops (e.g. winter wheat), and organic goat meat, had no local markets and needed to be marketed outside the local area. Farmers maintained conventional food chains for these products, but with less profit. Farmers also highlighted the difficulty in being paid by local commercial actors, especially restaurants, small groceries, and supermarkets. Providing local farm products to supermarkets seemed possible only when products were collected and organised by an intermediary actor. One unique LFS initiative identified in the case study sample was the "Carne Bovina di Pisa" a private meat label promoted by the local livestock producers' association, which is organised as a non-profit organisation by the local livestock association to add value to local livestock production. From the viewpoint of supermarkets, the intermediation by the association allows cows to be monitored and traced, and it organises the supply effectively. From the farmers' viewpoint, the association increases their bargaining power, which results in higher prices and guarantees that products are easier to sell in supermarkets.

Another market failure was the uncertainty some farmers expressed about the ability to sell all their products via direct on-farm sales and farmers' markets. This may have been due to the difficulty in predicting and managing expectations of final consumers, especially those who were not well known. For farms located further from urban centres, direct on-farm sales depend on the flow of people on roads, which may be less frequent. In these cases, farms maintain conventional food chains to sell the remaining products. Farmers stated that a major merit of the LFS was that final consumers paid

them immediately, unlike when they sold products to a cooperative or wholesale market that belonged to global food chains.

Market failures for commercial actors depended mainly on network failures, which cause market failures, as when few farms participate in multiple LFS, each one can provide only a small amount of product, or the frequency of production is highly irregular. Consequently, commercial actors, especially retailers, mentioned difficulty in negotiating contracts with farms. Thus, farmers in this case study seemed to have the market power in the LFS, deciding how much, when, and to whom to sell their products. This market power resulted from another market failure: information asymmetries between retailers and farmers (i.e. a lack of information about the farmers who can participate in LFS).

Another difficulty for small processors was organising supply to supermarkets. LFS products were usually distributed by the same processor who negotiated the supply to all supermarkets. Small processors were also concerned about consumers' expectations and preferences for a product; for example, fresh cheese was increasingly sought after, but it is not a typical product in the area. A high demand for local products was the main market merit for commercial actors. The certainty that consumers are sensitive to local food for its higher quality, traceability, lower environmental impacts, and ability to sustain the local economy was a strong driver for commercial actors to invest in LFS relationships. The PFS provided retailers and supermarkets with an advantage with consumers for developing new markets.

4.6 Directionality failures and merits

Directionality failures referred to the lack of a shared vision about the future of the local agro-food system.

Farmers recognized a lack of shared vision because they organised individual initiatives and because there was little recognition of their diversity and complementarity. There was also almost no recognition of the potential for sustainable and long-term integration with other food-chain actors. Farmers who sold products to groceries and supermarkets considered their participation in the LFS as temporary. Their objective was to be known by final consumers through retailers, restaurants, and other sellers to attract consumers to direct on-farm sales, which generate higher profits. Conversely, retailers tried to organise networks with local farmers to develop new markets for their own activities. Their directionality merit was that they envisioned a long-term economic strategy based on including local farmers who are invested in LFS opportunities as a long-term business strategy.

For processors, the slaughterhouse was an interesting example, as it had to interact with multiple actors (e.g. farmers, butchers, supermarkets) and their multiple strategies to manage their contracts and relationships. Consequently, the slaughterhouse actor interviewed perceived the slaughterhouse as a potential central node for coordinating individual initiatives, such as a territorial food-chain project. In this sense, an upstream example in the case study was "Campagna Amica", which is a national initiative that organises farmers' markets for members of the farmer's union. The local headquarters of the union decided to organise the market differently. The manager of the farmers' market allocated farmers among the markets in the area to regulate the products they supplied at the territorial level. This united the farmers in a single vision at the territorial level - the sustainability of local production - as farmers can sell only their own products. Similarly, the "Carne Bovina di Pisa" label united farmers, slaughterhouses, and supermarkets in a common vision of protecting local livestock production. Although these initiatives are initial attempts to promote individual efforts in a single vision, they include different shared visions which sometimes compete. In addition, the private nature of these initiatives drives the interests in specific directions, and sometimes lacks a systemic and territorial perspective.

4.7 Policy coordination failures and merits

For policy coordination, farmers mentioned public institutions which interpreted rules differently. The lack of dialogue among policy-makers resulted in rules that sometimes differed or overlapped, which indicated that policy-makers did not sufficiently address the innovations of farmers. There is a need for policy coordination and innovative public policies that can create a shared vision of the agro-food system. For example, several actors mentioned the lack of policies that promoted local products, such as farmers' markets or local labels which could highlight the specific connection between PFS and LFS. Public initiatives are needed in the area. For example, the province and the University of Pisa organised the "Piano del Cibo della provincia di Pisa", which aimed to encourage local dialogue to sustain LFS; however, the project ended when the local public administration changed. Other initiatives have been developed, but a gap remains for including local farmers.

5. DISCUSSION

The novelty of this study is the first application of the SI structural-functional approach to territorial analysis, especially for PFS that contribute to LFS. The study thus had an analytical objective: SI was used to envi-

sion innovation at the territorial level. The interviews with farmers and commercial actors identified relations between systemic failures and merits. By identifying factors that hinder development of innovation between PFS and LFS, it enabled actions, policies, and systemic measures to be identified that can solve the problems and highlight the positive drivers in the system (Wieczorek and Hekkert, 2012).

Results show that the systemic failures and merits expressed by periurban farmers and commercial actors are complementary, e.g. commercial actors' demands for diversified products and farmers' difficulty in investing in on-farm processing to diversify the supply. Thus, farmers and commercial actors have common visions of the potential future development of LFS, such as including processors to give farmers the opportunity to diversify the supply, specific policies that support group processing of farmers' products, and investing in new crops and products to diversify the local supply.

Actors seem to agree on the lack of merits of institutions, whose rules are perceived as just another cost. Actors also perceive a lack of policy coordination, especially when too many rules exist or seem to overlap, and require managing a large amount of bureaucracy. This is probably due to the lack of dialogue with public institutions, including local ones, which was indicated by previous analysis performed in the area (Lardon et al., 2016).

Actors seem to have different visions of periurbanisation, the infrastructure of this analysis. While commercial actors perceive periurbanisation as an opportunity, farmers perceive the obstacles involved in adapting cropping systems. For commercial actors, such as groceries, supermarkets and most processors, the farmers closer to the urban area are an opportunity as they are closer to their business activities and thus easily accessible. Including local farmers is also important for marketing strategies toward consumers. Nevertheless, commercial actors complain about the lack of regular supply because the same farmers are contacted for different LFS. In addition, as other studies in the area have shown, farmers do not always adapt to LFS: only 26 of the 58 farmers in the sample participated in LFS, and most of them maintained hybrid networks between conventional and alternative food chains (Filippini et al., 2016a). This study shows that farmers recognise the potential for commercialisation in LFS that periurbanisation provides, but they also recognise the impact of urban pressure on their farming practices.

Farmers' and commercial actors' differing perceptions and knowledge about the farming system must improve to develop innovation of the local agro-food system further. The farmers' adaptation to the new commercial opportunities of the nearby urban areas indicates that the process still needs to be improved for all actors in the LFS. Results of his study are consistent with those of other studies performed in the area. For example, Filippini et al. (2020) compared the viewpoints of livestock producers and supermarket managers when evaluating a food project based on the assumption that including all actors in the food chain is the only way to promote the sustainability of LFS. Sonnino (2014) suggested including all actors in the food chain to reinforce urban food security. Bloom and Hinrichs (2011) highlighted the difficulties of local buyers when interacting with local farmers. The present study provides a systematic review of the advantages and disadvantages that farmers and commercial actors encounter when they participate in LFS. The main outcome of the study is a consistent story of actors' viewpoints about the systemic functions and structures of LFS (e.g.. Lamprinopoulou et al., 2014). In this sense, it is interesting to observe how failures accumulate: grocers' lack of knowledge about the potential of PFS and lack of coordination at public and private levels causes network failures, which cause market failures. Moreover, the LFS appears to be a closed network for a few farmers who were not related to each other. This lack of connections makes it even more difficult for commercial actors to make profitable contact with farmers in LFS.

Although the results of this study are valid only for its case study, similar analysis in other areas could deepen and enrich the set of systemic failures and merits that influence system structures and functions. Among the actors usually connected to SI in the literature, the contribution of research to innovation was not considered (Lamprinopoulou et al., 2014), as the main purpose of the present study was to identify the phenomena accurately; likewise, policy-makers' contributions were not considered (Wieczorek and Hekkert, 2012). According to the literature, SI can help identify systemic measures that influence the functioning of the system innovation, especially to support policy design. Although identifying systemic measures lay beyond the objective of this study, it is possible to identify elements from this study which may improve innovation efforts due to the identification of systemic failures. In particular, it is recommended to pursue SI by coordinating individual initiatives; public institutions in particular should play a key role in developing a shared vision of PFS and LFS. There is potential for actions that coordinate all efforts in order to promote the innovation of PFS and LFS to new forms of sustainability. Doing so requires establishing a coordinated system of rules at the territorial level, along with coordinat-

ed activities that promote local food and LFS activities, to support the evolution to more sustainable LFS and PFS in the wider regional development (Sonnino, 2014). The potential of this coordination requires that research build on this analysis and integrate local and regional analysis, and the SI approach will help to integrate these levels (Klerkx et al., 2012). Future analysis should design better research projects that include policy-makers when applying a systemic policy framework (Wieczorek and Hekkert, 2012) to assess the SI of a particular area better. Finally, the use of educational tools is also recommended to provide a platform for learning and experimenting among actors (Lardon et al., 2016).

Regarding the multi-level approach, it may be complicated for researchers to leave the farm gate to address other actors and territorial processes. Comparing the data of actors, even those at the same level, may be problematic, as the data come from different sources. For example, data about food production and consumption or about farm and processor management may use different units of measure or have been obtained at different times. Research may also require scaling up from micro- to macro-analysis to create regional knowledge to influence regional development. This process may become complicated when qualitative and micro-level quantitative data obtained from actor interviews are combined with regional data. This may also occur when institutions with different objectives operate at different scales, are not used to working together, and thus generate data which are not always comparable. Nevertheless, leaving the farm gate is necessary to understand farms and the dynamics of their context better in order to improve innovation and sustainability. An interdisciplinary approach supports this perspective beyond sector-specific perspectives, which improves territorial and integrated analysis. Integrating economic, agronomic, and geographic perspectives requires dealing with different languages, concept definitions, priorities, and methods. It is not always easy to find a common basis for research, which makes the research complex and longer-term. Innovation is an evolutionary process, and fostering the sustainability of the agro-food system requires coordination between research and private and public actors. The benefits are related to using multiple skills toward a transversal purpose, recognising a variety of issues, and thus developing possible solutions.

6. CONCLUSION

In this study, SI identified systemic failures and merits, and outlined future development possibilities. Consequently, this study contributes to LFS and PFS literature by responding to claims from the literature. LFS is an innovation which may ensure adaptability and sustainable development for agriculture in periurban areas. In turn, adapting PFS involves differentiating the periurban farmers profit in LFS as an alternative model to global supply chains. LFS also represents a factor of sustainability for commercial actors who can respond to the increasing consumer demand for local and traceable high-quality food. Nevertheless, the connection between PFS and LFS needs to be reinforced further, and the SI perspective has helped to identify elements that hinder the long-term sustainability of the agro-food system. They include commercial actors' lack of knowledge about farming systems, individual initiatives of farmers that hinder more coordinated LFS, difficulties in adapting farming practices to urban pressure, a lack of dialogue with local public institutions, and a lack of coordination at the territorial level. By applying the SI perspective, this study is the first to describe the dialogue between farmers and commercial actors, which is the first step in outlining innovative systemic solutions.

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