

Review

Towards the Concept of Smart Municipality: Agribusiness Model Integrating Rural and Urban Areas for Organic Food Production: A Review

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Abstract: Smart cities leverage information and communication technologies to enhance urban life quality, essential in densely populated environments requiring comprehensive planning. A critical area in urban settings is food production and delivery, where effective management becomes vital. New technologies can assist, but require models that support innovative production and commercialization methods. This study proposes an integration model between family farming—producers of organic food—and urban areas—consumers of these products. The model focuses on the management of organic food production and delivery to meet urban demands, serving as a tool in the transformation of these areas into smart municipalities. Additionally, this study suggests an alternative certification method for organic food production within family farming. A systematic literature review was conducted using the Methodi Ordinatio methodology. Content analysis of the selected articles identified strategies cities can adopt to promote organic certification, emphasizing transparent governance, public food procurement policies, and participatory certification systems. The proposed model aims to reduce bureaucracy and improve family farmers' income, aligning with several Sustainable Development Goals: SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 15 (Life on Land), and SDG 17 (Partnerships for the Goals).

Keywords: smart cities; organic food production certification; SDG; family farming; sustainable development



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1. Introduction

In light of the continuous increase in population, changes in consumption habits, and the growing concentration of people in urban areas, it becomes increasingly urgent to transform cities into smarter and more sustainable environments [1,2]. This debate extends to rural areas, regions outside the urban perimeter that are now being studied to establish smart municipalities, a crucial step to guarantee more sustainable environments [3].

According to [4], the concept of smart city is generally based on principles of sustainable urban development, involving technological and non-technological aspects to improve

people's quality of life, but still lacks a well-established definition. According to [5], it is essential to organize society to support sustainable projects. Thus, smart cities can play an important role in promoting and adopting strategies aimed at sustainable development [4], with the Sustainable Development Goals (SDG) being the expression of the goals to be achieved by 2030 [6–8].

An important extension for cities is rural areas, which play a fundamental role in the production of food and raw materials, being important places to guarantee society's food security [9]. In this context, to maximize long-term economic, environmental, and social benefits, it is necessary to integrate cities and rural areas, focusing on strategies that promote sustainable development [10]. It is necessary to establish synergies between these environments, adapting technological and non-technological infrastructure to overcome the socioeconomic disparities of these locations [11–13].

An urban–rural cooperation model based on interdependence between various actors, shared innovation, and participatory governance focused on organic food production can be a response to these challenges. Investing in this type of organic food production is an intelligent strategy for cities to meet the growing demand for these products, promoting sustainability in the production chain [14,15].

From this perspective, the search for smart municipalities can boost sustainable production in rural areas, increasing the supply of organic products, strengthening the local economy through intelligent and social entrepreneurship [16,17]. This is because organic agriculture offers a more sustainable approach, significantly reducing greenhouse gas emissions through carbon sequestration, which are fundamental aspects for mitigating climate change and preserving biodiversity [18].

According to [3], municipalities that implement the smart city agenda expand their competitive advantage, attracting investments and generating new economic opportunities. This occurs as technologies advance and the boundaries between urban and rural become more fluid, shaping local economic dynamics, as well as the human and financial resources capable of promoting integrated solutions [11,19,20].

In this context, this study proposes a model to integrate rural and urban areas with a focus on organic food production. Additionally, this study proposes an alternative for certifying organic products at the municipal level.

Therefore, this article presents the following research objectives:

- (i) To investigate the mechanisms and strategies in the literature that can be used to enable municipalities to certify locally produced organic foods;
- (ii) To assess the opportunities and challenges involving different stakeholders, for instance farmers, consumers, civil society organizations, and government authorities, in the organic food certification at the municipal level; and
- (iii) To identify which sustainable development objectives can be achieved with the adoption of the model proposed in this paper.

As a result, it is expected that this study may help to guide the interaction between organic food producers and their customers, so that cities can promote an alternative certification process, which is within their participatory governance capabilities, extending the influence of management capabilities of smart cities beyond urban areas. Thus, as a final result, an increase in the production and consumption of organic food is expected, meeting the following sustainable development objectives: Sustainable Development Goals: SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 15 (Life on Land), and SDG 17 (Partnerships and Means of Implementation).

This work is structured into five sections, of which this one is the first. Section 2 presents the theoretical basis for the development of the research. Section 3 details the

methodological procedures used for the systematic literature review. Section 4 presents the results and discussion of the research. Finally, Section 5 ends the article with the research conclusions.

2. Theoretical Background

This section provides a theoretical approach to the themes of smart cities, rural areas, family farming, and organic food, aiming to understand the interconnections between the themes.

2.1. Smart Cities

It is estimated that 66% of the global population will reside in urban areas by 2050 [21]. There is growing and accelerated urbanization, demanding new ways of organizing cities, as well as sustainable and innovative public policies that meet growing urban needs [22]. The complexity of this challenge emphasizes the need for urban planning that is capable of meeting society's demands for fundamental resources, focusing on preserving the environment and promoting sustainable development [2].

The transition to a smart city is not just a matter of political will, but requires a set of well-designed policy initiatives [22]. These initiatives must be aimed at implementing principles and strategies that emphasize sustainability in the economic, social, and environmental dimensions, ensuring the long-term conservation of essential resources [23]. With advanced technologies, cities can efficiently integrate all urban sectors and advance sustainability [24,25]. According to [26], in several contexts, there is a more positive view of smart technologies, demonstrating that their use is an inescapable path.

Urban sustainability also depends on education and accessibility, with ICTs being fundamental to establishing a more efficient urban public administration [27,28]. Synergy between citizens, companies, and governments is crucial for sustainable development and effective participatory governance is fundamental to realizing the benefits of smart cities [29–31].

According to [32], the main approaches to defining a smart city are linked to how cities optimize their domains to achieve their objectives in favor of better results in urban services. Thus, smart cities must be evaluated globally so that it is possible to understand effective practices and address common challenges [33]. In general, the essential domains of smart cities include government, citizens, enterprises, and environment [24]. Smart cities facilitate citizen participation and enhance governance through technologies [30,34,35].

Therefore, while seeking to optimize urban management and promote a sustainable environment, smart cities face operational and social challenges due to the complexity of cities [36]. In this sense, smart cities can use collective knowledge, skills, and resources, involving many people in specific objectives to solve problems in a more efficient, innovative, and sustainable way [23,29,37,38]. In Section 2.2, smart municipality concepts are discussed, exploring how they can boost integration and sustainability between urban and rural areas.

2.2. Smart Municipality

Although the literature still lacks a common definition for smart municipalities that is widespread, the implementation of this concept in small municipalities and areas beyond urban areas is of great importance, having gained prominence in several studies [12,39]. Often, smart villages are seen as counterparts to smart cities [40]. Several studies have also examined the smart villages and rural areas approach, demonstrating the benefits of technological innovations in these areas, as well as the gains in the city governance process [12,41,42].

Hence, the concept of a smart municipality represents a modern and integrated approach to the urban management of cities that can use technologies that involve different areas and are capable of serving rural areas more efficiently [43]. Thus, a smart municipality is one capable of generating solutions to improve the efficiency of public services, promoting sustainability and quality of life for citizens [43]. According to [44], the key to the success of a smart municipality lies in collaboration between government, the private sector, and citizens, ensuring that technological innovations are applied in an inclusive and sustainable way.

This is corroborated by other authors who debate this subject, raising, for example, discussions about the integration of the concepts of smart cities and digital Earth, substantial opportunities for municipal administration that adopt a more holistic, efficient, and data-based approach to deal with contemporary urban life [43]. It is easily seen that the conceptual fusion between smart cities and smart municipalities not only improves urban areas, but also extends its benefits to rural areas, promoting balanced and sustainable development [3,43].

In this context, the adoption of technologies can result in significant and comprehensive development, crucial to improving several sectors, including education focused on environmental sustainability and health [45]. However, despite the potential benefits, there are challenges, such as inadequate IT infrastructure, resistance to technologies, and inequalities in digital transformation, which are significant barriers to smart cities serving rural areas and developing public policies for the countryside [46]. To mitigate these challenges, it is essential to strengthen interactions between urban and rural areas, promoting sustainable food production [47].

Collaboration between urban–rural actors, as well as the strategic use of information and communication technologies (ICTs), is essential for smart municipalities to be able to face the modern challenges of the interaction of such different environments [44]. In this way, it is clear that the municipality that implements the smart city agenda tends to amplify its competitive advantage over other municipalities, resulting in increased investment opportunities, as well as new economic opportunities [3].

One of the main concerns of governance must be the establishment and support of actions aimed at achieving sustainable development objectives, and one of the main concerns, especially in developing countries, is food production. In recent years, the search for organic foods has grown [48]. Therefore, Section 2.3 seeks to address these two relevant aspects of human settlements.

2.3. Sustainable Development Goals and Organic Food Production

By promoting sustainable agricultural practices and encouraging local organic food production, cities contribute to food security, public health, and environmental preservation. Thus, encouraging organic food production is one of the most efficient ways to achieve sustainability in agriculture, aligning with several Sustainable Development Goals (SDGs) established by the United Nations [6,49,50]. The SDGs related to the issue of food production and consumption are SDG 2, SDG 12, and SDG 13.

SDG 2—Zero Hunger and Sustainable Agriculture: aims to eradicate hunger, achieve food security, improve nutrition, and promote sustainable agricultural systems [51]. However, ref. [52] observes that small farmers lack support and incentives to comply with SDG 2. The authors of [53,54] emphasize the need for more effective public policies to promote sustainable agriculture. This aspect is corroborated by [55], which states that policies aimed at achieving SDG 2 must be structured with long-term strategies, addressing the challenges and actions necessary to eradicate hunger and ensure food security. In this sense, the production and consumption of organic products is a way to achieve this objective [56,57].

It is important to highlight that organic foods are cultivated without the use of synthetic pesticides and chemical fertilizers, promoting agricultural practices that respect biodiversity, soil health, and water quality [49,56,58]. This approach not only contributes to the production of healthier and safer foods but also reduces the environmental impacts associated with conventional agriculture [54,55,57].

Additionally, aligned with SDG 12—Sustainable Consumption and Production, organic food production systems aim to reduce waste and promote the efficient use of natural resources [54,59]. Organic farming generally adopts techniques such as crop rotation, composting, and integrated pest management, promoting a more sustainable management of natural resources [54,57,59].

Furthermore, SDG 13—Climate Action is positively impacted by organic production, as these systems tend to have a lower carbon footprint, contributing to mitigating climate change and enhancing the resilience of agricultural ecosystems to extreme weather events [50,60]. Therefore, investing in organic food production helps to achieve SDGs related to food security and environmental sustainability. Moreover, it promotes a more resilient and inclusive agricultural model, benefiting small farmers and rural communities around the world.

Complementing the aforementioned objectives, this work also encompasses SDG 17—Partnerships for the Goals. Its focus is to strengthen the means of implementation and revitalize the global partnership for sustainable development [61]. While its focus is on the international level, it is equally important to consider local partnerships in the pursuit of sustainable development. In this context, this study aims to establish partnerships between local organic family farmers, local governance through the municipality, and the buyers demanding organic products, configuring an important interaction for all involved.

Therefore, by adopting and promoting organic agricultural practices, we seek not only to improve people's health and well-being, but also to contribute to a more sustainable and fair future for all. Section 3 presents the methodological aspects of this study.

3. Material and Methods

This section is divided into two parts: Section 3.1 describes the procedures for the systematic literature review, Section 3.2 addresses technological support for content analysis, and describes the construction of the theoretical model for promoting the production of certified organic food through family farming in smart cities.

3.1. Systematic Literature Review

A literature review should focus on concepts and derive meaningful conclusions from the content of the articles [62]. For the systematic literature review of this research, the Methodi Ordinatio methodology was used [63–65]. The steps followed for the collection and selection of the portfolio works were as follows.

Steps 1, 2, 3, and 4: The intention of the research was to investigate the existence of a theoretical model for promoting the production of certified organic food through family farming in smart cities or municipalities. For this search, the search syntax described in Table 1 was used. The databases chosen were Science Direct, Scopus, and Web of Science, databases that presented a good number of articles related to the research topic. To this end, the following settings were defined in the databases:

- Science Direct: Search by title, abstract and keywords, selecting only articles and reviews, without time cutoff, and without using the Boolean operator (*) at the end of words where necessary;

- Scopus: Search by title, abstract, and keywords, selecting only articles and reviews, without temporal cutoff, using the Boolean operator (*) at the end of words where necessary;
- Web of Science: Search in all fields, selecting only articles and reviews, without temporal cutoff, using the Boolean operator (*) at the end of words where necessary.

Table 1. Search syntax and gross results.

	Keyword Combinations	Science Direct	Scopus	Web of Science	Gross Results
1	“Smart city” AND “organic food production” OR “family farming”	197	0	1195	1392
2	“Smart municipality” AND “organic food production” OR “family farming”	197	0	1195	1392
3	(“Smart city” AND “smart municipality”) AND “smart entrepreneurship” AND “community organization” OR “organic foods”	720	0	905	1625
4	(“Smart city” OR “smart municipality”) AND “smart entrepreneurship” AND “community organization” OR “organic foods”	720	0	905	1625
5	“Smart city” AND “participatory system”	0	4	1	5
	Total gross number			6.059	

Step 5: After the final search, the filtering processes for the articles were carried out. This procedure aims to eliminate duplicate works and those with themes outside the central context of this research. The criteria used for filtering the articles were: (i) eliminate duplicate articles; (ii) eliminate by document type; (iii) eliminate by content, through reading and analyzing the titles, abstracts, and keywords of the articles. The results obtained in this step are presented in Table 2.

Table 2. Results after filtering procedures.

Filtering Procedures	Number of Articles
Initial number of articles	6059
Eliminated due to duplication	(3244)
Eliminated due to document category	(398)
Eliminated due to content	(2155)
Final number of papers before applying RankIn	262

Step 6: From this point, the information from the articles was entered into the tool RankIn 2.0, which automatically collects the journal’s IF, generates a direct link to Google Scholar for each article to facilitate the collection of Ci, and finally, automatically fills in the publication year for each article.

Step 7: After obtaining the variables for all the articles in the portfolio, we applied the equation InOrdinatio 2.0 (1) [65] to obtain the articles ranked by scientific relevance.

$$\text{InOrdinatio 2.0} = \left\{ [\Delta * (\text{IF})] - \left[\lambda * \left(\frac{\text{ResearchYear} - \text{PubYear}}{\text{CitedHalfLife}} \right) \right] + \Omega * \left[\frac{\text{Ci}}{(\text{ResearchYear} + 1) - \text{PubYear}} \right] \right\} \quad (1)$$

Step 8: In total, 262 documents were ranked. Additionally, a cutoff was applied, analyzing documents with an InOrdinatio score greater than 100, meaning studies with higher relevance according to the InOrdinatio equation criteria. In the end, 170 documents remained for analysis and reading. The articles were located and downloaded in their entirety for reading.

Step 9: In this final step, all articles were analyzed. For content analysis, the MAXQDA software (version 24.2) was used to import and analyze the data, using the MAXdictio functionality for coding using a category dictionary. This allowed efficient scanning of keywords and auto-coding, which facilitated the analysis of thematic relationships, making readings more assertive. Regarding VOSviewer® (version 1.6.19), the analysis functions involved bibliographic coupling of documents and countries and the counting method used was full counting.

3.2. Construction of the Integrated Model for the Management of Production, Certification, and Distribution of Organic Food

After analyzing and processing the data, integrating factors highlighted in the literature, key information for the management model for the production, certification, and distribution of organic food in smart cities was identified. The proposed theoretical model was built based on PDCA (plan-do-check-act) [66–68].

This model was adapted to optimize management, planning, and integration between rural and urban areas, aiming to improve trust in organic products and governance. Furthermore, the analysis made it possible to associate the proposed actions with the Sustainable Development Goals. Therefore, the model aims to guarantee food quality through participatory certification systems specific to smart cities. In Section 4, the results and discussions are presented.

4. Results and Discussion

This section presents the results of the bibliometric analysis (Section 4.1), content analysis on organic food production (Section 4.2), and the proposed conceptual model to integrate rural areas and smart cities with a focus on organic food production (Section 4.3).

4.1. Bibliometric Analysis

The topic of this work is relevant to the vast majority of countries. The bibliographic coupling map by country (Figure 1) demonstrates the formation of several clusters, focusing on the connections between documents based on shared bibliographic references. This figure visualizes how research topics have been addressed in different regions.

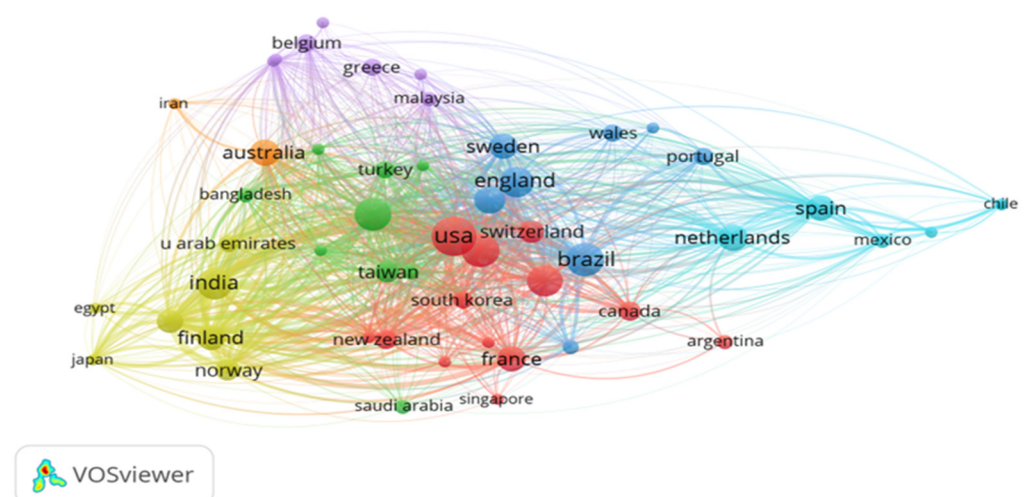


Figure 1. Bibliographic coupling map by country in 2024.

Examining Figure 1, the red cluster includes countries like the USA, France, Canada, and Argentina, representing strong bibliographic coupling. The USA stands out as a main center, influencing the research network. The light blue cluster includes Spain, Mexico,

Portugal, the Netherlands, and Chile, showing a shared thematic affinity. The dark blue cluster includes England, Sweden, Brazil, Portugal, and the Netherlands, indicating intense cooperation and shared references. The green cluster includes Taiwan, Turkey, and Saudi Arabia, pointing to collaboration between Asian and Middle Eastern nations. The yellow cluster involves India, Finland, and Norway, denoting relevant cooperation.

Finally, the purple cluster includes Belgium, Greece, and Malaysia, highlighting collaboration in specific topics or regions. High demographic countries like the USA lead in research on organic food production. Brazil, Germany, China, and India also focus on organic food production and sustainability. China and India prioritize food security due to their large populations.

4.2. Content Analysis of Organic Food Production

In the environment of organic food production, characteristics and aspects of the production and commercialization environment for organic foods were identified. These were organized into three axes. These axes present the descriptions, as well as their authors, and are detailed in Figure 2.

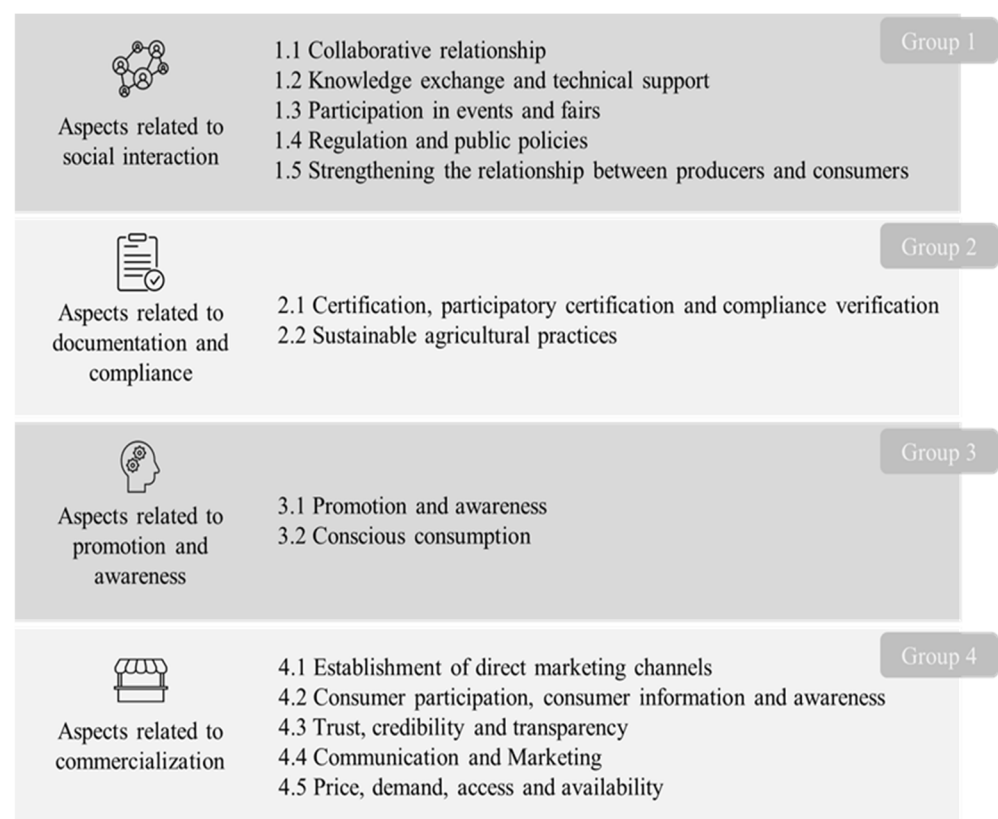


Figure 2. Characteristics and aspects of the organic food production and marketing environment.

Group 1.1—Collaborative relationship: The literature indicates that the interaction between organic food producers, organized in social control groups or participatory quality assurance systems, must be collaborative to optimize the organic food chain [15,69–72].

Group 1.2—Knowledge exchange and technical support: Sharing knowledge and experiences between producers and members of social control organizations and participatory guarantee systems promotes the continuous improvement of production practices [69,70,72].

Group 1.3—Participation in events and fairs: Consumers can interact directly with producers and members of social control organizations in participatory guarantee systems, participating in fairs and establishing direct connections with organic producers [69,73].

Group 1.4—Regulation and public policies: The literature points to the need to establish regulations and public policies for the organic food production chain [14,74–80].

Group 1.5—Strengthening the relationship between producers and consumers: Strengthen the relationship between organic producers and consumers, through interaction and dissemination of information about organic production, promoting trust and transparency [14,71,81].

Group 2.1—Certification, participatory certification and compliance verification: Social control organizations and/or participatory guarantee systems act as control and certification systems, involving community members in verifying and monitoring organic production [15,69,70,72].

Group 2.2—Sustainable agricultural practices: Implementing sustainable agricultural practices is fundamental in the organic production process [14,71,82–86].

Group 3.1—Promotion and awareness: Address promotion and awareness as significant strategies to increase the acceptance and consumption of organic foods [87–91].

Group 3.2—Conscious consumption: The interaction between organic producers and consumers aims to promote conscious consumption, informing and educating buyers about the benefits of organic food [92–111].

Group 4.1—Establishment of direct marketing channels: Social control organizations establish direct sales channels between producers and consumers, strengthening the relationship between them [14,69,71,73].

Group 4.2—Consumer participation, consumer information and awareness: Consumers play an active role in the organic food production interaction environment, providing feedback on the quality of purchased food, helping to continually improve production and quality assurance [87,111–114].

Group 4.3—Trust, credibility and transparency: The interaction between organic producers and consumers is based on trust, transparency, and active mutual participation [103,115–119].

Group 4.4—Communication and marketing: The literature demonstrates that effective communication and marketing strategies can influence the interaction between producers and consumers [87,111,120–122].

Group 4.5—Price, demand, access and availability: Organic food prices influence the interaction between producers and consumers. Despite consumers' willingness to pay a premium for these foods, affordability remains a challenge. Establishing competitive prices and providing subsidy programs or financial incentives can facilitate the purchase of organic foods [14,90,92,93,108,111,112,115,120,123–125].

Regarding the characteristics, factors, and aspects of the environment of organic food production and commercialization, from the perspective of social interaction aspects, collaborative relationships are essential for sustainability and trust in organic food production. Actors such as farmers, universities, suppliers, traders, consumers, and local authorities need to work together and have effective communication for food security (references from Group 1.1).

The exchange of knowledge and technical support is essential in promoting organic food production and ensuring food security. This is achieved through events, groups, guarantee systems, and accreditation that involve multiple stakeholders. These aspects strengthen the relationship between producers and consumers, establishing trust and transparency in organic food production (Group references 1.2 and 1.3).

On the other hand, regulations and public incentive policies play an important role in the organic food production chain, especially public food procurement policies. In many countries, these policies are responsible for generating demand for organic foods

(references from Group 1.4), and how organic certification occurs, or how regulations are established, can vary between countries [75].

References from Group 2.1 suggest that traditional certification processes are considered bureaucratic and expensive, creating significant barriers for small producers and limiting the availability of organic foods. Less bureaucratic systems, such as social control organizations and participatory guarantee systems, rely on constant interaction among actors in the organic production chain. These systems can promote sustainable agriculture and strengthening of the relationship between producers and consumers [69,70,72].

These certification systems are cheaper and more democratic, enabling small producers without resources for traditional certification to access markets [69]. However, the authors also acknowledge challenges, such as limited resources and potential conflicts between certification rigor and member participation.

Conversely, regulations can prioritize participatory organic certification systems, promoting more intense interaction among these actors and understanding the motivations of consumers who choose organic foods (references from Groups 1.4, 1.5, and 2.1). In this production mode, social media plays an important role, being capable of enhancing transparency about organic production practices and influencing consumers' purchasing decisions [71].

In this way, compliance is achieved when producers adopt sustainable practices by following a series of rules for organic food production. These practices should be highlighted to promote societal engagement, clearly informing how production occurs and the benefits of organic foods (references from Group 2.2). The studies demonstrate the importance of the relationship between consumers and producers, as well as the need to exchange information about the organic production process.

When considering aspects related to marketing, consumer awareness is a widely discussed topic. Under this bias, studies demonstrate that consumers need information and transparency to increase trust and awareness about these foods (references from Groups 3.1 and 3.2). The studies in Group 3.2 also address that conscious consumption can be discussed from the perspective of what consumers are consuming, a factor linked to the reliability of production, and the benefits that organic products bring to health, as well as the positive impacts generated on the environment.

These characteristics need to be disseminated effectively. Communication and marketing improve the perception of value in the organic production chain, influencing consumer interaction (references from Group 4.4). Therefore, information about the positive aspects of consuming organic products and their benefits for sustainability is essential for marketing campaigns [87,94,120]. The studies in Group 4.4 discuss strategies to promote organic products, raising awareness about health, food security, sustainability, and the socio-economic benefits of this form of food production. Additionally, studies highlight the need for identification and labeling seals for organic products, which effectively communicate the production and certification process [87,119,122].

In general, studies indicate that consumers identify the availability and accessibility of organic products as inadequate; that is, consumers have difficulty finding such products (Group 4.5). However, a portion of consumers are in favor of paying a premium for organic products, as they recognize the value perceived in these products [111]. Despite higher prices, demand for organic food is increasing, driven by concerns about health, food safety, environmental concerns, and sustainability [14].

Studies show that information about organic agriculture has a significant impact on consumers, considerably affecting demand from buyers concerned about having less impact on the environment [87,88,94,118]. Certification and accreditation systems have evolved, but they still lack standardization, harmonization, democratization, and coordination

between actors [15,69,111]. Therefore, effective management of the organic production process to reach the final consumer is seen to promote sustainability [115,117].

Finally, the findings in the literature allow for the identification of the main factors that can impact the interaction process between organic food producers, consumers, the public sector, and other stakeholders. Among these factors are:

- Level of awareness and knowledge about organic foods and their benefits [96–109].
- Price, accessibility, and availability of organic foods can affect demand [14,48,90,108,112,125].
- Trust, credibility, and transparency [103,116–119,126].
- Regulations and public policies [71,76,78–81,90,91].
- Partnerships and collaboration [15,69–72].
- Main barriers identified [48,84,88,95].

In a more didactic way, Figure 3 presents the main factors that can impact the interaction process between organic producers, consumers, the public sector, and other stakeholders.

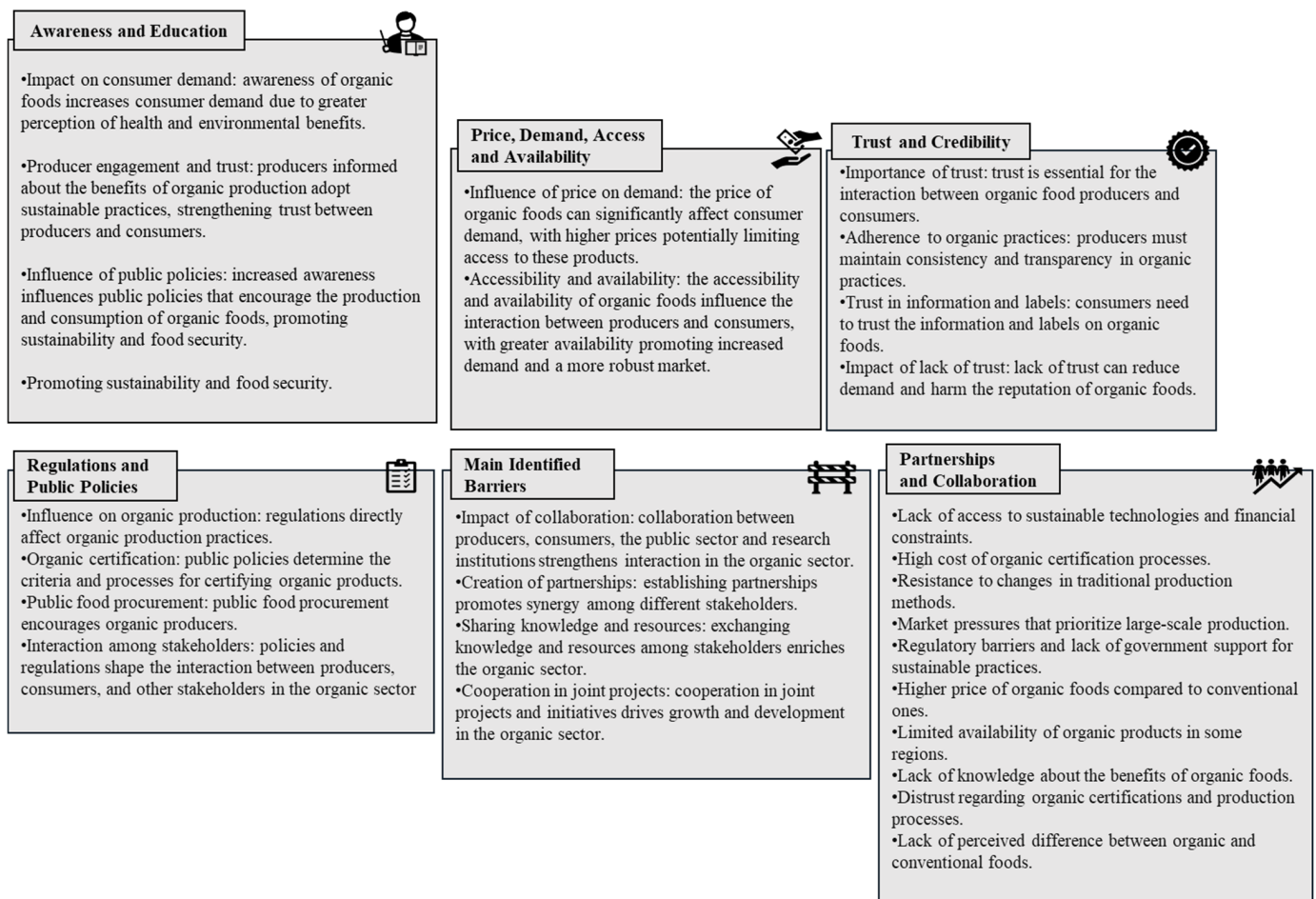


Figure 3. Main factors that can impact the interaction process between organic producers, consumers, the public sector, and other stakeholders.

The collaboration aspects are presented, as well as an action plan that addresses how smart cities can adapt to involve agents working in organic food production, is shown in Figure 4.

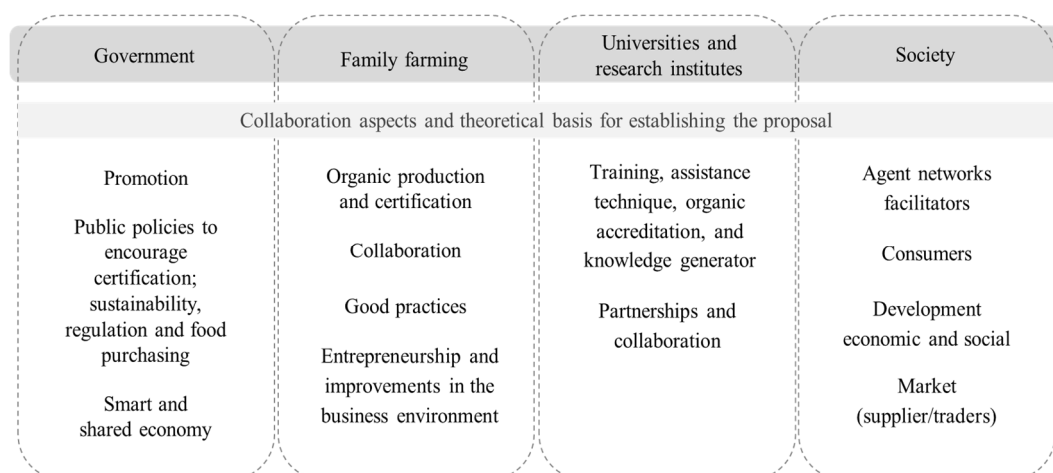


Figure 4. Actors and collaboration aspects and theoretical basis for establishing the proposal.

Figure 4 presents the actors and aspects and theoretical basis for establishing the proposal. Based on this organization, the question arises as to what and how smart cities can contribute in this scenario to achieve SDGs 2, 8, 11, 13, 15 and 17. Thus, the following actions are proposed.

Promotion: Develop participatory organic certification systems, as well as establish local organic certification networks, seeking sustainability and ecological citizenship [15,69,86]. Create a unique seal or label for municipal organic products [87,119]. Facilitate information exchange and encourage collaboration among farmers, distributors, and retailers to share information, promoting sustainability [87]. Encourage a more democratic and participatory approach to ensure that people's rights to adequate food are protected [15,69]. Promote the consumption of organic foods and identify the factors that influence consumer behavior and purchase intention [81,88,90,92].

Public policies to encourage certification, sustainability, regulation, and food purchasing: Provide technical assistance and rural extension [91]. Define organic standards and regulations and carry out periodic assessments [76,97,98]. Support the transition from traditional production methods to more sustainable methods [84]. Establish policies for public purchases of organic foods and encourage consumption [14,74,75,92]. Implement public policies to encourage and include small producers in cooperation networks, focusing on partnerships between producers and marketing establishments [14,74].

Smart and shared economy: Promote smart and shared economy in the organic supply chain [127]. Encourage the circular economy [85]. Encourage sustainable production chains and the local economy [14,84].

Organic production and certification: [72,128] seek organic certification. Ref. [128] investigate the significant influence of quality certifications on consumers' food choices. Refs. [15,69,72] participate in participatory certification systems. Ref. [83] contribute to analyze society's food security. Ref. [15] address limitations and challenges in authenticating organic products.

Collaboration: Highlight the importance of alternative food networks as a bridge between urban and rural areas [69]. Facilitate the establishment of collaborations between the different actors in organic food chains, promoting the creation of collaborative work groups and shared economy [127]. Strengthen the collective action of agricultural communities, cooperation and solidarity networks, promoting collective actions to guarantee access to food [127].

Good practices: Encourage sustainable family and organic farming practices [82,83,86]. Establish trust and credibility with consumers while maintaining transparency of the organic production process [115–119,126].

Entrepreneurship and improvements in the business environment: Exploit the growing demand for organic foods [14]. Form cooperatives and associations of healthy food producers, focusing on traceability [70]. Explore programs to strengthen family farming and public policies for the sector [74,80]. Increase the income and financial performance of organic producers [74].

Training, assistance techniques, organic accreditation, and knowledge generation: Train family farmers in organic practices [14]. Disseminate knowledge about sustainable products and practices through rural extension [91]. Monitor and control organic production; technical support for family farming [74].

Partnerships and collaboration: Establish partnerships and collaboration between farmers and companies in the organic sector and universities [127].

Agent network facilitators: Engage key actors and cooperation networks to support small organic food producers, involving the business sector [69]. Facilitate the exchange of information and awareness about organic food consumption [113,114,125,129]. Promote trust and transparency in the certification process [115,118]. Potential of technologies and applications to promote sustainable agriculture [105]. Assess the safety of organic foods in relation to conventional foods [82].

Consumers: Understanding the motivations of consumers of organic products [92–102,105,106,108–110,114,116,120,124,129,130]. Consumers tend to prefer foods certified by independent organizations [104]. Improve trust, credibility, and transparency of organic foods, aiming for conscious consumption [118,119]. Participate and interact with the participatory certification process, improving the exchange of information and awareness about organic food consumption [15,69,70,72].

Developing economic and social policies: Ensure affordable prices and improve the availability of organic food [14,48]. Consume organic food to improve producers' income [75].

Market (supplier/traders): Marketing strategies to promote organic foods [94,120,123]. Express personal values and beliefs regarding the environment, health, and social justice [87,121,122].

Figure 4 presents the main actions that smart cities can adopt to encourage organic food production, involving government, family farmers, universities/research institutes, society, and the market. Each of these agents plays an essential role in promoting sustainability and food security, with a focus on participatory governance of organic production.

The promotion of public policies, a smart and shared economy, family farming, education and research, societal engagement, and market strengthening are essential to achieving sustainable development goals. Therefore, all the actions presented allow us to understand the activities to be developed by smart cities that wish to increase the supply of organic food, achieving sustainability and food security.

In Section 4.3, the conceptual framework is presented with the proposed model to integrate rural and urban areas with a focus on the production, certification, and distribution of organic food.

4.3. Proposal for a Model to Integrate Rural and Urban Areas with a Focus on the Production, Certification, and Distribution of Organic Foods

Following the collaboration matrix, a preliminary conceptual framework was developed. As a draft, Figure 5 provides a synthesis of the framework for interaction among government, universities/research institutes, society, and organic producers, outlining the conceptual architecture designed to represent and support this research project.

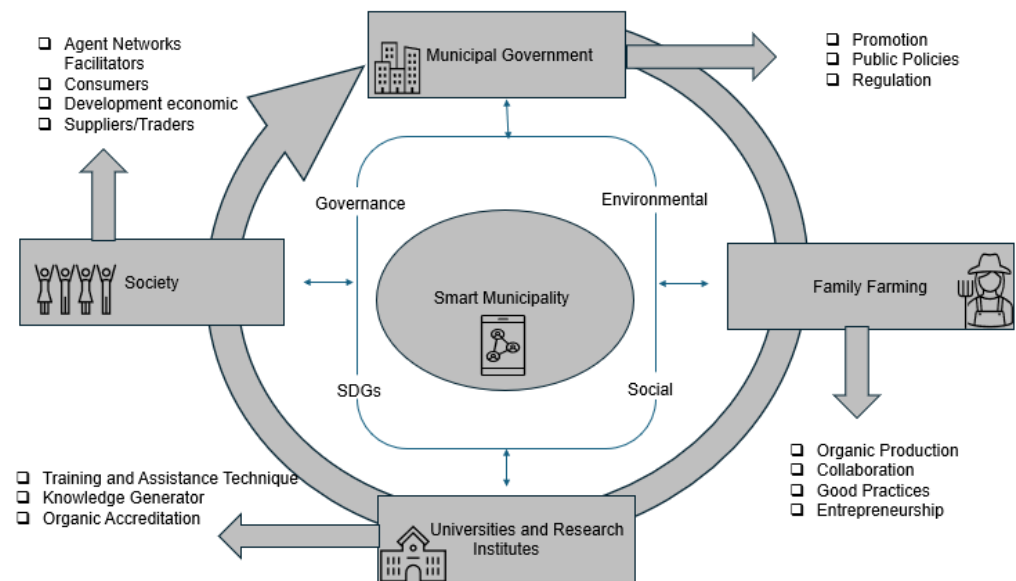


Figure 5. Model for integrating rural and urban areas with a focus on production, certification, and distribution.

Based on the aspects identified in the literature, Figure 5 describes the relationships that are established between the actors, involving public policies in cities, family farmers, universities/research institutes, and society. The idea is that the municipality is the agent responsible for the accreditation and organic compliance process.

- **Municipal governments:** As the political entity closest to food producers, municipalities are paramount in the proposed model. Consequently, the responsibility for the certification process and issuing of organic production compliance declarations falls to the cities. This shift aims to reduce certification wait times and encourage short supply chains. Municipal management should develop public policies that promote and support organic production, including laws and regulations allowing smart cities to issue organic compliance certificates. Additionally, investment should be made in public food procurement policies for schools, hospitals, and other public sectors [14,71,74–80,86,90–92,97];
- **Family farmers:** Encouraged by the municipality, family farmers should organize collectively, forming participatory systems or social control organizations (SCOs), and formalize these with the municipal agriculture department. This form of organic production organization is more democratic and less bureaucratic. Farmers play a crucial role in mutual inspection and can identify properties interested in converting from traditional to organic production [14,15,69–72,74,80,83–86,128];
- **Universities and research institutes:** Universities play a role in supporting the certification process by integrating academic and scientific knowledge to inform organic certification criteria. They can also develop training programs and strategic partnerships to provide technical assistance and monitor organic production through academic extension services [82,84,91];
- **Society:** Society includes consumers, suppliers, traders, and intermediaries who are directly or indirectly involved in the production or commercialization of organic food. They can act through networks that facilitate collaborative interaction, a necessary aspect of participatory organic production systems, and help monitor the process [71,103–105,107–110,114,119,129];
- **Governance:** The literature is clear on the need for governance of the certification process to ensure it is transparent and reliable. Transparency is integral to governance

and trust in organic production, demonstrating the commitment of producers and other stakeholders to providing clear and accurate information about their agricultural practices, as well as their environmental and social impacts. Governance also involves ethical and integrity aspects. Certified producers must adhere to strict and responsible standards, avoiding fraudulent practices. These standards can be verified by actors involved in the accreditation and certification processes managed by cities [105,117–119,126];

- Social: Engagement with the local community and encouragement of organic production can increase farmers' income. Moreover, this type of production can contribute to the social and sustainable development of communities, promoting social inclusion [74,75];
- Environmental: Organic certification promotes ecologically sustainable agricultural practices, such as using pesticide-free cultivation methods, preserving biodiversity, and conserving natural resources, thereby contributing to environmental sustainability [71,82–87];
- SDGs: Organic food production plays a crucial role in achieving the SDGs. Literature analysis identifies several SDGs that can be met through the promotion of organic food production, including SDGs 2, 8, 11, 12, 15, and 17. Key aspects for promoting organic production include raising awareness among society, consumers, producers, and public managers. Public food procurement policies and support for participatory certification methods are highlighted as viable means to address these SDGs [71,76,78–80,90,91,96–99].

The model aims to foster interaction between smart cities and rural producers by establishing communication and coordination mechanisms among the bodies responsible for organic certification. This interaction facilitates the exchange of information and monitoring of activities conducted in each locality. In this way, smart cities can adopt their own criteria and regulations to ensure the quality of food produced in their rural areas, thereby ensuring the compliance of organic production and the integrity of certification processes.

Therefore, the integration that the framework aims to establish involves participatory certification systems, involving the various actors from production to marketing. In this process, cooperation, as well as efficiency and harmonization of practices related to organic certification, are essential. Finally, thinking collaboratively facilitates the process of organic food certifications, promoting an increase in the supply of these products in smart cities.

4.4. Participatory Organic Certification for Smart Municipalities Based on the PDCA Cycle

The literature analyzed does not present a model focused on urban–rural interaction with an emphasis on organic food production. However, various strategies and actions identified in the literature can be adopted by smart cities aiming to increase the supply of organic food. Thus, based on the PDCA cycle (plan-do-check-act), the main actions have been compiled to facilitate understanding of the process and management activities that municipalities can implement.

The planning stage (plan), shown in Figure 6, establishes participatory organic certification systems for smart cities. This form of certification is highlighted in the literature as the most democratic. Planned actions include developing public policies to support organic certification, developing an exclusive certification seal for organic products certified by the municipality, as well as establishing standards for municipal organic certification.

Regarding the phase of implementation (do), the measures consist of creating a municipal body responsible for organic certification, establishing a participatory accreditation system to guarantee the quality and reliability of organic foods, and implementing the use of the exclusive certification seal for organic products.

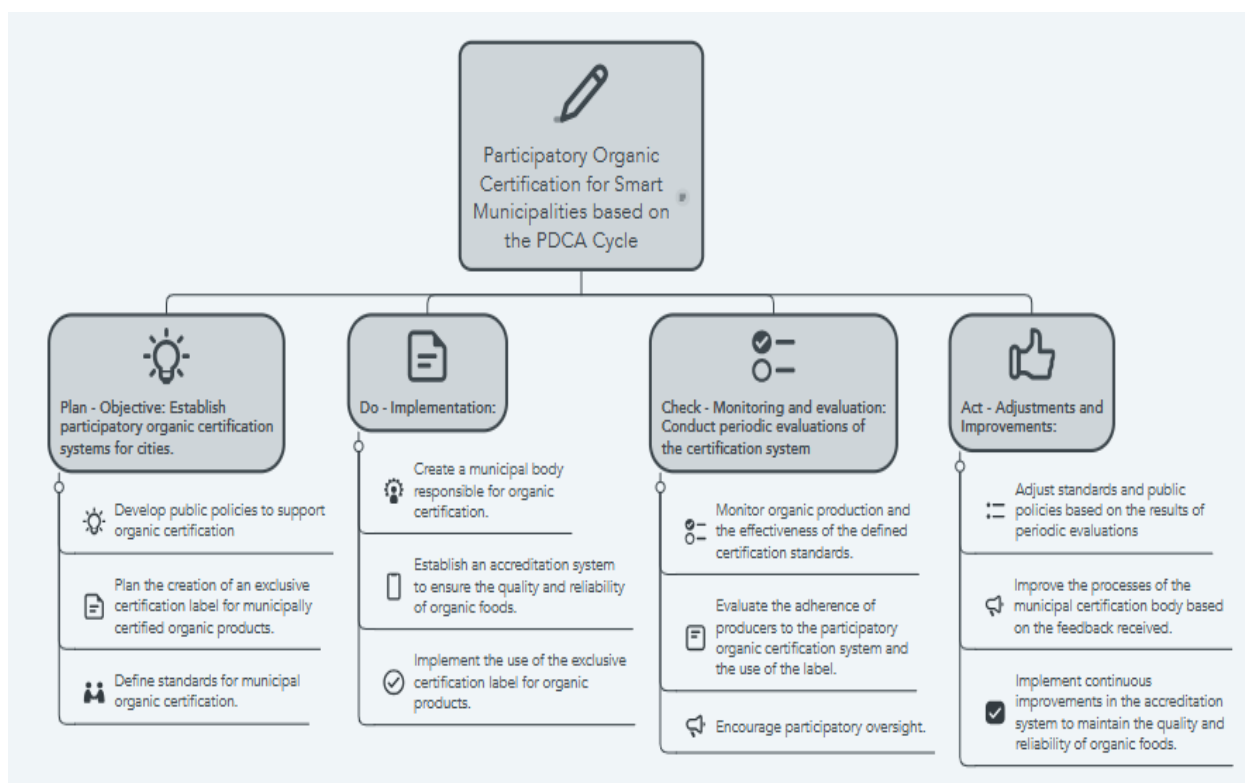


Figure 6. Participatory organic certification for smart municipalities based on the PDCA Cycle.

As for the checking stage (check), it is important to monitor organic production and the effectiveness of the standards defined for certification, and to evaluate producers' engagement in the participatory organic certification system and the use of the seal, in addition to encouraging participatory inspection.

Finally, in the phase of adjustments and improvements (act), regulations and public policies are adjusted based on the results of periodic evaluations. The management processes for organic certification are the responsibility of the municipal authority, optimized based on feedback from consumers, technicians, and other stakeholders. Additionally, continuous improvements are implemented in the accreditation system to maintain the quality and reliability of the food. Figure 6 provides a summary of the PDCA steps applied to organic food certification for smart cities.

The findings are discussed in Section 5.

5. Discussion

Although the reviewed literature does not specifically address the development of organic certification systems tailored for smart cities, there is a genuine potential for them to move in that direction. Strategies to promote organic food production are diverse and can be implemented by smart cities to establish organic compliance assurance programs, thereby fostering the production of these foods. In this process, the literature highlights the crucial role of public actors in supporting and encouraging organic production [14,74–80,84,92,97,98].

As political actors close to producers, city managers can develop public procurement policies and establish their own certification mechanisms within their jurisdictions. Bureaucracy, though, poses a significant barrier to increasing the availability of these foods, as indicated by various studies [14,71,78,80,91]. The implementation of participatory organic certification faces challenges related to the harmonization of local regulations with national legislation, resistance from stakeholders within the current system, and the training of

managers and technicians [14,74–80]. Thus, it is essential to establish regulations that allow smart cities to issue organic compliance certificates. To achieve this, it is necessary to harmonize municipal regulations with state and national legislation on organic certification, which may require legislative adjustments to delegate specific competencies to municipalities. These obstacles highlight the need for public policies that encourage participatory certification, promoting transparent governance [105,117–119,126] and trust in the process, which are essential to making the model viable in smart environments.

The approaches through which smart cities can achieve this are detailed in Figure 4. By emphasizing participatory organic food certification tailored to smart cities, the proposed model differentiates itself from existing studies that primarily focus on urban agriculture. Approaches such as those described by [131–134], which emphasize urban agriculture, offer comparable aspects to the proposed approach in terms of technological application and impact on smart cities. However, they do not address urban–rural interaction and organic food certification under the management of smart cities. On the other hand, some studies highlight essential elements for urban–rural integration, such as digital infrastructure, integrated public services, and participatory governance [135,136], aspects that can enhance the proposal. Participatory guarantee systems and social control, rooted in participatory governance, may also generate challenges related to legal, institutional, and cultural limitations [15,69,72,137]. These groups typically include family farming producers and small farms managed by the farmers themselves and their families [70,72].

In this regard, the governance of certification processes must be established transparently, and integrated and controlled through participatory methods. It is crucial that producers and other involved stakeholders demonstrate commitment by providing clear and accurate information about their agricultural practices, as well as the positive environmental and social impacts of this mode of production. Governance should also foster ethics and integrity, ensuring that certified producers adhere to the standards set by regulatory frameworks and avoid fraudulent practices [105].

In this sense, the suggested system goes beyond the existing literature by discussing the integration of urban and rural areas within the context of smart cities, focusing on the participatory production and certification of organic food and being based on the PDCA cycle. The approach presented in this study reduces bureaucracy and promotes the inclusion of small-scale farmers, addressing the limitations of traditional models. From the perspective of production management, transparency and the optimization of the organic food supply chain are highlighted as fundamental in the literature [103,115,119].

In the same sense, universities and research institutes play an important role in verifying organic production compliance and can collaborate with governance efforts [82,84,91]. Additionally, these institutions can facilitate training and strategic partnerships to provide technical assistance and monitor organic production [82,84,91]. The proposed model is based on collective organization, and participatory systems can include co-operatives or social control organizations formally registered with the city agriculture departments [15,69–72,131]. Therefore, smart city governance must ensure that production methods comply with municipal regulations by verifying the documents and records provided by producers.

In the suggested system, city governments are responsible for establishing public policies, a certification body, and an exclusive label for identifying organic products, promoting transparent governance and supporting small-scale farmers. Family farmers, in turn, must organize into participatory systems, adopt sustainable practices, and collaborate in production monitoring to ensure food quality [69–72,74,80,83–86,128]. Finally, consumers contribute by choosing certified organic products, providing feedback during the consumption process, and participating in initiatives that promote awareness and de-

mand. These integrated roles strengthen the system and promote sustainability, inclusion, and transparency.

The positive effects of public policies to encourage organic production are numerous and significant for smart cities. These include economic benefits, such as increased income for rural producers, and social benefits through community development and the promotion of inclusion. Cities can experience environmental improvements, with sustainable agricultural practices and adequate resource management, promoting biodiversity and conservation of natural resources [75,83].

The analysis of the articles responded to the following research objectives.

(i) To investigate the mechanisms and strategies in the literature that can be used to enable municipalities to certify locally produced organic foods.

In addressing this issue, the literature highlights several crucial strategies for enabling municipalities to manage organic food certification effectively. Firstly, it is essential to establish a transparent governance system that emphasizes ethical practices in the certification process. This ensures adherence to standards and compliance in organic production, thereby enhancing trust between producers and consumers.

Furthermore, public policies that promote organic production, such as acquiring organic food for schools and hospitals, are vital in fostering a stable market. These policies not only create demand but also stimulate an increase in the supply of healthier food options. Scalability depends on public policies that encourage food procurement, appropriate legislation, training for farmers and technicians, as well as accessible production control technologies designed for organic farmers. Additionally, scalability can also be justified through the use of platforms that enable the integration of more stakeholders, offering alternative solutions for production, organic production management, commercialization, and procurement of these foods. These advancements, essential for the implementation of the model, are not easily achieved without the use of ICTs.

The proposed approach is flexible and can be adapted to different geographical contexts. In regions with limited technological infrastructure, simplified methods, such as participatory certifications and mobile technologies, can be utilized. In more developed regions, the use of advanced technologies can enhance production control processes and promote sustainability in the supply chain. These aspects must be adaptable and efficient in different contexts, focusing on the participatory certification process and sustainability.

In order to achieve this point, regulations must be established that allow municipalities to issue organic certification. This should focus on promoting participatory certification systems and social control organizations. These certification models ensure that production methods adhere to municipal regulations, fostering a collaborative and transparent environment. They offer a less bureaucratic approach to organic production, with significant potential to increase the supply of organic foods and enhance social involvement in the production process. The model suggests cost reduction by adopting less bureaucratic participatory certifications, making them accessible to small-scale producers.

By promoting participatory organic food certification, involving farmers, consumers, universities, and local authorities in monitoring production, the foundation is laid for strengthening local governance and building more integrated environments. The innovation relies in the convergence of all these elements in a single model. The model thus explores how a cyclical and iterative process seeks to ensure transparency, efficiency, and reliability in the organic certification system, aligning with governance practices in smart cities and resulting in a greater supply of these foods. The practical outcomes include expanded market access for small-scale farmers through less burdensome and more inclusive certification systems, support for producers with technical training, and reduced environmental impacts through sustainable farming practices.

(ii) To assess the opportunities and challenges involving different stakeholders, for instance farmers, consumers, civil society organizations, and government authorities, in the organic food certification at the municipal level.

The literature review points out that, among the opportunities, the following stand out: the possibility of increasing farmers' income, promoting social development and inclusion. Furthermore, by encouraging good agricultural practices and adequate management of organic production, we significantly contribute to environmental sustainability. These aspects generate transparency and interaction between producers and consumers, strengthening people's trust in the organic production process, as well as increasing demand for such products.

Regarding the traditional organic certification process, this one is considered bureaucratic, presenting high costs, which represents a barrier for small producers who generally do not have the necessary financial resources to cover these costs. Lack of resources hinders these producers' ability to meet stringent certification requirements, creating a potential conflict between certification rigor and member participation.

(iii) To identify which sustainable development objectives can be achieved with the adoption of the model proposed in this paper.

Finally, it is inferred that the proposed model positively impacts the fulfillment of sustainable development objectives, allowing us to verify which sustainable development objectives can be achieved with the adoption of public policies and strategies aimed at increasing the supply of organic food in smart cities. The SDGs involved in the model are: SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 15 (Life on Land) and SDG 17 (Partnerships and Means of Implementation). In short, to ensure effective implementation of these goals, it is necessary to promote and support local cooperation and efforts.

6. Conclusions

As debates on smart cities generally focus only on urban areas, no studies were identified that indicate that these cities are managing the production of organic food. However, this study fills this gap by including rural areas in the scope of smart cities, recognizing their importance in the search for sustainable economic development.

This study seeks to offer elements to support the development of an organic production management model aimed at smart cities, which can facilitate the entire governance process. By identifying the main actors and barriers highlighted in the literature, this study presents a perspective on how the aspects highlighted in the literature can drive more effective and sustainable integration.

The literature review allowed us to identify a series of strategies that smart cities can adopt to increase the supply of organic food. Promoting the production of such foods contributes significantly to the sustainable development of smart cities. Thus, this article offers a comprehensive and innovative approach to the integration of urban and rural areas, indicating the ways that smart and sustainable communities can adapt to encourage organic food production.

The proposal for an organic certification model for smart cities highlights the need to expand public policies developed by cities beyond urban limits, also including rural areas. The advantages of the proposed model combine innovative planning, participatory organic certification, and decentralized governance to create a sustainable urban–rural connection, surpassing initiatives focused solely on urban or rural environments. These aspects emerge as a solution to increase the supply of organic food and establish synergies between smart cities and rural areas, with a focus on sustainability and food security. However, challenges

related to technological infrastructure, scalability, legal aspects, and cultural acceptance remain as limiting factors.

The proposed interaction between municipal government, family farming producers, consumers, market, universities, and research institutes aims to create an integrated ecosystem that promotes not only organic production, but also social inclusion, increased producer income, equity, and transparent governance of the production process of these foods. The framework presented aims to facilitate communication and coordination between different actors, promoting the exchange of information and effective monitoring of productive activities in participatory certification systems. Collaboration between smart cities and rural areas not only faces digital gaps, but also lacks innovation in ways of managing food production.

The implementation of the model faces challenges related to technological infrastructure, such as limited connectivity in rural areas and a lack of monitoring tools, which hinder integration with smart urban systems. In terms of public policies, harmonizing national and local regulations to enable municipalities to issue organic certifications presents difficulties and potential conflicts between different levels of government. Additionally, governance barriers include resistance from private certification bodies and associations to adopting participatory structures, while low consumer awareness of the benefits of organic products and participatory certification limits market demand.

To overcome these challenges, strategic interventions are necessary, such as public policies that empower municipalities to issue certifications and incentivize government purchases of organic products, economically strengthening farmers. Investments in digital infrastructure, monitoring tools, and farmer education can improve rural–urban integration. The integration of information and communication technologies (ICTs) into the production, distribution, and commercialization process of organic food is essential for production governance, improving transparency throughout the entire process. Thus, integrating ICTs, such as digital platforms, big data, agricultural sensors, and mobile applications that connect producers and consumers, can optimize the supply chain. Finally, engaging all stakeholders in the planning and implementation phases of the model can foster collaborative and efficient governance.

The model recognizes public policies focused on promoting participatory organic certification, creating economic incentives, and public food purchases are important strategies for smart cities to explore. These encourage entrepreneurship, healthy food production, and collaborative governance. Thus, implementing these strategies, applied through the model proposed, will help in achieving Sustainable Development Goals (SDGs) and promoting a more balanced urban–rural development: SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 11 (Cities and Communities Sustainable), SDG 12 (Responsible Consumption and Production), SDG 15 (Life on Land) and SDG 17 (Partnerships and Means of Implementation).

This article contributes to the debate on the role of smart cities in promoting family farming, as well as organic food production. The proposed theoretical model can be used as a basis for implementing public policies and programs to support family farming in smart cities, focusing on urban–rural interaction and increasing the supply of organic food guaranteed by the governance of smart cities.

The limitations of this research are directly related to the fact that no specific models for managing organic food production in smart cities were found in the analyzed literature. Therefore, it is essential that future research investigates the digital potential of the proposed model for the interaction between smart cities and organic food producers, aiming to improve food security for citizens.

As a suggestion for future work, empirical studies should be sought that demonstrate the interaction between smart cities and organic food producers, how the governance of the production and commercialization process occurs in practice, and improve understanding on the subject.

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