Agrociencia

CHARACTERISTICS, ROLES, AND FUNCTIONS OF THE INNOVATION AGENTS IN THE AGRI-FOOD SECTOR

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Citation: Vargas-Canales JM, Orozco-Cirilo S, Medina-Cuéllar SE, Camacho-Vera JH. 2022. Characteristics, roles, and functions of the innovation agents in the agri-food sector. Agrociencia https://doi.org/10.47163/agrociencia.v56i2.2781

Editor in Chief:
Dr. Fernando C. Gómez Merino

Received: September 17, 2021.
Approved: March 23, 2022.

Estimated publication date:
April 26, 2022.

ABSTRACT

The importance of innovation in all disciplines and sectors in the current economic dynamic is unquestionable. For several decades, it has been considered as the major force behind the promotion of economic expansion and development. However, the economic models are characterized by their constant change, transformation, and complexity, regarding relationships and interactions, as well as regarding agents and actors involved in such processes. In this regard, the objective of this analysis was to enhance the understanding about the performance of innovation agents and to clearly identify their characteristics, roles, and functions, in order to facilitate the design of strategies that enable the acceleration of the innovations diffusion within the agri-food sector. The definition of agent and its relationship with the territory are discussed as an important element, because the territory is the geographic space in which the innovation process takes place. Regarding the characteristics, roles, and functions, a summary about the identified innovation agents is carried out, along with an analysis of how their interactions enable innovation. Consequently, a characterization of the agents that develop, use, manage, and diffuse innovation allows the integration of clearer and more appropriate studies on the innovation processes that are being developed in the agri-food sector.

Keywords: innovation diffusion, innovation systems, innovation networks, rural territories.

INTRODUCTION

The importance of innovation in the current economic dynamic is unquestionable, considering that it is the driving force behind transformation, growth, and economic development. Therefore, without innovation development, the current economic model would enter a stage that could be described as stagnant. Consequently, the

innovation and the agents that take part in its development and diffusion have been studied in a wide range of disciplines, including sociology, economy, marketing, ecology, and computing (Zhang and Vorobeychik, 2019).

Regarding the analysis of adoption and innovation diffusion within the agri-food sector, there are two great traditions, which have been quite disconnected from one another (Monge and Hartwich, 2008). The sociological tradition about diffusing innovation is similar to a pandemic contagion process, due to the decision taken by the adopting agent (certain producer or company) leads to a subsequent adoption by others who are in touch with or are directly or indirectly influenced by the first producer or company. This process has a slow beginning until a certain number of adopters is reached; this number accelerates the decision-making process of the remaining neighbours. This process takes place mainly through the interaction between the actors, while the efforts of the external agents have an impact on the decision-making process of a minority of producers (pioneers and innovators), who are more receptive to external novelties (Rogers, 1995).

An individualist style tradition rose among the agronomic economists, according to which the agents make the decision to adopt an innovation, based on the profit that they could obtain from the implementation of the said innovation in their production systems. Consequently, each actor reasonably analyses the costs and expected benefits before making a decision, since there is a huge heterogeneity in the individual characteristics and limitations pertaining each producer, consequently a similar dispersion in their decision-making process is to be expected (Griliches, 1957). This tradition dominated the study of agricultural innovation, providing a theorical and empirical support to many policies, programs, and systems that were implemented in some countries, promoting a technological change among the producers and in the overall agricultural development (Monge and Hartwich, 2008).

The traditional literature about the diffusion of innovation has been dominated by the abovementioned behaviour and aggregated trend models. However, the paradigm of a model based on agent interaction is gaining popularity, because it captures the agents' heterogeneity and enables the detailed modelling of the interactions, which are connected by the networks in the territories (Zhang and Vorobeychik, 2019). In this regard, the networks function as a tool for diffusing innovation among the different agents. Additionally, they represent a complementary response to tackle the changes resulting from the development and the use of technology. Consequently, linking these actors with other agents, in order to share knowledge and to benefit from these interactions, is currently very important (Bullinger *et al*., 2004). Therefore, the analysis of the benefits obtained from the use of technology is not antagonistic with the interaction model and, they are currently complementary.

The model based in the innovation agents analysis offers two advantages for the study of the innovation diffusion: first, it facilitates the modelling of the heterogeneity of the agent and, second, it allows a detailed modelling of the interactions that shape the innovation networks (Zhang and Vorobeychik, 2019). Consequently, the potential

deficiencies of the innovation systems can be identified and the management schemes can be suggested; additionally, it provides clarity in the principles that rule the creation, diffusion, and adoption of innovation, as well as in the relationships among the knowledge and information inputs and outputs, which turn into innovation (Eito-Brun, 2020).

Meanwhile, the innovation agents can be found in different sectors of the value chain (production, stock, transformation, commercialization, and promotion). They also involve various and different actors that work at diverse levels (companies, national and local public organizations, civil society associations and organizations, and training and research institutes) (Ferreiro and Sousa, 2019). Additionally, they cooperate and compete in the same territories and in the same markets, which creates very complex innovation systems. Therefore, to a certain extent, they determine the effectivity of all their parts, encourage innovative processes in the same territories, and create a high-level competitiveness (Nosova *et al*., 2018).

In the agri-food sector, network management can be especially useful and efficient to trigger innovation processes. Agriculture and livestock management comprise a great number of small and medium companies, which produce food at different levels and carry out other functions. Compared with other sectors, the great number and diversity of the agents offer a high potential for the creation of networks, the integration of innovation systems, the boosting of the diffusion and adoption processes of innovation. However, innovation management does not only mean adopting an innovation created by farmers, rather it is a communication and cooperation process between the different innovation agents (farmers, researchers, government, and other interested parties) (Wu and Zhang, 2013).

Bullinger *et al*. (2004) suggest that universities, research centres, providers, clients, and other complementary stakeholders have an important impact in the knowledge and innovation creation process. Additionally, some case studies in developing countries highlight the relationship between network and the innovation capacity of small and medium companies (Biggs and Shah, 2006; Kaminski *et al*., 2008). The evidence shows that the long-term knowledge base of the companies that do not cooperate and that do not formally or informally exchange data is limited (Monge and Hartwich, 2008). At an institutional level, innovation systems play a key role in innovation management (Pittaway *et al*., 2004).

Networks arise, evolve, and reshape as another element of the territories. Together, they are the basic elements that create small local innovation systems, which in turn, connect and interact with other (regional, domestic, and international) systems and bring together different innovation actors. Additionally, if the joint initiatives about innovation management are successfully implemented by the different agents, the innovation groups collaborate to such a level, that it enables the creation of an unique network effect of innovative synergies, which guarantees a constant growth, a sustainable association of interrelated economic entities, and new opportunities through cooperation (Nosova *et al*., 2018).

In the case of the agri-food sector, the shaping of the innovation systems is not clear. This situation is potentially the result of the heterogeneity of the activities, the regional asymmetry, and scant links between the actors.

Meanwhile, few research that enable the identification of the impact of the different innovation agents in the sector have been developed. Agricultural extension programs have not been widely successful regarding technology diffusion and linking all the innovation agents. Finally, during the last years, participation has decreased. However, in some agri-food activities, especially those closely linked to international markets, the interactions between the innovation agents are increasingly visible and important, for example, in the production of berries (strawberry, raspberry, blackberry, and blueberry), avocado, tomato, lemon, and mango, among others. In addition, some efforts are being made to identify the impact that the innovation agents have in the productive sector (as an example, protected agriculture) (Vargas-Canales *et al*., 2022).

As an example, the market is currently a relevant actor that must be considered as another agent; in some cases, it might be considered the most important agent, because the users and beneficiaries demand constant improvements. In this regard, the use of platforms and open innovation (Eito-Brun, 2020) have also become one of the main agents related to the integration, management, and diffusion of innovation at all levels and in all sectors. Consequently, the objective of this analysis was to deepen the understanding about the performance of innovation agents and to clearly identify their characteristics, roles, and functions, in order to facilitate the design of strategies, which accelerate the diffusion of innovation in the agri-food sector. The structure of this essay comprises a discussion about the definition of innovation agents and their relationship with the territory. Subsequently, a characterization of the main agents of the agri-food sector is developed. Finally, some conclusions are posed about the objectives and their implications.

INNOVATION AGENTS AND THEIR TERRITORIES

There are multiple definitions about what an agent is, mainly as a result of the great diversity and heterogeneity involved in the roles and functions they perform (Tweedale *et al*., 2007). Currently, the economic and social dynamic has impacted all sectors and actors involved. Economic activities have diversified, and at the same time, they have become hyper specialized, creating very complex economic systems for the interaction between heterogenous, diverse, and even multi-faceted agents. This situation leads to the question: what is an innovation agent? Trying to simplify a definition that provides a better understanding, analysis, classification, and operation, an innovation agent is an actor that has learning, coordination, and autonomous capacities (Tweedale *et al*., 2007). These are the minimum characteristics required to create development, management, and innovation diffusion.

Additionally, an analysis of the geographic space where the whole innovation process takes place is required. Therefore, carrying out all these very complex processes requires an environment that favours their creation. In this regard, two key notions have emerged from the systemic analysis process: innovation systems (local, regional,

and domestic) and, more recently, the innovation ecosystems. These notions have become very relevant during the last years. Both require a specific, not clearly delimited environment, which enables the development, interaction, and competition of all innovation agents. According to Pedroza-Zapata and Silva-Flores (2020), in order to trigger development through innovation, these environments must have a strong scientific and technological element, in which universities play a fundamental role.

The territory is a space and, at the same time, a way in which society and relationships are built; it also brings together a set of heterogenous elements with diverse history, culture, and traditions. Their interaction keeps a constant flow of information; this dynamic allows them to evolve and transform (Vargas-Canales *et al*., 2018). The territorial approach must be taken into consideration, because it helps to understand the interaction and cooperation mechanisms between the different agents, encouraging the knowledge flows required to create innovation and competitiveness (Oliveira and Turčínková, 2019). Additionally, Ferreiro and Sousa (2019) mentioned that the academy lacks a deep knowledge about the innovation processes in the agri-food sector or about more traditional activities in rural territories. Therefore, a new conceptualization about the theoretical and methodology frameworks is required to research and to seek to understand the innovation phenomenon. Additionally, an indicator system that helps the researchers to characterize innovation in rural contexts with greater clarity must be developed.

From the point of view of the theory of evolution, each territory or environment is characterized by the interaction between the different organisms, populations, and communities, as well as by the impact of external factors (Arango-Londoño, 2012). Consequently, the interaction of internal and external factors forces the territories to develop adaptation and innovation mechanisms. Additionally, the territory should be thought of as a global entity that, nevertheless, keeps local characteristics. Regarding the networks and the interactions between the various agents, Arellano and Ortega (2005) mention than a network is an interested connection, linked to a process, which breaks with the idea about distance and proximity and allows researchers to discuss the associations and connections of the actors at all levels.

Consequently, agents with different types of influence can be identified. Undoubtedly, the most important element to manage innovation are local agents. The communities of practice (those who create, adopt, adapt, and spread knowledge, technologies, information, and practices) are located in this local dimension and it is there where the interaction between the rest of the agents takes place. In this regard, there are local and regional agents that can be classified as internal and domestic, and international agents who, as a result of their location, can be classified as external agents (Figure 1). We should highlight that each agent performs crucial functions in the development of the innovation process. Agents which are increasingly important and relevant, and who have a high influence in the innovation systems can be identified. For example, at an international level, external agents linked with the raw material (seeds and fertilizers) supply link are increasingly important, because nowadays value chains

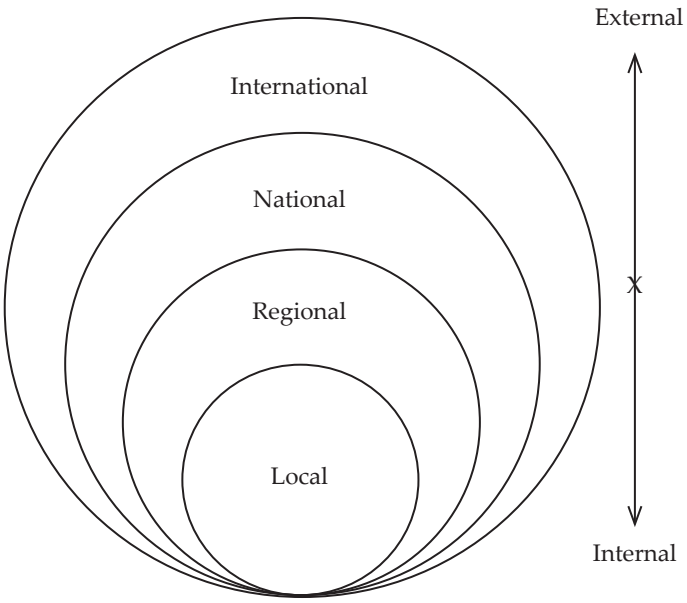

Figure 1. Level of influence of the actors that take part in the innovation processes of the agri-food sector.

are practically global. In this regard, international markets (final consumers) are the agents that determine what is produced, how it is produced, and when it is produced. Universities are major domestic innovation agents, because they are the places where science, technology, and knowledge is developed. These elements will be ultimately transformed into innovation at a local level.

In addition, as a result of the evolutionary process, new entities or agents appear and perform new functions and roles. This quality enables the development of agri-food systems because new agents are required to perform or develop new specific functions and activities. This situation complicates the understanding of the emergence of innovation in the agri-food sector: a very dynamic process, despite opinions on the contrary.

Therefore, using a non-evolutive analogy, human individuals —their interests, beliefs, values, and behaviour— interact in the territory, along with other non-human devices which perform certain functions, and the physical conditions of the environment (Arango Londoño, 2012). Consequently, non-human agents, which are increasingly important and have more influence in our societies, must be considered. Other authors have attempted to explain this situation; such is the case of the actor-network theory of Latour (2005), the theories of quasi-object and quasi-subject of Serres (1980), and the symmetry principle of Bloor (1991).

From the point of view of technological determinism, technology defines social changes; from the point of view of social determinism, technology is just a social construction,

incapable of autonomy or change. In this case, the actor-network theory breaks with that dichotomy and considers technology as the result of a socio-technological framework. Consequently, the interaction between multiple agents, processes, and devices, among others, is required to enable the development of any technology. Therefore, technology is the agent that shapes that social framework, and that (human, non-human) hybridization determines the paths that must be followed. This situation takes place because the technological devices start to have other meanings, to be able to link other actors, to have a certain degree of autonomy, and to be able to reshape themselves and acquire a new meaning. Given the current conditions that indicate that we are heading to agriculture 4.0 and 5.0 —which include artificial intelligence, automatic or autonomous learning, and real time solutions—, this type of approach is increasingly important, because it allows a more reticulated analysis development about the new arrangements that take place between science, technology, and society.

CHARACTERIZATION OF THE INNOVATION AGENTS

Consequently, following different authors who have researched the agents in charge of the development, management, and diffusion of innovation in the agri-food sector, a classification of those agents is summarized (Table 1). Each agent performs specific roles, in some cases, more than one. The different agents are described below:

Communities of practice: this type of actors are groups of producers or companies that develop an activity in the agri-food sector. This type of agent plays different functions including creation, adoption, adaptation, and diffusion of knowledge, technology, and innovation, that gradually shape the territory. This is the result of the dynamic

Table 1. Agents and actors that use, develop, manage, and diffuse innovation.

Agents	Actors		
Communities of practice	Rural companies	Social organizations	Society
Intermediaries	Non-governmental organizations	Public institutions	Public policy and regulatory framework developers
Coordinators and/or linkers	Agricultural extension	Specialized services providers	Specialized raw material providers
Generators of science, technology, and innovation	Universities	Research centres	Tech development companies
Technology diffusion	Technology demonstration modules	Technology diffusion centres	Innovation platforms
Enablers	Financial, credit, and savings companies	Standard-setting organisms (certification and accreditation bodies…)	Training organisms
Complementary stakeholders	Companies related to the chain value (commercialization, stockpiling, and logistics and transport companies)		
Market		Consumers	Competitors

Sources: Bullinger *et al*. (2004); Carlsson and y Stankiewicz (1991); Carlsson *et al*. (2002); García-Sánchez *et al*. (2019); Grovermann *et al*. (2019); Hermans *et al*. (2019); Kamara *et al*. (2019); Maggioni and Uberti (2009); Minh (2019); Vargas-Canales *et al*. (2018); Vargas-Canales *et al*. (2022).

interaction between the method of production, the social and political relationships, and the symbolic constructions, which shape the power and domination relations in their different forms (Lefebvre, 1991). Therefore, these agents develop economic activities (producers, companies, organizations of producers) and share regulations and interests.

Intermediaries: these agents serve as liaisons, facilitating some innovative activity, between two or more parts. Therefore, they establish connections or build bridges between the technology generators and the users of the said technology. Consequently, they perform different functions in order to introduce new products, processes, and organizational or commercial methods into the market (Pérez Hernández, 2016). Additionally, they implement public policies related to the activity and apply the regulatory framework to provide greater certainty to the rest of the agents.

Coordinators or linkers: the main role of these actors is to connect all the existing actors in the territory. They promote collaboration between actors and spread knowledge, practices, and information. Additionally, they arrange the harmonization of processes and facilitate the adoption and adaptation of new technologies. However, the main function of these agents is to provide technical support in the development of projects, for example, agricultural extension (Klerkx and Leeuwis, 2009).

Science, technology, and innovation generators: the main role of these agents is to generate and adapt knowledge and technologies, as well as to carry out experiments to develop products, processes, marketing methods, and forms of organization (Ruiz Castañeda *et al*., 2016). Consequently, these agents are the scientific and technological base focused in solving social problems.

Technology diffusers: nowadays, these actors are starting to play a major role in almost all the economic sectors. They can validate technologies *in situ* and make the knowledge generated available to almost any user who is interested in them. Consequently, these agents are expected to become main agents related to integration, management, and diffusion of innovation in all levels and sectors (Eito-Brun, 2020).

Enablers: these actors provide the resources required for the development and implementation of the innovations, and they also assess their capacity to adapt to the requirements of the market and their proper operation. Therefore, these actors promote competition and contribute to reduce the entry barriers of the markets. In addition, they function as a fundamental enabler to the territories; consequently, the education, training, and human resources capacities are considered as key factors to activate the innovation processes.

Complementary stakeholders: through their interventions and actions, these agents enhance the appreciation that clients have for the goods and services of the companies. Overall, they provide intangible elements and do not physically take part of the final product. In the agri-food sector, these agents perform essential functions: they develop the infrastructure required to integrate the value chain. Additionally, they develop and link new markets and take part in several activities throughout the value chain (Vargas-Canales *et al*., 2022).

Market: the role of this agent in any productive system is fundamental. The market compels the agents and all the links of the value chain to keep a constant competition, and this stimulates the development of innovation in the long term. Consequently, the agents become more competitive and comply with the regulations in force; above all, they adapt their product according to the taste, preferences, and wishes of the consumers (Geels and Schot, 2007; Vargas-Canales *et al*., 2018). Through the taste and preferences of the consumers, the market determines the type, characteristics, and ways of distribution of the products, among others. For example, there have been changes in the demand for agri-food products derived from the COVID-19 (SARS-CoV-2) pandemic; consequently, the demand is changing to innocuous, organic products, with high-antioxidant, aminoacids, and mineral content.

Based on this information, this analysis about the innovation agents in the agri-food sector come close to the proposals of Vargas-Canales *et al*. (2022). They mention that an innovation system in the agri-food sector is made up of universities, institutions, organizations, and companies, which interact through networks, knowledge exchange, information, practices, and experiences about a technology in a specific activity and that it also includes all the operations and transactions aimed at satisfying food demand. This includes all the agents linked to the value chain; this is, the actors related to the raw materials supply, primary production, storage, processing, transformation, logistics, distribution, and commercialization.

CONCLUSIONS

Current literature on innovation diffusion has been dominated by the paradigm of the model based on the interaction of the agents, with some elements of other currents, because it encompasses the heterogeneity of the agents and allows researchers to develop the detailed modelling of the interactions through territory networks.

Overall, despite the existing diversity, the main functions, and roles of the innovation agents in the agri-food sector can be clearly identified. It should be mentioned that these are heterogeneous, diverse, and even multi-faceted agents.

Establishing a clear characterization of the agents that develop, use, manage, and diffuse innovations enables the integration of clearer and more appropriate research about the innovation processes developed in the agri-food sector. Additionally, identifying the mechanisms and strategies that accelerate the diffusion of innovation in the agri-food sector is likewise important.

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