

ECOSYSTEM FOR SUCCESSFUL AGRICULTURE. COLLABORATIVE APPROACH AS A DRIVER FOR AGRICULTURAL DEVELOPMENT

Nino Adamashvili, Mariantonietta Fiore,
Francesco Contò, Piermichele La Sala¹



¹ Nino Adamashvili, PhD. student, nino.adamashvili@unifg.it, ORCID: 0000-0001-6907-8293; Ass. Prof. Mariantonietta Fiore, PhD., mariantonietta.fiore@unifg.it, ORCID: 0000-0002-9244-6776; Prof. Francesco Contò, francesco.conto@unifg.it, ORCID: 0000-0001-7837-0069; Ass. Prof. Piermichele La Sala, piermichele.lasala@unifg.it, ORCID: 0000-0003-2081-8013. University of Foggia, Italy

Abstract: The development of agribusiness sector is given gradually increasing importance. This work aims at identifying the elements that create the successful ecosystem for agricultural development, their benefits and application in agri-food systems; additionally, to bring on a light of the role of agricultural policies in these processes. For this purpose, the authors have carried out an analysis of the concern related literature and present a preliminary theoretical framework/model as a tool for supporting local development and incorporate a successful effective ecosystem. The key implications of this paper include an increased attention to agricultural research, to the role of the collaboration between relevant stakeholders, as well as of the agriculture, which uses information technologies for the better utilization of natural resources, and what is the most important is, the role of agricultural policies.

Keywords: ICT, Sustainable Agriculture, Collaboration, CAP

1. Introduction

The current world is witnessing a huge change resulting from continuously growing number of populations, resources depletion, environmental and climate changes. The world population is expected to surpass the 9.8 billion mark by 2050 (UN DESA, 2017), and agriculture has to increase the production of nutritious food to meet the growing demand and ensure food security for all (FAO, 2017). It also has to create new working opportunities, increase incomes, reduce poverty and lead rural economic growth. These are crucially important for the sustainable management of natural resources (Rapsomanikis, 2017). Therefore, farmers need to consider the value of natural resources and biodiversity and make the well-informed decisions while producing the food (European Union, 2012). Environmentally sustainable agriculture, which minimizes off-site environmental effects by using natural resources prudently, is crucial for our quality of life as now and for the future (Keeney, 1990).

It is becoming crucial in today's agricultural setting, that the gradual increase in the importance of information in agricultural activities is paid attention to (Miller *et al.*, 2018). Besides, millions of smallholder farmers all around the world deal with certain limitations on a general basis. Precisely, difficulties such as challenging entrance barrier on the market or poor access to financial services. Furthermore, some of the other barriers include unqualified human capital resulting from low level of education and training, agricultural research, related data, and problematic physical capital as well (FAO, 2018). Nevertheless, the climate has a big impact on agricultural activities and the ignorance of weather conditions may result in many difficulties related to farms (Tenzin *et al.*, 2017). There is also a gap between supply and demand in a long and short-term period of time. Meaning, farmers are not able to change the standard activities immediately, which correspond to the changes in consumer preferences (Teng, *et al.*, 2010). So, nowadays farmers need to make more and more complex decisions about the land use, what to produce and in which manner, how to choose suppliers, and how to segment consumers (Rossi *et al.*, 2012), how to reduce the risk of bankruptcy and at the same time maintain their livelihoods well and care about the society (Krantz, 2001).

Consequently, the aim of this work is to identify the elements creating the successful ecosystem for agricultural development, their benefits and application in agri-food systems; additionally, to bring on a light of the role of agricultural policies in these processes.

The following chapters of the paper are structured as follows: the next part includes the analysis of academic literature about the role of collaboration for making more sustainable agri-food and rural areas. Further, the benefits of the information technologies in agriculture are investigated. As for the third part of the article, the work presents a hypothesis of a model to provide the scheme of effective ecosystem. Finally, results and discussions, followed by the conclusion section complete the paper.

2. Literature review

2.1 The role of collaboration for sustainable agri-food and local areas

Agri-food and rural areas are facing different idiosyncratic and covariate shocks that lead to deep crisis. Therefore, similarly to many other sectors, the focus has moved from the individual activities of firms to the networks of collaboration (Kühne *et al.*, 2015). Agriculture sector needs to blend intensive, specialized production systems to traditional one while trying to reach a competitive advantage in a global marketplace and decreasing environmental impacts.

The changes taking place in the agri-food system require the development of partnerships increasingly oriented to the consolidation and growth of internal and external supply chains and territorial relations. There are many forms of integration that involve, at different levels, the stakeholders of the agri-food system aiming at strengthening partnership and increasing the contractual force and the market power of the stakeholders (Cantarelli, 2016; Alho, 2015).

Therefore, the actors' networks, rural and agro-food districts, and cooperatives conducting economic and social interactions, represent key forces to promote green and innovative local development in rural areas, thus reducing the informative gap (Barati *et al.*, 2017; Contò *et al.*, 2016). Indeed, according to Carrillo *et al.* (2014), strengthening the knowledge of economy through stimulating entrepreneurship and enabling social dialogue gets increasing importance. In addition, nested markets create more and more strong strategies for local development processes and policies, by creating new chances for families' livelihood in rural areas (Schneider *et al.*, 2016). Bojar and Drelichowski (2008) showed networking organizations of the agri-food SME in Spain, Greece, Bulgaria, Czech Republic, Lithuania and Poland that experience competition and cooperation approach, help to meet needs of consumers for safe and healthy food.

Kotu *et al.* (2017) demonstrated good rural infrastructure, rural road networks, and multiple information/knowledge sharing can boost adoption of sustainable intensification practices (SIPs), thus increasing the income of farmers. Therefore, the instruments of territorial and transnational integration assume great importance in the CAP. Among these instruments, the Local Action Groups (LAGs) represent the main form of territorial integration supported by the CAP in order to enhance rural areas and encourage instruments of territorial and transnational cooperation between farms and other rural development actors (Chmieliński *et al.*, 2018). The core seems to be also acquirement of better acknowledge in policy-making initiatives and opportunities (Huttunen, 2012). Many of these initiatives are encouraged by public policies and aimed at taking full advantage of the measures, the remainders try to meet specific requirements of territory and sector. In Italy, finally, following the law of orientation for the agricultural sector, the Agri-food Districts of Quality and Rural Districts have spread, aimed at improving the territorial governance processes for the development of farms, supply chains and rural areas, in particular areas with a strong vocation and agricultural production specialization (Contò *et al.*, 2012; Zecca *et al.*, 2014).

Furthermore, by investigating the EU project 'CAPIRE: Assessing the multiple Impacts of the Common Agricultural Policies on Rural Economies', Viaggi *et al.* (2011) highlighted the crucial role played by the Local Participatory Networks (LPN) in reaching good results in sustainable and economic development of rural economies. On the other hand, the agriculture that adopts latest technologies gives a major power to farmers since Smart grid technologies can be useful tools for increasing the sustainable energy supply from agricultural residue and waste, and for delivering benefits of agricultural systems of input (Odara *et al.*, 2015).

Furthermore, several scholars (Fischer, 2013; Casieri *et al.*, 2010; Simatupang & Sridharan, 2002) highlight social capital is a crucial factor for starting and maintaining economic development in poor rural areas. Moreover, close cooperation, agro-food agreements, collaborative relationships between public or private players, researchers and business-people help actors of rural systems to match demand and supply in an effective way and they are functional to perform activities with greeter results than when acting in isolation (Simatupang & Sridharan, 2002).

Adopting participatory multi-actor approach, involving consumers and knowledge exchange are perceived by stakeholder as the most relevant in order to enable a shift towards more sustainable systems and chains (Sacchi *et al.*, 2018).

The following figure assumes that the level of trust between buyers and suppliers (and vice versa) is determined by three interrelated factors: (1) the effective communication and adequate sharing; (2) the existence of positive past cooperation activities and (3) the existence of private and personal bonds that seems to be important when dealing with farmers. Above all, it appears significant to adopt vertical supply or value chain integration from farmers, food processors and grocery retailers in a durable way functional to develop and maintain sustainable relationships in rural areas (Fisher, 2013).

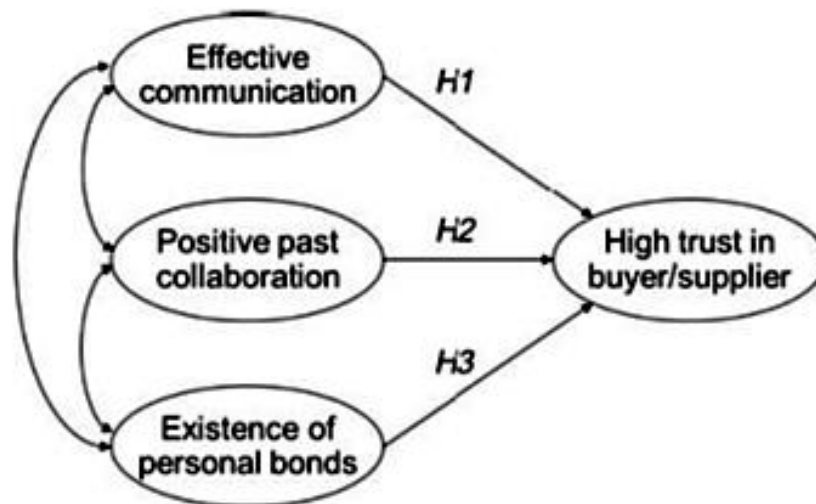


Fig 1. Assumed relationships among trust-affecting factors. Source: Fischer, 2013

Trust-based collaborations are promoted by Local Development Plans (LDPs) in order to build virtuous and continuous development mechanisms. Both Horizon 2020 framework and Common Agricultural Policy 2014–2020 stress the role of innovations: new Rural Development policies define new network tools as the European Innovation Partnership (EIP), the Operational Groups (OGs), and technological clusters designed for encouraging innovation processes (Nazzaro & Marotta 2016).

Integrated environmental research and networking of the agricultural economy in rural areas is a trend that already started for two decades ago when processes began to move towards the disappearance of the old rural organisation (Luostarinen, 1998).

Currently, in various French and Brittany regions, rural networks of farmers organise exchange groups to help newcomers and facilitate knowledge exchange on new tools and practices. The EU TRADEIT project (www.tradeitnetwork.eu) was born as a collaboration among researchers, food networks, traditional SMEs, clusters, technology providers, food associations and entrepreneurial networks with the aim to promote, smart use of IT for traditional food producers, relationship building, sustainable technology for food production and so on (EIP-AGRI, 2015). Besides, Weaver (2008) argues that increasing use of innovative technologies has opened new opportunities on the one hand, yet it has resulted in the need of strategic reorientation that should be supported by collaborative activities in the supply chain.

Finally, the manner to accomplish this approach can be built going through the currently fragmented marketplace based on power and competition via research and trust-based networks towards an integrated, consistent and entirely sustainable supply system (Fisher, 2013).

2.2 The benefits of adoption of IT in agricultural practices

Emerging technologies revolutionize the ways people live, interact with each other and do business (Schwab, 2017). Digitization has heavily affected agriculture as well. According to Stratigea (2009), Information and Communication Technologies (ICTs) contribute real-time systems that enable effective collaboration making the interaction and communication process easier between relevant stakeholders like policy makers, decision makers, farmers, researchers. In addition, the development of technology-driven agriculture and adoption of precision agriculture technologies (PAT) managing the in-field heterogeneity, gives the opportunity to the companies to design the agricultural value chain in detail (El Bilali & Allahyari, 2018; Stafford, 2000) and to face the challenges that agriculture and food industry meet. Consumers want high-quality food at low prices – with the utmost respect for animal and environmental protection. To achieve this, it is necessary to improve production and management processes (Banhazi *et al.*, 2012). With technically supported methods for the individualization of field management and livestock farming plants and animals in an agricultural enterprise receive exactly the treatment they need (Berckmans, 2014). Specifically, there occurs the targeted management of agricultural land – using intelligent electronics. Examples include sensor-assisted soil assessment, automated animal observation on pasture or targeted control of agricultural machinery. Modern methods of differentiated management allow a site-specific work within a parcel (Morimoto & Wadamori, 2018; Jordan *et al.*, 2016).

Technology-driven agriculture can provide environmental and economic benefits through the reduction or targeted introduction of agricultural inputs including water, pesticides and nutrients (van Evert *et al.*, 2017). So, accurate applications of nutrients can bring significant environmental and economic benefits. The goal is to apply only the nutrients that the plants need and can use (Zavala-Yoe *et al.*, 2017). In addition, it may be necessary to manage the application in environmentally sensitive areas (Luck *et al.*, 2010). Application rates will vary in the field depending on soil type, fertility levels and environmental sensitivity. Some areas may require reduced rates because of their environmental sensitivity (Fu *et al.*, 2018). Specific pesticide applications can provide economic and environmental benefits. For instance, the use of light bar guidance systems that are cheap and fast, leads environmental benefits for pesticide applications (Balafoutis *et al.*, 2017). These affordable lights bar guidance systems provide a simple method of getting equipment through a field to avoid overlap when pesticides are sprayed.

Sensors, drones and robots make it possible to collect exactly the information that is required for a tailor-made farm (Elijah *et al.*, 2018). With the help of sensors and satellite control, different soil characteristics and yield capabilities within the field can be electronically determined in a so-called field record file and individually responded to in real time (Faccilongo *et al.*, 2016; Zhao & Yang, 2018). Seed, fertilizers and pesticides can be used in a targeted and reduced way and fuel consumption can be reduced thanks to the satellite-controlled safe tracking of agricultural machinery and intelligent sensors (Zhang *et al.*, 2017). Sensors also determine wind conditions and solar radiation in order to automatically control the irrigation system based on the measured values or to trigger the order for a required fertilizer (Yan, 2017).

Aerial images of drones provide valuable information about the field, such as soil quality, accompanying flora and diseases on plants (Smith & Chan, 2017). The data are available at short notice and appropriate measures can be taken (Parra *et al.*, 2017). An agricultural company can measure its land, calculate the density of cultivation and control the growth and development of its plants and animals. The drones give the farmer an extra pair of eyes – much like satellites that monitor fields and pastures, and control agricultural machines with GPS signals (Fernandez, 2016).

Farming data play an outstanding role as its appropriate use can improve the production process and logistics, and at the same time sustainability, climate change adaptation and mitigation (Kamilaris *et al.*, 2017). However, the benefits of a data-driven agriculture can only be used if the necessary measures can be derived from the data. Surely, the data gets vast (Yao *et*

al., 2018) and farmers are not always able to analyze very large amounts of data without significant assistance. It is more likely to happen if the support is conditional on the adoption of BDA (Big Data Analytics) tools like machine learning or data mining (Ghosh, 2016; Van & Ryan, 2018; Rajeswari *et al.*, 2018). Then, FMIS (Farm Management Information System) and DSS (Decision Support Systems) can be the basis for successful information exploitation. After having all necessary information, using FMIS and DSS, it is possible to analyze and make them available in a useful form to the agricultural entrepreneur to improve the decision-making process and the farming system as a whole (Zaza *et al.*, 2018; Paraforos *et al.*, 2016). This means that farmers will be offered with choices that solve the problems regarding to production process and environmental impact (Fig. 2).

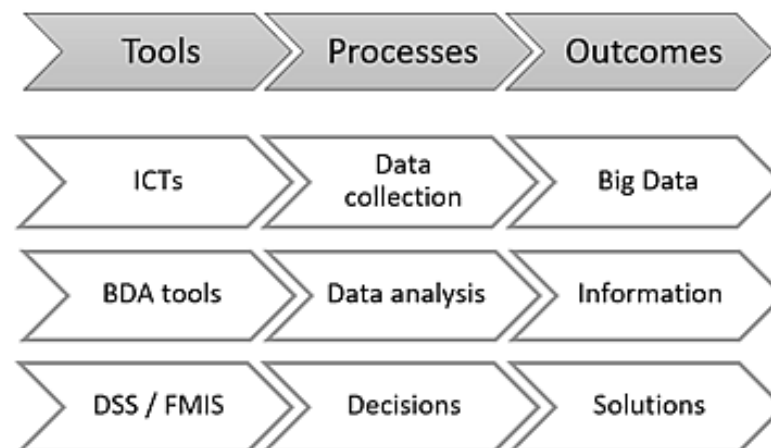


Fig 2. Data towards innovative solutions. Source: our processing

With the other words, ICTs provide farmers with enormous amount of data. The skills to analyze them exceed the human brain capacity. So, there is a need of specific tools for BDA that transform this enormous data into useful information. Then, DSS can provide particular choices for individual cases taking into account as productivity as environmental impact.

On the other hand, adoption of emerging technologies is quite costly and requires high initial investments. Not all smallholders are able to pay such a high price in machineries (Yigezu *et al.*, 2018). Therefore, there is a need of the investments aimed at the modernization and digitization of the companies and the processing of agricultural products. It will increase commercial value of the products and support the improvement of the supply chains, aggregating and strengthening the production phase, increasing the competitiveness of the producers (Bazzani & Canavari, 2013; Carbone, 2017). Indeed, many Italian regions use the measures useful for the development of technological and sustainable innovations for the improvement of products and production processes and for the promotion of food products (Frascarelli, 2012; La Sala *et al.*, 2017a; La Sala *et al.*, 2017b).

3. A model of successful ecosystem for agriculture sector

The data are becoming the capital of agricultural suppliers. They help to optimize offers and develop tailor-made products and services (Tripathy *et al.*, 2014). By sharing the data, knowledge and experience as well, additionally with targeted policies and relevant investment in the field, successful and sustainable agriculture sector will be developed (Rickard, 2015; Barakabitze *et al.*, 2015). So, for successful agriculture, it is essential that the relationship among actors be maintained, as agriculture is complex, individual processes depend on each other and a good return is associated with perfectly organized and efficient work steps (Teddell, 2016; de Olde *et al.*, 2017; Baker *et al.*, 2016). Therefore, the future-oriented aids, described in the previous sections, require a legal basis and relevant investment too (Barnes *et al.*, 2019; Koutsos & Menexes, 2019; Yigezu *et al.*, 2018). So, a farm success is seen at the center of a triangle between technology, collaboration and knowledge, strengthened by regulations and

funds (Fig. 3). Here, the government has a remarkable potential to foster innovations by making targeted policies and investments. On the other hand, government can play an important role to promote the technological advances and increase awareness of its importance in the country as a whole (FuJun *et al.*, 2018; Seeman *et al.*, 2007). In this way it is more prospective that more bodies will be involved in the process of sustainable development and will make investments for financial or environmental interests.

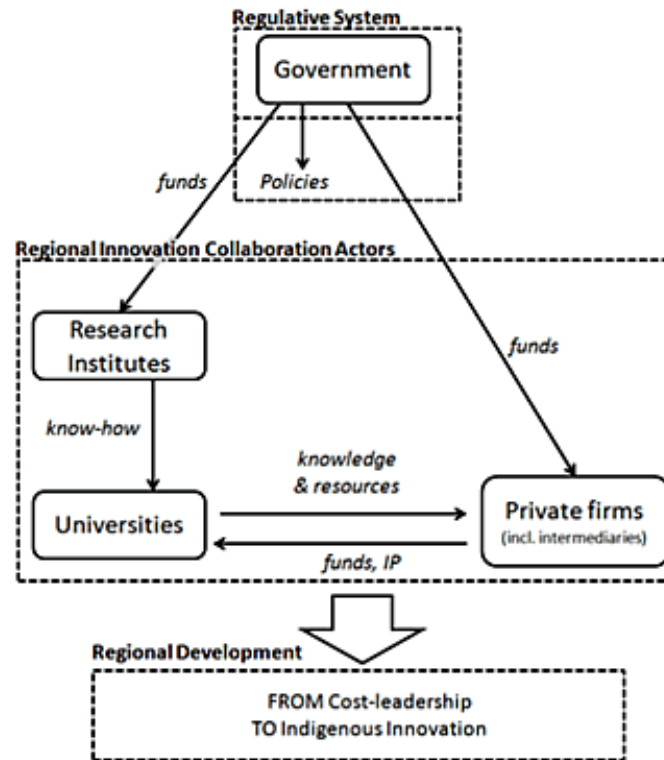


Fig 3. Conceptual model of regional innovation collaborations. Source: Zhao *et al.*, 2014

Regarding these necessities, Zhao *et al.* (2014) offer the model of innovation collaborations (Fig. 3). The model shows collaboration scheme where government regulates the policies and makes investment in research and private firms. These two are exchanging knowledge and funds. At the end, the system results in high innovative outputs instead of just cost leadership position.

Based on the idea of this model, we have reconstructed the “successful ecosystem for agriculture sector” model (Fig. 4), giving remarkable importance to the adoption of information technologies. Similarly, to the model of Zhao, we describe the ecosystem where government plays a crucial role by creating targeted policies, funding research activities, producer companies of information technologies and their adopter farms, so, making contribution in the development of emerging technologies. Research institutes and universities, on the other hand, provide knowledge that together with technologies and thanks to the collaboration of the actors and information/knowledge sharing, is a basis of farmers’ success.

In addition to Zhao’s model, we consider that promotion of emerging technologies, their adoption in agricultural practices and their role regarding sustainability issues can play remarkable role to increase awareness in profitability of their adoption in the sense of environmental and financial benefits (Mah & Yeo, 2014; Dong, 2007). This may cause increased interest of farms and private companies as investors.

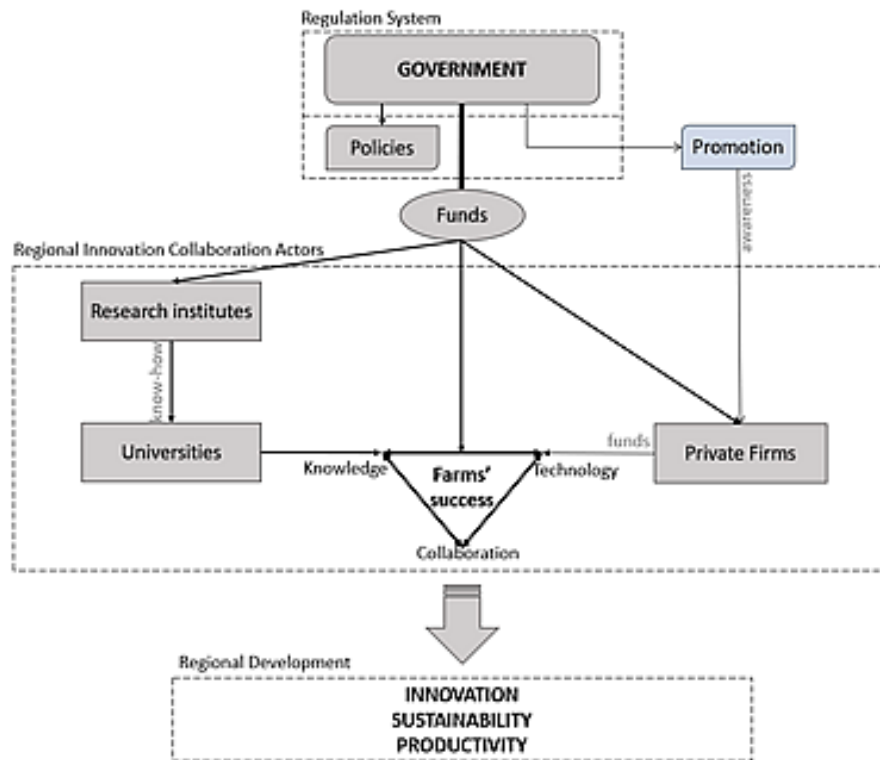


Fig 4. Model of successful ecosystem for agriculture sector. Source: our processing

The ecosystem that functions as described in the model, if all actors and stakeholders collaborate with each other, will result high innovation, productivity and sustainability in agricultural processes. Thus, instead of limiting with cost-leadership strategy, the farms will have an opportunity to move the focus towards indigenous innovations as it happened in the case of Zhao *et al.* (2014).

4. Results and discussion

Nowadays, the main trend that can be outlined is the increasing demand for safe and quality products allied to the environmental impact of agri-food sector, which is linked to the performance of supply chains. This trend leads to search for trust-based and alternative food networks and to identify visionary leadership with more effective collaborations between key stakeholders in both the public and the private sectors (Blom-Zandstra *et al.*, 2016) aimed at improving production process and contemporary at promoting sustainable impact (Bazzani & Canavari, 2013). Indeed, strengthening of the partnership enhances stakeholders providing them the contractual force and the market power (Cantarelli, 2016; Alho, 2015), which resulted in the ability to meet consumers' needs (Bojar & Drelichowski, 2008). Literally, strong network of key actors of agri-food supply and close collaborative relationships between public or private players, provide the industry with the ability to match demand and supply in an effective way. Additionally, stakeholders reach higher performance and greater results when acting collaboratively rather than in isolation (Simatupang & Sridharan, 2002; Sacchi *et al.*, 2018).

It is more likely to achieve afore-mentioned result if trust-based collaborations are promoted by regulations and Local Development Plans (LDPs). Governments can direct all the solutions to the specific circumstances of the local areas and to ensure that the necessity of territory and sector will be met (Kotu *et al.*, 2017). Furthermore, governments play significant role to promote new trends and to encourage the training of labour force regarding the requirements of modern market. Social capital, in turn, is a crucial factor for economic development (Fischer, 2013; Casieri *et al.*, 2010; Simatupang & Sridharan, 2002).

Moreover, in order to be able to keep agricultural operations up to date and as effective as possible, farmers in both upstream and downstream sectors require data regarding agricultural

issues, latest market developments and diverse farming methods (Kamilaris *et al.*, 2017). Knowledge became the key strategic element for competitiveness. In the era of information economy, the Information and Communication Technologies (ICTs) combined with data management are powerful tools (Ghosh, 2016; Van & Ryan, 2018). They gain information from the huge amount of data generated by the Precision Agriculture Technologies (PAT), such as environmental sensors, Unmanned Aerial Vehicles (UAVs), satellite images, etc. and analyse it (Rajeswari *et al.*, 2018). The agricultural working environment has recently been heavily affected by technological advancements, such as the use of electronic systems and data transmission. More precisely, being able to retrieve satellite imagery would allow stakeholders to monitor the territory and to plan how to use the landscape in order to avoid undesired results (FAO, 2015). Because climate change heavily influences agriculture and country operations, easily accessible digital tools get monitor forest cover, land use patterns and data changes over time, have growing potential for wide use. Consequently, the PATs give the opportunity to gain vast amount of data about agricultural practices, analyse them, share between stakeholders and make strong network of the key actors in agriculture sector. However, it is not easy for all smallholders to adopt to emerging technologies, since they are quite costly and requires high initial investments (Yigezu *et al.*, 2018). Therefore, the financial contribution of public and private sectors become crucially important.

5. Conclusion

The advances for sustainable agricultural production and overall process efficiency, largely depend on the advancement of agricultural research and on the implementation of effective strategies as well as on relevant policies that would be used in firms through innovation and technology transfer. Innovations such as the Internet of Things, Cloud Computing and Big Data are revolutionizing agriculture. Having access to supporting technology and establishing effective trust-based communication between farmers, researchers and policy makers are crucial for the overall process efficiency (Tesdaell, 2016). Collaboration is the main driving force for economic growth in the last century (Weaver, 2008) as it enhances innovation capacities of the network members (Kühne *et al.*, 2015). These circumstances underline a need for the effective agricultural policies that would lead the technological innovation and collaboration and information/knowledge exchange between key stakeholders. The agricultural policies that include collaborative activities between public and private players, farmers, suppliers, consumers and researches, will encourage the progress of agricultural processes. Therefore, a much more effective result that could be created is all three participating parties working on a unanimous solution for an effective policy that would boost the agricultural productivity (Baker *et al.*, 2016). Thus, the solution would be used towards improving the challenges with increased food production, effects of climate change and environmental factors. It needs to be emphasized that the increase in investments in agricultural research and interest in development of ICT, helps ICT and data management to progress in a refreshing way.

Based on the model proposed in the paper and consequently on the literature reviewed, authors elaborate several recommendations for the government:

- It would be very helpful for the industry if stakeholders had access to the necessary information, for instance, by establishing open data sources containing detailed information about agricultural practices;
- The government can increase the general awareness of the population about the benefits of IT and promote it in this way;
- The government can support the adoption of IT by financial aid;
- Establishing different grants for applicable research projects would have strong impact on the industry: it would increase the scientific knowledge; the projects may contain training activities for human capital; and the results of the projects will be useful for the industry.

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