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DIGITALIZATION IN THE AGRICULTURAL SECTOR

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Abstract: The agricultural sector has never ceased to innovate, and each generation brings new technological and organizational improvements, as well as new skills. However, the accelerated pace of technological innovation is faster than ever, and it is crucial for European farmers to fully benefit from this "digital revolution". The challenge lies in truly understanding the added value of these technologies, in deciding which ones are worth investing in, when to make these investments, and to what extent. In the European Union (EU), the "digital transformation" already plays an essential role in rural environments and in the agricultural sector. For example, the adoption of modern agricultural technologies, including those involving robots, the Internet of Things (IoT), and big data analysis, has significant potential to lead to more productive, sustainable, and environmentally friendly food production. Smart farming systems can assist farmers in making better decisions and developing more efficient operational and management practices.
Keywords: digitalization, agricultural sector, ICT, clound computing, environmental policies

INTRODUCTION

Information and Communication Technologies (ICT) are reshaping the world we live in. "Cloud computing," "Internet of Things," location–based monitoring, "social media," "blockchain," and "big data" represent unprecedented technologies and innovations that have led to innovative business models across multiple industries. These technologies are rapidly integrating into agriculture and food supply chains, spanning from the agricultural machinery industry and food processing to logistics, retail, and even consumers when it comes to food and health applications. These innovations encompass new business models and will likely bring about new changes in the organization of the entire agri–food chain, (*Anshari, M. et al, 2018*).

This has been acknowledged through the Cork 2.0 Declaration, "A Better Life in Rural Areas," which develops policy guidelines for innovative, integrated, and inclusive rural and agricultural policies. The Cork 2.0 Declaration has laid the foundation for facilitating digital transformation in agriculture and rural areas. It underscores the need for investments to harness the potential offered by connectivity and digitization in rural regions. Additionally, it emphasizes the importance of fostering research and innovation is essential to ensure that businesses in rural areas, including farmers, have access to appropriate technologies, state–of–the–art connectivity, as well as new management tools to bring about economic, social, and environmental benefits. Furthermore, as part of the strategy for developing the Digital Single Market, on April 19, 2016, the European Commission (EC) launched the Communication on "Digitising European Industry" (COM(2016) 180), the overall aim of which is to ensure that "every industry in Europe, big or small, wherever and in whichever sector, can fully benefit from digital innovations to enhance its products, improve its processes, and adapt its business models to the digital transformation, (*Stoian M, Aniței M. 2019*)." This requires the full integration of digital innovations across all sectors of the economy, including the agricultural and food sectors.

In the realm of product innovation, existing products (such as agricultural machinery) become much more data–intensive in terms of collection and utilization through the aid of ICT applications.

From a certain perspective, we can say that the hardware or offered product transforms into a service. This model is favored by tractor and agricultural machinery manufacturers, as well as producers of milking robots or developers of greenhouses and animal shelters, (*Stoian M, Aniței M. 2019*). Examples include agricultural machinery companies like the American company John Deere, which gathers data from the agricultural machinery sold to farmers. This encompasses the machines' locations, engine hours, operational data (such as fuel usage), and machine diagnostics. All the data is collected in the web portal MyJohnDeere.com. Another example is the Dutch company Lely Industries, which produces milking robots and

collects data regarding the performance of each cow.

In such a model, the data collected through ICT applications is exchanged between (for example) farmers and food producers in order to enhance the service component of the transaction. Examples demonstrate that software can be provided by agricultural product processors to support farm management while simultaneously improving the production or marketing processes of the food company. The UniTip software of the Dutch sugar cooperative Cosun is an example: farmers can record their field data in the cooperative's software (*Stoian M, Aniței M. 2019*). They subsequently receive management advice and indicators for measuring the economic performance of the farm.

At the same time, cooperatives utilize the data obtained through these applications to organize their logistics, production planning, and marketing (since it can provide customers with sustainability data). In this example, the pressure from the food and beverage industry for sustainable on–farm production methods led certain cooperatives to decide to make ICT software mandatory for their members by 2019, (*Birner, R. et al, 2021*).

Short supply chains that directly link consumers to farmers have many attractive characteristics for both parties. This can mean lower prices, better traceability, a better understanding of how products are obtained, increased sustainability, and contribute to the development of local communities, to name just a few of their advantages. Agricultural shops and farmers' markets are classic ways of organizing short supply chains. An extremely successful and interesting example comes from Finland. REKO is a system of direct sales from producers to consumers. It is incorporated into Facebook, where volunteer administrators manage closed Facebook groups with producers and consumers as members. Such groups are very easy to establish (from the perspective of the necessary information and communication technology): a group is formed, farmers post their offers weekly, and consumers use the commenting option on Facebook to place orders, (*Donaldson, A. 2022*). Orders are delivered to a central point and at a specific time interval for pickup and payment (for example, Saturday mornings between 10:00 and 11:00 at the local school's parking lot). Existing retailers are often happy to allow the transfer of products to their own parking areas, hoping that this will lead to consumer visits to their store for other products, (*Deng, H.Y. et. 2022*). The characteristics of this solution are that it's completely free for everyone (both producers and consumers), requires very little administration, and there are no intermediaries. By utilizing an established social media tool, there are no costs for developing and maintaining an ICT application. Three years ago, REKO launched two projects in the western part of Finland. It went well, and now there are more than 130 projects (REKO circles), with a total of over 180,000 involved members. The estimated turnover is 30 million euros annually. The initiator, Thomas Snellman, has received several awards for his initiative. This example shows that not always the technology itself, but the aspect of social innovation, creates new opportunities with a data–driven business model.

In a value chain integration business model, activities within an existing chain are organized through ICT in an alternative way, as the availability of data makes decision–making at a different point in the chain more efficient. An example is prescriptive agriculture, where a portion of the decision–making process is shifted from the farm to software at a different level of the value chain. A European example in the realm of services is the Dutch–Flemish breeding cooperative CRV, which assists dairy farmers in their insemination decisions for cows. While traditionally the farmer estimated whether a cow was in heat and ready for insemination, sensors have taken over this detection. CRV has developed an application that not only signals this status but also suggests semen from three possible bulls, and the delivery is done automatically, (*Fountas, S. et al, 2020*).

MATERIAL AND METHOD

Business models that create value from data by establishing new value networks essentially represent platforms that connect different customer groups and support their interaction. There is often an element of co–creation: the data from one group triggers activities of the other group and vice versa. Sometimes these platforms have strong network effects: it's attractive for users to join a platform where other customers have already subscribed, as seen with platforms like LinkedIn or Facebook. In agriculture, several platforms have been created that form ecosystems of applications. European examples include 365Farmnet and Akkerweb. Another example is the EU project FI Space (Future Internet Collaboration Space), now

available for commercial exploitation, offering a collaboration platform between enterprises that could connect platforms like MyDeere.com, 365Farmnet, Akkerweb, Agriplace, and others through an open–source model like Linux. Several EU FI–PPP accelerator projects such as SmartAgrifood, FINISH, and Fractals utilize this platform (*Klerkx, L.; et al, 2019, Stoian M, Aniței M. 2019*).

We are certainly aware of the issues facing Romanian agriculture, such as the fragmentation of agricultural lands, property disputes, the subpar state of agricultural infrastructure and irrigation systems, and the precarious state of mechanization. However, the purpose of this essay is not to detail these problems, but to propose a few steps to encourage farmers to adopt ICT solutions that can enhance the economic performance of farms.

The emergence and adoption of biosensors, nanotechnology, low–cost electronics, the Internet of Things, and remote sensing devices, among others, increase the importance of business models based on these technologies. However, it is clear that in the case of Romania, we are still in the early stages. We have the opportunity to connect existing initiatives by bringing interested parties closer together. This provides people with the chance to discuss, test, and enrich their ideas as they meet with other members of the community. Below are a few important principles to consider, (*Hackfort, S. 2021*).

Certainly, I understand that you do not wish to detail the specific problems of Romanian agriculture but to propose steps to encourage farmers to adopt ICT solutions to enhance farm economic performance. Let's delve further into this topic:

To encourage farmers to adopt ICT solutions that can improve farm economic performance despite specific challenges, you can propose the following approaches:

- Raising Awareness of Advantages: Education and awareness are essential. Encourage farmers to understand the benefits they can gain by adopting ICT technologies, such as increased yield, resource efficiency, and making more informed decisions.
- Governmental Support: Encourage the government to provide financial support or incentives for farmers adopting ICT technologies. This might include grants for equipment purchases or training programs.
- Partnerships with Universities and Research: Collaboration with higher education institutions and research centers can help develop and tailor ICT solutions to the specific needs of Romanian agriculture.
- Information and Communication Platforms: Establishing information and communication platforms within agricultural communities can aid in sharing knowledge and experiences related to using ICT technologies.
- Demonstrations and Awareness Events: Organize practical demonstrations and awareness events to show farmers how they can use ICT technologies in their daily activities.
- Sharing Successful Case Studies: Share success stories where farmers have successfully implemented ICT solutions and achieved positive results in terms of productivity and economic performance.
- Support Groups and Networks: Encourage the formation of support groups and networks of farmers who share common interests in adopting ICT technologies. These groups can provide support, advice, and resources.
- Access to Financing: Facilitate farmers' access to financing for acquiring ICT technologies through programs offering low–interest loans or partnerships with financial institutions.
- Testing and Evaluation of Solutions: Organize testing and evaluation programs for ICT solutions in collaboration with farmers. This can help identify the most suitable solutions for each farm's specific needs.
- Promotion of Collaboration: Incentivize farmers to collaborate in the use of ICT technologies. Sometimes, costs can be reduced through joint equipment purchases or knowledge sharing.

In conclusion, adopting ICT technologies in agriculture requires an integrated approach that combines education, government support, and collaboration among different stakeholders to ensure an efficient and beneficial transition for both farmers and the industry, (*MacPherson, J. et al. 2022, Stoian M, Aniței M. 2019*).

RESULTS

New business models based on ICT applications and sensors are being implemented in agriculture and the food supply chain. They greatly increase the amount of data collected and available in agricultural sectors and throughout the supply chain (from farm to fork). The emergence and adoption of biosensors, nanotechnology, low–cost electronics, the

Internet of Things, and remote sensing devices, among others, will further enhance the significance of the data domain.

The government can provide support for agricultural innovators in many ways, from (financial) support for beginners to research projects whose results can be utilized in commercial applications, to establishing innovation hubs in agriculture that offer farmers the opportunity to discuss, test, and enrich their ideas while engaging with other members of the agricultural community, (*Namani, S. et al., 2020*).

A primary opportunity would be to include agriculture in the national strategy for the digital agenda as one of its most important pillars. The JASPERS study "Analysis and Evidence Base of the R&D&I Market in Romania" identified agriculture as one of the four economic sectors with the highest development potential in our country.

Access to appropriate IT infrastructure is a fundamental aspect. An extensive broadband network that reaches all rural areas, including remote ones, access to powerful servers, the development of technology competence centers, and other physical infrastructures are basic requirements. Without investing in infrastructure, the opportunities for capitalizing on information technologies are significantly limited, which is why these types of investments need to be treated as a priority. Possible paths to follow could include supporting the development of new ICT tools for agriculture, promoting innovation and cooperation, as well as facilitating investments, (*Runck, B.C. et al, 2022*).

For financing specific innovative actions, the EIP–AGRI is implemented through initiatives primarily supported by two EU policies: the Rural Development Policy and Horizon 2020. The funding, implementation, and prioritization of actions occur through the implementation mechanisms embedded within these respective policies. Operational Groups (OGs) are key entities that operate within the EIP–AGRI framework. These groups bring together farmers, agricultural advisors, researchers, businesses, and other relevant stakeholders (such as civil society, including NGOs and governmental bodies).

The European Commission provides a high degree of flexibility regarding the size, composition, and specific commitments of OGs. An Operational Group must develop a plan that describes the proposed project and the expected outcomes. Additionally, OGs are required to disseminate the results of their projects, particularly through the EIP–AGRI network.

The exact content of a project plan depends on the involved actors and the issue, challenge, or opportunity that needs to be addressed. An innovation broker can help identify innovative ideas and assist partners in connecting and forming an OG around concrete projects.

Within Horizon 2020, two new instruments have been developed to support EIP–AGRI projects: multi–actor projects and thematic networks. The key feature of multi–actor projects is to address the needs, issues, and opportunities of end–users and generate the necessary interaction between researchers and end–users, such as farmers/producers, agricultural advisors, and businesses, by assigning distinct roles to different actors within the project.

The renewed interest in agricultural innovation policies (both at the EU, national, and regional levels) is undoubtedly commendable, as it focuses on a crucial determinant, if not the most important one – the long–term competitiveness of our agricultural enterprises. However, this interest doesn't always follow an adequate approach concerning the fact that much of the evidence and beliefs related to innovative processes in agriculture, considering the past, are susceptible and may risk losing relevance in today's times or at least are relevant for defining an appropriate strategy, (*Ruan, J.H. et al, 2020*).

The last century has been characterized by a remarkable growth in agricultural resource productivity. In the latter half of the past century, global agriculture experienced significant performance growth. Over the past 50 years, yield per hectare increased by nearly 150%, agricultural labor productivity by nearly 75%, and total factor productivity by about 55%, (*Wolf, S.A et al., 1996*).

In this process, those forms of knowledge, informal and gradually spread tacit innovative processes, constituted the real engine behind the "miracle" of productivity growth in the last century. Besides the primary challenge of the past century, the ability to produce enough food for a growing population in both number and consumption levels (food security), there remains another key issue: this challenge can only be won today under strict conditions, (*Shepherd, M et al., 2020*). The main condition is that of compatibility with the environment, or more precisely, sustainability. The second condition is that of multifunctionality.

The agriculture of the future will necessarily have the capacity to produce, in addition to food, other public non–food goods and services or collective interest services. Of course, among these are environmental services that lead us back to sustainability, but especially in affluent and post–industrial societies, agriculture is also needed to produce landscapes and aesthetic values, cultural and recreational services, physical and mental health, increased well–being, and more. We are the guarantor, as the first link in the food supply chain, of food safety and food quality, which means we ensure the safety, nutritional, ecological, and ethical quality of food, as well as their origin and provenance. However, sustainability and multifunctionality require a generation of knowledge and innovations of a different nature than the conventional challenge of food security, (*Subaeva, A.K. et. al. 2020*).

The process of innovation must, therefore, be redesigned to address these challenges and capitalize on the opportunities presented by ongoing technological changes. This reorganization can be managed through the progressive emergence of a genuine technological paradigm and the new technological trajectories that stem from it. The emerging General Purpose Technologies (GPTs), which are already dominant, or at least highly promising for future development (ICT, microelectronics and nanotechnology, modern biotechnology, neuroscience, robotics, advanced materials, photonics) have a potentially as broad application in agriculture as those of the last century, but with a substantially different nature (*Walter, A., 2016*).

CONCLUSIONS

An important goal in modern agricultural practices is that production should become less intensive and more integrated into systems aimed at reducing the use of fertilizers, pesticides, and especially minimizing the consumption of natural resources (water, soil, energy). The primary objectives of these systems should be to sustain both crop yields in quantitative and qualitative terms, preferably maintain or enhance agricultural income, and minimize the negative impact on the environment as much as possible.

Agriculture, a highly significant sector in our lives, couldn't remain disconnected from IT. If you asked a farmer 10–15 years ago whether they used a computer, now the absence of a computer and the lack of software applications for their agricultural activities is inconceivable. Currently, we talk about IT in agriculture in three main directions: as a tool for agricultural productivity, as an information tool for decision–making in agricultural and related activities, and as a tool for managing and ensuring subsidies and funds for agricultural modernization.

Currently, in agriculture as in any other field, the efforts and trends are focused on enhancing agricultural efficiency, and this is made possible thanks to new technologies. These new technologies encompass the construction of machinery used in various agricultural activities, the provision of high–performance inputs adapted to new climate conditions, and notably, the delivery of IT solutions that facilitate operations in this sector. The European Union also places special importance on this direction, providing support and programs. All of these efforts aim to help farmers produce more while ensuring the quality of food.

IT practically finds its way into each of the above–mentioned directions, and the term "precision agriculture" encompasses all of these aspects. A simplified description of precision agriculture is to "apply the right treatment in the right place at the right time". It is a concept based on observing, measuring, and responding to variability within agricultural crop management or aspects related to animal husbandry. Additionally, another frequently used term is IoT (Internet of Things), which essentially involves using the internet to connect all devices, in this case, that can add value in the agricultural domain.

To achieve high performance in agriculture, you need to combine diverse information gathered from various sources: field data, soil maps, weather information, humidity levels, pests, vegetation indices, planting recipes, and more. For each of these aspects, there are software solutions available, ranging from simple to complex, to assist farmers. To address all of these challenges, farmers have started seeking solutions that can integrate all this information. Initially, there were separate applications addressing specific aspects, but now integrated solutions are in high demand. Moreover, due to the rapid evolution of technology, such applications need to be optimized for mobile devices, such as phones and tablets.

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