NEW TECHNOLOGIES AS A DRIVER OF CHANGE IN THE AGRICULTURAL SECTOR

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A B S T R A C T

Faced with a demographic boom, enormous urbanization and a lack of agricultural land, traditional agricultural production is losing pace with new needs and demands. Due to the increased demand for food, efforts are being made to develop technologies that would improve production, with the sustainable use of existing resources. Solving this challenge is possible by introducing Internet of Things technologies, satellite navigation, mobile communications and ubiquitous computing, which is called smart agriculture. The main goals of smart agriculture are to increase yields (provide information needed to analyze and make decisions that will maximize yields), efficient water use, more efficient agricultural operations (automation of daily activities, real-time monitoring, advanced analytics, daily and seasonal forecasting), cooperation with suppliers and public administration are more efficient and take place in real time). This article highlights the potential of the Internet of Things, big data and drones in agriculture, as well as the challenges of applying these technologies in relation to traditional agricultural practices.

Introduction

According to estimates and with an accuracy of 95%, the global population in 2050 will be between 9,4 and 10,1 billion (WPP, 2019). To feed so many people, food production should increase by approximately 70% by 2050 (FAO, 2017). Modern agriculture faces several challenges, the most pronounced of which are the extraordinary population

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growth, environmental degradation, lack of natural resources, reduction of arable land, climate change, and declining productivity and profitability. Because agriculture is a significant sector in every country's economy, the traditional methods used for decades to produce food today cannot meet the greatly increased needs.

The accelerated development and adoption of technologies in the 20th and at the beginning of the 21st century and the way in which they are changing our lives and the environment is not a new phenomenon. However, many advances in biology, quantum theory, electronics, computing, communications, and materials science are relatively new. Deciphering the human genome, measuring gravitational waves, producing micro-integrated circuits, developing the internet, and mass adoption of personal computers and smartphones have mostly happened in the last 10 to 30 years. Certainly, artificial intelligence, machine learning, the IoT, sensors and blockchain, are just some of the examples of new technologies (Radic, 2020; Teodosijevic Lazovic, 2020).

Technology has provided a new landscape, in which businesses that adapt are well-placed to thrive. Businesses that are slow to adapt or are inflexible to change risk compromising their own productivity, ultimately jeopardizing their business' viability. We examined key trends facing agribusiness, outlining the potential ramifications and opportunities, that will create lasting effects in the supply chain for decades to come.

The goal of applying new technology in agriculture is to increase yields, reduce harvest times, reduce costs and environmental impact. The new age implies the use of technologies, applications and solutions implemented in the concept of Industry 4.0, which radically transform the production capabilities of all industries, including agriculture (Bonneau, Copigneaux, 2017). The integration of new technologies with modern agriculture results in better production and easier supply chain management. The basic applications of digital technologies in agriculture are so-called sensor technologies, such as meteorological stations on parcels, humidity sensors and soil scanners, yield mapping, satellite and drone images, the IoT and big data analytics.

These include precision farming and robotics, which enable optimal sowing, fertilization and crop protection, precise irrigation, precise weed control and automated harvesting, and, finally, predictive and prescriptive analytics, which enable correct decisions to be made based on sensor data.

The importance and potential of digital technologies became very visible during the crisis caused by the corona virus. Procurement of raw materials, consulting or direct connection of producers and consumers have become more complicated than ever, and with digitalization they could be significantly improved in agriculture after the end of the corona virus pandemic. Solving this challenge on a global level is possible by introducing IoT, satellite navigation, mobile communication, and computing.

As in other sectors, there must be conditions in the agricultural production sector that will ensure the efficient use of digital technologies. This primarily refers to the necessary infrastructure and connectivity, accessibility, educational level of future users of these technologies and support of institutions. Although the introduction of digital technologies in rural areas allows small farmers to connect with suppliers and enter the market, great challenges have been faced. With the migration to urban areas, the number of inhabitants in rural areas is decreasing, so the progress in the field of education is limited. The biggest problem is, of course, the lack of IT infrastructure and the high costs of establishing it in remote rural communities. Finally, taking into account developing and least-developed countries, high poverty rates are a particular challenge and a kind of limitation in the implementation of digital technologies (Cowie et al., 2020; Trendov et al., 2019).

The goal of the paper is to review empirical research on the adoption of new technologies in agriculture, and to present the possibilities and limitations of IoT, big data, and Unmanned Aerial Vehicles (UAVs) in agriculture context. The research methodology includes formulating of review, research questions, selecting relevant papers for review, and extracting useful information from those papers. Finally, the conclusion and suggestions for future work follow. The main research questions were:

- What are the advantages of applying digital technologies in the agricultural sector?
- What are the limitations of using these technologies?
- What are the current challenges and future expectations?

Literature review

The importance of technology for the development of society is immeasurable because technology includes all activities that create some value as a result, regardless of whether it is a product or a service. Technology contains knowledge, expertise, as well as ways to use factors of production to create products and services for which there is economic and social demand. Therefore, any breakthrough in one area of technology has a direct consequence of their application in another area. The need to apply new technologies in agriculture is not in question.

The need for technological development in agriculture, new technologies and their adoption by farmers are key drivers of maintaining the competitiveness of agriculture in the global world. After the application of digital technologies within the agricultural sector, as part of the Industry 4.0 concept, the term “Agriculture 4.0” has recently been attributed to it, and research activities and advancements have persistently enhanced over the years.

One area of information technology that has been developing rapidly in recent times is the Internet of Things (IoT). IoT technologies allow you to connect more users, devices, services and applications to the Internet. Devices connected to other devices and applications can exchange data directly and indirectly with each other. End users access this data via the web and mobile applications, configure device configurations, and manage and maintain IoT systems. IoT is defined as a global network infrastructure that enables the connection of physical and virtual devices with interoperable communication protocols and intelligent interfaces. The infrastructure consists of three basic components: smart devices, the network infrastructure for connecting them, and systems that use data generated by smart devices. The structure of IoT can be divided into three layers: hardware, infrastructure, applications and services (Gubbi et al., 2013).

An intelligent device is an instrument or machine with the properties of a computer. Its main feature is that it can communicate with other devices in the environment and perform intelligent operations. Such a device must have power, memory, processor and communication interface. Smart devices can be powered via the electricity grid, batteries, solar panels, etc. The memory of smart devices allows storing data from sensors and performing operations for which devices are programmed. The IoT device consists of input / output interfaces for sensors and actuators, an interface for internet connection, an interface for storage and memory and an audio and video interface. IoT devices include: sensors (for monitoring the status and notification of changes in the environment in which they are located), actuators (which based on detected changes in the environment through management actions perform physical activities), modules (which allow receiving commands in a particular environment), microcontrollers with built-in memory, clock and hardware for connecting to external devices), microcomputers (which have a microprocessor, memory and input-output devices on one chip).

Technologies used for the development of the Internet of intelligent devices are: network technologies and protocols, sensor networks, mobile technologies, cloud computing and big data. Mobile technologies that have contributed to the development and application of the Internet of Intelligent Devices are mobile telephony and mobile Internet networks, Bluetooth, RFID, WiMAX, Global Positioning System (GPS), Near Field Communication (NFC), ZigBee and others.

With the development of mobile business technologies, IoT and social media, the amount of data stored in the information systems of organizations (companies, companies, firms) is increasing. Requirements for the development of advanced e-business applications, which are characterized by reliability, distribution and scalability, cannot be realized using traditional databases. That is why new approaches are being developed for storage, fast search and analysis of large amounts of data in real time, based on big data technologies. The need for big data technologies is often explained by the use of three "V" models, according to which the main characteristics of big data are: data volume (Volume), data diversity (Variety) and speed (Velocity).

In the professional literature in the last few years, numerous authors have published papers related to IoT, intelligent devices and the concrete application of IoT in agriculture. These papers provide an overview of the concepts, infrastructure and technologies used to develop smart environment management applications, present solutions based on data collection from sensors on soil, temperature, humidity, pH, nutrients, pests, and the possibility of establishing a link between crop, weather and equipment data for efficient irrigation, reproduction and optimal livestock nutrition (e.g. Yadav et al., 2015; Forkan et al., 2015; Ribarics, 2016; Stubb, 2016; Nandyala & Kim, 2016; Ingale & Jadhav, 2016; Nalini & Suvithavani, 2017; Kamath et al., 2019; Khanna & Kaur, 2019; Rao et al., 2019; Shafi et al., 2019; Zikria et al., 2019).

Other authors point to big data analysis techniques and their application and suitability in different areas of agriculture (e.g. Hilbert, 2016; Rajeswari et al., 2017; Al-Kathani & Karim, 2018; Wolfert et al., 2018; Kumar & Menakadevi, 2018; Asghari et al., 2019; Sarker et al. , 2019; Tseng et al., 2019; Li et al., 2015; Li et al., 2019; Liu et al., 2019; Farooq et al., 2019). A special segment in the field of sensors is the establishment and integration of wireless sensor network (WSN - Wireless Sensor Network), which dealt with Anushree & Krishna (2018), Toth et al. (2019) and Rasooli et al. (2020) etc. Of course, a large number of generated and processed data requires their storage and uninterrupted access, which is coupled with the security aspect and the possibility of misuse or theft of such data. This segment of information technology has long been the focus of many experts and researchers, who recommend different methods, techniques and solutions (e.g. Stergiou et al., 2018; Hussein et al., 2020; Shang et al., 2020; Zhang et al., 2021).

Internet of Things in agriculture

The advent of new and better sensors and IoT has led to significant changes, such as automation of management, surveillance of protected areas and facilitated cultivation. IoT enables remote management, achieving greater efficiency, accuracy and reducing costs, saving time, especially if agricultural land is far away. IoT is a technological revolution, and it represents the future of computing and communications. Its development depends on technical innovations in many areas, from wireless to nanotechnology. Li et al. (2105, 2019) state that the basic concept of IoT is to sense the physical world by connecting physical objects with each other, which is based on different identification and tracking technologies that allow remote monitoring of these physical objects without the need to be in line-of-sight (Xu et al. 2014). As more and more physical objects are equipped with remote sensing and controlling devices, it is possible to continuously monitor the status of a specific physical object or its environment (Madakam et al., 2015).

Dramatic climate change, especially rapid depopulation, air, water and land pollution, increasing urbanization and shrinking agricultural land, and unprecedented demographic shocks have contributed to the technological transformation of the agri-food sector in recent decades. This refers not only to the automation and application of machines with new possibilities, but also to the greater use of digital technologies, especially IoT. In this way, farmers can gain better control over agricultural land, take corrective action and achieve desired yields. According to marketing estimates, the use of IoT in agriculture is expected to reach 20.9 billion dollars by 2024 (Chui et al., 2021). This is mostly influenced by increased demand, wider acceptance of IoT and related technologies by farmers, as well as the desire to increase the efficiency of agriculture.

Smart agriculture gathers data from the field frequently and accurately, combined with external sources (e.g., weather information, environment conditions, etc.) and administrative documents from the food chain (invoices, laboratory results, etc.). The combined collected data is analysed and interpreted, and insights are generated to support the farmers to make better decisions. These decisions can then be applied by using robotics and advanced machinery, and farmers can monitor in real-time the processes and get feedback. Technologies used include sensors, communication networks, edge computing, platforms, unmanned aerial systems, artificial intelligence and IoT as the pivotal technology for the future. Table 1 shows some of the benefits of using IoT in the agri-food sector.

Table 1. Benefits of IoT in the agri-food sector

1.	Collect data using sensors and IoT devices to track agri-food processes, equipment efficiency, fertilisers needed, and ensure uniform quality of the food.
2.	Sustainable cost management and waste optimisation using efficient control over production by identifying anomalies in crop growth or livestock health, to mitigate risks.
3.	Improving the functioning of the food chain by making farm data available to other actors and trigger consumers to buy more sustainable food.
4.	Process automation during the production cycle using IoT, digital technologies and platforms (e.g., fertilization, irrigation, pest control).
5.	Effective control of production processes to maintain high quality and volume of products.
6.	Accelerate the transition to sustainable fair food systems with a neutral or positive environmental impact, and ensure food security, nutrition, public health, preserve affordability of food while generating fairer economic returns, and promoting fair trade.

Source: Project “Internet of Food and Farm 2020”, EU, 2021.

The benefits of ensuring the successful development, deployment, and use of IoT solutions in the agricultural sector are quite apparent. It makes sense from an economic point-of-view (greater growth within the industry, increased productivity, reducing long-term costs, and costly waste). It is also very clear from an environmental perspective (reduce climate emissions, less food waste, less herbicide, and pesticide use [through greater optimisation], and improved yields, and a reduction of plant and animal disease through early detection). IoT solutions should be promoted and ensured through effective policy, supportive regulation, and incentives.

Technological limitations (Table 2) were a major inhibitor for adopting and implementing IoT solutions. These limitations were wide-ranging, and require a concerted effort between policymakers and technology providers to overcome these difficulties. Examples of use IoT in EU countries have identified many technological and regulatory differences between countries, such as bandwidth, internet access and IoT solutions. The lack of rural connectivity, poor or costly internet access, or interference with connectivity, proved to be one of the greatest challenges. Rural areas, where most of the agriculture activity is concentrated, have been traditionally underserved in terms of connectivity services. This represents a serious bottleneck for the development of digital agriculture and the uptake of its benefits (Ryan et al., 2021).

Table 2. Technological limitations IoT

1.	Transnational and national policymakers need to find greater convergence on regulation to ensure easy, effective, and mutually beneficial transitions between borders, allowing easier adoption of new agricultural IoT technologies.
2.	There needs to be clear policy to support technological innovation and adoption through economic incentives, advice, integration, and education.
3.	Implement sufficient internet connections in rural areas, ensuring fast, widespread, and reasonably priced availability. Ensure that rural areas have sufficient mains/electricity for IoT connectivity, promote an awareness of this availability, and education of how the sector can benefit from cloud-based services and online business channels.
4.	Make specific policy efforts for fair access to, and education of, technology to avoid the "digital divide" and information asymmetries. The digital divide is caused when there are those who benefit from, have access to, and can use digital technologies, while others cannot.
5.	Technology standards and the use of performance standards need to be set, along with policy decisions including holistic consideration of benefits, costs, effects of digital technologies, climate, re-use, and recycling. The technology itself must be robust and reliable, achieved through independent testing facilities to ensure they are effective.

Source: Project "Internet of Food and Farm 2020", EU, 2021.

Efficient use of IoT and digital technologies in agriculture depends on enabling technologies, connectivity infrastructure, edge computing processing and data collection. However, among all the above parameters, in the agri-food sector, the most important is the connectivity. Connectivity requires low-cost IoT networks that are easy to set up, support multiple devices, and provide superior real-time data performance. Only with the fulfillment of these requirements can it be expected that the advantages of advanced IoT implementation will be used in the best way.

Agriculture is expected to be one of the sectors that will be extremely affected by progress in the IoT domain (Tzounis et al., 2017). The main advantages of using IoT in agriculture are higher crop yields and lower costs. Gralla (2018) states that yields on the average farm using IoT increase by 1.75%, the cost of energy used decreases from 17 to 32 dollars per hectare, and the use of water for irrigation decreases by 8%.

Potentials and problems of using drones in agriculture

Unmanned aerial vehicles (UAV) or Unmanned Aerial Systems (UAS) are aircraft of various shapes and sizes, which can be remotely controlled or can fly autonomously. Drones are made of lightweight composite materials to reduce weight and increase the ability to change position. Due to the use of composite materials that have high strength, they can fly at extremely high altitudes. In principle, they can be equipped with a wide range of navigation systems or recording devices (RGB and infrared cameras, GPS). In addition to low weight, the advantages of using drones are that they are easy to transport, they can take high-resolution images, change the flight altitude depending on the needs of data collection, they can move on terrains that are not accessible to off-road vehicles. In addition to the above, the most important feature is the availability of data in a short time interval (Simelli & Tsagaris, 2015).

The UAVs are characterized by small dimensions, portability, as well as the possibility of quick and easy installation in the field. In agriculture, UAVs show unlimited potential and they are used to processing of photographs and obtain a significant amount of information on the condition of crops on agricultural land. They are used for chemical protection, sowing and fertilization. The UAVs can also be used to monitor the condition of crops and mapping production areas, classification of plants on production areas, monitoring the occurrence of diseases and pests, detection of areas where stress occurred in plants due to excessive water or other factors, detection of areas where perform watering or drainage, assessment of plant biomass, as well as monitoring of weeds present on production areas (Zhang & Kovacs, 2012).

It can be concluded that there is a wide range of activities in agriculture that can be implemented using UAVs, which include soil analysis for field planning, crop monitoring, crop spraying, irrigation, crop health assessment, crop surveillance, controlling weed, insect, pest and diseases, tree / crop biomass estimation, and scaring birds (Kim et al., 2019; Pathak et al., 2020).

With the help of cameras with different characteristics installed on unmanned aerial vehicles, it is possible to generate 2D and 3D high-resolution soil maps, based on which useful information on soil properties, crop condition, moisture content, soil erosion, stressed surfaces, etc. is obtained. The use of UAVS can reduce the use of pesticides and maximize efficiency by decontamination on a large scale (up to 50 ha per day), which requires only 10 minutes of work on 0.5 ha of surface. Thus, research in the field of unmanned aerial vehicles aims to reduce the need for physical engagement of farmers (Luck et al., 2010). For example, the Chinese company DJI, with a large share in the market of UAVs, launched the MG-1 model for spraying pesticides. The MG-1 has eight rotors, a payload of 10 kg and can spray up to 4 ha per hour, and automatically adjusts the required (lowest) amount of pesticides to flight speed (Kim et al., 2019).

For optimal production, crop monitoring is necessary, which in the case of large farms requires significant time and work. Therefore, it is proposed to monitor crops through unmanned aerial vehicles, which significantly reduce the working time. The UAVs, equipped with multispectral cameras and thermal sensors, can also be used to control irrigation. In the United States, pest infestations and infections cause damage of about 33 billion dollars annually, so early warning and diagnosis is necessary because the damage is spreading rapidly (Kim et al., 2019). Nebiker et al. (2016) conducted research on potato fields to infect and showed that high-resolution RGB cameras and multispectral sensors mounted on UAV accurately and quickly detect pathogens.

For example, in Xinjiang, the most important region for cotton production in China, cotton production takes place on areas of over 2,5 million hectares. Before the cotton is harvested in October, defoliants must be sprayed so that the harvested cotton does not contain impurities from the leaves. For this activity, local producers, apparently, use tractors, which can damage the land and 5-8% of the obtained amount of cotton. Lately, however, more and more farmers are turning to UAVs to do these jobs, because flying over areas with cotton UAVs does not cause additional damage. It is estimated that one UAV does the job as 60 farmers in one hour, which is a significant saving of time and labor costs. Since productivity measures the efficiency with which farmers use inputs to produce outputs, it is obvious that the use of UAVs increases productivity. Also, during 2019, about 4500 UAVs performed tasks on 65% of the cotton fields in Xinjiang, which increased the total cotton production in the region by 400.000 tons and resulted in an increase in revenue of more than 430 million dollars. Across China, there are over 50.000 agricultural UAVs in operation, which have sprayed with fertilizer and pesticides on an area of 30-33 million hectares of crops (Wang et al., 2019). The constant adoption of new technologies and practices enables farmers to increase the quantity and quality of agricultural products, use inputs and reduce production costs. Xia et al. (2017) cites the example of farmers in Australia who have reduced the use of inputs (including land, working capital) by approximately one percent per year in the last four decades.

The advantages of using UAVs are expressed in several ways. For example, the flight of UAVs is controlled from a distance by trained pilots, which eliminates direct contact of farmers with toxic substances. Secondly, on large areas with agricultural crops, farmers would have to work longer and get more tired, which reduces their efficiency. The UAVs do this in a shorter time, eliminating other delays in the field, because they can spray 20-40 ha per day, depending on the capacity of the UAV (which is up to 30 times larger than traditional sprayers with a backpack). Automation affects even spraying which reduces spillage and saves up to 30% of pesticides. The UAVs use ultra-low volume spraying technology, which saves 90% of water compared to traditional spraying methods. Since the work of farmers in traditional spraying is longer and requires intensive use of labor, the price of conventional spraying is affected by the number of farmers and the area on which they are engaged. The use of drones in this operation provides a lower cost of spraying by as much as 97%. The main characteristics of UAVs used in agriculture are ease of use, long projected service life, easy maintenance, availability and replacement of spare parts that are not expensive (Pathak et al., 2020).

Since UAVs are used in agriculture in only a few countries in the world (USA, Japan, China, Spain, Australia, Brazil, India, South Africa), examples of specific use are related to both technological and regulatory constraints. Technological constraints relate to the characteristics and specifications of UAVs (mass, materials, fixed wings or multirotors, application of different types of sensors, cameras and other equipment). Regulatory constraints apply to the legal framework defined by national aviation authorities (classification of UAVs into categories according to mass, altitude and speed, and range, obtaining a permit to fly, examinations for operators, etc.).

In addition to specific advantages, UAVs for application in agriculture also have certain limitations. The flight duration of UAVs, due to the higher carrying capacity (sensors, camera, accompanying equipment), ranges from 20-60 minutes, which is reflected in the lower coverage of the land surface in one pass. On the other hand, the price of UAVs that have the option of a longer flight is progressively increasing. The UAVs that are used in agriculture to record the land and the condition of agricultural crops are, most often, with fixed wings and their market price is around 25,000 dollars. The price of UAVs, of course, is influenced by the characteristics of sensors, cameras and accompanying equipment. The choice of UAV is similar to the choice of other machines, devices or tools used in agriculture. The farmer decides on a specific UAV based on his own needs (land area, type of agricultural crop, available finances and willingness to invest) and offered UAV specifications, their availability, maintenance costs and spare parts and prices.

A big problem facing farmers is online coverage, which is mostly unavailable on arable farms. In such a situation, farmers who intend to use UAVs must invest certain financial resources in the connectivity infrastructure and procure UAVs that have the ability to store data in an appropriate format.

The problem that is already present is the availability of appropriate software for receiving, storing and processing data (information). Software is an integral part of the application of UAV in agriculture, because a large number of individuals and companies are engaged in creating programs of specific capabilities. Sometimes, in addition to online access, it is necessary for the farmer to receive real-time data on the condition of land and crops, all with the aim of applying preventive and corrective measures to prevent damage. Sensors, cameras and software are market goods, the price of which is influenced by many factors. However, the farmer must be sure that the data obtained from the UAVs are accurate and that they reflect the real situation on the ground (Ampatzidis et al., 2020). The reasonable assumption is that the average farmer does not have specialized knowledge and skills for processing the collected data, so he must train or hire qualified staff for such activities.

As in other areas of computing, in the phases of data collection and processing, there is the problem of information security, illegal downloading or violation of privacy (Gupta et al., 2020; Pathak et al., 2020).

The biggest problem in the application of UAVs in agriculture is related to weather conditions. In conditions of rain or fog, as well as strong wind, cameras and built-in sensors on UAVs cannot provide images of the required and sufficient resolution, and obtaining reliable data. This requires waiting for the weather to improve, repeating the flight, and re-collecting (and later processing) field data (Simelli & Tsagaris, 2015).

Conclusions

The era of new technologies and intensive development of new models and methods of production and work has largely affected all types of industrial production. We are witnessing the fourth industrial revolution and the great breakthrough of computers, sensors and smart devices in everyday life. We are also witnessing an unprecedented demographic boom, industrialization and urbanization, dramatic climate change and its consequences. With the growing population, the requirements for providing food in terms of quantity and quality become even more urgent. The only solution to such challenges is to grow crops in a smart and precise way. The industrial development of the new age also affects the agricultural sector and enables a new evolution in the digitalized industry. In that sense, new information and communication technologies can make agricultural production more efficient. This includes the development of new technologies and solutions in the field of micro- and nanoelectronics, signal processing, artificial intelligence, IoT, big data, robotics, satellite crop monitoring. By applying advanced methods of machine learning and artificial intelligence, it is possible to analyze large amounts of data and extract new knowledge about agricultural production and crop development. This knowledge, further, is used to answer practical questions, crucial for agricultural production. In accordance with the concepts of precision agriculture, it is possible to give recommendations for fertilization, irrigation and application of pesticides, which ensures proper plant treatment, risk reduction, increased yields and, above all, resource savings (seeds, fertilizers and pesticides).

Agriculture, without a doubt, is the oldest form of business, and the advancement of technique and technology has a huge role in its development and improvement (Luković et al., 2021). The main benefits that digital technology provides to agriculture are sustainability, knowledge and efficiency. When we talk about sustainability, we mean not only productive, but also environmental and social. Knowledge means more awareness of the dynamics of internal processes in production itself, supply chains and competition. Efficiency means reduced costs, shorter operating and production times, better management control and higher productivity.

Digitization of agriculture means the evolution of precision agriculture achieved by collecting, integrating and analyzing data from the field via sensors. In fact, digital agriculture is a set of tools, machines and strategies that enable farms to synergistically use interconnected advanced technologies in order to make production more efficient and sustainable. Digitization of agriculture is the only way to increase the competitiveness of agricultural production in a short time, because most other solutions to increase productivity work only after a long period of time. New technologies favor the optimization of resource use, and the world of agriculture needs intelligent equipment that allows everything to be more efficient in terms of sustainability.

Digitization of agriculture is a process that depends not only on those who create these innovations, but also on the users of these innovations, i.e. from the farmers themselves. Prejudices and mistrust towards the new, as well as the lack of desire for education related to the digitalization of agriculture must be overcome, and that is the basic precondition for facing one of the most difficult challenges of our time.

The proposal for future work refers to the analysis of the potential for modern digital technologies to be applied in agriculture in Serbia and to emphasize the need for wider involvement of scientific institutions in solving problems related to IoT infrastructure, connectivity, data collection by sensors or UAVs, etc.

Conflict of interests

The authors declare no conflict of interest

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