AGRICULTURE 4.0 - A CHALLENGE FOR ROMANIAN AGRICULTURE / *AGRICULTURA 4.0 – O PROVOCARE PENTRU AGRICULTURA ROMÂNEASCA*

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ABSTRACT. Given that the labor market in Romania has an acute shortage of labor (about 1 million people), in agriculture this lack is felt even more acutely because the population in the villages is declining and aging, thus it is increasingly difficult for Romanian farmers to find labor, let alone skilled labor. One solution can be the digitization of agriculture, ie the introduction of the latest management concepts, sensors, automation, robots, etc. in the modernization of work processes in agriculture, thus reducing the need for labor, while increasing productivity and efficiency in agriculture.

REZUMAT. *Având în vedere ca pe piaţa muncii din România există o lipsă acută de forţă de muncă (de aprox. 1 milion de persoane), în agricultură aceasta lipsă se face resimţită şi mai acut deoarece populaţia de la sate este în scădere şî îmbătrânită, fiind astfel tot mai greu pentru fermierii români să găsească forţă de muncă, fără a mai vorbi de forţă de muncă calificata. O soluţie o poate reprezenta digitalizarea agriculturii, adică introducerea celor mai noi concepte de management, senzori, automatizări, roboţi, etc. în modernizarea proceselor de lucru din agricultură, reducând astfel necesarul de forţă de muncă, concomitent cu creşterea productifităţii şi eficienţei în agricultura.*

INTRODUCTION

Digital agriculture seems to be a promising alternative for meeting the need for gains in management efficiency, enabling the correct allocation of resources and ensuring the development of people working in the fields.

Digitization will allow the collection of data through the Internet of Things, ie sensors, machines and drones that collect information in real time, which are then stored and processed in the cloud. Due to the detailed control of the data, resources will be made more efficient, such as reducing labor costs, observing and preparing for climatic conditions that interfere with production processes, monitoring the spread of pests and diseases and others [32].

Although labor is still sought in the agri-food industry, global uncertainty has led to a decrease in the recruitment of specialized personnel during this period, even though the number of agricultural employees has increased by 2-3% compared to last year.

Romanian agriculture in 2019 was over 40 billion lei, with a share of 4.1% of GDP, and representatives of banks, some of the main financiers in the field, say that farmers are more sophisticated than ten years ago, have high-performance equipment , work more organized and think about investments, thus being more bankable.

The big problem remains the staff deficit, of 25,000 people, ie 10% of the total, and the effects of this will be seen in ten years, when 50% of Romania's successful farmers (15,000 now) will retire and will have to be replaced either by a new generation, or the merging of the lands, so discussed, will become the optimal solution [33].

In the EU, Romania is the eighth agricultural power, as a value of the sector, but the low degree of technology condemns the country to the last place in terms of labor productivity. The study also shows that only 1% of agri-food enterprises in the country use industrial robots, Romania being, at this chapter, at the end of the ranking.

In Romania there are 18 industrial robots per 10,000 employees. Romanian agriculture has both pluses and minuses - with the balance tilted towards minuses. The share of gross value added in GDP places Romanian agriculture in first place in the EU. We are the 8th agricultural power as a value of the sector in the EU, but the low degree of technology sends us to the last place in terms of labor productivity, our country being almost 4 times below the EU average (in 2017). Romania is on the last place in terms of the share of human resources engaged in science and technology.

The inaco competitiveness initiative shows that only 1% of Romanian enterprises, active in the agri-food industry, use industrial robots - compared to the European average of 7%. The best performing countries in this field are Sweden (31%), the Netherlands (22%), Denmark (16%), Slovenia (10%).

In Romania, there are 18 industrial robots per 10,000 employees, ie 6 times less than the European average. In agriculture, industrial robots mean autonomous tractors / combine harvesters, supervised and coordinated by a single operator, using a computer. It also means smart machines that pick fruit or animal husbandry, which help feed and care for animals. And we must not forget the drones, which can monitor, herbicide or fertilize huge areas of fertilizer [34].

MATERIAL AND METHOD

In recent years, important steps have been taken towards precision agriculture - Agriculture 4.0. Important companies, foreign and Romanian, have developed digital solutions for measuring the amount of water in the soil or detecting the amount of treatments applied in the soil. But not only technological evolution forces us to keep up, but also the environment. Climate change affects us every year through prolonged drought for months, torrential rains and hail - sometimes devastating - or recent tornadoes in Romania [35].

In the Romanian context, technology serves both as a threat and as an opportunity. Given the fact that Romania's agricultural system brings only 4.5% of GDP, compared to 25% for the IT industry, there seems to be an extraordinary opportunity for growth. But the associated problems are complex. On the one hand, the predominantly small farm structure of the country, the fragmented ownership of the land and the low levels of mechanization are palpable barriers to the rapid change of the system. On the other hand, farmers cite the growing shortage of available labor as the main obstacle they face in staying in business, a challenge in which digitalisation and automation are obvious solutions.

However, these are not universal solutions. Rural labor may be declining, but paid employment opportunities are fundamentally important for many rural households, and automation replaces the type of repetitive tasks that generate valuable rural income - albeit small [36].

The agricultural sector needs to enter the digital age due to the growing demand for agricultural products. The introduction of new technologies helps farmers to manage their farms in a sustainable way. Innovative technologies can range from IT solutions to culture systems.

The introduction of new information and communication technologies in the agricultural sector could significantly contribute to its future viability as well as to the quality of life for farmers and consumers. Innovations will improve the quality of plant production, the quality of animal health, but, essentially, the quality of life for farmers.

Innovation must be driven by farmers in order to meet their needs and must be involved at an early stage in research processes. This is crucial for the future of rural areas. Farmers never stop innovating. Each generation brings new technological and organizational improvements. Farmers themselves generate innovative solutions that often go unnoticed by the public. There is a huge amount of hidden knowledge that needs to be revealed and used effectively and more should be done here. Collaboration is the key to innovation. Collaboration is particularly relevant when it comes to opportunities in digital agriculture, where technologies need to be tailored to the needs of users.

The first step in innovating and adapting technologies is research. The development of new products, processes and practices always involves repeated testing both in laboratory conditions and in the field.

There are many different techniques and technologies that can be applied to agriculture. These include:
- crop improvement, biotechnology (including genetically modified organisms);
- GPS (global positioning systems);
- GIS (geographic information systems),
- planting, processing and spacing technology, water management and irrigation;
- Agricultural cyber-physical systems (ACPS);
- Cloud Computing;
- Internet of Things (IoT);
- Artificial Intelligence (AI) and Machine Learning (ML); - Big Data;
- Robotic and autonomous systems;
- Drone, etc. [12].

RESULTS AND DISCUSSIONS

Existing approaches in the agricultural sector seek to take advantage of innovative smart technologies that offer technological solutions at all levels of agricultural production, which makes it possible to develop an end-to-end farm management structure that self-optimizes in the context of agriculture 4.0 which can be easily organized and used by all stakeholders involved. Some key technologies that are particularly significant for Agriculture 4.0, together with their capabilities and effects for the benefit of sustainable farm management, are presented below [11]:

- agricultural cyber-physical systems (ACPS) are based on the constant integration of physical components and computational algorithms. Recent advances in cps allow autonomy, usability, scalability, adaptability, resilience, and security that go far beyond the attributes of integrated systems. Agricultural cybernetic-physical systems (ACPS) address the application of agricultural operations in particular to materialize more sophisticated fms (farm management systems) [1]. Acps are able to constantly monitor, with high efficiency, various fundamental characteristics of cultivation (ie: temperature, humidity, soil moisture, plant health, etc.) through sensory devices, which are deployed spatially in the field, usually in wireless networks [14, 16] and thus control the operations of agricultural installations in an automatic way [7, 21].

Because Agriculture 4.0 provides an effective field for the development and application of ACPS, this technology is considered to be able to provide an effective way to change workforce performance, optimize the safety, flexibility and reliability of field activities, and applying the production of a high quality yield at a lower cost [25]. In this way, ACPSs are expected to promote efficient farm management accuracy in terms of both system issues (ie functionality, efficiency, reliability, etc.) and end-user requirements (e.g., user-friendliness, graphical interfaces), versatility and powerful user, reliability and robustness of communication, etc).

- cloud computing, often referred to simply as "cloud", is a technology that was launched in the early to mid-2000s [3] to provide hardware, software and computing resources delivered as a service through a network private or public, such as the internet. In particular, cloud computing integrates a seamless system capable of delivering on-demand computing services to end users by combining high computing power, storage, and network technologies in terms of load and reuse balance [3, 29].

Considering that agricultural environments tend to generate large amounts of heterogeneous sensory data corresponding to huge storage spaces, while, in addition, the development of sophisticated smart infrastructures is constantly increasing the demand for more complex smart services [26], the performance of such operations on local servers could lead to a lack of scalability and inefficiency of fms.

Given that cloud computing is an information and communications technology (ICT) that provides centralized storage and processing power, along with the availability of services on demand, it is considered deliberate to transfer data processing and storage operations from local infrastructures. to distributed cloud environments to facilitate the management of such extremely large amounts of agricultural data, thereby improving the time for processing and generating information, as well as expanding the capacity to provide complex, specialized services for FMS [4]. In this regard, the incorporation of cloud computing technology works for the benefit of sustainable farm management, as it denies the need for expensive computing resources, while facilitating the management and dissemination of information to effectively support decision-making on critical cultivation issues.

- The Internet of Things (IoT) can be semantically defined as a global network of unique addressable objects, which are interconnected based on standard communication protocols, such as the Internet [2]. Consequently, the Internet serves as a storage and communication infrastructure that incorporates representations of virtual objects that integrate information relevant to physical objects. In this context, virtual objects serve as hubs of information about centralized objects, continuously updating and combining data from a wide range of various sources, so as to control any necessary process remotely via the Internet [2, 9].

IoT Farm (AIoT) indicates a promising framework in line with the Agriculture 4.0 Guidelines, through which various farm-related data can be acquired, processed, managed and disseminated as a mechanism through which a diverse range of systems and services can be achieved perfectly. integrated into FMSs [13, 28]. Such systems will be able to:

- successfully manage various growing real-time data flows;
- manage various incomplete and, in some cases, contradictory data;
- obtain, correlate and merge data in real time;
- dynamically affect the behavior of the network in order to change the rules for data acquisition, routing or recording;
- facilitate the detection activity organized by the ability of individual network nodes to reason, operate and collaborate in a collective framework, recognizing the coexistence of both individual and common objectives, by adopting distributed and multi-intelligence approaches -agents.

Consequently, aiot is considered to be an indispensable technology for smart farms, while its development in relation to the future internet approach provides a basis for a new generation of farm management information systems, enabling entire smart farms to become active nodes in agricultural value chains.

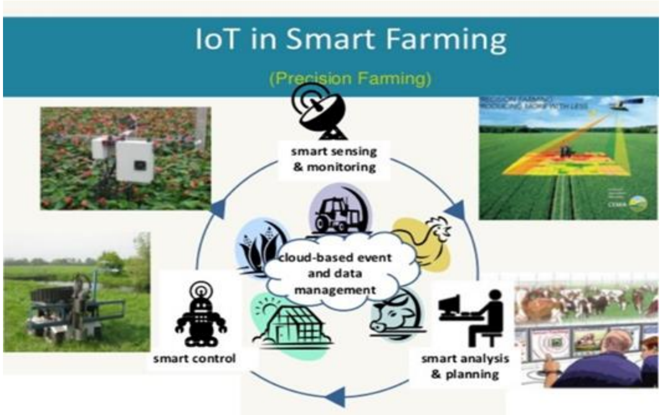

Fig.1. IoT in smart agriculture [39]

- Artificial intelligence (AI) and machine learning (ML). Agriculture faces many challenges as it is characterized by uncertainty in various operations, such as seed sowing, pesticide control, weed management, crop disease infestations, lack of irrigation and drainage facilities or even lack of storage management. To enable efficient risk management, reduce prediction costs in decision-making, and subsequently improve agricultural accuracy and increase productivity, artificial intelligence (AI) and machine learning (ML) techniques offer intelligent software applications. and systems capable of performing knowledge activities, operations involving subtle judgments, and unstructured commands [15].

Because agricultural environments are characterized by huge amounts of information, several levels of data extraction and various feature selection techniques, such as classification and grouping, are needed to obtain the exact content value for heterogeneous data. Data fusion classification techniques, in particular, can be widely used in multisensory environments aiming at merging and aggregating data from several heterogeneous distributed sensors (such as those deployed in agricultural fields), in order to obtain a lower probability of error detection and higher reliability. For this purpose, FMSs may use various AI-based methods, such as Artificial Neural Networks (ANNs), C5.0 classification algorithms, Bayesian fusion, and Hidden Markov Model (HMM) methods, while in some cases, unsupervised learning may also apply. Moreover, clustering, as an exploratory technique of data analysis, is widely used to identify subgroups (clusters) in data depending on the similarity or diversity of data points [17, 5].

AI-based technologies help to improve efficiency in all areas and also manage the challenges facing various industries, including various areas of the agricultural sector, such as crop yields, irrigation, soil content detection, crop monitoring, weeding, harvest establishment. Agricultural robots are built to provide a high value AI application in that sector. With the growth of the global population, the agricultural sector is facing a crisis, but AI has the potential to provide a much-needed solution. AI-based technological solutions have allowed farmers to produce more with less input and even improved the quality of production, while also ensuring faster market entry for the crops obtained. By 2020, farmers will use 75 million connected devices. By 2050, the average farm is expected to generate an average of 4.1 million data points each day. The different ways in which AI has contributed to the agricultural sector are as follows:

- Skills and workforce: Panpatte (2018) said that artificial intelligence makes it possible for farmers to collect large amounts of data from public sites, analyze them all and provide farmers with solutions to many ambiguous problems, as well as to provide a way to smarter irrigation, which results in higher yields for farmers. Thanks to artificial intelligence, agriculture will prove to be a mixture of technological and biological skills in the near future, which will not only serve as a better quality outcome for all farmers, but will also minimize losses and burdens. for work.

- **Maximize the result:** Ferguson et al. (1991) said in his wok that variety selection and seed quality set the maximum level of performance for all plants. Emerging technologies have helped the best selection of crops and even improved the selection of hybrid seed options that are best suited to the needs of farmers. It was implemented by understanding how the seeds react to different weather conditions, to different types of soil. By collecting this information, the chances of plant disease are reduced.

- Farm chatbots: chatbots are nothing more than virtual conversation assistants that automate interactions with end users. Artificial intelligence chatbots, along with machine learning techniques, have made it possible to understand natural language and interact with users in a more personalized way [27].

- **Big Data** is changing the scope and organization of agriculture, as it is used to provide predictive information in agricultural operations, to make real-time operational decisions and to redesign processes [10]. Significant issues, such as improved efficiency, food security and safety, climate change and sustainability, will be addressed through Big Data applications. In this respect, the objectives of Big Data applications extend far beyond agriculture, but cover the requirements of the entire supply chain related to sensor deployment, benchmarking, predictive modeling and risk management in terms of Agriculture 4.0 guidelines [6, 8].

Big Data technologies play a key and reciprocal role in this development: machines are equipped with all sorts of sensors that measure the data in their environment, which are used for the behavior of machines. This ranges from relatively simple feedback mechanisms (e.g., a thermostat that regulates temperature) to deep learning algorithms (e.g., to implement the correct crop protection strategy). This is capitalized on by combining with other external Big Data sources, such as weather or market data or landmarks with other farms. Due to rapid developments in this field, a unifying definition of Big Data is difficult to give, but it is generally a term for data sets so large or complex that traditional data processing applications are inadequate. Big data requires a set of techniques and technologies with new forms of integration to reveal information from data sets that are diverse, complex and on a massive scale.

Big Data is the information assets characterized by such a high volume, speed and variety to require specific technology and analytical methods to transform it into value. The Data FAIRport initiative emphasizes the more operational dimension of Big Data by providing the FAIR principle, which means that data should be found, accessible, interoperable and reusable (Data FAIRport, 2014). This also implies the importance of metadata, ie "data about data" (eg time, location, standards used, etc.) virtual conversation assistants that automate interactions [23].

Fig.2. Big Data în agriculture [38]

- **Robotic and autonomous systems** are generally extremely complex, as they consist of different subsystems, which must be properly integrated and synchronized to perform tasks perfectly as a whole and to successfully disseminate any necessary information. This type of integration is essential for accounting cycles and delays, as well as for the communication characteristics between all subsystems [24].

Robotic and autonomous farming systems, which perform various field tasks such as sowing, pruning, phenotyping, targeted fertilization, harvesting and sorting in automated or near-automated ways, are even more complex and sophisticated because they have to operate in unstructured agricultural environments. to facilitate the workload of farmers, increase productivity rates, advance soil health and yield quality, and optimize resource management [19, 22]. In order to successfully integrate robotic systems into agricultural processes, the following significant issues need to be addressed:

- ✓ Problems, such as ever-changing conditions and variability in agricultural production and the environment, as well as harsh environmental conditions (ie dust, vibration, extreme temperature and humidity), must be overcome by developing appropriate equipment and intelligent systems so that to achieve a successful operation in such environments.
- ✓ The costs of robotic systems must be taken into account in FMS, so as to achieve the practical use of different types of robots and to penetrate more widely into the agricultural sector. In this respect, the costs of robotic systems must be reduced enough to justify their use economically, as agricultural products have a relatively low value. In order for autonomous systems to be suitable for unsupervised operation in open fields, the inherent safety and reliability issues must be overcome, as the protection of people, the environment, crops and machinery is still mandatory [11].

Agricultural robotics is a promising solution for digital agriculture and for managing the problems related to unemployment and declining profitability. Initial tests with one of the latest technologies available for automatic harvesting (the Harvey robot) have already shown a success rate of 65% and a detachment rate of 90% for harvesting sweet peppers in the actual planting scenario where there are no leaves and fruits (these being cut or removed). Robot field agents that independently monitor and collect data provide producers with real-time detailed information about their crops and farms, revealing upstream images for real-world decision-making. The agricultural robot takes agricultural practices into a new phase, becoming smarter, detecting sources of variability in the field, consuming less energy and adapting its performance to more flexible tasks.

The trend in food production is towards automated farming techniques, agro-compact agricultural cubes and cultivation systems that have the minimum human interface in which skilled labor is replaced by robotic arms and mobile platforms. In this context, digital agriculture has integrated new concepts and advanced technologies into a single framework to provide farmers and stakeholders with a fast and reliable method of real-time plant-level observations (ie, field data collection and crop monitoring). and acting at a more precise level (eg diagnosis, strategic decision-making and implementation).

Figure 3 shows a conceptual illustration of digital agriculture and its relationship with agricultural robotics, which shows that data collected by robot agents is sent to a cloud consulting center for decision making. The actions are then implemented quickly and accurately by using robots or other automatic machines, sending operational updates and notification feedback to farmers and sections of the agricultural industry. This computer-robot communication system combined with sophisticated simulation software, analysis applications and data sharing platforms offers much smoother control over agricultural operations. In addition, it provides farmers with details of historical field data to improve performance and optimize crop yields for specific plots or even the development of new business models. [18].

Fig. 3. A conceptual illustration of digital agriculture and virtual orchards, with an emphasis on the role of agricultural robotics [31]

- ***The drones.*** The use of drones for precision agriculture is gaining momentum due to their ability to provide the most up-to-date information quickly and efficiently. The evolution of drone software and its general accessibility are also responsible for the increased application of drones [30].

Drones have emerged as one of the most promising technologies. The use of drones to monitor fields that investigate moisture and nutrient deficiencies in crops has massive potential for farmers, while highly advanced imaging equipment has details that are too subtle for the human eye to detect [12].

Agricultural applications of drones: Soil and field analysis: Drones can be essential at the beginning of the crop cycle. They produce accurate three-dimensional maps for early soil analysis, useful in planning seed planting models. After planting, soil analysis by drones provides data for irrigation and nitrogen level management.

Crop spraying: Drones can scan the soil and spray the right amount of liquid, modulating the distance from the ground and spraying in real time for even coverage. The result: increased efficiency with a reduction in the amount of chemicals that enter groundwater. In fact, experts estimate that aerial spraying can be completed up to five times faster with drones than with traditional cars.

Crop monitoring: wide fields and low efficiency in crop monitoring together create the biggest obstacle to agriculture. Monitoring challenges are exacerbated by increasingly unpredictable weather conditions, which lead to risks and maintenance costs on the ground.

Irrigation: Drones with hyperspectral, multispectral, or thermal sensors can identify which parts of a field are dry or in need of improvement. In addition, once the crop grows, drones allow the calculation of the vegetation index, which describes the relative density and health of the crop, and shows the amount of energy or heat emitted by the crop. [20].

Fig.4. Agricultural drone [37]

CONCLUSIONS

One of the challenges for Romanian agriculture is the adoption of new technologies and innovative practices. Solving this problem requires the support of Romanian institutions and associations, together with European experience in this sector. Some examples of such measures and solutions for the development of the Romanian agricultural sector are: implementation of LEADER measures; establishment of the National Rural Development Network and implementation of the National Rural Development Program; support for task forces set up under the European Innovation Partnership; organizing national and international conferences to accelerate the transfer of research results into practice.

Digital technologies will transform the agricultural sector in the coming years and will fundamentally reshape the agri-food value chain in Europe. Smart and digital agriculture has many promises for a more sustainable, productive and competitive EU agricultural sector. Innovation is not limited to a technical or technological dimension. It increasingly refers to strategy, marketing, organization, management and design.

Farmers do not necessarily apply "new" technologies: their innovations appear as a result of "different ways of thinking and different ways of doing things" and in recombining different knowledge in an innovative way. Innovation is both "problem solving" and "taking opportunities".

Romania needs agricultural innovations to support the resource base, communities, cooperation and solidarity of farmers. Scientific research could explain why / how some agro-ecological practices are effective. Cooperation between laboratory sciences, agronomy and farmers is vital, especially for improving their knowledge of natural resources for sustainable production methods.

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