BENEFITS REGARDING THE IMPLEMENTATION OF AGRICULTURE 4.0 IN THE CURRENT CONTEXT

TĂBĂRAȘU A-M.[1)], ANGHELACHE D.[1)], DUMITRU D.[1)]

[1)]INMA Bucharest / Romania;
E-mail:anamariatabarasu22@yahoo.com

Keywords: agriculture 4.0, sensors, IoT, microprocessors.

ABSTRACT

Agriculture 4.0 is comprised of different already operational or developing technologies such as robotics, nanotechnology, synthetic protein, cellular agriculture, gene editing technology, artificial intelligence, blockchain, and machine learning, which may have pervasive effects on future agriculture and food systems and major transformative potential.

This paper presents some considerations regarding the technologies used in agriculture 4.0, namely: cheaper and more accurate sensors and microprocessors, cloud and IoT improvement and the use of radio units for data transmission and analysis and processing of large volumes of data.

INTRODUCTION

Agriculture 1.0 refers to the traditional agricultural era, responding mainly to labor and animal forces. At this stage, although simple tools, such as sickles and shovels, have been used in agricultural activities, people still cannot escape heavy manual labor, so productivity has remained low. By the 19th century, steam engines had been widely improved and used to provide new power in all walks of life and industries, including agriculture. It reached the era of Agriculture 2.0, when various agricultural machines were hand-operated by farmers and a lot of chemicals were used. Obviously, Agriculture 2.0 has significantly increased the efficiency and productivity of agricultural work. However, this substantial improvement has also had harmful consequences: chemical field contamination, destruction of the ecological environment, excessive energy consumption and waste of natural resources. In the twentieth century, Agriculture 3.0 emerged from the rapid development of computing and electronics. Computer programs and robotic techniques have allowed agricultural machines to perform efficient and intelligent operations. Before the remaining issues in Agriculture 2.0 go too far, the strategies were adjusted in Agriculture 3.0. Reasonable distribution of works to agricultural machinery has reduced the use of chemicals, improved irrigation accuracy and so on.

Nowadays, the evolution of agriculture enters Agriculture 4.0, due to the use of current technologies such as the Internet of Things, Big Data, Artificial Intelligence, Cloud Computing, Remote Sensing, etc. Applications of these technologies can significantly improve the efficiency of agricultural activities.

It has been observed that Agriculture 4.0 has the potential to be disruptive and transformative in many ways. It can have a biophysical, economic and social impact on food security and nutrition, as well as on the ways in which agricultural production systems are designed and how they operate. It will also have implications for how agriculture is embedded in ecosystems and landscapes. In addition, it is possible to change the way agricultural supply chains work and the way products are made up of food producers, sold by retailers, bought by final consumers, and food waste is prevented [2,4].

Several authors see in Agriculture 4.0 technologies the possibility of creating a new “Green Revolution” and refer in this regard to the “Green Revolution 2.0” [1,8,9].

Some commentators consider Agriculture 4.0 as part of a Digital Agricultural Revolution that could eventually lead to “Agriculture 5.0”.

MATERIAL AND METHOD

The evolution of Agriculture 4.0 takes place in parallel with comparable developments in the industrial sector (Industry 4.0), based on an idea for future production. Agriculture 4.0, like Industry 4.0, represents the combined internal and external interaction of agricultural operations, providing digital information to all sectors and agricultural processes. Even in agriculture, as in the industrial sector, the 4.0 revolution is a great opportunity to take into account the variability and uncertainties involved in the agri-food production chain. Factories are becoming smarter, more efficient, more secure and more environmentally sustainable through the combination and integration of production technologies and devices, information and communication systems, data and services into network infrastructures.

Today, the technical equipment of farms has reached a level comparable to that of industries. The growing use of data heralds a digital agricultural revolution in agriculture driven by several innovations.

Advances in robotics have allowed for greater automation, and lower cost of sensor technology has allowed farmers to monitor factors such as soil properties and the movement of animals in near real-time circumstances. The computing power accessible in this condition has created new decision support tools (eg tractor dashboards and mobile applications) for better management practice.

Emerging Big Data analytics platforms, for example, cloud computing and machine learning algorithms, drive artificial intelligence and have supported a relevant increase in the volume, speed, variety and veracity of data generated in agriculture. Subsequently, agricultural data are rapidly becoming a major factor not only in production and food chain revolutions, but also in environmental management. Agriculture Technologies 4.0 refers to production systems that use robotics, sensors and Big Data analysis, allowing farmers to manage their farms at detailed spatial and temporal scales. Although precision agricultural technologies have been used for about a decade and normally take the form of yield monitors in robotic dairy farming systems and milking parlors, the pace of innovation has grown since the cost of sensors and robotics fell [7].

Wireless technologies are proving to be the most convenient solution in terms of energy consumption and the range of communications in agriculture. In particular, narrowband IoT (NB-IoT) is a new IoT system built on existing long-term (LTE) functionalities.

Digitization in agriculture is thus expected to ensure the technical optimization of agricultural production systems, value chains and food systems. In addition, it has been argued that it can help address societal concerns about agriculture, including the origin and traceability of food, animal welfare in livestock industries and the environmental impact of various agricultural practices. Digitization is also expected to improve knowledge exchange and learning, using ubiquitous data and improve monitoring of crises and controversies in agricultural chains and sectors. The international use of digital technologies in the last two decades has been most widespread in agricultural sectors, such as precision cultivation and viticulture and, to a lesser extent, in animal farming and there are high expectations regarding diffusion and its transformation potential [11].

Digitization can change the culture of agriculture from “practical” management and experience to a data-based approach [5]and can “discipline” the work routine of farmers. in certain ways, conditioned by “algorithmic rationality” [5].

RESULTS AND DISCUSSIONS

Big data technologies play a vital role in the digital agriculture revolution. During the period of digital agriculture, while machines are equipped with all sorts of sensors to measure the data around them, deep learning algorithms and machine behaviors can be generated as a result of analyzing this data.

"Big Data" means the processing of a massive amount of data collected from information, communications and technologies (ICT) and lead to rapid decision-making data to improve productivity.

As all data are available from the last decade in storage on the crop cycle, production issues, emphasizes that each farmer takes preventive measures with new tools in agriculture 4.0 for different conditions. Recently, in Industry 4.0, the development of a new machine learning technique defined as artificial intelligence (AI) is increasing the demands in various activities. This artificial intelligence (AI) used previously stored data to make decisions and the requirement of the agricultural sectors, with the preparation of the program of these activities.

The role of big data is one of change, probably the biggest change observed in agricultural operations in this century. Big data will make the whole chain more competitive and profitable, but these benefits will not only extend to those at the higher level. Farmers will be empowered through increased knowledge and precise advice given to them. Stricter specifications and traceability - made possible by data connectivity - will increase margins along the supply chain, while increasing quality to meet the requirements of local and international buyers. Increased visibility for all parties will lead to greater results and greater confidence, which in turn will lead to more consistent returns and increased profitability - amid better use of resources and environmental impact.

In recent years, there has been a steady increase in farm adoption rates for advanced data solutions in agriculture. The image of "Big Data is just for Big Farming" is finally starting to fade. More and more farms understand the value of being able to measure their performance, including variable rate pH control, variable rate nutrition, variable rate sowing, in-line quality sampling. Many farmers take an experimental and business-oriented approach to using solutions that work for them - testing and implementing an improvement at one time over several seasons.

Big data is not so much about the changes as it is about how we get there. Data is the means by which industry can take the next steps towards a more sustainable and profitable future.

Smart and informed decisions are the basis of all success. We could say that accurate information in the agricultural sector is obtained mainly from the nutrition of data provided by tools such as satellites, drones and soil mapping.

- Satellites. Some professionals in the fusion of agriculture and technology have developed VHR satellites that allow obtaining images with a spatial resolution of 3 meters (GSD). Visits can be made daily, and information is captured by a sensor built into an artificial satellite.

- Drone. For example the eBee Plus RTK / PPK drone equipped with multispectral and thermal cameras. It allows high accuracy and is able to achieve a resolution of 3cm / pixel in images. Its thermal and multispectral cameras are optimal for obtaining accurate data and farm characteristics.

- Soil mapping. It allows the detailed knowledge of 100% of the soil in which it is worked, as well as the identification of the variability of the textures, of the composition and of the structure of the soil. The information obtained through this designed technology allows the identification of the most suitable land and the efficient planning of planting, irrigation, fertilization and modifications.

- And last and most important, all the sensors installed in the plant and soil (humidity probes, dendrometers, temperature, pressure, etc.), which measure and control what really happens in certain areas of the farm [13].

Figure 1: Promised areas for agricultural improvements based on data [13]

The Internet of Things (IoT) has accelerated immensely in recent years, with smart devices becoming more widespread and able to share more and more. According to the Gartner research agency, a project of 20.5 billion connected devices will be used by 2020 - exceeding the number of people by 4 to 1.

The use of IoT farming devices is set to become the norm, not the exception, as mobile software becomes more and more interoperable (meaning that different applications are able to share and use the same data sets). This would mean the end of the introduction of the same data sets several times in different systems, significantly reducing the financial and time costs arising from human error. Farm sensors are already used to monitor soil nutrition, temperature, humidity and more. IoT means connecting all these systems together, eliminating the need to repeatedly enter data in multiple applications that do not talk to each other. In short, imagine a farm where all the useful information is unified automatically and smoothly, leaving the farmer to work with important work [12].

Recent research indicates that the IoT creates a value of $ 14.4 trillion in all companies. Adoption means smarter use of data along the agricultural supply chain, leading to better informed, more profitable and sustainable agricultural and food production.

Finally, another important challenge in adopting IoT in agriculture is the development of communication infrastructures in rural areas. Current wireless communications networks have been implemented with a B2C focus, with a strong focus on urban areas.

As we have seen, the ability to change and analyze data (often at the platform level) is the key to the success of Agriculture 4.0. Thus, communication networks will have to be developed in rural areas. The availability of wireless coverage in rural areas of Europe is about 40%, but with regional diversity still important, despite the use of the European Regional Development Fund (ERDF) and the European Agricultural Fund for Rural Development [7].

Connectivity and location (GPS) technologies optimize the use of these agricultural tools. Tractors can drive on their own, they can map the fields to a few centimeters, they can check their own movement, so as not to waste fuel, fertilizers or seeds. IoT also relies on the installation of sensors on instruments to enable precision farming (AP). Sensors monitor and control crop treatment, allow for significant gains in efficiency and productivity [10].

Fig.2. Sensors in tractors [10]

IoT (Internet of Things) is a simplification of the investigation, collection and general distribution of resources using sensors on materials and equipment. The sensors are located around the field with image recognition technology, which allows farmers to see their field or crops from anywhere in the world. The sensors provide real-time up-to-date information to farmers, so it will be easy to make appropriate changes to their crops. A special application (for example the FarmWave application) suggests when the plants will need water or another type of food. The IoT (Internet of Things) sensors in the field do the same thing, but on a larger scale, which leads to higher food production and less waste.

Weather tracking: Weather is an important factor for animals and crops. Sunlight, temperature and rainfall have major effects on crops. Weather forecasting technology is a science for predicting the state of the atmosphere in the future for a given location. Weather forecasting technology determines the weather condition that will evolve in the coming days by collecting data on the current state of the atmosphere, which includes wind, humidity and temperature, etc., this information being received from weather balloons, weather observations, satellites, weather stations and drones. The need to accurately predict the weather has therefore led to an increase in weather forecasting departments in almost all countries around the world. These departments are responsible for advising the farmer on the expected rainfall in a certain place, the temperature that will predominate in a certain place, the humidity levels, among many other aspects of the weather. The study and use of information provided by the forecast departments ensured that farmers make the appropriate agricultural decisions.

Fig.3. Climate monitoring sensors [10]

Agriculture and robotics: Like the use of artificial intelligence and robots in other industries, robotic technology improves productivity in the agricultural industry, leading to faster and higher yields. Such robots such as weeding and spraying robots (purchased by JohnDeere) can be useful for reducing agrochemical use by almost 90%. Camera and laser guided weeding robots are used to identify and remove weeds independently, without human intervention. This type of robot can be used as a guide to navigate between rows of crops independently, so that the workforce will be reduced. There is also a tested robot for plant transplantation, nut harvesting and fruit harvesting, which is effective in traditional methods [10].

Fig.4. Agriculture and robotics [10]

Blue River Technology: Blue River Technology is the next or next generation of smart agricultural equipment. Includes visualization and spraying technology, which allows the counting of each plant or crop. Farmers are currently facing weed control challenges, but the Blue River has a solution to this. Blue River sprays herbicides only where necessary. He sees each plant and sprays herbicides only on weeds and can avoid spraying chemicals on crops that are weed-free [10].

Fig.5. Blue River Technology - See and Spray [10]

Agricultural robots will operate in different fields, such as production, processing, distribution and consumption.

These robots distinguish the service atmosphere and provide intelligent work separately. The fourth revolution resulted in the use of robots in many agricultural equipment to select the right product and the correct distribution of pests to control insects.

This technique was also established with the air vehicle used to control health, with regular monitoring of fruits, vegetables and animals in agriculture. Robots specially designed in Agriculture 4.0 are used as follows: robot used in the open field in agricultural operations, such as water irrigation and crop cultivation, robot known as plant robot used to monitor crop yields and control agricultural activities, robot called animal robot used to take care of animals used in agricultural sectors. This revolution in the agricultural sector aims to increase productivity through automation, unmanned agriculture and the promotion of organic farming.

As in any industry, production efficiency requires automation and the elimination of problems related to human factors, which leads to a great interest in incorporating robotics into the agricultural industry. This has led to many technological and engineering challenges, which in turn have led to increased interest in research in the field of precision mobile agricultural robots and autonomous farming.

Drones

For years, drone supporters have cited precision agriculture - crop management using GPS and big data - as a way to increase crop yields while resolving water and food crises. Unfortunately, drones have not had a significant impact on agricultural practices, at least until recently. A lot has been happening lately about the applications of drones in agriculture and precision agriculture. From the ability to imagine, recreate and analyze individual leaves on a corn plant from 120 meters high, to obtaining information on the water retention capacity of soils for variable rate applications, agricultural practices are changing due to drones that provides agricultural information for both farmers and agricultural consultants [6].

Mid-season crop health monitoring: The ability to inspect crops growing from a height of about 100 meters using standardized plant difference indicators (NDVI) or non-infrared sensors (NIR) is, so far, the first application for drones in agriculture. This was a task traditionally performed by often reluctant college interns walking in the field with a notepad. Current generation drones allow you to cover a larger area in a much shorter period of time, as well as capture data that cannot be seen by the human eye (such as NDVI or near infrared).

Moreover, it eliminates much of the human error aspect of traditional inventory, although a physical inspection of an area of interest after viewing images is still recommended.

Monitoring irrigation equipment: Managing several irrigation pivots is fine, it is laborious, especially for large growers with many fields spread in a county or region. Once crops, such as corn, begin to reach certain heights, mid-season inspections of nozzles and sprinklers on the irrigation equipment that supplies much-needed water really become a thorough exercise.

Mid-field weed identification: Using NDVI sensor data and in-flight image processing to create a map of weeds, farmers and agronomists can easily differentiate areas of high-intensity weed proliferation from healthy growing areas right next to them. Historically, many farmers have not realized how pronounced the problem of weeds is until crops are harvested.

Variable-rate fertility: Although many will argue that ground inspections combined with satellite imagery, along with a dedicated soil sampling program, are more practical for refining nitrogen, phosphorus and potassium applications in agriculture, drones fit. A US drone service start-up company has used NDVI maps to target seasonal fertilizer applications to corn and other crops. Using drone-generated variable rate (VRA) maps to determine the strength of nutrient uptake in a single field, the farmer can apply 300 kg / ha of fertilizer in areas of difficulty, 200 kg / ha in areas of medium quality, and 150 kg / ha in healthy areas, lower fertilizer costs and increase yields.

Monitoring the number of cattle: Many farmers during periods of low commodity prices have resorted to diversifying their farms by adding cattle or pig operations. Drones are a solid option for monitoring top herds, tracking the amount and level of activity of animals in their own fields.

They are particularly useful for monitoring at night due to the inability of the human eye to see in the dark [6].

Agriculture 4.0 also has several advantages, namely [11]:

- The digitalization of agriculture depends on the production of new machines and tools. New production equipment can ensure high quality and productivity. Tractors are the basic vehicles for the agricultural industry. With GPS technology, the use of tractors can be optimized. Harvesting and planting would be much easier and fuel use would be much lower.
- Sensors on products can check productivity and protect sensitive products.
- Data collection, use and data sharing are the advantages of Agriculture 4.0 to increase productivity.
- Ability to collect data and measure soil quality, weather conditions and insect level, etc.
- Increased crop productivity;
- Reduction of production losses;
- Reduction of expenditure on agricultural inputs (fertilizers, pesticides);
- Reducing the damage to the environment with the greatest precision in the use of fertilizers and pesticides;
- Reducing the time for fulfilling the tasks of soil preparation and cultivation;
- Reducing water consumption for irrigation;
- Possibility of task automation;
- Greater facility for monitoring operations and field conditions;
- Easier management with the use of specific systems.

CONCLUSIONS

Smart farming focuses mainly on connectivity between tools through automation, so that tools and equipment can operate independently in the field and provide real-time information to the farmer. Thanks to smart farming, farming will be easy and farmers will receive a lot of benefits and increase profits.

Smart farming can, of course, bring enormous benefits to sustainable agriculture, increasing the efficiency and productivity of food creation, as well as potentially providing social and environmental benefits. However, this fourth agro-technological revolution brings potential environmental, ethical and social costs.

ACKNOWLEDGEMENT

This work was supported by a grant of the Ministry of Education and Research on the Programme 1 – Development of the national research-development system, subprogramme 1.2 – Institutional performance – Projects for financing excellence in RDI, contract no. 16 PFE and Projects PN 19 10 01 01: "Research on the realization of integrated systems for the bioeconomy field according to the concept of intelligent agriculture" – contract NUCLEU 5N/07.02.2019.

BIBLIOGRAPHY

1. **Armanda, D.T., Guinée, J.B., Tukker, A.,** 2019 - *The second green revolution: Innovative urban agriculture's contribution to food security and sustainability – A review. Glob. Food Secur*. 22, 13–24;
2. **Brandt, K., Barrangou R.,** 2019 - *Applications of CRISPR technologies across the food supply chain. Ann. Rev. Food Sci. Technol.* 10, pg. 133–150;
3. **Bronson K., Knezevic I.,** 2016 - *Big Data in food and agriculture; Big Data Soc*.;
4. **Burton, R.J.F.,** 2019 - *The potential impact of synthetic animal protein on livestock production: the new "war against agriculture"?* J. Rural Stud. 68, 33–45;
5. **Carolan M**., 2019 - *Automated agrifood futures: robotics, labor and the distributive politics of digital agriculture*;
6. **Frank V.**, 2015 - *The Rise of the Drones in Agriculture*;
7. **Ilaria Z., Massimo C., Gianluca E., Maria G.S., Andrea C**., 2019 - *Revolution 4.0: Industry vs. Agriculture in a Future Development for SMEs*;
8. **Llewellyn, D.,** 2018 - *Does global agriculture need another green revolution?* Engineering 4, 449–451.
9. **Lowry G.V., Avellan A., Gilbertson L.M.,** 2019- *Opportunities and challenges for nanotechnology in the agri-tech revolution*. Nat. Nanotechnol. 14, 517–522;
10. **Mrs. Shilpa K., Prof. Abhijit Kh**., 2019 - *Industry 4.0 in agriculture from IoT aspects*;
11. **Rose D.C., Chilvers J**., 2018 - *Broadening Responsible Innovation in an Era of Smart Farming*;
12. https://proagrica.com/news/what-is-agriculture-4-0/;
13. (https: // conapa.es/big-data-en-la-agricultura-caminando-hacia-un-futuro-mas-rentable/.