AGRICULTURAL FIELD MANAGEMENT PROBLEMS: FROM CLASSIC AGRO-TECHNOLOGIES TO ARTIFICIAL INTELLIGENCE

Sabina Valiyeva
Azerbaijan Cooperation University, Baku, Azerbaijan

ABSTRACT

The text is straightforward and precise. The agricultural sector has been significantly impacted by artificial intelligence (AI) technologies such as expert systems, natural language processing, speech recognition, and machine vision. This is due to factors such as the rising global population, increasing demand for food, changing weather conditions, and water availability. AI has not only increased the quantity of work in agriculture but also improved its quality. Researchers and scientists are now adopting new IoT technologies in smart farming to enable farmers to use AI technology for the advancement of seeds, crop protection, and fertilizers. This would enhance the financial viability of farmers and contribute to the general economic growth of the nation. AI is being used in three primary areas in agriculture: soil and crop monitoring, predictive analytics, and agricultural robots. Farmers are increasingly using sensors and soil sampling to collect data for farm management systems, which will be utilized for future studies and analysis. This paper enhances the area by doing a study of artificial intelligence applications in the agriculture industry. The text provides an introduction to AI, covering several AI techniques used in the agricultural sector, such as machine learning, the Internet of Things (IoT), expert systems, image processing, and computer vision.

Keywords: Agriculture, Agricultural Strategies, Artificial Intelligence, Management Problems

INTRODUCTION

Artificial intelligence (AI) is a discipline in computer science that focuses on creating intelligent computers, robots, or sensors that can imitate human activities to perform jobs on behalf of people and contribute to society. Application programs use information technology devices to govern these activities. The agriculture sector is a crucial component of the production industry. The field of study encompasses all facets of agricultural endeavors and is categorized into four primary subsectors: crops, forestry, livestock (including production and animal health), and aquaculture. Smart agriculture utilizes a combination of AI techniques and conventional agricultural practices to enhance national economies. It does this by using precision farming principles to monitor and optimize crop development. By utilizing these strategies, along with the assistance of machine learning, the Internet of Things (IoT), and cloud computing, it is possible to monitor all environmental aspects in order to determine the most suitable environment for each type of crop. This is achieved through the classification of the collected data using one of the various classification techniques available. The Internet of Things (IoT) is a network of interconnected physical devices or objects equipped with sensors, processing capabilities, software, and other technologies. These devices and objects are able to connect to and exchange data with other devices and systems over the Internet or other communication networks. This exchange of data occurs without the need for direct interaction between humans and computers or between humans themselves.

Smart irrigation is an emerging agricultural approach that assists farmers in automating irrigation operations by gathering data via the use of smart devices like Raspberry Pi. After gathering the data, it is examined to determine the most effective method for controlling the water flow on the farm, either turning it on or off.

Artificial intelligence (AI) and machine learning may be used to continuously monitor the condition of crops and the quality of soil, enabling enterprises to accurately assess agricultural yields and forecast the optimal timing for harvesting in order to optimize profitability. Moreover, the timely categorization of plant diseases would enable farmers to use optimal techniques in combating them.

LITERATURE REVIEW

The phenomenon may be described as a transformation that state governments are anticipated to embrace after the participation of individuals and the commercial sector in big data and particularly artificial intelligence plans. It would be incorrect to assume that nations are not engaged in the advancements in big data and artificial intelligence, which have permeated all aspects of society and are widely recognized as significant. In reality, Russian President Vladimir Putin said that the individual or entity that has exclusive control of artificial intelligence would have dominion over the planet. The comment also reflects the level of importance that developed nations attach to this problem. The measures implemented in this domain result in accelerated and more effective operations in nations. The use of big data and artificial intelligence in public administration is crucial for ensuring the effective and prompt delivery of public services and the smooth operation of public affairs. What is of more significance, according to Putin's genuine statement, is the exportation of these technology. Given that each advancement in this domain confers advantages to both persons and nations, the development and commercialization of these technologies will propel the country forward in the economic realm and establish it as a frontrunner. Countries are now using technology like big data and artificial intelligence in public administration to facilitate digital transformation. Digital transformation refers to the process of leveraging information technology and conventional structures by transitioning them into the electronic environment (Sunay, 2019).

Artificial intelligence is emerging in different types day by day, but generally four types of artificial intelligence are mentioned here (Hintze, 2016; Say, 2017):

➢ Reactive Machines: These are the most basic artificial intelligence systems, capable of creating memories and using past experiences to inform current decisions. . Deep Blue, the computer that defeated Garry Kasparov, is an example of such machines.

➢ Limited Memory: This type of artificial intelligence is machines that can look into the past. Self-driving cars are an example of this. They observe the speed and direction of other vehicles and act accordingly. Limited memory is more a case of identifying specific objects and tracking them over time.

➢ Theory of Mind: What is meant by this type, which creates more advanced machines, is to understand not only the world but also other agents or entities in the world, which is expressed as "theory of mind" in psychology. That is, artificial intelligence systems not only understand humans but also their thoughts, feelings, expectations, etc. They will have to understand this and shape their behavior accordingly (Avaner, T., Çelik, M., 2021).

Self-Awareness: Here AI researchers will have to not only understand consciousness, but also build machines that have it. In a sense, this is an extension of “Theory of Mind”. Consciousness is also called “self-awareness” for a reason. Conscious beings are self-aware, know their internal states, and can predict the emotions of others. For example, one might assume that someone honking their horn from behind in traffic is impatient or angry. Without a theory of mind, it is not possible to make such inferences. At this stage, it is aimed for artificial intelligence to be able to do this. In fact, the artificial intelligence Twitter user named Tay, created by Microsoft, can be given as an example. It is aimed for people to learn the language features, but it has learned too much and Tay has become a user who takes on his own characteristics, such as being a Hitler fan. Say defined the stages of artificial intelligence as "teaching by explaining", "teaching by showing" and "self-learning". Because artificial intelligence is first taught information by humans, then the information is visually encoded, and finally, artificial intelligence learns on its own using this information (Say, 2017). This explanation can be considered as a brief explanation of the steps listed above.

The use of sensors, machine vision, AI models, and robotics enables the execution of harvesting tasks with enhanced precision and efficiency, relieving personnel from such responsibilities. Furthermore, it aids in minimizing crop loss in the field, a common occurrence with conventional harvesting methods. By using artificial intelligence methodologies and technologies, it is feasible to anticipate the optimal timing for fertilizing fields and sowing seeds in order to get the highest potential crop production and secure more favorable pricing within the appropriate timeframe and method. Chemical spraying is a crucial technique used to manage pest insects, fungus, and bacterial illnesses that affect plants.

Artificial intelligence in agriculture is used to several tasks that may be effectively managed using AI. These activities can be categorized as:

- Conduct crop and soil monitoring to assess the health of the crops. AI and machine learning may be used to continuously monitor the condition of crops and soil, enabling enterprises to accurately forecast agricultural yields and determine the optimal time for harvesting in order to optimize profitability.
- Early categorization of plant diseases facilitates the implementation of appropriate strategies to combat them. Early categorization of plant illnesses will enable farmers to use optimal tactics in combating these diseases.
- An agricultural robot designed to address labor concerns. The use of sensors, machine vision, AI models, and robotics enables the execution of harvesting procedures with enhanced precision and swiftness, hence reducing the need on human labor. Predictive insights facilitate informed decision-making.
- Crop yield prediction involves forecasting the optimal timing for sowing crops. By using artificial intelligence methodologies and tools, it is feasible to anticipate the optimal timing for fertilizing fields and planting seeds in order to get the highest potential crop production and secure more favorable pricing within an appropriate timeframe and way.
- Intelligent spraying enables cost reductions. Utilizing intelligent spraying techniques may effectively minimize crop loss in the field, which is often seen when employing conventional harvesting methods. Chemical spraying is a crucial technique used to manage pest insects, fungus, and bacterial illnesses that affect plants (Elbasi, E., Mostafa, N., et.al. 2022).

Ensuring the agricultural sector operates with optimal efficiency and sustainability is crucial for guaranteeing food security. This importance has been further emphasized in the wake of the third and fourth industrial revolution phases in agriculture. Population development leads to an increase in food consumption, input prices, climatic and environmental strain. At the same time, water availability declines, biodiversity decreases, and nutrition and food security concerns occur. Additionally, there is a need to restore damaged arable lands. Agriculture and food production need a substantial amount of water, and the inadvertent use of plant nutrients (Kılıç, 2020), medications, and comparable inputs exacerbate water pollution. Issues such as the escalation of nitrate, nitrogen, and phosphorus contamination in groundwater, as well as the decline in soil health and production, highlight the need for agricultural technology that minimize input use (Çakmakçı, 2019). The European Union (EU) advocates for an economy that follows biological principles and highlights the significance of digital technologies in enhancing the food system's resilience against climate change. This is achieved through the farm to fork (F2F) strategy, which focuses on optimizing the use of agricultural inputs, developing biological fertilizers, bioenergy, and biochemicals as specific measures. Future agricultural strategies must prioritize adapting to climate change, enhancing resource use efficiency through advanced technologies, promoting digital technologies, disseminating precision agriculture (HT), applying artificial intelligence (AI), and developing and implementing innovative technologies for soil cultivation, fertilization, and plant protection . The European Union acknowledges that the use of pesticides and excessive nutrient accumulation from fertilizers have a detrimental impact on biodiversity and ecosystems. As part of their conservation efforts, the EU aims to decrease pesticide use by 50% by 2030. Additionally, in line with the EU nitrate directive, the EU plans to reduce low-input agriculture and the use of high-technology (HT) and nutrient-rich fertilizers by 20% . Artificial intelligence (AI) in agriculture, together with predictive analytics and linked sensors provided by AI, may enhance both plant productivity and the efficiency of water, plant nutrients, and other inputs. The progress in remote sensing technologies, data collecting, analysis, storage, management, transmission and sharing, communication, and processing technology has enhanced the capacity to transport large quantities of data and automate analytical procedures. The incorporation of remote sensing technologies, powerful algorithms, sensors, artificial intelligence (AI), and big data has become essential for achieving highly productive and sustainable agriculture (Martos et al., 2021).

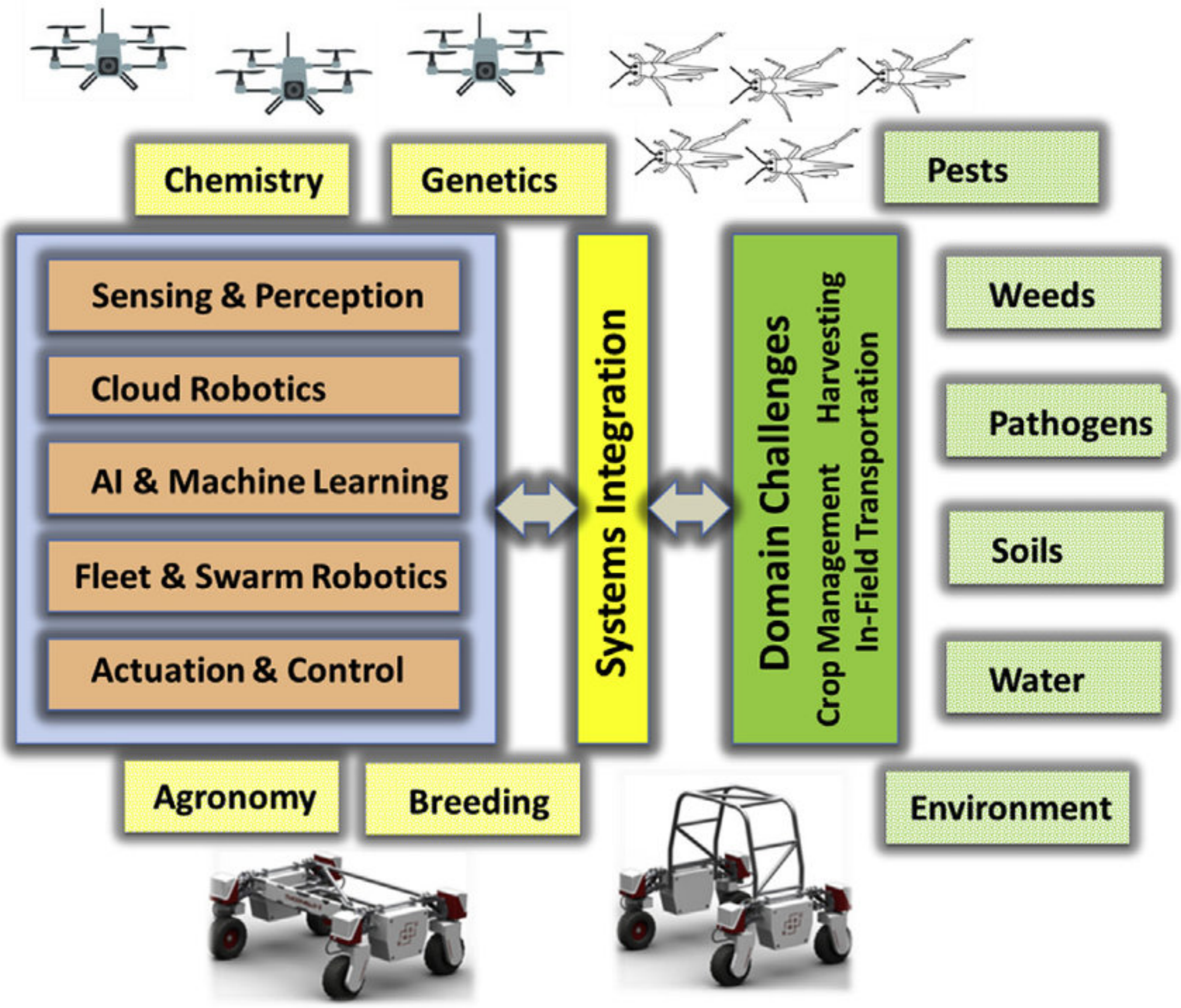

Figure 1: Smart technology subsystems for broadacre agriculture.

Source: Grieve, B., Duckett, T., Collison, M., Boyd, L., West, J., Yin, H., Arvin, F., & Pearson, S. 2019

Today, several technologies are being used in different fields such as data gathering, analysis, and evaluation, production optimization, remote sensing (UA), internet of things (IoT), unmanned aerial vehicles (UAV), cloud computing technology, smart sensors, blockchain, robots, decision support systems in trade, and smart agricultural applications. Wide area networks (WANs), global area networks (GANs), wireless sensor networks (WSNs), deep neural networks (DNNs), artificial intelligence (AI), low power wide area networks (LPWANs), long range wide area networks (LoRaWANs), big Various combinations of technologies, including data analytics (BVA), machine learning (ML), and deep learning (DL) algorithms, have been effectively utilized in agriculture as promising advancements (Pivoto et al., 2018). Technological improvements that lower input costs and losses, such as water and fertilizer, while increasing plant yield, quality, and resource use efficiency, have the potential to address several economic, social, and environmental issues. Artificial intelligence encompasses AI, a technique for analyzing data, and deep learning, a specific branch of AI that involves artificial neural networks designed to imitate human brain processes. AI pioneers a technology that emulates the cognitive abilities of the human brain, including several tasks like as cognition, learning, and problem-solving. AI, or artificial intelligence, has two fundamental components. The first is the field of machine learning, which involves analyzing previous data to make predictions about the future. The second component is the capacity of AI systems to learn from programming. Additionally, AI may also acquire knowledge by processing data using DSA (Data Structures and Algorithms) techniques, as discussed by Kodali and Sahu (2016) and Sukhadia et al. (2020). Furthermore, neural networks, a crucial component of artificial intelligence, serve as the foundation for artificial intelligence algorithms (Gu et al., 2018). Artificial Intelligence (AI) encompasses several domains including AI, computer vision, deep learning, image processing, and neural networks. It plays a crucial role in addressing agricultural challenges such as soil health, plant yield, herbicide resistance, and enhancing overall productivity. In order to adhere to sustainability principles, it is imperative to decrease the emission of nitrous oxide derived from fertilizers, mitigate the toxicity of pesticide residues, and address nutrient imbalances. This can be achieved through the utilization of satellite imaging in conjunction with artificial intelligence, remote sensing technologies such as unmanned aerial vehicles (UAVs), monitoring changes in land use (Ferreira et al., 2020), and implementing variable rate technologies (Lieder and Schröter-Schlaack, 2021). Artificial intelligence (AI) enables computers to engage in interactions, make logical deductions, and acquire knowledge in order to fulfill activities that need intelligence, such as interpreting visual information, recognizing voice, and making decisions. AI offers significant advancements in computer vision tasks, including object detection, movement tracking, action recognition, pose estimation, and semantic segmentation (Voulodimos et al., 2018). Additionally, AI facilitates data collection and exchange through sensors and devices, enabling it to draw inferences. is capable of generating data. Intelligent systems use a blend of cloud computing, machine-to-machine communication, big data analytics, and IoT to function and acquire knowledge. Despite being less digitalized and lagging behind other sectors, AI research in agriculture is gaining speed and expanding in relevance. This research focuses on areas such as plant and soil monitoring systems, computer vision algorithms, autonomous robots, and intelligent decision support systems.

Remote sensing (RS) enables the non-destructive monitoring of plants on a broad scale. UA incorporates sensors capable of collecting and analyzing data from electromagnetic radiation that is bounced back from plants attached to unmanned ground vehicles, satellites, or field robots. UA, a crucial technology in modern agriculture, relies on sensors located on the ground, in space, and in the air to gather comprehensive data about the environment and plants. The system's objective is to provide data and solutions based on certain biochemical, morphological, phenological, and physiological functional parameters (Weiss et al., 2020). It also assesses the plant's performance and appropriateness. The data supplied by UA, including metrics such as plant density, leaf area, leaf content and functions, vegetation cover, soil temperature, and moisture, are analyzed and used to assess plant health, nutrient shortage, irrigation requirements in terms of duration and quantity, as well as crop production (Weiss et al., 2020; Martos et al., 2021). Unmanned aerial (UA) applications in agriculture have numerous advantages. These include the ability to identify good plant varieties, optimize plant management, monitor agricultural phenology, screen biodiversity, estimate production, provide soil and water resource services, and monitor plants and land. These advantages have been highlighted in studies by Sishodia et al. (2020), Weiss et al. (2020), and Zheng et al. (2021). Stress detection is a crucial aspect of urban agriculture. In agriculture, various techniques such as near infrared, synthetic aperture radar, and fluorescence spectroscopy are employed for tasks such as plant classification, monitoring plant growth, estimating soil moisture, determining geometric properties, assessing physiological and biochemical characteristics, measuring chlorophyll and nitrogen content, calculating leaf area, evaluating plant health, monitoring water levels, and analyzing erosion. Imaging sensors, light detection sensors, multispectral sensors, hyperspectral sensors, and visible red, green, and blue (KYM) vegetation indices sensors are extensively used in various studies. Traditional ground-based sensors have been in use for an extended period, although wireless sensors, KSA (Knowledge, Skills, and Abilities) and frequency identification, and compact sensing devices have emerged more recently. Wireless sensor technologies and KSA (knowledge, skills, and abilities) are mostly used in animal husbandry, greenhouses, and for measuring factors such as soil moisture, temperature, and conductivity (Martos et al., 2021). The agricultural industry seems to be transitioning into the age of the internet of drones, while there are growing concerns over the safeguarding of sensor data and ensuring security. Research on yield, illness, and automation using AI is rapidly growing. The use of knowledge, skills, and abilities (KSA) and control automation is also on the rise. Furthermore, remote-controlled aircraft have practical applications in agriculture, including tasks such as monitoring plant growth, diagnosing diseases, analyzing soil and land conditions, managing irrigation and fertilization, harvesting crops, controlling weeds, facilitating mechanical pollination, and assessing livestock and crop insurance.

AI is a computing system that automates intelligent behavior and generates logical outputs by reaching a certain degree of intelligence via programming. Despite being in its early stages, AI technologies are recognized for their substantial promise in several agricultural domains, including yield optimization, product monitoring, irrigation management, soil composition analysis, product sorting, and product development. With the advancement of AI, its applications in agriculture are expanding (Shaikh et al., 2022). According to the European Commission, the industry 5.0 age has started, and modern agriculture relies on remote sensing, artificial intelligence, and cloud computing as the fifth revolution (Martos et al., 2021). AI has made significant contributions to the agricultural industry, particularly in the areas of image identification and perception, optimizing yield, and improving skills and manpower. Artificial intelligence (AI) is a type of intelligence that can carry out various tasks, such as visual perception, learning, comprehension, planning, movement, and communication, in a manner similar to humans. It encompasses predictive analytical capabilities that can be applied in areas such as disease detection, soil management, pest and weed control, plant management, water usage optimization, identification of nutrient deficiencies, product analysis, and monitoring and predicting environmental impacts. AI serves the purpose of promoting sustainable production. Artificial intelligence (AI) and its application in agriculture have the capacity to optimize the utilization of sensor data, enhance the quality and quantity of products, streamline internal processes, boost work efficiency, minimize waste, and reduce costs. Smart agriculture, on the other hand, is a technology that relies on the integration of AI and the Internet of Things (IoT) . The Internet of Things (IoT) is a network-based system that enables the flow of data without the need for direct connection between machines or humans in order to carry out certain tasks. IoT refers to devices that own distinct identities and capacities for the purpose of remotely detecting, monitoring, and temporarily storing blocks of data. The utilization of IoT and its sensors in smart agriculture is driven by their notable attributes, including their wide range of application, effectiveness, cost-effectiveness, long-lasting nature, storage capacity, portability, energy efficiency, dependability, convenience, ability to enhance productivity, monitoring capabilities, resource optimization, smart irrigation, product and pest monitoring, control over agricultural processes, and safeguarding of harvest and product quality. Is seeing a moderate upward trend. The technology of IoT sensor components is used for the purpose of gathering and quantifying environmental aspects and variables (Gómez et al., 2017). Given that the bulk of Internet of Things (IoT) applications rely on the transmission of data via wireless means, Wireless Sensor Networks (WSN) play a significant role in the implementation of IoT technologies. The integration of Internet of Things (IoT) devices is becoming more prevalent in agricultural procedures. Notable uses of NI include geographic and temporal mapping and sampling, water stress evaluations, pest and weed control, vegetation indices, yield evaluation, and precision fertilization. Furthermore, Internet of Things (IoT) technologies are utilized in various applications such as smart irrigation systems that adjust watering based on plant and soil stress levels influenced by weather conditions . IoT is also employed in disease and pest control through image processing and early diagnosis techniques . Additionally, IoT aids in harvest planning and determining optimal nutrient requirements. It has shown effective use in prediction (Suganya et al., 2019). NI applications have been shown to enhance the efficiency of agricultural resource use , mitigate diseases and pests (Bischoff et al., 2021), and decrease energy consumption and CO_2 emissions. Furthermore, it has been suggested that NI applications hold promise for the future (2022). While not the main objective, the use of NI technology in organizations helps to the conversion of agriculture into a sustainable production system.

METHODOLOGY

This article focuses on the results and benefits of using artificial intelligence in agriculture. The used methods were analysed, synthesized and compared based on the scientific works of different authors.

DISCUSSION

Artificial intelligence has made important contributions to agriculture, increasing productivity and reducing costs, while creating advantages in every field.

CONCLUSION AND RECOMMENDATION

The issues encountered in agriculture need scientific and technical advancements, which will continue to grow in importance in order to enhance output. Recent advancements in technology have the potential to enhance efficiency and facilitate accurate decision-making in the realm of food production, ensuring safety, high quality, and sustainability. These technologies have the potential to enhance crop productivity and quality, lower expenses, mitigate soil salinity, optimize irrigation accuracy, and improve the efficiency of plant nutrient use. Additionally, it may mitigate pollution resulting from the judicious use of fertilizers and pesticides. In the future, it may be suggested to use machine and deep learning models to identify important traits in all types of plants. The integration of biosensors into plants has the potential to accurately monitor various plant molecular processes, nutrient absorption, antioxidant synthesis, ethylene levels as an indicator of fruit ripening, and other significant parameters. Historical and present field data may be used to approximate soil fertility. However, the presence of undernourished plants in a certain region might suggest the existence of circumstances like salt and drought stress. The integration of remote sensing technology into agriculture, via the resolution of cost-related issues, may enhance the long-term viability of the food industry.

REFERENCES

Avaner, T., & Çelik, M. (2021). Türkiye'de dijital dönüşüm ofisi ve yapay zeka yönetimi: Büyük Veri ve Yapay Zeka Daire Başkanlığı'nın geleceği üzerine. Medeniyet Araştırmaları Dergisi, 6(2), 1-18.

Cakmakcı, R., (2019). A Review of biological fertilizers current use, new approaches, and future perspectives. International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET), 5(7), 83-92.

Elbasi, E., Mostafa, N., AlArnaout, Z., Zreikat, A. I., Cina, E., Varghese, G., ... & Zaki, C. (2022). Artificial intelligence technology in the agricultural sector: a systematic literature review. Ieee Access, 11, 171-202.

Ferreira, B., Iten, M., & Silva, R.G. (2020). Monitoring sustainable development by means of earth observation data and machine learning: a review. Environmental Sciences Europe, 32,120.

Gómez, J.E., Marcillo, F.R., Triana, F.L., Gallo, V.T., Oviedo, B.W., & Hernández, V.L. (2017). IoT for environmental variables in urban areas. Procedia Computer Science, 109, 67-74

Grieve, B., Duckett, T., Collison, M., Boyd, L., West, J., Yin, H., Arvin, F., & Pearson, S. (2019). The challenges posed by global broadacre crops in delivering smart agri-robotic solutions: A fundamental rethink is required. Global Food Security, 23, 116-124. https://doi.org/10.1016/j.gfs.2019.04.011

Gu, J., Wang, Z., Kuen, J., Ma, L., Shahroudy, A., Shuai, B., Liu, T., Wang, X., Wang, G., & Cai, J. (2018). Recent advances in convolutional neural networks. Pattern Recognition, 77, 354–377.

Hintze, A. (2016). Understanding The Four Types Of Artificial Intelligence. https://www.govtech.com/computing/Understanding-the-Four-Types-of-ArtificialIntelligence.html

Kılıc, Z. (2020). The importance of water and conscious use of water. International Journal of Hydrology, 4(5), 239-241.

Lieder, S., & Schröter-Schlaack, C. (2021). Smart farming technologies in arable farming: towards a holistic assessment of opportunities and risks. Sustainability, 13, 6783.

Martos, V., Ahmad, A., Cartujo, P., & Ordoñez, J. (2021). Ensuring agricultural sustainability through remote sensing in the era of agriculture 5.0. Applied Sciences, 11, 5911.

Pivoto, D., Waquil, P.D., Talamini, E., Finocchio, C.P.S., Corte, V.F.D., & de Vargas Mores, G. (2018). Scientific development of smart farming technologies and their application in Brazil. Information Processing in Agriculture, 5(1), 21-32.

Say, C. (2018). 50 Soruda Yapay Zekâ. İstanbul: Bilim ve Gelecek Kitaplığı.

Sunay, N. (2019). Dijital Dönüşüm. https://www.sektorumdergisi.com/dijital-donusum/

Voulodimos, A., Doulamis, N., Doulamis, A., & Protopapadakis, E. (2018). Deep learning for computer vision: A brief review. Computational Intelligence and Neuroscience, 2018, 7068349.

Weiss, M., Jacob, F., & Duveiller, G. (2020). Remote sensing for agricultural applications: A meta-review. Remote Sensing of Environment, 236,111402.

ABOUT THE AUTHORS

Sabina Valiyeva, email: sabinavaliyeva12@gmail.com

Dr. Sabina Valiyeva is an Associate Professor and Dean of the Faculty of "Finance" at Azerbaijan Cooperation University in Azerbaijan. Author is successfully continuing active scientific research on agrarian economy and the financial sector. ORCID NO. 0000-0002-6027-1692