ITM Web of Conferences **72**, 03004 (2025) https://doi.org/10.1051/itmconf/20257203004
HMMOCS-III 2024

Engineering and technological aspects of the application of artificial intelligence models in modern agriculture

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Abstract. The article examines the application of artificial intelligence models in modern agriculture as a crucial area of innovative development within the agricultural sector. The use of artificial intelligence models in contemporary farming opens up vast opportunities for increasing efficiency, optimizing processes, and minimizing costs. Modern artificial intelligence technologies, such as machine learning, neural networks, and computer vision, are being utilized for predicting crop yields, monitoring plant health, managing irrigation, and automating agricultural machinery. However, the implementation of such solutions, particularly the adherence to technical standards governing digital data processing and management, ensures the reliability, security, and environmental sustainability of modern digital technologies in agriculture.

1 Introduction

Modern society is characterized by a high level of integration of information and communication technologies into the key sectors of the state's infrastructure, which is primarily a direct result of scientific and technological progress. Scientific and technological progress is the process of continuous development of science, technology, and techniques aimed at creating new knowledge, developing innovative methods and means of production, as well as improving existing technologies. On one hand, in the conceptual model, scientific and technological progress implies the evolutionary development of all elements of the productive forces of social production based on extensive knowledge and the mastery of external forces of nature. On the other hand, it is closely linked to the development of theoretical knowledge and its practical application. The introduction of new technologies and methods leads to a significant transformation of existing problem-solving approaches in the economic sector, with an emphasis on the environmental aspect, the problems of which are caused by anthropogenic impact [1]. Furthermore, scientific and technological progress lays the foundation for sustainable development. It opens up new horizons for the introduction of environmentally clean technologies and renewable energy sources, as well as implementing

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solutions aimed at reducing the negative impact on the environment. At the same time, progress serves as the basis for new approaches in the economy, such as digital transformation, Industry 4.0, and the circular economy, which focus on resource optimization and sustainable production. These directions not only contribute to economic efficiency but are also aimed at the harmonious development of society, taking into account environmental and social factors.

Scientific and technological progress has been reflected in many fields, particularly in the agricultural sector. Key achievements in this area include the mechanization and automation of processes, the use of tractors, combines, seeders, and other agricultural machinery, which significantly reduced labor costs and increased the speed of performing various agricultural operations. Automation also enabled efficient management of large agricultural areas, ensuring accuracy and timeliness in carrying out tasks. The implementation of precision farming using GPS navigation, sensors, and monitoring systems allowed farmers to precisely manage crops, irrigation, and fertilizers, contributing to resource savings, improved yields, and reduced environmental impact. The introduction of biotechnology and genetic engineering has greatly enhanced the resistance of plants and animals to diseases, pests, and adverse weather conditions, as well as increased crop yields and product quality, which plays an important role in ensuring food security. New irrigation methods, such as drip irrigation and other water-saving technologies, have helped to use water resources efficiently, which is particularly important in regions with limited access to water and in the context of climate change. The introduction of information technologies and the digitalization of farm management processes has enabled effective planning of planting areas, controlling financial flows, analyzing data on the condition of crops, and making informed decisions on resource management. Additionally, in response to growing demands for sustainable development and environmental protection, technological progress has facilitated the introduction of environmentally friendly technologies in agriculture, such as biopreparations for pest control, organic fertilizers, and minimal soil processing methods, which help preserve ecosystems and the sustainability of agricultural production. Thus, technological progress in agriculture has significantly improved its efficiency, reduced costs and environmental impact, ensured food security, and helped address many global issues related to climate change and demographic growth.

However, the integration of technological solutions requires careful consideration of engineering and technological aspects, including the adaptation of equipment, integration with digital platforms, and tuning of algorithms for specific tasks. Particular attention should be given to developing solutions that comply with the current regulatory acts governing the use of technologies in the agribusiness sector. Proper adherence to technical standards, including GOSTs (state standards) that regulate digital processing and data management, ensures the reliability, safety, and environmental efficiency of applying modern digital technologies in agriculture. However, in addition to technological aspects, attention must also be given to reducing the impact of the agricultural sector on nature [2].

2 Materials and methods

Agriculture is one of the key sectors of the economy, which determines the relevance of the issue of sustainable development. Modern scientific research and practical-oriented directions in the agro-industrial complex are focused on solving existing problems in the sector, as well as finding ways to increase production efficiency, agricultural sustainability, improve product quality, and minimize environmental impact.

One of the key areas of development in the agro-industrial complex is digitalization – the process of integrating information and communication technologies (ICT) and digital technologies into the core business processes of agricultural enterprises. Digitalization covers areas such as smart farms, precision farming, automation and robotics, Big Data, Block chain, fintech solutions, drones, and Geographic Information Systems [3].

A smart farm is a fully autonomous and robotic agricultural enterprise designed for breeding various types of crops and livestock. These farms use a variety of technological solutions for real-time monitoring, analysis, and management of processes, enabling more efficient use of resources, minimizing losses, and reducing environmental impact. The Internet of Things, sensor systems, and devices are installed on the farm to collect data on various parameters, such as temperature, humidity, light levels, soil condition, and animal health. These devices are connected to a network and transmit data to central platforms for further analysis. Artificial intelligence processes large volumes of data to predict the needs of plants and animals and to automatically adjust the conditions of their environment. Smart farms use automated systems to manage irrigation, feeding, and animal health monitoring. This reduces dependence on manual labor and increases operational efficiency. Drones are utilized for monitoring crop and pasture conditions, as well as for distributing fertilizers and plant protection products. This allows for more precise control over field conditions and treatment applications. Intelligent irrigation management systems automatically adjust the water supply based on weather conditions and soil status, helping to save resources and prevent water wastage. Smart farms use analytical tools to process the collected data, enabling the identification of trends and the optimization of production processes.

Precision agriculture, also known as site-specific agriculture, represents a modern approach to farming that leverages advanced technologies to optimize the processes of crop cultivation. This method takes into account the variability within fields and the individual conditions of each piece of land. The primary goal of precision agriculture is to use resources such as water, fertilizers, pesticides, and energy as efficiently and rationally as possible, which helps reduce costs, increase yields, and minimize negative environmental impacts. Precision agriculture relies on the collection and analysis of data using various technologies, including GPS, GIS, sensors, and drones. The data collected from the fields allows for the precise identification of areas with different conditions, such as soil fertility, moisture levels, temperature, and other parameters, enabling a tailored approach to the treatment of each area. Through precision agriculture, farmers can optimize the use of fertilizers and pesticides, which reduces their consumption and minimizes environmental pollution. It also allows for precise irrigation control, thereby reducing water usage and preventing wastage. Moreover, precision agriculture helps manage the microclimate in fields, identify areas with specific growth conditions for plants, and adapt agronomic practices accordingly. These technologies aim to enhance operational efficiency, reduce labor costs, improve product quality, and decrease environmental impact.

Automation and robotics technologies are aimed at increasing efficiency, reducing costs, and improving the quality of agricultural production. These technologies allow for the replacement or significant reduction of reliance on human labor, as well as the optimization of workflows. Automation involves the implementation of various devices and systems for managing processes such as irrigation, fertilization, crop processing, and harvesting. For example, automated irrigation systems enable precise water dosing, helping conserve resources and prevent overuse. The use of automated tractors and cultivators allows farmers to significantly accelerate land preparation processes while reducing errors associated with human factors. Robotics refers to the creation and use of robots capable of performing specific tasks on farms. Robots can be employed for tasks such as seed planting, harvesting, feeding animals, tending plants, and even monitoring the health of livestock and crops.Harvesting robots, such as berry or vegetable pickers, can operate around the clock, ensuring faster and more efficient harvesting without compromising quality. This reduces labor costs and allows for more consistent production, making agricultural operations more sustainable and profitable.

The use of Big Data allows for the collection, storage, and analysis of vast amounts of information, which helps make more informed decisions, improve crop yields, minimize costs, and efficiently manage resources. In agriculture, Big Data covers a wide range of data, including information on soil conditions, weather, the health of plants and animals, as well as financial and logistical indicators. With data collected from the fields (e.g., through drones or soil sensors), specialists can monitor crop conditions in real-time. Analyzing this data allows for accurate crop yield predictions, identification of potential threats such as pests or diseases, and prompt measures to address them. Big Data also helps optimize the use of resources such as water, fertilizers, and pesticides. Big Data aids in weather forecasting, allowing farmers to prepare in advance for possible climate changes. Predictive models based on Big Data can warn of droughts, frosts, or extreme weather events, helping to minimize risks and losses. Additionally, using data about the health of plants and animals, the emergence of diseases or pests can be predicted, allowing for more efficient use of pesticides and other protection methods, thereby reducing their application and cutting costs.Data analysis also improves supply chain processes, reducing delivery times and minimizing logistics costs. To work with Big Data in agriculture, technologies such as sensors for collecting data from fields, livestock, and equipment, drone technologies for monitoring crop and livestock conditions from the air, geographic information systems (GIS) for analyzing and visualizing data about land, climate, and crop yields, analytical platforms for processing and analyzing large data volumes, as well as artificial intelligence and machine learning for automated analysis and process optimization, are used.

Blockchain in agriculture enhances the transparency, security, and efficiency of processes. It enables the tracking of product origins, ensuring transparency in supply chains, which increases consumer trust. Blockchain can also automate contracts through smart contracts, improve product certification, and manage land ownership rights. By reducing the need for intermediaries, blockchain lowers costs, increases the transparency of financial transactions, and ensures the effective distribution of subsidies. The adoption of this technology contributes to increasing the resilience and competitiveness of the agricultural sector.

Fintech solutions in agriculture include alternative financing methods such as crowdfunding and online lending, which help farmers obtain loans. Technologies are also used for flexible risk insurance, such as protection against natural disasters, and mobile payment systems for convenient transactions. Digital trading platforms allow farmers to access markets directly, minimizing intermediaries. These solutions improve financial accessibility, reduce risks, and enhance the efficiency of agribusiness.

Drones in agriculture are used for monitoring, analysis, and management of agricultural processes. They help collect data on field conditions, crop yields, plant and animal health, and improve farm efficiency. With drones, it is possible to accurately measure soil moisture, identify plant problems (such as diseases or pests), and track the condition of livestock. Drones are also used to create field maps that help optimize the use of fertilizers and pesticides, as well as for irrigation, planting, and even harvesting. These technologies significantly improve accuracy, reduce costs, and enhance productivity in agriculture.

GIS in agriculture are used for collecting, storing, analyzing, and visualizing spatial data, which helps make more informed decisions. With GIS, land plots can be mapped, soil conditions can be analyzed, crop yield can be monitored, irrigation can be planned, and agronomic processes can be managed. GIS also helps farmers consider climatic conditions, track plant and animal health, and plan the efficient allocation of resources. These technologies increase precision, minimize costs, and improve yields, enhancing farm management at all stages of production.

The integration of technological solutions in the agro-industrial complex requires careful consideration of engineering and technological aspects. Special attention should be given to the development of solutions that comply with the existing regulations governing the use of technology in the agro-industrial complex—compliance with standards such as GOSTs that define requirements for digital data processing, storage, as well as methods of information management and protection. Proper adherence to these standards is crucial to ensuring the reliability, security, and environmental efficiency of modern technology applications.

Additionally, compliance with regulatory requirements helps minimize risks associated with the use of new technologies, such as data leaks, violations of environmental standards, or inefficient resource use. It also establishes the foundation for long-term sustainable development, where digitalization in the agro-industrial complex not only helps increase productivity but also minimizes the negative environmental impact and adheres to safety standards.

The primary reason for implementing strict regulations and standards in agriculture lies in the impact of climate change on both the agricultural sector and the environment as a whole. Climate change has a significant effect on agriculture, leading to unpredictable weather conditions, droughts, floods, and shifts in growing seasons, which negatively affect crop yields and productivity. At the same time, agriculture is a major source of greenhouse gases and other pollutants, contributing to the acceleration of global warming.

In response to these challenges, stricter regulations and standards have been introduced to reduce the negative environmental impact of the agro-industrial complex. The implementation of such regulations, including environmental norms and standards for the use of new technologies, not only helps minimize the agricultural carbon footprint but also promotes more sustainable and environmentally friendly production. Although changes within agriculture alone cannot fully address the issue of climate change, they play an important role in initiating changes in other sectors such as energy, transport, and industry. These efforts create incentives for broader changes in the economy aimed at sustainable development and reducing the negative impact on the climate. The introduction of clean technologies and standards in agriculture could serve as an example for other industries, accelerating the transition to more sustainable and low-carbon technologies at the global level [4].

3 Results and discussion

Agriculture has a significant impact on the environment, including water pollution, soil degradation, loss of biodiversity, and increased greenhouse gas emissions. The introduction of the technologies discussed can have both positive and negative effects on ecology. Smart farms, on the one hand, can help improve the environmental situation by optimizing the use of resources (such as water, energy, and fertilizers), which reduces the level of environmental pollution and increases agricultural productivity while minimizing waste and chemical overuse. On the other hand, improperly configured smart farm systems can lead to the overuse of energy or water resources if they do not accurately account for the actual needs of crops or animals. Precision farming helps minimize the use of chemicals and improves soil health, but if technologies are applied incorrectly, they can lead to the deterioration of ecosystem quality. Automation and robotics contribute to reducing the need for chemicals and increasing operational efficiency, but their excessive use can lead to soil degradation and ecosystem imbalance. Big Data and artificial intelligence help manage agricultural processes precisely, reducing resource consumption at each stage, but incorrect settings may lead to erroneous decisions that worsen environmental conditions. Blockchain enhances transparency and sustainability of supply chains; however, the significant computational costs associated with this technology may increase the carbon footprint. Fintech solutions enable more efficient financial management and attract investment in environmentally clean technologies, but without considering environmental risks, they may encourage unsustainable use of natural resources. Drones, through accurate monitoring and fertilizer application, reduce environmental pollution, but their widespread use may increase the carbon footprint if they do not rely on renewable energy sources. Geographic Information Systems (GIS) help optimize land and resource usage, reducing pressure on natural ecosystems, but if applied incorrectly, they can contribute to the expansion of agricultural lands into areas with high ecological risks [5].

The aforementioned technologies contribute to the sustainable development of agriculture by enabling more precise resource management, increased productivity, reduced costs, and minimized environmental impact. At the core of digitalization are artificial intelligence (AI) and machine learning, which enable the analysis of large data sets, optimization of processes, and informed decision-making. These technologies open new opportunities for forecasting and improving all aspects of agriculture, from enhancing land use efficiency to automating processes for plant and animal care. AI and machine learning provide the intellectual foundation for all other technologies. They process data, optimize actions, and adapt processes.

Artificial intelligence is a branch of computer science aimed at developing intelligent artificial systems (a set of technological and software solutions) that mimic and operate according to algorithms similar to the principles of human intelligence.

Key areas of AI include machine learning, deep learning, neural networks, and computer vision. These areas are fundamental components that enable the creation of intelligent systems capable of solving complex tasks, learning from data, and interacting effectively with the environment.

Machine learning is a field of AI that focuses on developing algorithms and models capable of learning from data and making predictions or decisions without explicit programming. The main goal of machine learning is to create models that can process vast amounts of data and extract useful information to solve specific tasks.

Deep learning is a subset of machine learning that utilizes multi-layered neural networks to tackle more complex problems. Deep learning allows models to learn from large data volumes and extract high-level features without manual intervention [6].

Neural networks are mathematical models inspired by the human brain's functioning, consisting of interconnected nodes (neurons). These networks are used to process data, identify patterns, and make decisions.

Computer vision is concerned with creating algorithms that allow machines to "see" and interpret images and videos. It is used for object recognition, motion tracking, scene analysis, and other tasks that require processing visual information.

At the core of smart farms are systems that use data on weather conditions, soil health, animal welfare, and other factors to make informed decisions. One of the key areas of machine learning application in smart farms is yield prediction and monitoring animal health. To predict yield, regression models are commonly used Linear Regression and Random Forest. Linear Regression – a statistical method for analyzing data that models the relationship between a dependent variable (or response) and one or more independent variables (or predictors). This method assumes a linear relationship between variables, meaning changes in the independent variable are associated with proportional changes in the dependent variable. Random Forest – a machine learning method used for classification and regression. It is based on an ensemble of decision trees, which improves the accuracy and stability of the model compared to a single decision tree. The method involves creating multiple decision trees, each trained on randomly selected subsets of the data, and then combining their results to generate a more accurate prediction. These models can analyze data such as weather conditions, soil types, moisture levels, and information about previous harvests. With these models, it is possible to predict precisely how many resources will be required to achieve optimal yields, allowing farmers to prepare in advance for various environmental changes. For example, a regression model can predict the level of fertilizers and water needed to maximize the yield of a specific crop [7].

Classification models such as Logistic Regression, Support Vector Machines and Decision Trees are widely used in various fields, including smart farms, for tasks related to classification and forecasting. Logistic Regression – a statistical model used to predict the probability of an object belonging to one of two classes. In smart farms, this model could be applied to classify the health status of animals (healthy or sick) based on parameters like body temperature, activity, or other biometric data. Logistic regression allows easy interpretation of results and analysis of the impact of each factor on the final decision. SVM – a powerful classification method that builds a hyperplane to separate data into different classes. SVM is efficient when working with high-dimensional data, such as data from farm sensors or images, and can be used to solve complex classification tasks, such as detecting diseases in animals or classifying soil types. SVM also performs well with smaller datasets, which could be useful in some cases on smart farms where data might be limited. Decision Trees – an algorithm that builds a model representing a tree structure, where each node corresponds to a question about a feature, and the branches represent possible answers. This method is used for classifying objects based on their characteristics. In smart farms, decision trees could be used to classify the health of plants (healthy or need additional care) or to predict outcomes (e.g., yield) based on factors like weather conditions and soil quality. Decision trees are easy to interpret, making it simple to understand which factors influence decision-making.

DNN are used for more complex tasks related to image processing and time series analysis. One such technology is CNN, which are used for analyzing images from cameras installed on farms. These networks enable the system to recognize animals, assess their condition, and detect signs of diseases. For example, CNN can analyze photos from cameras set up in barns or on pastures to track whether animals show signs of diseases, such as skin rashes, changes in behavior, or appetite.

RNN are used for analyzing time-series data related to factors influencing plant growth and animal health. These models analyze data on weather conditions, changes in moisture levels, and temperature over time. For instance, RNNs can predict how yield will change based on weather forecasts. This enables farmers to prepare in advance for potential environmental changes, such as droughts or sudden temperature shifts, and adjust their actions to minimize losses.

In precision agriculture [8], various machine learning and deep learning models are used to increase crop yield and optimize resources. Clustering (k-means) helps divide land into groups with similar characteristics (soil composition, moisture), allowing for efficient distribution of resources such as fertilizers and water. Lasso regression predicts the optimal amounts of fertilizers and water to be applied, taking into account influencing factors, which improves the accuracy of agricultural practices. Convolutional Neural Networks (CNN) analyze images, such as satellite photos, to assess plant condition, detect diseases, and identify defects. Generative Adversarial Networks (GAN) generate virtual scenarios of plant growth and climate analysis, helping to predict the impact of changes on yield. These models help agronomists make informed decisions, improving the sustainability of agriculture and minimizing environmental risks.

Automation and robotics in agriculture use various machine learning and deep learning models to improve efficiency, accuracy, and process optimization. Reinforcement Learning (RL) algorithms help robots learn effective actions by interacting with the environment and receiving rewards or penalties. This enables robots to make decisions like identifying plant needs or animal health, improving efficiency in tasks such as watering and fertilizing. Classification models like decision trees, SVM, or logistic regression are used to recognize objects and conditions, such as pests or soil states. Robots can then take real-time actions, like applying pesticides only to affected areas, reducing chemical use and environmental impact. For deep learning, Recurrent Neural Networks (RNN) predict robot movement trajectories, improving navigation on uneven or unpredictable surfaces and allowing robots to avoid obstacles and adjust paths based on previous movements. Convolutional Neural Networks (CNN) process images from robot-mounted cameras, helping robots recognize objects, such as plants, obstacles, or diseases, and take appropriate actions like watering or pest control. Overall, machine and deep learning in agricultural automation enhances robot efficiency, task accuracy, and resource optimization, contributing to more sustainable and eco-friendly farming.

Big Data plays a crucial role in agriculture by processing and analyzing large volumes of data from sensors, satellites, and other sources, enabling accurate predictions, pattern detection, and process optimization. Clustering algorithms (e.g., DBSCAN, k-means) group data based on similarity, helping analyze soil, weather, and crop data. Clustering identifies trends, such as areas with different water or fertilizer needs, allowing for efficient resource distribution and planning. Classification models sort data into categories, such as classifying crops by quality or detecting plant diseases. This helps in accurate data processing and informed decision-making based on sensor inputs. In deep learning, autoencoders reduce data dimensionality, retaining important features for analysis. They are useful for processing large data volumes and detecting anomalies, like changes in soil moisture or plant health. Generative models (e.g., GANs) generate simulated data, useful for training models on limited data or predicting plant growth under varying climate conditions. They can improve forecasting and enhance data synthesis for soil or yield analysis. These models in Big Data enable more efficient, data-driven decision-making in agriculture, enhancing productivity and sustainability [9].

Blockchain technologies are actively used in agriculture to enhance supply chain transparency, ensure transaction security, and prevent fraud. Machine learning models like anomaly detection (e.g., random forests, neural networks) help identify fraudulent transactions or data falsification, ensuring the authenticity of product origins and preventing scams. Classification and regression models analyze blockchain transaction data, predicting trends such as commodity prices and market fluctuations, thus improving supply chain forecasting. In deep learning, neural networks predict security threats by detecting unusual transaction patterns, helping safeguard agricultural supply chain data from tampering or attacks.

In fintech solutions, machine learning models play a key role in optimizing financial management, forecasting market trends, and improving access to financing for farmers. Classification models, like logistic regression and random forests, assess creditworthiness based on financial data, aiding in loan decisions for agricultural businesses. Regression models predict market trends, currency rates, and commodity prices, helping businesses plan financial strategies and manage market risks. Deep learning models, especially recurrent neural networks (RNN), analyze time series data for forecasting future values like commodity prices and demand fluctuations. Generative models, like GANs, simulate financial scenarios and market changes, allowing for risk management and strategic planning under uncertainty, useful for pricing strategies and contract testing in agriculture [10].

Drones are widely used in agriculture for monitoring fields, managing crop and livestock conditions, and improving operational efficiency. They use machine learning and deep learning models, such as CNNs for image classification to identify plants, animals, or obstacles, and reinforcement learning (RL) for optimal navigation and obstacle avoidance. These models help automate crop monitoring and detect issues like pests or diseases. CNNs also analyze environmental conditions and plant health, while recurrent neural networks (RNNs) predict changes over time, such as crop yields or disease trends.

Geographic Information Systems (GIS) are used for analyzing spatial data to manage land resources and predict environmental changes. Machine learning models like classification and clustering are used to categorize land types and assess risks, while regression models forecast changes in landscapes, such as soil degradation. CNNs process satellite and aerial images to monitor natural resources and landscape changes, and generative models, like GANs, simulate future scenarios, helping to predict climate impacts and guide long-term agricultural and ecological planning.

4 Conclusion

Modern artificial intelligence technologies are actively used in agriculture to solve various tasks. They play a key role in forecasting crop yields, monitoring plant health, managing irrigation, and automating agricultural machinery. For example, machine learning algorithms, such as clustering, help agronomists group land areas based on similar characteristics (e.g., soil composition or moisture levels), which allows for more accurate resource allocation and improves the efficiency of water and fertilizer use. Regression models, such as Lasso regression, predict optimal fertilizer and water application rates, contributing to increased crop yields and reduced costs.

Convolutional neural networks (CNNs), on the other hand, are used to process images from drone cameras and satellite imagery, enabling precise assessment of plant health, detecting diseases or defects, and monitoring environmental changes. These technologies significantly enhance diagnostic accuracy and help make timely decisions aimed at improving crop quality and preserving ecosystems. Generative adversarial networks (GANs) are used to create simulations of plant growth and model the impact of climate changes, allowing agronomists to more accurately predict growing conditions and plan effective strategies.

Reinforcement learning (RL) algorithms are applied in the automation of agricultural machinery, teaching robots to navigate fields efficiently, avoid obstacles, and perform tasks such as harvesting or plant care. These technologies enable robots to adapt to environmental changes and optimize their performance.

However, to ensure the reliability, safety, and ecological efficiency of implementing such solutions, it is necessary to adhere to certain standards and regulations that govern data processing and management.

One of the key aspects is compliance with technical standards that ensure the accuracy and safety of data processed in agriculture. For instance, GOST standards related to the development and use of software for data processing in agriculture, as well as standards defining the requirements for systems that collect and process information from sensors, sensors, and drones, are crucial. An important element is also adherence to standards regarding personal data protection when using data from farmers or agricultural enterprises.

To ensure data security and protection from unauthorized access in blockchain technologies for agriculture, it is vital to implement standards regulating the use of cryptographic methods, as well as compliance with international and national data protection norms. For example, the ISO/IEC 27001 standard, which governs information security management, provides recommendations for data protection in information systems.

Furthermore, ecological efficiency is a crucial factor when applying digital technologies in agriculture. It is important to follow standards aimed at minimizing environmental impact. This may include regulations on the use of resources, such as water and chemicals, to optimize their consumption. For instance, ISO 14001 standards, which regulate environmental management systems, can be applied to assess and manage environmental risks associated with the use of digital technologies in agriculture.

It should also be noted that for the effective application of artificial intelligence and machine learning in agriculture, the standardization of data collection from various sources, such as satellite imagery, sensors, and drone cameras, is important. The use of standards like

ISO/IEC 25010, which focuses on software quality and reliability, contributes to optimizing workflows and improving the accuracy of forecasts and decisions made based on data.

Creating and adhering to stringent standards in the digital processing and management of data in agriculture ensures not only improved efficiency but also safety, ecological sustainability, and the reliability of applied technologies. The implementation of such solutions in the agricultural sector, following the necessary technical and environmental norms, promotes the achievement of sustainable and safe agricultural development.

There are several aspects that complicate the introduction of new regulations in the agricultural sector. The first one is related to the creation of the rules. In theory, the rules could work, but in practice, there are numerous factors that need to be taken into account when implementing new regulations. Even if the rules are drafted with clear descriptions, they are often difficult to adopt due to bureaucracy and other barriers. New regulations often meet strong resistance from farmers and those working in the sector.

Another problem with their implementation is the requirement for rapid changes. Modern regulations must be immediately implemented into processes, otherwise, they are considered illegal. This puts a strain on the sector, as it has to quickly navigate through various changes. Of course, most large corporations will comply with the regulations as prescribed, but for ordinary farmers, these rules tend to be a low priority. One can see the complexity of the idea behind the regulations and their impact on the sector.

Another issue is the chain reaction. This could be one regulation that needs to be introduced into the sector, but this regulation may affect all processes. For example, new regulations may require the replacement of equipment (technology) with newer, more environmentally friendly alternatives. This technology would require all surrounding technologies to be compatible with it. The workforce would need to be retrained or new personnel hired to match the new setup. This, one way or another, would trigger a chain reaction that disrupts all processes.

The introduction of new regulations does not necessarily guarantee the same quality and quantity of the product. If production levels were high before, with the new setup, these figures may change, and often in a negative direction. This is due to the primary goal of these regulations. They are introduced to reduce environmental impact and, therefore, mitigate climate change. Increasing production rates or profits is not the objective. As a result, these regulations often face resistance, as mentioned earlier.

Nevertheless, these regulations must be adhered to and followed with the proper attitude. There are also other issues addressed when implementing new regulations. Some of these rules are well-documented and work as intended. They genuinely help to reduce the impact on climate change. In the coming years, more regulations will be introduced, which will completely transform the established sector. New problems will arise, and therefore, new regulations, leading to further changes.

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