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Strategic priorities of agricultural development based on the Agricultural 5.0 and Agricultural 6.0 concepts

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The evolution of technological achievements in agriculture has been summarized based on their development from traditional systems to the concepts of "Agricultural 5.0" and "Agricultural 6.0", innovative products of their implementation are highlighted. The concept of "Agriculture 4.0" and its main tools are highlighted: sensor technologies, high-speed mobile communications, big data analytics, sensor technologies, artificial intelligence, robotics. It is emphasized that digital agriculture includes digital and geospatial technologies for monitoring, assessing and managing soil, climate and genetic resources, and the digital data generated by them is a type of business resource. It is argued that digital technologies have combined all technological processes of agri-food production and goods movement into an integrated value chain, which has changed the implementation of business processes. The positive and negative impacts of digitalization on the resulting indicators of agricultural development are summarized.

It is substantiated that the concept of «Agricultural 5.0» is a new approach to the development of agriculture, the main technological solutions of which are the robotics use, technologies of «augmented or augmented reality», 6G technologies, AI, big data, biotechnology, microrobots, biological robotic systems. The impact of this model on increasing the efficiency of production activities, implementing the principles of sustainable development, improving technological processes, minimizing losses in technological processes, food waste at the consumption stage, as well as the introduction of methods for controlling emissions of harmful substances is systematized. The promising concept of «Agricultural 6.0» of integrative agriculture and its main elements are characterized: regenerative farming systems, circular economy, biorevolution, biofuels and bioenergy, carbon credits, etc. It is proven that this model contributes to achieving the sustainability of agricultural production and increasing human well-being based on the rational and sustainable use of natural resources.

It is emphasized that domestic agricultural production is at the stage of transition to a digital agriculture model, which involves changes in practices and methods of implementing technological operations at the level of all participants in the agri-food supply chain. It is substantiated that the strategic development of Ukrainian

agriculture should be oriented towards the implementation of modern innovative models, which requires the development of appropriate strategic programs with an effective set of organizational and economic tools and measures to achieve innovative and sustainable development of the industry.

Key words: smart agriculture, digital agriculture, precision agriculture, digital technologies, sustainable development, renewable technologies, bioeconomy, circular economy.

Problem statement and analysis of recent research. Changing technological patterns create new market opportunities that create conditions for increasing the competitiveness of individual industries and the economy of countries. Our country has achieved significant results in ensuring food security and is among the leading agrarian states that play an important role in shaping export supplies to the world agri-food market. The main elements of the country's agricultural development were investments and improving the quality of internal organizational management, increasing the purchasing power of the population, however, this industry is currently under the influence of global challenges, war in the country and other negative factors, which necessitates the transition to a new technological level in order to preserve and strengthen its role in the national and foreign markets.

It should be noted that digital transformation is considered as the process of transition of socio-economic systems to a qualitatively new level of use of digital technologies in accordance with the strategy of transition to a development model and implementation of priority areas of the digital economy formation. The global goal of digital transformation, from the point of view of society, can be defined as the formation of a new information and technological system, that is, a high-quality environment for social development [1]. At the same time, local goals can be defined as a set of guidelines for the development of society, which reflect the positive effects of digital transformation.

It is obvious that technological innovations in agriculture are an element of overcoming poverty and stimulating economic growth in society, which is relevant for the current conditions of development of the world community. Thus, according to the World Bank forecasts, by 2050 the world population will reach almost 10 billion inhabitants, which implies a doubling of consumer demand for agri-food [2]. However, today the goal of overcoming hunger in the world by 2030 is difficult to achieve, since new and existing military conflicts are emerging in various agrarian countries, the impact of global climate change is increasing and, as a result, high prices for agri-food lead to a deterioration in food security.

Agriculture has always been considered the basis of survival and prosperity of mankind, its development took place in parallel with innovative paradigms of industrial development, and therefore each stage introduced significant changes in agricultural production technologies [3]. At the same time, the studied industry has certain limitations, such as lack of experience and IT infrastructure, which prevent the rapid implementation of technological breakthroughs, overcoming which should be the main goal of strategic agricultural programs during the post-war recovery of our country.

The evolution of technological achievements in agriculture is considered on the basis of their development from traditional systems to the concepts of "Agricultural 5.0" and "Agricultural 6.0", which involve the use of Internet of Things (IoT) technology, big data, geolocation systems (GPS), unmanned aerial vehicles (UAVs), sensors, 3D printing, information management systems, robotic artificial intelligence systems, etc. [4-6]. There is no doubt that the use of the above technologies, as well as the development of intelligent solar and wind energy systems, the introduction of water desalination technologies and other breakthrough innovative developments should become priority areas for the development of "smart" agriculture. It should be noted that the introduction of new technologies and innovative developments takes place not only in the field of agriculture, but at the level of all participants in agri-food chains [7]. At the same time, the intensity of the implementation of available innovative products and services in domestic practice will depend on numerous factors, among which it should be noted the victorious end of the war, since otherwise the period of full adaptation to the latest technologies can be very long. Under such conditions, there is a need to develop and implement unified approaches

to justifying strategic priorities for the development of agriculture on the basis of the latest conceptual models of technological transformation of the industry.

The purpose of the research is to study the conceptual foundations of modern agricultural development models "Agricultural 5.0" and "Agricultural 6.0", systematize the main technologies and practices of their practical use by agricultural producers, and substantiate the areas of influence on the prospective development of the industry under study.

Material and methods. The theoretical basis of the study was the scientific works of domestic and foreign scientists on the evolution of technological changes in agriculture, the conceptual foundations of the models "Agricultural 5.0" and "Agricultural 6.0", as well as the directions of their influence on the future development of the industry under study.

When conducting the study, such scientific methods as systemic and scenario approaches, quantitative and qualitative comparisons were used. The study also used the following methods: theoretical generalization when formulating tasks; induction and deduction when revealing the main elements of modern models implementation of agricultural development; monographic and abstract-logical for a comprehensive and in-depth study of individual phenomena, processes that arise as a result of the models implementation "Agricultural 5.0" and "Agricultural 6.0", identifying cause-and-effect relationships of their influence on the performance indicators of agricultural production and substantiating priority areas of industry development, as well as presenting conclusions.

The information base of the study includes scientific publications in the scientometric databases "Scopus" and "Web of Science", as well as scientific data obtained by domestic researchers. The use of the bibliometric analysis method in the study allowed to structure knowledge in the field of the latest conceptual models of technological transformation of the industry and the directions of their influence on the strategic development of agriculture.

Research results and discussion. The evolution of technological development is characterized by successive changes in the stages of industrial revolutions, each of which led to significant changes in society and the economy. Thus, the development of agriculture within the framework of the “Agricultural 1.0” model was characterized by traditional methods of production of dairy and crop products based on the intensive use of labor, productive and working livestock, poultry, and energy of various types [8]. This approach ensures a low level of productivity of agricultural production with a predominance of manual labor. This model is usually adapted to local conditions, labor-intensive, has a diversified structure of production of the main types of products in small volumes, which is the basis for achieving sustainable development of rural areas. It is obvious that family farms most successfully represent this approach to farming.

As for the Agricultural 2.0 model, the main elements of its implementation were the introduction of agricultural machinery, mineral fertilizers, pesticides, herbicides, and high-quality seed materials into production activities, which contributed to an increase in production volumes based on a significant increase in crop yields and animal and poultry productivity. It was during this period that scientifically sound methods of managing technological processes in crop and livestock production appeared, as well as new technologies, synthetic means of production, and chemical pesticides for large-scale production. Thus, the transition of agricultural production to the Agricultural 2.0 model contributed to its modernization, which is called the Green Revolution in scientific literature, which ensured an increase in the efficiency of agricultural production and food production based on the active use of scientific research results and a decrease in its vulnerability to natural and climatic conditions.

This approach led to intensive use of the production potential of agriculture, which focused on increasing the volume of agricultural production based on increasing crop yields and productivity of farm animals and poultry, which led to an increase in the negative impact of the industry on the environment and neglected the social development of rural areas. Thus, intensive use of natural resources in agricultural production led to pollution of groundwater and surface waters, widespread soil erosion and transformation of landscapes with the loss of national, cultural and household values in rural areas [9].

The next stage in the technological development of agricultural production is associated with the conceptual model "Agricultural 3.0", which is based on the active development of computerization and software products. The transition to this model of agricultural production led to the fact that agricultural technical resources, previously controlled by a person, began to use GPS signals, which increased the efficiency of techno-

logical operations. These models of agricultural production provided a partial solution to global problems and challenges, since, for example, the model of precision agriculture reduced the need for mineral fertilizers, pesticides, herbicides and optimized irrigation systems [10].

It is known that after 2010, sensor technologies, high-speed mobile communications, and analytics of large data sets began to be used in agricultural production. Thus, the Internet of Things (IoT) technology is one of the technologies of Industry 4.0 and a key component of agricultural programs in the Agriculture 4.0 model, which allows transmitting raw data collected by various sensors to the cloud. Thanks to sensor technology, information such as the type of fertilizer to be used, soil condition, moisture and nutrient parameters in the soil, the estimated time of harvest and weather conditions help farmers make rational management decisions for production, as a result of which production costs are optimized and agricultural production productivity is ensured [11].

Digital agriculture encompasses digital and geospatial technologies for monitoring, assessing and managing soil, climate and genetic resources, illustrating that they are an effective response to new challenges in balancing economic, environmental and social aspects and achieving sustainable agriculture and rural areas [12]. There is no doubt that the digitalization of agriculture leads to the manifestation of certain problems, the which solution requires domestic agricultural science and education to move to a critical review of priority areas of scientific research and educational programs for training agricultural specialists.

It should be noted that the concept of "Agriculture 4.0" involves the use of a complex of digital technologies in agricultural production, which contribute to increasing the competitiveness of the industry in domestic and foreign markets. Among the priority areas for the development of the domestic agri-food industry, such issues as ensuring the physical and economic availability of food, food safety, the formation of agri-food chains with high added value, as well as reducing the volume of losses of agricultural products in technological processes and food waste [13, 14]. In addition, domestic producers of agri-food products have not yet implemented smart technologies in the functioning of safe and transparent agri-food chains at the level of each of its participants, which would prevent the risks of the spread of low-quality products and increase the competitiveness of food.

Thus, the Agriculture 4.0 model involves the use of IoT technologies, big data, artificial intelligence and robotics, which is called “digital agriculture”, “smart agriculture”. Increasing demand in the global agri-food market for high-quality and safe food products motivates agricultural producers, food industry enterprises, and distribution logistics infrastructure organizations to digitize technological processes of production, processing, transportation and promotion of agricultural products. It is obvious that effective management of material, information and financial flows between participants in agri-food supply chains will contribute to the creation of value at the level of each participant by forming friendly partnerships, optimizing parameters such as volume, costs, speed and quality of supplies. It is known that digital programs used for planning and managing agricultural production generate large amounts of information, the processing and analysis of which has become possible based on the introduction of information and communication technologies (ICT). It is the implementation of integrated ICT technologies that will provide the management of each participant in the agricultural supply chain with access to reliable information, the use of which will ensure the adoption of rational management decisions.

Thus, the “Agriculture 4.0” model focuses on precision farming technologies, IoT, and the use of large data sets to increase the efficiency of agricultural production. Thanks to the use of the listed tools in practical activities, agricultural producers have the opportunity to avoid production losses and waste based on calculating the exact amount of water and mineral fertilizer needs, and timely detection of the onset of individual diseases and pests in plants and animals on the farm. This model involves the use of artificial intelligence (AI) to accumulate large data sets, assess the current situation, and propose management decisions in real time, which allows for the prompt adoption of effective management decisions for the effective development of agricultural production.

As experts note, digitalization and the use of digital data have fundamentally changed the technological processes of agricultural production and processing, food manufacturing, which leads to radical changes in agri-food chains. These technological changes are currently under the influence of a new stage of digitalization and technological progress, which is accompanied by the further

development of information technologies, such as cloud computing, big data analytics and AI, which accelerate the process of digitalization [15]. Today, digital data has become a new type of business resource, which, in combination with digital technologies, has allowed to integrate all technological processes of agri-food production and goods movement into the value chain, as a result of which the conditions for implementing business processes have changed, which is the next "technological revolution" in agriculture [16].

As researchers emphasize, the digitalization of agriculture creates not only new opportunities, but also causes certain negative consequences. Thus, among the advantages of digitalization, it should be noted that it contributes to increasing the efficiency of the use of material and technical resources, has a positive effect on climate change, biodiversity, animal welfare, increases the transparency and traceability of food production. In addition, digitalization expands the possibilities for the spread of sustainable and environmentally friendly agricultural practices, as more precise use of nutrients and/or pesticides, herbicides is used, as a result of which the negative impact on the environment is reduced. In addition, there are opportunities to establish systematic monitoring of technological processes and improve the quality of information provided by digital technologies, on the basis of which management decisions are made.

The digitalization of agriculture creates opportunities for mitigating global climate change, the degradation of agricultural land and the increase in the world's population due to the fact that technological progress has led to a sharp increase in crop yields and productivity of farm animals and poultry, as well as the efficiency of agricultural production, but has increased environmental risks. First of all, transformational processes in agriculture have also led to changes in socio-technological development and increased the risk of increasing inequality in access to new technologies due to different financial capabilities of agricultural producers. In addition, there is a risk of data misuse among agricultural producers: agricultural producers disclose personal data about the management of the enterprise, but are poorly informed about how this information is stored, used and controlled. Finally, the implementation of digitalization by agricultural enterprises requires them to use more complex technical systems, which entails the risks of internal system failures, threats to the cybersecurity of digital systems.

We share the opinion of researchers who emphasize that digitalization can affect employment patterns in rural areas through job losses or the emergence of new types of employment [17]. At the same time, the digitalization of agriculture contributes to ensuring food safety by preventing risks and rational decision-making in agri-food supply chains.

The development of new models of digitalization of agri-food supply chains creates opportunities and a need to generate large amounts of information, on the basis of which systematic monitoring of food quality and safety is ensured, compliance with safety rules in technological processes and tracking the movement of products in supply chains, labeling, etc. There is no doubt that the ability to collect and analyze large amounts of data has played a revolutionary role in providing farmers with the opportunity to obtain more information to substantiate rational management decisions in agricultural production. It should be noted that until recently, agricultural producers lacked information for making decisions on the rational use of production resources, protecting crops from pests and diseases, as well as preserving livestock and poultry, and quickly adapting to changing weather conditions, which, with the introduction of digital technologies, makes it possible to control and analyze technological processes in real time. Thus, the Agriculture 4.0 model provides producers with the opportunity to create large data sets and use them when making management decisions, which contributes to the development of measures to improve technological production processes, increase efficiency and achieve sustainability of agricultural production.

Further development of digital products and innovative developments in the field of agriculture was oriented towards adherence to the principles of sustainable and innovative development, in particular the development of autonomous automated decision-making systems based on robotic complexes, which led to the justification of the concept of "Agricultural 5.0". The latest model of agricultural development characterizes an innovative era in which innovative technologies are introduced to increase the efficiency of production activities and its sustainability. Thus, the use of robotics, "augmented or augmented reality" technologies and 6G technologies is progress in the development of the studied industry, which contributes to the establishment of real-time monitoring and automation of technological processes of agricul-

tural production. Artificial intelligence and big data play an important role in the effectiveness of the "Agriculture 5.0" model, as they provide valuable information for making management decisions based on data analysis and developing relevant forecasts.

The concept of "Agricultural 5.0" plays an important role in achieving the principles of sustainable development based on increasing the efficiency of agricultural activities and the sustainability of agribusiness enterprises. This model is oriented towards improving technological processes based on their automation, minimizing losses in the production, transportation and storage of agricultural products, food waste, as well as introducing methods for controlling harmful emissions into the environment. As experts note, the combination of intelligent machines and systems in agriculture allows optimizing the use of land and water resources, reducing the use of pesticides and fertilizers, and reducing costs. An important aspect is also minimizing the risk of accidents when performing technological operations in extreme conditions, mountainous terrain, steep slopes, etc. In addition, intelligent machines and systems lead to the creation of an appropriate digital infrastructure that will ensure interaction and exchange of information between numerous agricultural producers [18]. If properly designed, automated agricultural machines help reduce the workload of farm workers, as they allow one worker to remotely control many units from the main control point [19]. Obviously, the effectiveness of the automated system will depend on the farmer's ability to quickly receive information from each production unit via an interface and use it to make operational management decisions.

An important element of the "Agricultural 5.0" model is biotechnology, which allows the agricultural producer to be more efficient while simultaneously reducing the negative impact on the environment [20]. Thus, biological technologies used in agriculture include solar energy production, water harvesting and conservation, etc. It should be noted that biotechnology has become widely used in agriculture, which allows to increase crop yields and increase the productivity of farm animals and poultry.

One of the elements of the Agricultural 5.0 model is microrobots that can perform special tasks. It is known that scientists from the University of Exeter (Great Britain) have developed biohybrid microrobots that integrate synthetic and biological elements to perform nanoscale biochemical procedures with very high precision [21]. As experts emphasize, biological robotic systems have unique properties, but require significant costs. This is explained by the fact that, unlike robots with a rigid body, soft biocomposite materials are expensive, as they include artificial intelligence [22].

Let us consider the next element of this model, which is the technology of digital twins (Digital Twin), which is characterized by a high potential for bringing "smart agriculture" to a higher level of productivity and sustainability. Digital twin technology is a multi-scale and probabilistic simulation model that uses modern sensors and models to reproduce real conditions in the digital sphere and vice versa [23]. So, the technology "digital twin" is a computer program that accepts as input data - parameters about the real state of an object or system, and generates, as output data, forecasts or modeling scenarios of their impact on individual technological processes or the enterprise as a whole. The scientific literature provides numerous areas of application of this technology in agricultural production, in particular in precision agriculture, smart livestock (digital twin platforms Prefix, Ditto and Watson), vertical farming [24].

One of the elements of the concept of "Agricultural 5.0" is the fifth generation of mobile technologies (5G), which have certain limitations due to: high cost of infrastructure; limited coverage area; guarantee of high security [25]. According to preliminary estimates, the 6G network will be adapted for combined communications and perception based on their conversion into a sensor to create a digital sixth sense, which increases human intelligence, will provide ubiquitous wireless connectivity and access for less affluent segments of the population. Undoubtedly, the full use of the potential of Agriculture 5.0 technology depends on the creation of an appropriate state structure and digital infrastructure that would provide support for agricultural producers to implement innovative technologies, organize training and practical training for beginners to learn how to use them.

At the same time, it is necessary to take into account that technological industrialization and modernization of agricultural production increases environmental risks, such as soil quality degradation, erosion, compaction and pollution. In addition, it is important to consider social problems that may arise when implementing the "Agricultural 5.0" model. Taking into account the above, there is a need to introduce ecologically

and climate-oriented technologies for the production of agricultural products, as well as develop programs for the development of entrepreneurial initiative among residents of rural areas. Let us consider the next stage of technological renewal of agriculture, which is envisaged by the new concept of "Agricultural 6.0". This model clearly demonstrates the desire to achieve the Sustainable Development Goals based on the rational use of production resources and minimal negative impact on the environment, which will allow leaving conditions no worse than the current ones for future generations. This means that in the near future, the relationship between humans, agriculture and nature should be balanced on the basis of making management decisions in agriculture taking into account the requirements of environmental conservation and ecosystem restoration, which will contribute to increasing the well-being of the population, achieving ecological balance and preserving biodiversity.

This model uses regenerative farming systems, which include moisture and soil conservation farming, organic farming, innovative biosecurity and biosafety systems that contribute to the restoration of soil and environmental quality. In addition, the implementation of the No-Till farming system makes it possible to prevent soil erosion, ensure water retention and increase carbon absorption by the system [26]. Another practice is integrated pest management based on the use of biological products, which, in addition to plant protection, contribute to the release, transfer and circulation of essential nutrients from the soil to the plant.

Another technological solution of the Agricultural 6.0 concept is the circular economy, which involves the reuse of resources. The circular economy provides the following benefits: waste disposal; reduction of negative impact on the environment; reduction of the use of natural resources; savings due to a closed production cycle; use of innovative methods of consumption and production; creation of new jobs [27]. Thus, the circular economy increases the productivity of agriculture by reducing waste and replacing disposal with reuse flows. It is obvious that this production model is important for agriculture, as it ensures the transformation of waste into new value-added products, such as biofertilizers, bioenergy and biomolecules.

It should be noted that the components of the promising concept of agriculture are the development of biotechnology, bioeconomy, bioecology, bioresources, methods of synthetic biology and genetic engineering. One of the strategic directions of agricultural development is also the production of biofuels and of bioenergy energy.

Generalized characteristics of agricultural development concepts are presented in Table 1.

Undoubtedly, agriculture is the leading sector of our country's economy, which demonstrates sustainable development in times of war, as it creates up to 10% of GDP and over 40% of foreign exchange export earnings. However, given the increasing impact of global climate change and the destruction and restrictions on the use of the resource potential of agricultural production caused by military actions, we should expect an increase in the downward dynamics in the volume of production. It is known that military actions have made almost 5 million hectares (12%) inaccessible for agricultural production [28]. This situation requires comprehensive support for agricultural producers in implementing innovations, investing in the construction of irrigation systems, implementing digital technologies and sustainable management practices. Thus, in 2024, almost $1.2 billion was invested in the modernization of agriculture, namely: drones for monitoring crops (15% of farms have implemented the technology); precision farming; organic farming.

It is obvious that the strategic development of agriculture in our country should be oriented towards modern innovative models. It should be noted that the transition from one concept of agriculture to another occurs sequentially, which requires the development of appropriate strategic programs with an effective set of organizational and economic tools and measures to implement the corresponding model. It is known that in Ukraine an Agrotech development strategy has been developed, which provides for the development of the direction of digitalization, automation and increasing the efficiency of agriculture and the food industry [29]. The developed document will contribute to the creation of conditions for the introduction of digital technologies, AI, the Internet of Things and robotic systems into agricultural production, which will allow accelerating the transition to Agricultural 5.0 technology in domestic practice. The implementation of this strategy will ensure the solution of the following tasks: production of agri-food with high added value; labor shortage; carrying out demining work and improving the quality of agricultural lands; adaptation of agricultural producers to climate change; modernization of the livestock industry.

Table 1 – **General characteristics of the main concepts of agricultural development**

Type	Characteristics	Period	Practices	Impact on performance indicators
Agricultural 1.0 Traditional Agriculture	Traditional Practices	Before 1950	Intensive use of resource potential	Low level of production productivity
Agricultural 2.0 Mechanized Agriculture	Beginning of modernization and improvement of agricultural practices	1950-1990	Implementation of scientific results, intensive use of means of production, pesticides, entry into new markets	Increasing production efficiency and productivity, however, led to chemical pollution of agricultural land, excessive energy consumption and excessive use of natural resources
Agricultural 3.0 Precision Agriculture	Agricultural system management, productivity monitoring..	1990-2015	Georeferencing technology, biotechnology, management per unit area	Reducing the use of chemicals, increasing the accuracy of technological operations.
Agricultural 4.0 Digital Agriculture	Development of new digital skills based on databases that link the production model and the different actors in the value chains	2015 - present	Equipment and digital tools for collecting and analyzing data from the field: IoT, big data, cloud computing, image processing, geographic information system (GIS), drones, communication technologies, blockchain	The evolution from a traditional system to a digital system reduces time, costs, increases production efficiency and product quality.
Agricultural 5.0 Smart Agriculture	Management based on big data, implementation of robotics with AI algorithms	Present	Intelligent systems using unmanned and autonomous decision support systems: robotics and AI - decision automation; machine learning; wireless sensor networks бездротові сенсорні мережі	Improving the decision-making process, increasing profitability, solving the problem of labor shortages, ensuring more accurate use of production resources.
Agricultural 6.0 Integrative agriculture	Specialized solutions based on environmental protection, ecosystem management and restoration requirements	Future	Renewable systems, circular economy, biorevolution, biofuels and bioenergy, carbon credits	Achieving sustainability of agricultural production based on the rational and sustainable use of natural resources and improving people's well-being

Source: summarized by the author.

Conclusions. The obtained research results allow us to conclude that technological progress over a long period of time has significantly transformed agriculture and production systems. Today, innovative methods, practices and technologies are being introduced into agricultural production that increase its efficiency and sustainability.

Today, domestic agricultural production is at the stage of transition to a digital agriculture model, which involves changes in practices and methods of performing technological operations at the level of all participants in the agri-food supply chain. The introduction of digital technologies leads to the modernization of production activities and places demands on agricultural workers in the development of new skills and competencies. In addition, digitalization has opened a new stage of agricultural transformation, an important part of which are digital platforms that open up new opportunities for implementing the principles of sustainable development in agricultural practice.

The main priorities of the strategic development of domestic agriculture are the introduction of such technologies as: information and communication; digital; "smart" agriculture; Internet of Things; sensor technologies; unmanned aerial vehicles; robotic systems; large data sets, etc. We believe that the implementation of the latest models of agricultural development in national conditions requires the development of appropriate strategic programs, in which it is advisable to combine organizational and economic tools for achieving innovative and sustainable development of the industry. As for agricultural science, there is a need to develop methodological approaches to assessing the level of digitalization of agricultural production, especially the concepts of "smart agriculture" and "precision agriculture". It is obvious that the promising model of agricultural development "Agricultural 6.0" represents a paradigm shift that combines the principles of innovative and sustainable development, which will contribute to strengthening the country's position in the global market as a supplier of competitive agri-food products. The integrated agricultural model involves the rational use of resource potential based on the development of bioeconomy, circular economy, biofuels, renewable technologies, and other innovative developments, which will allow achieving balanced development between human well-being and the environment.

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Стратегічні пріоритети розвитку сільського господарства на засадах концепції Agricultural 5.0 і Agricultural 6.0

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Узагальнено еволюцію технологічних досягнень у сільському господарстві на основі їх розвитку від традиційних систем до концепцій «Agricultural 5.0» та «Agricultural 6.0», виділено інноваційні продукти їх реалізації. Висвітлено концепцію «Agriculture 4.0» та її основні інструменти: сенсорні технології, високошвидкісний мобільний зв'язок, аналітику великих масивів даних, сенсорні технології, штучний інтелект, робототехніку. Наголошено, що цифрове сільське господарство включає цифрові та геопросторові технології для моніторингу, оцінювання та управління ґрунтовими, кліматичними та генетичними ресурсами, а сформовані ними цифрові дані є видом бізнес-ресурсу. Аргументовано, що цифрові технології поєднали в інтегрований ланцюг вартості всі технологічні процеси виробництва і товароруху агропродовольства, що змінило здійснення бізнес-процесів. Узагальнено позитивні та негативні впливи цифровізації на результуючі показники розвитку сільського господарства.

Обґрунтовано, що концепція «Agricultural 5.0» є новим підходом до розвитку сільського господарства, основними технологічними рішеннями якої є використання робототехніки, технологій «розширеної або доповненої реальності», технологій 6G, ШІ, великих масивів даних, біотехнології, мікророботів, біологічних роботизованих систем. Систематизовано впливи цієї моделі на підвищення ефективності виробничої діяльності, реалізацію принципів сталого розвитку, удосконалення технологічних процесів, мінімізації втрат у технологічних процесах, продовольчих відходів на етапі споживання, а також запровадження методів контролю викидів шкідливих речовин.

Охарактеризовано перспективну концепцію «Agricultural 6.0» інтегративного сільського господарства та основні її елементів: відновлювальних систем землеробства, циркулярної економіки, біореволюції, біопалива та біоенергетики, вуглецевих кредитів тощо. Доведено, що ця модель сприяє досягненню стійкості сільськогосподарського виробництва та підвищенню добробуту людини на основі раціонального та сталого використання природних ресурсів.

Наголошено, що вітчизняне сільськогосподарське виробництво знаходиться на стадії переходу до моделі цифрового сільського господарства, яке передбачає зміни у практиках та способах здійснення технологічних операцій на рівні усіх учасників агропродовольчого ланцюга постачання. Обґрунтовано, що стратегічний розвиток українського сільського господарства має бути зорієнтованим на впровадження сучасних інноваційних моделей, що вимагає розроблення відповідних стратегічних програм із дієвим комплексом організаційно-економічних інструментів та заходів щодо досягнення інноваційного та сталого розвитку галузі.

Ключові слова: розумне сільське господарство, цифрове сільське господарство, точне сільське господарство, цифрові технології, сталий розвиток, відновлювані технології, біоекономіка, циркулярна економіка.

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