DIGITAL AND ENGINEERING TECHNOLOGIES AS A FACTOR OF INTENSIVE DEVELOPMENT OF AGRICULTURE

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Abstract

In modern conditions, digital and engineering technologies are becoming a key factor for the intensive development of agriculture. The introduction of modern digital sensors, satellite monitoring systems, computer vision technology and artificial intelligence makes it possible to optimize production processes, increase productivity and product quality, reduce labor costs and resource intensity of products. In the context of global agricultural development trends, digitalization and engineering innovation play a critical role in ensuring food security and sustainable rural development. This article discusses modern digital and engineering technologies and the potential for their use in the agro-industrial complex of the Russian Federation. Sustainable development is a process of positive transformation that ensures economic growth, social justice and environmental protection for future generations. The development of directions for sustainable development of enterprises, territories, national and global economies should be carried out on the basis of a comprehensive analysis of the theoretical, methodological and socio-economic aspects of human interaction with the environment. This article analyzes various models and concepts of sustainable development, highlighting their key characteristics and applicability in the modern world. In the context of growing global challenges related to public health and environmental degradation, the collaboration between government and civil society has become increasingly vital.

Keywords: sustainable development, reproductive health, environmental sustainability, public policy, partnership, gender equality.

I. Introduction

Agriculture is traditionally one of the significant sectors of the national economy of the Russian Federation. The socio-economic prerequisites for the development of agriculture are determined by the scale and overall development of the territory, its population, the provision of labor resources, as well as regional differences in the economic situation: rising prices, investments, the proximity of markets for products. In the twentieth century, large-scale industrialization of the Russian state displaced the agricultural sector from the priority areas of the country's development, and today it accounts for only 4% of total GDP. At the same time, in the context of the intensification of fundamentally new sanctions and epidemiological threats, strengthening agriculture directly meets the objectives of ensuring the country’s national security.

Agriculture is the only Russian industry that demonstrates fairly sustainable development even in a crisis situation in the national economy (Fig. 1).

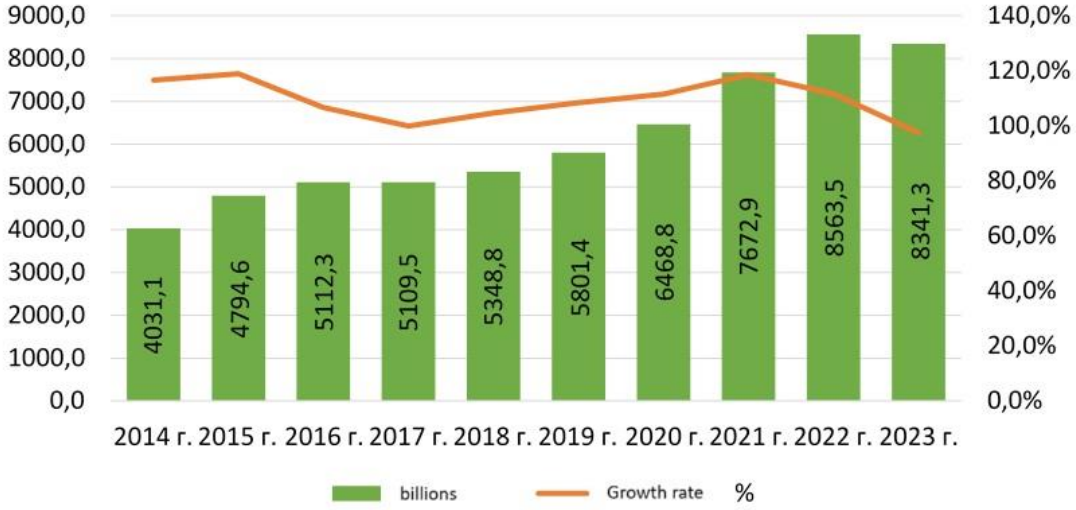

Fig. 1. Volume of production in the agricultural sector

To date, 355,000 enterprises operating in the agricultural sector are registered in the Russian Federation, more than half of which are private farms or individual entrepreneurs. The development of private farms is a priority in the development of the domestic agro-industrial complex.

II. Methods

In accordance with Decree of the President of the Russian Federation No. 20 of January 21, 2020, the Doctrine of Food Security of the Russian Federation was approved, which is a strategic planning document reflecting official views on the goals, objectives and main directions of state policy in the field of providing the population with domestic agricultural products and other food. The implementation of the provisions of this doctrine can be achieved through comprehensive support for innovative reform and digital transformation of the country's agro-industrial complex.

A new stage in the development of production, associated with the widespread introduction of digital technologies and automation, is called Industry 4.0. This stage involves a new approach to agricultural production, based on the massive introduction of information technology into industry, large-scale automation of business processes and the spread of artificial intelligence. Digital and engineering technologies can be used in the following areas (Fig. 2).

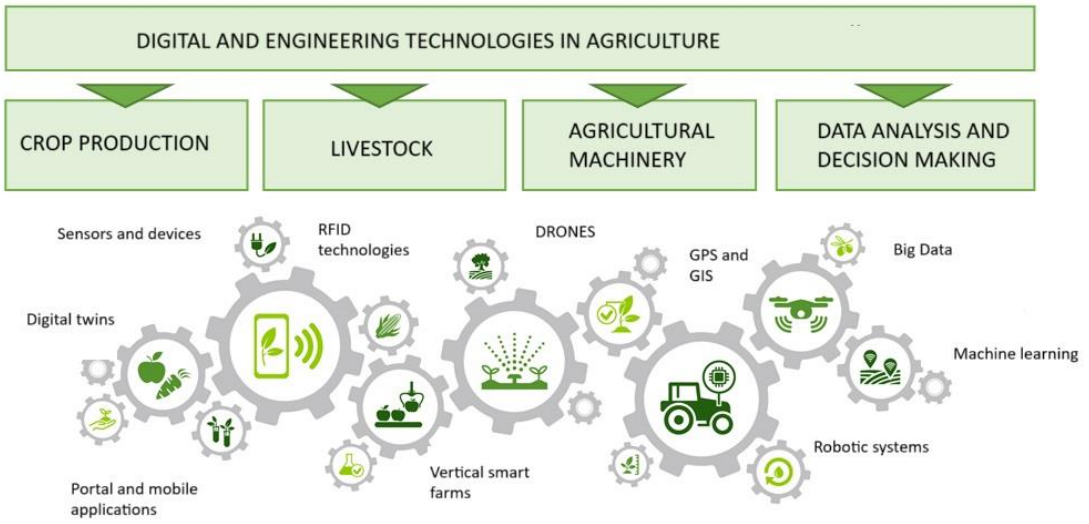

Fig. 2. Digital and engineering technologies in agriculture

Geographic information systems (GIS) are a system for collecting, storing, analyzing and graphically visualizing spatial (geographic) data and related information about the necessary objects. They combine data on the geographic location of crop areas with such significant categories of information as soil characteristics, climatic conditions, terrain, and the history of use of a particular piece of land. GIS allows you to create digital maps of fields, analyze their characteristics and determine the optimal locations for planting various crops. Agricultural producers can also use GIS to plan irrigation, fertilization, and crop protection systems to optimize resource use and increase yields. In addition, GIS allows you to track changes in fields, analyze and predict crop yields, and manage risks associated with climate change and other factors. They can also be used to control the transportation and storage of agricultural products.

The use of modern information and communication technologies (ICT), sensors and Internet of Things (IoT) devices in agriculture opens up new opportunities to increase efficiency and improve control of production processes. Sensors placed in fields and livestock farms collect data on climate conditions, soil moisture, and the condition of plants and animals. This data is transmitted in real time to cloud platforms and mobile applications, allowing agronomists and farmers to analyze it and make informed decisions.

The use of IoT devices can also automate many processes, such as watering, fertilizing and pest control, which helps optimize resource use and reduce costs. Thanks to modern information technologies, agricultural enterprises can implement the principles of precision agriculture, allowing them to increase production efficiency, reduce costs and minimize the negative impact on the environment. Precision agriculture is based on collecting and analyzing data about soil, plants, weather and other factors using sensors, GPS, drones and other technologies. Instead of treating the entire field in the same way, precision farming involves differentiated dosages of water, fertilizers and pesticides, taking into account differences in soil characteristics, humidity, and yield of areas. The main elements of the precision farming system are presented in Fig. 3.

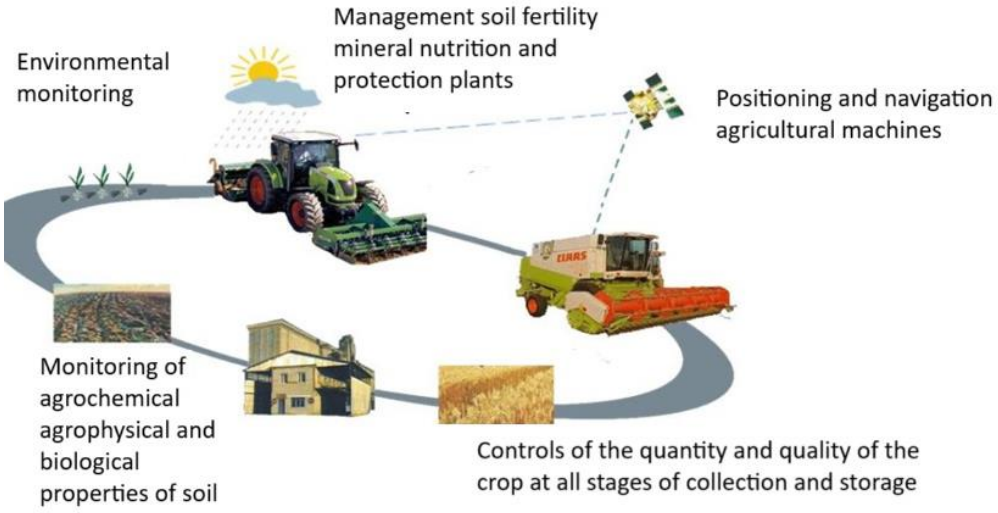

Fig. 3. Main elements of a precision farming system

III. Results

Modern digital sensors allow you to measure soil moisture, air temperature, light levels, the presence of nutrients in the soil and other relevant indicators. Unmanned aerial vehicles and special cameras continuously monitor farmland. Analysis of the resulting images using computer vision and machine learning algorithms allows us to identify signs of diseases, nutrient deficiencies and other problems that impede plant development. Spectrometers and other devices measure the spectral

characteristics of light reflected by plants, allowing them to determine the ongoing physiological characteristics of grains, fruits and vegetables. Mobile applications provide farmers with a convenient way to monitor plant health, receive care recommendations, and make operational decisions based on data collected from the fields.

Radio frequency identification (RFID) technology is used for marking and identifying animals. RFID tags can be implanted in an animal's ear or attached to an animal's neck, allowing location, health, and other characteristics to be tracked both currently and over time. RFID can be used to create digital reports and documentation of every stage of production, from animal breeding to food processing. This will ensure transparency and reliability of the food chain, as well as compliance with food safety standards. Automatic systems for dispensing feed and water for animals allow farmers to accurately control the diet and reduce labor costs in the organization. Digital technologies also make it possible to track animal reproductive parameters and optimize artificial insemination programs, which improves the efficiency of herd management. Virtual reality goggles showing green pastures can reduce anxiety and increase milk production in cows.

Automation of agricultural machinery and equipment using AI and robotics improves the accuracy and productivity of operations. Modern agricultural production is equipped with such innovative equipment as robotic weeders, automated seeders, tractors, shepherds and harvesters (Fig. 4).

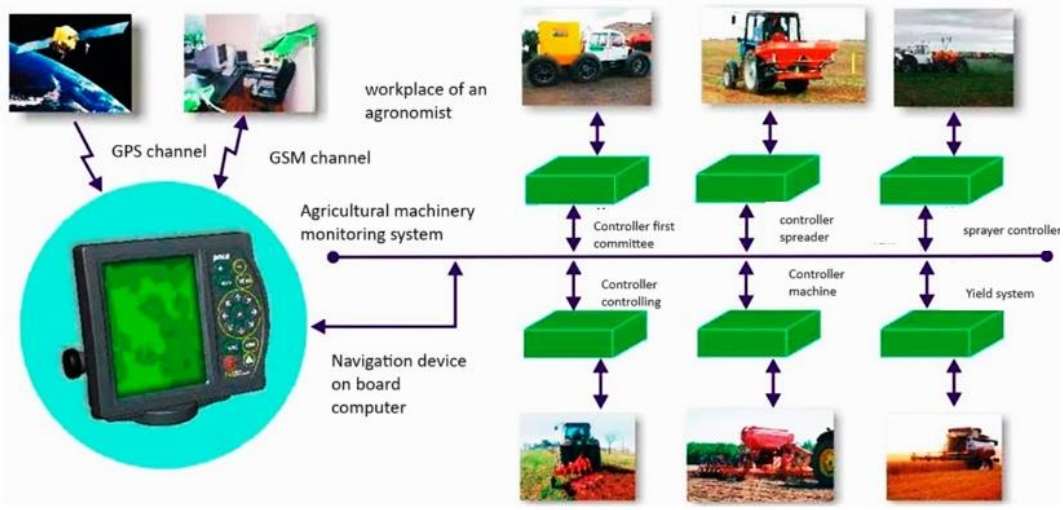

Fig. 4. Automation of agricultural machinery and equipment

A promising engineering solution in the field of crop production are vertical “smart” farms, which are highly automated agro-industrial complexes for growing crops using hydroponics or aeroponics indoors. The main differences between vertical agricultural production and traditional greenhouses are the multi-tiered placement of plantings and a fully controlled indoor climate. In a vertical farm, a water cycle is organized, which makes it possible to significantly save this valuable resource, reducing operating costs and increasing the environmental friendliness of production (Fig. 5).

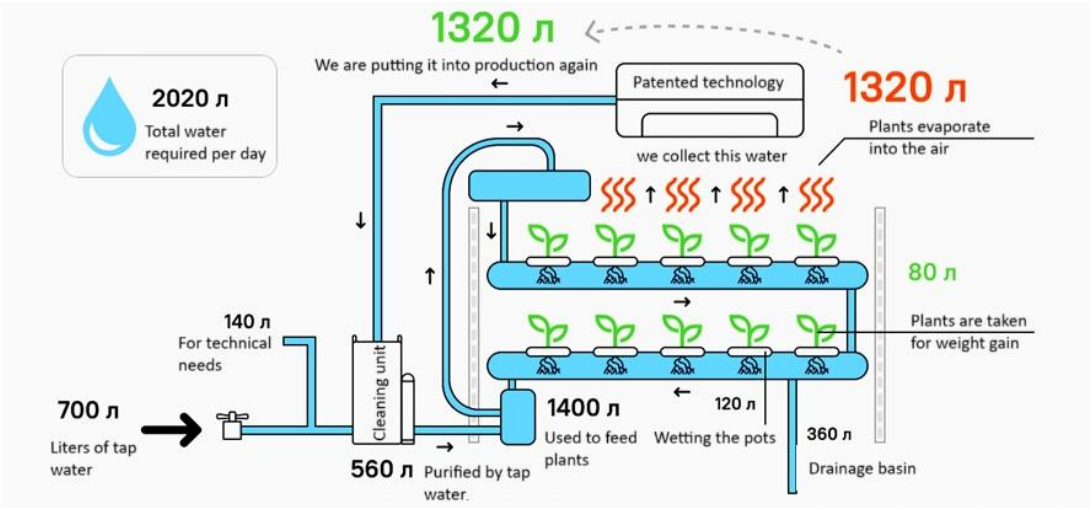

Fig. 5. Water cycle on a vertical farm with an area of 1000 m2

Big Data technologies in agriculture play a significant role in collecting, analyzing and using huge volumes of data to optimize production processes and decision making. Thus, the collection and analysis of data on soil fertility and weather conditions during different periods makes it possible to create predictive models that help farmers estimate yields in different areas of the fields. Data analytics and machine learning algorithms can be used to predict the occurrence of diseases and pests on plants, allowing farmers to take disease prevention and timely treatment measures, minimizing crop losses.

Monitoring and analyzing data from agricultural equipment allows you to predict possible failures and carry out preventive maintenance, which helps reduce downtime and increase operational efficiency. Analyzing data about growing and processing processes allows farmers to optimize these processes to achieve higher quality products, which in turn helps to increase competitiveness in the market. Platforms powered by Big Data connect farmers with buyers, reducing the cost of intermediaries and enabling more efficient trading of agricultural products.

IV. Discussion

I. Subsection One: The Complementary Roles of State and Civil Society

At the present stage, simulation technologies using digital twins are gaining great importance in agriculture. Digital twins are virtual models of real objects or systems that can be used for monitoring, analysis and control. Digital twins can be created to simulate fields to plan crops, manage watering and fertilization, and predict yields. Also, based on data on natural and climatic conditions, soil cover parameters and the specifics of economic intervention, the growth of various plants can be simulated to make optimal management decisions. Digital twins can be used to create virtual models of farm equipment and vehicles, allowing farmers to monitor equipment condition, predict maintenance needs, optimize routes and manage logistics. Thus, digital twins represent a powerful tool for improving the efficiency of agricultural production.

The active development and digitalization of agricultural production in the Russian Federation is ensured through a well-thought-out national program implemented by the Ministry of Agriculture of the Russian Federation together with JSC Rosselkhozbank, which is the leader of national credit and financial support for the agro-industrial sector and rural areas. Today, there are more than 30 types of government support for agricultural producers, the main one of which is to subsidize part of the interest rate on long-term loans. The state program to support agriculture has made it possible in recent years to increase the level of financing in the agricultural sector and provide state insurance in case of crop loss or death of livestock. Beginning farmers can take advantage of government grants to create a farm,

one-time assistance for household equipment, subsidies for the implementation of digital investment projects and to pay the first payment for leasing automated agricultural equipment.

In 2021, Rosselkhozbank has set itself the ambitious task of creating a digital ecosystem for residents of rural areas, which will allow optimizing the purchase and sale of commercial products, property management, finding jobs, obtaining financial services, as well as attracting ecotourists and volunteers. There are currently four service applications running:

- "Svoe Selo" – allows you to receive almost the entire range of services for arranging country life online;
- "Own Housing" - helps meet the needs of rural residents related to the purchase of real estate;
- "Own Farming" - focuses on supporting agricultural enterprises, as well as farmers and other agricultural producers;
- "Svoe Rodnoe" is a digital B2C platform that allows farmers to directly sell their products to consumers.

The functionality of these applications is included in the digital ecosystem "Svoe" from Rosselkhozbank [4].

Comprehensive financial, credit, information and digital support provided by Rosselkhozbank JSC contributes to the active development of the Russian agricultural industry, meeting food security requirements, intensive digital transformation and ensuring the competitiveness of Russian food products on the world market.

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