Direction of Digital Transformation of Agriculture in Russia*

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Abstract. The research relevance lies in the analysis and development trend of the agro-industrial complex at the current stage: "Agriculture 4.0." The paper aims to develop practical recommendations on the formation and development of digital technologies and the digital environment of the Russian agro-industrial complex. The research goals include (1) determining the theoretical aspects of the development of the digitalization of the agro-industrial complex of Russia within the "Agriculture 4.0"; (2) analyzing and establishing trends in the development of digitalization at the international and national levels; (3) identifying the direction of digitalization of agriculture in Russia, taking into account the horizon planning of key trends in the agro-industrial complex. In the introduction, we considered the directions and trends of technological development ("Agriculture 4.0"), established the concept of cyber-physical systems, and determined the significance of the introduction of cyber-physical systems in the digital transformation of society. The materials of the theoretical research were publications addressing the digital transformation of agriculture in Russia. Report of the XXI April International Scientific Conference on Problems of Economic and Social Development. The methodological basis comprises general scientific, private, and economic research methods, monographic research, abstract-logical, and statistical methods. In this case, the general scientific methods are represented by the dialectical method, and the private scientific methods include analysis, observation, hypothesis, and scientific abstraction. The result of the study is practical recommendations for the formation of a cyber-physical system in agriculture. The discussion section covers various aspects of digital transformation and the statements of representatives of the manufacturing sector. The conclusion section offers future trends and directions for studying the development of digital infrastructure.

Keywords: Agro-industrial complex, Agriculture, Agriculture 4.0, Digitalization of agriculture, Digital transformation

1 Introduction

Currently, the innovative development of the agro-industrial complex involves digitalization and globalization, which provides for digital technologies and a technical and technological way of life within the framework of "Agriculture 4.0" and "Industry 6.0." "Agriculture 4.0" is the transition of the industry to a new technological way, implying the following factors [1]:

- Increase in yield, productivity, and quality of raw materials and prevention of losses;
- Changes in value creation due to knowledge intensity in genetics and IT engineering technologies;
- Introduction of information infrastructure (data processing centers, digital platforms that meet the needs of consumers and ensure the development of agricultural business).

Innovative development of the agro-industrial complex, the planning horizon, and key technological development trends of "Agriculture 4.0" are based on the digitalization of agriculture (Fig. 1).

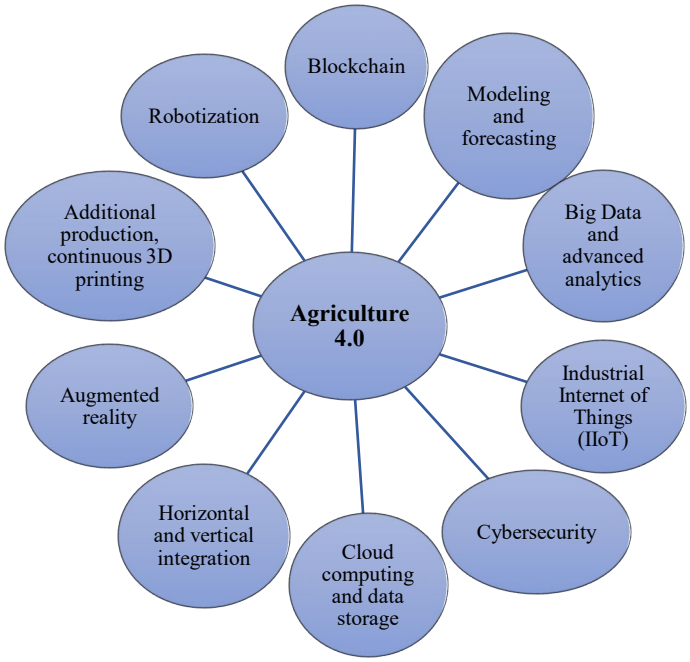

Fig. 1. The direction of technological development of "Agriculture 4.0". *Source*: Compiled by the authors.

Digital agriculture means a fundamental change in the quality of technological process management and production management, taking into account forecasting and the information basis of the agro-industrial complex of Russia and its regions.

The use of digital technologies in agriculture allows one to create optimal conditions for the production, processing, and sale of agricultural products.

The development of intelligent agriculture and innovative, intelligent technologies will make the agricultural industry attractive to investors and producers. The introduction of smart technologies in agriculture requires reengineering all sectors of the agro-industrial complex related to the production, processing, storage, transportation, and delivery of products. The use of intelligent systems in agricultural production minimizes the use of external resources (fertilizers, chemicals, and fuels) and maximizes the use of local factors (biofuels, organic substances, and own energy sources) [6].

In our opinion, there is a need for a system based on the interaction of physical and computational processes – cyber-physical systems [CPS].

Thus, CPS is the interaction of physical and computational elements at five layers:

- I – physical;
- II – network;
- III – data storage;
- IV –processing and analytics layer;
- V – application layer.

Also, CPS is a promising direction affecting the quality of life of the rural population and the production of agricultural products. However, at this stage, cyber-physical systems have certain drawbacks.

The significance and relevance of the research lie in the study of the concept of CPS within the technological development of “Industry 4.0” and “Agriculture 4.0” [7].

The study aims to develop theoretical and practical recommendations for forming and developing the digital environment in the agro-industrial complex.

There are the following research tasks:

- Determining the theoretical aspects of the development of digitalization of the agro-industrial complex in Russia within the framework of “Agriculture 4.0”;
- Analyzing and establishing trends in the development of digitalization at the international and national level;
- Identifying the direction of digitalization of agriculture in Russia, taking into account the horizon planning of key trends in the agro-industrial complex.

The research object is represented by the enterprises of the agro-industrial complex and the rural territories of Russia.

The research subject is trends, patterns, and factors of the formation and functioning of the digital environment in agriculture.

2 Materials And Methods

Theoretical and practical issues of digital transformation of agriculture in Russia are considered in the information edition of the Department of Digital Development and Management of State and Information Resources of the Agro-Industrial Complex [5].

The information edition reflects the following aspects:

- Problems of digital transformation of agriculture in Russia;
- Need for such a transformation;
- Purpose and objectives of measures to digitalize agriculture in Russia;
- Stages of digitalization and indicators of their implementation;
- Regional view on the problems of digitalization;
- Regional-level activities.

Prerequisites for the transformation of the agro-industrial complex and global trends were announced in the report of the Institute for Agrarian Studies of the Higher School of Economics together with the National Association for Technology Transfer and the SKOLKOVO Foundation for the plenary session of the April Conference of the Higher School of Economics on Innovative Development of the Agro-Industrial Complex of Russia. The report examines the key challenges and promising areas of development of the Russian agro-industrial complex, as well as the prerequisites, growth factors, and barriers to its global competitiveness [2].

Methods of factor analysis and grouping and tabular and graphical methods of visualization of statistical data served as statistical tools. The MS Excel, STATISTIKA, Eviews, and STATA application software packages were used for information processing. Abstract-logical, computational-constructive, analytical, and other methods were applied. When processing the initial information, we also used an economic-statistical, retrospective, and comparative analysis of expert assessments, correlation, regression, and sociological research. When substantiating the research results, the following methods were used: system analysis, cluster and content analysis, economical-mathematical and simulation modeling, forecasting, and predictive scenario.

3 Results

Global problems of the modern state of agriculture imply biotechnology modernization of the agricultural sector, taking into account the trends and requirements of “Agriculture 4.0” and “Industry 4.0.”

The concept of “Agriculture 4.0” is a breakthrough in biotechnology agriculture, which allows one to obtain the maximum effect (profit) from the resources, tools, and capacity of farms in the region and the entire country (Fig. 2).

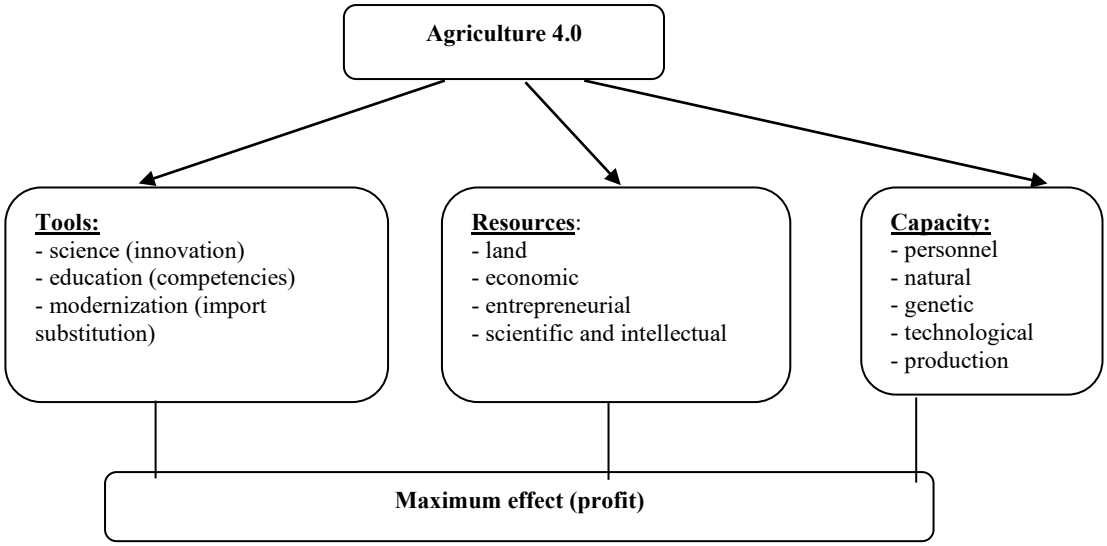

Fig. 2. The main tools, resources, and potential of "Agriculture 4.0.". *Source*: Compiled by the authors.

Digital transformation in agriculture involves a new model of agricultural production, taking into account the transition of society to an information-industrial stage. The transition of society to digital transformation increased competition between producers, processors, and sellers of raw materials for the consumer and market share. Besides, price competition is complemented by competition in the quality of raw materials [5]. Currently, there is an informational and industrial formation and the introduction of cyber-physical systems in the agricultural complex of the regions. Therefore, CPS is progress, technical, and technological trend (Fig. 3).

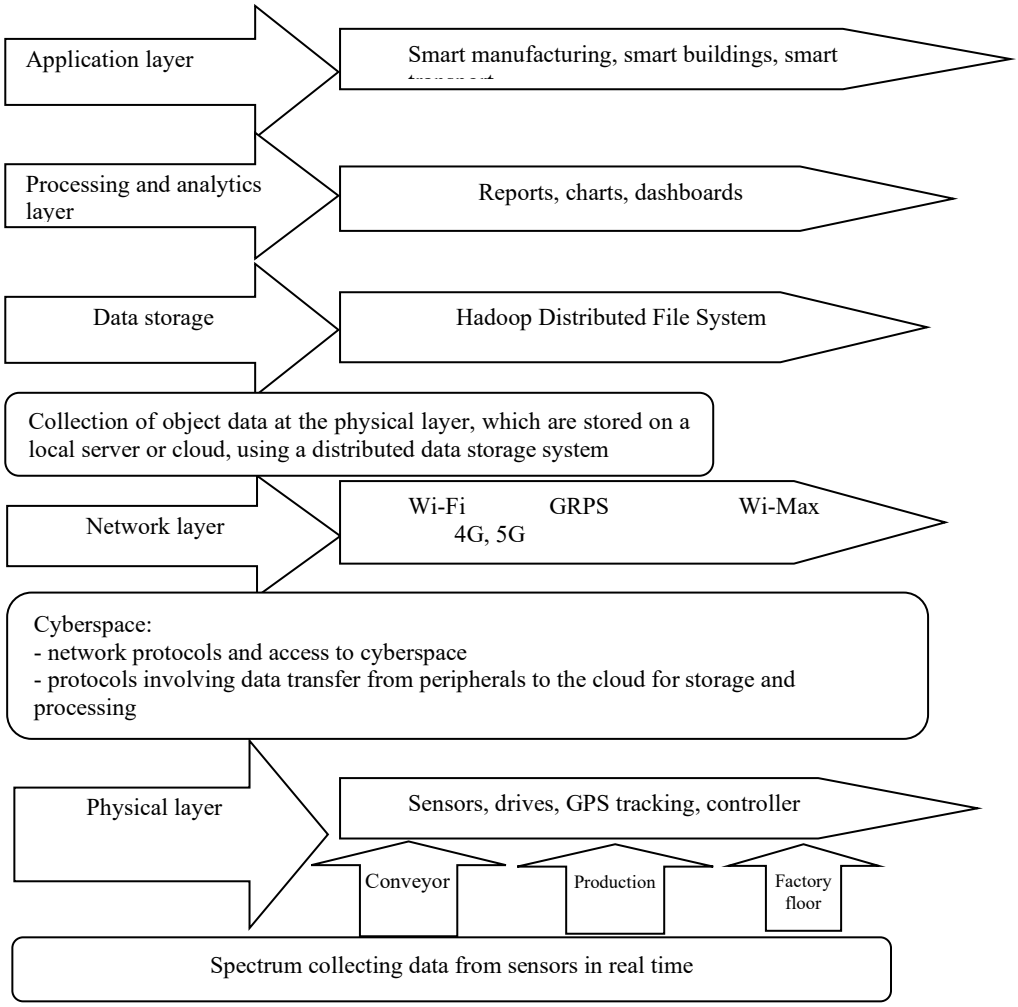

Fig. 3. CPS concept model. *Source*: Compiled by the authors.

In this regard, the conceptual model of the CPS for agriculture has its specifics reflecting the digital transformation of agriculture.

As part of the digital transformation, many information platforms should be created and be open to participants. This step will accelerate digitalization, ensure competition between IT companies and consulting agencies, and guarantee the reliability of data turnover in agriculture (Fig. 4).

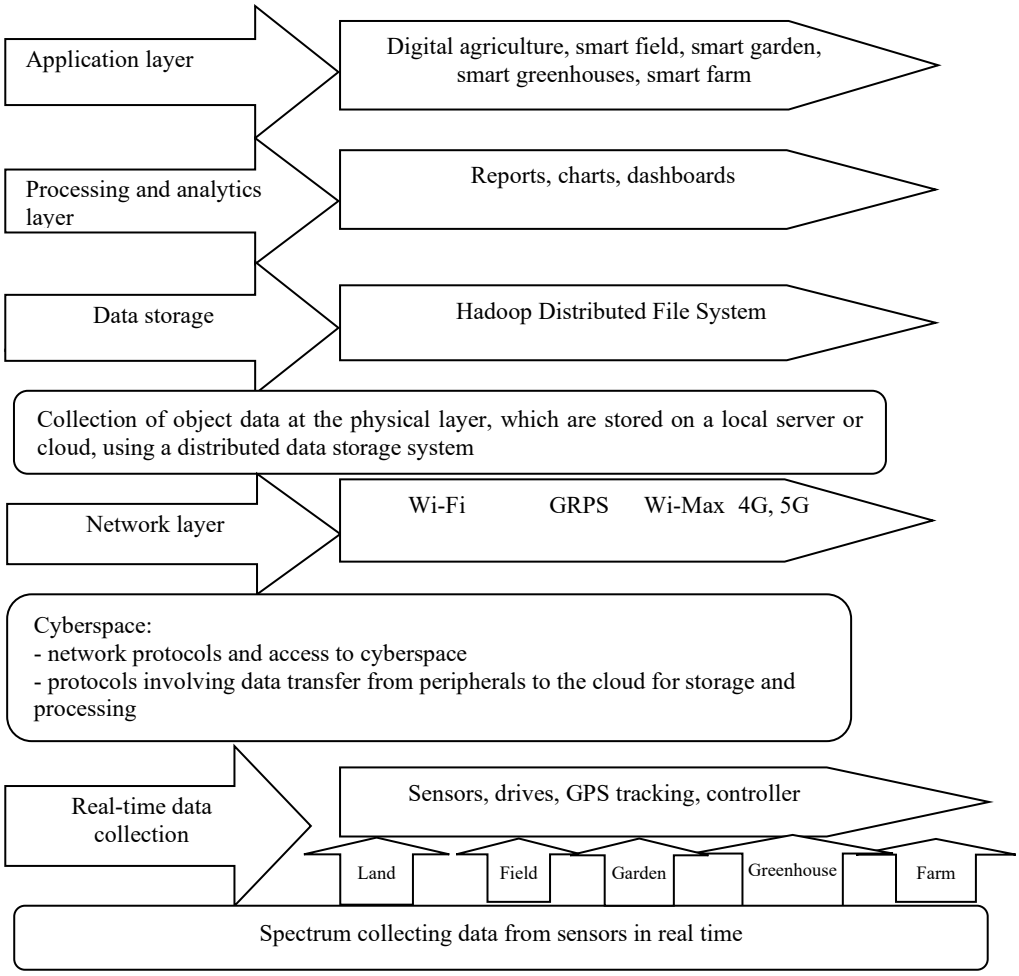

Fig. 4. Levels of CPS in the digitalization of agriculture. Source: Compiled by the authors.

The digital transformation scenario assumes a systematic, accelerated digitalization of agricultural production and integration with the directions of the national program "Digital Economy of the Russian Federation."

The direction of the digital transformation of agriculture is the satisfaction of the vital human need for food products (socio-biological purpose) and the achievement of maximum economic efficiency (profit) by increasing labor productivity and reducing costs.

4 Discussion

Helen Gill was the first to use the term CPS.

Norbert Wiener defined the concept of "cybernetics" (from the Greek *κυβερνητική* – the art of management) as a symbiosis of control and closed-loop communication (with a feedback and logic control of physical processes) [3]. According to Wiener, the classical concept of cyber-physical control systems combines physical processes, computing, and communications.

Thus, CPS is the integration of information modeling of knowledge in the system of the digital economy.

The digital transformation of society and the economy has the following technical characteristics (Fig. 5):

- Real-time process;
- Visualization;
- Data management process (IIoT, GPS, wireless data).

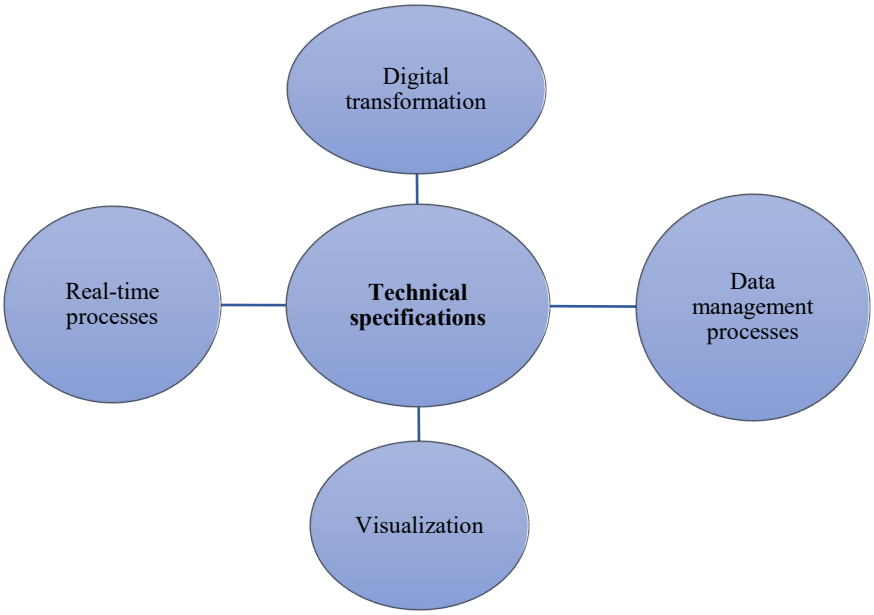

Fig. 5. Digital transformation of society and economy in agriculture. Source: Compiled by the authors.

Consequently, cyber-physical systems (CPS) can act as a technical characteristic of digitalization. Digital transformation involves the following stages:

- Systematic accelerated digitalization of agricultural production;
- Stimulated domestic consumption;
- Development of export of products;
- Design of platforms providing end-to-end digital solutions;
- Creation of the life cycle of production and sale of products.

In our opinion, the introduction of CPS in agriculture is a current trend. According to the representatives of the agricultural sector of Russia (Anna Hvorostyana, Yulia Novikova [NATT], Ekaterina Yavkina, Elena Bobkova [NIR Foundation], Pavel Ragozin [MSU TTO], Evgeny Serov, Nadezhda Orlova, Dmitry Nikolaev, Alexey Naumov, Renat Yanbykh, Valery Arefiev [Institute for Agrarian Studies], Artem Belov [Soyuzmoloko], Roman Kulikov [Skolkovo], Olesya Smirnova [Association of Holstein Cattle Producers], Alexander Grigel [A2 Moloko], Andrey Orobinsky [Agrotech-Garant], Alexander Krichevsky [Sibbio-farm], Vladimir Kalensky [EvroChim], Alexander Chulok [Institute for Statistical Studies and Economics of Knowledge], Alexander Sokolov [Institute for Statistical Studies and Economics of Knowledge], Alexander Eremin [Uralchim], Elena Kultysheva and Ekaterina Zdot [LK Respect — FOSS], Stepan Plisko [Progress Agro], Sergey Filippov [Dmitrovskie Ovoshchi] and Viktor Semenov [Belaya Dacha]), the development of digitalization at the global level involves the following [4]:

- Digitalization and implementation of digital technologies (GRPS, artificial intelligence, etc.);
- Strategic horizon planning (3–5 years) with the use of ready-made commercial technologies widely tested in the world practice;
- Conceptual change in the use of technical means associated with the introduction of self-driving systems, crewless vehicles, and the transition to new energy sources;
- Transition to new food products with a focus on safety, environmental friendliness, and a wide range of products;
- Modernization of technology transfer emphasizing priority and brand new technologies.

5 Conclusion

In the modern world, the COVID-19 pandemic has identified the importance of digital networks and services to ensure economic sustainability and the possibility of continuous representation of countries.

The analysis of theoretical and practical aspects allowed us to conclude that CPS in agriculture is not implemented adequately. In this regard, the digital transformation aims to introduce CPS in the agro-industrial complex of public services.

There is a digital transformation, implementation of digital technologies, Big Data, artificial intelligence, Internet of Things, Blockchain, and CPS.

We believe that CPS is a key trend and horizon of strategic planning in the Russian rural economy.

The introduction of CPS will allow one to accumulate physical processes (technological operations) and an intelligent management and planning system.

Thus, the digital transformation in agriculture aims to create complex automated production and logistics chains that are used by producers, processing producers, processors, consumers, program developers, designers, and educational

institutions. In other words, this phenomenon represents the collaboration of science and innovation, education and competence, modernization and import substitution.

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