Assessment of the development of innovative and ecological potential of agriculture

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Abstract. Nowadays, serious problems of economic transformation are changing the direction of investment flows, so the issue of innovation is incredibly relevant. A number of volatile factors have affected the development of the global economy, and also made future economic prospects even more confusing. The purpose of this study is to explain how modern technologies in agriculture affect the socio-economic development of Russian regions. The methodology used in this work is to evaluate the world experience and practice of modern technologies used in agriculture. How the use of these types of technologies has made agriculture smarter and better. By using smart technology, a farmer can improve his crop and livestock production and save time. Due to the traditional way of farming, farmers are unable to produce more crops and are unable to find the right solution due to lack of information and other necessary things. But with the help of artificial intelligence and the Internet of Things, farmers can get all the information they need in just one click. The article shows the priority strategic directions for the development of the innovative potential of agriculture and what the state and investors should pay attention to.

1 Introduction

According to the scientists' forecasts, agricultural production, especially field farming, should increase by 70% by 2050, when the world population will exceed 9.7 billion people [1]. Simultaneously, increased agricultural activity leads to waste and exploitation of irrigation water, fertilizers and other phytosanitary products, threatening environmental sustainability and farmers' profits [2-4]. Standard management practices in conventional agriculture include consistent use of water and agrochemicals, neglecting the diversity of growing conditions and field requirements [5]. Globally, this approach is no longer viable for achieving high levels of production while limiting environmental damage, hence new sustainable alternatives such as precision agriculture must be proposed and implemented [6].

Nowadays, artificial intelligence applications related to machine learning are growing rapidly. The field of machine learning includes artificial intelligence techniques that help...
machines to perform certain processes and solve problems without being specifically programmed for this purpose [7, 8]. The performance of computer systems in these applications has reached a very high level, which makes them capable in certain cases, even though completely replacing the human factor, then at least to a large extent successfully contributing to it. Developments in artificial intelligence, deep machine learning, Internet of Things, blockchain and other digital technologies are currently being used in both crop and livestock production, as well as in transition sectors in the new era of smart farming [9, 10].

The main goal of smart farming is divided into two components:

1) support the decision-making process when managing a crop or herd, and also increase the number of correct decisions made per unit of cultivated area or per animal, taking into account the available time.

2) integrate clean energy sources into smart farms in order to achieve sustainable development of the agricultural sector [11].

As for the first goal, it can be achieved by facilitating the collection of the necessary data from the field, as well as its fast and reliable processing, which allows the adaptation of agricultural methods used. Accordingly, these procedures are performed with the combined use of precision equipment, Internet of Things (IoT), Big Data, geolocation systems (GPS), non-GPS manned vehicles, robotics, sensors, 3D printing, agricultural automation and management information systems [12, 13].

![Fig. 1. Roadmap for agricultural development from Traditional to Smart agriculture][14]

The purpose of this article is threefold. First, moving towards smart farming can help agricultural professionals, as well as regions across Russia, improve their productivity and competitiveness, thereby attracting more investment into their regions. Secondly, the aim is to highlight the new trends in smart agriculture that have emerged in the modern world. Third, this study contributes to the continuation and modernization of the discussion on the strategies that agricultural practitioners should develop, focusing on the key trends in the development of artificial intelligence technologies in the digital age. Population growth is forcing farmers to change farming methods to meet the growing demand for high-quality food. Figure 1 shows the roadmap for agricultural development. It shows that the level of automation in agriculture increases with each technological paradigm, and the level of

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[14]: https://example.com/fig1.png
impact on the environment first increased, and then changed its vector towards reducing harmful impacts. The introduction of new technologies and the transition from traditional to smart farming can encourage more farmers to use clean energy sources. Using renewable energy not only offers farms a reduced environmental impact, but also other additional benefits. These alternative energy sources can contribute to the sustainable and efficient use of agricultural resources and the production of energy that meets local needs. Moreover, the combination of using latest technologies and clean energy can create new employment opportunities for local people in every rural area. For example, young people using new forms of energy will give local people the chance to improve their income and standard of living by recycling agricultural waste and reducing the use of chemical fertilizers. These improvements can strengthen rural areas and make them more vibrant.

2 Materials and methods

The theoretical basis for scientific research was formed by the concepts and methodological developments of international scientists on the development of innovative ecosystems. The methodology of the article is determined by the study of the technological transformation of agriculture based on the study of theoretical and methodological approaches of leading scientists in this field of research. The methodology takes into account the key features of agriculture and is based on the use of a system of general scientific and special research methods that allow solving the problem more effectively. The main ones are the analysis and synthesis with the help of which the stages of agricultural development are studied, as well as the study of theoretical approaches to agriculture 5.0. Using the expert method, the consequences of the technological transformation of agriculture were assessed. Statistical and comparative methods were also used to study the relationship between the innovative potential of the country's regions and the level of agricultural development. An analysis of the current state of innovation in agriculture in Russian regions was carried out. Also, the authors proposed programs that will contribute to the development of digitalization in Russian agriculture.

The main methodological and methodologically sound approaches used in the formation and implementation of innovative strategies of the region were developed in the works of foreign and domestic authors, namely P. Drucker, R. Cantillon, A. Marshall, J. Schumpeter, G. Markowitz, N.D. Kondratyeva, S.Yu. Glazyeva, V.Ya. Gorfinkel, I.G. Andreeva and others.

Patterns, problems and prospects for the development of the regional segment of the national innovation system are presented in the works of scientists M. Miller, F. Modigliani, S. Ross, B. Terborg, V.V. Bocharova, Yu.A. Doroshenko, D.A. Endovitsky, I.V. Somina, A.G. Ivasenko, N.V. Kiseleva, A.A. Rudychev, P.P. Taburchak and others.

Periodical, statistical, analytical and translated literature on the area under study was used as information resources.

3 Results

Actively ongoing processes of globalization and integration have a significant impact on tightening competition between regions for the right to be investment attractive, have a highly developed infrastructure and a high level of well-being of citizens. The relevance of the problem of competition is also associated with the limited economic growth potential of the country's subjects and financial flows from potential both domestic and foreign investors to the regions of the country [15, 16].
Analyzing the growth in the number of high-tech industries over recent decades, we can formulate the conclusion that science is acquiring an increasingly important role in the economy with each century. In modern production, innovations, as a result of scientific activity, are beginning to play a special role, including in agriculture. In the coming decades, modern agriculture will face two enormous challenges unseen in previous generations. The first is the impact of climate change on agricultural systems, which causes destabilization of agricultural practices and irregular harvest seasons due to excessive heat and water shortages in large productive areas, inevitably leading to the emergence of new invasive pests or increasing severity of existing ones. The second is to produce food for growing human and animal populations while ensuring food security by using fewer agrochemicals and introducing strict controls throughout the agricultural supply chain [17, 20]. Considering this near future, agriculture must come up with creative solutions based on artificial intelligence, machine learning algorithms and other technological innovations that constantly interact with plants and the environment, which will undoubtedly require various scientific studies. Agriculture is at the dawn of a new era - the era of Agriculture 5.0.

Agriculture 5.0 is nothing less than the fifth revolution in the agricultural production sector. It includes improving productivity, sustainability, and profitability by automating variable application rates, inputs, and the ability to extract better data for on-site decision making.

The goals of Agriculture 5.0 can be divided into four groups:

1) Reduce waste. With all the optimization of processes in the fields, it becomes possible to reduce possible operational waste. This applies to working conditions, and even to the yield of each crop.

2) Improving quality. The new agricultural revolution 5.0 also allows for large-scale production. However, it is not only about quantity, but also about quality. Because new technologies will make it possible to map the best sowing conditions, as well as more precise analysis regarding, among other things, harvest timing.

3) Healthy eating with less environmental impact. The main focus of Agriculture 5.0 is to encourage healthy eating. This will provide more nutritious food to the population, while also managing and reducing the environmental impacts that may be caused by these activities.

4) Food security. Agriculture 5.0 will allow everyone to have access to food and inputs at affordable prices as technology will play a greater role in reducing production costs.

Advanced technology can improve farming practices, from sensors that monitor changes in the environment to robots that act like harvesters. Basically, different types of agricultural machinery are combined with technology to help farmers. Figure 2 shows an example of the use of a borderless ecosystem for companies and farmers using digital technologies.

Being one of the world’s largest agricultural powers, Russia lags far behind its competitors in the quality of its scientific product. The lag is due to the insufficient efficiency of investments in agricultural science. The lack of qualified specialists also hinders the penetration of technology into the agricultural sector. Today in Russia only about 10% of farms use modern technologies; in leading countries in Europe this figure is 60%, or even 80%. According to a report by the National Research University Higher School of Economics, in terms of spending on innovative developments, Russia lags behind the Netherlands by about 50 times, and behind Poland by 10 times. The number of IT specialists employed in the Russian agro-industrial complex is approximately half that in the UK and Germany. Experts note that the Russian agro-industrial complex is highly heterogeneous: for example, in large agricultural holdings the level of digitalization can meet the highest international standards, while small farmers have to solve other problems every day. They lack financial and human resources for digitalization.
In the past, investors have been hesitant to get involved in digital technology in agriculture, believing that the industry will not provide a reasonable return on their investment. However, recent technological developments have led to an explosion in the popularity of digital technologies in agriculture. In Russia, the volume of investments in projects related to digital technologies in agriculture does not exceed 1% of the global total. The Russian market is now at a nascent stage due to a lack of investment. Nevertheless, interest in projects in this area is gradually emerging, both from investors and industrial partners. Close proximity to fast-growing Asian markets and a reputation for environmentally friendly and high-quality agricultural products make Russia an important

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**Data collection, mapping and weather monitoring:**
- Collection of data for further processing: cartographic data, aerial and satellite images, soil measurements, localized GIS and GPS data
- Collect, store and use this data to predict crop yields, irrigation, fertilization, harvesting and preparation for protection from hazardous weather conditions

**Artificial intelligence algorithms, analytics and cloud calculations:**
- Converting input data into actionable commands by learning from previous and newly acquired data
- Recognizing patterns and applying rules for economical use of resources
- Creating forecasts in near-real mode and sending automated commands

**Robotics, drones and autonomous equipment:**
- Execute commands based on artificial intelligence, based on data
- The equipment can begin harvesting on command, guided by a navigation system with a given route
- Autonomous tractors can change routes in real time using autopilot based on weather changes or new forecasts from the artificial intelligence system
- Self-driving farm equipment may be more reliable than self-driving cars because it operates in less risky, predictable environments with fewer obstacles than busy city streets
- Drones and robots can begin to water and harvest crops, guided by precise maps
- Artificial intelligence can monitor climate conditions on indoor farms, recognizing yields using image and video processing algorithms

**Traceable supply chain, blockchain and delivery:**
- Monitoring product quality
- Producers can label seeds and products using QR codes
- Distributed ledger technology can provide traceable and transparent data on the origin of food at every stage of the supply chain, while logistics companies deliver products to retailers' shelves

**Affordable payments, sharing economy, transport:**
- Offering easier payment options
- Smart contracts may be available as a payment option for small farms to make equipment rental affordable for farmers without upfront payment
- The sharing economy is moving into agriculture, providing easy ways to share equipment and heavy machinery between farms and fields
- New solutions for optimizing the route for transporting heavy equipment help with delivery, taking into account all the risks along the way

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![Fig. 2](image-url)
part of the global food supply chain and well positioned to meet growing demand. Investments in agriculture can bring profit, both in the form of income and capital growth, and are a proven tool for protecting investment portfolios from inflation. Given the current inflationary pressures caused by fiscal and monetary stimulus, supply chain disruptions and geopolitical events, now is the time for investors to consider assets that could provide inflation protection. To assess the problems and opportunities for introducing innovation and digital technologies into Russian agriculture in the next 10 years, the authors conducted a SWOT analysis (Table 1). The SWOT-analysis was conducted based on how digital technologies and innovations in agriculture are already being used in countries such as Canada, the Netherlands, Germany, Japan, Australia and China. In addition, statistical data was used on changes in economic indicators of agricultural development under the influence of individual initiatives in the field of digitalization and innovation, similar to Russian ones.

**Table 1. SWOT-analysis of the innovations and digitalization processes in Russian Agriculture [19].**
The presented SWOT-analysis allows us to conclude that the positive vector of the consequences of digitalization and innovation in agriculture applies to all potential participants in the process of modernization of the industry. At the same time, risks and negative consequences affect only individual participants in this process, which should be taken into account when redistributing farm income to the state.

4 Discussion

The state needs to pay attention to the following priority strategic directions for the development of innovative potential, such as:

- support and strengthening of fundamental research of domestic science in the field of innovation in order to develop scientific potential;
- ensuring the reproduction of human resources for science, technology and innovation in the regions;
- development of the technical and technological base that determines the scale and pace of innovation;
- direct or indirect financial stimulation of innovation activities in order to develop financial potential;
- improving the regulatory framework for innovation in order to develop institutional capacity;
- formation of regional innovation infrastructure in order to develop organizational potential;
- formation of information infrastructure to support innovations and take into account their results in order to develop information potential.

To spearhead the Russian Federation's leadership in digital agriculture and create a global path from proven innovation to large-scale impact, the authors propose that the
Russian government, ministries and departments, as well as their partners, launch the Digital Agriculture for Food Security program. Thanks to an international call to action, Russia can intensify research, development and investment in the next generation of digital technologies and solutions to ensure yields and livelihoods for more small and medium-sized agribusinesses by 2030 (22-26). This large digital agriculture project will consist of the following short- and long-term activities:

1. Provide funds to launch a Digital Agriculture Innovation Fund to fund, support and scale new solutions that leverage technology to seamlessly deliver yields, food security and livelihoods to smallholder farmers. The activities of the fund should be aimed at:
   - Financing pilot and research projects in the field of agriculture. Funding is provided for research, user design and pilot testing to industry innovators, NGOs and universities to create and test digital innovations such as personalized weather forecasts, digital empowerment, micro-insurance, micro-lending, and local sales representative directories and directories. This could be done using the small business innovation research model and using technical assistance within the foundation and partner organizations to support the development of new promising businesses or products/services from existing players.
   - Scaling and commercialization of digital agriculture. Invest in grants and investments in proven digital agriculture solutions as bridge capital to expand their adoption into new markets or products. Funding should be directed more towards digital start-ups as well as businesses targeting foreign markets to ensure broader impact. This should attract private capital and promote the development of competitive, sustainable enterprises.
   - Formation of the market and public-private partnership. Creation of a team, a group of employees to bring technologies to the market. They will seek marketing opportunities for new technologies in the innovation pipeline, as well as consultancy and other assistance programs for digital development in the agriculture sector.

2. Convene a digital agriculture summit among BRICS countries to develop a comprehensive approach to promote and accelerate the adoption of integrated digital agriculture products and services that improve yields and sustainability. The Russian government will announce the creation of a special fund, bringing together its interdepartmental partners, officials and leaders of partner countries to chart ways and create opportunities for cooperation across sectors. The summit can help build a community of experts and strengthen commitments to financial support and resources for innovation in digital agriculture. Also, annual meetings of innovators, investors and stakeholders at the summit will facilitate the exchange of knowledge and results, which should help attract more private capital.

5 Conclusions

The analysis shows that modern agricultural management systems can process large volumes of data, and group the results according to individual case of each farm. This assistance to farmers in the form of digital solutions unites efforts of robotics and artificial intelligence to bring the idea of 'Agriculture 5.0' to life. To get the most out of Agriculture 5.0, there is a need to provide in-depth training to the users, ideally young farmers eager to learn and apply modern technologies in agriculture and enable the generational renewal that is yet to come. Russia's agricultural sector needs to move forward towards a modern and sustainable agriculture that can demonstrate the power of data-driven management to address the challenges of food production in the 21st century. The transition to Agriculture 5.0 is on the agenda of most major agricultural producers around the world for the next
decade. Russia must not lag behind world-class trends and therefore investments in this area of activity will play a key role in this movement. Russian regions need to focus on the innovative path of development, effectively interacting with all participants in the innovation process in the region, coordinating all stages of the innovation cycle, ensuring continuity and dissemination of scientific and technical knowledge.

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