The role of the Internet of Things as direction for the development of agriculture 4.0 for rural areas

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Abstract. The article discusses trends and opportunities for the development of the digitalization of agriculture. The potential of the Internet of Things (IoT) for agriculture is innovative. The rationale for this is the creation of cloud platform solutions determines the grounds for this research. Particular attention is paid to quantitative and qualitative trends in the development of the Internet of Things in agricultural production. The article analyses the benefits of the Internet of Things for agriculture and rural development. The industrial Internet of Things helps to improve the competitiveness, efficiency and safety of agricultural production. IoT platforms and mobile apps allow to control and track production along the entire value chain. They also help to make decisions with a high level of risk in agricultural production. Significant amount of the information available in the agriculture is not fully utilized. Digitalization of agriculture improves efficiency and productivity in the industry. The Internet of Things in agriculture is a promising direction of technological breakthrough for a rational resource-saving agriculture 4.0.

1. Introduction
Global trends in the development of agriculture 4.0 are associated with ecology, digital technologies, economic and social problems. Agriculture 4.0 is an extensive volume of information flows, including price fluctuations in commodity markets, unusual weather conditions, technological changes in production methods, institutional regulation, changes in consumer preferences and more. The relevance of the study relates to the digital development of future agriculture. A lot of publications are devoted to digitalization of agriculture and the industrial Internet of Things. But there are questions regarding legislation for the Internet of Things, device certification, cybersecurity. Digitalization in agriculture leads to the diversification of agricultural production. Changes are taking place in crop production, livestock production, processing, transportation, storage, planning and management of agricultural production. The present study shows that the Internet of Things in agriculture is a promising model for the development of the agricultural sector. Future Agriculture 4.0 is resource-efficient and resource saving, competitive agricultural production. Further research is required by the issues of applying the experience of developed countries in the field of the Internet of Things.

2. Materials and methods
The purpose of the article is to define the role of the Internet of Things for digital agriculture and to consider opportunities for the development of rural areas.

The theoretical basis of this article is the research works of Russian and foreign authors devoted to
the different aspects of the using Internet of things technology in the innovative agriculture.

As general research methods, we use economic and statistical, a comparative analysis, document analysis, grouping and systematization.

When evaluating the potential of an Internet of things, the following problems arise:

determination of a measurable effect for a stage in the value chain [1];

the use of not only quantitative indicators but also qualitative ones for development of the rural economy.

The article presents statistical data that confirm the purpose of the research. The article ends with a discussion of the strategic role of the Internet of Things for the digitalization of rural areas.

3. Results

The Internet of Things is a system of high-tech units that control the entire production cycle in the food value chain. The International Telecommunication Union (2012) use a definition: 'A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies'. An IoT system always includes a machine-to-machine (M2M) connection [2].

The Internet of Things in agricultural production increases the volume of information flows. This allows us to talk about a new quality of production, the need for additional research on the methodology of assessment and development of strategy. The purpose of using the Internet of Things in the value chain of raw materials, agricultural products and food products is expressed in increasing efficiency, increasing transparency and safety of agricultural production. This is justified by the high requirements of developed countries for a rational resource-saving rural economy.

The new types of digital, bio-, agro-, energy technologies of the Internet of Things are closely interconnected by complex networks. Industry 4.0 digital technologies network consumer production and interaction through. The general present market structure of IoT technologies is presented in figure 1, where it is evident that the majority of the market is focused on smart cities and industrial IoT [3].

![Figure 1](image-url)

**Figure 1.** General market structure of the Internet of Things technologies [3].

Important segments of the Internet of Things market will be unmanned aerial vehicles, agricultural machinery with GLONASS / GPS navigation sensors, acceleration of selection, genetic engineering, new energy sources, affordable biofertilizers, personalized meals, digital platforms and resource-saving agriculture.

Based on the analysis of various sources such as Gartner, IDC, McKinsey, Forrester, IoT Analytics,
the Internet of Things for the agriculture industry is a collection of network elements of devices, sensors, gateways, security systems, cloud systems that provide remote control, interconnection, storage, transfer and security of data used in agricultural production. Data the Internet of Things allows to collect, analyze, process and transmit data about the state of its elements to other objects via the Internet [4].

Russian agriculture is just in the beginning of its Internet of Things in agriculture. So far, only large producers have been using digital technologies for precision farming, digital platforms, and GPS monitoring. Increasing profitability and cost effectiveness is the main reason for the investment attractiveness of the IoT market [5]. According to the forecast of PwC (Pricewaterhouse Coopers), the minimum economic effect from the Internet of Things in agriculture in 2025 may amount to 469 billion rubles. The Ministry of Agriculture of Russia expects the following results: a decrease in the cost of grain production by 1,513.3 rubles / ton, the total increase in agricultural production may amount to 361.4 billion rubles, the expected increase in crop production - 193.9 billion rubles.

The long-term effect of the Internet of Things is associated with the system of organizational and economic effects (table 1).

Table 1. Promising areas of application of digital technologies in the agricultural industrya

| Organization and technology | Effects |
|-----------------------------|---------|
| Customization of production and consumption of agricultural products | Optimization of food markets |
| Information infrastructure development | the emergence of new professions |
| Digital modeling | Improving production efficiency |
| Geographic information systems | Safety of raw materials and agricultural products |
| Meteorological stations | |
| Technologies for automatic determination of the use of biofertilizers | |
| Green agriculture | |
| Recycling technologies for agricultural waste | Production intensification |
| Additive manufacturing | Optimization of logistics and product storage |
| Electronic certification and identification of livestock and animal products | |
| Cloud technologies | Sustainable development |
| Big data analytics and digital platforms | Horizontal and vertical integration |
| Increasing the investment attractiveness of agricultural sectors | |
| Telecommunication networks of a new type | |

aSource: Compiled by the authors

In addition to the economic benefits, IoT technologies promise significant environmental benefits. Various useful data about crops could be collected and used for yield monitoring and the detection of potential diseases in advance that can significantly reduce the yields of specific crops. The monitoring of soil and nutrients would rationalize agricultural production processes and lead to water savings that are precious in some specific geographical regions.

The application of IoT technologies in the agricultural sector would lead to advancements that could drastically modify current production procedures in agriculture.

Target indicators of the impact of the Internet of Things are an increase in production, an increase in profits and profitability, productivity, an acceleration in the turnover of working capital, and an increase in lending. In agricultural production, this means obtaining environmentally friendly raw materials and food products [6]. In the agricultural sector, new professions are emerging, such as agro cybernetic, GMO agronomist, city farmer, agricultural ecologist, agronomist-manager.

The length of the value chain for raw materials and agricultural products from the field to the consumer can be shortened. Within the framework of value chains, the importance of software is
increasing, in particular, organization resource planning - ERP (Enterprise Resource Planning), customer relationship management - CRM (Customer Relationship Management), supply chain management - SCM (Supply Chain Management), management of fixed assets of the organization - EAM (Enterprise Asset Management).

The multiplying effect of the Internet of Things, digitalization, automation is also manifested in the development of related industries and the sphere of human life (table 2).

Thus, the technologies of the Internet of Things along the entire technological chain are developing cooperative forms of labor organization, resource-saving, environmentally friendly technologies.

### Table 2. Interconnection of digital technologies and potential effects in the agricultural value chain

| Value chain         | Technologies                                                                 | Potential Effects                                           |
|---------------------|------------------------------------------------------------------------------|-------------------------------------------------------------|
| Production of capital goods | Drone aircraft, Automatic weather stations, Robotic plants, Highly effective fertilizers and plant and animal protection products | Strengthening control over production processes, Improving the quality of raw materials and products, Reduced equipment downtime, Eco-friendly fertilizers |
| Agriculture         | Digital production control, Selection and hybrid work, Geolocation systems, Crop management systems, Resource-saving technologies | Increasing the transparency of processes in crop and livestock production, Reduction of losses of raw materials and fuels and lubricants, Improving the efficiency of fertilization |
| Processing and storage | Robotization of processes, Forecast supply systems, Warehouse and stock management, CCTV systems, Integrated accounting system with products, Diagnostic devices and sensors, Automatic weighing equipment | Reducing costs, Increase in productivity, Improving processing efficiency, Improving supply chain efficiency, Reduced personnel costs, Speed up processes, Improving product quality and reducing scrap |
| Implementation      | Scanning devices, Accounting process automation systems, Data processing automation systems | Improving the level of service, Increased sales, Reducing implementation losses |

*Source: Compiled by the authors*

To maximize the potential of IoT technologies, it is necessary to solve the following set of problems and tasks:

- the development of Internet access in the regions of agricultural production;
- the creation of platform solutions for agricultural producers that integrate the Internet of things, cloud solutions, networks;
- solving institutional and legislative issues of data ownership and data sovereignty in the agricultural sector;
- the prevention of cybercrimes in the relations of agricultural producers;
- overcoming the vulnerability of digital relations between actors in the agricultural sector; the sixth one is, incentives and tax breaks for agricultural organizations implementing the Internet of Things;
- improving the education and qualifications of agricultural workers;
- the development of breeding and genetics, the sector of agrobiochemistry;
• the formation of innovative business processes and business models.

The main constraints to the implementation of IoT technologies in Russia are the following:

• in the field of forming a system of relations: the availability of digital infrastructure in rural areas; financial ability of agricultural organizations for digital transformation, staffing and digital competencies;
• in the field of state support: volumes and directions of support through direct financing, through public-private financing, through program and project financing; financing security systems and networking; implementation of programs for the spatial and regional development of the Internet of Things for rural areas;
• in the field of regulatory and legal regulation and safety - uncertainty in relation to new types of technologies (sensors); imperfection of the regulatory framework for the use of Internet of Things technologies;
• in the field of standardization - the creation of uniform security standards for the Internet of things; creation of functioning standards, creation of standards for compatibility of databases and indicators for various industry digital platforms.

4. Discussion

The Internet of Things in agriculture will contribute to the high attractiveness of agricultural production for investors, regional spatial development of rural areas; improving the level, conditions and quality of life in rural areas; development of domestic agriculture and the export potential of products with a high level of processing; raising the level of education and qualifications of agricultural workers, as well as the introduction of highly competitive specialties in data analytics, machine learning and artificial intelligence in agriculture; growing demand for high-tech products of domestic engineering and for research and development work in the field of breeding, seed production and genetics; development of new types of digital services and electronic trading platforms in agriculture. To do this, it is necessary to identify and assess the prospects, risks, conditions, factors for the implementation of Internet of Things projects.

An interesting activity might be the benchmarking of all the existing IoT platforms and their proposed functionalities and mapping them with Agri-Food stakeholders’ requirements. The integration of IoT capabilities will support farmers in the harvesting of new data sources to create new valuable services [7].

Therefore, it is necessary to further investigate the issues of methodology for assessing and statistical accounting for investments and the use of the Internet of Things in agriculture. To ensure the efficiency of digitalization processes, their systematic and high-quality monitoring is necessary. As the study showed, the role of the Internet of Things is changing the food production value chain and agribusiness management.

5. Conclusion

Thus, this study allows to clarify the prospects for the application of the Internet of Things in agriculture. The transition to the industrial Internet of Things requires an Internet infrastructure, cloud technologies, cheaper electronic components, software and storage systems, data processing and protection. IoT technologies in the value chain are eliminating pre-existing connections, replacing them with automated solutions. Agriculture becomes agriculture 4.0, and then Farming 5.0. The Internet of Things creates complex, highly automated production and supply chains in conjunction with trading companies. This creates a network with adaptive control. Accessibility of IoT technologies requires tax incentives and government support. This is especially true for medium and small agricultural producers, because the cost of the final product and operating costs will decrease. The study has shown that the use of IoT technology has the potential to radically change the governance of the agricultural sector. The obtained
study results serve to the understanding of the prospects for transforming traditional agricultural organizations into organizations of a new generation.

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