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DIGITALIZATION OF AGRICULTURAL MECHANIZATION PROCESSES

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Abstract
This article presents a comprehensive study of the methodological foundations for the digitalization of agricultural mechanization processes in Uzbekistan, with a focus on the conditions of the Surkhandarya region. The research aims to enhance the effectiveness of digitalization in agriculture by monitoring soil moisture in real-time and optimizing agro-technical parameters such as machinery speed, working depth, and equipment selection. The scientifically grounded approach, based on modern digital technologies including IoT sensors, artificial intelligence, and mobile/web applications, contributes to the efficient management of land resources and the generation of useful recommendations for farmers. The results indicate that decisions supported by automated monitoring systems lead to increased crop yields and more efficient use of resources.

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Keywords : Agricultural digitization, soil moisture, agro-technical operations, artificial intelligence, IoT sensors, recommendations, mobile application, agricultural machinery, data analysis, real-time monitoring, drone observation.

Introduction

In recent years, large-scale reforms have been carried out to increase the efficiency of land resource use, increase productivity and improve labor productivity through the introduction of digital technologies into agriculture. In particular, the issue of planning agrotechnical measures based on the real state of the soil, in particular, its moisture level, is considered an important factor in improving agricultural mechanization. Surkhandarya region is one of the regions with high agro-economic potential, and due to climate variability and limited water resources, it has become necessary to introduce modern and precise technological approaches to land cultivation. Agrotechnical activities carried out by traditional methods often do not take into account the real situation related to the stages of crop development, soil condition or weather conditions. Therefore, within the framework of this study, a digital solution is proposed for the effective organization of agrotechnical activities by determining soil moisture and, on this basis, determining the depth, speed and appropriate type of equipment used for tillage, plowing, cultivation, namely, a mobile platform project called "AgroSmart Surxon". This platform provides farmers with precise recommendations on the situation in the fields through IoT sensors, drone observations and an artificial intelligence-based recommendation system.

The relevance of this work is determined by the optimization of agrotechnical decisions based on scientifically based approaches to the use of land and water resources, as well as the development of technological solutions appropriate to regional conditions. Regulatory legal acts of the Republic of Uzbekistan and presidential decrees create the basis for the development of digitalization. The “Strategy for the Development of the Digital Economy of the Republic of Uzbekistan until 2030” defines the introduction of digital technologies in agriculture as a priority task. At the same time, the resolution “On the Further Development of Agriculture” provides for the modernization of mechanization

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and increasing efficiency. These documents became the legal basis for the application of the digitalization methodology.

Literature Review

International and domestic literature and legislative documents serve as an important basis for studying the digitalization of agricultural mechanization processes. Scientific research on the digitalization of agriculture is largely focused on the use of technological tools, optimization of agrotechnical operations and their impact on productivity. Internationally, including the Food and Agriculture Organization of the United Nations (FAO) and the World Bank Agriculture Innovation Systems (AIS) Reports, it is noted that the automation and optimization of agricultural processes using digital technologies plays an important role in increasing resource efficiency. N. Shukurov in his scientific article "The role of digital technologies in the innovative development of agriculture in Uzbekistan" analyzed the impact of artificial intelligence, sensor technologies and data analysis on agricultural efficiency. It is noted that agrotechnical measures can be accurately determined by real-time monitoring of fields based on IoT and geolocation technologies. In a study conducted by JTKarimov, it was noted that the introduction of digital monitoring systems for the use of water resources in the Surkhandarya region increased productivity by 12–15 percent. This directly demonstrates the practical effectiveness of a management system based on soil conditions. Also, TZYusupov's scientific work on optimizing tillage technologies describes the scientific basis for developing specific recommendations for determining the depth and speed of plowing equipment depending on soil density and moisture level. To give an example from international experience, digital agroplatforms such as John Deere Operations Center and CropX develop recommendations for crop care based on real-time monitoring and artificial intelligence. They are mainly successfully used in the USA, Israel, and European countries. These sources and experiences show that in the process of digitizing agriculture, in particular, determining soil moisture and recommending appropriate tillage techniques, is a key factor in supporting farmer decisions.

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On this basis, this research, which is being conducted to develop the "AgroSmart Surxon" platform, serves to deepen existing scientific work from a regional and practical perspective.

Research Methodology

The study was carried out taking into account the climatic and agrotechnical conditions of the Surkhandarya region. Sensors based on IoT technologies are installed on farms to monitor soil moisture and temperature in real time. The data obtained from these sensors are transmitted to a specially developed cloud database and analyzed. Drone observations and visual analysis methods are used to assess the growth rate of plants in the fields. The data collected in the system are processed using artificial intelligence algorithms and recommendations are developed on the depth, speed and type of technical processing. These recommendations are delivered to farmers in a visual and interactive form through the AgroSmart Surkhon mobile application. In the form of an experiment, the results of two different groups - fields processed using a digital system and fields processed using a traditional method - were compared and analyzed. The results were evaluated using statistical methods based on yield, water and fuel consumption, and processing efficiency indicators.

Analysis and Results

Analysis of the digitization of agricultural mechanization processes in Uzbekistan and the expected results. The analysis was based on FAO data, the “Digital Uzbekistan 2030” strategy, and the resolution “On the Development of Agriculture”. During the study, the effectiveness of soil moisture detection and appropriate technical treatment was assessed on farms in the Denov, Shorchi and Zharkurgan districts of Surkhandarya region. Recommendations developed using artificial intelligence based on data collected using sensors and drones were applied to the experimental group, while traditional methods were retained in the control group.

1. Soil monitoring and machinery cultivation parameters: In the experimental groups, the recommended depth of the machinery was 18–22 cm and the speed was 4–5 km/h, while in the control groups, these parameters were used in the

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same way: 20 cm and 6 km/h. The adjusted parameters based on the data detected by the sensors increased the cultivation efficiency.

2. Differences in yield : An average yield difference of 13–17% was observed between the control and experimental groups. Especially in fields with moisture content above 45%, a positive shift in plant development was noted as a result of treatment based on recommendations received via drone.

3. Resource efficiency. Compared to the experimental groups: water consumption decreased by 11%; fuel consumption decreased by 8%; equipment operating time decreased by 15%; the number of cases of land reclamation decreased.

4. Farmers' opinions: According to farmers who have used the system, the alerts and recommendations received through the mobile application have increased the ability to cultivate the land on time. Many have evaluated the application used as having a simple interface, practical and cost-effective.

Table 1

Indicator	Control group	Experimental group	Difference (%)
Productivity (s/ha)	48	55.5	+15.6%
Water consumption (m^3/ha)	640	570	–10.9%
Fuel consumption (l/ha)	21	19.3	–8.1%
Technical processing time (hours/ha)	1.7	1.45	–14.7%

Results of the experimental and control groups (average)

These results show that agrotechnical recommendations developed based on digital technologies are highly effective in effectively planning and managing farm activities.

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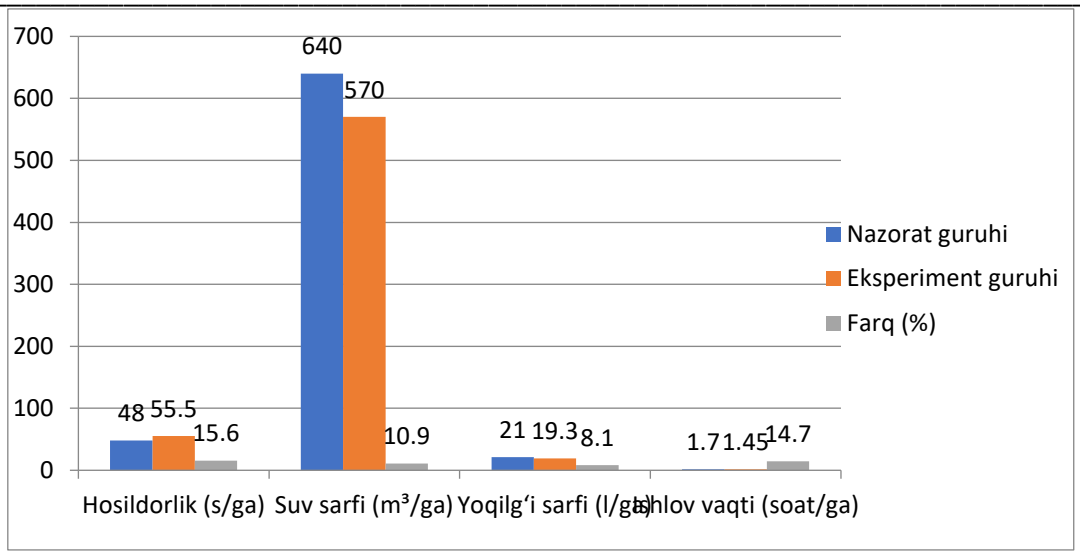

Figure 1. Graph comparing key indicators between the control and experimental groups.

The development of approaches that allow for optimal cultivation of agricultural land through digital technologies, in particular IoT sensors and artificial intelligence-based recommendation systems, significantly increases efficiency. The above positive changes were observed in the experimental groups, that is, in the fields where the recommended cultivation parameters were applied through the AgroSmart Surxon mobile application. Below are the results of this mobile application.

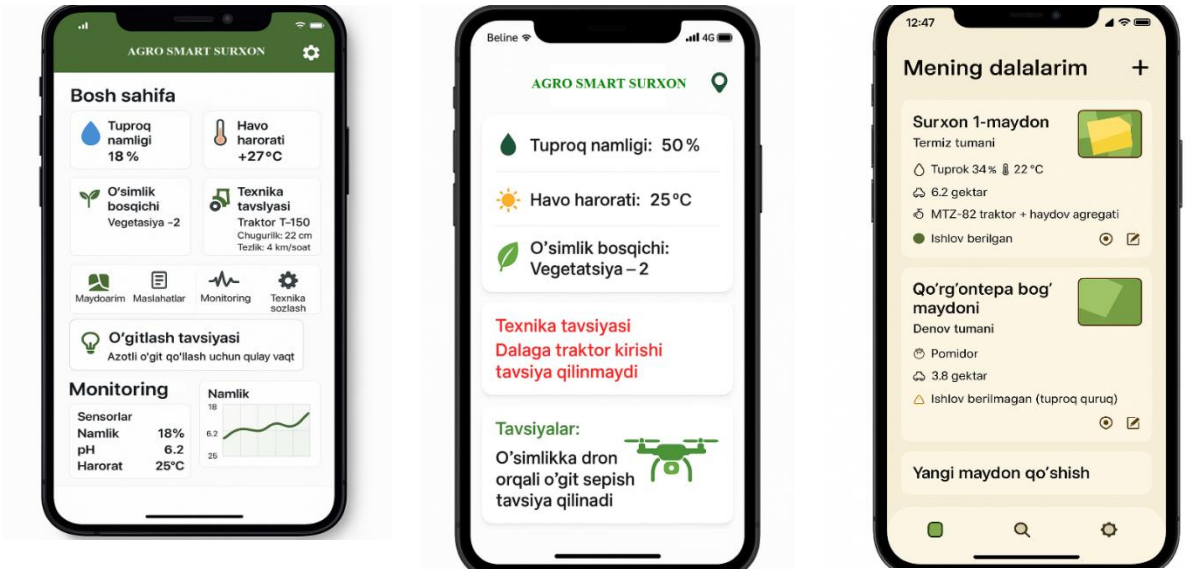

Figure 2. "AgroSmartSurxon" application interface

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The mobile app interface has become an effective tool for farmers to monitor the real-time condition of the field, receive alerts, and know which equipment to use, when, and at what depth.

Results

The main results are: increased productivity, reduced water consumption, fuel savings, reduced processing time, the ability to receive real-time notifications, alerts and recommendations through the application, with data-driven decisions. Recommendations developed based on artificial intelligence were formed based on indicators such as soil moisture, temperature and plant condition, which reduced uncertainty and ensured accurate processing.

Conclusions and Suggestions

Agricultural mechanization in Uzbekistan is currently working inefficiently, therefore, based on our scientific research, which has increased attention to the digitalization of the sector, the following conclusions and suggestions were made. Based on research in the Surkhandarya region, it was proven that it is possible to achieve high efficiency by introducing digital technologies in agriculture, in particular, by monitoring soil moisture and optimizing agrotechnical processing. The solutions developed on the example of the digital platform “AgroSmart Surkhan” provided the following main advantages: Productivity increased by more than 15%; Resources such as water and fuel were saved; Technical processing efficiency improved; The decision-making process for farmers was simplified. The parameters recommended based on artificial intelligence through the mobile application were adapted to soil conditions and plant development, providing clear guidelines for optimal agrotechnical processing in the fields.

The research results show that the introduction of digital technologies in agriculture not only increases economic efficiency, but also environmental sustainability. Such solutions are of strategic importance, especially for regions with limited water resources.

Suggestions:

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Implementation of the "AgroSmart Surkhon" platform on a large scale (at the regional and republican levels).
Strengthening infrastructure for the smooth operation of technologies.
Creating a system to train and support farmers in digital literacy.
Continue to adapt artificial intelligence algorithms to local crop types and agroclimatic conditions.
The proposed mobile application and model, by installing IoT sensors on a tractor and the "AgroSmartSurxon" application, will save diesel fuel and bring billions of soums of economic benefits to our economy. Ecologically, it will reduce CO_2 emissions by 10-15%, which is in line with global environmental goals and makes agriculture sustainable. Socially, farmers' income will increase, new jobs will be created in sensor installation and maintenance.
The study showed that digitalization depends on infrastructure, internet coverage, farmer literacy, and government support. While the Digital Uzbekistan 2030 strategy and several other resolutions provide a legal framework, there is a lack of specific mechanisms aimed at developing the sector and saving fuel - this article fills this gap.

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