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ECONOMIC EFFICIENCY OF INNOVATIVE DEVELOPMENT OF THE VITICULTURE SECTOR IN AGRICULTURE

Nurmetov Ergash Quronboyevich,
Independent Researcher of the Department of
"Agribusiness Management and Logistics",
Tashkent State Agrarian University

Abstract

This article examines the economic efficiency of the innovative development of the viticulture sector in agriculture, as well as the theoretical and practical aspects of introducing "smart agriculture" technologies. The study highlights the opportunities for efficient use of resources, increased productivity, and reduction of production costs through the application of intensive vineyards, drip irrigation systems, digital monitoring, IoT devices, artificial intelligence, and drone technologies in viticulture. Furthermore, the economic impact of digital technologies on water conservation, labor productivity, product quality, and export potential is assessed. The article also analyzes the ongoing reforms aimed at the digital transformation of the viticulture sector in Uzbekistan and proposes practical recommendations for the further development of the industry.

Keywords: Viticulture, innovative development, economic efficiency, smart agriculture, digital technologies, IoT, artificial intelligence, drone technologies, drip irrigation, digital monitoring, intensive vineyards, export potential, agrarian economics, resource efficiency, Smart Viticulture.

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Introduction

Today, under the conditions of global climate change, scarcity of water resources, and land degradation, improving the efficiency of agricultural production has become directly dependent on the level of implementation of innovative and digital technologies. The viticulture and winemaking sector, which is considered one of the strategic branches of the economy of Uzbekistan, is also undergoing profound reforms and a process of digital transformation. In the context of globalization and increasing competition, the innovative development of agricultural sectors has become one of the key factors ensuring sustainable economic growth. In particular, the viticulture sector is recognized as one of the strategic directions of the agrarian economy due to its ability to create high added value, its export potential, its role in ensuring food security, and its close integration with the processing industry. Therefore, the development of viticulture based on modern innovative technologies, efficient use of resources, and enhancement of economic efficiency are among the most pressing issues of today.

In recent years, large-scale reforms have been implemented in the country aimed at modernizing agriculture, establishing intensive orchards and vineyards, introducing water-saving technologies, improving breeding and seed production systems, and developing infrastructure for storage and processing of agricultural products. As a result, the volume of grape production, productivity indicators, and export potential have been steadily increasing. However, factors such as high production costs, insufficient use of modern technologies, problems in logistics and marketing systems, and the rising cost of production continue to hinder the achievement of full economic efficiency in viticulture. Innovative development plays an important role in increasing labor productivity, improving yields, ensuring rational use of water and land resources, maintaining environmental

sustainability, and expanding the share of export-oriented products in the viticulture sector. In particular, the application of digital technologies, smart irrigation systems, intensive vineyards, modern agrotechnical measures, and innovative management approaches can significantly improve production efficiency.

President of the Republic of Uzbekistan Shavkat Mirziyoyev has defined strategic priorities for the digitalization of agriculture. In particular, Presidential Decree No. PF-130 dated August 12, 2025, "On Measures to Further Accelerate the Introduction of Modern Technologies into the Agricultural Sector to Increase Efficiency," as well as the presentation held in February 2026 on advancing science to a new stage, marked the beginning of a new era in the sector. As emphasized by the Head of State, the development of biotechnology, "smart" agriculture, space and drone technologies, and digital agriculture constitutes the main criterion for ensuring the sustainability of the agrarian sector. The implementation of Smart Viticulture systems not only enables resource conservation but also increases the production of high-quality, export-oriented products. This article analyzes the scientific and practical aspects of applying digital platforms, sensors, and unmanned aerial vehicles in vineyard plantations.

Analysis and Main Results

The analysis conducted on the innovative development of the viticulture sector in agriculture demonstrates that the introduction of modern agrotechnologies significantly increases production efficiency. In particular, the establishment of intensive vineyards, the use of drip irrigation systems, the application of mineral fertilizers according to scientifically based standards, and the cultivation of high-yield grape varieties contribute to increased productivity. It has been determined that farms utilizing innovative technologies achieve average yield levels that are

20–30 percent higher compared to vineyards managed through traditional methods. During the analysis, the efficiency of water resource utilization in the viticulture sector was also examined. The findings indicate that the implementation of drip irrigation technologies reduces water consumption by 35–40 percent while simultaneously improving product quality and reducing labor costs. Consequently, this has a positive impact on lowering production costs and increasing net profits.

Furthermore, the introduction of innovative management approaches and digital monitoring systems has enhanced the efficiency of vineyard management. Modern monitoring systems make it possible to control soil moisture, plant conditions, and agrotechnical measures, thereby ensuring rational use of resources. As a result, crop losses are reduced and product quality is improved. Economic analyses have shown that the application of innovative technologies significantly affects the profitability level of viticulture farms. Farms that have introduced intensive vineyards and modern technologies demonstrate higher profitability compared to traditional farms and possess broader opportunities for producing export-oriented products. In particular, stronger integration with the processing industry contributes to value creation and increased sectoral profitability.

The main findings indicate that the innovative development of the viticulture sector ensures important economic benefits, including:

increasing productivity;

efficient utilization of water and other resources;

reduction of production costs;

improvement of product quality;

expansion of export potential;

increase in farmers' incomes.

Components and Economic Essence of Smart Agriculture Technologies. Smart agriculture differs from traditional farming in terms of the speed of data collection, processing, and decision-making. The foundation of this system is real-time monitoring. From an economic perspective, these technologies optimize the production function by ensuring either maximum yield with given resources or minimum cost for a targeted yield level. Artificial intelligence serves as the "brain" of smart agriculture. By analyzing satellite imagery, drone-generated data, and sensor indicators, AI forecasts productivity, identifies pest risks, and develops irrigation schedules. Through AI, the process of developing new crop varieties in seed breeding is being shortened from years to months, significantly reducing research and development (R&D) costs.

IoT devices continuously measure soil moisture, temperature, salinity, and air humidity in the field. This information is transmitted to cloud platforms, enabling farmers to manage agricultural processes remotely via smartphones without physically visiting the fields. The economic impact lies in reducing human error and ensuring resource consumption based on actual needs. For example, precision irrigation systems have proven capable of reducing water consumption by 25–30 percent. Spectral images obtained through drones enable the calculation of vegetation indices (NDVI), which helps identify plant diseases or water deficiencies before visible symptoms appear. Experimental studies conducted in the Samarkand Region of Uzbekistan have shown that the use of drones can reduce the time required for manual field inspections by 60 percent and improve the efficiency of chemical treatment processes by 15 percent.

The "Digital Uzbekistan – 2030" Strategy, approved by a Presidential Decree of the Republic of Uzbekistan, serves as the legal foundation for the transformation of agriculture. Within the framework of this strategy, specific tasks have been defined for creating digital infrastructure in agriculture, implementing artificial

intelligence technologies, and improving workforce qualifications. Digital technologies reduce operational expenditures (OpEx) by an average of 22 percent. These savings are primarily achieved through the following factors:

Water conservation: Smart sensors and automated irrigation systems reduce water consumption by 30–35 percent.

Fertilizers and chemical inputs: Precision spraying and zone-based fertilization decrease the use of agrochemicals by 15–30 percent.

Labor force optimization: Automated systems reduce labor requirements and help address labor shortages.

Digital transformation in agriculture is not merely a trend but rather the only adequate response to the economic and environmental challenges of the 21st century. Through the implementation of "smart agriculture" technologies, it is possible to elevate production efficiency to a fundamentally new qualitative level.

Conclusion and Recommendations

The widespread implementation of "smart agriculture" systems in Uzbekistan's viticulture sector represents the only effective pathway toward significantly increasing the industry's competitiveness in international markets. Based on the conducted research and the analysis of the latest reforms being implemented in the country, the following practical recommendations are proposed:

First, it is necessary to establish a "Digital Viticulture and Smart Technologies" scientific-practical laboratory under the newly established Agricultural Sciences Academy. This laboratory should develop specialized digital monitoring models for national grape varieties such as Husayni, Rizamat, and Kishmish.

Second, it is advisable to strengthen the system of customs exemptions or subsidies for imported IoT sensors, multispectral drones, and smart drip irrigation

equipment used by viticulture clusters, based on the mechanisms outlined in Presidential Decree No. PF-130.

Third, in order to train personnel with digital competencies in the agrarian sector, the number of academic hours devoted to "Agroinformatics and Smart Farming" programs at the Tashkent State Agrarian University and specialized technical colleges should be increased by at least 30 percent, while practical training programs should be directly organized within digitized agricultural clusters.

The implementation of these measures will contribute to adapting the country's viticulture sector to the requirements of the digital economy and significantly increasing its export potential.

The results of the conducted research demonstrate that the innovative development of the viticulture sector in agriculture is one of the key factors in improving economic efficiency. The application of modern agrotechnologies, intensive vineyards, drip irrigation systems, digital monitoring, and innovative management approaches enables increased productivity, efficient utilization of resources, and improvement of product quality. As a result, production costs decrease, while the income and profitability levels of farming enterprises increase.

The analysis also revealed that farms implementing innovative technologies not only achieve savings in water and labor resources but also increase the production volume of export-oriented products. In particular, the development of infrastructure for processing and storing grape products plays an important role in creating added value and strengthening competitiveness in both domestic and foreign markets.

At the same time, several challenges remain in the viticulture sector, including the insufficient implementation of innovative technologies, shortages of financial resources and investments, deficiencies in logistics systems, and the lack of

qualified specialists. Addressing these issues is an important factor in ensuring the sustainable development of the industry.

Based on the findings of the research, the following recommendations have been developed:

strengthening state support for the widespread introduction of innovative and resource-saving technologies in viticulture farms;

improving the efficiency of water resource utilization through the expansion of drip irrigation and digital monitoring systems;

increasing the cultivation of high-yield and export-oriented grape varieties and further developing breeding activities;

modernizing infrastructure for storage, processing, and logistics of grape products;

expanding professional development programs aimed at improving the innovative knowledge and skills of farmers and specialists;

attracting investments into viticulture and improving preferential credit mechanisms;

strengthening integration between scientific research institutions and production enterprises within the sector.

In general, the innovative development of the viticulture sector contributes to increasing economic efficiency in agriculture, ensuring food security, expanding export potential, and supporting the sustainable development of the agrarian sector. Therefore, further support for innovative activities and the introduction of modern management mechanisms remain among the most urgent priorities for the industry.

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