



## SUSTAINABLE WATER MANAGEMENT AND FARM PRODUCTIVITY IN UZBEKISTAN: ECONOMIC OPPORTUNITIES AND CONSTRAINTS IN AGRO-MANAGEMENT

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<https://doi.org/10.5281/zenodo.23204414>

### Abstract

This article analyzes the relationship between sustainable management of agricultural water resources and farm productivity in Uzbekistan from an agro-management perspective. Agriculture in the country is significantly dependent on irrigation water, and climate change, limited water resources, aging irrigation infrastructure, rising energy costs, and increasing demand for water make water management a strategic issue. The aim of the study is to identify the economic opportunities for increasing water use efficiency, the impact of modern irrigation technologies on farm productivity, and the main constraints to their implementation. The study was conducted based on a systematic narrative literature review. It analyzed international and institutional sources on water management, irrigation efficiency, climate-adapted agriculture, digital technologies, and agro-economics. The results show that irrigation planning, drip irrigation, canal modernization, land leveling, soil moisture monitoring, remote sensing, and digital management systems can improve water use efficiency. However, the implementation of these technologies is limited by high initial investment, limited financial resources, lack of technical knowledge, infrastructure problems, and insufficient institutional coordination in water management. The study concluded that sustainable water management in Uzbekistan requires, in addition to technological solutions, training farmers, improving financial mechanisms, developing digital information systems, and strengthening cooperation between water management institutions.

**Keywords:** sustainable water management, irrigation management, agro-management, farm productivity, water use efficiency, Uzbekistan, climate-adapted agriculture, agricultural economics.

### Abstract

V state analiziruetsya vzaimosvyaz mejdya ustoychivym upravleniem vodnymi risuksami i proizvoditelnostyu fermerskikh hozyaystv v Uzbekistane s tochki zreniya sovremennogo agroupravleniya. Znachitelnaya chast selskohozyaystvennogo proizvodstva strany depends on irrigation, v to vremya kak change of climate, ogranichenost vodnykh resursov, amount of irrigation infrastructure, true energy costs and increase in demand for water create additional risks for selskohozyaystvennogo proizvodstva. Tsel issledovaniya zaklyuchaetsya v izuchenii ekonomicheskikh vozmozhnostey povysheniya effektivnosti ispolzovaniya vody, potensila sovremennykh technological improvement i osnovnykh ogranicheniy ix vnedreniya. Issledovanie issledovanie osnovano na structirovannom narrativnom obzore nauchnoy i institsionalnoy literatury. The analysis shows that rational planning of irrigation, kapelnoe irrigation, modernization of canals, vyравnivanje zemel, monitoring of soil moisture, remote sensing and digital control systems can increase the efficiency of water use and production of agriculture.

Vmeste s tem vnedrenie takikh tekhnologiy ogranichivaetsya vysokimi pervonachalnymi investment, ogranichennym dostopom k finansirovaniyu, lack of technical knowledge, infrastructural problems and institutional ogranicheniyami. V state obosnovyvaetsya neokhodimost kompleksnogo podkhoda, sochetayushchego tekhnologicheskies reshenia s obucheniem fermerov, finansovoy podderjkoj, razvitiem tsifrovix informatsionnyx sistem i sovershenstvovaniem koordinatsii mejdu uchastnikami upravleniya vodnymi risursami.

**Klyuchevye slova:** ustoychivoje upravlenie vodnymi risuksami, upravlenie orosheniem, agroupravlenie, proizvoditelnost fermerskikh hozyaystv, effektivnost ispolzovaniya vody, Uzbekistan, klimaticheskij ustoychivoje selskoe hozyastvo, ekonomika selskogo hozyaystva.

### Abstract

This article examines the relationship between sustainable water management and farm productivity in Uzbekistan from an agro-management perspective. Agricultural production in the country is substantially dependent on irrigation, while climate variability, increasing water scarcity, aging irrigation infrastructure, rising energy costs, and growing competition for water are creating additional risks for farmers. The purpose of the study is to examine the economic opportunities associated with improved agricultural water management, the potential contribution of modern irrigation technologies to farm productivity, and the major constraints affecting their adoption. A structured narrative literature review was conducted using academic and institutional evidence related to irrigation management, water-use efficiency, climate-smart agriculture, digital agriculture, and agricultural economics. The findings indicate that improved irrigation scheduling, drip irrigation, land leveling, canal modernization, soil-moisture monitoring, remote sensing, and digital farm-management systems can contribute to improved water-use efficiency and agricultural productivity. However, adoption is constrained by high initial investment costs, limited access to finance, infrastructure deficiencies, insufficient technical knowledge, and institutional coordination challenges. The study argues that sustainable agricultural water management in Uzbekistan requires an integrated approach that combines irrigation technologies with farmer training, financial mechanisms, digital information systems, infrastructure modernization, and stronger coordination among water-management institutions. Farm-level economic analysis is also necessary to determine whether individual technologies generate sufficient returns under different crop, farm-size, and regional conditions.

**Keywords:** sustainable water management, irrigation management, agro-management, farm productivity, water-use efficiency, Uzbekistan, climate-smart agriculture, agricultural economics.

### ENTRANCE

Water is one of the most important natural and economic resources for agricultural production, and its strategic importance is even higher in the conditions of Uzbekistan. Since a significant part of the country's agricultural production depends on irrigation, the amount of water resources and the efficiency of their use directly affect the productivity, income and economic stability of farms. At the same time, climate change, changes in the precipitation regime, increased demand for water and the aging of water infrastructure are increasing the demand for water management in agriculture [1].

Water management is not limited to the process of supplying water to irrigation systems. From the point of view of modern agro-management, when, where, how much and how much

water is supplied should be assessed together with the technical condition of irrigation systems, energy consumption, labor costs, crop type, soil moisture, financial capabilities and expected yields. Therefore, water use efficiency is one of the important indicators of the overall economic efficiency of a farm.

FAO emphasizes the need to combine the efficient use of natural resources, economic sustainability, and environmental responsibility in transforming agricultural and food systems [1]. The World Bank, on the other hand, considers water management, productivity, and climate resilience as interrelated dimensions within the framework of climate-resilient agriculture [3].

One of the important directions for increasing the efficiency of water use in agriculture is the introduction of modern irrigation technologies. Drip irrigation, sprinkler irrigation, soil moisture sensors, automated irrigation systems, satellite imagery and remote sensing technologies allow farmers to more accurately determine the timing and amount of water application. However, the availability of technology does not mean that it is economically efficient. The cost of the technology, energy costs, crop type, farm size, water availability and the technical knowledge of the farmer affect the final result.

Therefore, the main objective of this study is to analyze sustainable water management as an important element of agro-management in Uzbekistan, to examine the impact of water use efficiency on farm productivity and economic outcomes, and to identify economic, technical, and institutional constraints to the implementation of modern water management technologies.

#### REVIEW OF RELATED LITERATURE

in agriculture has been closely linked to sustainable development, climate change and food security in recent years. FAO studies on agrifood systems highlight the need to improve the efficiency of natural resource use as a key factor in ensuring the long-term sustainability of agricultural systems [1].

to water management focus not only on reducing water consumption, but also on increasing the output and economic value of each unit of water. From this perspective, "water productivity" is an important economic indicator for farm management. For example, a farm may reduce water consumption, but if this results in a significant decrease in productivity, the overall economic result may be negative. Therefore, water conservation and economic efficiency should be assessed together.

climate-resilient agriculture highlights the need to develop management approaches that integrate agricultural productivity, climate resilience, and environmental sustainability [3]. Water efficiency can be linked to all three goals. Efficient irrigation supports productivity, reduces the risk of water scarcity, and enables the rational use of limited water resources.

on digital technologies also shows that new opportunities are emerging in water management. Satellite imagery, sensors, meteorological data, and digital farming platforms can make irrigation decisions more accurate. However, implementing such technologies requires internet, electricity, maintenance, data processing skills, and financial resources.

Thus, the literature review shows the need to view water management not as a technical issue, but as a complex agro-management issue that combines technology, economics, farmer knowledge, and institutional management.

#### RESEARCH METHODOLOGY

This study is based on a structured narrative literature review methodology. The study analyzed scientific and institutional materials on agricultural water management, irrigation efficiency, water productivity, climate-adapted agriculture, digital technologies, and farm economic management in Uzbekistan .

Four main areas were identified in the literature review : water use efficiency, economic outcomes, technological management, and institutional and organizational constraints. Within the framework of water use efficiency , irrigation planning, water loss reduction, soil moisture management, and precision irrigation were considered.

Economic outcomes included production costs, energy consumption, productivity, farm income, and investment requirements. Technological management included drip irrigation , sensors, remote sensing, digital platforms, and automated systems.

This article is not based on original field experiments or farmer surveys. The study summarizes the available scientific and institutional evidence to reveal the economic relevance of sustainable water management in agro-management in Uzbekistan .

### ANALYSIS AND RESULTS

The results of the analysis showed that improving water management in agriculture can affect farm productivity through several interrelated mechanisms. First, adjusting irrigation to the actual water needs of the crop can reduce excess water consumption and increase water resource efficiency.

The economic aspect of irrigation efficiency is also important. Transporting water to the fields, using pumps, electricity and maintaining irrigation infrastructure require costs. Therefore, excessive water consumption can lead to not only environmental but also economic losses.

Drip irrigation is a technology that allows water to be delivered more precisely to the root zone of a crop. The economic efficiency of this technology depends on the crop type, yield value, area size, installation cost, maintenance, and farmer management skills. The potential for additional investment recovery may be higher in high-value crops, while simpler and cheaper water-saving methods may be economically viable in low-value crops.

Moreover, improving water efficiency does not always require sophisticated technologies. Measures such as correctly timing irrigation , leveling land, reducing losses in canals, improving drainage systems, and monitoring soil moisture can also yield significant results.

Table 1. Main water management approaches and their potential agro-economic impacts

| Water management direction | Potential benefit                          | Basic management issue                    |
|----------------------------|--------------------------------------------|-------------------------------------------|
| Drip irrigation            | Efficient water use and precise irrigation | Installation and maintenance costs        |
| Irrigation planning        | Reducing excess water consumption          | Farmer knowledge and reliable information |
| Soil moisture monitoring   | Accurately determine watering times        | Sensor price and technical skills         |
| Leveling the land          | Even distribution of water in the field    | Technical and investment requirements     |

| Water management direction | Potential benefit                         | Basic management issue            |
|----------------------------|-------------------------------------------|-----------------------------------|
| Modernization of channels  | Reducing losses in water transportation   | Infrastructure investment         |
| Remote sensing             | Determining water stress in crops         | Interpreting data                 |
| Digital agro-management    | Improving water and production accounting | Digital skills and infrastructure |
| Improve drainage           | Reducing flooding and soil degradation    | Infrastructure and maintenance    |

*Source: Developed by the author based on sources [1; 3; 4].*

Digital technologies offer the potential to further improve water management. Remote sensing and satellite imagery help monitor crop growth and water stress at a regional scale. Soil moisture sensors allow farmers to more accurately determine irrigation timing.

However, the availability of digital information does not automatically generate economic benefits. Farmers need to understand the information, make decisions based on it, and have the appropriate technical tools . Therefore, digital water management technologies need to be developed in conjunction with farmer training and advisory services.

water management and farm profitability is also of particular importance. Water-saving technologies can reduce water and energy costs, but their initial investment cost is likely to be high. Therefore, a farmer should assess the return on investment and expected returns before implementing a new technology.

For example, the following indicators are important when choosing a technology :

- the amount of water used per hectare;
- yield per cubic meter of water;
- energy consumption;
- labor costs;
- production cost;
- net farm income;
- investment payback period;
- investment profitability.

From this perspective, saving water is not the ultimate goal. The ultimate goal is to create **more products and economic value per unit of water** .

Climate change also increases the importance of water management. Changes in temperature and rainfall can alter the water needs of crops. In such conditions , careful irrigation planning, the use of drought-tolerant varieties, soil moisture conservation, and production diversification can increase farm resilience [3].

between farmers, water users, local organizations, and state water management institutions is essential for water resource management . Transparency in water allocation, maintenance of infrastructure, farmer participation in decision-making, and availability of information on water use can increase the effectiveness of technological solutions.

Table 2. Priorities for sustainable agricultural water management in Uzbekistan

| Priority direction         | Basic management question                         | Expected result                    |
|----------------------------|---------------------------------------------------|------------------------------------|
| Precise irrigation         | What is the actual water requirement of the crop? | Increased water productivity       |
| Irrigation infrastructure  | Where are water losses occurring?                 | Reduction of physical water losses |
| Farmer training            | Can the farmer use technology effectively?        | Increased technology efficiency    |
| Digital monitoring         | Can sensor and satellite data improve decisions?  | Quick control                      |
| Financing                  | How does a farmer cover the cost of technology?   | Increased technology adoption      |
| Institutional coordination | How can water distribution be improved?           | Water supply stability             |
| Farm research              | Which technology is cost-effective?               | Better investment decisions        |

Source: Developed by the author based on sources [1; 2; 3; 4].

## DISCUSSION

The results of the study show that sustainable water management should be considered not only as a question of irrigation technology, but also as a question of integrated agro-management. Installing efficient irrigation equipment is not enough. The maintenance of the equipment , the level of farmer knowledge, water allocation, financial planning and the condition of the infrastructure also affect the final result.

Economic factors are crucial in the adoption of technologies. Farmers are usually willing to adopt a new technology only if the expected benefits justify its costs and risks. Therefore, water management programs should demonstrate the technologies' clear economic outcomes in addition to their environmental benefits.

the farm and the market value of the crop also influence the choice of technology. For high-value crops, it may be economically viable to invest in precision irrigation and monitoring technologies. For small farmers, it may be more cost-effective to use cooperative services, shared equipment, remote monitoring services, or general water management consulting services rather than purchasing equipment individually.

Another important issue in Uzbekistan is the lack of farm-level economic data on water management. International experience can show the potential benefits of water-saving technologies , but actual economic outcomes can vary significantly depending on region, crop type, energy prices, water supply, farm size, and infrastructure.

Therefore, future research should compare the economic efficiency of water management technologies across different regions of Uzbekistan and across major agricultural crops. This should include not only water savings, but also productivity, production costs, energy consumption, labor costs, farmer income, and return on investment .

Digital water management is also a promising area of research. Systems based on satellite imagery , sensors, meteorological data, and artificial intelligence could enable more accurate irrigation decisions in the future. However, the economic benefits of these technologies for

farms need to be assessed in conjunction with their cost, infrastructure, and farmers' digital skills.

should consider water availability as a key factor in crop selection, production cost calculation, investment planning and climate risk assessment.

### CONCLUSION AND SUGGESTIONS

in Uzbekistan and the high dependence of agriculture on irrigation make sustainable water management one of the strategic directions of modern agro-management. The results of the study showed that irrigation planning, drip irrigation, land leveling, canal modernization, soil moisture monitoring, remote sensing and digital management systems have the potential to increase water use efficiency.

However, technological modernization alone is not enough. High initial investment costs, limited financing options, the technical condition of irrigation infrastructure, farmers' knowledge and skills, and institutional coordination problems can hinder the widespread adoption of water-saving technologies.

Based on the research, the following proposals were developed:

- assess the efficiency of water use on farms based on regular economic indicators;
- selecting water-saving irrigation technologies appropriate to the region, crop type, and farm size;
- calculating the return on investment when introducing drip irrigation and other modern technologies;
- modernization of irrigation canals and water supply infrastructure;
- enhance practical training for farmers on water management, irrigation planning, and digital technologies;
- developing cooperative or service-based water management technologies for small farmers;
- development of digital water monitoring based on the use of satellite, sensor and meteorological data;
- improve information exchange between water management institutions, farmers and local organizations;
- development of loans, subsidies and other financial mechanisms to finance water-saving technologies;
- Expand farm-level research that examines the real economic efficiency of water management technologies across different regions and crops in Uzbekistan .

In conclusion, the main goal of sustainable water management in Uzbekistan should not be simply to reduce water consumption, but to ensure the long-term sustainability of water resources, while obtaining higher productivity and economic value from each unit of water . To do this, technological innovations must be combined with the economic interests of farmers, knowledge and skills , financial capabilities, and effective institutional management.

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