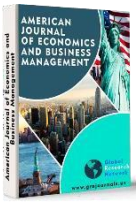

American Journal of Economics and Business Management

Vol. 8 Issue 8 | **pp.** 3803-3807 | **ISSN:** 2576-5973
Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Article

The Necessity and Possibilities of Introducing Water-Saving Technologies in Agriculture in The Republic of Karakalpakstan

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Abstract: Water scarcity in arid regions such as Karakalpakstan poses serious threats to agricultural sustainability, economic stability, and public health, exacerbated by the ecological consequences of the Aral Sea crisis. Despite efforts to implement modern irrigation systems, most agricultural lands in Karakalpakstan continue to rely on traditional irrigation methods, resulting in inefficient water use, soil salinization, and reduced productivity. The limited and inconsistent application of water-saving technologies, compounded by a lack of farmer training and institutional support, hinders effective water management and the realization of long-term agricultural goals. This study investigates the necessity, current state, and potential for introducing modern water-saving technologies—such as drip and sprinkler irrigation—in Karakalpakstan's agricultural sector. Findings indicate that only 7% of irrigated land utilizes modern systems, while traditional methods still dominate. Adoption remains uneven across years, with significant fluctuations in implementation, undermining consistency. The research highlights the systemic barriers to effective adoption, including weak legal foundations, lack of technical training, and insufficient support services, making this a comprehensive case study for sustainable irrigation transformation in post-crisis regions. A scientifically grounded, institutionalized approach—focused on education, technical maintenance, and strategic policy—is essential for achieving sustainable water use and boosting agricultural productivity. These insights provide a foundation for policy development not only in Karakalpakstan but also in similar ecologically vulnerable regions globally.

Keywords: Karakalpakstan, Irrigation Systems, Drip Irrigation, Water Efficiency, Agricultural Productivity, Traditional Irrigation

Citation: Uzakbergenovich N. T. The Necessity And Possibilities Of Introducing Water-Saving Technologies In Agriculture In The Republic Of Karakalpakstan. American Journal of Economics and Business Management 2025, 8(8), 3803-3807.

Received: 30th Jun 2025
Revised: 08th Jul 2025
Accepted: 26th Jul 2025
Published: 8th Aug 2025

1. Introduction

Water is one of the most vital natural resources for sustainable agricultural development, especially in arid and semi-arid regions. The Republic of Karakalpakstan, located in the northwestern part of Uzbekistan, faces significant challenges related to water scarcity due to its geographical position, climate conditions, and the environmental consequences of the Aral Sea crisis. Agriculture, being the backbone of the region's economy and the primary source of livelihood for a large portion of the population, heavily depends on irrigation. However, traditional irrigation methods result in substantial water losses and are no longer sufficient to meet the growing demands of both food production and water conservation[1].

Water is a critical resource for agricultural development, particularly in arid and ecologically vulnerable regions like the Republic of Karakalpakstan. Positioned in northwestern Uzbekistan, the region has endured severe environmental degradation due to the desiccation of the Aral Sea, resulting in water scarcity, land salinization, and declining agricultural productivity. Agriculture remains a cornerstone of the local economy, yet it continues to rely on inefficient traditional irrigation methods such as open canals and gravity-based systems. These practices not only waste significant water resources but also degrade soil quality, leading to reduced crop yields and economic instability. The limited adoption of modern irrigation technologies such as drip and sprinkler systems highlights systemic challenges, including lack of technical expertise, weak institutional support, and insufficient farmer awareness. Addressing these challenges is essential for ensuring sustainable water use, improving agricultural efficiency, and securing livelihoods. This study explores the necessity and feasibility of introducing water-saving technologies in Karakalpakstan's agricultural sector.

2. Materials and Methods

In this context, the introduction of modern, water-saving technologies in agriculture has become not only a necessity but also a strategic priority. These technologies offer promising solutions to optimize water use, enhance crop productivity, and ensure environmental sustainability. This paper explores the necessity of implementing water-saving technologies in Karakalpakstan's agriculture and examines the opportunities and potential benefits such innovations can bring to the region[2].

In recent years, the territory of Karakalpakstan is recognized as the region most affected by the environmental crisis caused by the construction of the Aral Sea. This environmental problem has large-scale and negative consequences and poses a serious threat to human health and economic stability. Pollution of air and Water Resources has become a dangerous factor for the health of the population. There has also been a dramatic increase in unemployment as a result of the complete loss of the historically important fishing industry. And the desertification processes observed in the region have a negative impact on agriculture, reducing the biological yield of land resources. To solve these problems, it is necessary to carry out long-term and comprehensive financial and institutional measures by the state. If sustainable solutions are not immediately applied to this situation, environmental and social problems are more likely to deepen[3].

Agriculture in Karakalpakstan still relies on traditional irrigation methods, leading to inefficient use of Water Resources. Open channels and gravity irrigation systems are causing significant water loss, increasing the salinity of the land. In such conditions, a decrease in agricultural productivity and a negative impact on land quality are inevitable[4].

Modern irrigation technologies — including drip and spray irrigation systems-have not yet been widely introduced in Karakalpakstan. The gradual transition to these technologies is important to ensure sustainable use of water resources as well as to increase productivity in agriculture. Therefore, institutional support for the introduction of water-saving technologies and strengthening information and educational work among farmers is an urgent task [5].

3. Results and Discussion

The total area of irrigated land in Karakalpakstan is 415 thousand hectares. Of this, 382,000 hectares or 92% are irrigated by conventional irrigation, indicating a high level of inefficient use of Water Resources. The use of modern technology is to a lesser extent: spray irrigation was introduced on an area of only 5,000 hectares (1.3%) and drip irrigation on an area of 22,000 hectares (5.7%). This situation indicates that water saving opportunities are not being used enough and the need for the widespread introduction of modern irrigation systems to solve problems in water supply. Also, the reduction of traditional

irrigation methods and the transition to innovative approaches is a decisive factor in ensuring water stability in Karakalpakstan, see Table 1[6].

Table 1. Irrigation areas according to irrigation methods in Karakalpakstan (2024).

Irrigation method	Area (ha)	Area (%)
Traditional irrigation	382.000	92
Sprinkler irrigation	5.000	1,3
Drip irrigation	22.000	5,7
Total irrigation area	**415.000**	**100**

Despite some positive changes in the implementation of water-saving irrigation systems in Karakalpakstan during 2019-2024, the growth rate is still insufficient. While spray (sprinkler) irrigation has not been used at all in 2019 and 2020, attention to it has increased since 2021, reaching 1.900 hectares in 2024. This technology was introduced in a total of 4.664 hectares of land in 6 years[7].

In the case of drip irrigation technology, however, in 2019-2020, very small amounts were used — 387 and 211 hectares. In 2021, the rate rose sharply to 9.824 hectares, but in the following years there was a decline, reaching 4.150 hectares in 2024. In total, drip irrigation was introduced in 6 years on an area of 21.897 hectares.

From this information, it can be seen that although there have been Promotion and practical activities on both technologies, the pace of implementation is not stable and there are large differences in the cross-section of years. Sustainable political, financial and educational support is necessary for this technology in irrigation to have a wider scope. It also shows that current growth trends are not enough to reach long-term goals, see Table 2[8].

Table 2. Areas opened to modern irrigation over the years in Karakalpakstan.

Year	Sprinkler irrigation (ha)	Drip irrigation (ha)
2019	-	387
2020	-	211
2021	446	9.824
2022	1.304	3.304
2023	1.014	4.021
2024	1.900	4.150
TOTAL	**4.664**	**21.897**

In Karakalpakstan, the reform of irrigation systems to effectively use water resources and increase productivity in agriculture is an urgent task. Currently, existing irrigation canals and traditional irrigation systems are not efficient enough and require modernization. At the same time, it is important to determine the specific water needs of plants, to draw up a scientifically based irrigation schedule for all types of crops. In addition, water economy and agrotechnical efficiency can be achieved through the extensive use of modern technological tools such as automatic meteorostations, soil moisture sensors, automation systems, drones and artificial intelligence in irrigation[9].

The introduction of modern irrigation systems serves to dramatically increase the efficiency of water and resource use. According to analyzes, through these technologies it is possible to reduce water consumption by 40-50%, fertilizer consumption by 60-70%,

electricity by 55-60% and labor consumption by 45-50%. However, there is also a significant increase in productivity: for example, for tomatoes, the yield can increase to 60%, and in cotton-up to 55%. These indicators demonstrate the economic efficiency of modern irrigation methods, making it possible to significantly increase the income of farmers. Therefore, the widespread introduction of these systems will lead to sustainable development in Karakalpakstan agriculture, see Table 3[10].

Table 3. Advantages of drip irrigation.

No	Advantage	Amount, %
1.	Water saving	40-50
2.	Fertilizer saving	60-70
3.	Energy (electricity) saving	55-60
4.	Labor saving	45-50
5.	Increased yield (maximum yield increases: 60% in tomato, 55% in cotton)	30-60
	Result: Sıgnıfıcant Increase In Income	

There are a number of systemic problems in the process of introducing modern irrigation technologies such as drip irrigation in the Republic of Karakalpakstan. First of all, in many cases, installed drip irrigation systems are carried out without relying entirely on legal grounds and do not operate effectively[11]. Farmers are implementing these systems mainly at the request of the state or various organizations, but do not have sufficient knowledge and practical skills in their proper use. At the same time, there is no focus on scientific and technical foundations on the part of the companies that install the system, the mechanism of education and maintenance is not sufficiently established[12].

As a result, the efficiency of using systems is low, and the drip irrigation method is assessed as ineffective among farmers. In some cases, farmers are forced to abandon the system altogether and return to traditional methods, which negatively affect water conservation, productivity growth and economic efficiency[13]. In order to eliminate such situations, it is an urgent task to organize the system on a scientific basis, ensure the participation of industry professionals and support farmers with targeted training and technical support. These measures provide the basis for the widespread and effective introduction of drip irrigation technologies [14].

The introduction of modern irrigation technologies in Karakalpakstan is an important factor for saving water resources, increasing productivity in agriculture and achieving economic stability[15]. In practice, however, the failure of these systems to be implemented on a scientific basis, the lack of adequate qualifications of farmers, lack of maintenance and education, results in the assessment of drip irrigation as ineffective, and in many cases it is observed that it is abandoned. This is a serious obstacle to the development of water-saving technologies. Therefore, it is necessary to eliminate these problems by introducing the system on the basis of a scientific and methodological approach, training farmers, establishing maintenance and institutional support. Only then will it be possible to form sustainable agriculture through modern irrigation systems[16].

4. Conclusion

The analysis of water use in agriculture in the Republic of Karakalpakstan clearly demonstrates the urgent need for the introduction of water-saving technologies. Given the region's arid climate, limited freshwater resources, and the ongoing ecological consequences of the Aral Sea disaster, traditional irrigation practices are no longer sustainable. Scientific studies and international experience show that modern water-

saving methods—such as drip irrigation, sprinkler systems, and moisture sensors—can significantly reduce water consumption while maintaining or even increasing agricultural productivity.

Moreover, the successful implementation of these technologies requires a comprehensive approach, including farmer education, investment in infrastructure, and supportive policy frameworks. If properly adopted, water-saving technologies can contribute to food security, improve the livelihoods of rural communities, and promote sustainable agricultural development in Karakalpakstan. Thus, the transition toward efficient water management in agriculture is not just a necessity but a scientifically and economically justified step for the region's future.

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