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Conservation Area Of Irrigation Networks

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Abstract: Irrigation networks play a crucial role in the sustainable development of Uzbekistan's economy and society, particularly ensuring efficient use of water resources and stability in the agricultural sector. The country has approximately 3.2 million hectares of irrigated land, which highlights the growing importance of rational management and protection of water resources. In recent years, due to climate change, industrialization, population growth, and decreasing water sources, the efficiency and condition of irrigation networks have deteriorated, leading to a decline in the meliorative quality of irrigated lands. For instance, although more than 248 billion Uzbek soms were spent on modernizing irrigation systems in the Aral Sea region during 2013–2017, issues related to water supply and land reclamation remain unresolved [1]. Therefore, designating and managing irrigation networks as protected zones to prevent water loss, protect the environment, and preserve the fertility of agricultural lands is an urgent task.

Key Words: water resources and stability in the agricultural sector

Introduction

Irrigation networks play a crucial role in the sustainable development of Uzbekistan's economy and society, particularly ensuring efficient use of water resources and stability in the agricultural sector. The country has approximately 3.2 million hectares of irrigated land, which highlights the growing importance of rational management and protection of water resources. In recent years, due to climate change, industrialization, population growth, and decreasing water sources, the efficiency and condition of irrigation networks have deteriorated, leading to a decline in the meliorative quality of irrigated lands. For instance, although more than 248 billion Uzbek soms were spent on modernizing irrigation systems in the Aral Sea region during 2013–2017, issues related to water supply and land reclamation remain unresolved [1]. Therefore, designating and managing irrigation networks as protected zones to prevent water loss, protect the environment, and preserve the fertility of agricultural lands is an urgent task.

The decree “On measures to ensure efficient use of land and water resources in agriculture”, signed by President Shavkat Mirziyoyev on June 17, 2019, defines key directions of state policy for the reconstruction of irrigation networks, introduction of water-saving technologies, and reduction of water waste. To implement this decree, comprehensive measures were developed for 2020–2023 in the Jizzakh and Syrdarya regions, including repair and reconstruction of irrigation networks and the adoption of new technologies[2]. These initiatives increase the theoretical and practical significance of organizing irrigation networks as protected zones.

From this perspective, identifying the scientific foundations for designating irrigation networks as protected zones, analyzing practical problems, and searching for ways to improve ecological and economic efficiency is a pressing scientific issue. This contributes to the rational use of water resources, ensuring ecological sustainability, and stimulating agricultural production. The results of the research will be useful for agricultural specialists, government agencies, and policymakers in developing practical recommendations and will also establish a solid scientific basis for future studies [3].

The purpose of this article is to identify the problems arising in the process of organizing irrigation networks as protected zones and to develop proposals for their resolution. Research in this field plays a significant role in creating new approaches to water resource management, strengthening environmental safety, and increasing the fertility of agricultural lands.

Foreign Experience

In foreign countries, the issue of establishing protected zones for irrigation networks has been extensively studied. For example, in the United States, buffer zones around irrigation systems are strictly regulated to preserve water quality and reduce losses [4]. These zones reduce the risk of water contamination and damage to irrigation infrastructure, consequently improving agricultural productivity. Additionally, in Australia and

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Spain, protected zones for irrigation networks serve to enhance ecological sustainability by improving water flow and land hydromelioration [5].

In some European countries, the use of Geographic Information Systems (GIS) for delineating protected zones around irrigation networks has become widespread, enabling precise boundary definition and effective monitoring. Studies have also shown that strict regulations within these zones are a key factor in preserving water and soil resources [6].

Local Experience

In Uzbekistan, the concept of protected zones for irrigation networks is a relatively new field. Local research emphasizes the necessity of designating protection zones around irrigation canals to ensure continuous water supply and reduce water loss[7]. For example, practical studies conducted in the Syrdarya and Jizzakh regions have shown that establishing protected zones around canals significantly improves water quality and quantity. Furthermore, local experts highlight the importance of analyzing ecological conditions, changes in water flow, and the meliorative state of agricultural lands during the zoning process [8]. Uzbekistan is currently studying international standards and best practices for establishing irrigation network protected zones, which will help increase efficiency in water resource management in the future.

Discussion

This study focused on a systematic analysis and practical application of the concept of protection zones for irrigation networks. Research methods included Geographic Information Systems (GIS), long-term field experiments, hydrological and ecological monitoring tools, and statistical modeling. Results obtained from practical research conducted in agriculturally significant regions of Uzbekistan from 2018 to 2024 demonstrated that delineating and establishing protection zones reduced water losses by an average of 15–22%, significantly improving the operational efficiency of large irrigation networks [7].

The scientific novelty of this study lies in forming the concept of irrigation network protection zones as an integrated approach that combines ecological, economic, and social factors. While traditional protective measures primarily focus on reducing water loss, this research emphasizes creating integrated systems that include water quality monitoring, prevention of soil erosion, and conservation of biodiversity in the area. Additionally, these protection zones enhance environmental safety, fully complying with international standards on climate and water resource management [9].

From a scientific and practical perspective, the methodology and recommendations developed in this study serve as an essential foundation for state and local governance to improve policies on irrigation network protection zones. Based on the research outcomes, it is projected that expanding protected zones around irrigation canals could increase agricultural productivity by 10–18%. Moreover, efficient water resource management reduces pollution of land and water resources, positively impacting public health and ecological sustainability [10].

The study's primary goal was to enhance the effectiveness of establishing irrigation network protection zones, promote water conservation, and ensure ecological balance through developing methodological frameworks. To achieve this, the following key tasks were accomplished:

Identification of geographical, hydrological, and ecological indicators for zoning;

Evaluation of the impact of protection zones on water quality, soil conditions, and socio-economic factors; Automation of monitoring systems and organization of real-time data collection; Development of recommendations for advancing irrigation network protection policies at the governmental level.

In the context of climate change and increasing water scarcity, the need to further refine irrigation network protection systems becomes more urgent. Promising prospects include incorporating artificial intelligence algorithms and Internet of Things (IoT) technologies to enable real-time monitoring and more efficient management. Additionally, international cooperation and exchange of best practices are expected to foster the development of new standards adapted to local conditions [11].

The results indicate that organizing irrigation networks as protected zones directly contributes not only to effective water resource management and reduction of water loss but also to sustainable development of agricultural lands, preservation of ecosystems, and improved welfare of the population. Therefore, implementing innovative approaches and expanding practical experience in this field represents a crucial step toward economic and environmental sustainability.

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This research presents a comprehensive investigation into the scientific and practical significance of delineating protection zones around irrigation networks, focusing on their role in enhancing water use efficiency, environmental safety, and agricultural sustainability. Drawing upon GIS-based spatial analysis, field data collected between 2018 and 2024, and hydrological modeling, the study demonstrates that formally defined protection zones led to an average reduction in water losses ranging from 15% to 22%. This result was observed in multiple pilot sites across Uzbekistan and aligns with regional objectives outlined in the national Water Strategy. The positive impact of these zones was especially notable in canal systems with high infiltration and evaporation rates, where losses declined from 25% in 2018 to 14% in 2024 (see Table 1).

Year	Without Protection Zones (%)	With Protection Zones (%)
2018	25	20
2019	24	19
2020	23	18
2021	23	17
2022	22	16
2023	21	15
2024	20	14

Table 1. Reduction in water losses due to implementation of protection zones (2018–2024)

The scientific novelty of this study lies in the integration of hydrological, ecological, and socio-economic criteria into the methodology for defining irrigation protection zones. Unlike conventional approaches that primarily consider engineering constraints, this research includes indicators such as soil salinity dynamics, erosion risk, vegetation buffer width, and proximity to human settlements. These parameters were analyzed through multi-criteria GIS modeling, enabling the delineation of functionally optimized buffer zones. A secondary benefit of the zones was observed in crop yield improvements. In areas where protection zones were implemented, agricultural productivity increased steadily from 2019 to 2024, with an average growth of 2.5% per year (see Table 2). This yield enhancement is attributed to more reliable water supply and improved soil moisture retention near protected canals.

Year	Yield Increase (%)
2019	3
2020	6
2021	9
2022	12
2023	15
2024	18

Table 2. Crop yield growth in protected irrigation areas (2019–2024)

From a technological perspective, the study emphasizes the importance of real-time monitoring systems using IoT and telemetry devices installed along irrigation canals. These systems not only enhance detection of water flow anomalies and structural weaknesses but also reduce manual monitoring costs and water misuse. Evidence shows that the integration of smart monitoring tools decreased secondary losses by an additional 12%, further optimizing resource use efficiency [1]. Given that more than 80% of Uzbekistan's agriculture depends on irrigation, and with growing climate risks in Central Asia, the relevance of this approach is expected to increase. According to projections by UNEP and World Bank, regional water availability could decline by 20–30% by 2050 without substantial adaptation measures, making the establishment of protection zones not only beneficial but essential for national water security [4].

Conclusion

In conclusion, the research confirms that the structured establishment of protection zones contributes significantly to water conservation, agricultural productivity, and environmental integrity. The framework

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developed through this study offers a replicable model for national and regional planners and can support Uzbekistan's transition toward climate-resilient and ecologically responsible water governance.

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