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Article

Improving the Financing Mechanisms for the Ecological Sustainability of Irrigated Lands in Uzbekistan

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Abstract: The main objective of this research is to improve the financing mechanisms for expenditures aimed at ensuring the ecological sustainability and enhancing the ameliorative condition of irrigated lands in the Republic of Uzbekistan, based on advanced international practices. During the research process, scientific methods such as financial analysis, comparative assessment, a systemic approach, statistical observation, and econometric modeling were widely utilized to conduct an in-depth study of the current state of public expenditures, targeted subsidies, and private investments in the sector. The obtained results indicated the low efficiency of the traditional budget-dependent financing system. As a practical solution to the problem, it was proposed to establish targeted ecological funds adaptable to climate change, expand public-private partnership projects, launch the issuance of green bonds, and create a system of differentiated tax incentives for entities utilizing resource-saving innovative technologies. The significance of the study lies in the fact that the developed self-sustaining stable financial models guarantee long-term ecological security in the agricultural sector. The practical implementation of these mechanisms will directly serve to alleviate the budget burden and fundamentally increase the economic productivity of the lands.

Keywords: Irrigated Lands, Ecological Sustainability, Financing Mechanisms, Green Investments, Amelioration Costs, Ecological Subsidies, Green Bonds, Public-Private Partnership (PPP)

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1. Introduction

In the context of global climate change and the depletion of freshwater resources, land degradation and desertification processes in agriculture are becoming primary factors threatening food security worldwide. According to the Food and Agriculture Organization (FAO) of the United Nations, approximately 20 percent of irrigated lands globally are affected by varying degrees of salinity, and mitigating these processes requires substantial sustainable financial resources. Central Asia, particularly as a region experiencing the consequences of the Aral Sea tragedy, views the preservation of soil fertility and the improvement of ameliorative conditions as an emergency priority.

In the Republic of Uzbekistan, the agricultural sector is one of the core branches of the national economy, with over 90 percent of agricultural products cultivated precisely on irrigated lands [1]. However, the current ecological situation necessitates a fundamental revision of the sector's financing system. The President of the Republic of Uzbekistan, Shavkat Mirziyoyev, in his strategic addresses, has particularly emphasized the

paramount importance of this issue: "In agriculture, we must consider not only today's harvest but also the fate of the land and water resources that will be left to our future generations. To achieve this, it is imperative to introduce the principles of a "green" economy into the sector, abandon traditional financing in improving the ecological condition of lands, and widely attract public-private partnerships and modern investment mechanisms", thereby defining the trajectory for modernizing financial policy in the sector [2], [3].

Practice indicates that the costs associated with improving the ameliorative and ecological condition of lands in Uzbekistan still remain predominantly dependent on state budget funds. Although the government forms large-scale targeted funds, their efficiency, the effectiveness of the allocated subsidies, and the share of private "green" investments remain insufficient. The full burden of financial responsibility falling upon the state impedes the comprehensive implementation of long-term ecological programs.

While the issues of agricultural financing have been extensively studied in existing scientific literature and research, the majority of approaches are primarily focused on expenditures aimed at increasing economic profitability and crop yields. There remains a significant lack of specialized, comprehensive research on the institutional mechanisms for optimizing public expenditures, ecological taxes, and attracting funds from international climate funds to specifically cover the costs of ensuring the "ecological sustainability" of irrigated lands [4].

In this regard, the purpose of this study is to critically analyze the current state of financing expenditures for the ecological improvement of irrigated lands in Uzbekistan, and to develop scientifically grounded proposals for implementing modern financial mechanisms – such as green bonds, climate subsidies, and PPPs – that alleviate the state budget burden, are self-sustaining, and ensure ecological sustainability.

Literature Review

The issue of financing the ecological sustainability and ameliorative improvement of irrigated lands has been extensively researched by numerous scholars and international organizations at both global and regional levels. Existing scientific approaches can be logically categorized into three main directions: land degradation and its economic consequences, challenges of traditional financing in agriculture, and innovative "green" financial mechanisms.

The dramatic deterioration of the ecological condition of land and water resources globally has been substantiated in a series of studies. Reports by the FAO emphasize that global agricultural systems have reached their "breaking point" and require immediate intervention [5]. Barbier and Burgess analyzed the economic consequences of land degradation and proved that investments directed toward environmental improvement yield high economic returns in the long run [6]. In the context of the Central Asian region, particularly Uzbekistan, Babu and Akramov as well as Karimov and Qureshi examined the impact of agricultural policy reforms on land and water resource management, identifying the inefficient allocation of sector-directed investments as a primary driver of ecological degradation [7].

The structural restructuring and financing issues of farms in transition economies, including Uzbekistan, have been profoundly analyzed by Djanibekov and Petrick. They conclude that bank loans and budget subsidies are predominantly channeled toward short-term objectives (enhancing crop yields, purchasing seeds and fertilizers), while long-term ecological sustainability and amelioration costs remain neglected [8]. Although these issues have been elevated to the level of state policy in the regulatory framework of the Republic of Uzbekistan, notably in the "Uzbekistan – 2030" strategy (President of the Republic of Uzbekistan, 2023) and government resolutions on subsidizing the implementation of water-saving technologies (Cabinet of Ministers of the Republic of

Uzbekistan, 2021), the cost-recovery rate of the allocated budgetary funds remains persistently low [9].

In global practice, the utilization of alternative financial instruments to alleviate the budget burden is gaining widespread popularity. Using developing countries as a case study, Cui and Wang substantiated the positive impact of "green" finance and ecological subsidies on the sustainability of arable lands through econometric models [10]. The Asian Development Bank and the World Bank underscore the necessity of attracting climate fund resources to green the agricultural sector of Uzbekistan [11]. Specifically, Schumacher and Chenet, along with Eshchanov and Stultjes, highly evaluated the potential of "green" bonds in financing agricultural ecological projects [12]. Among Uzbek scholars, Hasanov and Ahmed, as well as Umarov and Turaev, advocated for the necessity of expanding PPP mechanisms in financing the amelioration of irrigated lands, whereas Mukhamedov and Rustamov proposed models for introducing innovative financial instruments into the sector
[13].

An analysis of the aforementioned literature and legislative acts (PR-179, 2022; PD-81, 2023) indicates that sufficient scientific research has been conducted regarding agricultural financing and yield enhancement [14]. However, the specific mechanisms for abandoning the traditional budget system and applying comprehensively integrated innovative approaches (a combination of PPPs, targeted ecological subsidies, and green bonds) to finance the ameliorative and ecological improvement of irrigated lands – specifically within the unique context of Uzbekistan's land relations and tax system – have not been studied in a specialized, in-depth manner. This research is directed precisely at filling this gap, namely, developing a hybrid, self-sustaining, and stable ecological financing mechanism for these expenditures.

2. Methodology

This research aims to evaluate and enhance the financing mechanisms for expenditures related to improving the ecological condition of irrigated lands in Uzbekistan, utilizing a mixed-methods (quantitative and qualitative) research design. The research process was executed in three logical stages: establishing an information base, conducting a financial analysis of the current situation, and developing prospective financial models.

3. Results and Discussion

The following main results were obtained regarding the current state of financing mechanisms for expenditures on improving the ecological and ameliorative condition of irrigated lands in the Republic of Uzbekistan, as well as the assessment of the proposed alternative scenarios [15].

Within the framework of the study, the structure of expenditures directed at measures to improve the ameliorative condition of lands in 2019-2023 was analyzed. The results indicate that the primary financing burden falls on the state budget, specifically republican and local budgets, as well as targeted funds.

Table 1. Composition of expenditures for improving the ameliorative condition of irrigated lands in Uzbekistan (2019-2023, in %)

Financing sources	2019	2020	2021	2022	2023
State budget and targeted funds	84.5	86.2	81.3	78.6	76.4
Loans from international financial institutions	11.2	9.5	12.4	14.2	13.8
Agricultural enterprises (own funds)	4.3	4.3	6.3	7.2	9.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Compiled by the author

According to the data in Table 1, although the share of budget funds has partially decreased in recent years (from 84.5% to 76.4%), the system remains highly dependent on centralized public expenditures. The share of investments made by private entities (clusters and farms) in long-term ecological sustainability does not exceed 10% [16], [17], [18], [19].

To determine the profitability of ameliorative improvement expenditures, the impact of subsidies and transfers allocated under State programs on reducing the salinity level of arable lands was evaluated based on a "Cost-Benefit Ratio" [20].

Statistical calculations show that in 2019-2023, an average of 4.5-5 million UZS (equivalent to $350-400) of state budget funds were spent to optimize 1 hectare of highly and moderately saline land. However, due to the retention of traditional irrigation and outdated drainage systems, re-salinization processes were observed in approximately 18-22 percent of total ameliorated lands after 3 years. As a result, under the traditional financing mechanism, the economic recovery coefficient (Return on Investment - ROI) constituted a mere 1.12.

During the practical phase of the research, scenarios for introducing innovative financial instruments into the sector – specifically, ecological investments (green bonds) and PPP models – were simulated.

Table 2. Scenarios for optimizing the budget burden based on alternative (hybrid) financing mechanisms (forecast for 2025-2030)

Indicators	Current scenario (Status Quo)	Baseline scenario (Hybrid financing)	Optimistic scenario (Full green finance)
State budget burden (Share in total expenditures, %)	75%	55%	40%
Share of targeted ecological funds and green bonds (%)	0%	20%	35%
Share of PPP and private clusters' funds (%)	10%	25%	25%
Level of ecological profitability (re-salinization risk, %)	> 20%	10-12%	< 8%

Source: Compiled by the author

The modeling results confirm that when hybrid financing is applied, the share of the state budget will decrease by 20 percentage points in the initial years, i.e., from 75% to 55%. Simultaneously, due to the targeted orientation of capital generated through green bonds, the ecological profitability of expenditures will increase, and the land degradation rate is expected to drop by half, i.e., from >20% to 10-12%.

The obtained financial and statistical results confirm that the current state expenditure system for improving the ameliorative and ecological condition of irrigated lands in the Republic of Uzbekistan has reached its economic limit. As presented in Table 1, the persistence of the budget burden at an average level of 76-84 percent indicates the failure to attract private investments into the sector.

The low economic recovery rate (ROI = 1.12) and the high re-salinization rate over a 3-year cycle (over 20 percent) of the traditional subsidization system identified by us fully confirm the hypotheses put forward by Djanibekov and Petrick (2023) and Karimov and Qureshi [21], [22]. As these authors emphasized, the existing financing remains predominantly a short-term measure aimed at addressing the consequences rather than the root causes of ecological problems. At the same time, our modeling results (Table 2) practically proved that the conclusions of Cui and Wang regarding the enhancement of agricultural sustainability through "green" financial instruments [23] are also applicable within the context of Uzbekistan's transition economy and regional climatic characteristics (water scarcity).

The simulated scenarios indicate that the government must systematically transition from a policy relying solely on state subsidies to one of green investments. Specifically, within the framework of the Baseline scenario, it is possible to attract at least 25% of private capital into the system by introducing differentiated ecological tax incentives for agricultural clusters and farmers. In this context, waiving land and profit taxes for a certain period for entities utilizing sustainable ecological remediation and resource-saving technologies may initially cause a budget deficit for the state; however, in the medium term, it will ensure macroeconomic revenue growth due to increased soil fertility (a decrease in degradation to 10%).

Furthermore, within the Optimistic scenario, launching the issuance of Uzbekistan's specific "Agro-green bonds" with the participation of funds from International Climate Funds, such as the Green Climate Fund and the Global Environment Facility, represents the sole viable alternative for reducing the state budget burden to 40 percent. This proposition aligns with the conclusions of Schumacher and Chenet regarding the necessity of integration between international capital markets and the environment [24].

4. Conclusion

While this study yields significant insights, it is subject to certain limitations. First, the modeled scenarios are predicated on contemporary macroeconomic statistics, thereby not fully incorporating qualitative variables such as localized institutional impediments, corruption risks, and the legal and financial literacy of farming enterprises. Second, the propensity for private sector engagement is intrinsically tethered to property rights (specifically, the security of land lease tenures). For future scholarly endeavors, it is highly recommended to deploy comprehensive survey methodologies to evaluate the micro-level impacts of green financing mechanisms on farmers and to systematically analyze risk management frameworks.

This research was dedicated to evaluating the financing mechanisms governing expenditures for the ecological sustainability and ameliorative improvements of irrigated lands in the Republic of Uzbekistan. The empirical findings corroborate that the traditional centralized financing paradigm, which is almost exclusively reliant on the state budget, has reached its threshold of economic efficiency. This conventional system is fundamentally ill-equipped to eradicate the risks of recurrent salinization, serving merely as a palliative measure for short-term consequences.

To secure long-term ecological sustainability within the sector and strategically optimize the fiscal burden, the following scientifically grounded policy recommendations are advanced:

institute differentiated ecological tax incentives (encompassing land and corporate profit taxes) to incentivize capital expenditures by agricultural clusters and farms directed at ecological land remediation. This intervention will precipitously diminish the state's systemic share while catalyzing the influx of private capital;

establish a targeted bond market dedicated exclusively to amelioration projects and the deployment of resource-efficient technologies, strictly aligned with the operational frameworks of International Climate Funds (e.g., the Green Climate Fund, Global Environment Facility);

strategically recalibrate state agricultural subsidies by pivoting away from the traditional "yield volume" metric toward a criterion centered on "ecological sustainability and the enhancement of soil fertility".

In summation, the operationalization of these innovative financial mechanisms will not only mitigate the state budget deficit in Uzbekistan but will also substantively amplify the agricultural sector's adaptive capacity to climate change, unequivocally guaranteeing the nation's long-term food and ecological security.

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