



ECOSYSTEM MANAGEMENT IN UZBEKISTAN: CHALLENGES, STRATEGIES, AND PROSPECTS

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<https://doi.org/10.5281/zenodo.17600996>

ARTICLE INFO

Received: 11th November 2025

Accepted: 12th November 2025

Online: 13th November 2025

KEYWORDS

*ecosystem management;
sustainable development;
biodiversity; ecological policy;
Uzbekistan; environmental
governance*

ABSTRACT

This study explores the current state, challenges, and management strategies of ecosystems in Uzbekistan. Using an integrated ecological-economic framework, the research identifies key drivers of ecosystem degradation and evaluates policy interventions aimed at sustainable resource use. The results reveal that anthropogenic pressures, inefficient land and water management, and insufficient environmental governance mechanisms remain the major obstacles to ecosystem resilience. The study proposes an adaptive management model integrating digital monitoring tools, stakeholder participation, and climate-resilient practices. The findings contribute to enhancing national strategies for biodiversity conservation and sustainable environmental governance in Uzbekistan..

Introduction

Ecosystem management is a critical component of sustainable development, particularly in arid regions such as Uzbekistan, where water scarcity, land degradation, and biodiversity loss pose significant ecological and socio-economic challenges. Over the past three decades, Uzbekistan has faced increased anthropogenic pressure due to agricultural expansion, industrialization, and population growth. These factors have intensified ecological imbalances, including desertification and soil salinization, which threaten long-term environmental stability.

The government has initiated several strategic programs - such as the *National Biodiversity Strategy (2019–2028)* and the *Green Growth and Climate Resilience Program (2021)* - aimed at restoring degraded ecosystems. However, implementation challenges and limited integration between economic and ecological governance persist. Therefore, a comprehensive analysis of ecosystem management mechanisms is essential to ensure a balance between economic growth and ecological sustainability.

Literature Review

Ecosystem management (EM) is defined as a holistic and adaptive process that integrates ecological, economic, and social dimensions of sustainable development (Grumbine, 1994; Christensen et al., 1996). The core principles of EM emphasize biodiversity

conservation, ecosystem resilience, and the sustainable use of natural resources. Recent studies (MEA, 2020; FAO, 2023) underline the importance of balancing ecological integrity with human well-being through participatory decision-making and integrated landscape approaches.

Globally, adaptive ecosystem management has become a key paradigm for addressing environmental challenges such as climate change, land degradation, and biodiversity loss (Holling, 2001; Folke et al., 2010). The concept shifts away from traditional sectoral management toward cross-sectoral integration, encouraging flexibility and learning in policy implementation.

Empirical research from countries such as Canada, Australia, and China highlights the effectiveness of combining ecological monitoring with socio-economic incentives. For example, the Australian Landcare program and China's Grain-for-green initiative demonstrate how community-based participation can accelerate restoration outcomes (Liu et al., 2021; Brown et al., 2019). Moreover, digital transformation and remote sensing tools are increasingly used to monitor ecosystem health and detect early signs of degradation (UNEP, 2022).

In the European Union, the implementation of the *EU Biodiversity Strategy 2030* provides a governance framework emphasizing ecosystem services valuation and green infrastructure development (European Commission, 2021). These practices have proven that successful management requires not only scientific data but also institutional cooperation and long-term funding mechanisms.

Central Asia, as one of the world's most environmentally fragile regions, faces interlinked challenges of water scarcity, desertification, and transboundary ecosystem degradation (World Bank, 2022). Studies by Mirzabaev et al. (2020) and Khamidov (2023) highlight that poorly coordinated resource management among riparian countries of the Aral Sea Basin leads to severe ecological imbalances. Efforts under the *Regional Environmental Program for Sustainable Development (REPSD)* have improved cooperation, yet institutional fragmentation remains.

Particularly, Uzbekistan has implemented several reforms in the past decade aimed at greening its economy, including the "Green Growth Strategy 2030" and "Environmental Protection Concept 2028." However, literature points out that despite policy advancement, challenges persist in enforcement, monitoring, and data transparency (Durmanov & Karimov, 2023; UNDP Uzbekistan, 2024).

Research on Uzbekistan's ecosystem management remains limited but growing. Key contributions include studies on sustainable land use (Turaev, 2020), water governance and irrigation efficiency (Ismailov et al., 2022), and biodiversity restoration in the Aral Sea region (Yusupov, 2023). Most works converge on the necessity of integrating ecological monitoring with socio-economic development plans.

Durmanov and Kholikulov (2024) emphasize that digital technologies -particularly GIS, satellite mapping, and AI-based monitoring - can significantly improve the efficiency of ecosystem management in Uzbekistan. Similarly, the State Committee for Ecology (2024) highlights the need for increased community involvement and environmental education to enhance local stewardship.

Despite these initiatives, persistent problems such as salinization, inefficient irrigation, and insufficient ecological financing remain major constraints to achieving sustainable outcomes. The literature agrees that long-term success requires institutional coordination, investment in environmental data systems, and policy alignment with the Sustainable Development Goals (SDGs).

While numerous studies address environmental issues in Uzbekistan, there is still a lack of comprehensive research on integrated ecosystem management frameworks that connect ecological data, governance mechanisms, and socio-economic drivers. The majority of previous works focus separately on land degradation, water management, or biodiversity, without constructing a unified analytical model.

Therefore, this study aims to fill this gap by proposing an integrated and adaptive ecosystem management model for Uzbekistan that combines quantitative environmental indicators with policy evaluation, digital tools, and stakeholder analysis. This approach contributes both to theoretical development in sustainability science and to practical policy-making for national environmental governance.

Methods

This study employs a mixed-methods approach combining quantitative data analysis and qualitative policy review.

1.Data sources: The research utilized data from the State Committee for Ecology and Environmental Protection of Uzbekistan (2015–2024), FAO, and UNDP environmental indicators.

2.Indicators: Key indicators analyzed include forest cover ratio, biodiversity index, water resource efficiency, and land degradation level.

3.Analytical tools:

Correlation and trend analysis for ecological indicators (using SPSS 26.0).

Policy evaluation framework to assess the effectiveness of environmental strategies.

Stakeholder analysis based on interviews with local environmental experts and NGOs.

Results

The empirical findings highlight several important trends in Uzbekistan’s ecosystem management:

- Forest and vegetation cover: Increased slightly from 7.5% (2015) to 8.3% (2023), largely due to state afforestation programs in the Aral Sea region.

- Land degradation: Despite rehabilitation efforts, 18–20% of irrigated lands remain saline.

- Biodiversity: The national biodiversity index decreased by 6% over the last decade, indicating persistent ecological stress.

- Water efficiency: Implementation of drip irrigation and water-saving technologies has improved water use efficiency by 12% since 2020.

- Governance effectiveness: Digital monitoring and GIS-based environmental mapping have improved transparency but remain underutilized at the regional level.

Table 1 summarizes key environmental performance indicators.

Table 1. Key Environmental Indicators of Uzbekistan (2015–2024)

Indicator	2015	2020	2024	Change
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				(%)
Forest cover (%)	7.5	8.0	8.3	+10.7
Biodiversity index	0.74	0.70	0.69	-6.8
Land degradation (% of arable land)	18.2	19.1	19.8	+8.8
Water efficiency index	0.61	0.65	0.68	+11.5

Discussion

The findings suggest that while Uzbekistan has made progress in ecological restoration - particularly in afforestation and water resource management - major structural challenges persist. Weak institutional coordination, limited public participation, and financial constraints hinder the long-term effectiveness of environmental programs. An adaptive ecosystem management model is proposed, emphasizing three key pillars:

1.Digital governance: Integration of remote sensing, GIS, and big data for ecosystem monitoring.

2.Stakeholder engagement: Inclusion of local communities, farmers, and NGOs in decision-making processes.

3.Resilience-based planning: Adoption of climate-smart agriculture and renewable energy in ecosystem restoration.

The analysis of ecosystem management in Uzbekistan reveals a complex interaction between environmental, economic, and institutional dimensions. The moderate improvement in forest cover and water efficiency indicates positive effects of state-led ecological initiatives; however, these changes remain limited compared to the scale of degradation. The persistent rise in land salinization and biodiversity loss reflects insufficient integration between ecological restoration projects and agricultural policy frameworks.

The results align with global empirical studies suggesting that *top-down environmental governance* without adequate community involvement often yields temporary improvements but fails to ensure long-term sustainability (Holling, 2001; Liu et al., 2021). In Uzbekistan, most environmental programs remain centralized, with limited participation from local stakeholders and private sector actors. As a result, implementation efficiency varies significantly across regions.

A key insight emerging from this study is the need for adaptive and decentralized management mechanisms. Local ecosystem units—particularly in the Aral Sea basin, Fergana Valley, and Zarafshan region—require context-specific governance frameworks integrating scientific monitoring with local knowledge. Digital tools such as GIS-based mapping, satellite observation, and real-time ecological dashboards could play a crucial role in monitoring soil salinity, vegetation dynamics, and water quality.

Moreover, the discussion highlights that economic incentives for sustainable practices remain underdeveloped. While state subsidies exist for water-saving technologies, there is limited financial motivation for biodiversity conservation or land restoration by private entities. International experiences (e.g., EU Green Deal, China's Ecological Compensation System) demonstrate that financial mechanisms -such as payments for ecosystem services (PES) and green investment bonds - can substantially enhance ecological accountability and attract private capital.

Institutionally, the findings suggest that fragmentation among governmental agencies undermines ecosystem governance efficiency. The State Committee for Ecology, the Ministry of Agriculture, and regional administrations often operate under overlapping mandates. Effective coordination could be achieved through an integrated *National Ecosystem Management Platform*, supported by unified digital reporting and performance indicators aligned with the UN Sustainable Development Goals (SDGs).

From a scientific perspective, the discussion supports the notion that resilience-based management - focusing on maintaining adaptive capacity rather than static preservation - is more suitable for Uzbekistan's semi-arid context. Climate-smart agriculture, agroforestry, and reforestation in saline lands represent promising directions for building ecosystem resilience.

Finally, this study contributes to both academic and policy debates by bridging ecological monitoring data with governance theory. The results demonstrate that sustainable ecosystem management in Uzbekistan is not solely an environmental task but a multidimensional governance challenge requiring policy coherence, participatory institutions, and technological innovation.

Conclusion

Ecosystem management in Uzbekistan requires a transition from reactive conservation measures to proactive, integrated, and data-driven policies. Sustainable progress depends on enhancing institutional capacity, aligning environmental goals with socio-economic policies, and strengthening scientific-policy cooperation. Implementing adaptive and participatory management frameworks will help ensure ecological stability and sustainable development for future generations

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