

**OPPORTUNITIES TO INCREASE THE ENVIRONMENTAL EFFECTIVENESS OF
GREEN PROJECTS**

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Abstract. This article examines the opportunities for improving the environmental effectiveness of green projects and emphasizes the importance of precise, multi-stage, and context-specific evaluation criteria. The study analyzes the current indicators used in Uzbekistan—such as waste volume, energy and water consumption, and the share of green areas—and highlights their limitations in capturing deeper impacts related to ecosystem services, climate resilience, and biodiversity. As a solution, the paper proposes the introduction of a comprehensive indicator system measured across the entire project life cycle, including ex-ante, in itinere, and ex-post stages. Particular attention is given to the integration of digital technologies such as IoT, GIS, remote sensing, and artificial intelligence, which enhance the objectivity, transparency, and real-time monitoring capacity of environmental assessments. The study also argues for sector-specific differentiation of evaluation criteria to better address the unique characteristics of agriculture, energy, industry, transport, and housing sectors. The article concludes that digital integration, regulatory improvement, targeted planning, and broader participation of local communities and the private sector are **ключ** factors for ensuring long-term sustainability and higher ecological impact of green projects.

Keywords: green projects; environmental effectiveness; evaluation criteria; ex-ante assessment; in itinere monitoring; ex-post evaluation; environmental monitoring system; real-time monitoring; Internet of Things (IoT); GIS technologies; remote sensing; artificial intelligence; big data analytics; sectoral differentiation; green finance; green sukuk; sustainable development.

Increasing the environmental effectiveness of green projects is directly linked to the precision, comprehensiveness, and contextual suitability of their evaluation criteria. Although the assessment criteria currently used in Uzbekistan are largely based on international methodologies, their full adaptation to national conditions—as well as integration with practical measurement tools and real-time monitoring systems—has not yet been fully established. Therefore, improving these criteria is a pressing issue not only for effective project management, but also for ensuring the overall strategic effectiveness of environmental policy.

At present, assessment systems often rely on core indicators such as waste volumes, energy and water consumption, and the share of green areas. However, these indicators frequently fail to capture deeper layers of project impact—such as dynamic effects on ecosystem services, climate resilience, or the real contribution to biodiversity. In addition, existing criteria often do not allow for measuring sustainability after a project has ended.

To address these limitations, evaluation systems should be improved in a multi-stage and multi-sector format. This requires developing a set of indicators measured **before the project (ex ante)**, **during implementation (in itinere)**, and **after completion (ex post)**. For example, in a carbon footprint reduction project, it is advisable not only to measure greenhouse gas emissions, but also to monitor impacts on local climate, flora and fauna, and public health.

Another key opportunity is integrating digital technologies into evaluation systems. Through IoT devices, remote sensing, GIS technologies, and real-time monitoring systems, indicators can be recorded not only quickly, but also accurately and independently. This increases project transparency and enables evidence-based policymaking. At the same time, incorporating social indicators into

evaluation criteria (e.g., level of environmental education, public participation, and environmental awareness) allows the comprehensive social impact of projects to be taken into account.

Moreover, evaluation systems should differentiate indicators by sector based on national conditions and environmental needs. Environmental criteria cannot be identical across agriculture, industry, energy, transport, and housing. Each sector requires separate evaluation indicators and alignment coefficients.

Improving evaluation criteria is not merely a technical process; it is a crucial mechanism that advances the state’s environmental policy at a strategic level. Such a system enables not only higher effectiveness of current projects, but also the planning of future green initiatives on a more precise, reliable, and accountable basis.

Table 4.4.1

A staged approach to improving evaluation criteria for green projects

Evaluation stage	Recommended criteria	Role of digital technologies
Ex ante (before the project)	Environmental risk/threat assessment, status of existing resources, ecosystem value of the project area	GIS-based spatial assessment, analysis of historical data
In itinere (during implementation)	Real-time indicators: waste volume, energy and water use, level of public participation	IoT sensors, remote monitoring, real-time data transmission
Ex post (after completion)	Climate impact, changes in biodiversity, rate of resource recovery, level of sustainability	AI-supported impact modeling and forecasting for post-project monitoring

Source: Prepared by the author based on UNEP Project Evaluation Guidelines (2022), the World Bank Environmental and Social Monitoring Framework (2021), and recent scientific studies on IoT- and GIS-based environmental monitoring (2020–2023).

The table presents a staged and functional approach to evaluating green projects, explaining which criteria should be applied at key phases of the project life cycle and how digital technologies support implementation. In the **ex ante** phase, evaluation focuses on the ecological, social, and economic justification of the project by assessing ecosystem value, resource status, and potential risks using GIS-based spatial analysis. In the **in itinere** phase, continuous analysis of direct performance indicators (waste volume, water and energy use, participation levels, and monitoring outputs) is enabled through IoT sensors and online platforms, improving accuracy, transparency, and responsiveness. In the **ex post** phase, sustainability and long-term impacts are assessed through indicators such as carbon footprint reduction, biodiversity changes, resource recovery dynamics, and ecosystem quality shifts, with AI-based analytics and forecasting models supporting evidence-driven conclusions.

This approach enables evaluation based on concrete quantitative and qualitative indicators at each stage, strengthening not only reporting, but also policymaking, rational resource allocation, and environmental accountability. Digital integration improves objectivity, modernization, and alignment with international standards.

Innovative technologies and advanced management solutions

Introducing innovative technologies and advanced management solutions is a strategic direction for increasing the environmental effectiveness of green projects. Globally, technology-driven approaches are being deployed to adapt to climate change, use natural resources rationally, and reduce environmental impacts. Uzbekistan is also giving special attention to such solutions in its green transformation strategy.

First, digital monitoring systems create new opportunities to assess projects in real time, identify the radius of impact, and track sustainability. IoT-based sensors can automatically measure and analyze indicators such as water consumption, air quality, and soil moisture. For example, in Bukhara region, sensor-enabled smart drip-irrigation systems have supported the development of optimal irrigation schedules, reducing water use by **30–40%**.

In addition, artificial intelligence (AI) and big data analytics expand forecasting and performance modeling capabilities. These technologies are used to analyze plant growth, automatically detect pollution sources, predict urban air conditions, and optimize waste flows. In Tashkent, within an “Smart City” initiative, AI-based monitoring is being used to track air pollution dynamics and urban heat island formation.

Another innovative approach is the use of biotechnology for ecological restoration. In saline and technogenically polluted areas of Uzbekistan, microorganism-based soil restoration technologies are being introduced. These methods are environmentally safe and, compared to traditional chemical approaches, more sustainable and cost-effective.

A further important solution is resource management based on circular economy principles, particularly through “waste-to-resource” models. Plastic, paper, metal, and organic waste are being processed using different technologies. In Tashkent and Andijan, automated sorting equipment for solid household waste is being introduced, increasing recycling coefficients to **up to 45%**.

Financial technologies also represent a key innovation area, including instruments such as green sukuk, green loans, and environmental insurance. With support from GGGI and the World Bank, work has begun to develop Uzbekistan’s green bond market, creating pathways for long-term and stable financing of environmental projects.

Implementing innovative technologies significantly increases the effectiveness of green projects, enables systematic solutions to environmental challenges, and accelerates Uzbekistan’s transition to a green economy. This process is shaped through scientific research, international technology transfer, and broad-based cooperative partnerships.

Table 4.4.2

Innovative technological solutions used in green projects and their expected environmental effectiveness

Innovative solution	Application area	Expected environmental effectiveness
IoT-based monitoring systems	Monitoring of water, air, and soil	Reduces resource use by 30–40%; enables real-time control
Artificial intelligence and big data analytics	Forecasting and performance modeling	Identifies pollution sources; optimizes project outcomes
Biotechnological soil restoration	Restoration of saline and polluted land	Restores organic content; accelerates natural regeneration
Waste recycling technologies	Sorting and converting household waste into resources	Increases recycling coefficient up to 45%
Green sukuk and green finance	Long-term financing of environmental projects	Ensures continuity through sustainable financing

Source: Developed by the author based on open reports published in 2020–2024 by the Ministry of Ecology, Environmental Protection and Climate Change of Uzbekistan, UNDP, GGGI, the World Bank, the GCF, and projects such as “Green City,” “Smart Irrigation,” and “Zero Waste.”

The table systematizes the main innovative solutions used in green projects and links each to its application area and expected environmental benefits. IoT monitoring reduces resource waste and improves transparency; AI and big data strengthen detection and prediction; biotechnology supports safe restoration of degraded land; recycling technologies reduce landfill pressure and increase secondary resource use; and green finance instruments strengthen long-term viability beyond donor or grant dependence.

Developing an advanced monitoring system

A developed, digital, and networked monitoring system plays a decisive role in improving the effectiveness of green projects and determining their real environmental impacts. While Uzbekistan has existing monitoring systems for environmental observation, their scale, technological base, and sectoral integration remain limited, preventing precise assessment of project outcomes. Therefore, implementing and improving a modern monitoring system and ensuring stable data flows has become essential.

First, monitoring development requires automated observation facilities based on digital technologies. Through IoT devices, smart sensors, and remote sensing equipment, indicators for water, air, soil, waste, and biological parameters should be monitored continuously in real time. For example, in Tashkent and Navoi regions, pilot remote air-quality monitoring stations operate 24/7, recording pollutants such as PM_{2.5}, NO₂, and SO₂ and transmitting data automatically—enabling early detection of environmental risks and rapid response.

Second, monitoring systems require sectoral and institutional integration. Currently, different ministries and agencies (e.g., Ecology, Water Resources, Energy, Agriculture) run separate monitoring processes, leading to inconsistent data, duplicated costs, and inefficient resource use. Therefore, it is necessary to develop a unified **National Environmental Monitoring System** as a single digital platform integrating all data centrally. This strengthens not only project monitoring, but also strategic environmental governance.

Third, the indicator system should be diversified to include not only physical parameters, but also ecosystem services, health indicators, public feedback, and environmental culture. For example, biodiversity monitoring should go beyond counting species and include habitat conditions, roles in food chains, migration patterns, and impacts on ecological balance—providing a broader ecosystem perspective.

In addition, openness and user interactivity of monitoring data are crucial. Environmental indicators should be provided to the public in real time through mobile applications, web portals, and visual maps. This strengthens public participation and increases accountability pressure on decision-making institutions.

Developing monitoring systems is not merely a technical task; it is a strategic tool for objectively measuring project impacts, grounding environmental policy in scientific evidence, and strengthening public trust. A unified, digital, integrated, and open monitoring system should become a key pillar of ensuring the real effectiveness of green projects.

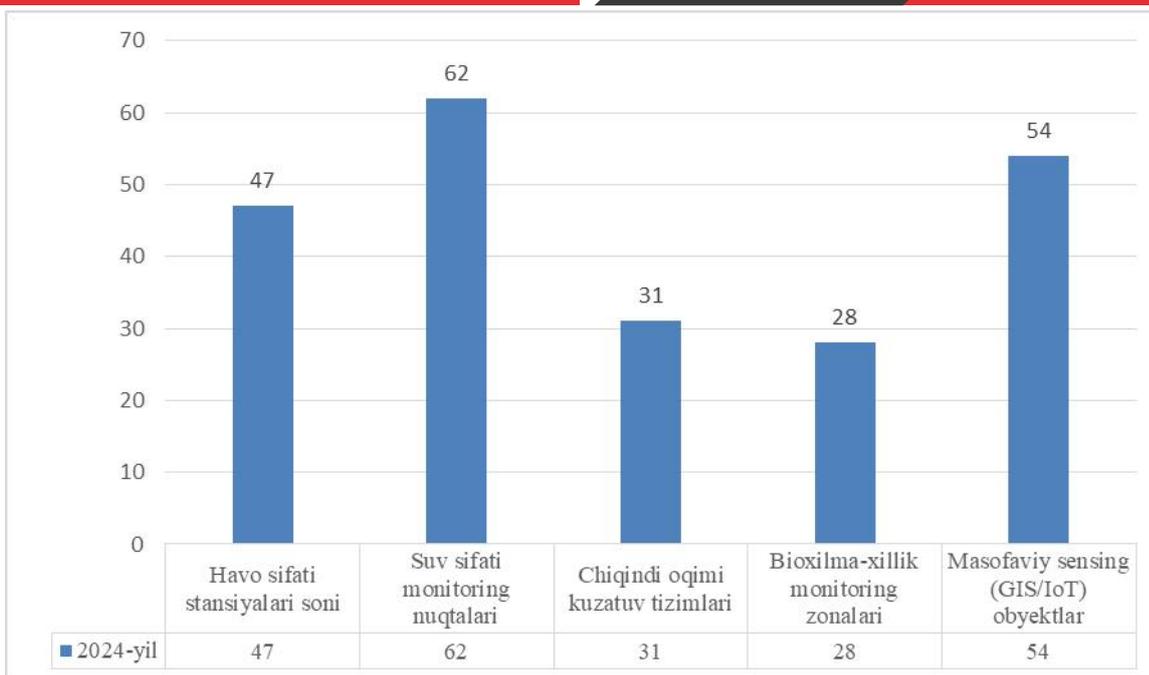


Figure 4.4.1

Functional distribution of environmental monitoring facilities in Uzbekistan (2024)

Source: Prepared by the author based on data from the Ministry of Ecology of Uzbekistan, *Green Development Monitoring 2024* reports, UNEP materials, and the World Bank’s *Environmental Monitoring Systems* (2023).

The figure reflects the functional distribution of environmental monitoring facilities in Uzbekistan as of 2024 and allows analysis of coverage and sectoral development trends. The most monitoring points are in water quality (62), reflecting high ecological pressure on water resources. Air-quality stations number 47, mainly located in major cities such as Tashkent, Nukus, and Samarkand, tracking pollutants like PM2.5, SO₂, and NO₂. Waste-flow monitoring operates at 31 points, supporting waste optimization and recycling. Biodiversity monitoring zones number 28, primarily located in sensitive protected areas. Additionally, 54 remote sensing objects (GIS/IoT-based) monitor environmental conditions via satellites, drones, and automated sensors, helping detect risk zones quickly.

Overall, the figure suggests that while monitoring infrastructure is expanding, balance across networks and technological integration still require further development. Integrating monitoring into a single digital platform, optimizing existing resources, and expanding advanced technologies are strategically important for improving environmental effectiveness.

Key directions for improving green project effectiveness

Improving the environmental effectiveness of green projects plays an important role in Uzbekistan’s sustainable development strategy. Effectiveness depends not only on technical and financial capacities, but also on a complex systems approach, scientifically grounded indicators, public participation, and institutional capacity. While some green projects in Uzbekistan have already delivered positive outcomes, several directions remain critical for further improvement.

1. **Phased planning and targeted implementation.** Projects should be divided into segments based on threat levels, resource reserves, and local socio-economic contexts, allowing rational resource allocation and maximal impact.
2. **Strengthening legal and regulatory frameworks.** Environmental standards, licensing, reporting, and evaluation mechanisms need better alignment. Adopting a national

methodology or a specific government decision on environmental performance indicators would improve clarity, transparency, and coordination.

3. **Expanding participation of communities and the private sector.** Increasing environmental impact requires behavioral change and awareness. Dialogue with the public, environmental education, green entrepreneurship, and social incentives can significantly improve effectiveness.
4. **Real-time, automated, and open monitoring and evaluation.** A unified digital platform should centralize project data and publish it through open statistics, strengthening transparency, investor trust, and decision-making accuracy.
5. **Wider adoption of innovative technologies and financing instruments.** Renewable energy, automated waste sorting, smart irrigation, and AI-based pollution forecasting can multiply ecological effectiveness, while green loans, green sukuk, and environmental insurance ensure long-term sustainability.

In sum, improving green project effectiveness is not a one-time technical reform, but a strategic, phased, and system-wide reform agenda based on sectoral cooperation—only then can ecological, economic, and social benefits be achieved in an integrated way, supporting Uzbekistan’s stable transition to a green economy.

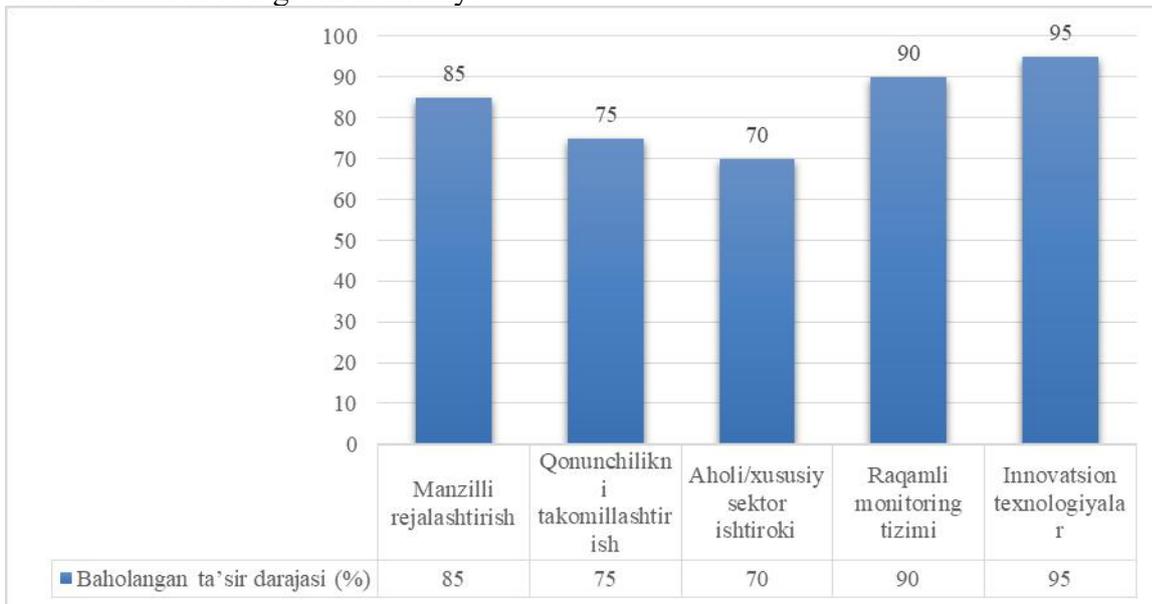


Figure 4.4.2

Assessed impact level of five pathways to improve green project effectiveness (2024)

Source: Prepared by the author based on the Ministry of Ecology of Uzbekistan’s *Green Development Strategy* (2023), *UNEP Environmental Governance Reports* (2022), and the World Bank’s *Green Transition and Digital Monitoring* (2023).

The figure presents expert assessments (on a 100-point scale) of five strategic directions: innovative technologies (95%), digital monitoring (90%), targeted planning (85%), legal improvement (75%), and public/private participation (70%). The highest score for innovation reflects the strong potential of digital solutions, renewables, automation, and AI-based monitoring to improve performance. Monitoring strengthens transparency and accountability; targeted planning optimizes resources; legal reform improves coordination; and participation strengthens long-term social sustainability.

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