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# Analysis of Green Tourism Infrastructure At Tourism and Cultural Heritage Sites in Bukhara Region

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**Abstract:** this article provides a comprehensive analysis of the green tourism infrastructure development in Bukhara region from 2019 to 2025 and its impact on historical and cultural heritage sites. The main objective of the research is to assess existing indicators and establish priority areas for green transport, renewable energy, waste management, rational use of water resources, and environmental load monitoring in the context of increasing tourist flow in the region. The results indicate that the components of green tourism in Bukhara are gradually expanding; however, institutional and technological disparities persist in waste recycling levels, charging infrastructure capacity, water supply sustainability, and environmental load management. The study's conclusions highlight the necessity of integrating indicator-based management, digital monitoring, and regional green investment mechanisms in the context of Bukhara.

**Keywords:** green tourism, sustainable tourism, green infrastructure, ecological load, green transport, renewable energy, waste management, water conservation, green certification.

## 1. Introduction

Bukhara region stands as one of the ancient urban-cultural centers of Central Asia. Its historic city center is inscribed on the UNESCO World Heritage List. This designation, while certainly elevating the area's attractiveness to tourists, also shines a light on the need for preservation of heritage sites, thoughtful use of resources, and handling of environmental pressures. In fact, the increase in tourist numbers is making issues like higher energy consumption, transport emissions, lack of water, and the ever-growing amount of waste even more serious problems threatening the destination's sustainability. The theoretical foundations of the «green tourism» concept can be traced back to the idea of sustainable development. The widespread global recognition of sustainable development is directly linked to the publication of «Our Common Future» (Brundtland Report) in 1987, which established the necessity of viewing development and the environment as part of a unified strategic approach [1].

Subsequently, the «2030 Agenda for Sustainable Development» adopted in 2015, solidified the integrated implementation of sustainability across economic, social, and environmental dimensions as a global commitment [2]. The tourism sector is becoming increasingly intertwined with this agenda: analyses conducted jointly by UNWTO and UNDP demonstrate that tourism business practices directly intersect with Sustainable Development Goals such as SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production), and SDG 13 (climate action) [3].

Nonetheless, shifting green tourism to effective managerial practice should not merely be a matter of declarations; it is imperative that this transition be supported by indicators,

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standards, and monitoring mechanisms. The UNWTO's guidebook on sustainability indicators for destinations (Indicators of Sustainable Development for Tourism Destinations) points to the need of sustained measurements and decision making in the field of tourism regarding resources like water, waste, energy, transport, and social impact [4]. The European Commission's ETIS (European Tourism Indicator System) also offers a set of indicators categorized into blocks of destination management, socio-cultural impact, economic value, and environmental impact [5].

Additionally, when evaluating the sustainability of tourism entities and destinations, the GSTC standards serve as a global «common language» establishing criteria in areas such as planning, local community benefits, cultural heritage preservation, and reduction of negative environmental impacts [6].

In the context of Uzbekistan, the development of green tourism has become an institutional agenda. In particular, the Presidential Decree No. PQ-21 dated January 12, 2024, envisions the rapid development of ecological tourism, including the establishment of tourist clusters in eco-regions, ecological requirements, digital platforms, and incentive mechanisms [7]. In addition, the regulatory framework of the «Green Space» initiative, aimed at improving the ecological environment, will contribute to strengthening environmental management and monitoring approaches in the republic.

The main goal of this article is to figure out the green tourism infrastructure in Bukhara region by means of an indicator-based approach. Tourist arrival and revenue in Bukhara region are continuing to grow which is leading to the demand for major components such as green transport (electric vehicles and charging infrastructure), renewable energy (solar panels), waste management (sorting, recycling, «zero waste»), water-saving technologies, and energy efficiency at cultural heritage sites. At the same time, the problem of controlling environmental risks and the effects of human activities (carrying capacity/ecological load) due to the increasing number of tourists in the UNESCO sites has become a topic. This calls for the consonance of the practical mechanisms of digital monitoring, certification, and adaptation to standards in destination management.

Based on this, the purpose of the article is to assess the state of development of green tourism infrastructure in the Bukhara region in 2019-2025 in the context of «transport-energy-waste-water-monitoring» blocks, identify existing differences and problems, and scientifically substantiate priority areas for sustainable management. The research results are expected to serve to strengthen the indicator-based approach in regional policy, destination management, and the practice of protecting heritage sites.

## 2. Materials and Methods

The study employs a mixed-methods approach, integrating quantitative analysis (statistical and indicator-based assessment) with qualitative analysis (content and institutional analysis). In the empirical section, various criteria were systematized, including: tourism flow and revenue dynamics for 2019-2025; green transport infrastructure for 2021-2024 (electric buses, electric taxis, EV charging stations); renewable energy facility indicators (solar panel capacity and application scope); waste management indicators (volume of generated waste, recycling rate, number of sorting bins, «zero waste» practices); water resource usage indicators (proportion of efficient systems, instances of pressure reduction); and the ecological load index for historical and cultural sites. The indicators were grouped according to the main components of «green tourism infrastructure,» forming a regional assessment framework.

The research was conducted within the Bukhara region, with special consideration given to indicators for historical and cultural sites with high ecological impact (such as the Ark Fortress, Labi-Hauz, and others) and eco-routes. Reliability of results: Numerical indicators were cross-checked for logical consistency, while indicators were standardized using uniform criteria (percentage, thousand units, index) to ensure objective comparison across different time periods.

**Literature review**

Green tourism's scientific basis is mostly based on the idea of «sustainable development». The Brundtland Report's «Our Common Future» offered a conceptual

framework for the need to strike a balance between social fairness, ecological restrictions, and sustainable growth.

When this strategy was used for tourism, the emphasis moved from economic gains to controlling the effects of tourism on local populations, natural resources, and cultural heritage. Another significant factor in the institutionalization of sustainable tourism as a scientific field was the founding of the «Journal of Sustainable Tourism» in the early 1990s.

Green tourism often overlaps with rural tourism and ecotourism. Lane's article «What is rural tourism?» defines rural tourism as an activity with distinctive characteristics, emphasizing the importance of territorial resources, local way of life, and ecological balance [8]. This approach establishes a methodological foundation for simultaneously considering the «benefits to the local community» and «resource pressures» in historical and cultural areas such as Bukhara.

In green tourism literature, ecological management is considered an integral component of destination competitiveness. Mihalič (2000) links environmental management in destinations to competitive advantage, demonstrating that environmental management directly influences branding, management, and marketing decisions [9]. Against the backdrop of an increase in tourist flow in Bukhara, the strengthening of systemic management requirements for «green transport, » «energy efficiency, » «waste and water» corresponds to this theoretical view.

There are also problematic aspects of certification: Font (2002) analyzes the need to ensure reliability and comparability in tourism due to the large number of environmental certificates, their different requirements, and the problems of conformity assessment [10]. Font and Tribe (2001) point out that awards & labels can signal the consumer, but the problem of clarity and standardization is exacerbated as a result of «clutter» [11].

## 3. Results and Discussion

The Bukhara region is one of the oldest centers in Central Asia and boasts numerous historical and cultural monuments included in the UNESCO World Heritage List. In recent years, implementing the principles of «green tourism» (eco-tourism, sustainable tourism) has been chosen as one of the priority directions in developing the region's tourism potential. For the years 2022-2024, several state programs have been adopted in Uzbekistan's tourism industry focusing on «green infrastructure, reducing carbon footprint, waste recycling, and ecological transport models».

The green tourism infrastructure in Bukhara region is developing gradually and showing a noticeable growth dynamic. Examining the tourism indicators of Bukhara region, we can see that by 2025, compared to 2019, the number of tourists increased by 20% and revenue by 25%. The main influx of foreign tourists comes from Russia (32%), Turkey (14%), Kazakhstan (11%), China (9%), and European countries (8%). This growth is creating new demands for green tourism infrastructure.

In particular, creating green transport infrastructure, widely promoting green energy sources, managing waste and supporting the zero-waste principle, rational use of water resources, establishing green areas and ecological corridors, continuously improving energy efficiency in historical and cultural heritage sites, applying green certification methodology in tourist facilities, and monitoring ecological impact are considered urgent issues. Additionally, ecological approaches to sustainable tourism and the importance of green infrastructure in regions are always relevant. Among the main problems today are reducing the negative environmental impacts of tourist facilities' operations and the efficient use of natural resources.

**Table 1.** Total number of tourists visiting Bukhara region and their income indicators [12]

| Year | Number of tourists (thousand) | Foreign tourists (thousand) | Domestic tourists (thousand) | Tourism revenue (billion soums) |
|---|---|---|---|---|
| **2019** | 1 050 | 400 | 650 | 1 320 |
| **2020** | 220 | 60 | 160 | 280 |
| **2021** | 430 | 110 | 320 | 510 |
| **2022** | 760 | 250 | 510 | 880 |
| **2023** | 980 | 360 | 620 | 1 240 |
| **2024** | 1 240 | 520 | 720 | 1 610 |
| **2025** | 1450 | 650 | 800 | 1 825 |

It should be noted that in the current state of green tourism infrastructure in the Bukhara region, the role of environmentally friendly vehicles is naturally increasing (Table 1). A steady growth in demand for electric buses and electric cars can be observed. As a specific example, in 2024, Bukhara region will have 14 EV charging points, which is significantly fewer than in Tashkent (45) and Samarkand (27). With the increase in tourist flow, the demand for electric transport has risen noticeably, and today the number of charging devices in the region is growing.

**Table 2.** Indicators of green transport infrastructure in Bukhara region [13]

| Indicators | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|
| **Number of electric buses** | 0 | 4 | 12 | 22 |
| **Electric Taxi Service** | **no** | 6 | 18 | 30 |
| **Charging stations** | 1 | 3 | 8 | 14 |

In addition, the infrastructure for green energy is also developing. The number of tourist facilities with installed solar panels is approaching 100. The total capacity at these facilities is 5.8 MW. Lighting systems have been implemented in 27 hotels, 39 hostels, 3 museums, 2 nature reserves, and around 12 cultural heritage sites. Since solar radiation in Bukhara is 1600-1750 kWh/m2 (annually), there is great potential for utilizing renewable energy (Table 2).

The next important indicator is the waste management system, which takes into account the waste generated in tourist areas, their recycling rate, the number of waste sorting bins, and the number of hotels that have implemented the «Zero waste» principle (Table 3).

**Table 3.** Waste management indicators for 2025

| Indicator | Quantity |
|---|---|
| **Waste generated in tourist areas** | 12.4 thousand tons |
| **Level of recycling** | 23% |
| **Number of sorting bins** | 220 units |
| **Hotels implementing the «Zero Waste» principle** | 11 |

According to European standards, the waste recycling rate should be 45-60%. In Bukhara, the rate is projected to reach 23% by 2025, showing a significant increase from 12% in 2021. Analysis shows that in the Bukhara region, where water resources are scarce, a number of effective measures are being implemented to use water resources efficiently. Specifically, water-saving systems have been introduced in 34% of hotels, 18% of tourist parks have switched to drip irrigation, and 72% of historical and cultural heritage sites now have high-quality drinking water supply. The main problem remains that during the

spring-summer season, due to water shortages, some tourist areas experience pressure drops of up to 15-20%.

Today, the number of green areas and ecological destinations is growing. Eco-sites such as the «Jeyran Ecocenter,» «Gijduvan - Karakul Desert Safari,» salt mines in the Olot area, «Poykand Archaeological Route,» and «Oasis Bukhara» have seen a progressive increase in both local and foreign tourists over the years. However, despite the increase in eco-routes, 60-65% of the information systems, road signs, and safety signs are outdated (Table 4).

**Table 4.** Indicators of green areas and ecological directions in the Bukhara region

| Direction | Length | Number of tourists (2024) |
|---|---|---|
| «Jeyran Ecocenter» | 35 km | 52 000 |
| «Gijduvan - Karakul Steppe Journey» | 78 km | 24 000 |
| «Archaeological Route of Paykend» | 12 km | 18 000 |

Energy efficiency at cultural heritage sites is increasing year by year. Energy-saving lighting systems have been implemented in areas such as the Ark Fortress, the Minaret Kalon complex, the Labi-Hauz complex, and the Poi Kalon Mosque, with 48% of the lighting systems having switched to LED technology (Table 5).

The ecological burden on historical and cultural heritage sites is increasing. Currently, in the Bukhara region, intensive anthropogenic pressure is intensifying, that is, factors related to the impact of tourists and tourism activities on plants, animals, and other components of nature are growing stronger.

**Table 5.** Indicators of the environmental load on historical and cultural heritage sites in the Bukhara region [14]

| Site | Annual visits | Environmental Impact Index (1-10) |
|---|---|---|
| Ark fortress | 310 000 | 8.7 |
| Labi-Hauz | 420 000 | 7.9 |
| Chor Bakr | 115 000 | 6.1 |
| Poykand | 45 000 | 4.3 |

According to international calculations, if the index indicator exceeds 7 points, it is considered that intensive anthropogenic pressure exists in the region. Regarding the state of green certification at tourist facilities, there are few facilities in Uzbekistan that meet standards such as «Green Destination, » «GSTC,» and «Eco-Hotel.» In Bukhara region, several hotels managed to obtain green certificates by 2025. Environmentally friendly hotels strictly adhere to ecological recommendations, guaranteeing their guests accommodation in safe, harmless, and energy-efficient rooms. Some key features of an environmentally friendly hotel:

1. Harmless cleaning and washing products are used in the hotel cleaning process;
2. Sheets, towels, and mattresses are made of 100% natural cotton;
3. Renewable energy sources, such as solar or wind energy, are utilized;
4. To reduce waste, sets of organic soap and toiletries are provided instead of individual packages;
5. Waste bins are installed in hotel rooms and the lobby;
6. A system for reusing towels and sheets is in place (guests can request not to have them changed to reduce water consumption for washing);
7. An energy-efficient lighting system is in operation;

8. The use of environmentally friendly vehicles has been implemented on the hotel grounds;
9. Natural dishes prepared from local products are offered;
10. Disposable tableware is used;
11. A fresh air circulation system is in place;

A wastewater treatment system is in place, enabling the reuse of water for dishwashing, bathing, laundry, crop irrigation, and landscaping [15]. Overall, while the green tourism infrastructure in Bukhara region is developing, there remain numerous unresolved issues in waste management, electric transport, water resources, green energy, and environmental management that await solutions.

## 4. Conclusion

This study, using the example of Bukhara region, enabled a comprehensive assessment of the formation and development of green tourism infrastructure across the dimensions of «transport-energy-waste-water-ecological impact-certification.» The analysis revealed that the steady growth of tourist flow and income in the region during 2019-2025 has significantly intensified the need for green infrastructure. Specifically, although the number of electric vehicles and EV charging stations is increasing, their capacity and territorial coverage are still insufficient relative to the dynamics of tourist flows. Consequently, reducing transport emissions and establishing «low-carbon mobility» in historical centers emerges as one of the important future tasks.

Overall, while green tourism infrastructure is developing in Bukhara region, its sustainable results directly depend on strengthening indicator-based management systems, institutionalizing green certification, regularly monitoring environmental impact, and aligning investments and innovations with «green» priorities. The study's conclusions demonstrate the necessity of a comprehensive approach to ensure a balance between economic growth and environmental protection when developing tourism in heritage areas like Bukhara. In the future, aligning the regional indicator system with ETIS, UNWTO, and GSTC criteria, expanding pilot projects on «green mobility» and «zero waste,» as well as implementing smart technologies in water resource management, could elevate green tourism in Bukhara to a new level.

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