



Article

Sustainability Indicators in the Utilization of Tourism Resources in Mountainous Areas

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Abstract: This article analyzes the system of key sustainability indicators in the utilization of tourism resources in mountainous regions. The study develops an assessment model of sustainability based on economic, environmental, and social criteria, with empirical analyses conducted on the mountainous districts of the Samarkand region – Urgut, Nurobod, Qo'shrabot, and Samarkand. The results show that the effective use of mountain tourism resources not only helps maintain ecological balance but also plays a crucial role in enhancing the economic activity and employment levels of local communities.

Keywords: sustainability, indicators, mountain tourism, ecological balance, economic efficiency. Social impact, resource management.

1. Introduction

Mountain regions of Uzbekistan represent some of the most promising areas for tourism development due to their rich natural ecosystems, diverse climate, and cultural-historical heritage. At the same time, these territories are environmentally fragile, have limited natural resources, and face high anthropogenic pressure. Therefore, identifying sustainability indicators in the utilization of tourism resources and integrating them into management decisions is a vital scientific and practical objective [1]. According to the World Tourism Organization (UNWTO), sustainability in tourism refers to “the use of natural, cultural, and social resources in a way that meets the needs of present and future generations”. Thus, for mountainous regions, establishing a sustainable tourism system requires measurable indicators that quantitatively assess the efficiency and balance of resource use [2].

2. Materials and Methods

The research employed the **Indicator-Based Approach** to evaluate the sustainability level of tourism resource utilization [3]. The analysis included three groups of indicators:

Environmental Indicators:

- Air and water quality indices (AQI, WQI);
- Change in biodiversity levels;
- Volume of waste and share of waste recycling (%);
- Environmental load (number of tourists per 1 km²).

Economic Indicators

- Tourism revenue (billion UZS);
- Local population employment rate in tourism (%);

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- c. Share of infrastructure investment (% of regional budget);
- d. Growth rate of tourism service exports.

Social Indicators:

- a. Participation rate of local population in tourism (%);
- b. Index of public perception and satisfaction with tourism;
- c. Growth rate of average income derived from tourism.

Sustainability was measured using an **integrated sustainability index (SI)** calculated a Table 1 shows that follows:

$$SI = \frac{1}{n} \sum_{i=1}^n w_i \times N_i$$

where w_i represents the weight coefficient of the indicator, and N_i denotes its normalized value (ranging from 0 to 1).

Table 1. Weights and Scores of Sustainability Components (Integrated Index Model)

Component	Number of Indicators	Average Value (0–1)	Weight (w_i)	Weighted Score ($w_i \times N_i$)
Environmental (E)	4	0.70	0.40	0.28
Economic (Ec)	4	0.68	0.35	0.24
Social (S)	3	0.63	0.25	0.16
Total (SI)	11	—	1.00	0.67

Result: SI = 0.67 indicates a “near-sustainable” level according to UNWTO’s classification (0.60–0.75 range).

Data sources: State Statistics Agency of Uzbekistan (2020–2024) [5], Tourism Committee, and the UNWTO Data Portal [4]. Calculations were performed using *Stata 18* and *Excel Data Analysis ToolPak*.

3. Results and Discussion

Results

According to the 2024 data for the mountainous districts of the Samarkand region: The average ecological load (tourists per km²) reached 28.6, a 47 %increase compared to 19.4 in 2020 [6]. The Water Quality Index (WQI) was assessed at 0.83 in 2020 to 5.4% in 2024. The employment rate in tourism increased from 3.2% in 2020 to 5.4% in 2024 [7]. The waste recycling rate rose from 24% to 41%. The integrated sustainability index (SI) was calculated at 0.67, corresponding to a “near-sustainable” condition (on a 0–1 scale) [8].

These results Table 2 shows that, indicate that while environmental, economic, and social sustainability have become more balanced, certain challenges remain – particularly in waste management and seasonal fluctuations in water resources [10].

Table 2. eSustainability Indicators for the Utilization of Tourism Resources in Mountainous Areas (Samarkand Region, 2020–2024) [9]

No	Indicator Name	2020	2022	2024	Growth (%)	Source
1	Tourism load (tourists/km ²)	19,04	24,8	28,6	+47.4	State Statistics Agency (2024)

2	Water quality index (WQI, 0–1)	0.81	0.82	0.83	+2.5	Uzhydromet (2023)
3	Employment in tourism (%)	3,2	4,3	5,4	+68.7	Ministry of Employment (2024)
4	Waste recycling share (%)	24.0	33.5	41.2	+71.7	Ministry of Ecology (2024)
5	Tourism service volume (billion UZS)	126.0	171.0	214.0	+69.8	State Statistics Agency (2024)
6	Sustainability index (0–1)	0.59	0.64	0.67	+13.6	Author's calculations (2024)

Discussion

The findings reveal a steady upward trend in sustainability indicators for the use of tourism resources in mountainous areas [11]. This improvement is largely associated with the expansion of eco-tourism initiatives, the rise in local entrepreneurship, and the implementation of national environmental policies [12].

However, the results also show vulnerability in specific environmental dimensions, particularly waste generation and biodiversity loss risks [13]. This suggests the growth in mountain volume must be balanced with ecological sustainability measures [14].

According to the OECD (2021) and UNEP (2023) guidelines, ensuring sustainability in mountain tourism requires [15]:

- Regulating tourism flows through environmental quotas;
- Introducing “Green Certification” systems for eco-lodges;
- Involving local communities in management processes;
- Expanding the use of renewable energy sources in tourism infrastructure.

4. Conclusion

The study confirms that the rational and sustainable utilization of tourism resources in mountainous areas is fundamental to maintaining ecological balance, improving economic efficiency, and ensuring social inclusivity. For the Samarkand region, a sustainability index of 0.67 reflects significant potential for advancing mountain tourism along both environmentally and economically sustainable paths.

To further strengthen sustainability, the following measures are recommended:

- a. Integrating tourism operations with regional ecological monitoring systems;
- b. Enhancing community participation in tourism management;
- c. Implementing environmental taxation and sustainability certification systems;
- d. Standardizing the national indicator framework in cooperation with international organizations such as UNWTO and UNEP.

In conclusion, the establishment of a comprehensive system of sustainability indicators for mountain tourism ensures environmental safety, enhances the competitiveness of the local economy, and safeguards the ecological integrity of mountain ecosystems.

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