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# *THE ROLE OF TECHNOLOGY AND INNOVATION IN THE DEVELOPMENT OF SUSTAINABLE TOURISM IN THE CONTEXT OF CLIMATE CHANGE AND SPATIAL PLANNING*

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***Abstract:***

Tourism in Montenegro represents one of the key economic sectors, but it increasingly requires the application of innovative technologies that enable sustainable development, minimize negative ecological impacts, and ensure efficient spatial planning. National parks and protected areas are key resources for the development of ecologically responsible tourism, with technology and innovation being essential for their preservation and enhancement. This paper explores strategies and models of sustainable development, including the concept of carrying capacity, zoning, permitting, and visitor management, as well as the application of smart technologies in monitoring the impact of tourism on the environment. Special emphasis is placed on digitalization, the use of artificial intelligence, and Geographic Information Systems (GIS) for monitoring climate change and sustainable planning of tourist destinations. The results highlight the need for integrating technological solutions into sustainable tourism strategies to ensure long-term protection of natural resources, stimulate economic development, and preserve biodiversity.

**Keywords:** sustainable tourism, innovation, climate change, national parks, spatial planning, technology.

## ULOGA TEHNOLOGIJE I INOVACIJA U RAZVOJU ODRŽIVOG TURIZMA U USLOVIMA KLIMATSKIH PROMjENA I PROSTORNOG PLANIRANJA

**Apstrakt:**

*Turizam u Crnoj Gori predstavlja jednu od ključnih ekonomskih grana ali i sve više zahtijeva primjenu inovativnih tehnologija koje omogućavaju održiv razvoj, minimiziranje negativnih ekoloških uticaja i efikasno prostorno planiranje. Nacionalni parkovi i zaštićena područja predstavljaju ključne resurse za razvoj ekološki odgovornog turizma, pri čemu su tehnologija i inovacije od suštinskog značaja za njihovo očuvanje i unapređenje. Ovaj rad istražuje strategije i modele održivog razvoja, uključujući koncept nosećeg kapaciteta, zoniranje, izdavanje dozvola i menadžment posjetilaca, kao i primjenu pametnih tehnologija u praćenju uticaja turizma na životnu sredinu. Poseban fokus je na digitalizaciji, upotrebi vještačke inteligencije i GIS (geografsko informacioni sistemi) sistema za monitoring klimatskih promjena i održivo planiranje turističkih destinacija. Rezultati ukazuju na potrebu za integracijom tehnoloških rješenja u strategije održivog turizma, kako bi se obezbijedila dugoročna zaštita prirodnih resursa, podstakao ekonomski razvoj i očuvao biodiverzitet.*

*Ključne riječi: održivi turizam, inovacije, klimatske promjene, nacionalni parkovi, prostorno planiranje, tehnologija,*

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## 1 Introduction

National parks are the cleanest, ecologically most valuable areas of preserved nature, with diverse functions and contents. Their establishment and protection represent the only contact between people and nature. National parks are tourist attractions, major tourist resources, and an important link in international tourism. Tourism planning and management are interconnected and conditional on the impacts of tourism on the environment. Strong control results in quality management and a positive impact of tourism on managing tourist destinations. To eliminate and mitigate the negative consequences of tourism and encourage positive effects, sustainable tourism development applies management and planning strategies.

There are several strategies and planning models, and the most commonly applied include:

• **Carrying capacity** – a concept that refers to the limitations in tourism, i.e., the maximum use of any tourist destination without causing negative consequences to resources, reducing visitor satisfaction, or causing adverse effects on the local population, society, economy, and culture of a certain area (Popesku, 2008). This concept emphasizes the importance of considering how many people can visit a certain area without affecting wildlife, the quality of water or air.

In national parks, carrying capacity refers to the survival of a particular species population within a defined habitat, without causing harm to the ecosystem on which it depends.

• **Limits to Acceptable Change (LAC model)** – relates to desirable ecological conditions.

• **Zoning** – connecting types of development or activities with specific zones as specified in plans. In Montenegro, zoning is conducted within national parks. Each zone has a specific level of protection and allowed activity levels. In Montenegro, zoning is done in three zones. Zone I - protection zone: a high level of protection, of special significance for preservation, and access to visitors is strictly prohibited. Zone II - a more liberal protection zone that allows visits to tourists but only on specific trails and under defined rules of behavior. This zone also allows the restoration of seasonal settlements, grazing, agriculture, and space arrangements aimed at improving the tourist offer. Zone III - protection zone: a more liberal zone where, in accordance with ecological standards, all tourism and recreational activities can take place. In this zone, it is possible to build tourist facilities that comply with the spatial plan.

• **Issuance of permits** – within the park, permits are issued to tourists that vary in price and the range of activities they cover, depending on the zone within the park. Permit holders are also obligated to ensure that their activities will not negatively impact the environment and must behave according to the guidelines established by the park. The revenues from permits are used by the park to restore and improve tourist facilities and maintain them.

• **Environmental quality standards** – based on legal regulations. In national parks, the use of specific building materials that do not disrupt the park's appearance is strictly defined.

• **Strategic environmental impact assessment** – integrates the goals and principles of sustainable development into spatial and sectoral planning (traffic, energy, water management, agriculture, forestry, tourism, etc.), to avoid or limit negative impacts of planning decisions on the environment (Popesku, 2008). Environmental audits address the resources used in production and waste management.

• **Visitor management** – regulates the number, movement, and activities of tourists to keep them away from sensitive areas. Visitors must be familiar with the rules of behavior within national parks, as well as the sanctions resulting from non-compliance.

• **Environmental adaptation** – in certain parts of parks, in order to protect wildlife and vegetation, concrete walls, walking paths, erosion-preventing nets, and similar measures may be installed.

• **Educational and marketing strategies** – aimed at raising tourists' awareness about environmental conservation. These strategies focus on activities that will not harm the environment. Employee education includes ethical codes for tourists concerning the environment and behavioral rules.

• **Research and control** – aim to improve the understanding of the relationship between tourism and the environment, to promptly identify factors that negatively impact the environment and prevent their further development.

Effective environmental management is essential for successful management of tourist destinations. It includes the necessary knowledge and skills to protect vegetation, air, and water.

Modern trends in tourism show an increasing role of sustainability in the industry. Sustainable development is an integral part of the concept of national parks that create a new type of tourism, which is increasingly becoming the future of all forms of business. Protected areas are sustainability moderators for development design in the areas they occupy. Montenegro's national parks, with their diversity of potentials, can fully meet the modern requirements of global tourism and, in the long term, occupy a position as a world destination by applying the concept of sustainable development (Janković, Luburić, & Šofranac, 2017).

Sustainable tourism ensures a high level of tourist satisfaction, providing them with an unforgettable experience while promoting tourist destinations. Marketing promotes tourist destinations and services, and national parks especially contribute to the positive impact of tourism on the environment. They represent aspects of tourism in line with the principle of sustainability. Sustainability is a key strategy in managing such tourist destinations, in which the principles of restoration, preservation, and protection of the physical environment are applied. Montenegro has implemented a sustainable development strategy, an important document promoting sustainable development principles.

"However, one of the main obstacles limiting faster progress relates to insufficient support for environmental protection plans and programs, limited implementation of regulations. The prolonged duration of the economic crisis significantly impacts the slower recovery of the economy, leading to budgetary constraints for addressing development issues.

Inconsistent policies are being implemented in the fight against poverty, corruption, social protection reforms, education, healthcare, and environmental policies. In protected areas, the main limitations are related to resolving potential inconsistencies in the process of designating and placing certain territories under protection through consultations with all stakeholders and securing necessary resources for proper management. Improvements in this area require substantial investments: it is estimated that the investment in infrastructural projects in relevant strategic documents is around 560 million euros for the period up to 2028 (Janković, Luburić, & Šofranac, 2017).

Sustainability is also based on the development of ecological awareness, as the greatest problem arises from unregulated waste dumps, illegal bird hunting in Ramsar areas, and deforestation in national parks. Therefore, in the future, state policy should be directed towards adequate political, financial, and human resource support for achieving the target values of sustainable development improvements. The National Sustainable Development Strategy foresees the protection of natural areas covering 10% of the national territory and protection of at least 10% of coastal areas, along with the improvement of the legal framework for biodiversity protection, strengthening human capacity building, and an efficient biodiversity monitoring system. The public company "National Parks of Montenegro" is responsible for the protection and management of Montenegro's national parks.

National parks are the result of the positive impact of tourism on the environment, based on sustainability, the most important strategy in managing such tourist destinations. Sustainability includes the restoration, preservation, and protection of the physical environment. Tourism can serve as an initiator of the restoration of culturally and historically significant sites. Thus, all activities conducted within national parks are adapted to the environment in which they are located. NP management, following market demands, views them according to the sustainable development of the destination. NP aim to protect plant and animal species in their natural habitats. They also serve as unique natural reserves for the preservation of cultural and historical heritage.

In scientific terms, national parks serve as sites for research and its application to improving sustainability in various life areas. They are important for educating tourists and staff, as well as for developing ecological awareness, which is crucial for a sensitive planet.

In tourism, preserving productive resources, especially renewable resources, is crucial for ensuring open access to the preservation of flora and fauna, sustainability of food and material sources, avoiding the use of harmful materials for the environment, reducing waste and energy consumption, as tourism expansion results in environmental degradation. Many resources, such as national parks and wildlife reserves, natural reserves, and forests, are vital for tourism. Additionally, the various landscapes that form the backdrop of tourism are also impacted by human activity. This is our assertion that the so-called Bio-economic principle of sustainable highest income, based on common economic conditions and recognizing Bio-economic processes, could be helpful. Proper resource management in tourism is key to success (Janković, Luburić, & Šofranac, 2017).

Around 7% of Montenegro's territory is protected by national parks. The main deficiencies in managing Montenegro's national parks are the lack of a national strategic approach to expanding protected areas, limited knowledge and experience in establishing and managing other categories of protected areas, less attention to sites with lower levels of protection, except for national parks, the underutilization of the northern region's tourist potential, and the need for better valorization of national parks, as well as a more comprehensive approach to cultural heritage (Janković, Luburić, & Šofranac, 2017).

It is recommended that in national parks, small, exclusive, high-quality hotels be built or integrated into the landscape – eco lodges. New funding sources (donations, international aid) should be sought. A master plan should be developed for each national park to plan future improvements and developments. The plan includes all the facilities and capacities necessary for visitors and park operations. This includes visitor centers, information desks, offices, camping areas, parking, roads, trails, utilities, and many others, as outlined in the Master Plan (2008) and Tourism Development Strategy.

In national parks, technological solutions for sustainable tourism should also be introduced, such as smart infrastructure and energy efficiency, including systems to optimize electricity consumption in tourist facilities, renewable energy sources, and solar panels in tourist complexes, as well as smart heating and cooling systems that reduce electricity consumption.

Digitalizing the tourist experience brings numerous benefits for travelers as well as for environmental protection. Virtual and augmented reality (VR/AR) allow for the exploration of destinations in an environmentally friendly way, reducing the need for physical travel and thus lowering harmful gas emissions. Digital guides and mobile applications replace printed materials, significantly reducing paper consumption and contributing to the preservation of the environment. Technologies also improve the management and monitoring of tourist behavior in real-time, ensuring compliance with environmental standards and minimizing negative impacts.

According to the experiences of countries where sustainable tourism is implemented, Montenegro’s national parks should develop thematic trails focusing on cultural and historical values, offer interactive tours based on new technologies (augmented reality, VR), and encourage tourists to participate in conservation efforts like planting trees

or cleaning up natural areas. The future of national parks in Montenegro depends on the consistent implementation of sustainability strategies and creating a balance between preserving nature and benefiting from tourism.

The key goal is to educate tourists and locals on the importance of protecting natural resources while simultaneously fostering economic development. One of the strategies should be creating educational programs, lectures, and interactive activities aimed at educating the public and tourists about sustainability, climate change, wildlife conservation, and other relevant topics. It would also be essential to integrate sustainable practices into everyday life in these areas, such as encouraging the use of renewable energy, eco-friendly transportation, waste reduction, and sustainable food production. By adopting these measures, national parks can thrive as a sustainable destination, protecting both their natural and cultural heritage for future generations.

## 2 Field of Research

The subject of this research focuses on tourism management in the national parks of Montenegro, with an emphasis on the application of sustainable development in tourism. The study examines the role of national parks as key natural resources and tourist destinations, analyzing various strategies and tourism management models that can minimize the negative impacts of tourism on the environment while simultaneously enhancing the economic and social development of local communities.

Special attention is given to the planning and implementation of sustainable tourism practices, such as destination carrying capacity, visitor management strategies, educational programs, and ecological initiatives that enable a balance between nature conservation and tourism. The research also explores the challenges and obstacles in achieving sustainable tourism, as well as recommendations for improving the management of national parks in accordance with sustainability principles.

## 3 Methodology

In the preparation of this study, a combination of qualitative and quantitative research methods was used. The applied methods, i.e., the basic research procedure, consist of data collection from literature and documents using content analysis. An analysis of secondary data sources was conducted through a review of available literature and strategic documents related to tourism and nature protection in the national parks of Montenegro. Additionally, a field survey was carried out to collect relevant data. This methodology provides insight into the current state of sustainable tourism and serves as a basis for proposing concrete measures to improve sustainable tourism management in Montenegro's national parks.

## 4 Research Results

The study included 40 respondents and was conducted during the period of January–February 2025. The significance of this survey, as a quantitative research method, lies in supplementing existing data and providing new insights. The survey offers an understanding of attitudes and opinions regarding the application of innovations and technology in the development of sustainable tourism, with a particular emphasis on spatial planning and climate change. By analyzing the survey results, we arrive at the following conclusions. The majority of respondents believe that technology and innovations are highly important for the development of sustainable tourism. A total of 82.5% of respondents consider the impact of climate change on tourism to be significant, with rising temperatures, increasing year after year, identified as the greatest challenge. When it comes to sustainable technologies, 70% of respondents recognize solar panels as highly important for reducing negative environmental impacts, followed by waste

management systems at 55%. However, there are numerous obstacles to implementing new technologies, such as high costs and a lack of political support. A significant number of respondents see investment in new technologies as a challenge, particularly in less developed tourist destinations. Despite this, 75% of respondents are optimistic that tourism will become more sustainable in the coming years. Based on this survey, strategies and policies can be developed to further enhance sustainability in tourism and integrate technology into the development of tourist destinations.

## *5 Conclusion*

The preservation of natural resources, economic development, and the enhancement of the tourism offer can only be achieved if sustainable tourism is established as a key strategy. National parks, as protected areas, play a crucial role in this process by balancing tourism growth with environmental protection. Minimizing the negative impacts of tourism is possible through the implementation of innovative technologies such as digitalization, GIS systems, artificial intelligence, and smart infrastructure solutions. Past experiences show that over-tourism and the unsustainable use of natural resources can lead to negative consequences, including ecosystem degradation, pollution, and the loss of the authenticity of tourist destinations. At the same time, poor infrastructure and a lack of innovative solutions further hinder the achievement of sustainable development goals. To overcome these challenges, it is necessary to introduce modern tourism management methods, including the application of digital technologies and the adoption of ecological standards in the tourism sector. The use of smart technologies such as GIS analysis, digital tracking of tourist flows, artificial intelligence, and sustainable transport can significantly contribute to optimizing tourism activities and protecting natural assets. A particularly important aspect of sustainable tourism involves raising ecological awareness among tourists and local communities, encouraging responsible use of natural resources, and preserving Montenegro's unique natural and cultural heritage. In addition to these measures, it is essential to improve the legislative framework and enforce environmental regulations to ensure that tourism development does not harm ecosystems or compromise the long-term sustainability of destinations. Diversifying the tourism offer through the promotion of rural, eco, and adventure tourism can reduce pressure on coastal regions and enable a more balanced development of tourism across the country. Sustainable tourism is not only an imperative for nature conservation but also an opportunity for Montenegro's economic progress. If appropriate strategies, digital innovations, and ecological standards are implemented, Montenegro has the potential to become a leading destination for sustainable tourism in the Balkans.

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