

SMART TOURISM AND SUSTAINABILITY IN RURAL MOUNTAIN AREAS: EMERGING MODELS OF DEVELOPMENT

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RESEARCH ARTICLE

Abstract

Tourism in rural mountain areas is at the intersection of two major trends: the pressure to ensure economic development and the need to protect fragile ecosystems and vulnerable communities. In this context, the concept of smart tourism – based on the use of digital technologies, data and social innovation to optimize the tourist experience and destination management – is increasingly associated with the objectives of sustainability and resilience of mountain.

The article aims to analyze the role of "smart" tourism in supporting sustainability in rural mountain areas, through a narrative review of recent scientific literature, case studies and public policy documents (UN Tourism, FAO, European Commission). The main emerging development models are discussed – from smart mountain villages and smart destinations focused on sustainability, to digital solutions for mobility, visitor flow management and co-creation of the tourist experience. The results suggest that, under conditions of participatory governance and appropriate investments in infrastructure and skills, smart tourism can significantly contribute to: reducing environmental impact, increasing local economic benefits, preserving cultural and natural heritage and mitigating rural depopulation.

However, risks and limitations are also identified, such as the digital divide, excessive dependence on technologies, vulnerability to climate change and external shocks to tourism demand, as well as possible tensions between tourism growth and the carrying capacity of mountain territories

Keywords: smart tourism, sustainable development, rural mountain areas, smart destinations, emerging development models.

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INTRODUCTION

Rural mountain areas represent spaces with a double strategic value: on the one hand, they concentrate natural resources, landscapes and cultural heritage with high value for tourism; on the other hand, they are areas sensitive to climate change, depopulation and rapid socio-economic transformations (FAO, 2021).

Rural mountain tourism is often promoted as a driver of local development, offering opportunities for income diversification, jobs and stimulating local entrepreneurship. Recent studies from the Romanian Carpathians show that rural mountain tourism can be perceived by visitors as an authentic product, linked to nature and tradition, but its success depends on the quality of services, infrastructure and the integration of sustainability principles (Dobre et al, 2024).

In parallel, the digital transformation of the tourism economy has led to the emergence of the concept of smart tourism and smart

tourism destinations, in which information and communication technologies (ICT), the Internet of Things (IoT), mobile applications, augmented reality and data analysis are used to improve the tourist experience, resource management and decision-making (Samancioglu et al, 2024).

European initiatives, such as the European Capital of Smart Tourism and the Green Pioneer of Smart Tourism, promote the integration of digitalization, sustainability, accessibility and valorization of cultural heritage, providing a reference framework and good practices that can also be adapted in rural mountain destinations (European Commission, 2024). At the same time, EU policies on sustainable tourism and rural mobility – including the guidelines for sustainable mobility in rural tourism and ecotourism regions – underline the need for smart solutions for transport, connectivity and management of tourist flows in fragile areas (EISMEA, 2025).

Globally, UN Tourism and UNDP promote tourism as a vector for achieving the Sustainable Development Goals (SDGs),

showing that digitalization and innovation can support the transition to more responsible and resilient tourism models, including in mountain regions.

In this context, this article aims to:

- to clarify the concept of smart tourism in relation to sustainability;
- to highlight the specifics of rural mountain areas in relation to these concepts;
- to identify emerging development models based on smart tourism and sustainability;
- to discuss the opportunities and challenges associated with these models.

MATERIAL AND METHOD

The research is a narrative and exploratory review of the specialized literature and public policy documents relevant to the topic of "smart tourism and sustainability in rural mountain areas".

Scientific databases (Scopus, Web of Science, ScienceDirect, MDPI, SpringerLink) and research platforms (ResearchGate, Google Scholar) were consulted, as well as official websites of international organizations (UN Tourism, FAO, European Commission) and European

The keywords used (in various combinations) included: smart tourism, smart tourism destinations, rural tourism, mountain tourism, sustainability, smart villages, rural mobility, digitalization in tourism, smart rural tourism. The following were selected:

- scientific articles with a focus on smart tourism and/or rural mountain tourism;
- case studies on mountain destinations that have integrated smart technologies;
- reports and policy guides on sustainable tourism and smart tourism;
- examples of good practices from recent European projects.

To capture the current dynamics, priority was given to works published after 2018, but previous sources were also included, considered reference for the conceptualization of smart tourism and its connection with sustainability.

The sources were analyzed by:

- identifying definitions and conceptual frameworks regarding smart tourism, smart destinations and sustainable tourism;
- extracting elements specific to rural mountain areas (characteristics, challenges, opportunities);

- classification of emerging development models (e.g. smart villages, smart mountain routes, participatory digital platforms);
- identifying key success factors and barriers.

The results are presented in an integrated form, combining theoretical perspectives with practical examples. experimental/statistical design and methods should be presented in this section. Measurements should be expressed according to the metric system or SI units. Full names of abbreviations should be provided when first used in the text.

RESULTS AND DISCUSSIONS

Smart tourism and destination sustainability

The literature defines smart tourism as the systematic use of ICT, sensors, data (big data), mobile applications and collaborative platforms to improve the tourist experience, streamline resource management and increase the competitiveness of the destination (Samancioglu et al, 2024).

The concept of smart tourism destination is based on digital infrastructure (connectivity, data platforms), collaborative governance (involvement of public, private and community actors), accessibility, sustainability and innovation. Recent studies show that the sustainability dimension – environmental, social, economic – is becoming central in the evaluation of smart destinations, and smart technologies are seen as tools for monitoring and reducing tourism impact (energy, water, waste, mobility) (Samancioglu et al, 2024).

In rural mountainous areas, the potential of smart tourism is closely linked to:

- connectivity (broadband internet, mobile coverage);
- digitalization of services (online reservations, electronic payments, guidance applications);
- heritage interpretation tools (augmented reality, virtual tours);
- smart mobility solutions (on-demand transport, timetable integration, eco routes) (European Commission, 2024).

Particularities of rural mountain areas

Rural mountain areas face a few structural challenges:

- poor accessibility and limited transport infrastructure;
- increased seasonality of tourist demand;
- youth migration and population aging;

- vulnerability to climate change (snow retreat, extreme weather phenomena) (FAO, 2021).

At the same time, they have competitive advantages for sustainable tourism: impressive natural landscapes, high biodiversity, cultural and gastronomic traditions, and perception of authenticity. Case studies from the Romanian Carpathians and other European mountain regions (Alps, Slovenian Carpathians, etc.) show that tourists are increasingly interested in personalized experiences, direct contact with local communities and “green” tourism products (Dobre et al, 2024).

In Romania, recent research on rural mountain tourism highlights the segmentation of the public according to motivations (relaxation, nature, culture, outdoor activities) and emphasizes the importance of digital communication, online presence and integrated services to meet the expectations of younger generations of tourists. (Gherdan et al, 2025).

Emerging development models based on smart tourism

From the literature reviewed and from policy and practice examples, several emerging development models in rural mountain areas can be identified, in which smart tourism plays a central role.

Smart mountain villages

The smart village concept applied in the European rural environment involves the coordinated use of digital technologies, renewable energy, smart public services and community participation to improve the quality of life and local attractiveness (European Commission, 2024).

In mountainous areas, concrete applications include:

- public lighting systems and energy infrastructures based on renewable and digitally monitored solutions;
- local booking platforms for guesthouses and tourist experiences (local guides, gastronomy, hiking);
- use of GIS and mobile applications for marking and interpreting mountain trails;
- promoting local products through online markets and digital branding of the village (EISMEA, 2025).

Studies on the development of rural mountain tourism in Carpathian villages show that the presence of a digital infrastructure and a coherent online identity (websites, social media, reviews) becomes a critical factor of competitiveness, complementing investments in

service quality and environmental protection (Dobre et al, 2024).

Smart mountain destinations oriented towards sustainability

At the destination level (valley, mountain micro-region), smart tourism manifests itself through:

- systems for monitoring visitor flows and pressure on routes (sensors, mobile phone data);
- smart mobility management – integration of public transport, shuttle services, walking and cycling trail networks;
- integrated reservation and ticketing systems for attractions, events and transportation;
- Real-time communication regarding environmental conditions, congestion and less frequented alternatives (Karawanken-Karavanke Geotrail, 2024).

European examples, such as the Karawanken-Karavanke mountain route or Alpine destinations implementing clean energy and sustainable mobility plans, show how smart infrastructure can support low-impact, diversified and climate-adapted nature tourism (European Commission, 2024).

Participatory digital platforms and co-creation of experience

Another emerging model is that of digital platforms that actively involve the local community in the design and delivery of tourism experiences:

- applications that connect tourists with local hosts, producers and guides, facilitating household-based tourism and micro-entrepreneurship;
- real-time review and feedback systems that allow the adjustment of the tourist offer and the monitoring of the quality of services;
- digital storytelling tools (podcasts, audio tours, augmented reality) that capitalize on the cultural and intangible heritage of mountain communities (Samancioglu et al, 2024). Studies on tourist behavior in rural mountain tourism in Romania indicate that online recommendations, photos and user-generated content play a major role in destination choice, confirming the importance of the “smart” dimension of marketing and communication (Dobre et al, 2024).

Projects and networks for smart and sustainable tourism in the mountains

At the European level, projects such as FACILITY or initiatives within Smart Tourism Destinations provide technical support and

tools for the digitalization and green transition of destinations, including rural and mountain ones. In parallel, thematic projects focused on climate change adaptation in winter resorts (e.g. BeyondSnow) explore the use of data and participatory platforms to rethink the tourism offer and increase the resilience of Alpine communities.transition-pathways.europa.eu+1

Recent articles also highlight investments in smart tourism in remote mountain regions, as a means of promoting sustainable development, heritage conservation and local prosperity, with a focus on connectivity, green energy and community engagement.

Benefits, risks and challenges

Potential benefits identified:

- Efficiency and reduction of environmental impact: Smart technologies for monitoring resource consumption, waste management and controlling visitor flows can limit the degradation of mountain ecosystems (Gherdan et al, 2025).

- Increasing local incomes and diversifying the rural economy: Digital platforms facilitate direct access of small providers (guesthouses, local producers, guides) to markets, reducing intermediation and creating new business opportunities.

- Strengthening social capital and community involvement: Smart village projects and participatory platforms encourage collaboration between authorities, entrepreneurs and residents, creating stronger local networks (Karawanken-Karavanke Geotrail, 2024).

- Adaptation to climate change and market shocks: Smart, data-driven tourism allows for more flexible planning, the development of "low season" products and a reorientation towards forms of tourism less dependent on snow, for example.

Risks and challenges

- Digital division: Many rural mountain communities lack adequate digital infrastructure or digital skills, which can create new forms of exclusion and dependence on external actors. (European Commission, 2024).

- The risk of "localized overtourism": Although the total volume of tourists may be moderate, their concentration in certain "instagrammable places" or on certain routes may exceed local support capacity, in the absence of smart management (Ghimire, 2025).

- Data protection and digital ethics issues: The collection and use of data on tourist movement and behavior raises questions about privacy, transparency, and data governance.

- Limited institutional capacity: The implementation of smart projects requires technical skills, project management and inter-institutional cooperation, resources that may be scarce in rural mountain communities (Ballina, 2020)

Overall, the literature emphasizes that smart tourism is not a panacea, but a set of tools that can support or, on the contrary, compromise sustainability, depending on how it is integrated into a local development vision, public policies and governance structures (European Commission, 2024).

CONCLUSIONS

The analysis carried out allows the formulation of several main conclusions:

1. Smart tourism and sustainability are complementary, not alternatives. Smart technologies can provide powerful tools for the sustainable management of mountain destinations – from impact monitoring to co-creation of tourism experiences – but only if they are integrated into a clear framework of environmental, social and economic objectives.

2. Rural mountain areas have high potential for innovative development models, such as smart mountain villages, smart tourist routes or digital collaborative platforms, which can combat depopulation and increase economic resilience, provided that participatory planning and respect for the carrying capacity of the environment are adhered to.

3. European policies and initiatives represent a favourable framework for the development of smart and sustainable tourism in the mountains, through funding programs, networks of good practices and recognitions (European Capital and Green Pioneer of Smart Tourism, guides for sustainable mobility and resilient tourism).

4. The risks and challenges – from the digital divide to overtourism and data governance issues – call for a cautious and reflective approach. Smart tourism must be accompanied by training measures, institutional strengthening and clear regulations on data protection and the responsibility of the actors involved.

5. For the future, research and action directions are outlined such as: the development of integrated indicators of "smart

& sustainable mountain destinations", longitudinal studies on the impact of smart projects on mountain communities, as well as the development of guides adapted to the local context (e.g. Carpathians, Alps, Balkan mountains).

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