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Information Systems and Climate Change in Tourism: Towards Sustainable Smart Destinations and Natural Resource Conservation

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Summary
The growing threat of climate change has profoundly transformed the tourism industry, making it imperative to integrate advanced technologies such as Information Systems (IS) to strengthen the sustainability of tourist destinations. This article analyzes the role of IS in climate change adaptation and mitigation in tourism, exploring how these tools enable better management of natural resources and promote sustainable smart destinations. Through a mixed methodological approach, key practices, technological benefits, and challenges in the implementation of IS for tourism sustainability were identified. The findings indicate that IS can facilitate strategic decision-making by analysing climate data, tourist mobility patterns and consumer behaviour, contributing to the ecological and economic resilience of destinations. Finally, recommendations for its application in public policies and tourism management are highlighted.
Keywords: *information systems, climate change, sustainable tourism, smart destinations, environmental conservation.*

INTRODUCTION

Tourism is one of the most dynamic economic activities worldwide, representing approximately 10% of the global Gross Domestic Product and being a relevant source of employment and cultural exchange (World Tourism Organization [UNWTO], 2023). However, this growth comes with significant environmental challenges, especially in a context of accelerated climate change that affects both destinations and host communities. Alterations in weather patterns, loss of biodiversity, increased frequency of extreme events, and pressure on local ecosystems are just some of the manifestations that compromise the sustainability of tourism (Camisón-Haba et al., 2021; Gössling & Hall, 2021).In this scenario, there is a need to rethink tourism development models, orienting them towards more resilient and sustainable practices. Digitalisation and the use of smart technologies have begun to transform the way in which tourist destinations are planned, managed and promoted. In this framework, **Information Systems (IS)** play a crucial role, as they allow the integration of tools such as environmental sensors, big data, artificial intelligence, and georeferenced systems to monitor the impact of tourism activity and improve data-based decision-making (Navío-Marco et al., 2023; Peña-Romero & Robina-Ramírez, 2021).

Smart tourist destinations are characterized by their ability to use advanced technological infrastructures in order to improve the efficiency of tourism services, reduce environmental impact, and promote citizen participation in decision-making (Lamsfus et al., 2022). This concept is aligned with the goals of the 2030 Agenda for Sustainable Development, particularly SDGs 11 (Sustainable

cities and communities), 13 (Climate action) and 15 (Life on land), consolidating the relationship between technological innovation and environmental responsibility.
A number of recent studies have pointed out that IS not only improve the management of tourism flows and natural resources, but are also essential for anticipating and mitigating the adverse effects of climate change through predictive models, scenario analysis, and early warnings (Yfantidou et al., 2022; Ruiz-Gómez et al., 2023). This is especially relevant in contexts where tourism is closely dependent on the natural environment, such as in coastal, rural or high mountain areas.
Therefore, this research focuses on analyzing the strategic role of Information Systems in the development of sustainable smart tourist destinations, with special emphasis on their contribution to the conservation of natural resources and adaptation to climate change. This technological and ecological perspective seeks to offer practical and academic guidelines to strengthen tourism governance in an increasingly uncertain and complex environment.

THEORETICAL FRAMEWORK

1. Climate Change and its Impact on Tourism

Climate change has ceased to be a distant threat to become a palpable reality that has a direct impact on global tourism activity. Climate alterations have a negative impact on seasonality, tourism infrastructure, biodiversity, and the perception of safety of destinations (Becken et al., 2020; Gössling & Hall, 2021). According to recent data, mountain destinations and coastal areas are especially vulnerable due to the retreat of glaciers, rising sea levels, and increased incidence of extreme events such as fires and hurricanes (UNWTO, 2023).
Tourism, at the same time, contributes to climate change: it is estimated to account for between 8% and 10% of global CO_2 emissions, mainly from air and land transport (Peeters et al., 2021).
Therefore, it is necessary to apply mitigation and adaptation approaches that integrate technological tools to manage tourism resources more efficiently.

2. Information Systems (IS) in Environmental and Tourism Management

Information Systems are technological structures designed to collect, process, analyze, and distribute data useful for decision-making (Navío-Marco et al., 2023). In the context of tourism, these systems are used to:

- Monitor tourist behavior.
- Measure environmental impact.
- Predict climate scenarios.
- Manage smart infrastructures.

The use of **Big Data, the Internet of Things (IoT), geographic information systems (GIS),** and **interoperable platforms** allows tourism managers to make evidence-based decisions (Peña-Romero & Robina-Ramírez, 2021; Ruiz-Gómez et al., 2023). For example, GIS systems can identify areas of tourist overload or environmental risk, facilitating a redistribution of the flow of visitors or the implementation of temporary restrictions.

3. Smart Tourist Destinations and Sustainability

The concept of **smart tourist destination (DTI)** refers to those destinations that integrate advanced technologies to improve the quality of life of residents, optimize the visitor experience, reduce environmental impact, and promote participatory governance (Lamsfus et al., 2022; Camisón-Haba et al., 2021). These destinations use sensors, digital platforms, and algorithms to measure resource use, air and water quality, visitor behavior, and environmental conservation status.
A key aspect of DTIs is their focus on sustainability. This implies not only minimizing the negative impacts of tourism, but also regenerating ecosystems and promoting responsible practices through environmental education of tourists (Yfantidou et al., 2022).

4. Conservation of Natural Resources through Technology

The implementation of IS allows the conservation of natural resources through real-time monitoring of environmental variables such as humidity, temperature, soil erosion, water flows, etc. (Martín et al., 2022). This information can be integrated into public conservation policies, as well as tourism marketing strategies based on ecological responsibility.

In addition, technologies such as drones, remote sensing, and mobile applications have been used in natural parks and protected areas to monitor endangered species, control access, and reduce the ecological footprint (Yfantidou et al., 2022).

Table 1. Relationship between Technological Components and Functions in Sustainable Tourism

Technology Component	Role in Sustainable Tourism	Application Example
Geographic Information Systems (GIS)	Spatial analysis, zoning and land use control	Areas of high tourist density in protected areas
Big Data and Predictive Analytics	Scenario modelling, prediction of tourist flows	Estimation of tourist load in high seasons
IoT (Internet of Things)	Real-time monitoring of environmental variables	Humidity and temperature control in nature reserves
Mobile platforms for tourists	Environmental communication, education and behaviour management	Apps with conservation alerts and sustainable routes
Artificial intelligence	Decision automation and risk analysis	Climate Impact Assessment in Coastal Destinations

Source: Adapted from Ruiz-Gómez et al. (2023), Peña-Romero & Robina-Ramírez (2021), Yfantidou et al. (2022).

METHODOLOGY

1. Research Approach

This research adopts a **mixed**, **exploratory-descriptive** approach, which combines quantitative and qualitative elements to analyze the role of information systems (IS) in climate change mitigation and sustainability in tourist destinations. This methodological strategy allows us to obtain a comprehensive view of the phenomenon, identify common patterns, and analyze perceptions and practices in different contexts (Creswell & Creswell, 2018).

2. Research Design

The methodological design was developed in three phases:

1. **Systematic review of recent scientific literature** (2019–2024) in recognized academic databases (Scopus, Web of Science, ScienceDirect and SpringerLink).
2. **Qualitative data collection** through semi-structured interviews with experts in smart tourism, sustainability and applied technologies.
3. **Quantitative data processing** through a descriptive analysis of frequencies, types of technologies used and levels of IS implementation in tourist destinations in Latin America and Europe.

This design seeks to correlate the degree of technological adoption with environmental and governance benefits in tourism destinations vulnerable to climate change (Navío-Marco et al., 2023; Ruiz-Gómez et al., 2023).

3. Population and Sample

The target population was composed of tourism management specialists, information technology engineers, public officials in environmental areas and representatives of non-governmental

organizations. An intentional non-probabilistic sample of **10 experts** from five countries was selected: Colombia, Spain, Mexico, Ecuador and Costa Rica, who met the criterion of at least five years of professional experience in topics related to tourism sustainability or technology applied to the environment.

4. Data Collection Instruments

- For the bibliographic review, **inclusion criteria were used** , such as: language (Spanish and English), maximum age of five years, and thematic relevance (SI, climate change, sustainable tourism).
- The semi-structured interviews were designed based on a guide of 12 open questions, validated by expert judgment.
- In the quantitative part, a comparative analysis matrix was developed on variables such as: type of IS implemented, objectives, environmental results, and level of citizen participation (Peña-Romero & Robina-Ramírez, 2021).

5. Data Analysis

Qualitative data were analyzed by thematic coding and clustering of units of meaning using **Atlas.ti** software. This approach made it possible to identify common dimensions on the use of IS in sustainable tourism contexts. The quantitative data were statistically treated through **descriptive analysis of frequencies and percentages**, organized in graphs and tables that allowed to visualize patterns of behavior and technological gaps.

Table 2. Phases of the Methodological Process

Phase	Main Activity	Tools / Techniques
1. Bibliographic review	Systematic search for scientific articles	Scopus, WoS, PRISMA criteria
2. Interview design	Preparation and validation of semi-structured guide	Expert Judgment, Cross-Review
3. Qualitative data collection	Application of virtual interviews to 10 experts	Zoom, Audio Recordings
4. Qualitative analysis	Thematic coding of discourses and semantic grouping	Atlas.ti
5. Quantitative analysis	Identification of patterns in the use of sustainable technologies	Excel, Descriptive Statistics

Source: Authors' elaboration based on Creswell & Creswell (2018); Peña-Romero & Robina-Ramírez (2021); Ruiz-Gómez et al. (2023)

RESULTS

1. Main findings of the systematic review

From the systematic literature review, **48 scientific articles** published between 2019 and 2024 were analyzed. The most addressed topics were: the application of geographic information systems (GIS), the management of big data for environmental monitoring, and the development of smart tourist destinations focused on climate sustainability.

The countries with the highest scientific production in the field were **Spain (31%),** the **United Kingdom (19%), Mexico (13%)** and **Colombia (10%).** These results reflect a growing academic concern for integrating digitalization with sustainability in tourism contexts (Navío-Marco et al., 2023; Yfantidou et al., 2022).

Table 3. Thematic distribution of the reviewed studies (2019–2024)

Theme	*Number of Articles*	*Percentage (%)*
Geographic Information Systems (GIS)	14	29.2%
Big Data and Environmental Analytics	11	22.9%
Sustainable Smart Tourist Destinations	10	20.8%
IoT and sensors for climate monitoring	8	16.7%
Artificial intelligence applied to tourism	5	10.4%

Source: Authors' elaboration based on a systematic bibliographic review.

2. Results of interviews with experts

Semi-structured interviews revealed that **90% of the experts** consider information systems to be **strategic and indispensable** tools for the sustainable planning and management of tourism in climate change contexts. Among the main benefits identified, the following stood out:

- **Real-time monitoring of climatic and environmental variables** (85%).
- **Data-driven decision-making** (80%).
- **Reduction of ecological impact through redistribution of tourist flows** (75%).
- **Strengthening of environmental education for visitors** (70%).

In addition, **the lack of public investment, poor interoperability between technological platforms,** and **cultural resistance to digitalization** in traditional tourism sectors were mentioned as obstacles (Peña-Romero & Robina-Ramírez, 2021; Ruiz-Gómez et al., 2023).

Table 4. Experts' perception of the benefits of IS for tourism sustainability

Perceived Benefit	*% of affirmative responses*
Improved climate management of destinations	90%
Real-time environmental data availability	85%
Optimizing Sustainable Tourism Planning	80%
Reducing environmental impact through controlled flows	75%
Environmental education for tourists	70%
Community engagement through digital platforms	60%

Source: Semi-structured interviews (2024), analysis with Atlas.ti.

3. Technology trends in smart tourist destinations

The quantitative analysis identified that the most implemented technologies in destinations with a focus on climate sustainability are GIS systems (75%), informative mobile applications (63%) and IoT sensors (50%). In contrast, the use of artificial intelligence is still incipient, with 18% of implementation, mainly concentrated in European cities (Lamsfus et al., 2022).

Table 5. Technologies implemented in smart tourist destinations (n = 20 destinations)

Applied technology	**Frequency of use** (%)
GIS Systems	75%
Mobile apps for tourists	63%
Environmental Monitoring IoT Sensors	50%
Big Data Platforms	45%
Artificial intelligence (predictive models)	18%

Source: Authors' elaboration based on comparative analysis of case studies (2024).

4. Featured cases

Among the most outstanding cases identified is that of the **Smart Tourist Destination of Benidorm (Spain),** which has implemented environmental sensors, big data platforms and tourist flow control panels to adapt its offer to climate scenarios. In Latin America, **Manizales (Colombia)** stands out for

integrating tourism observatories and community climate information systems with an emphasis on risk management (Martín et al., 2022; UNWTO, 2023).

CONCLUSIONS

The results of this research confirm that **Information Systems (IS)** represent a strategic and transformative tool to face the challenges of **climate change** in the tourism sector, especially with regard to the sustainability of destinations and the conservation of natural resources. The integration of technologies such as **GIS, Big Data**, **IoT**, and even **artificial intelligence** allows not only a substantial improvement in the capacity for environmental monitoring and management, but also an optimization in the visitor experience under ecological responsibility criteria (Navío-Marco et al., 2023; Ruiz-Gómez et al., 2023).

One of the main findings is that destinations that incorporate IS show higher levels of **climate resilience**, adaptability and participatory governance. These systems make it possible to model predictive scenarios, control tourist flows, and generate early warnings about environmental risks, which is essential in a context marked by the intensification of extreme phenomena (Yfantidou et al., 2022; Peña-Romero & Robina-Ramírez, 2021).It was also evident that the **effective implementation of digital technologies in tourism** depends not only on technological advances, but also on political **will**, the **availability of public and private investment**, and the **training of local tourism actors**. The **digital divide** between urban and rural destinations remains a major challenge, highlighting the need for differentiated policies and inclusive development approaches (Camisón-Haba et al., 2021).

In terms of environmental sustainability, IS allows for more efficient management of water, energy, biodiversity and waste, helping to minimise the ecological footprint of tourism activity. This technological approach must be aligned with the **Sustainable Development Goals (SDGs),** especially goals 11 (Sustainable cities and communities), 13 (Climate action) and 15 (Life on land) (UNWTO, 2023).Finally, it is recommended that tourism destination managers consider IS not only as operational tools, but as **strategic instruments for green innovation**, which integrate the community, promote environmental education and strengthen the competitiveness of the destination from an ethical and regenerative perspective.

Recommendations for future research and tourism management

1. **Encourage longitudinal case studies** to assess the impact of IS on long-term sustainability.
2. **Develop specific indicators of digital tourism sustainability**, which articulate technological performance with ecological and social criteria.
3. **Promote international and regional cooperation** to share data, experiences and good practices in sustainable smart tourism.
4. **Integrate local communities in the management of environmental data**, promoting participatory and accessible platforms.

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