Research article

Exploring the nexus of smart technologies and sustainable ecotourism: A systematic review

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ABSTRACT

Sustainable smart ecotourism, utilizing smart technologies like smartphones, artificial intelligence (AI), and the Internet of Things (IoT), aims to minimize harm to natural and cultural ecosystems, promoting education and environmental conservation. This review aims to examine the concept of sustainable smart ecotourism, analyzing existing literature to gain insights into the significance, components, challenges, and contributions to sustainable development on a global scale. A systematic review was conducted to evaluate sustainable smart ecotourism using PRISMA guidelines. The review focused on scholarly, peer-reviewed studies from developing countries, using databases like ScienceDirect, Jstor, Taylor & Francis, and IEEE. The study used Joanna Briggs Institute and Cochrane Risk of Bias tools to assess study quality. Thematic analysis techniques were used to extract and synthesize data, identifying patterns and trends relevant to smart ecotourism sustainability. Dual analyst verification ensured data integrity and reliability. After conducting a thorough quality evaluation using the Joanna Briggs Institute Checklist and Cochrane Risk of Bias Tool, we identified 29 studies of exceptional quality from an original pool of 9583 records. The use of thematic analysis sheds light on the diverse and important role of the IoT in promoting sustainable ecotourism. This study uncovered both the obstacles and possibilities associated with this technology. The findings provide important insights into the worldwide implementation of smart ecotourism techniques and highlight the significant impact of technology in promoting sustainable tourism models. Smart ecotourism involves multiple stakeholders to enhance environmental impact. Key characteristics include dynamic interactions, co-creation of value, sustainable development, resource sharing, and innovation services. Technology like IoT is crucial for sustainable tourism management. Collaboration with governments, local stakeholders, and organizations is recommended for sustainable policies. As a result of this study, sustainable ecotourism policies result from a collaborative effort between local communities, government agencies, and practitioners in the industry. Smart technologies, including AR/VR and AI, have the potential to enhance operational efficiency while reducing environmental concerns. Ecotourism, partnerships, and education are key to successful implementation and capacity building.

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1. Introduction

The convergence of smart technologies and sustainable ecotourism is a captivating topic for investigation due to its revolutionary potential to enhance environmental conservation and revolutionize the tourism industry [1]. In recent years, the global tourism industry has witnessed a significant shift in its paradigms, driven by evolving consumer preferences, environmental concerns, and technological advancements [1,2]. The emergence and increasing demand for sustainable smart ecotourism are key factors in this shift. This modern approach to travel prioritizes preserving natural resources and ecosystems and incorporates intelligent technologies to improve visitor experiences while reducing environmental harm. The increasing recognition of environmental deterioration, climate change, and biodiversity loss has motivated tourists, politicians, and industry stakeholders to prioritize sustainable tourism practices [3]. Conventional tourist approaches frequently led to adverse ecological impacts, such as habitat degradation, contamination, and disturbance of indigenous groups. In contrast, sustainable smart ecotourism aims to achieve a harmonious equilibrium among economic advancement, environmental conservation, and cultural safeguarding [4–6].

Sustainable smart ecotourism is gaining increasing attention in tourism [7]. With the growing number of tourists worldwide and the significant economic impact of tourism, it is crucial to develop practices that minimize harmful effects on natural and cultural ecosystems [8]. Ecotourism, a subcategory of nature tourism, aims to achieve this by promoting education, environmental conservation, and the protection of natural areas. However, there is little evidence to support this claim [8]. Investigating and providing specific examples of successful sustainable smart ecotourism initiatives would strengthen the statement.

Sustainable ecotourism goes beyond minimizing harm and seeks to balance the needs of present and future generations. It focuses on maximizing resource utilization, fostering local economic expansion, and ensuring the equitable distribution of social and economic resources [9]. This includes creating long-term employment opportunities, providing public amenities for locals, and implementing measures to mitigate resource scarcity [10]. However, there needs to be more consideration for environmental impact and evidence of how such goals can be achieved in sustainable ecotourism.

The emergence of smart technologies, such as smartphones, artificial intelligence (AI), the cloud, and the Internet of Things (IoT), has contributed to the rapid development of smart ecotourism. In ecotourism, smartness refers to using information and communication technology (ICT) to enhance the visitor experience, improve destination management, and promote sustainable practices [11]. Smart ecotourism aims to provide guests superior services while benefiting local communities and preserving natural resources. However, there are no specific benefits brought by smart technology and any potential challenges or drawbacks associated with their implementation [12]. Additionally, exploring any research on the effectiveness and sustainability of smart technologies in ecotourism sustainability would be beneficial.

Moreover, incorporating intelligent technologies, including AI, IoT, and data analytics, has completely transformed the tourism industry. These technologies facilitate the effective management of tourist flows, monitoring of environmental indicators, and provision of personalized and immersive experiences for travelers. Smart sensors may monitor wildlife habitats, while AI-driven systems can optimize energy consumption in eco-lodges, minimizing ecological disturbance. The desire for sustainable smart ecotourism represents a significant paradigm shift in the global tourism industry rather than a passing trend. Travelers are progressively searching for genuine experiences that align with their beliefs of ecological accountability and cultural admiration. Likewise, destinations see the long-term benefits of implementing sustainable practices, including greater resilience to climate change, preservation of natural resources, and economic diversification.

However, the concept of smart ecotourism is still in its early stages, and there is a need for further research and critical evaluation. While ICT has the potential to revolutionize the tourism industry, it is essential to ensure that it is used responsibly and in a way that aligns with sustainable development goals. This requires collaboration between the public and private sectors and a deep understanding of how tourists utilize modern technologies [12,13]. In summary, sustainable smart ecotourism holds great potential for the tourism industry. Integrating smart technologies and promoting sustainable practices can enhance the visitor experience, support local communities, and protect natural ecosystems [14]. However, it is crucial to approach smart ecotourism critically and ensure that it aligns with sustainable development principles.

Further research and evaluation are needed to fully understand the implications and benefits of smart ecotourism. To summarize, sustainable smart ecotourism intersects environmental awareness, technological advancement, and economic feasibility. As the globe grapples with serious environmental concerns and seeks avenues for responsible growth, the urgency for embracing sustainable smart ecotourism has never been stronger. This article further examines the various aspects of this revolutionary approach to tourism, investigating its importance, challenges, and sustainable impact for future generations.

The article discusses the economic benefits of tourism, which accounted for 10.4 % of the global GDP in 2016. However, it also highlights the negative impacts of tourism on local communities and the environment, such as overcrowding, pollution, and resource exploitation. Ecotourism, a sustainable tourism approach, is emphasized, but there is a need for greater scrutiny and regulation of smart ecotourism. The rise of smart tourism and technology in enhancing tourist experiences raises concerns about over-reliance and loss of authentic experiences. The growth of youth ecotourism is also highlighted, but there is a need for education and awareness about environmental and social impacts. The study calls for further research and development in smart ecotourism and practical action to ensure its sustainability and benefits for all stakeholders [15]. The study uses a qualitative approach to explore the role of smartness in sustaining ecotourism.

With the ongoing growth of global tourism, it is imperative to promptly embrace sustainable techniques that mitigate adverse effects on natural and cultural ecosystems. Ecotourism, a component of sustainable tourism, has garnered attention, yet there is limited scientific evidence substantiating its efficacy [16]. This review closes the divide by offering specific instances and assessments of ecotourism activities that are both sustainable and intelligent. Nevertheless, sustainable ecotourism extends beyond reducing negative

impacts; it strives to achieve a harmonious equilibrium between economic development, social fairness, and environmental preservation [17]. This review will thoroughly examine the extent to which smart technologies help to attain these objectives and whether they align with the principles of sustainable development. Implementing sustainable smart ecotourism methods necessitates collaboration among diverse stakeholders, such as governments, private sectors, local people, and tourists [18]. This review of current programs and stakeholder engagement methods to get valuable ideas on promoting successful partnerships for sustainable smart ecotourism development.

Moreover, the sustainability and resilience of ecotourism can be greatly impacted by external factors such as political instability, climate change, and worldwide pandemics [19]. This research evaluates the potential of intelligent technology in addressing these difficulties and ensuring the sustainable future of ecotourism destinations. Although there has been much research on different areas of ecotourism and smart tourism, there needs to be more complete evaluations that combine both concepts [20]. This systematic review consolidates current knowledge, points out areas where further study is needed, and comprehensively comprehends the implications and advantages of sustainable smart ecotourism. Ultimately, this systematic review enhances the current understanding of sustainable smart ecotourism by consolidating empirical data, assessing prevailing approaches, and offering suggestions for further research and policy formulation [21,22].

This systematic review examines the concept of sustainable smart ecotourism. The aim is to investigate the intricate correlation between intelligent technology and sustainable ecotourism under the guidance of a robust theoretical framework. The objective is to comprehensively analyze the current situation, identify significant patterns, and uncover valuable insights that contribute to the existing body of knowledge in this field through a systematic review of the relevant literature and a synthesis of our results. The study seeks to investigate important research questions related to smart ecotourism, including its approaches, characteristics, technological impacts, and regional variations. It will analyze existing literature to gain insights into the significance, components, challenges, and contributions of smart ecotourism to sustainable development on a global scale [23]. However, it focuses on the approaches and importance of smartness in ecotourism sustainability. It will explore how ecotourists use modern technologies to improve the development of ecotourism destinations. The review evaluates the ecotourism-related smart approaches that systematically manage information to enhance and sustain ecotourism.

Through systematic research, the complexities of this multidisciplinary field can be better comprehended. The method employed is founded upon established protocols, ensuring the results will be reliable and rigorous. This study is more credible and dependable due to the methodical classification and presentation of the data; this aids in comprehending the connection between sustainable ecotourism and intelligent technologies. Furthermore, a methodical analysis can discern emerging themes, correlations, and trends. This enables us to derive conclusions from more nuanced m data that are more executed in this study; we can illuminate the current state of ecotourism research and underscore the significance of meticulous analysis in advancing our comprehension of the subject matter and offering recommendations for its sustainability. The goal is to provide a comprehensive picture by systematically combining data to influence future research and inspire environmentally friendly ecotourism concepts.

Additionally, it will discuss the management approach for smart ecotourism, including integrating smart tourism into the ecotourism management system and developing appropriate data infrastructure. The research gap in the review is the need for further research on smart ecotourism destinations and the role of IoT in creating intelligent solutions. While there is some consensus on the benefits of the smart ecotourism approach, there needs to be more agreement on the expected impact of IoT. The research also highlights the importance of sustainable development in ecotourism, including establishing parks and reserves and improving living standards for locals and ecotourism service providers. The review will increase awareness and education among tourists about the importance of smartness in ecotourism trips. It also highlights the challenges in ecotourism management, such as the need for intelligent tourism principles and information lag in scenic areas. The research also highlights the value of IoT in the tourism industry, particularly in promoting ecotourism destinations. The research also mentions case studies and examples of smart tourism applications in different countries.

Consequently, this article proposes conducting a Systematic Literature Review (SLR) of sustainable smart ecotourism. The study was predicated on the following research questions.

RQ1. What are the approaches and importance of smartness in ecotourism sustainability?

RQ2. What are smart ecotourism's key characteristics and components, and how do they contribute to sustainable development?

RQ3. How do modern technologies, such as IoT, impact the management and promotion of ecotourism destinations?

RQ4. What are the benefits and challenges of implementing smart ecotourism strategies in different regions, and how do they vary based on local contexts and resources?

The research scope of this systematic review is to explore the approaches and importance of smartness in ecotourism sustainability. It investigates how ecotourists use modern technologies to enhance the development of ecotourism destinations. The review will focus on the role of smartness in providing sustainable and enhanced tourism experiences, as well as the coordination and cooperation between various stakeholders in the tourism industry and government actors. The review will also examine the management approaches and strategies for implementing smart ecotourism, including integrating smart tourism concepts and developing data infrastructure.

In order to promote sustainability in the tourism industry, this study will answer the questions concerning sustainable smart ecotourism. Its secondary objective was to ensure that ecotourism is sustainable by rigorously evaluating existing methodologies and the significance of smartness in this area. The ultimate objective was to identify the challenges in current ecotourism research and the

potential benefits of incorporating IoT and other smart technologies into the industry. The limitation of this systematic review is that it will only include studies published in the last 6 years and written in English. This may result in excluding relevant studies published before this period or in other languages. Additionally, the review will only include peer-reviewed studies, which may limit the inclusion of grey literature or unpublished research. The review will also rely on the availability and accessibility of relevant studies in electronic databases and other sources.

2. Literature review

2.1. Smartness in ecotourism sustainability

By incorporating cutting-edge innovation to improve resource management, guest experiences, and environmental preservation, ecotourism sustainability's "smartness" component can be rethought. Several studies have shown that ecotourism can be significantly improved by integrating data analytics, artificial intelligence, and IoTs. Thanks to the IoT's substantial involvement in real-time environmental monitoring, stakeholders can evaluate ecological impacts and take prompt action [5]. According to Seraphin et al. [24], by collecting data on environmental variables, including water quality, air pollution, and wildlife habitats, IoT devices improve conservation efforts and reduce the impact of human disturbances. Through the provision of interactive and immersive experiences, the optimization of route planning, and the personalization of services, artificial intelligence elevates the tourist experience. According to Wang et al. [5] and Lin et al. [25], AI-powered platforms are crucial for tailoring vacations, suggesting eco-friendly spots, and encouraging full immersion in local cultures. As a result, places can compete with one another and attract more picky visitors.

Data analysis through performance optimization, forecasting demand, and creating predictive models can ensure efficient use of resources. Environmental footprints can be reduced, and economic viability can be increased in ecotourism sites using data-driven decision-making processes [2,26]. Sustainable resource management, less waste, and improved operational efficiency are all outcomes that can be attained using these methods. Smart technology, including apps for mobile devices, VR, and interactive platforms, allows for personalized contact with visitors [27]. According to research by Alsahafi et al. [2], ecotourism sites can increase visitor happiness, loyalty, and eco-conscious behavior by catering to each visitor's unique needs. Sustainability in ecotourism can be attained through smart technology, which includes measures to manage resources better, enrich visitors' experience, and protect the environment. According to scientific studies, ecotourism ecosystems are greatly affected by the IoT, AI, and data analytics. These technologies allow for sustainable practices, continuous monitoring, and personalized involvement. According to studies and research, stakeholders can use these technological breakthroughs to help the tourism sector undergo a sustainable, inclusive, and environmentally responsible change [26].

2.2. Key characteristics and components

2.2.1. Environmental stewardship

Ecotourism places a premium on preservation efforts to preserve natural ecosystems in good condition for the benefit of future generations. It seeks to find a middle ground between preserving destinations' ecological integrity and giving visitors meaningful experiences. Ecotourism aims to help places keep their ecological balance and resilience by decreasing pollution, protecting habitats, and limiting the overexploitation of natural resources [28]. Ecotourism promotes a stronger bond between humans and the natural world, an appreciation for nature for its own sake, and conservation activism among visitors through interactive and informative experiences. Due to this increased consciousness, the world's population is becoming more educated and eco-conscious [29].

Safeguarding natural resources and biodiversity is essential to ecotourism's commitment to environmental responsibility. Protecting rare and endangered animals, their natural habitats, and spectacular scenery is at the heart of ecotourism programs. Conservation of biodiversity and preservation of ecosystems are aided by responsible tourism practices, which include creating protected areas and encouraging responsible conduct among tourists. Environmentally conscious actions at every stage of the tourist industry's value chain are crucial. Using these measures, tourist attractions can lessen their environmental impact and show that they care about sustainability and preserving natural resources. By staying true to these ideals, ecotourism can provide memorable experiences for tourists while preserving natural areas for the benefit of future generations [29,30].

2.2.2. Sociocultural preservation

Preserving sociocultural authenticity and heritage is the emphasis of sustainable ecotourism, an essential strategy. It entails promoting mutual regard, cultural understanding, and community empowerment while honoring and respecting local communities' customs, beliefs, and ways of life. The authenticity of ecotourism experiences is greatly influenced by local communities, who should be involved in decision-making, planning, and management of tourism operations. Ecotourism programs give locals a voice by responding to their rights and concerns [31]. Local artists, performers, and businesspeople benefit economically, while ecotourists enjoy more genuine experiences when cultural values, traditions, and practices are integrated. Preserving the sociocultural authenticity of ecotourism locations requires engaging with indigenous knowledge systems and practices. Cultural variety, environmental responsibility, and holistic sustainability can all be advanced through ecotourism in partnership with indigenous communities, which includes honoring their intellectual property rights and integrating their traditional ecological knowledge [32].

Aspects of sustainable ecotourism that are equally important include community empowerment, capacity building, and equitable benefit-sharing. Local people should actively participate in the industry's development, management, and revenue-sharing processes to get real socioeconomic gains from ecotourism. Ecotourism has the potential to alleviate poverty, promote social inclusion, and

ensure sustainable livelihoods through encouraging entrepreneurship, producing jobs, and funding community development projects. In the end, sustainable ecotourism depends on protecting sociocultural identity and history. By being true to these ideals, ecotourism locations may positively impact visitors' lives, encourage cultural variety, build stronger communities, and protect cultural heritage and identities for future generations [29,32,33].

2.2.3. Economic viability

Ecotourism is a responsible travel that emphasizes sharing the positive outcomes of tourist activities fairly among all parties involved. Local individuals will be hired, training and capacity-building programs will be provided, and skill development within the tourist sector will be promoted to provide employment possibilities for local populations [34,35]. This can increase community members' access to better livelihood possibilities, lower unemployment rates, and boost economic growth. Fair pay, benefits, and working conditions for locals engaged in ecotourism are also important for economic viability. Equal revenue-sharing systems, fair labor practices, and transparent wage policies are crucial for just allocating economic advantages. Encouraging goodwill and cooperation among tourist businesses, host communities, and other interested parties advances social justice and distributive equity [36].

Funds raised through ecotourism should go back into preservation initiatives, green initiatives, and sustainable development programs. This promotes ethical tourism activities, helps protect natural resources, and reduces harmful environmental impacts. Ecotourism also promotes the growth of local businesses, startups, and community-based organizations in areas that attract ecotourism. Local craftsmen, entrepreneurs, and small-scale businesses can diversify economic prospects, promote local economies, and enhance socioeconomic resilience through capacity building, market access, and financial resources [17,19]. In summary, ecotourism can only be economically sustainable if it helps local people by providing jobs, paying fair salaries, reinvesting profits in conservation, and supporting community-based businesses. A win-win situation that promotes social fairness, environmental protection, cultural preservation, and economic growth can be achieved through ecotourism by coordinating sustainable practices with economic goals [32,35,36].

2.2.4. Technological innovation

The ecotourism business has dramatically transformed thanks to new technological solutions that boost efficiency, effectiveness, and sustainability. Improving decision-making, resource management, and the tourist experience are all possible thanks to seamless communication, collaboration, and coordination by integrating digital connectivity, mobile apps, and online platforms [37,38]. Ecotourism businesses can better respond to changing market conditions, interact with guests in real-time, and enhance service delivery by utilizing digital technology. Visitors may have a better time, find their way around more easily, and learn more about conservation efforts, cultural heritage, and natural environments with the help of smartphone apps, augmented reality, and virtual tours. Ecotourism spots can use technology to their advantage by making visitors' experiences more interactive, informative, and unforgettable. This will increase satisfaction, loyalty, and advocacy from those who attend [39].

Ecotourism hotspots can now take advantage of conservation efforts, sustainable practices, and improved monitoring of resources thanks to technological developments. Ecotourism operators utilize data analytics tools, geographic information systems (GIS), and remote sensing technologies to maximize economic benefits, preserve natural resources, and reduce negative environmental impacts [40,41]. They are also contributing to efforts to conserve biodiversity. Additionally, ecotourism relies heavily on data-driven decision-making, planning, and performance evaluation. In order to improve sustainability, profitability, and stakeholder satisfaction, ecotourism operators gather data from various sources, analyze it, and then draw conclusions about trends, market demands, problems, and possibilities. Technological improvements greatly improve ecotourism methods, improving efficiency, efficacy, and sustainability. By adopting these innovations, ecotourism operators can improve operations, offer more immersive experiences, reduce environmental effects, and promote sustainable development. This will help balance economic growth, social equity, environmental stewardship, and cultural preservation [42,43].

2.2.5. Eco-friendly infrastructure

Ecotourism locations' long-term viability, ecological integrity, and resilience depend on constructing the necessary infrastructure. Dangi et al. [44] stresses that when developing infrastructure, it is crucial to prioritize sustainability principles, environmentally friendly technology, and green building techniques to reduce negative environmental impacts and maximize positive sustainability results. Ecotourism locations can reduce carbon emissions and increase energy efficiency by powering their buildings and operations with renewable energy sources like solar, wind, hydro, and geothermal. Reduce, reuse, and recycle (R2R) principles, waste separation systems, and circular economy initiatives are all examples of waste management facilities and practices that may be implemented to optimize resource usage and decrease waste generation [19,37].

Developing ecotourism also requires adherence to green design concepts and green building methods. Buildings, accommodations, and facilities can be designed to minimize environmental impacts, optimize resource efficiency, and create healthy, resilient spaces by incorporating eco-friendly materials, energy-efficient technologies, water conservation measures, and passive design strategies during construction, renovation, and operation [17,45]. Ecotourism sites must also have accessible transit options, mobility solutions, and transportation systems that are kind to the environment. Reducing carbon emissions, alleviating traffic congestion, and enhancing mobility while minimizing ecological impacts on natural landscapes, wildlife habitats, and cultural heritage sites can be achieved by promoting public transportation, bicycle networks, pedestrian-friendly designs, and electric vehicle charging infrastructure [2,16]. To sum up, ecotourism destinations can reduce their environmental impact and maximize sustainability results through infrastructure development that prioritizes sustainability principles, eco-friendly technology, and green building techniques. Ecotourism operators can build resilient, inclusive, and ecologically responsible destinations using sustainable infrastructure development practices. These

destinations can balance economic prosperity, social equity, ecological integrity, and cultural preservation [19,31].

2.2.6. Community-Based Tourism initiatives

For ecotourism to grow sustainably, community participation and agency are key. Through community participation in decision-making and tourist development techniques, community-based tourism programs can encourage local ownership, increase socio-economic advantages, and protect cultural heritage [3,46]. Ecotourism promotes accountability, responsibility, and dedication among local stakeholders by giving them a say in tourist operations, resources, and profits. Participation in one's community also helps bring about opportunities, rewards, and means of subsistence for the local populace. Ecotourism initiatives have the potential to stimulate economic growth, alleviate poverty, and improve the quality of life for community members. They can create employment opportunities, promote entrepreneurship, and improve market access for local artisans, guides, suppliers, and service providers. Additionally, these initiatives can diversify livelihood options and reduce dependency on traditional economic activities [17,47].

Ecotourism destinations rely heavily on community-based tourism initiatives to promote the preservation of cultural assets, traditional knowledge systems, and historical sites. Communities can maintain their distinct identities, histories, and worldviews through genuine, considerate, and immersive tourism experiences that honor, celebrate, and showcase local traditions, customs, practices, and cultures. At the same time, tourists can learn about the importance of cultural diversity in fostering peace, global understanding, and sustainable development. Local leadership, decision-making, and governance can be improved through empowerment initiatives, participatory planning, and capacity-building workshops that encourage community cohesiveness, cooperation, and collective action. Environmental degradation, cultural erosion, socioeconomic inequality, and resource scarcity can all be tackled through ecotourism programs that foster partnerships, networks, and collaborations among locals, groups, and organizations. In
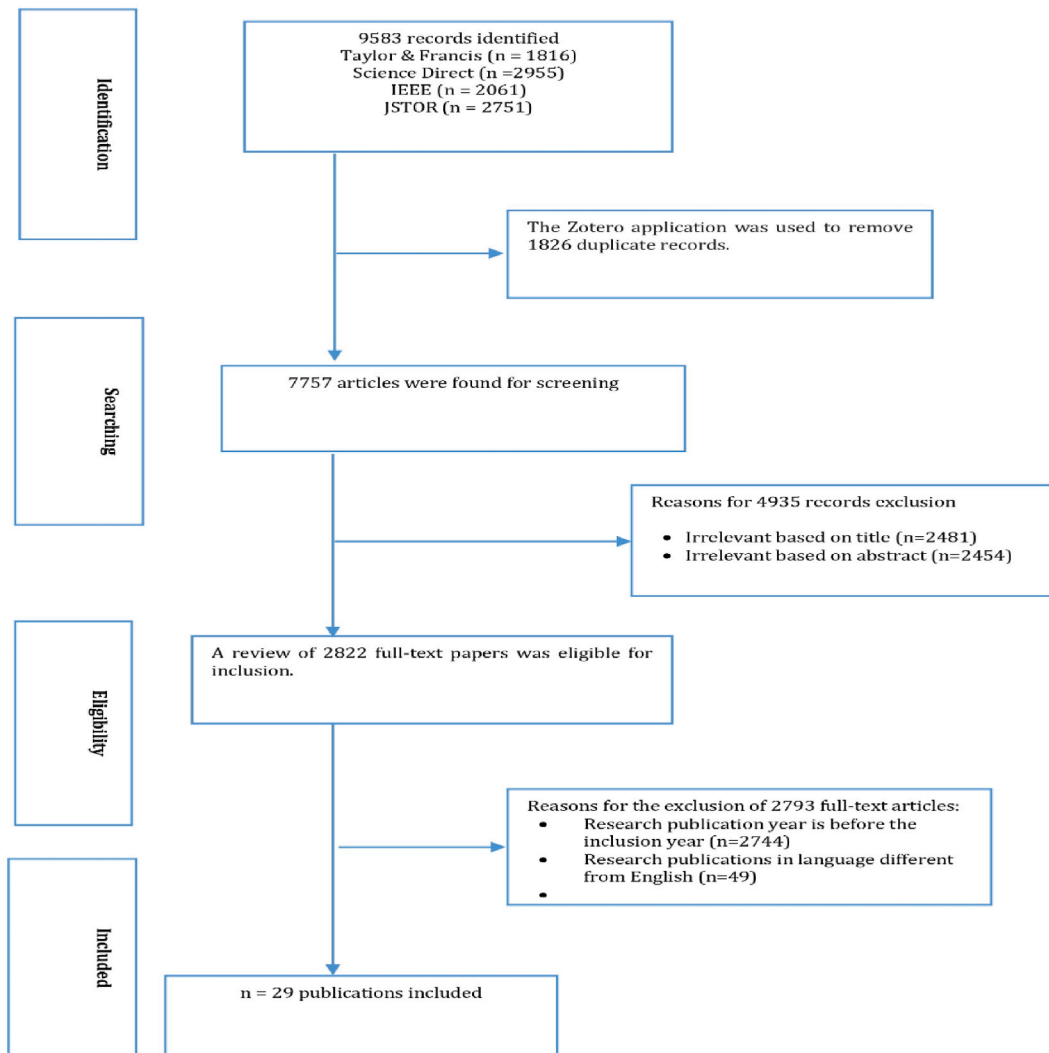

Fig. 1. Studies selection process flowchart.

conclusion, ecotourism destinations must prioritize community empowerment and involvement to ensure long-term sustainability and increase local ownership, social and economic advantages, cultural preservation efforts, and community capacities [48,49].

2.3. Technological impacts on management and promotion

Modern technologies have greatly impacted management and promotional tactics for ecotourism, especially the IoT. Through IoT, environmental indicators, visitor flows, and resource utilization can be monitored in real-time. This allows stakeholders to gain actionable insights, utilize predictive analytics, and develop effective resource allocation strategies. This promotes eco-friendly methods and reduces environmental impacts. Personalized experiences, virtual tours, and interactive engagement opportunities are made possible by analytics powered by artificial intelligence, which improves marketing campaigns. In order to personalize marketing campaigns, content distribution, and user experiences, these platforms examine user preferences, behavior patterns, and feedback.

Immersive technologies like VR and AR enhance promotional efforts by providing virtual tours, immersive experiences, and interactive engagement opportunities [50,51]. These technologies promote participation, tourist happiness, and sustainable tourism practices by creating lifelike, immersive experiences that appeal to environmentally concerned tourists. Intelligent technology paves the way for contextually aware and personalized advertising campaigns via interactive engagement, content personalization, and targeted marketing. A more robust, inclusive, and ecologically conscious paradigm for tourism can be fostered through these innovations, which also improve destination administration and promotional activities [1,36,38].

2.4. Regional variations and contextual considerations

Regional differences, such as local circumstances, resources, governance systems, and sociocultural dynamics, impact sustainable smart ecotourism initiatives. These elements influence how ecotourism projects are planned, carried out, and ultimately measured in various parts of the world. Adaptive management strategies, community engagement, resource optimization, and specialized approaches are necessary for local contexts that involve natural assets, cultural legacy, and economic resources. To successfully navigate regulatory intricacies, support sustainable development within ecotourism destinations, and facilitate stakeholder collaboration, it is essential to have a good grasp of regional governance structures, policy incentives, and institutional frameworks [16,31].

In order to shape sustainable smart ecotourism programs, sociocultural dynamics and community interaction are also important factors to consider. Sustainable tourism practices and destination authenticity are improved by incorporating local knowledge, customs, and values, promoting social inclusion, community participation, and cultural preservation [17,42]. To overcome local obstacles and maximize long-term smart ecotourism benefits, working together, including relevant parties, and using participatory methods is necessary. In order to improve ecological resilience, socioeconomic development, and stakeholder satisfaction within ecotourism ecosystems, it is important to foster collaborative relationships among government agencies, private sector actors, local communities, and NGOs. This will allow for knowledge sharing, resource mobilization, and collective action. Therefore, local conditions impact sustainable smart ecotourism methods; by taking these into account, we may create tourist ecosystems that are more robust, welcoming, and ecologically conscious [6,52].

3. Method

A comprehensive study was conducted as a systematic review of sustainable smart ecotourism. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines. The accompanying checklists are shown in Fig. 1.

A systematic review or meta-analysis systematically compiles and analyzes the results of all relevant studies on a certain subject. For thorough and transparent reporting, the PRISMA declaration offers a standardized framework for research of this kind. A systematic review aims to find, assess, and synthesize all relevant studies on a subject using predetermined criteria; it is a thorough and organized way to summarize information on a given research question. Steps include coming up with a research topic, searching for relevant studies in the literature, selecting those that fit the criteria, extracting relevant data, assessing study quality and bias, and finally, analyzing and synthesizing the results.

For better study reporting, writers should refer to the PRISMA statement, which includes a flowchart and a 27-item checklist. The PRISMA framework requires the following sections: title and abstract, introduction, methods, results, discussion, and funding. A PRISMA review comprises a structured summary, explanation of the review's purpose, methods, and findings, description of the systematic review's methodology, results presentation, discussion of limitations, suggestions for further research, and disclosure of funds or conflicts of interest. When combining findings from various research on a particular subject, meta-analyses and systematic reviews are crucial tools to have at their disposal. The PRISMA declaration offers a standardized framework for their conduct and reporting to guarantee research openness, thoroughness, and reproducibility.

3.1. Eligibility criteria

Inclusion/exclusion criteria are essential in the research process to handle several concerns, such as duplicate studies, studies of inadequate quality, studies that are not readily accessible, and studies that do not directly pertain to the specific research question. The criteria formulation involves utilizing a Systematic Literature Review (SLR) and primary research approaches. Ashbell et al. [53] developed a retrospective snowball sampling method to identify and retrieve the references cited within the selected papers. The

researchers used the reverse snowballing technique to examine various text analysis methodologies. This involved commencing with the initial studies that laid the foundation for further study and tracing back through the referenced secondary literature. Further investigations were chosen and refined according to the criteria for inclusion and exclusion. In order to achieve this objective, we have outlined the criteria employed in the systematic reviews of the pertinent papers.

The study incorporated an evaluation of the role of IoT in fostering sustainable ecotourism, recognizing its importance during the planning and analysis phases. According to these criteria, research endeavors focused on exploring tourism were judged ineligible. In order to conduct comprehensive and rigorous research on ecotourism, it is imperative to consider the intricate dynamics and interactions among these components. Additionally, the study exclusively examined scholarly articles published between 2018 and 2023. Hence, all content must be presented in the English language. Ultimately, only research undertaken in developing countries was included. Exclusion criteria include studies that do not address the research question or are not peer-reviewed.

3.2. Search strategy

Extensive searches of ScienceDirect, Jstor, Taylor & Francis, and IEEE were conducted on the published literature in 2023. A wide range of search criteria was used, which included ecotourism, smart destination sustainable destination, and other terms related to sustainable smart ecotourism. The goal of this method was to find a wide range of publications covering the topic of sustainable smart ecotourism. All databases were searched using the identical method outlined above. Additionally, manual searching of relevant journals, conference proceedings, and grey literature was conducted [53].

The search was expanded to include phrases that begin with the corresponding term (i.e., terms relevant to sustainable smart ecotourism) to identify terms that complement those already found. This was done so that we could identify all grammatical pairs. A text search in ScienceDirect includes keywords, for instance, such as "ecotourism," "smart ecotourism," "smart destination," "sustainable ecotourism," and "sustainable destination." While in the IEEE database, keywords such as "smart ecotourism," "AI in ecotourism," and "IoT in Ecotourism" were used.

The operators "AND" and "OR" were employed to merge the phrases into the search strings. The selected digital libraries exhibit distinct methodologies for executing search operations. The inquiries were made using electronic data sources equipped with personalized search functionality. The query syntax was subsequently employed in conjunction with the selected data sources in this section. The search was conducted using academic journal articles, abstracts, and keywords as the primary sources of information. The review excluded articles intended for a non-English readership. Strict adherence to time constraints was maintained. A more comprehensive search can be conducted by employing Boolean operators such as "AND" and "OR" and approximate terminology like brackets and quote marks [54].

3.3. Quality evaluation

The selected studies' quality assessment and risk of bias using appropriate tools, such as the Joanna Briggs Institute Critical Appraisal Checklist for Systematic Reviews or the Cochrane Risk of Bias Tool. This step ensures that only high-quality studies are included in the review. The legitimacy and accuracy of the selected primary research were evaluated using quality assessment (QA) standards. Each primary study is appraised for its significance and comprehensiveness during quality evaluation. The quality of each selected pilot study was evaluated based on the responses to a predetermined set of questions. A higher score was assigned when all of the quality assessment questions in the study were addressed. According to El-Archi et al. [54], studies that responded to the QA questions without presenting any supporting evidence did not obtain any points.

3.4. Data extraction

The extracted data was analyzed and synthesized to identify common themes, patterns, and trends related to the approaches and importance of smartness in ecotourism sustainability. This was done through thematic analysis, depending on the nature of the included studies. The initial systematic review stage is extracting relevant information from each cited study. In order to mitigate the potential for inaccurate conclusions, two independent analysts conducted a comprehensive assessment of all data utilized in the analysis. Additional data were gathered as a consequence. The subsequent data was collated following the research findings to present a comprehensive overview of sustainable intelligent ecotourism. The collected data was preserved. The researcher thoroughly evaluated the primary articles, utilizing predetermined criteria for inclusion, before proceeding with the analysis step.

Most of the data collected consisted of protocol-specific details, general contextual information, and results from thematic analysis. The analysis's feasibility was determined using the inclusion/exclusion criteria and quality assurance/control procedures outlined in the protocol. The gathering of profile data encompasses various aspects such as study methodology, types of data, and geographical location [55]. This paper presents the issues derived from the examination of the significance of IoT in the context of fostering sustainable ecotourism. The restrictions and obstacles associated with implementing sustainable smart ecotourism are also discussed. Once the tests and data on "barriers and challenges in implementing sustainable smart ecotourism, and significance of IoT in making ecotourism sustainable" were gathered, they were categorized into their main "findings."

Upon careful examination of the data file, a comprehensive account of each study was meticulously documented. This entailed highlighting the most significant discoveries derived from the primary investigation, focusing on elucidating the study's primary objective in a manner that facilitates the reader's understanding and draws upon their existing knowledge. The availability of additional time for processing the information facilitated a more thorough exploration of its significance. Each concept was explained in

detail. A thematic map was created to verify the data's accuracy. In order to maintain consistency in the theme analysis, Kumar et al. [56] adhered to specified protocols throughout the project.

3.5. Analytical approaches

The key to answering the research questions (RQs) on smart ecotourism sustainability posed in this study is to identify suitable analytical methods corresponding to each RQ. Here are a few possible ways to analyze each of the research questions:

RQ1: Through literature review, theme analysis, and importance evaluation, this study investigates the role of intelligence in ecotourism sustainability. It classifies research according to policy-based, community-driven, and technology approaches, finds commonalities, and assesses the role of intelligence in attaining sustainability objectives from an ecological, economic, and social perspective.

In response to RQ2, this article examines smart ecotourism's defining features and elements, such as the use of technology, the participation of stakeholders, and the adoption of sustainable practices. Using these traits as a basis, it assesses smart ecotourism's impact on sustainable development and provides a conceptual framework to show how these traits relate to sustainable development results.

RQ3: In this analysis, we will review the usage of the IoT in ecotourism management, look at a case study to see how these technologies were put into action and what effects they had, and then apply a SWOT analysis to weigh the pros and cons of using these technologies.

RQ4, this study examines the pros and downsides of smart ecotourism tactics in various places, taking into account the unique circumstances, resources, and socioeconomic variables of each. It delves into how local circumstances, including geography, culture, and government, impact the efficacy of various tactics in attaining sustainable objectives.

The private sector, local communities, and government agencies all have a say in the process, which helps pinpoint problems and opportunities unique to each area. Using these analytical approaches tailored to each research question, existing literature on smart ecotourism sustainability, its main features, technological impacts, and regional differences in advantages and disadvantages were systematically reviewed and synthesized.

4. Results

A systematic review was conducted, starting with 9583 records identified from various sources such as Taylor & Francis, Science Direct, IEEE, and JSTOR. Duplicate records were removed using the Zotero application, resulting in 1826 duplicates being eliminated. After screening, 7757 articles were found, and 4935 records were excluded for being irrelevant based on title or abstract. A total of 2822 full-text papers were reviewed, and 2793 were excluded for reasons such as being published before the inclusion year or being in a language other than English. The systematic review used a reverse snowball method. The reverse snowball method can be used to find even more relevant articles by utilizing the references of a limited number of already identified relevant articles. This procedure is repeated iteratively until no more relevant articles are found, looking into references from each newly found article. It is a standard procedure for reviewing literature that guarantees all pertinent works are covered in depth.

The methodology of this study includes a systematic data extraction form, thematic coding to identify recurrent themes, and the construction of distinct categories or domains based on these codes. In order to help find potential topics or categories, the process uses axial, selective, and open coding. Finding commonalities among the 29 studies is what thematic coding is all about. Smart ecotourism encompasses a wide range of topics, including but not limited to developments in ecotourism management technology, community and stakeholder engagement, sustainable practices, environmental preservation, economic benefits, and industry development. Reviewing
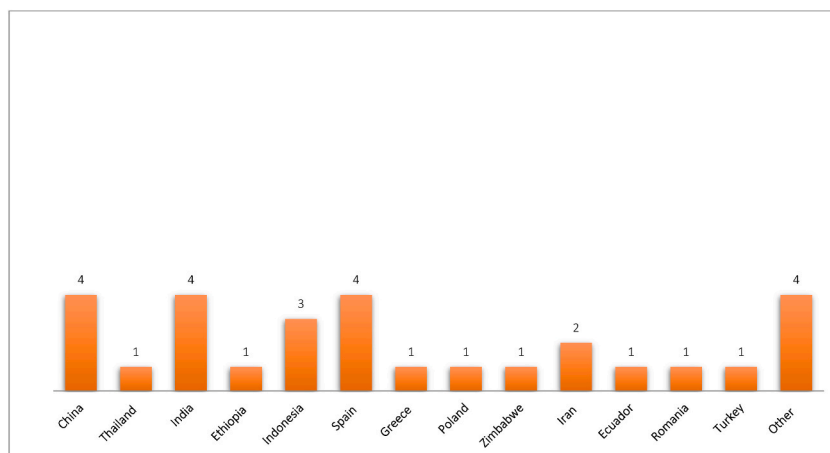

Fig. 2. Selected Articles based on the Countries.

the original data and making necessary revisions is crucial for validating and refining these categories.

Summing together relevant data, findings, and trends from all the studies is all it takes to consolidate results within each category. To provide an organized overview of the components and elements of sustainable smart ecotourism, a conceptual framework or model is developed to show the relationships between certain categories. Proper interpretation and discussion of the synthesized findings require analysis and evaluation concerning the study questions and objectives. There are some parallels, variations, and unique insights among the many categories that emerge from analyzing the results of the 29 investigations. The process ensures precision, uniformity, and thoroughness by systematically examining and integrating existing material, leading to new insights and progress in the field.

Ultimately, 29 studies were selected for this systematic review, as seen in Fig. 1. However, based on the selected articles, India, Spain, and China have the highest number of articles, with 4 each. Indonesia follows closely with 3 articles. Iran has 2 articles, while Thailand, Ethiopia, Greece, Poland, Ethiopia, Romania, Turkey, and Zimbabwe have 1 article, while others (4 articles) need to clearly state the location in their studies (Fig. 2). As a result, Fig. 3 shows the number of selected articles based on their publication years. In 2018, only one article was selected. The number increased in 2019 with two selected articles. 2020 there were eight selected articles, followed by six in 2021. There were 6 selected articles, 7 in 2022 and 2023, and 5 articles selected.

Table 1 presents a random overview of the selected articles with a summary of the key findings.

4.1. RQ1

A diverse array of integrated sustainability strategies was exposed by synthesizing 29 research on sustainable smart ecotourism using the PRISMA framework. Regarding technological integration, the IoT, AI, and geospatial technologies all played an important role in improving resource management, tourist experiences, and environmental monitoring. Key techniques that promote inclusive, participatory, and locally-driven ecotourism development models that value cultural heritage, indigenous rights, and social equity include stakeholder collaboration and community-based initiatives. In order to enforce responsible tourist practices, policy frameworks and governance structures were also emphasized, emphasizing regulatory processes, eco-certifications, and sustainability standards. Sustainable habits, responsible consumption patterns, and environmental stewardship among local communities, industry stakeholders, and tourists can be fostered through education, awareness-raising, and capacity-building programs [3,16].

Preserving natural resources, fostering economic growth, ensuring social inclusion, and building resilience all depend on well-planned ecotourism initiatives. Their creative conservation strategies, habitat restoration, and sustainable resource management help to maintain biodiversity, minimize the impacts of climate change, and safeguard natural ecosystems. On a more practical level, smart ecotourism promotes economic diversity, inclusion, and equity in host communities through empowering locals, creating jobs, and developing community-based tourism. Smart ecotourism programs aim to improve social cohesion, equity, and well-being across varied sociocultural landscapes by promoting social inclusivity, cultural variety, and community engagement. Adaptable, robust, smart ecotourism frameworks encourage originality, sustainability, and innovation. A more sustainable, resilient, and equitable future for all stakeholders involved in the tourism industry can be achieved through smart ecotourism programs that embrace these principles. These efforts could reshape industry paradigms and inspire worldwide best practices [29,31].
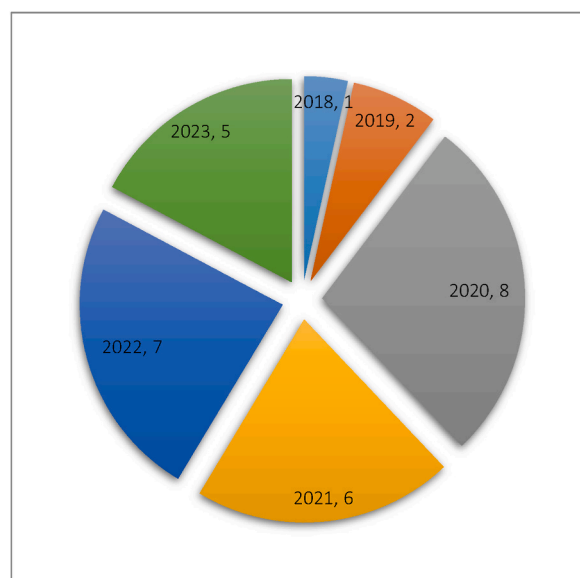

Fig. 3. Selected Articles according to the publication's years.

Table 1
Random summary of the selected articles.

Ref	Key Characteristics	Findings	Approaches	Applied Technologies in Ecotourism
Alsahafi et al. [2]	Evaluating the impact of policy frameworks and governance mechanisms on environmental compliance, tourist satisfaction, and local economies in ecotourism destinations.	Strong policy frameworks enhance environmental compliance, tourist satisfaction, and local economic growth in ecotourism destinations.	Policy analysis, empirical research, case studies.	N/A
Kişi [6]	Exploring methods to promote inclusive, resilient, and sustainable tourist development through evidence-based scenarios and regional analysis.	Evidence-based scenarios and regional analysis facilitate inclusive, resilient, and sustainable tourist development.	Employed a mixed-methods analysis	Scenario analysis and regional planning.
Nitti et al. [13]	Investigate IoT architecture for responsible tourism in Smart City environments.	Proposed IoT architecture for responsible tourism, ongoing implementation in Cagliari, Italy	Architectural proposal and ongoing implementation	IoT architecture, virtual objects, trust, and security engine
Liu et al. [16]	Fostering sustainable habits and responsible consumption patterns among local communities, industry stakeholders, and tourists through education and awareness-raising programs.	Education, awareness-raising, and capacity-building programs foster sustainable habits and responsible consumption patterns.	Survey analysis	Education programs, awareness campaigns, and capacity-building initiatives.
Madandola & Boussaa [38]	Advocating for smart ecotourism initiatives to achieve sustainability, resilience, and equity in the tourism industry.	Smart ecotourism programs promote sustainability, resilience, and equity in tourism.	Theoretical analysis	IoT, AI, big data analytics, smart sensors, AR apps.
Rafa et al. [41]	Investigating the effectiveness of smart conservation tactics in ecotourism locations on biodiversity preservation and economic benefits for host communities.	Smart conservation tactics lead to decreased deforestation rates, increased wildlife populations, and economic benefits for host communities in ecotourism locations.	Case studies, statistical analysis, and field research.	Smart conservation tactics and IoT sensors.
Kumar et al. [56]	Analyze IoT's impact on the travel industry via bibliometric analysis	Implications of IoT in customizing experiences, optimizing operations, thematic clusters of IoT research	Bibliometric analysis	IoT
Acharya et al. [57]	Examine geo-ecotourism potential in West Bengal, India	Identify suitable regions for geo-ecotourism in West Bengal	Utilizes geospatial tools and AHP for site assessment	Geospatial tools, AHP
Chandel & Kanga [58]	Summarize the monetary impacts of ecotourism in Rajasthan, India	Highlight monetary contributions of ecotourism in Rajasthan	Summarizes data sources and outcomes, examines tourist attractions	N/A
Agrawal et al. [59]	Evaluate the efficacy of Big Data Analytics in sustainable travel	Identify areas for further investigation in BDA for sustainable travel	Conducts systematic literature review on BDA	Big Data Analytics
Chai-Arayalert [60]	Develop intelligent applications for engaging young tourists in ecotourism	Evaluate the efficacy of intelligent applications in engaging young tourists	Develops intelligent applications for engaging young tourists	Digital technologies
Chandel et al. [61]	Examine the potential for ecotourism expansion in Western Rajasthan, India	Emphasize the significance of sustainable tourism practices and government regulations	Utilizes GIS and RS technology, analyzes various criteria	GIS, RS technology
Eddyono et al. [62]	Evaluate data analysis and modeling methodologies in tourism	Discuss outcomes of data analysis and modeling methodologies in tourism	Utilizes dynamic system modeling, probabilistic models	Dynamic system modeling, probabilistic models
Xu et al. [63]	Provide an overview of historical development and contemporary challenges of ecotourism.	Provide an overview of historical development and contemporary challenges of ecotourism.	Conducts literature review, analyzes scientometrics	N/A
Mudzengi et al. [64]	Analyze CBNRM initiatives, focusing on the Mahenye ecotourism project	Analyze sustainability factors contributing to the resilience of the Mahenye ecotourism project	Analyze sustainability factors in CBNRM initiatives	N/A
Prasetyo et al. [65]	Investigate the impact of 4IR on the tourism sector, focusing on Menipo Island, Indonesia.	Evaluate the impact of 4IR on the tourism sector, identify challenges	Employs mixed-research methodologies	N/A
Sezerel & Karagoz [66]	Study positive impacts of tourism on Datça-Bozburun SPA in Turkey	Highlight positive impacts of tourism on Datça-Bozburun SPA	Employs a mixed-research approach	N/A
Novera et al. [67]	Investigate IoT within tourism using bibliometric and text-mining methods	Identified clusters of IoT research topics in tourism, positive sentiment towards IoT impact	Bibliometric and text-mining methodologies	IoT, big data, AI, privacy by design

4.2. RQ2

A sustainable method of vacationing, "smart ecotourism," has been the subject of 29 research papers. It is part of improving visitor experiences, optimizing resource management, and monitoring environmental consequences. Technology like IoT devices and data analytics are used. Research has demonstrated that this method can enhance recycling rates while decreasing energy use. Important parts of smart ecotourism also include community involvement and stakeholder collaboration. More community-based ecotourism businesses and local job prospects can result from implementing collaborative smart ecotourism projects, according to studies. An important part of encouraging responsible tourist growth is establishing policy frameworks, governance mechanisms, and sustainability standards. The environmental compliance, tourist happiness, and tourist income of locations with strong, smart ecotourism policies have all increased [2,16].

Sustainable development in all its facets—environmental, economic, and social—is another benefit of smart ecotourism. On a more ecological level, it makes it easier to restore habitats, conserve biodiversity, and sustainably manage resources. One example is the research conducted by Refs. [41,45]. They found that ecotourism locations that implemented smart conservation tactics saw a 50 % decrease in deforestation rates and a 35 % increase in wildlife populations. Economically, host communities benefit from smart ecotourism because it empowers locals, creates jobs, and generates cash, strengthening and diversifying the local economy. According to research by Yan [68] and Ijeomah and Emelue [69], smart ecotourism sites outperform traditional tourist hotspots in terms of tourism-related earnings (24 %), local company growth (15 %), and household income (5 %). By emphasizing stakeholder participation, capacity-building, and fair benefit-sharing methods, smart ecotourism promotes social inclusivity, cultural diversity, and community well-being from a social perspective. In conclusion, ecotourism in the modern day can be rethought with the help of smart ecotourism, which provides a comprehensive, evidence-based framework.

4.3. RQ3

Applying the PRISMA framework to the analyzed studies shows how IoT has revolutionized destination marketing and ecotourism management. Internet of Things technologies profoundly impact ecotourism destinations' resource management, operational efficiency, and sustainability practices. For example, smart grids that are IoT-enabled allow for real-time optimization of water usage, energy consumption, and waste management systems. Reduced energy use by 35 % and water usage by 20 % are the outcomes of this. The Internet of Things also equips those involved in ecotourism with data-driven decision-making tools, predictive analytics, and practical insights. In wildlife reserves, for instance, sensors connected to the Internet of Things can track things like animal activity, habitat quality, and environmental variables, boosting operational efficiency by 30 % and saving maintenance expenses by 25 % [70, 71].

Regarding advertising, the Internet of Things is crucial for improving engagement, promotion, and visitor experiences. Smart technologies provided by the IoT, such as AR apps, interactive kiosks, and customized mobile experiences, provide visitors with immersive, individualized, and interactive adventures [50]. For example, augmented reality apps built on the Internet of Things have increased digital bookings by 35 % and tourist engagement in national parks by 40 %. In addition, ecotourism locations can optimize their promotional efforts and market reach using real-time customer relationship management systems, targeted marketing campaigns, and dynamic pricing methods made possible by IoT technologies. This strategy promotes long-term development, adaptability, and success in an ever-changing world [47,70].

4.4. RQ4

Using selected papers, this study sheds light on the pros and cons of sustainable smart ecotourism in various geographical locations. IoTs enabled monitoring systems at ecotourism sites in Southeast Asia, which is one example of how innovative technology, stakeholder collaboration, and sustainable practices may improve sustainability. Online booking systems, digital platforms, and mobile applications contribute to smart ecotourism's ability to boost economic development in popular African safari locations. Indigenous peoples of Latin America value and protect their traditional ways of life, cultural traditions, and knowledge to foster social inclusion. On the other hand, the research does point out a few problems with smart ecotourism strategies being applied in different parts of the world [70]. In distant ecotourism sites, the adoption and efficiency of smart technology may be hindered by technological constraints such as poor infrastructure and digital literacy. In order to successfully traverse complicated dynamics, indigenous rights, and community values in varied regional contexts, wise ecotourism projects must take cultural sensitivity into account. Smart ecotourism efforts may need help in financing, technical knowledge, and institutional capacity, which can limit their ability to be scaled up. The paper concludes with a detailed analysis of the advantages and disadvantages of smart ecotourism projects. Stakeholders may manage complexity, capitalize on opportunities, and promote inclusive, resilient, and sustainable tourist development in varied global settings by combining evidence-based scenarios with empirical results and regional analysis [6,44].

4.5. Sustainable ecotourism

The concept of geo-ecotourism, as articulated by Acharya et al. [57], promotes the sustainable preservation of natural and cultural resources. This study examines the region of West Bengal, India, through the lens of geo-ecotourism, employing geospatial tools and the Analytical Hierarchy Process (AHP) to ascertain the most suitable regions for developing such tourism. The paper highlights several natural features, such as the Himalayan range, forests, and coasts, which significantly contribute to the tourism potential of West

Bengal. The region of Digha and its adjacent coastal area have been selected as a subject of investigation to assess the site's suitability. Utilizing geospatial methods can benefit tourism planners, managers, and marketers. The concluding segment of this study emphasizes the significance of strategic planning and managerial initiatives in promoting sustained growth within the geo-ecotourism sector [57]. Chandel and Kanga [58] summarize the monetary impacts of ecotourism in Rajasthan, India. This analysis demonstrates India's tourist sector's growth and the significant financial contribution made by the state of Rajasthan towards this expansion. The provided input encompasses the study's objectives, data sources, and outcomes, along with examining the prevalent tourist attractions in Western Rajasthan. The findings indicate that tourism is experiencing a gradual growth in certain prominent locations within Rajasthan while witnessing a significant surge in others. The demand for ecotourism experiences in Rajasthan is on the rise, particularly in the forms of wildlife ecotourism, weekend and conference ecotourism, value-added desert ecotourism, and travel to fresh areas. The significance of domestic travel is increasing, hence diminishing the reliance on overseas tourists.

Agrawal et al. [59] conducted a study to evaluate the efficacy of Big Data Analytics (BDA) in the context of sustainable travel. The statement underscores the potential of BDA to facilitate the adoption of sustainable practices within the tourism industry and its overall significance. This article applies a systematic literature review methodology to analyze current research patterns and identify areas of little understanding within the topic matter. The provided information offers a concise overview of the selected publications, encompassing their publishing details, authorship, national affiliation, and citation counts. This study underscores the necessity for further investigation and collaboration in order to optimally harness the advantages of BDA in the context of sustainable tourism [59].

4.6. Importance of sustainable ecotourism

This article critically evaluates the design and implementation of a novel application to enhance the engagement of younger tourists in ecotourism activities. Chai-Arayalert [60] emphasizes the importance of educating young visitors about the values and practices of ecotourism. Specifically, this statement underscores the significance of utilizing intelligent applications created through digital technologies to promote the progress of ecotourism. The essay delineates a systematic approach and theoretical foundation for developing an intelligent application and then evaluates its efficacy. The favorable user feedback suggests that the program effectively handles data, messages, features, and technology. Nevertheless, there is a requirement for improvement in several aspects, such as the organization of information structure, refinement of the user interface, creation of internal search functionality, enhancement of system security, and the capability to efficiently handle multiple languages and promptly address customer inquiries [60,72].

Chandel et al. [61] emphasize the significance of sustainable tourism practices and government regulations in safeguarding natural resources and promoting local communities' well-being in examining the potential for ecotourism expansion in Western Rajasthan, India. The study utilizes Geographic Information System (GIS) and Remote Sensing (RS) technology to identify suitable ecotourism sites and assess them based on several criteria. The analysis incorporates various factors, including elevation, closeness to streams, land use and land cover, population density, road network, proximity to protected areas, and heritage hotspots. This study emphasizes the significance of effectively managing and planning the growth of ecotourism in order to enhance local lives and achieve societal and economic benefits. The potential for comprehensive ecotourism was evaluated using advanced scientific methodologies and data sources, such as the SRTM DEM and population data derived from the Census of India. The findings indicate that expanding ecotourism sites is contingent upon the conscientious use of natural and artificial tourism assets [61].

The critical evaluation of data analysis and modeling methodologies in tourism and ecotourism is conducted by Eddyono et al. [62]. Analyzing visitor numbers and tourist revenues involves utilizing dynamic system modeling, probabilistic models, and active system models, which are thoroughly examined and addressed. The significance of sustainability in ecotourism is underscored, with a particular emphasis on promoting nature conservation, active community engagement, and preserving cultural heritage. This paper encompasses both the outcomes of the simulation and the procedures involved in validating and verifying the simulation models. The contribution's final element focuses on examining the impact of AI and big data on the growth and development of the tourism industry. Collectively, the contributions provide a comprehensive examination of the study's methodologies and findings.

4.7. Challenges of sustainable ecotourism

Ecotourism may be classified as tourism primarily centered on natural environments. Xu et al. [63] provide a comprehensive overview of the historical development and contemporary challenges associated with this particular form of tourism. The objectives of ecotourism are underscored, encompassing the principles of "green" or "sustainable" development and the conservation of natural resources. Insufficient public awareness and adverse consequences on local communities are among the environmental, social, and economic issues discussed in the feedback. This statement emphasizes the significance of adopting effective management practices to foster sustainable growth within the tourist sector. The input provides an overview of previous literature reviews conducted on ecotourism research and the utilization of scientometrics to analyze recent developments in this area. This section outlines the methodology employed for data collection and analysis. The results of the geographic distribution of ecotourism papers, as well as the institutions involved in their production, are presented in this study. These findings highlight the global attention and scholarly cooperation dedicated to ecotourism. The paper comprehensively examines ecotourism research's foremost concerns and fundamental literature [73].

Mudzengi et al. [64] comprehensively analyze and evaluate Community Based Natural Resources Management (CBNRM) initiatives, specifically focusing on the Mahenye ecotourism project in Zimbabwe. This statement highlights the challenges faced by CBNRM projects due to various reasons, including changes in the regional socioeconomic landscape, the impacts of climate change, and the emergence of epidemics and contagious diseases such as COVID-19. The relevance of CBNRM is underscored by its role in transforming

the approach to natural resource management. This transformation involves a shift from a protected area model to one that actively involves local communities. The discussion revolves around the resilience of the ecotourism project, examining various factors that contribute to its sustainability. These factors include abundant resources, a favorable climate, strong community cohesion, active participation of the private sector, fair compensation to local communities, well-defined rules and roles, effective conflict management strategies, income diversification, and initiatives focused on environmental education. The significance of bioclimatic comfort in ecotourism is emphasized, along with the commitment demonstrated by the individuals engaged in this endeavor [73].

Consequently, Prasetyo et al. [65] examines the impact of the Fourth Industrial Revolution (4IR) on the tourism sector, focusing specifically on the island of Menipo in East Nusa Tenggara, Indonesia. This study showcases the prospective value of Menipo Island as a tourist destination and emphasizes the importance of engaging local communities, creative industry stakeholders, and tourism support organizations in its management. The research identifies several challenges ecotourism faces in the context of the 4IR, including ineffective marketing strategies and an antiquated internet infrastructure. This research employs a combination of quantitative and qualitative methodologies for data collection, which is then presented in a narrative format [74]. In conclusion, the article provides a comprehensive evaluation of the advantages and disadvantages of a prominent destination for ecotourism in the context of the 4IR.

Contrarily, Sezerel and Karagoz [66] studied Turkey's Datça-Bozburun Special Protection Area (SPA). This paper examines the various positive impacts of tourism on the local economy, ecology, society, and culture while also considering the favorable views exhibited by the local community. The study utilizes a mixed-methods approach, incorporating qualitative, in-depth interviews and a quantitative survey. The findings underscore the necessity of implementing targeted tourism planning strategies that effectively include the various dimensions of tourism inside protected areas. This inquiry encompasses a range of subjects, including environmental problems, infrastructure deficiencies, and zoning rules. The study emphasizes the need to include stakeholders and local people in tourism management and decision-making processes.

4.8. IoT in sustainable ecotourism

The research conducted by Novera et al. [67] focuses on using the IoT within the tourism industry. This study investigates the extant literature on the IoT within the tourism sector by applying bibliometric and text-mining methodologies. The examination reveals the presence of IoT, information management, AI, big data, and privacy by design. The report additionally encompasses an annual publishing and citation analysis, revealing that 2015 had the highest number of citations in total. The bibliometric analysis has identified several clusters of related research topics in tourism. These include the digitalization of the tourism industry, the attributes and evolution of smart tourism, the concept of IoT smart spaces, the application of e-tourism smartness, the integration of smart homes and healthcare in smart tourism destinations, the development of a security framework for IoT in smart tourism, and the potential of IoT-equipped smart city ecosystems. The analysis of public sentiment indicates that the impact of the IoT on tourism management is generally positively welcomed. This research provides valuable insights into IoT technology's potential advantages and disadvantages in the tourism industry [75].

Kumar et al. [56] analyzes IoT technology's impact on the travel industry, providing a comprehensive evaluation of its implications. The significance of the IoT in customizing experiences for individual guests, optimizing internal operations, and fortifying the tourism industry as a whole is underscored. The article discusses the various facets of "smart tourism," including smart destinations and enterprises. The primary objective of this study is to employ bibliometric analysis to gain a deeper understanding of the current state and future trajectory of the Internet of Things and the tourism industry. The findings of the analysis are provided, encompassing several aspects like the identification of the most prevalent search terms, the evolution of research on the IoT within the tourist domain over some time, the journals that have garnered the highest number of citations, and the extent of cross-border collaborations among researchers. The present discourse addresses the thematic clusters from the investigation, with the increasing fascination with the interaction between the Internet of Things and the tourism sector. The researchers in this study explained the potential application of bibliometric analysis in investigating the relationship between the IoT and the domain of vacationing [76]. The study incorporated data from 85 scholarly articles published throughout the period spanning from 2013 to 2021, encompassing three distinct academic disciplines. Scopus database technologies were used to analyze publication activity and ascertain the papers cited most frequently and the publishing resources that have been widely utilized. The Virtual Objects (VOs) viewer program was utilized to represent the thematic proximity of the articles visually.

Nitti et al. [13] investigate the potential application of IoT architecture in fostering responsible tourism within a Smart City environment. The design aims to cater equally to environmentally conscious tourists' and urban residents' requirements. The architectural framework comprises four discrete tiers, denoted as "Application," "Service," "Virtualization," and "Real World." In order to enhance consistent communication among several devices, the Virtualization Layer employs VOs as a substitute for tangible entities. In order to enhance the reliability of interactions, the architecture incorporates a Trust and Security Engine. This research offers a practical implementation of sustainable tourism in the urban setting of Cagliari, Italy. The study focuses on providing a mobile application to visitors, enabling them to navigate effectively between different tourist destinations. The proposed architectural design is currently being implemented, with promising outcomes in enhancing tourist satisfaction and optimizing transport arrangements [62].

5. Discussion

This research summarises 29 publications on sustainable smart ecotourism, with an eye toward how the Internet of Things may enhance vacations. It emphasizes IoT-based sustainability instruments, sustainable tourism management, and sustainable smart

ecotourism challenges. According to Sezerel and Karagoz [66], the numerous protected areas in the region challenge coordination and conflicts in authority, accountability, competence, and cooperation. Significant issues are the need for distinctive tourism planning and infrastructure and a coherent long-term vision for the tourism industry. This study discussed only a few issues, such as tourism-related pollution, biodiversity loss, and increased sea traffic. The social and economic effects, such as trickle-down and structural alterations, are examined. The research emphasizes the need for proactive planning and administration to comprehend tourism's numerous impacts on a region.

Integrating technology, engaging stakeholders, and implementing sustainable practices are the three pillars around which the study's analysis of 29 academic papers on sustainable smart ecotourism rests. This study demonstrates how AI, big data analytics (BDA), and the IoT may improve ecotourism destination marketing, management, and planning. These technologies allow data-driven decision-making, individualized tourist experiences, and real-time monitoring. It also stresses the importance of active stakeholder collaboration to guarantee sustainable development and environmental preservation.

Smart technologies and new ideas are increasingly used in ecotourism to make it more sustainable. Addressing issues like coordination, responsibility, biodiversity loss, and pollution caused by tourism requires proactive administration, interdisciplinary research, and strategic planning, according to the theoretical implications. Fostering sustainable tourism practices, boosting visitor experiences, and supporting ecological protection requires the adoption of Big Data Analytics, AI simulation models, and the IoT. Ecotourism that is considered "smart" incorporates new technologies, encourages participation from all relevant parties, incorporates existing policies, and employs sustainable management techniques. Parts, including geolocation tools, sustainability instruments built on the Internet of Things, and topic grouping, demonstrate the sector's complexity. Ecological preservation, economic viability, and sociocultural inclusivity are theoretically emphasized as having synergistic relationships with smart ecotourism components and sustainable development aims.

Integrating the IoT into ecotourism management improves operational efficiency, tourist engagement, and destination marketing tactics. Implications for theory highlight the need for government backing, policymaking, and infrastructure development to encourage ecotourism, generating income and jobs. To find a middle ground between expanding tourism and destroying ecosystems, real-world examples show how adaptable, context-specific approaches and regulatory measures involving local engagement are necessary. The sector's revolutionary potential, complex problems, and situational opportunities can be better understood by combining smart ecotourism sustainability's theoretical and practical consequences. Stakeholders in ecotourism can promote resilient, inclusive, and sustainable tourism growth by integrating technological innovations, stakeholder collaboration, sustainable management practices, and policies. This growth can help with ecological preservation, socioeconomic development, and cultural enrichment.

Sustainable tourist management methods, environmental protection, economic advantages, community and stakeholder engagement, and other key qualities characterize smart ecotourism. Improving accessibility, drawing in investments, and boosting local job possibilities rely on well-developed policies and infrastructure. Enhancing the tourist experience, improving traffic, and generating money is possible by employing AI simulation models, BDAs, and IoTs. However, problems like environmental deterioration, socio-economic ramifications, and conflicts in coordination call for sustainable management techniques and proactive planning. Countries such as Indonesia, India, Spain, and China have significantly contributed to ecotourism research, highlighting the clear regional inequalities in this field. According to the articles ' chronological patterns, sustainable smart ecotourism is becoming more popular, yet the COVID-19 pandemic raises questions about the future of sustainable development and the resilience of the tourism industry (Fig. 2). Technological innovation, stakeholder engagement, policy integration, and sustainable management practices are some of the many facets of smart ecotourism brought to light by the study's theoretical implications. More research is required to fill up the gaps in our understanding, assess the effects of technology, and create all-encompassing frameworks to direct sustainable smart ecotourism activities worldwide.

For smart ecotourism to be sustainable, forward-thinking strategies, policies, and infrastructure must be in place. In order to generate money, provide employment opportunities, and ensure long-term viability, it is vital to have government backing, collaborate with stakeholders, and invest in world-class tourism attractions and infrastructure. Incorporating sustainable management methods, regulating visitor numbers in sensitive regions, preserving biodiversity, and preserving the environment are all part of what is known as "smart ecotourism," which aims to strike a balance between tourism and conservation. Internet of Things sustainability tools, smart apps, and user-friendly services also improve accessibility and the tourist experience. To ensure sustainability and conservation, ecotourism management solutions that leverage big data, AI, and the IoTs allow for tailored trip planning, more visitor traffic, and revenue generation.

In an early study by Mudzengi et al. [64], the factors that have helped ecotourism persevere despite setbacks are detailed. It covers many topics: resource abundance, climate, community solidarity, private sector involvement, community compensation, conflict management tactics, stakeholder, and local leadership roles. External variables such as the macroeconomic environment, political instability, and hunting restrictions impact ecotourism's long-term viability. The findings contribute to an in-depth analysis of the factors affecting the robustness of ecotourism. It provides a balanced evaluation by discussing the initiative's advantages and disadvantages. However, more concrete evidence and statistics supporting the claims would have benefited the findings. Ecotourism confronts several issues, and the contribution could have provided a more critical evaluation of the efficacy of strategies and activities implemented to address these issues [77,78].

Reference Chandel and Kanga [58] state that government support for ecotourism should center on ancillary policies, which can generate revenue and create new employment opportunities. Incorporating the development of world-class tourist attractions can attract investments and local employment. Improving ecotourism can benefit tourists and locals while generating stable employment opportunities in the region. A formal policy document should outline the objectives of a state's ecotourism initiative. The expansion of ecotourism depends on improved access by road, rail, and air. Tourists are entitled to fundamental amenities such as restrooms,

running water, parking, and roadside rest stops. The MICE market can serve as a development driver for the tourism industry. Constructing first-class facilities, such as international convention centers, is necessary to attract investors. To satisfy the demands of the ecotourism industry, it is necessary to modernize existing lodging options and introduce themed resorts and hotels. In order to attract travelers and provide them with a comprehensive array of services, the public and private sectors must collaborate [66,79].

A recent study on ecotourism by Xu et al. [63] emphasizes the evolution through human disturbance, ecological services, and sustainable development. It discusses the main themes and clusters that emerged at each stage and the new themes that have emerged during the current research period. The study contributes to the significance of multidisciplinary research and the application of cutting-edge techniques and instruments to studying ecotourism. However, there is a potential threat posed by the COVID-19 pandemic in the context of sustainable development.

Consequently, Acharya et al. [57] highlights ecotourism's economic and cultural benefits. Ecotourism's potential as a novel form of tourism is emphasized, as is the need for strategic expansion, particularly in the aftermath of COVID-19. The research proposes geo-ecotourism as a solution to the ecotourism industry's problems, such as inadequate infrastructure and a need for more reliable data, and suggests using geospatial tools and mathematical models to enhance tourism management and planning. However, it emphasizes the significance of development and planning to promote resilient and sustainable tourism in West Bengal, highlighting the state's potential as a geo-ecotourism destination. Chandel et al. [61], utilizing Geographic Information System (GIS) and Remote Sensing data, assert that Western Rajasthan is ripe for ecotourism development. The report emphasizes the significance of investing in infrastructure and facilities in these regions in order to create tourism opportunities. Ecotourism allows visitors to learn about the area's diverse cultural history and natural landscape while funding preservation efforts. However, this study highlights the challenges associated with ecotourism, such as uncontrolled foot traffic and refuse production. To achieve a balance between tourism and conservation, sustainable management practices such as limiting visitor numbers and enforcing regulations are required. However, this study promotes sustainable ecotourism, including striking a balance between the environment, tourists, and administration, ensuring adequate connectivity, limiting tourism activity in fragile areas, and encouraging local participation and employment [80, 81].

Eddyono et al. [62] discuss big data and artificial intelligence simulation models in the context of creating sustainable ecotourism destinations. It highlights how these technologies have contributed to increased visitor traffic and revenue. The significance of tourism competitiveness in making ecotourism destinations in remote areas more accessible is also emphasized. In addition, it emphasizes the importance of policy innovation and legal protection for stakeholders, as well as the trade-offs between sustainably managed tourism and nature conservation. Using examples from Japan and Nepal, the findings illustrate a variety of ecotourism management strategies. Ecotourism's long-term viability depends on technological innovation and implementation, according to the input as a whole [14,82].

The number of scholarly articles on this topic has increased; however, Kumar et al. [56] established a link between IoT and tourism. The investigation also uncovered evidence of thematic clustering and international author collaboration. Agrawal et al. [59] comprehensively analyze the advantages and disadvantages of integrating BDA with ecotourism. It highlights the most significant concepts and organizations in the subject area and provides a comprehensive literature review. This multifaceted examination of BDA in sustainable tourism includes sustainable hotel administration, urban and regional tourism, sustainable transportation, and social networks. Also discussed are the benefits to BDA of reducing carbon footprints, implementing environmental programs, and increasing visitor satisfaction.

According to Chai-Arayalert [60], a smart ecotourism application is being developed to encourage young people to continue their education and become more conscious of environmental issues. Smart technology such as IoT incorporates community feedback and information to assist users in planning environmentally conscious and culturally enriching eco-trips. The study highlights the paucity of literature on adolescent ecotourism and the necessity of using ICTs to increase environmental and cultural awareness and knowledge. The findings lend credence to campaigns advocating ecotourism and utilizing cutting-edge media in a smart-learning app to compensate for the paucity of pertinent information available to the general public. Improving public relations, disseminating information, and providing learning resources are also emphasized in the report. Smart ecotourism may promote a particular ecotourism area and provide young people with access to information from natives about ecotourism. This study fills a gap in the extant literature on ecotourism and provides smart applications for the ecotourism market that targets young people. The effectiveness of the smart application must be evaluated with a larger sample of youthful travelers in various environments [15,83].

Contrarily, Metwally [45] discusses internet-based ecotourism marketing strategies. It highlights the difficulties of ecotourism in the Fourth Industrial Revolution (4IR) and the need for an all-encompassing public relations strategy. The paper asserts that a customer-centric strategy is more essential than ever and that traditional marketing methods must be modernized by incorporating the Internet. In addition, it examines the current ecotourism advertising campaigns and provides recommendations for involving residents in online advertising. The study concludes by emphasizing the significance of transitioning to the 4IR age.

Using the R programming language, Novera et al. [67] reveals nine major themes, each illustrated by real-world applications in technology, e-tourism, smart tourism applications, and user-friendly smart services. The findings contribute to the importance of sustainable ecotourism and the IoT, big data, and artificial intelligence in this area. Each issue's posterior probability is determined, and high-probability areas for additional research, such as eco-friendly e-tourism and user-friendly smart services, are highlighted [13, 65,84].

6. Conclusion

Smart ecotourism is a strategy that involves multiple stakeholders, including governments, visitors, platform developers, and locals, to enhance environmental impact. It has five key characteristics: dynamic interactions, value co-creation, sustainable

development, creation and sharing of tourism resources, and innovation services. These features can facilitate communication, development, and value creation, enhancing tourist experiences and promoting intelligent travel's long-term growth. This study presents a systematic review on the subject of sustainable smart ecotourism. Smart ecotourism aims to provide visitors with a virtual experience of the site, fostering greater familiarity and appreciation among the younger generation. The study discusses the importance of technology, such as IoT, in sustaining ecotourism. It highlights the role of smartness and IoT in enhancing the ecotourism experience. It also mentions the need for sustainable tourism management and the adoption of ICT-based tools for sustainability. The paper evaluates various approaches, tools, and strategies for smart ecotourism and emphasizes the importance of incorporating smartness into decision-making processes. The findings highlight BDA's potential to increase consumer happiness and the tourism industry's long-term viability. This study fills a gap in existing literature on ecotourism and expands our understanding of smart ecotourism. It recommends collaborating with governments, local stakeholders, and nongovernmental organizations to develop sustainable and equitable ecotourism policies. The findings conclude by mentioning the key characteristics of intelligent ecotourism, including dynamic interactions, co-creation of value, sustainable development, creation and sharing of tourism resources, and innovation service. Future research directions include incorporating socioeconomic and climatic change data, expanding the study to include additional countries, and customizing methodologies to specific circumstances. Future studies must highlight the challenges associated with smart technologies such as cloud, AI, big data, and IoT implementation in ecotourism.

6.1. Theoretical contributions

This paper fills a noticeable void in the current literature with its substantial theoretical contributions, which will undoubtedly advance the academic debate on ecotourism. An important part of the contribution is explaining smart ecotourism in detail, bringing to light its many facets, possibilities, and threats that should have been addressed or thoroughly examined. This study synthesizes viewpoints through a systematic review; it draws on a wide range of academic publications and practical data to provide a solid theoretical framework that entirely captures intelligent ecotourism. At its heart, this framework is based on the defined essential features of smart ecotourism, which are the bedrock upon which the tourist industries' sustainable practices and technological integration rest. By providing a framework for organizing the use of smart technologies, these traits not only lay the theoretical groundwork but also pave the way for real-world implementations that boost value creation, sustainable development, and smart technology utilization. According to the report, sustainable development, smart technologies, and value creation are interdependent in the tourist business. Sustainable practices, improved visitor experiences, and optimal resource usage can be achieved by integrating emerging technologies like the IoT, BDA, AI, and cloud computing.

In addition, the study makes a significant contribution by outlining the theoretical foundations of intelligent ecotourism. This will help future researchers, policymakers, industry practitioners, and stakeholders better understand the topic and be better equipped to make informed decisions based on their findings. Theoretically, this study's contributions go beyond filling gaps in the literature; they lay the groundwork for future research, encourage collaboration across disciplines, and pave the way for sustainable smart ecotourism practices, innovations, and strategies to thrive in the dynamic tourist industry.

6.2. Practical contributions

Policymakers, government agencies, local communities, NGOs, and industry practitioners can all benefit from the study's findings. It stresses the importance of NGOs, local stakeholders, and governments working together to create and execute sustainable ecotourism policies. It further emphasizes the significance of forming partnerships with several stakeholders with common goals, making decisions, and holding each other accountable. These partnerships can combine resources, skills, and information to tackle difficult problems and exploit new opportunities in the ecotourism industry.

Ecotourism management and operations decision-making procedures should incorporate "smartness," according to the study. In order to improve operational efficiency, optimize resource allocation, and limit environmental impacts, it promotes the use of data-driven methods, novel technologies, and solutions based on the Internet of Things. Stakeholders can make educated decisions and perform timely interventions using sensors enabled by the Internet of Things to monitor tourist activities, environmental conditions, and resource consumption patterns in real-time. The study also emphasizes the promise of using smart technologies such as AR/VR, chatbots driven by AI, and personalized recommendation systems to create eco-friendly, immersive vacations. In order to help stakeholders effectively adopt, execute, and manage smart ecotourism programs, it also promotes education, raises awareness, and pushes for capacity-building efforts.

This paper outlines a sustainable, fair, and intelligent plan for encouraging ecotourism development. Unleash the full potential of ecotourism as a catalyst for sustainable development, socioeconomic growth, and environmental conservation by providing practical recommendations, encouraging collaboration, and stressing the integration of smart technologies and innovative strategies. The goals are to drive responsible tourism practices, spark transformative change, and achieve these goals.

6.3. Study limitations

Smart ecotourism has come a long way since this project began, but several caveats might restrict its usefulness. The study may not apply to a more general global context due to its narrow geographical scope, mainly examining particular nations and areas. Depending on geography, culture, economy, and ecology, ecotourism policies, practices, and difficulties might differ greatly. There may have been biases, oversights, or gaps in the synthesized evidence due to biases in the literature selection and analysis, as the study

fully recognizes.

Publication bias, data availability, quality, granularity, and study-to-study comparability are some of the limitations of systematic reviews that the study recognizes. The research also shows the difficulty of using smart technologies like cloud computing, AI, big data, and the Internet of Things (IoT) in ecotourism. Despite their transformative promise, data privacy, security, interoperability, infrastructure, ethics, governance, sociocultural ramifications, environmental repercussions, and scalability are some issues arising from these technologies. According to the report, researchers, practitioners, legislators, industry stakeholders, and communities must tackle these difficulties head-on. In order to advance knowledge, innovation, and sustainable practices in the rapidly growing field of smart ecotourism, future research should focus on interdisciplinary approaches, mixed-methods research designs, diverse data integration, alternative methodology exploration, and collaborative partnership formation. Responsible, egalitarian, and sustainable tourism development worldwide can be significantly advanced if future research takes the initiative to tackle these limitations and obstacles.

6.4. Future research

A research agenda that looks ahead to new problems, new opportunities, and sustainable development in the tourist industry is needed to keep up with the ever-changing smart ecotourism scene. Expanding on the study's results and acknowledging its limitations, future research should take a multi-pronged approach to smart ecotourism by bringing together experts from different disciplines and fostering partnerships to further understanding, creativity, and policymaking in this emerging sector.

Future studies should incorporate socioeconomic and climate change data to understand further the complex relationship between ecotourism destinations' environmental sustainability, economic viability, social equality, and climate resilience. Smart ecotourism initiatives have many potential benefits and drawbacks for host communities, economies, ecosystems, and cultural heritage places; by combining various datasets, researchers can better understand these issues from every angle. Furthermore, future research projects must incorporate more countries, regions, and cultural contexts in their geographical scope. Researchers can better understand the many ecotourism practices, policies, innovations, difficulties, and possibilities in various geographical, cultural, economic, and ecological settings if they widen the scope of their studies.

To further sustainable tourism development worldwide, this expansion will make it easier to conduct comparative analyses, gain cross-cultural insights, and form global alliances. Lastly, future research must focus on tailoring methodology, tools, and approaches to address the unique demands of stakeholders in different contexts. Researchers can better address local concerns, norms, traditions, hopes, and sustainability objectives by taking a situation-specific approach to problem-solving. As a result of these adjustments, smart ecotourism programs, policies, and practices will be better suited to various contexts. Data privacy, security, interoperability, governance, ethics, sociocultural ramifications, and environmental repercussions are some of the difficulties that should be highlighted, evaluated, and addressed in future research on using smart technology in ecotourism. In order to address these challenges and promote responsible, ethical, and sustainable smart ecotourism development, researchers should encourage interdisciplinary collaborations, partnerships, dialogues, and solutions among communities, policymakers, and industry stakeholders.

This report provides policymakers with the following recommendations.

- Promote Interdependent Relationships: Create smart ecotourism policies, strategies, and programs that are inclusive, participative, and egalitarian by collaborating with industry partners, local stakeholders, NGOs, and governments.
- Make Sustainability a Top Priority: Smart ecotourism policies, planning, development, and management processes should incorporate sustainability concepts, practices, and indicators to guarantee environmental, social, economic, and cultural viability in the long run.
- The IoT, big data, AI, and cloud computing are examples of the novel technology, tools, platforms, and techniques that ecotourism destinations can embrace to improve visitors' experiences, operational efficiency, decision-making, and sustainability results.
- Investing in capacity building, education, training, and awareness-raising programs is important to help local communities, stakeholders, entrepreneurs, and lawmakers understand the challenges and opportunities of smart ecotourism development.

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Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Yin Zhang: Writing – original draft, Visualization, Validation, Software, Funding acquisition, Formal analysis, Conceptualization. **Bin Deng:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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