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Forest Tourism and the Use of AI Technologies Towards Clean and Safe Environments: The Cases of Turkey, Lithuania, and Morocco

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Abstract

The rapidly expanding use of artificial intelligence (AI) technologies in recent years presents significant opportunities for achieving sustainable, clean, and safe environmental objectives. This study aims to comprehensively examine the potential use of AI technologies for clean and safe environmental goals in forest tourism areas in Turkey, Lithuania, and Morocco, and to conduct comparative analyses specific to each target country. The research was conducted using a qualitative methodology within a case study design. In line with purposive sampling principles, the sample was limited to a total of 72 participants from the three countries (24 from Turkey, 24 from Lithuania, and 24 from Morocco). To identify expert opinions relevant to the study objectives, semi-structured interviews were conducted across the three country samples, and the collected data were processed and analyzed using NVivo 14 software. The data were transformed into findings through descriptive analysis and content analysis. The results indicate that AI technologies are employed in forest tourism areas for diverse purposes and objectives related to clean and safe environmental management. In Turkey, AI applications are primarily directed toward proactive measures addressing pressing environmental issues, such as forest fires. In Lithuania, as an EU member state, AI technologies are utilized in a more strategic, institutional, and comprehensive manner across multiple areas and objectives. In contrast, Morocco appears to lag in AI adoption, focusing on international collaborations to enhance digital infrastructure and facilitate technology transfer.

Keywords: AI-based decision support; cross-country comparison; environmental monitoring; forest; smart tourism solutions



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1. Introduction

Forest tourism has gained increasing importance in recent years as a tool for conserving ecosystems and biodiversity, facilitating leisure activities, and fostering local development within the framework of sustainable tourism goals [1,2]. It serves as a medium for maintaining human interaction with nature in the post-industrial era. Participation in activities organized in natural settings and forested areas directly contributes to individuals' physical, social, and mental well-being [3,4]. Furthermore, engaging in such activities not only creates opportunities for socialization but also fosters the development of environmental awareness [5–8]. Beyond individual and societal impacts, forest tourism holds particular significance for sustainable development [9–12]. Forest ecosystems play a crucial role in

preserving natural balance (e.g., carbon storage, biodiversity conservation, and the continuity of natural resources such as water) while simultaneously supporting tourism and recreational activities [13,14].

However, the rise in human mobility and the growing number of visits to forested areas in recent years have generated significant environmental challenges [15]. Chief among these are the uncontrolled use of natural resources, waste generation, and ecosystem degradation [16–19]. Human activities in forest tourism areas can harm not only the environment but also cause economic and social problems. Therefore, monitoring ecological damage, managing visitors, tracking carbon emissions, and ensuring responsible resource use are essential for both nature and tourism. Therefore, measures like monitoring environmental degradation, managing visitor flows, tracking carbon emissions, and using natural resources responsibly are crucial for both ecology and tourism [20,21]. Consequently, integrating clean and safe environmental goals into forest management is essential for sustainable tourism and ecosystem preservation.

With the rise of digitalization and technological advancements, the use of AI technologies has expanded across all institutional domains. In this context, the application of AI in forest tourism areas to achieve clean and safe environmental objectives has become inevitable. AI facilitates sustainable management by enabling environmental monitoring, early warning systems for disasters, waste management, and visitor tracking, contributing to both ecological preservation and visitor safety in forest tourism areas [22–24]. Furthermore, AI supports the planned utilization of natural resources while enhancing tourism activities within the framework of clean and safe environmental objectives [25,26].

Despite the ecological and touristic benefits of AI applications in forest tourism areas, research exploring the full potential of these technologies remains limited. Moreover, comparative studies across countries with distinct geographical, cultural, and social contexts are scarce. In this regard, Turkey, Lithuania, and Morocco present valuable examples for comparative environmental management research due to their diverse characteristics.

Turkey, with its rich ecosystems and biodiversity and substantial ecotourism potential, creates significant value; however, increasing human mobility and visitor density pose challenges in balancing tourism development with effective environmental management [27,28]. Lithuania, on the other hand, has successfully integrated AI into environmental management by aligning sustainable development plans with European Union standards and combining them with its technological and digital infrastructure [29,30]. Morocco offers a unique perspective by harmonizing forest tourism and development goals within the North African context, emphasizing resource conservation and management while maintaining its own distinctive approach [31–33].

Assessing AI use in addressing environmental challenges in forest tourism across Turkey, Lithuania, and Morocco, and comparing these countries, can inform practices, plans, and policies for clean and safe environments. Based on expert insights, this study examines AI application processes and enables comprehensive comparisons of innovation and technology adoption in sustainable environmental management.

In designing the research framework, it was considered that studies jointly addressing AI technologies and the concept of sustainable environments in forest tourism areas in Turkey, Lithuania, and Morocco remain insufficient. Existing research predominantly focuses on sustainability in a general sense, yet it lacks comparative studies that include multiple countries. Consequently, evaluations remain limited and tend to fall short of adopting an interdisciplinary perspective. However, as in the present study, conducting comparative research across countries with distinct economic, social, cultural, and administrative characteristics is essential. Such an approach not only helps to address the gaps in the literature but also enables an understanding of whether practices vary across

different contexts. The use of AI and digital transformation in sustainability enhances cross-disciplinary cooperation and creates potential for technology transfer. Accordingly, this study is expected to bring a new perspective to the literature.

The scope of this study is limited to Turkey, Lithuania, and Morocco due to the distinct socio-cultural, economic, and environmental contexts each country presents regarding forest tourism and the use of AI technologies in environmental management. Turkey offers diverse and extensive forest areas, and Lithuania provides a context shaped by European Union policies and sustainability practices, while Morocco presents unique challenges and opportunities related to limited water resources and desertification risks. This contextual diversity enables the collection and interpretation of data in a manner consistent with the study's comparative analytical objectives. Accordingly, the selection of these countries was not random; rather, it followed a process aligned with the fundamental objectives and methodological design of the research.

Accordingly, the main purpose of this study is to undertake an in-depth investigation of the potential use of AI technologies for achieving clean and safe environmental goals in forest tourism areas in Turkey, Lithuania, and Morocco, and to carry out country-specific comparisons. In line with this aim, the study sets out the following core objectives:

- To identify the contributions of AI technologies to sustainable forest tourism objectives through monitoring, data collection, processing, and management processes;
- To delineate the responsibilities and ethical obligations of stakeholders involved in management processes;
- To comparatively examine the use of AI in forestry within the tourism sector in Turkey, Lithuania, and Morocco, highlighting similarities and differences across countries.

2. Materials and Methods

2.1. Theoretical Framework

This study employs a multi-layered theoretical framework to evaluate and present findings on the use of AI technologies in achieving clean and safe environmental objectives within forest tourism areas. To begin with, the Technology Acceptance Model (TAM) was adopted as the primary reference for assessing the use of AI technologies in the target countries. TAM offers a valuable lens to understand and interpret the tendencies of individuals and institutions to adopt and utilize new digital technologies such as AI. Through this approach, it becomes possible to evaluate the role of innovative technologies in environmental sustainability processes in the respective countries [34,35].

In addition to TAM, the study also draws upon the Institutional Theory, specifically the Cognitive Pillar and Institutional Isomorphism approaches [36]. These perspectives provide opportunities for a comparative evaluation of perceptions, regulatory pressures, and prevailing norms regarding the adoption of AI technologies for clean and safe environmental objectives in forest tourism areas of Turkey, Lithuania, and Morocco. Such an understanding highlights that AI technologies are not merely components of digitalization but are also embedded in broader social and institutional processes [37,38].

Furthermore, the Resource Dependence Theory (RDT) was employed to interpret findings related to external dependency, which emerged as a significant theme in the examined countries. RDT provides an effective lens to analyze how reliance on external resources influences the adoption and implementation of innovative solutions such as AI, particularly in contexts where infrastructural gaps exist [39,40]. Minimizing external dependency and ensuring stronger ownership of resources are thus critical for achieving clean environment goals.

Finally, the Sustainable Development Framework, with particular emphasis on the United Nations Sustainable Development Goals (UN SDGs), guided the overall interpreta-

tion of the research findings. As globally recognized policy benchmarks for environmental sustainability, the SDGs offer a comprehensive structure for aligning AI-enabled practices with broader development objectives. Within the scope of this study, SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 11 (Sustainable Cities and Communities) are particularly relevant [41]. Positioning AI technologies within the pursuit of the SDGs not only underscores their environmental contributions but also emphasizes their societal benefits. Taken together, the theoretical framework of this study is built upon technology adoption dynamics, institutional mechanisms, resource dependency considerations, and global sustainability objectives. This integrated approach enables a comprehensive and comparative understanding of how AI technologies can be utilized for clean and safe environmental goals in forest tourism areas across Turkey, Lithuania, and Morocco.

In evaluating the findings of the study, an approach grounded in a multi-layered theoretical framework was employed. The Technology Acceptance Model (TAM) contributes to explaining the differences in the use of AI technologies within forest tourism areas in Turkey, Lithuania, and Morocco. It aims to assess and interpret the perceptions and usage tendencies of individuals, communities, and institutions toward innovative digital tools. In Turkey, TAM's dimensions of perceived usefulness and perceived ease of use are particularly effective in understanding and explaining the potential for AI adoption in environmental monitoring and visitor management processes. However, financial and infrastructural limitations constrain the broader adoption of these technologies in the country.

Institutional Theory, including the Cognitive Pillar and Institutional Isomorphism approaches, serves to clarify how regulatory pressures, social norms, and institutional practices shape observed differences. In this context, Lithuania's status as an EU member state and its alignment with EU policies significantly facilitate the adoption and use of AI technologies. In contrast, in Morocco, the dominance of traditional methods in forest tourism management and reliance on international collaborations for development highlight the determining role of societal norms. Resource Dependence Theory (RDT) provides an explanatory framework for issues related to infrastructure, access to digital tools, and the adoption and utilization of AI technologies. In Turkey and Morocco, the findings indicate the necessity of reducing dependency on external resources and strengthening domestic resource ownership to enhance AI integration.

Finally, framing the findings within the Sustainable Development Goals (SDG 11, 13, and 15) is particularly important for demonstrating that AI applications are not only relevant to sustainable environmental management but also contribute to broader societal benefits. This integrated theoretical perspective reveals the adoption, usage, applicability, and challenges of AI technologies in forest tourism areas in Turkey, Lithuania, and Morocco, illustrating that these processes are closely linked to technological, institutional, resource-based, and sustainability-oriented factors.

2.2. Methodological Structure

This study employed a qualitative research approach to examine the intersection of environmental management, tourism, forest area management, and the disciplines of AI and technology. Within the scope of qualitative research, a case study design was adopted. The case study design allows for an in-depth exploration of complex processes and serves as a valuable tool for comprehensive investigations [42]. Qualitative research provides a holistic perspective, enabling evaluations from the part to the whole [43,44]. Moreover, it facilitates detailed analyses directly aligned with the research questions, with findings primarily presented through participants' statements rather than quantitative metrics [45].

By emphasizing participants' expressions and wording, the study centers the focus on individuals while guiding them in a manner consistent with the research objectives [46].

2.3. Sample Group

To achieve a comparative analysis and obtain in-depth insights, purposeful sampling was employed in selecting the study participants. Individuals were selected based on their knowledge and expertise in the field [47]. The primary criterion for inclusion was the relevance, representativeness, and adequate experience of participants concerning the research questions [48,49]. Accordingly, the sample consisted of 72 participants from Turkey, Lithuania, and Morocco (24 from each country).

A multi-stakeholder sample was formed to examine the relationships among forest tourism, AI technologies, and environmental sustainability across the three countries. The sample comprised four key stakeholder groups in each country: (a) forest area managers, (b) nature tourism managers, (c) AI and technology experts, and (d) academics/researchers. Participants volunteered for the study and were deemed experts based on the study's objectives. The criteria for defining participants as experts included: sufficient knowledge and experience in the field, institutional and managerial responsibilities, relevant academic qualifications, and significant contributions to research and practice in the area. Additionally, the following steps were undertaken to identify and select the experts:

- **Forest Area Managers:** Participants were required to have at least five years of experience in managerial processes related to the conservation of ecosystems and biodiversity in forested areas, demonstrating responsibility in maintaining ecological integrity.
- **Nature Tourism Managers:** Selection criteria emphasized sufficient experience in planning and implementing nature-based tourism activities, along with responsibility and expertise in sustainable tourism practices.
- **AI/Technology Experts:** Participants were included to assess the impacts of AI applications on environmental sustainability in forest tourism areas. Eligibility criteria included software experience in AI and other digital technologies, as well as expertise in data processing, analysis, and digital solutions.
- **Academics/Researchers:** Selection was based on a strong record of national and international academic publications in tourism, environmental sustainability, environmental management, and digital solutions/AI technologies. Participants were also required to have conducted diverse research projects in these fields.

In this study, the inclusion of 24 experts from each of the three countries was guided by the principles of a qualitative research design. According to this framework, sufficient diversity and representativeness within the sample groups are sought to obtain comprehensive and in-depth insights. Existing literature indicates that qualitative studies involving interviews typically consider sample sizes of 12–30 participants adequate to ensure both diversity and representativeness [50]. In qualitative research, sample size is determined not by statistical generalization but by the principle of achieving data saturation [51]. Therefore, the inclusion of a total of 72 experts from the three countries was designed to ensure data saturation, representativeness, and diversity.

2.4. Data Collection Tool

For the interviews conducted with 72 experts from Turkey, Lithuania, and Morocco, a semi-structured interview protocol was developed by the researchers. The preparation of this protocol involved a comprehensive literature review and consultation with expert academics and researchers in the field. Given that interviews were conducted in multiple languages, linguistic experts performed final checks to ensure consistency across translations.

The semi-structured interview format was chosen as the preferred data collection tool to obtain detailed and comprehensive information aligned with the research questions and objectives [52]. A key advantage of this tool is its flexibility, allowing participants to be guided in accordance with the study's objectives while also enabling rich and nuanced data collection [53].

Following an extensive literature analysis, the interview questions were finalized. Content validity was assessed using the Content Validity Index (CVI). The threshold value for CVI was set at 0.78. Questions falling below this threshold were revised by the researchers to meet or exceed the cutoff, ensuring the validity of the instrument. Prior to the interviews, the average S-CVI value for the questions was calculated as 0.87, indicating a high level of content validity. The finalized interview questions included:

1. What practices are being implemented in your country to achieve clean and safe environmental objectives in forest tourism areas?
2. How are artificial intelligence (AI) technologies currently used or potentially applicable in these practices?
3. What are the main challenges and opportunities in this area?
4. In your country, in which areas is AI usage and environmental management strong, and in which areas could it be improved?
5. What recommendations do you have for improving environmental management and AI utilization in the future?

2.5. Analysis of Interview Data

The interviews conducted with experts from Turkey, Lithuania, and Morocco were analyzed using NVivo 14. Both content analysis and descriptive analysis methods were employed to identify main themes and sub-themes. The process of theme identification and coding is illustrated in Figure 1.

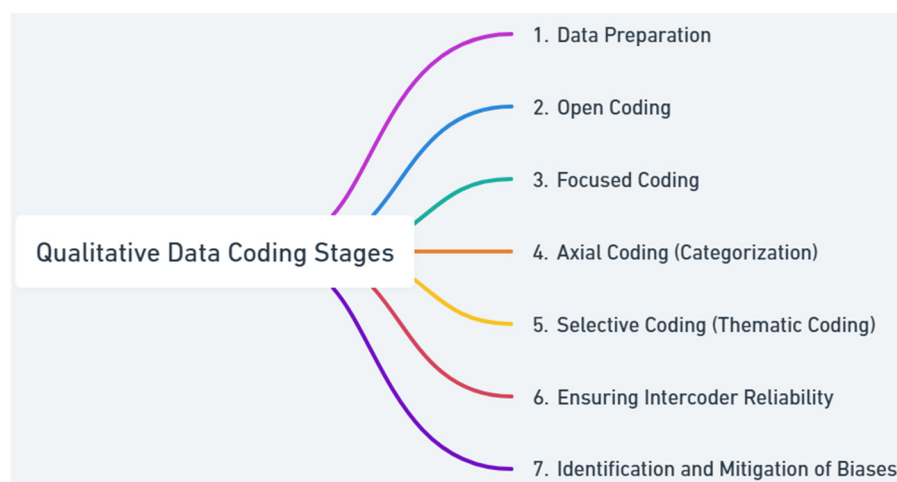


Figure 1. Determining themes and coding process.

Thematic coding and descriptive content analysis methods enabled the systematic presentation of the findings [54]. Using NVivo, the results were organized through thematic differentiation, with relationships between themes further elaborated via sub-themes [55]. In interpreting these themes, the experts' perspectives were directly quoted and presented within the text.

3. Results

In this section of the study, the findings obtained through thematic and content analysis of the interview data are presented comprehensively. Expert responses were systematically classified by the researchers, and the resulting findings were visualized for clarity. To support the analysis, direct quotations from experts in all three countries were included.

Figure 2 illustrates the main and sub-themes that emerged regarding practices implemented in forest tourism areas to achieve clean and safe environmental objectives, based on expert insights from Turkey, Lithuania, and Morocco. Based on the analysis of each expert's responses pertaining to their respective countries, six main themes were identified: (a) Environmental Protection and Monitoring, (b) Waste and Resource Management, (c) Visitor Management and Safety, (d) Stakeholder Engagement and Responsibility, (e) AI and Technology Applications, and (f) Education and Awareness.

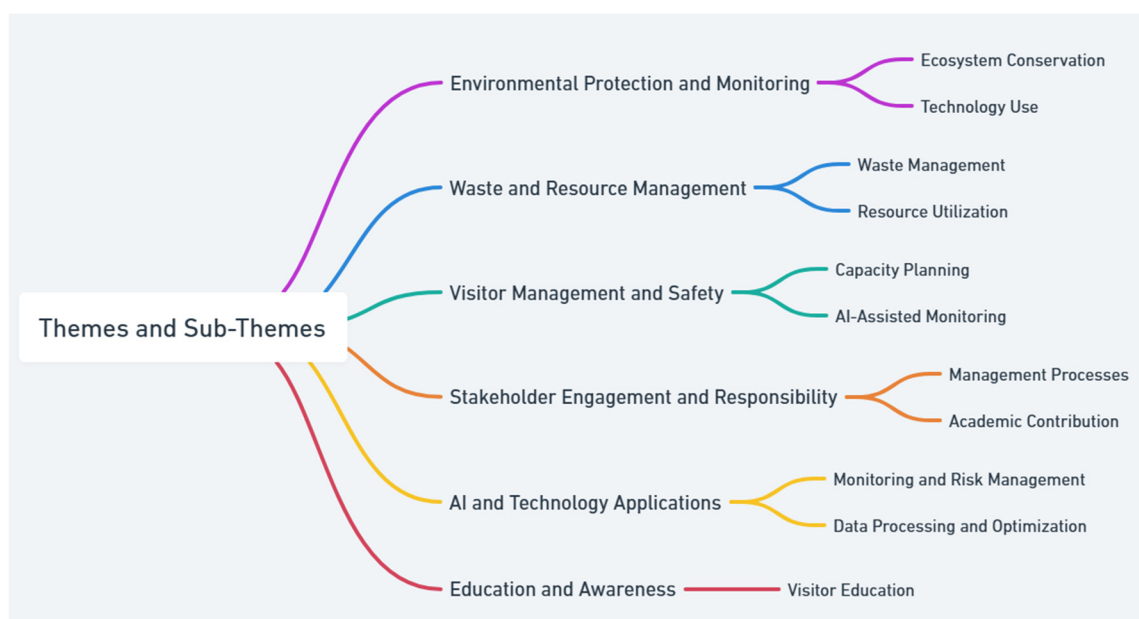


Figure 2. Themes and sub-themes for practices in Turkey, Lithuania, and Morocco.

The expert opinions from Turkey, Lithuania, and Morocco reflect a holistic understanding aimed at the conservation of forest ecosystems, ensuring the safety of participants and visitors, and fostering sustainable tourism practices. In this context, highlighting strengths and identifying weaknesses provides opportunities for improvement across the three countries.

The findings show that, although the three countries share similarities in implementing clean and safe environmental objectives in forest tourism areas, significant differences also exist. Shared priorities include environmental protection, waste management, stakeholder responsibility and engagement, and monitoring of visitor capacity. However, variations are observed in the form, scope, and digital infrastructure support of these practices.

In Turkey, particularly due to the increasing number of forest fires in recent years, the emphasis has been on drone- and GIS-based monitoring and control systems to contain fires and protect ecosystems. Forest management practices also involve determining visitor capacities in certain areas and implementing sustainability-oriented educational programs. Additionally, AI integration into forest tourism management processes has facilitated early fire-warning systems and the monitoring of visitor flows.

“A more monitoring- and protection-oriented management approach prevails. In national and nature parks, drone technologies allow us to continuously monitor the areas. We also

make significant efforts to ensure that waste is collected promptly and systematically. This enables us to take precautions against natural disasters, especially fires, while protecting biodiversity” (Forest Area Manager, Turkey-1). “Some areas are becoming increasingly popular. In areas attracting many visitors for nature tourism purposes, we occasionally limit visitor numbers for conservation purposes. We monitor visitor density with tracking systems and impose restrictions when necessary” (Nature Tourism Manager, Turkey-4). “We develop software specifically for national park managers and provide the necessary infrastructure to facilitate their work. Devices are integrated to prevent forest fires” (Technology Expert, Turkey-3).

In Lithuania, three main approaches have been adopted in forest tourism areas: the use of IoT devices, monitoring and protection through sensors, and the implementation of various certification programs to comply with EU environmental policies. These practices are both significant and decisive. The management of facilities within forested areas in harmony with the environment, the implementation of measures to protect forest ecosystems, and plans to prevent visitor overcrowding are systematically applied. Inter-agency collaboration is also prominent in Lithuania, with public institutions and academics/researchers actively involved, supporting an interdisciplinary approach to management processes.

“Recently, we have strengthened the digital infrastructure in forest areas. Especially through IoT devices, we have made significant progress in visitor tracking, fire risk management, and waste management. EU policies and our efforts to comply with them help us manage our forest areas effectively. We are obliged to implement these policies, but we do not see it as a mere obligation. These areas are our natural assets” (Forest Area Manager, Lithuania-3). “We try to use technology effectively. With smart sensors, we can obtain real-time data and take appropriate actions accordingly” (AI/Technology Expert, Lithuania-4/Nature Tourism Manager, Lithuania-2). “Honestly, I have participated in many projects, and I am pleased. As an academic, being part of these collaborations motivates us because an interdisciplinary approach can generate diverse perspectives and ideas” (Academic, Lithuania-5).

In Morocco, expert opinions indicate that traditional methods are still preferred in forest tourism management, although initiatives for local community participation are being implemented. AI technologies have been integrated only in pilot trials. Key priorities in the management of forest tourism areas include the protection of clean water resources, sustainability, erosion control, and the conservation of protected areas. Technology usage remains limited, with local communities and managers primarily overseeing operations.

“In our country, traditional methods are still mostly used in the sustainable management of forest areas serving tourism. Controls are conducted through managers and other staff on the ground, and we also involve the local community in this process” (Forest Area Manager, Morocco-2/6). “Regarding the management of tourist areas, our country has lagged in using technology. Many countries now conduct 24/7 monitoring and inspections through digital methods. Achieving this solely with human labor is extremely difficult. We particularly need to use AI and other technological tools” (AI/Technology Expert, Morocco-3). “Human resources alone are insufficient to manage extensive areas. Even with great effort, it is not feasible. Therefore, academia, public institutions, and technology experts should collaborate to explore possible solutions, as human mobility nowadays is very high” (Academic/Researcher, Morocco-5).

Table 1 presents the main and sub-themes that emerged regarding the use of AI technologies for clean and safe environmental objectives in forest tourism areas, based on expert opinions from Turkey, Lithuania, and Morocco. The table also highlights similarities and differences in the practices of each country.

Table 1. AI-based environmental management practices in forest tourism areas.

Theme	Sub-Theme	Turkey	Lithuania	Morocco
Use of Artificial Intelligence Technologies	Visitor Management and Safety	AI-powered cameras and sensors are being developed for early fire warning systems. Visitor density is increasingly monitored via mobile apps.	Smart sensors and GPS-based tracking systems are used to monitor visitor mobility. Drone-based surveillance solutions are being tested in pilot projects for safety.	Although still limited, smart counter systems for visitor density and pilot AI-supported surveillance applications are being implemented in tourist areas.
	Environmental Monitoring and Sustainability	AI algorithms have begun to be used in monitoring air quality, water consumption, and waste generation.	AI-supported sensors are employed to measure carbon emissions and assess impacts on flora and fauna.	Environmental data collection processes remain largely manual; however, UNESCO-supported projects have begun using AI to monitor soil erosion and water resources.
	Data-Driven Decision Support Systems	AI-based decision support systems have been developed for local administrations, focusing on energy efficiency and waste management.	Digital twin applications are used to conduct scenario analyses for the management of nature tourism areas.	Still at an early stage, preparations are underway to integrate AI-based data use in tourism area planning.
	Education, Awareness, and Digital Guidance	AI-powered mobile guide applications have been developed for visitors (eco-friendly routes, safety alerts, etc.).	Smart applications provide visitors with environmental awareness content. VR/AR-based educational tools are especially applied for younger audiences.	Digital guidance applications are limited; however, AI-supported chatbot guide projects for tourists are currently under consideration.

Based on the analysis of experts' responses from each country, the primary theme that emerged naturally from the purpose and content of the question was "Use of Artificial Intelligence Technologies". Four sub-themes reflecting the similarities and differences in practice were identified: (a) Visitor Management and Safety, (b) Environmental Monitoring and Sustainability, (c) Data-Driven Decision Support Systems, and (d) Education, Awareness, and Digital Guidance.

The use and objectives of AI technologies in forest tourism areas reveal both similarities and differences across the three countries. In Turkey, AI is primarily employed as a tool for environmental monitoring and protection strategies, while also being used to track visitor density and ensure safety. Specifically, AI is effectively applied in early warning systems for forest fires, and mobile-based applications support visitor management processes, technology transfer, and digital transformation initiatives.

"We are particularly working in collaboration with local administrations. In recent years, we have been utilizing AI for the development of systems, monitoring protected areas, and ensuring the safety of forests open to visitors" (AI/Technology Expert, Turkey-5). "Recent forest fires have caused us great concern. To prevent them, we employ early warning systems with AI, aiming to minimize damage" (Forest Area Manager, Turkey-2). "In

Nature and National Parks, we have been experiencing high visitor density in recent years. We developed mobile applications to monitor visitor numbers and peak times, informing relevant areas accordingly. These applications significantly facilitate our work” (Nature Tourism Manager, Turkey-1).

In Lithuania, expert opinions indicate extensive use of AI and other digital tools. Advanced technology transfer is implemented, including carbon emission measurements and digital twin projects for forest areas. Furthermore, AI technologies are strategically employed in VR/AR-based educational projects and applications.

“We create educational content on VR/AR platforms for both youth and adults. Through training in schools and various institutions, we aim to increase environmental knowledge and awareness” (AI/Technology Expert, Lithuania-6). “In the areas I manage, we have been monitoring visitor movement with smart sensors for approximately four years, even identifying peak hours and taking appropriate measures” (Forest Area Manager, Lithuania-2). “Some of the data we use in our research includes carbon emission measurements of forest tourism areas, allowing us to monitor the negative environmental impacts caused by human activity” (Academic/Researcher, Lithuania-3). “In one city, we implemented a digital twin project for a protected yet publicly accessible forest area, simulating potential environmental damage and guiding the implementation of necessary preventive measures” (AI/Technology Expert, Lithuania-2).

In Morocco, in comparison to Turkey and Lithuania, the use of AI technologies is very limited and in the initial stages. Only pilot applications and testing of digital platforms have been reported. Human labor and field personnel remain central to operations.

“Most of the data in forest tourism areas is still collected manually. We have started using digital counters in some regions, but they are still limited and not widespread” (Forest Area Manager, Morocco-4). “We are currently in a transitional phase regarding the use of AI or other technological tools. Pilot trials are being conducted, testing smart monitoring systems for field data collection” (Academic/Researcher, Morocco-5). “Regarding the tourism aspect, we need to move towards digital guide applications, which are not yet available. Recently, AI-based chatbot guide projects for tourists have begun to be developed and even tested” (Nature Tourism Manager, Morocco-1).

Table 2 presents the main themes and sub-themes that emerged regarding the opportunities and challenges in the use of AI technologies in forest tourism areas, based on expert opinions from Turkey, Lithuania, and Morocco. The table also highlights the similarities and differences in the implementation of these applications across the three countries.

Based on expert opinions obtained from the three countries, the main theme “Challenges and Opportunities in Artificial Intelligence Applications” has been identified. While the analysis results revealed a single main theme, depth and comprehensiveness are achieved through four sub-themes, which are: (a) Technical Infrastructure and Data Management, (b) Institutional Coordination and Collaboration, (c) Human Resources and Capacity Building, and (d) Strategic and Operational Opportunities.

The opportunities and challenges encountered in the use of AI technologies in Turkey, Lithuania, and Morocco show both differences and similarities in practice. In Turkey, a closer look at the challenges highlights the insufficiency of technical infrastructure and the lack of financial resources to develop it. Regarding opportunities, the use of AI technologies as a practical tool for solving immediate problems is notable. Due to recent large-scale forest fires, AI technologies are considered a valuable opportunity for early warning systems.

“Technology is expensive. However, sufficient resources should be allocated considering the benefits it can provide. I believe the main problem is the inability to establish infrastructure due to inadequate budget allocation” (Academic/Researcher from Turkey-3).

“Infrastructure and equipment are insufficient. Forested areas are vast and need to be equipped with technology, but unfortunately, it is very inadequate” (Nature Tourism Manager from Turkey-1). “Recently, we have faced very large forest fires. Continuous monitoring with AI technologies can allow intervention before a fire starts and mitigate risks. I see this as an opportunity. Human resources or other means are insufficient. Very large fires can be prevented this way” (Forested Area Manager from Turkey-6).

Table 2. Opportunities and challenges in AI-supported forest tourism area management.

Theme	Sub-Theme	Turkey	Lithuania	Morocco
Challenges and Opportunities in AI Applications	Technical Infrastructure and Data Management	Lack of technical infrastructure and limited financial resources for AI integration	Lack of data sharing and regulations; limited digital adaptation of small businesses	Limited AI infrastructure, field-level practices remain manual and at the pilot level
	Institutional Coordination and Collaboration	Bureaucratic barriers in inter-institutional data sharing	Lack of coordination among different institutions; absence of a common vision	Limited institutional collaboration; coordination mainly through international projects
	Human Resources and Capacity Building	Need for training for technical staff and field workers	Lack of interdisciplinary integration and expertise in AI	Insufficient AI expertise and training capacity; human resource development is a priority
	opportunities	Drone and GIS-based monitoring, visitor management, and AI-based decision support systems	Digital twin applications, sustainable tourism certification, smart monitoring, and VR/AR-based training applications	International collaborations, pilot AI projects, prototype applications for environmental monitoring and tourist safety

In Lithuania, challenges are primarily related to data collection, sharing, and regulation, as well as coordination gaps and insufficient AI specialization. On the other hand, digital twin applications, certification programs, and VR/AR-based educational projects emerge as significant opportunities.

“The main challenge regarding AI use is recording large datasets and securely sharing them. This situation can bring important legal and ethical issues” (AI/Technology Expert from Lithuania-4). “Legal regulations are needed. Direct regulations are required for data processing and sharing” (Academic/Researcher from Lithuania-1). “Forested areas attract many people. Managing these areas requires support from multiple individuals or institutions. Municipalities, local communities, and other organizations need to collaborate and be ready, but often we must face all challenges alone” (Forested Area Manager from Lithuania-3). “We cannot refrain from using AI technologies. The world is evolving, and we must act early to benefit from this technology. For this, we participate in educational projects. We establish monitoring systems in some protected areas. These are very important developments, and we should further develop and advance them”

(AI/Technology Expert from Lithuania-2). *“I prepare educational content using AR/VR. These are used by various institutions to provide environmental awareness education”* (AI/Technology Expert from Lithuania-6).

From the perspective of Morocco, similar to Turkey, the most significant challenge is the insufficient technological infrastructure. Additionally, the lack of collaboration and limited AI expertise resemble the challenges faced in Lithuania, while limited educational capacity emerges as another key issue. In terms of opportunities, Morocco views international collaborations and projects as strategic opportunities and is also exploring pilot applications for environmental monitoring.

“In our country, the technological infrastructure for AI is extremely limited. As in every field, infrastructure must be established first, but the main challenge for us is the infrastructure” (AI/Technology Expert from Morocco-5). *“Universities should develop programs and courses on AI. Programmers and software engineers must be trained. China is currently a global leader with intensive university training. We need to develop our own experts”* (Academic/Researcher from Morocco-2/4). *“We participate in many international projects. This is crucial; we cannot be disconnected from the world. We must give importance to global collaborations. These projects and partnerships provide significant opportunities for us”* (Academic/Researcher from Morocco-1). *“I manage a protected area, and my colleague manages another. In both of our areas, monitoring systems have been installed and are being tested. These contribute significantly to our staff, and they should be further developed and disseminated”* (Forested Area Manager from Morocco-6).

Table 3 presents the main and sub-themes emerging from expert opinions in Turkey, Lithuania, and Morocco regarding the strengths and areas for improvement of AI technologies in forest tourism management. Based on the analysis of each expert's responses specific to their country, two main themes were identified: (a) Strong Areas of AI Technologies, and (b) Areas for Improvement in AI Technologies. The sub-themes associated with these two main themes are detailed in the table.

Table 3. Strengths and areas for improvement in AI applications in forest tourism management.

Theme	Sub-Theme
Strong Areas of AI Technologies	Digital tracking of waste management
	Monitoring of water resources
	Use in energy efficiency
	Urban air quality monitoring
Areas for Improvement in AI Technologies	Policy and strategy integration
	Data management and standardization
	Training and capacity building
	Local-level implementation

Table 4 presents the practices that contributed to the emergence of these themes and highlights the differences between countries. These practices reflect the operational approaches implemented in each expert's area of work and provide opportunities for comparative analysis across countries.

Table 4. Country-based differences in AI applications in forest tourism management.

Themes	Turkey	Lithuania	Morocco
Strong Areas of AI Technologies	Significant steps in waste management and recycling, but mostly limited to local municipalities. AI-based solutions in energy efficiency are widely applied in metropolitan areas. Air quality data collection through sensors is increasingly widespread.	AI is particularly strong in renewable energy (especially wind and biomass). Effective use in monitoring water and forest resources. Waste management practices are well-organized at the city level	AI is strong in water resource protection and agricultural irrigation. AI applications in waste management and recycling are just emerging. Energy efficiency solutions (solar energy-oriented) are expanding.
Areas for Improvement in AI Technologies	National-level data integration is weak; inter-institutional coordination is limited. Local governments face capacity shortages. Integration of AI at the policy level is still not strong.	National-level data integration is weak; inter-institutional coordination is limited. Local governments face capacity shortages. Integration of AI at the policy level is still not strong.	Data management and technological infrastructure are limited. Awareness at the policy level is increasing, but implementation is weak. Training and expert capacity building are needed.

In Turkey, the effective and strong use of AI technologies in forest tourism areas is primarily reflected in the monitoring of water and energy resources, ensuring the control of natural resource management, tracking air and environmental quality, and integrating waste management processes. Furthermore, experts emphasize that to maximize the benefits of AI technologies, harmonized policy decisions, increased local capacity, infrastructure improvements for data processes, and the implementation of long-term strategic plans are necessary.

“In the area I manage, there is a 24/7 monitoring and tracking system. This allows us to ensure that water resources are not wasted or polluted, thereby protecting natural resources” (Forest Area Manager, Turkey-5). “Through monitoring systems, we can identify areas with high waste accumulation. As far as I know, collection schedules can also be digitally planned according to waste intensity” (Nature Tourism Manager, Turkey-2). “To advance technological developments, specific legal regulations should be established. Data collection and storage pose legal risks, so policymakers should issue targeted laws and regulations” (Academic/Researcher, Turkey-5). “For large datasets, robust infrastructure services are necessary” (AI/Technology Expert, Turkey-3).

In Lithuania, AI technologies are utilized effectively. Experts particularly highlight AI as a powerful tool in biodiversity conservation and its contribution to the sustainable use of water resources. Additionally, AI is seen as a strong opportunity for renewable energy usage, with the EU standards acting as a key driving force. Areas for improvement include low awareness, implementation gaps, and the limited scope of pilot applications.

“I believe we have a very rich ecosystem and biodiversity. AI and similar technological tools make their protection possible, and monitoring and tracking systems facilitate our work” (Forest Area Manager, Lithuania-5). “AI technologies simplify management processes in terms of monitoring, protecting, and ensuring the sustainable use of natural resources such as water and energy. We can plan and easily identify deficiencies and damages” (Forest Area Manager, Lithuania-6). “We are required to adopt environmental management models in line with EU standards. Laws and other local regulations provide a framework for member countries, which I believe also facilitates managers’ work”

(Academic/Researcher, Lithuania-4). *“To make more effective use of AI in practice, education and awareness need to be increased. It is a specialized field, but by educating everyone at a basic level, strong awareness can be created”* (AI/Technology Expert, Lithuania-1). *“More software and applications are needed across additional forest areas. Experiments are being conducted, but they are limited to certain regions. Considering that Lithuania is a small country in terms of land area, scaling these experiments nationwide could be feasible”* (Academic/Researcher, Lithuania-6).

In Morocco, the practical use of AI technologies differs from that in Turkey and Lithuania. Although the scope of application is limited, AI technologies in Morocco are utilized for managing water resources, preventing soil desertification, and enhancing agricultural productivity. However, insufficient budgets and resources, and consequently, a severely underdeveloped digital infrastructure, represent urgent areas for improvement.

“The main challenge is monitoring water resources due to climate change. Although limited, we try to leverage technology because the risk of desertification is significant for our region” (Academic/Researcher, Morocco-4). *“I think the financial resources allocated are insufficient. The biggest challenge in the AI field is money. This needs to be addressed so that we can establish infrastructure comparable to that in other countries”* (AI/Technology Expert, Morocco-1/4).

A comparative evaluation across the three countries indicates that Lithuania leverages AI technologies in a holistic and strategic manner, supported by EU standards and policy frameworks. Turkey, despite possessing economic and policy potential, demonstrates limited use due to strategic planning, data management, and structural policy challenges. In contrast, Morocco utilizes AI technologies specifically for water resource management and mitigating desertification risks. In this process, financial shortages and inadequate infrastructure constitute the most significant barriers, highlighting a clear divergence from the other countries. Accordingly, it can be concluded that Lithuania’s strength lies in its robust institutional framework, Turkey’s in its high potential, and Morocco’s in its focus on environmental challenges. The areas requiring improvement in AI technology use differ across the three countries depending on their political, financial, and social structures.

Figure 3, based on expert opinions from Turkey, Lithuania, and Morocco, presents recommendations for advancing environmental management and AI utilization in the future. The emerging main themes are in Turkey, “Integration of AI in forestry and tourism areas”; in Lithuania, “AI integration aligned with EU policies”; and in Morocco, “Use of AI in water management and combating desertification.” The sub-themes indicating the practices driving these main themes in each country are detailed in Figure 3. The results derived from these sub-themes highlight significant differences reflecting each country’s unique priorities.

In Turkey, the highlighted strategies for enhancing the use of AI technologies focus primarily on the development of early warning systems in forested areas, as well as mechanisms for monitoring and tracking visitor flows. The emergence of these priorities can be attributed largely to the recent occurrence of large-scale forest fires. Additionally, the establishment of a national data platform and the development of both local and national software solutions are emphasized. In this process, the collaboration between universities and the industry sector is of critical importance.

In Turkey, recent large-scale forest fires have highlighted the urgent need for the establishment and nationwide deployment of early warning systems. Significant forested areas have been lost due to these fires (Forest Area Manager from Turkey-2/6). *National parks and nature reserves are experiencing very high visitor traffic, with people engaging in leisure, sports, and other activities. This necessitates the monitoring of*

visitor flows, control of visitor numbers, and tracking of peak periods. The development of local software solutions is suggested to reduce dependency on external technologies (Academic/Researcher from Turkey-4). Collaboration among experts from different sectors is also recommended; for instance, software companies, universities, and investors could jointly develop new AI tools, which could then be tested and implemented in forest tourism areas (Academic/Researcher from Turkey-1).

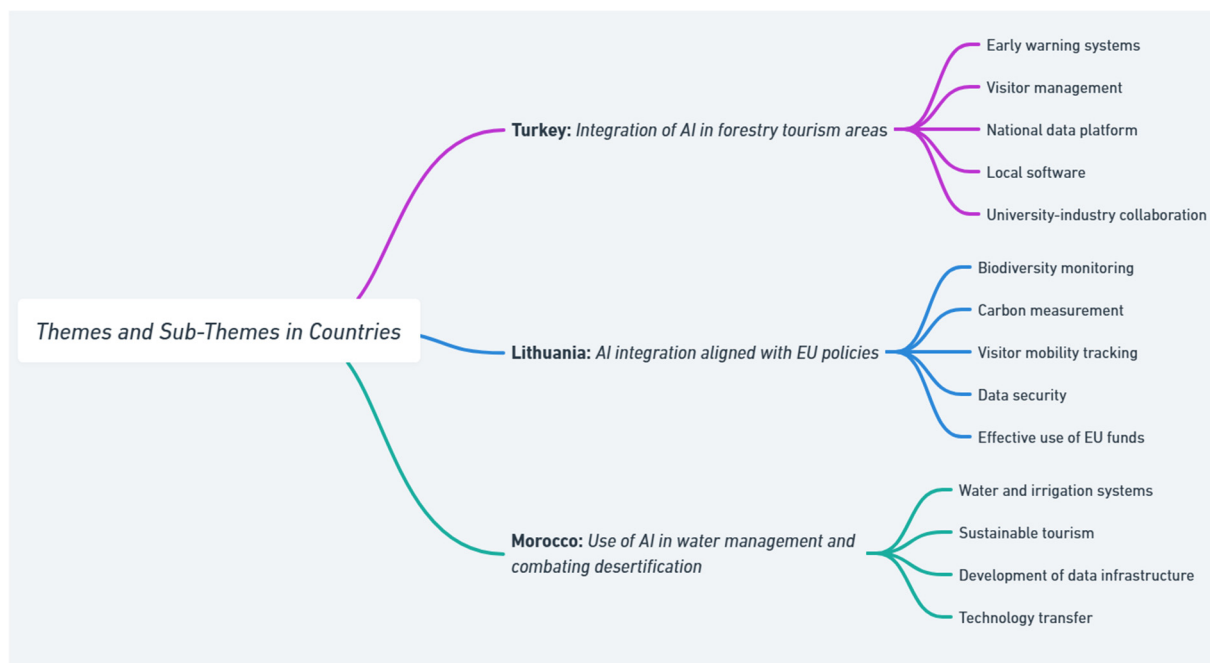


Figure 3. Future strategies for AI-supported forest tourism area management.

In Lithuania, the main advantage is seen in the EU regulations and legislative framework. The focus is on monitoring and protecting biodiversity within ecosystems, enhancing carbon emission measurements, and expanding related applications. The implementation of visitor tracking systems is highlighted, alongside the need for proper data processing and security measures. It is also noted that EU funding should support these initiatives, and that leveraging such funds is essential.

“We have a rich biodiversity, and existing practices should be further developed to protect it” (Nature Tourism Manager from Lithuania-3). “Visitor tracking systems have become widespread. Software and digital infrastructures that consolidate various datasets exist, but their development and broader application are necessary” (AI/Technology Expert from Lithuania-1). “Under the EU framework, numerous project programs exist. Academics and researchers should put more effort into following these calls and accessing project funds, as AI and related technologies are costly. Funding from the EU can provide significant financial support” (Academic/Researcher from Lithuania-5).

In Morocco, AI utilization primarily focuses on the planned management of water resources and measures against desertification. Key recommendations include technology transfer, strengthening digital infrastructure, and enhancing international collaborations, particularly to address environmental challenges arising from climate change.

“The drought and desertification risks are highly felt in our country, and efforts to mitigate them are ongoing. Utilizing technology is unavoidable in this process, and infrastructure must be acquired and continuously improved” (Forest Area Manager from Morocco-4). “Infrastructure is the most critical aspect for AI applications. A robust infrastructure and

adequate equipment are required” (AI/Technology Expert from Morocco-6/2). “We should engage in joint projects with Western countries and gain experience through international collaborations to develop our own system” (Academic/Researcher from Morocco-4).

4. Discussion

This section discusses the use of AI technologies for clean and safe environmental objectives in forest tourism areas in Turkey, Lithuania, and Morocco, using theoretical lenses such as the Technology Acceptance Model, Cognitive Pillar, Institutional Isomorphism, and Resource Dependence Theory. The results reveal significant similarities and differences across the three countries.

Expert opinions from Turkey, Lithuania, and Morocco indicate that while there are commonalities in practices for ensuring clean and safe environments in forest tourism areas, notable differences also exist. Across all three countries, priorities such as the preservation of natural environments, waste management, stakeholder responsibility and participation, and monitoring of visitor capacities emerge as shared concerns.

In Turkey, following major forest fires, priority has been given to technology-based GIS monitoring and drone systems. This approach can be explained through the lens of contingency and responsive adaptation. The strong emphasis on early warning systems for forest fire management aligns with institutional theory, particularly the contingency perspective and reactive adaptation approach [56–61]. Previous studies indicate that digital tools are rapidly adopted in management processes after natural disasters such as forest fires and floods, and authorities and institutions often use them as instruments of legitimacy [62–64]. The immediate deployment of digital solutions, such as AI technologies, following the aforementioned natural disasters, aims to enhance institutional effectiveness. Moreover, it facilitates grounding decisions and implementations on a solid societal and legal basis. Consequently, digital and technological interventions after natural disasters also increase the accountability capacity of management processes [65,66].

In Lithuania, current practices are aligned with EU environmental management regulations, and the frequent use of IoT- and sensor-based systems in forest tourism area management is evident. This can be understood as the influence of coercive institutional pressures stemming from EU membership obligations [67,68], Lithuania’s approach not only targets sustainable environmental management but also aims to strengthen its position in international environmental governance.

In Morocco, limited technological infrastructure has led to the persistence of traditional methods and a strong emphasis on local community participation, reflecting cultural and institutional influences. The continued reliance on local participation instead of technology-based approaches represents the primary distinction from Turkey and Lithuania. This observation can be interpreted through the lens of the common-pool resource management theory, where the weak institutional framework affects the inclusion of local communities in decision-making processes [69–71].

The institutional theory perspective posits that organizations and institutions shape their behaviors not only based on internal structures but also in response to environmental conditions, regulations, norms, and the pursuit of legitimacy [72–74]. Therefore, differences in forest tourism management practices in Turkey, Lithuania, and Morocco can be influenced not only by internal dynamics but also by political, economic, social, and financial structures and expectations. A closer examination of the research findings reveals both similarities and differences in how AI technologies are used in sustainable forest tourism management across the three countries. In Turkey, AI tools are primarily employed for monitoring and tracking, environmental surveillance, control measures, and visitor safety. This reflects the adoption of the reactive adaptation perspective within institutional theory,

showing that organizations respond to environmental needs through adaptive management [75–77]. The underlying issue is that while institutions and managers recognize environmental needs, they are less inclined to adopt innovative AI technologies.

Lithuania, in contrast, appears to be at a more advanced stage. Particularly in environmental management, technology transfer initiatives and digital twin applications have been implemented, reflecting the adoption of mimetic isomorphism theory [78–81]. This aligns with EU environmental governance and green transition policies, where best practices are emulated [81]. Moreover, the use of AR/VR-based educational content can be understood through the lens of the Technology Acceptance Model, as the adoption of AR/VR technologies is directly related to the acceptance level of technology by individuals, communities, or institutions [82–86]. In Morocco, the limited pilot applications and experimental stage of technology use indicate that the diffusion of innovations theory is being applied. Within this framework, individuals or institutions are positioned as “early adopters” or innovators [87–90]. Insufficient infrastructure in Morocco guides the early adoption process, as necessary investments and infrastructure development could advance innovation adoption. Overall, AI technology usage in the three countries demonstrates varying management approaches supported by different theoretical models. This variation is largely shaped by national policy priorities, institutional structures, technological infrastructure, and the level of technology acceptance.

According to another research finding, the opportunities and challenges associated with the use of AI technologies in Turkey, Lithuania, and Morocco present both similarities and differences in practice.

The technical and institutional challenges and opportunities emerging in the context of Turkey, Lithuania, and Morocco can be interpreted through the lens of Resource Dependence Theory and Institutional Theory [91,92]. In Turkey, the primary challenges are identified as insufficient technical infrastructure and financial resources. Consequently, the reliance of individuals or institutions on external resources limits their operational autonomy and may disrupt management processes [93–95]. In this context, continuous dependence on external sources in the use of AI technologies and other digital tools can gradually diminish the potential for control and decision-making within the relevant institutions and organizations [96]. Despite these challenges, initiatives to deploy AI technologies for early warning systems following large forest fires exemplify the contingency perspective in sustainable environmental management in Turkey. Indeed, the tendency of governments or institutions to adopt innovative solutions to address major natural events and climate crises serves as a concrete illustration of this approach [97,98].

In Lithuania, insufficient expertise in AI and challenges in data processing and sharing are considered major obstacles. These issues can disrupt institutional functioning and coordination. Addressing these challenges can be conceptualized through the “regulative and cognitive pillars” of institutional theory [99]. The cognitive pillar plays a significant role in remedying deficiencies and embedding practices as standard [100,101]. Therefore, all actors in the process must leverage collective perceptions and consider cultural norms to overcome challenges related to data sharing and expertise shortages.

At the same time, in Lithuania, digital twin applications and AR/VR-based training programs are considered opportunities for sustainable environmental management. This process can be interpreted through the dynamic capabilities approach [102,103], which emphasizes how organizations adapt to changes, improve management processes, and enhance competitive potential in a rapidly evolving environment [104–106]. Compared to the other two countries, Lithuania has effectively integrated technology transfer initiatives, particularly AR/VR technologies, into environmental management practices. AR/VR technologies have recently emerged, through technology transfer, as innovative approaches

in sustainable environmental management. These technologies enable individuals to gain experiential insights into environmentally related behaviors, while also presenting the potential to promote pro-environmental practices [107].

In Morocco, the challenges encountered are primarily characterized by insufficient infrastructure and limited expertise. Like Turkey, this situation emphasizes external dependence for resource needs, which can be explained through Resource Dependence Theory [108]. The inadequacy of internal resources and the reliance on external sources pose potential risks for managers and institutions in their operational processes. Conversely, in Morocco, the perception of international cooperation and projects as opportunities is interpreted as an effort to mitigate resource dependence. International collaboration and project opportunities provide avenues for knowledge and technology exchange in sustainable environmental management. They also facilitate the sharing of best practices, while playing a crucial role in the development and dissemination of globally oriented solutions for environmental sustainability [109,110]. From the perspective of Institutional Isomorphism Theory [111–113], engaging in international collaborations and projects allows institutions to respond to external pressures and maintain legitimacy.

When examining the strengths of AI technologies in forest tourism areas and the recommendations for enhancing their use in future environmental management processes across Turkey, Lithuania, and Morocco, notable differences between countries emerge.

The findings suggest that the use of AI technologies in forest tourism can be interpreted through the lens of Institutional Theory. In Lithuania, AI technologies are effectively employed in biodiversity conservation and the monitoring of water resources. The alignment with EU standards guides institutions across the country toward similar practices under the framework of institutional isomorphism, representing a strong structural foundation for AI utilization [114,115]. Institutional isomorphism promotes similar organizational structures and practices, aiming to align managerial processes across institutions [116–118]. EU standards further ensure the convergence of practices among member countries.

Regarding recommendations for the future use of AI technologies, these are also interpreted through the same theoretical lens. In Lithuania, ensuring data security, developing applications for carbon emission measurement, and establishing visitor monitoring systems are highlighted as critical for environmental management, with EU standards serving as the main guiding framework [119–121]. In Turkey, the areas where AI technologies are strongly utilized include the monitoring of natural resources, waste management, and environmental surveillance. From a cognitive pillar perspective [122–124], it can be argued that institutions and managers in the country consider AI technologies as an integral and essential part of environmental management. In this process, nationwide early warning systems, visitor monitoring, and national data platforms represent key recommendations for AI implementation [125–127].

In Morocco, access to AI technologies is limited by external dependence and insufficient financial resources, which can be explained within the framework of Resource Dependence Theory. This external reliance significantly constrains infrastructure and hardware capacity. Although limited and in pilot phases, AI technologies in Morocco have begun to be applied for water resource management and combating desertification. To overcome the limitations, collaboration and partnerships with other actors and stakeholders are essential [128–130]. To address this necessity, experts highlight the importance of initiating technology transfer measures in the country, which includes strengthening the digital infrastructure. This, in turn, could reduce external dependency [131,132].

5. Conclusions

This study provides a comprehensive comparative opportunity to examine the use of AI technologies for clean and safe environmental goals in forest tourism areas across Turkey, Lithuania, and Morocco, countries with distinct geographies, cultures, and social structures. In each country, existing practices in the sustainable management of forested areas were analyzed, potential opportunities and encountered challenges were identified, and recommendations and expectations for the use of AI technologies in environmental management were determined. The findings suggest that while there is considerable potential for the use of AI technologies in forest tourism areas in Turkey, Lithuania, and Morocco, significant differences exist in practice. Both the potential and the differences are shaped by the countries' geographic, social, economic, and cultural contexts. Based on the views and statements of the experts included in the study, the conclusions below can be drawn.

In Turkey, recent large-scale forest fires have heightened the need to adopt AI technologies. The use of early warning systems, drones, and GIS-based tracking in forest areas has been expanding. AI integration into visitor monitoring, environmental education, and natural resource management is also seen as important. However, limited financial resources and weak digital infrastructure remain major barriers to broader adoption.

In Lithuania, as an EU member state, IoT infrastructure and sensor-based monitoring systems have been widely deployed in line with EU environmental policies and standards. Additionally, digital twin applications are being utilized to simulate potential risks. The integration of AI applications into environmental education through AR/VR technologies is also observed. With AI applications, carbon emission measurements are conducted, and decisive steps are taken to preserve ecosystems and biodiversity. Despite these significant advances, challenges remain in data processing and sharing, regulatory barriers, and insufficient societal awareness. What sets Lithuania apart from Turkey and Morocco is its ability to leverage EU funds to make necessary investments in technology and digital transformation.

Compared to Turkey and Lithuania, Morocco is still at an early stage in integrating AI technologies into environmental management. Consequently, traditional methods and human resources remain the primary drivers in forest area management. Even at this nascent stage, AI technologies in Morocco are being utilized for the planned management of water resources, improving agricultural productivity, and combating desertification. To overcome the constraints of limited AI usage, Morocco is actively seeking international collaborations aimed at technology transfer. However, reliance on external resources, insufficient digital infrastructure, limited expertise, and low educational capacity are identified as the most significant challenges.

In Turkey, increasing technological initiatives emphasize the development of domestic software and digital tools, as well as the reduction in external dependency. Early warning systems for forest fire management and visitor monitoring are being expanded to protect natural environments. In Lithuania, EU policies and standards present a significant opportunity, and AI technologies are extensively used in areas such as education, big data processing and management, visitor monitoring systems, sensors, and carbon emission tracking. In contrast, applications in Morocco primarily focus on fundamental environmental issues and the planning and control of natural resources, with limited AI usage distinguishing it from the other two countries. International collaboration is considered the most important opportunity for expanding AI technology adoption in Morocco.

This study focuses on the use of artificial intelligence (AI) technologies to achieve clean and safe environment objectives in forest tourism areas in Turkey, Lithuania, and Morocco. The findings indicate that the application of AI technologies is largely determined by each

country's infrastructure, priority needs, and administrative/institutional capacities. Based on these priorities, the following country-specific recommendations are proposed:

- ✓ In Turkey, while existing applications should continue, a strategy-driven, data-based system should be established to facilitate long-term environmental planning.
- ✓ In Lithuania, the broader adoption of AI technologies that support environmental sustainability should be encouraged, with particular emphasis on optimizing visitor management and environmental monitoring systems.
- ✓ In Morocco, the expansion of AI usage requires first addressing infrastructure deficiencies, leveraging international collaborations and project opportunities to build capacity.
- ✓ For all three countries, knowledge and experience-sharing platforms should be established to facilitate the transfer of AI-based environmental management and tourism technologies.
- ✓ Comparative learning mechanisms among Turkey, Lithuania, and Morocco should be strengthened, enabling successful practices to be adapted across countries.
- ✓ Considering regional, cultural, administrative, and financial differences, best-practice guides and policy recommendations should be developed.

By highlighting the role of socio-cultural, institutional, and infrastructural contexts in the adoption of AI applications, policymakers and managers in other regions can adapt technology-based solutions to local conditions. The implementation of early-warning systems, visitor-flow monitoring, and data-driven decision-making processes—as applied in Turkey, Lithuania, and Morocco—can enhance transparency, accountability, and sustainability in forest tourism and natural resource management.

This research aims to examine the influence of socio-cultural, environmental, and institutional contexts on the adoption and effectiveness of AI applications. Moreover, it provides current and novel insights by adopting an interdisciplinary perspective from an international standpoint. The study particularly emphasizes emerging developments in technology while integrating management and operational processes, employing a comparative, multi-country approach. Finally, it is anticipated that the findings of this research will contribute to the development of theories, the improvement of administrative processes, and the shaping of policy decisions in the fields of environmental sustainability and forest tourism management on a global scale. Decision-makers can use these findings as a guide in the design and implementation of environmental management and sustainability policies. The results support decision-making in strategic planning by helping to prioritize actions, allocate resources effectively, and integrate innovative technologies. Additionally, they provide actionable recommendations for strengthening stakeholder collaboration and enhancing environmental awareness.

Limitations of the Study

This study is structured with certain limitations while also offering opportunities for future research. The research is primarily confined to Turkey, Lithuania, and Morocco; therefore, the findings are evaluated within the context of these three countries. In subsequent studies, comparative analyses involving countries with different geographical, cultural, and social characteristics appear feasible. Furthermore, as the data are derived from expert opinions in these countries, the study conceptually outlines the current situation. Future research is expected to enrich these findings through the incorporation of quantitative data. Conducted within a qualitative research methodology, this study provides a comprehensive and in-depth framework for understanding the potential use of AI technologies in sustainable environmental management.

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