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Amalgamation of Sustainable Tourism Development with Industry 5.0

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ABSTRACT:

The merger of Industry 5.0 with developing sustainable tourism software systems gives a new approach to planning trips that are more advanced technologically, more socially equitable, and more environmentally friendly. Industry 5.0 is defined as a human-centred technology that focuses on sustainability and which addresses the challenges in the travel and the tourism sector. The use of advanced technologies, such as blockchain, robotics, the Internet of Things and artificial intelligence (AI) encourages green strategies, enhances efficacy of resources utilization and elevates the visitors' overall experience.

Local communities and cultural heritage are central to human-centric design in sustainable tourism, from a philosophy point of view, in synchronization with Industry 5.0. Smart technology brings down the impact of tourism on the environment while reducing trash, enabling energy management, and real-time ecosystem monitoring. Blockchain ensures transparent supply chains for fair trade and ethical sourcing for any goods or services sold during tourism.

The tourism industry can step forward toward a responsible and resilient future by merging state-of-the-art innovations with sustainable practices. Industry 5.0 and sustainable tourism development together aim to provide a balanced approach ensuring that technological

advancements support ecological conservation, cultural preservation, and equitable economic growth. In addition, assistive technologies that enhance the accessibility of people with disabilities and VR/AR augment tourism by making pre-trip experiences more interactive and conscious, encouraging responsible tourism decisions. By leveraging AI and big data analytics, data-informed insights on resource allocation and visitor flow may be optimized and the risks associated with overtourism and degradation of the environment may be decreased.

Another significant outcome of this integration is inclusivity, as assistive technology makes accessibility easier for people with disabilities. Data analytics and AI enhance decision-making and reduce congestion and its associated impacts by optimizing resources and visitor flow. Besides resolving social and ecological concerns, this integration ensures economic viability, promotes equitable growth, and conserves cultural heritage.

It is the combination of Industry 5.0 and sustainable tourism development that makes possible an inclusive, resilient, and ecologically conscious tourist future. This creative strategy ensures that tourism develops as a force for good in balance with the environment, emphasizing the possibility of using technology for the greater good.

Keywords: Accessibility, Artificial Intelligence, Augmented Reality, Blockchain, Cultural Heritage, Data Analytics, Environmental Sustainability, Ethical Tourism, Human-Centric Design, Industry 5.0, Inclusivity, Internet of Things, Resource Management, Smart Systems, Sustainable Tourism, Virtual Reality.

INTRODUCTION

The hospitality industry forms the backbone of the global economy, which is responsible for job creation, increasing the rate of economic growth, and promoting intercultural dialogue. This lively industry comprises a vast spectrum of businesses, including hotels, resorts, restaurants, and tour operators, all contributing enormously to the global GDP. However, the expansion of this sector also throws numerous challenges along with its outstanding potential, especially in the context of sustainability. With globalization, the economic, social, and

environmental impacts of the hospitality sector have been brought to the forefront of concerns regarding sustainability.

The hospitality industry has grown rapidly in the last few decades, and resource consumption has increased at an equally rapid rate. With billions of tourists visiting the world every year, there is an increased demand for raw materials, water, and electricity. Deforestation, pollution, and the depletion of freshwater sources are only a few examples of the serious environmental deterioration brought on by this increased strain on natural resources. The United Nations World Tourism Organization (UNWTO) estimates that tourism and hospitality sectors together add nearly 8% of the world's emissions to greenhouse gases, thus illustrating how significant this industry has been in causing climate change. These effects on the environment show how urgently the industry needs to adopt sustainable methods.

The concept of sustainable tourism development has emerged as a vital strategy to cope with these increasing challenges and ensure the long-term monetary sustainability of the hospitality industry while minimizing harmful environmental consequences. Sustainable tourism aims to achieve an equitable balance of economic, social, and environmental impacts of travel such that present needs may be met without compromising the ability of future generations to meet their own. This requires an integrated approach aimed at resource protection, waste elimination, ethical consumption, and protecting regional cultures and ecosystems.

Thus, the tourism industry has begun adopting Industry 5.0 principles within which advanced innovation, teamwork, and human-centred technologies play a key role to address the challenges of sustainability, focusing on human well-being over achievements in technology. Building upon technological automation and efficiencies of the predecessor, Industry 4.0, Industry 5.0 offers a way to explore, sustainably change, and revolutionize the management and the experience of tourism. Indeed, Industry 5.0 may solve numerous issues that the sustainability of the travel industry faces by providing intelligent systems that maximize the use of all resources to providing AI-based, customized travel experience.

The fusion of Industry 5.0 technology with the concept of sustainable tourism can be considered a solid ground to create a more resilient, inclusive, and eco-sensitive tourist model in the process of hospitality development. This creative combination has the ability to enhance travel experiences to be more immersive, equitable, and accessible to all and also reduce negative impacts on the environment and society by the tourism industry. For that reason, the future of sustainable tourism is really marked by the industry 5.0 change.

This study delves into the method of the implementation of Industry 5.0 technologies as tools for implementing effective good change within the tourism hospitality industry with sustainable tourist development as the central core. Drawing upon current applications, case studies, and previous knowledge, the analysis aims at clearly identifying potential synergies of integration between two realms and proposals as to how to work jointly on developing the increasingly technologically more sophisticated and therefore more accessible yet sustainable sector in tourism. The following sections will discuss the core concepts of Industry 5.0 and sustainable tourism and then discuss how these two concepts can be integrated for mutual benefit.

The ultimate goal of this paper is to show how this integration has the potential to enhance the social and economic value of the tourism industry while at the same time reducing its ecological footprint, ensuring that it evolves into a more responsible, resilient, and human-centred sector for the future.

BACKGROUND:

The hospitality sector around the world generates millions of employments and boosts economic growth, thus making it a significant contributor to the world economy. The industry covers various segments of companies, which consist of lodging facilities, resorts, dining establishments, travel agents, and tour operators. All of these are aspects that would be integrated into cross-cultural interaction and global connectedness.

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The tourism industry is one of the fastest-growing sectors, accounting for around 10% of the world's GDP, with the tourist and hospitality sectors. Environmental problems have been made worse by the increased demand for resources like raw materials, electricity, and water as a result of this quick growth. Negative environmental impacts of tourism include deforestation, pollution, and abuse of natural resources, besides causing biodiversity loss. Tourism is also one of the major contributors to climate change. According to the UNWTO of the United Nations, tourism currently accounts for some 8% of the world's greenhouse gas emissions.

In this respect, the new concept of Industry 5.0 provides a unique opportunity to transform the travel and tourism industry. Based on the technological breakthroughs of Industry 4.0, such as robotics, artificial intelligence (AI), and the Internet of Things (IoT), Industry 5.0 focuses on sustainable and human-centric innovation. Human-machine collaboration will be given the utmost importance for the betterment of environmental sustainability, inclusiveness, and human well-being. Industry 5.0 technology in the travel and tourism industry may find creative answers to many problems related to resource management, waste reduction, and environmentally friendly practices. Blockchain will ensure transparency in the supply chain and authenticate the sustainability of tourism products, while AI and big data will improve resource use and cut waste in tourism operations.

Integration of Industry 5.0 is one of the possible ways forward for the tourist sector as it faces growing pressure to be more sustainable. By tapping into the power of advanced technologies to support sustainability objectives, the tourism sector can tackle its environmental, economic, and social challenges and offer travellers more personalized, inclusive, and responsible travel experiences. This context sets the basis for probing the relationships between the growth of sustainable tourism and the revolutionary potential of Industry 5.0 technology. In this connection, the new concept of Industry 5.0 provides a unique opportunity to transform the travel and tourism industry. Industry 5.0 discusses sustainable and human-centred innovation beyond technological novelties of Industry 4.0: robotics, artificial intelligence, and the Internet of Things.

PROBLEM STATEMENT:

The hospitality and tourism sectors, therefore, must adopt sustainable practices immediately in order to ensure long-term benefits, striking a balance between growth, environmental responsibility, and social inclusivity, given that their negative effects on the environment and local communities include resource depletion, pollution, and greenhouse gas emissions.

OBJECTIVE:

- Assessing the possibility of using Industry 5.0 technology in collaboration with sustainable tourism concepts.
- The primary objective is to investigate how innovations in Industry 5.0, including blockchain, AI, IoT, and VR/AR, can be applied to minimize the adverse effects of tourism on the environment.
- to assess how these technologies support socially conscious travel that enhances regional cultures and communities.
- To consider the potential of development in the long run and the economic viability of introducing Industry 5.0 technologies into sustainable tourist practices.
- To put forth a resilient and ethical tourist strategy in the context of sustainability objectives developed by technology innovations.

LITERATURE REVIEW:

- The Development of Sustainable Tourism and Its Importance For nearly two decades, sustainable tourism has been a 'hot issue' in tourist studies. It is described as travel that is respectful of the financial, social, and environmental impact of visitors and aimed at minimizing harmful impacts while maximizing long-term benefits. The **UNWTO (2019)** stated that sustainable tourism is meant to maximize the benefits of travel to both the location and its tourists in such a way that the sector can be sustained without damaging the environment or cultural heritage. This has been more critical lately because the world's tourist industry grows faster, and its harmful effects on the environment and society—like the generation of wastes, excessive consumption of

resources, and social displacement—become more evident. Scholars argue that innovative approaches that address the challenges of sustainable tourism are required.

- Challenges in Applying Sustainable Tourism Though sustainable tourism ideas have gained immense popularity, applying such practices is still a hard job in the tourism and hospitality industry. The very rapid development of tourism makes sustainability measures not as easy to be implemented on an appropriate scale according to **Gössling et al. (2021)**. The major hindrances include low awareness, poor enforcement of policy, and slow adoption of new technologies. Overtourism severely contaminates the environment, destroys ecosystems, and increases carbon emissions, in particular, in popular destinations.
- Most tourism enterprises prioritize profits over sustainability, and this worsens the impacts on the environment and society. According to scholars, achieving sustainability in the tourist industry requires substantial changes in consumer behaviour, public policy, and corporate accountability aside from industry stakeholders adopting sustainable practices **(Dube & Ren, 2017)**.
- Industry 5.0 and Its Basics Industry 5.0 is a shift from the technology-based Industry 4.0 towards a more sustainable and human-centred approach, with a focus on collaboration between humans and advanced technologies. Industry 5.0 combines blockchain, robotics, the Internet of Things (IoT), and artificial intelligence (AI) while being centred on inclusivity, sustainability, and human welfare **(Chryssolouris et al., 2020)**. Industry 5.0 aims at minimizing the impacts of industrial activity on society and the environment. The industry shall create more custom-fit and agile systems that rely not only on automation but also human involvement in such systems. The tourism industry, for example, can help transform towards greater sustainability through technologies available for effective waste management, efficient use of resources, and reduced carbon footprints.
- Technological Innovations in Tourism: Role of AI and IoT Various studies have focused on how cutting-edge technologies, such as artificial intelligence (AI) and the Internet of Things (IoT), can enhance tourism's sustainability. For instance, AI can be utilized to predict demand patterns, optimize operational processes, and manage resource

consumption efficiently **(Buhalis & Sinarta, 2019)**. On the other hand, IoT can facilitate monitoring environmental factors like energy consumption, water consumption, and waste production in real-time, enabling tourism businesses to obtain information that will be used to make informed decisions. In this case, the smart hotels and resorts, through IoT devices, can minimize energy consumption and enhance proper waste disposal as far as sustainability goals are concerned. Integration of AI and IoT into tourism systems, therefore, has implications both on efficiency and on environmental impact.

- Challenges in the Integration of Industry 5.0 to Tourism Industry Industry 5.0 holds significant potential for sustainable development of tourists, but major barriers exist regarding integration into the tourism industry. The digital divide, high costs, and lack of technology infrastructure are some of the challenges for SMEs in the tourism industry **(Xie & Lee, 2020)**. Another significant challenge that can hinder the wide adoption of Industry 5.0 technologies is the slow pace of regulatory frameworks in most countries. A coordinated plan for incorporating Industry 5.0 solutions in tourism is also hindered by the difficulty of coordinating many parties involved, including governments, local communities, companies, and travellers.

APPLICATION OF INDUSTRY 5.0 in SUSTAINABLE TOURISM

- Two of the AI-driven platforms that are utilized by states such as Kerala, for instance, are **Tourism Forecasting Models**, which use data analytics and artificial intelligence to forecast tourism trends and improve resource allocation. For example, AI could predict the peak tourist flow during Munnar's Neelakurinji bloom and help officials manage crowds while protecting this delicate ecosystem.
- **Resource Optimization:** Incredible India 2.0 is using AI and data analytics to track visitor preferences, offering travel and lodging options that are friendly to the environment, thus reducing the negative impact on the environment.
- **Supply Chain Transparency:** The Sikkim Tourism Blockchain Initiative ensures that the tourism services' locally sourced, eco-friendly goods are transparent. For example,

blockchain tracks the provenance of handwoven clothing or organic teas that tourists buy.

- **Eco-Certification Tracking:** Initiatives such as Green Haat validate and certify sustainable business practices in tourism-related enterprises through blockchain technology, encouraging ethical and fair commerce.
- **Smart Resorts:** Rajasthani eco-resorts are using IoT to control energy consumption in an effective way. For instance, the rooms have motion sensors and IoT-enabled thermostats that prevent the wastage of electricity when there are no visitors.
- **Environmental Monitoring:** IoT sensors in Ladakh provide real-time data on glacier health and air quality, which helps control tourism activities to save the ecosystem.
- **Pre-Trip Experiences:** Sites such as MyGov Tourism AR offer virtual tours of destinations such as the Taj Mahal and Hampi, in addition to educating visitors on the importance of conserving cultural heritage and hence responsible travel.
- **Lowering Overtourism:** Virtual safaris and augmented reality experience for Gir National Park keep visitors interested while lessening the physical burden on ecosystems and species.
- **Improving Service Efficiency:** The use of cobots or, in other words, collaborative robots help with concierge services in a high-end hotel like Leela Palace Bengaluru and reduces human labour dependency while improving efficiency.
- **Hospitality Inclusivity:** Some hotels are using Cobots to provide services such as automated check-in and accessible room features that are specifically designed for visitors with disabilities.
- **Accessible Tourism for All:** Projects such as the Accessible India Campaign, which employs AI-enabled apps like Sugamya Bharat to help tourists with disabilities navigate popular destinations, rely heavily on Industry 5.0 technologies.
- **Inclusive Experiences:** To make the Shore Temple in Mahabalipuram accessible and inclusive, it offers AR-based tours with audio descriptions for the blind and visually impaired.

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CHALLENGES AND BARRIERS TO INTEGRATING INDUSTRY 5.0 WITH SUSTAINABLE TOURISM

TECHNOLOGICAL CHALLENGES

- **High Initial Investment Costs:** The adoption of Industry 5.0 technologies, such as blockchain systems, robotics, and IoT infrastructure, by small and medium-sized tourism businesses is quite challenging because these require high investment costs.
- **Limited Technological Expertise:** Most of the tourist stakeholders lack the technical know-how to implement and maintain the latest technologies, especially in rural and disadvantaged areas.
- **Connectivity Issues:** The deployment of IoT devices and real-time data management systems is hindered in isolated or rural tourist areas by unreliable internet and network infrastructure.

ECONIMIC BARRIERS

- **Financial Constraints for Small Operators:** Independent and small travel agencies often cannot afford the cost of employing the latest technologies.
- **ROI is Not Clear:** Because of the issues related to long-term profitability and measurable benefits, tourism businesses may not be willing to adopt Industry 5.0 technology.

SOCIAL AND CULTURAL RESISTANCE

- **Resistance to Change:** Many tourism-related professions and communities are resistant to adopting new technology due to a lack of belief in their effectiveness or fear of losing their jobs.
- **Adoption Rates are Reduced**: Due to a lack of knowledge on the possible benefits of Industry 5.0 in terms of sustainability among local communities and tourism stakeholders the adoption rate of the new change is on lower side.

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POLICY AND GOVERNANCE ISSUES

- **Lacks Comprehensive Policy Frameworks:** Regulatory guidelines and standards for the introduction of advanced technology in tourism might be inadequate.
- **Data security and privacy concerns**: These issues arise, mainly due to AI, IoT, and blockchain technologies used while handling the information of the tourist in such situations.
- **Lack of Appropriate Incentives and Support:** Most governments do not offer incentives such as subsidies, grants, or tax incentives to push businesses into Industry 5.0 technologies.

ENVIRONMENTAL AND SUSTAINABILITY CHALLENGES

- **Energy Consumption:** Unless powered by renewable resources, the significant amounts of energy required by many Industry 5.0 technologies, such as data centres and the Internet of Things, can increase the carbon footprint.
- **E-waste Management:** Green practices may be hindered by the rapid adoption of technological advancements, which may lead to an increase in electronic wastes.

OPERATIONAL CHALLENGES

- Integration with Existing Systems: Most tourism businesses use legacy systems that are not compatible with Industry 5.0 technologies, making integration expensive and challenging.
- Interoperability Issues: Seamless communication between technologies such as AI, blockchain, and IoT is difficult and resource-intensive.

CULTURAL AND COMMUNITY IMPACTS

- **Risks of Over-Tourism:** Unless controlled, technological innovations such as VR/AR may lead to increased numbers of travellers going to places already congested, which would exacerbate the over-tourism problem.

- **Uneven Distribution of Benefits:** Advanced technologies may provide greater benefits to larger businesses and urban areas, whereas disadvantaged operators and rural communities shall fall behind.

EDUCATIONAL AND TRAINING BARRIERS

- **Skills Gap:** Training is needed for tourism workers and operators to use and maintain new technologies efficiently, but training programs are often unavailable or inaccessible.
- **Slow Implementation In Educational Curricula:** Implementation of Industry 5.0-related skills within tourism and hospitality education often is slow, delaying when new graduates will be ready.

ISSUES WITH CULTURAL HERITAGE

- **Loss Of Authenticity:** Heritage tourism may lose all its authenticity due to excessive use of technology which may jeopardize the sustainability of the culture.
- **Technology Overload:** Overuse of technology may obscure the authentic, cultural, and natural aspects of travel experiences, giving visitors a phony, less genuine connection.

FUTURE TRENDS & IMPLICATIONS

Extreme Customization in Travel Experiences

- Hyper-personalized itineraries based on current traveler preferences will be made possible by advanced AI and data analytics, encouraging environmentally friendly lodging and low-impact activities as well as other sustainable options.
- For instance, AI-powered applications that recommend unusual travel spots can help cut down on excessive tourism in well-known regions.

Growth of Intelligent Travel Locations

- Using IoT, destinations will develop into networked ecosystems where intelligent sensors optimize visitor flows, trash management, and energy utilization.

- For instance, IoT is being used by smart cities like Jaipur to monitor and regulate the air quality close to popular tourist destinations.

Growing Use of Blockchain

- Blockchain will transform supply chains by guaranteeing ethical sourcing and enabling the traceability of travel-related goods. Additionally, it will protect traveller data and digital transactions.
- Example: Green travel loyalty programs powered by blockchain that incentivize travellers to make sustainable decisions.

Growth of Augmented and Virtual Reality

- AR and VR technologies will offer immersive pre-trip planning and virtual tours, reducing the environmental impact of physical visits and encouraging responsible tourism.
- Example: Virtual safaris of national parks like Ranthambore to minimize human-wildlife interactions.

Cobot (Collaborative Robot) integration

- Cobots will improve hospitality service delivery by emphasizing speed and inclusivity while freeing up human employees to work on higher-value duties.
- As an illustration, consider Cobots supporting multilingual services in major global travel destinations like Delhi and Mumbai.

Sustainability Driven by Data

- AI analytics and real-time data from IoT devices will inform resource management and environmental preservation decisions.
- As an illustration, consider using predictive analytics to control the amount of visitors at busy times in environmentally delicate regions such as Sikkim.

Put Accessible Travel First

- In order to make travel inclusive for everyone, technologies like AI, AR, and IoT will improve accessibility for those with disabilities.
- For instance, visually handicapped travellers visiting historical sites like Hampi can use smart guidance apps.

Shift Toward Decentralized Platforms

- The trend toward decentralized platforms will increase the number of peer-to-peer platforms made possible by blockchain, which will lessen the need for centralized booking systems and encourage direct communication between tourists and local service providers.
- One example would be decentralized platforms that link visitors to ecotourism projects in tribal areas.

IMPLICATIONS

Environmental Impacts:

- **Positive:** Better resource management and less overtourism will safeguard biodiversity and fragile ecosystems;
- **Negative:** If advanced technologies are not balanced with the adoption of renewable energy, increased energy consumption could present sustainability challenges;

Economic Impacts:

- **Positive:** Data-driven marketing can increase revenue;
- **Negative:** Small businesses may find it difficult to compete with larger players that have access to advanced technologies;

Social and Cultural Impact:

- **Positive:** Accessibility and inclusivity will improve, enabling diverse populations to enjoy and benefit from tourism;

- **Negative:** An excessive reliance on technology may undermine the authenticity of cultural experiences.

Technological Developments:

- Ongoing innovation will make sustainable solutions, like blockchain-verified ethical practices and IoT-enabled green infrastructure, more scalable, but they may also widen the digital divide between developed and developing nations.

Policy and Governance

- Governments must enact strong regulations to ensure ethical data use and fair access to Industry 5.0 technologies, and international cooperation will be crucial to standardize practices and promote sustainable tourism worldwide.

Educational and Workforce Evolution

- New skill requirements in AI, blockchain, and IoT management will revolutionize tourism and hospitality education, creating a workforce prepared for the future.
- Upskilling current employees will be crucial to reducing job displacement due to automation.

Business Models for Tourism

- The desire for responsible travel and Industry 5.0 developments will propel traditional tourist models to adopt sustainability-focused strategies.
- For instance, subscription-based ecotourism businesses that provide customized, environmentally friendly vacation packages.

Improved Experience for Travelers

- Industry 5.0 will guarantee smooth travel experiences by integrating systems that incorporate sustainability, customisation, and ease.
- For instance, AI assistants can offer real-time suggestions for environmentally friendly eateries or modes of transportation.

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CONCLUSION

Addressing the urgent environmental, social, and economic issues facing the global tourism sector can be done in a revolutionary way by combining sector 5.0 with sustainable tourism development. Although tourism is essential to both economic development and cross-cultural interaction, its explosive rise has resulted in serious resource depletion, environmental damage, and social injustice. A paradigm changes toward sustainability—which prioritizes social inclusion, environmental responsibility, and long-term economic viability—is required in light of these issues. A technology-driven, human-centred framework provided by Industry 5.0 easily fits the objectives of sustainable tourism.

Artificial intelligence (AI), the Internet of Things (IoT), blockchain, robotics, and virtual/augmented reality (VR/AR) are some of the cutting-edge technologies of Industry 5.0 that offer creative answers to the intricate problems of sustainable tourism. AI and IoT make it possible to monitor and optimize resources like garbage, water, and electricity in real time, which lessens the environmental impact of tourism operations. Blockchain promotes trust in sustainable practices by guaranteeing accountability and transparency in supply chains. By providing immersive virtual experiences that emphasize the need of environmental care and cultural preservation, VR and AR can, in the meantime, lessen the need for actual travel.

The tourism sector can adopt strategies that are not only effective and scalable but also socially inclusive and equitable by using these technologies, going beyond conventional approaches to sustainability. In order to provide more individualized and flexible solutions that meet the many needs of stakeholders, such as tourists, local communities, and enterprises, Industry 5.0 places a strong emphasis on human-machine collaboration. This human-centred approach makes sure that the value of cultural heritage, community well-being, and ethical tourist practices are not overshadowed by technical improvements.

However, major obstacles must be removed for Industry 5.0 to be successfully included into the development of sustainable tourism. Governments, industry stakeholders, and local communities must work together to solve the digital divide, high implementation costs, and regulatory obstacles. Legislators must create strong frameworks that encourage the use of green

technologies, control their negative effects on the environment, and guarantee that the advantages of tourism are distributed fairly. Additionally, increasing visitor understanding of sustainability and responsible travel practices is essential to boosting demand for environmentally and socially responsible travel experiences.

The tourism industry's future could be completely reshaped by the combination of Industry 5.0 and sustainable tourism. The industry may lessen its effects on the environment, promote social inclusion, and guarantee that financial gains are distributed fairly by utilizing technology to improve sustainability. This strategy places the tourism industry as a leader in the shift to a more sustainable global economy and is in line with international sustainability goals, such as the Sustainable Development Goals (SDGs) of the UN.

In the end, combining Industry 5.0 with sustainable tourism development is not only a chance but also essential to the tourism sector's long-term survival. Stakeholders can develop a tourism model that balances technological innovation with social justice, cultural preservation, and environmental conservation by adopting this integrated approach. This will guarantee that tourism continues to be a positive force in a world that is changing quickly.

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