JOURNAL OF TOURISM, SUSTAINABILITY AND WELL-BEING
2025, VOL. 13, NO. 3, 159–188
ISSN: 2795-5044 | https://doi.org/10.34623/wkw4-yd03

# Tourism 4.0: Unveiling the Digital Transformation and Sustainable Development of the Tourism Industry

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## ABSTRACT

This study aims to provide a comprehensive overview of Tourism 4.0, a concept that enhances the value of the tourism industry through innovation, technology, knowledge, and creativity. Using a systematic review approach, the research analyses selected scholarly articles to clarify definitions, explore related digital technologies, and examine the concept's potential to support sustainable tourism development. A total of 26 articles were chosen from an initial pool of 148 based on defined quality criteria. The analysis, supported by NVivo and VOSviewer software, reveals the major themes and drivers behind Tourism 4.0, emphasising its transformative role in the tourism sector. The findings demonstrate that Tourism 4.0 can meaningfully contribute to the sustainable growth of tourism destinations by enabling digital transformation and innovation. The study identifies key research gaps and provides insights to guide future academic efforts and policymaking. By synthesising existing literature, this research offers a solid foundation for understanding Tourism 4.0 and supports informed decision-making in shaping the future of tourism through digital advancements.

## KEYWORDS

Tourism 4.0, Digital Transformation, Sustainable Tourism Development, Smart Technologies, Fourth Industrial Revolution, Systematic Review.

## ARTICLE HISTORY

Received 30 January 2025 Accepted 30 May 2025

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## 1. Introduction

The tourism industry, closely linked with social development and technological advancements, has gained significant attention in the digital age, attracting approximately 3.1 billion global travelers annually (Peceny et al., 2019). Recognized for its pivotal role in national economies, the tourism sector generates substantial foreign exchange earnings and government revenues, emphasising the importance of technological integration (Tasya & Usman, 2019). The rapid evolution of tourism markets underscores the critical role of innovation in establishing a sustainable competitive edge (Lim et al., 2021).

As we enter the fourth industrial revolution, the emergence of Industry 4.0, driven by global competition and mass customisation, reshapes various sectors, including tourism (Korže, 2019; Oztemel & Gursev, 2020). Industry 4.0 technologies promise to create sustainable value across economic, environmental, and social dimensions, garnering extensive study by international associations, industry communities, and universities (Sima et al., 2020; Ghobakhloo et al., 2021). The integration of these technologies within tourism aligns with several Sustainable Development Goals (SDGs), such as fostering innovation, promoting decent work, reducing inequalities, and ensuring responsible consumption (United Nations, 2015; Urosevic et al., 2018; Boluk et al., 2019). This alignment underscores the tourism industry's commitment to global sustainability efforts while embracing technology-driven innovation. Sustainability is essential for the success of smart tourism destinations (El Archi et al., 2023), highlighting the need for a comprehensive approach to developing smart and sustainable tourism strategies.

This technological revolution has led to the emergence of Tourism 4.0, characterized as a value ecosystem within the tourism sector that operates on a technology-driven service generation paradigm (Korže, 2019; Pencarelli, 2020). As the integration of technology progresses, the implementation of Industry 4.0 represents a significant stage in enhancing tourism products and services sustainably (Harish & Thomas, 2023). Tourism 4.0 fosters environmental sustainability through eco-friendly innovations, supports community engagement and contributes to economic sustainability by creating new business models and improving service delivery (Femenia-Serra et al., 2019; Peceny et al., 2019; Shafiee et al., 2022). It also aligns with SDGs related to innovation and inclusive growth by optimizing resource use, reducing environmental impacts, and ensuring that technological advancements benefit all stakeholders, including local communities (Buhalis & Amaranggana, 2015; Urosevic et al., 2018; Pencarelli, 2020; El Archi et al., 2023).

Tourism 4.0 introduces disruptive technologies that revolutionize operations within the industry, embracing digitization and the exponential growth of data to enhance destination competitiveness. Leveraging Industry 4.0 technologies such as the Internet of Things (IoT), big data, blockchain, Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), it aims to drive service excellence in an evolving technological landscape. This movement towards increased customisation and improved service delivery, driven by advances in AI and robotics, is set to redefine the trajectory of the tourism industry (Peceny et al., 2019; Dhoundiyal & Mohanty, 2022).

Moreover, Tourism 4.0 supports the development of smart urban destinations by integrating digital tools to manage tourist flows and mitigate negative impacts like overcrowding and pollution (Buhalis & Amaranggana, 2013; Coca-Stefaniak & Seisdedos, 2020). Urban tourism, characterized by dense populations and cultural significance, stands to benefit from the advanced infrastructure promoted by Tourism 4.0. The application of these technologies can revolutionize urban tourist experiences through smart city solutions, enhanced data analytics, and interactive platforms. For instance, smart technologies such as IoT, AR, and AI can offer personalized, real-time services to visitors, contributing to efficient crowd management, improved transportation systems, and seamless interactions between tourists and city infrastructure (Zhang & He, 2020; Matušíková & Šambronská, 2023; Pranita, 2023).

Despite significant advancements, understanding the broad scope of Tourism 4.0 remains a challenge (Gomes et al., 2023). Recent studies have explored the implementation of various Industry 4.0 technologies in tourism (Balasubramanian & Ragavan, 2019; Osei, Ragavan, & Mensah, 2020b), evaluating the advantages and challenges of AI, robots, and service automation (Alexis, 2017; Ivanov & Webster, 2017; Murphy et al., 2017), as well as the impact of big data (Miah et al., 2017; Xiang & Fesenmaier, 2017). The critical components of the fourth industrial revolution and their opportunities in tourism highlight technology's importance in revitalizing the industry during crises (Gretzel et al., 2020; Lau, 2020; Zeng et al., 2020).

While existing literature has shed light on various aspects of Tourism 4.0, further exploration is needed (Korže, 2019; Stankov & Gretzel, 2020). This research aims to address this gap by examining key concepts, components, and drivers of sustainable development within the framework of Tourism 4.0. Although previous studies have explored technology integration and innovation (Stankov et al., 2020), ), there is a lack of systematic analysis focusing specifically on the distinct characteristics of Tourism 4.0.

The development of Tourism 4.0 has seen a growing number of articles, particularly a surge in 2020, indicating that research on this topic is in its formative phase. However, a more detailed analysis is needed to track its evolution and identify key milestones. While literature acknowledges the technological, organizational, and environmental determinants of digital transformation (Kindzule-Millere & Zeverte-Rivza, 2022; Bekele & Raj, 2024), a comprehensive assessment of these challenges is warranted. This includes understanding the complexities of technology integration, resource allocation, and the influence of environmental factors on sustainability objectives (Pencarelli, 2020; Ramos & Brito, 2020).

The primary contributions of Tourism 4.0 lie in its potential to transform the industry through new-generation technologies and innovative business models, encompassing growth in tourism demand, sustainable practices, and the impact of technology during crises, such as the COVID-19 pandemic (Trunfio & Pasquinelli, 2021; Kurniati & Suryanto, 2023). However, further exploration is necessary to fully understand these contributions and their implications.

The novelty of this research lies in its exploration of Tourism 4.0 as a distinct paradigm within the digital evolution of tourism. While much attention has focused on smart tourism, this study specifically examines the broader and more integrated concept of Tourism 4.0. By investigating its key components, drivers for sustainable development, and its capacity to create immersive, interconnected experiences, this study fills a critical gap in the literature.

We will conduct a systematic review following PRISMA guidelines, employing NVivo software for data organization and analysis. The systematic review will include a comprehensive literature search, data evaluation using Sandelowski and Barroso's model (2006), and synthesis of findings to ensure a robust research process. The selection of the PRISMA protocol underscores our commitment to rigor in article filtration and data synthesis.

This study aims to address the following research questions:

- What are the key concepts of Tourism 4.0, and how does digital evolution impact the industry?
- What are the constructive components of Tourism 4.0?
- What are the drivers for sustainable development in Tourism 4.0, and how can these drivers be effectively integrated to achieve sustainable outcomes?

By addressing these questions, this study will provide an overview of the existing knowledge on Tourism 4.0, enabling a comprehensive assessment of its implications and potential for the tourism industry.

The first part introduces the problem statement and research questions. The second part presents the methodology and systematic review process employed. The third part provides an overview of the research results, followed by a detailed discussion in the fourth section. The fifth section presents conclusions and discusses the implications of the work, while the sixth section addresses the study's limitations and suggests future research directions.

## 2. Methodology

The rapid growth of academic research across various disciplines has made it difficult for scholars to stay current with the latest developments. In response, systematic approaches like meta-studies have become popular for synthesizing and analyzing previous research on specific topics. When conducted qualitatively, a meta-study is known as a meta-synthesis, which integrates findings from various studies (Zimmer, 2006). Meta-synthesis is a qualitative method used to systematically review and combine results from both qualitative and quantitative studies, continuing until information saturation is achieved (Thorne et al., 2004). This study follows a systematic review approach, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring a structured and transparent process for identifying, selecting, and synthesizing relevant literature. PRISMA is widely used in social sciences

and business to enhance the reliability and reproducibility of systematic reviews (Shamseer et al., 2015; Alsharif et al., 2022).

In addition, the Sandelowski and Barroso model was applied, which provides a methodological framework that involves six phases: problem formulation, literature search, data evaluation, data analysis, interpretation, and presentation (Sandelowski et al., 2006). This model offers a rigorous and transparent structure for conducting qualitative meta-synthesis and supports the credibility of the study.

By using PRISMA and the Sandelowski and Barroso model as foundational frameworks, this study ensures the systematic collection and analysis of literature, providing a robust basis for synthesizing key findings.

## 2.1 First Step – Research Question

The first step in the meta-synthesis process is formulating the research question (Finfgeld-Connett, 2018), addressing the what, who, when, and how aspects to guide the study (Bondas & Hall, 2007; Paul & Barari, 2022).

- What: This involves identifying key concepts, technologies, and drivers of Tourism 4.0 development by exploring emerging technologies and the forces shaping the evolution of Tourism 4.0.
- Who: The study's population includes all research on Tourism 4.0 and Industry 4.0's impact on the tourism sector, based on reputable scientific articles and studies. This ensures a broad sample, offering insights into the intersection of these fields.
- When: Given that the field is relatively new, only studies from 2016 to 2022 are considered, ensuring the review focuses on recent, relevant contributions to the field.
- How: The meta-synthesis utilises existing studies as secondary data, analyzing all research on Tourism 4.0 and Industry 4.0's influence on the tourism sector to build a strong foundation for the synthesis.

## 2.2 Second Step – Systematically Review the Literature

This step involves systematically identifying and reviewing literature relevant to the research questions. Articles were selected using specific keywords, with English-language articles from chosen scientific databases serving as the primary information source. The selected articles underwent a comprehensive evaluation process, excluding those that did not meet the specified criteria.

Initially, articles were assessed based on how well their titles aligned with the research subject, question, objective, and approach. The criteria established in the first step facilitated an efficient review within the systematic literature review framework (Swift & Wampold, 2018). The authors conducted a thorough review, screening titles, abstracts, and full texts to determine eligibility and eliminate duplicates.

After comparing assessments, the authors reached a 90% agreement on eligible studies, ultimately achieving 100% consensus on the selected articles through discussion. To ensure a systematic review, specific criteria outlined in Table 1 were applied to review and select articles, addressing any potential overlap, especially for articles retrieved from Google Scholar.

**Table 1.** Article Review Criteria

| Parameters | Inclusion Criteria | Exclusion Criteria |
|---|---|---|
| Paper's language | English-language studies | The excluded articles are those with titles, abstracts, and keywords in English but do not have the full text written in English. |
| Paper presentation time | Papers published between 2016 to 2022 | No articles were found in this field before 2016 |
| Research subjects | Articles that exhibit a strong semantic connection to the research domain and incorporate relevant keywords | An article in the field of "FIR" whose content is not related to tourism and its subcategories |
| Categories of research studies | Research papers that have been published in peer-reviewed journals, international conferences, and book chapters | Non-academic articles, such as editorial materials, conference reviews, content summaries, or forewords |

| | | |
|---|---|---|
| Research information status | Papers that provide transparent research methodologies and present clear research findings | articles without evidence of a serious concern involving tourism and industry 4.0 |

Source: Own Elaboration

The information sources for this study comprised English-language articles from scientific databases such as Science Direct, Emerald, Taylor & Francis, Springer, and Google Scholar. While other databases exist, these were prioritized due to their extensive coverage of scholarly publications relevant to the research question. The selection of these databases was strategic. Science Direct offers a vast repository of scientific articles, providing rich material pertinent to the study (Tober, 2011; Samadzadeh et al., 2013). Springer, Emerald, and Taylor & Francis were included for their comprehensive coverage across multidisciplinary domains closely aligned with our investigation. Google Scholar, known for its inclusivity of diverse scholarly literature (Tober, 2011; Giustini & Boulos, 2013), was essential for broadening our literature search. We excluded Scopus and Web of Science due to access limitations and subscription availability.

To address potential overlap in articles retrieved from Google Scholar and other databases, a meticulous screening process was implemented to identify and remove duplicates. Additionally, we prioritized conference proceedings, book sections, and journal articles to ensure credible, relevant, and up-to-date scholarly content (Webster & Watson, 2002). These sources are known for their rigorous peer-review processes, contributing to the scholarly integrity and quality of our analysis.

## 2.3 Third Step – Search and Select Relevant Articles

The texts and articles evaluated in this study included all studies pertinent to the research purpose, categorized by their qualities and research methods. Following the identification of the information sources, relevant articles were selected using specific keywords such as “Industry 4.0,” “Industry 4.0 Revolution,” “tourism,” “Tourism 4.0,” and “smart tourism”. Articles were screened based on these keywords and the criteria outlined in Table 1, focusing on the title, abstract, content, and conclusion. The retrieved papers were filtered to identify and remove duplicates, and articles unrelated to the research subjects were excluded. This rigorous process resulted in the final selection of 26 articles, which were reviewed according to the designated keywords.

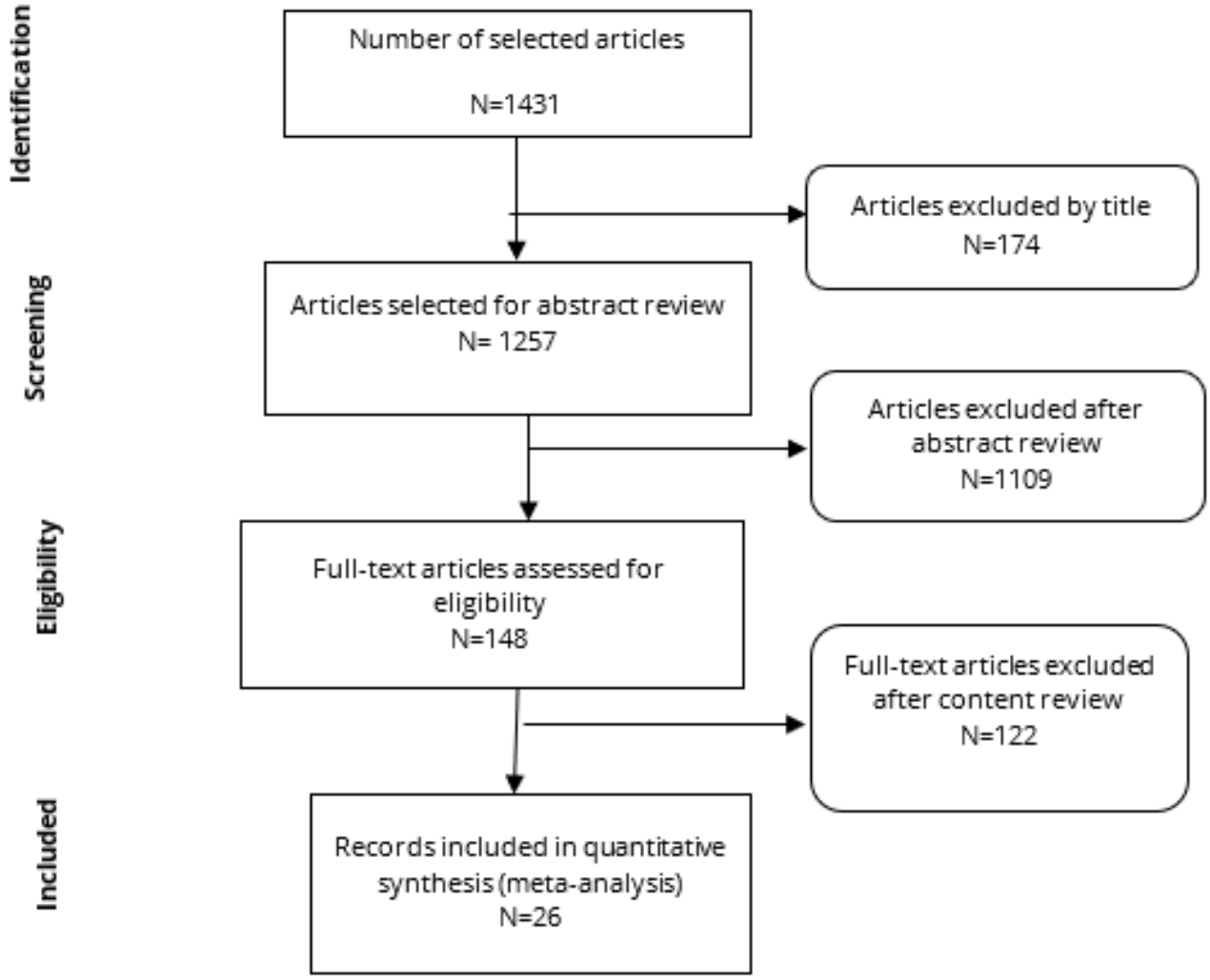
**Table 2.** Articles Reviewed In Databases

| Databases | Number of articles | Articles removed in the first step | Articles removed in the Second step | Final articles |
|---|---|---|---|---|
| Science Direct | 473 | 381 | 91 | 1 |
| Springer | 75 | 64 | 6 | 5 |
| Emerald | 451 | 429 | 18 | 4 |
| Taylor & Francis | 139 | 132 | 6 | 1 |
| Google Scholar | 293 | 251 | 27 | 15 |
| Sum | 1431 | 1257 | 148 | 26 |

Source: Own Elaboration

The results of the article filtration process are presented in Table 2. Additionally, Figure 1 illustrates the PRISMA diagram, detailing the systematic literature review process (Shamseer et al., 2015), including the selection criteria covering the search period from 2016 to 2022. The flowchart visually represents the systematic approach to identifying, screening, and selecting relevant articles based on the specified criteria.

**Figure 1.** Flowchart of Selection Criteria (Search Period: 2016-2022)




Source: Developed based on PRISMA guidelines, Own Elaboration

## 2.4 Fourth Step – Extract Article Information

To ensure the reliability and credibility of our study, we implemented several supplementary measures, including inter-rater reliability checks among the researchers involved in data collection and analysis. Kappa statistics were utilised to assess agreement levels and ensure consistency in our results (Lampe et al., 2017). Data validation techniques, including standardized methods, were employed to confirm the accuracy of our findings. Quality control measures were rigorously implemented throughout the research process, emphasising our commitment to high standards of research integrity. Ethical considerations were also meticulously documented to reinforce the credibility and trustworthiness of our study (Davison et al., 2000; Levy & Ellis, 2006).

During this stage, the selected articles were systematically examined for analysis. Information was extracted from the 26 chosen articles and categorized based on their main topics. Given the substantial volume of qualitative data, we used Nvivo software, which is optimal for analyzing qualitative data across various disciplines (Berg, 2004; Silverman, 2006). Nvivo facilitated the coding and categorizing of article information, including details such as year, type, publisher, and journal name, thereby organizing the data efficiently. Additionally, the final articles were imported into VOSviewer software, a tool specifically designed for visualizing bibliometric networks, allowing for an in-depth understanding of the evolution of scientific disciplines (Madzík et al., 2023). VOSviewer's specialized algorithms and user-friendly interface made it suitable for exploring term co-occurrence and creating word clouds to identify key themes within the dataset (Van Eck & Waltman, 2010; Kirby, 2023). Although the use of R-tool software was considered, we opted for VOSviewer due to its efficiency and ease of use, aligning with our focus on qualitative analysis.

After a thorough review and the removal of duplicates, a final list of 26 articles was confirmed. These articles were then inputted into Nvivo for further analysis, including extracting specific details. VOSviewer was employed to visualize bibliometric networks, determining the co-occurrence of terms and generating word clouds to highlight relevant themes.

## 2.5 Fifth Step – Analysis and Synthesize Findings

In this phase, the data extracted from the selected articles underwent a systematic synthesis and analysis to effectively address the research questions. A comprehensive search strategy was employed to ensure the inclusion of relevant documents published between 2016 and 2022. This strategy involved querying selected academic databases with predefined search terms and filters. Additionally, manual searches of relevant journals, conference proceedings, and book chapters were conducted to minimize the risk of overlooking significant publications (Chapman et al., 2010). Upon retrieving the initial set of documents, a rigorous screening process was implemented to select articles that met the established inclusion criteria. This process involved reviewing titles, abstracts, and full texts as necessary to ensure relevance to the research objectives while excluding irrelevant or outdated sources. Any discrepancies in the selection process were resolved through consensus among the research team.

Data extraction commenced systematically once the final set of documents was identified. Each selected article was thoroughly scrutinized, with pertinent information extracted and synthesized to address the research questions effectively. The extracted data included key insights, findings, methodologies, and other relevant information. The culmination of this step was the presentation of research findings that encapsulated the responses to the specific inquiries posed. Data synthesis began by treating all extracted content as distinct codes. These codes were categorized based on their thematic content and contextual relevance, constructing research concepts and categories by amalgamating related codes into a coherent analytical framework. To facilitate this process, a comprehensive codebook was meticulously crafted using NVivo software, following the guidelines of Miles Matthew et al. (2014). The codebook contained a detailed list of thematic nodes and their descriptive explanations, ensuring precision and alignment with the research objectives (Oliveira et al., 2013).

As phrases and segments from the articles were extracted, new codes were generated to capture the essence of the data in alignment with the research questions. The codes recorded in the codebook underwent rigorous scrutiny (Bandara et al., 2015), with discrepancies promptly identified and resolved through consensus before proceeding to code the entire repository of studies. This iterative process involved continuous refinement and organization of codes until reaching saturation, indicating that no new codes were emerging. Each article underwent an in-depth analysis, with pertinent sections assigned appropriate codes based on the criteria delineated in the codebook. This involved aligning text segments from the articles with predefined codes and making necessary adjustments for accurate data representation. Throughout the coding phase, detailed notes and memos were maintained to capture insights, patterns, and emerging themes, enriching the analysis process. To address challenges encountered during coding, a team approach was adopted to enhance the reliability and validity of the findings (Cascio et al., 2019). Two researchers independently coded a subset of articles, resolving any discrepancies through collaborative discussions and consensus-building.

Through the synthesis and analysis of the coded data, key themes and patterns emerged, providing a robust basis for addressing the research questions and yielding meaningful insights into the subject matter under investigation. This meticulous approach ensured a comprehensive analysis of the dataset, fostering transparency and credibility in the research findings.

**Table 3.** Final Code Extracted

| Category | Final Code Extracted | References |
|---|---|---|
| Influence of the digital revolution on the tourism sector | -The emergence of tourism 4.0<br>-Development of digital transformation strategies<br>-Create innovation<br>-Sustainable development<br>-Create smart travel strategies<br>-Development of ICT infrastructure<br>-Increasing the competitiveness of tourism destinations | (Bilsen Bilgili & Koc, 2021; B Bilgili & Özkul, 2019; Dalkiran, 2022; Kononova et al., 2020; Korže, 2019; Nugraheni et al., 2021; Pencarelli, 2020; Ramos et al., 2020; Singh & Bashar, 2021; Suryawardani et al., 2021; Thoi, 2021; Tuncalı Yaman & Başeğmez, 2022; Urbančič et al., 2020; Zeqiri et al., 2020) |
| Constructive components of Tourism 4.0 | -Virtual Reality<br>-Augmented Reality<br>-Big Data<br>-Artificial Intelligence<br>-Internet of Things<br>-Cloud Computing<br>-Blockchain | (Abdurakhmanova et al., 2022; Gajdošík & Orelová, 2020; Hsu & Tseng, 2022; Korže, 2019; Melike & Kudret, 2018; Osei, Ragavan, Kandappan, & Mensah, 2020a; Osei et al., 2020b; Ozturk, 2021; Stankov et al., 2020; Tasya et al., 2019; Urbančič et al., 2020; Zeqiri et al., 2020) |
| Tourism 4.0 sustainability drivers | -Economic Advantages<br>-Social Advantages<br>-Environmental Advantages | (Dewi, 2020; Fakhimi et al., 2022; Peceny et al., 2019; Tasya et al., 2019; Thoi, 2021; Tuncalı Yaman et al., 2022; Urbančič et al., 2020; Zeqiri et al., 2020) |

Source: Own Elaboration

## 2.6 Sixth Step – Comprehensive Quality Control

In this study, a comprehensive framework for qualitative assessment was adopted, grounded in expert judgment and predefined quality criteria. The framework was informed by a diverse body of literature encompassing qualitative, quantitative, and mixed-method designs. To ensure rigor, a panel of five experts—each with experience in conducting systematic reviews—was engaged to provide independent and continuous feedback throughout the evaluation process.

We used the Critical Appraisal Skills Program (CASP) as the primary tool for quality assessment due to its validated 10-item checklist and widespread use in systematic reviews (Casp, 2018; Long et al., 2020). CASP criteria covered essential aspects such as research objectives, methodology, design, recruitment strategies, data collection, researcher-participant relationships, data analysis, findings, significance, and ethical considerations. A customized checklist based on CASP was developed, and each article was scored accordingly. Articles were independently assessed by both the authors and a panel of five academic experts. A team-based approach was adopted to facilitate discussion, minimize bias, and ensure a more balanced and consistent evaluation. Prior to the assessment, a briefing session was conducted to standardize the evaluation process across reviewers. The total score for each article ranged from 31 to 46, categorizing them as very good (31–40) and excellent (41–50) in quality, based on the scoring system derived from the CASP framework. To assess the consistency of evaluations, Cohen's Kappa was used as a robust measure of inter-rater agreement (Viera & Garrett, 2005; Pérez et al., 2020). The process involved independent coding of the selected articles by the expert team, followed by comparison with the primary researcher's coding. The Kappa statistic compares observed agreement (Po) with expected agreement (Pe) using the formula:

$$kappa = \frac{po - pe}{1 - pe}$$

The analysis was conducted using SPSS software, resulting in a Kappa index of 0.692, which falls within the 0.61–0.80 range, indicating substantial agreement. This confirmed the reliability and consistency of article selection and coding throughout the meta-synthesis process.

**Table 4.** Testing the Coding Agreement between the Primary Researcher and the Team of Experts

| | | Value | Asymp. Std. Error[a] | Approx. T[b] | Approx. Sig. |
|---|---|---|---|---|---|
| Measure of Agreement | Kappa | 0.692 | 0.140 | 3.573 | 0.000 |
| No. of Valid Cases | | 26 | | | |

Source: Own elaboration based on coding results

### 2.7 Seventh Step – Present Findings

In this step, the findings from the previous phases were presented. Based on the analysis of the coded meanings, the data were categorized into related concepts. This categorization facilitated the identification of overarching themes and patterns, providing a clear framework for understanding the insights derived from the systematic review.

## 3. Results

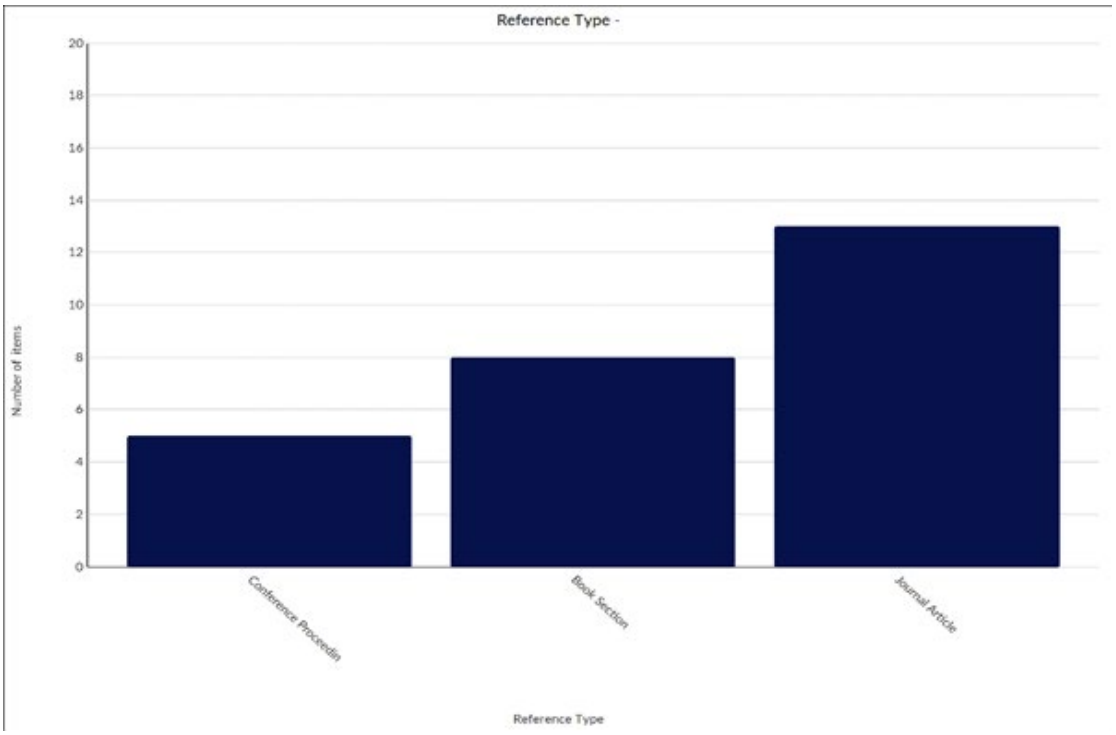
### 3.1 Addressing Articles' Features

The term "Tourism 4.0" was introduced in Portugal in 2016, following Germany's earlier introduction of "Industry 4.0" in 2011 (Ramos et al., 2020). Notably, these concepts emerged from public sector entities, such as governmental institutes and policymakers, rather than academic institutions. Despite this, researchers have begun to prioritize Industry 4.0 as a significant research agenda. In tourism studies, the focus has largely been on smart cities, smart destinations, and smart tourism, rather than the specific concept of Tourism 4.0 (Korže, 2019).

The analysis of the descriptive features of the articles reveals several interesting insights. Figure 3 illustrates that the first selected articles on Tourism 4.0 were published in 2018, indicating that this area of research is still in its early stages. However, there is a notable upward trend in the number of publications each year, with the volume nearly doubling annually. The significant number of articles published in 2020 reflects a growing interest in Tourism 4.0.

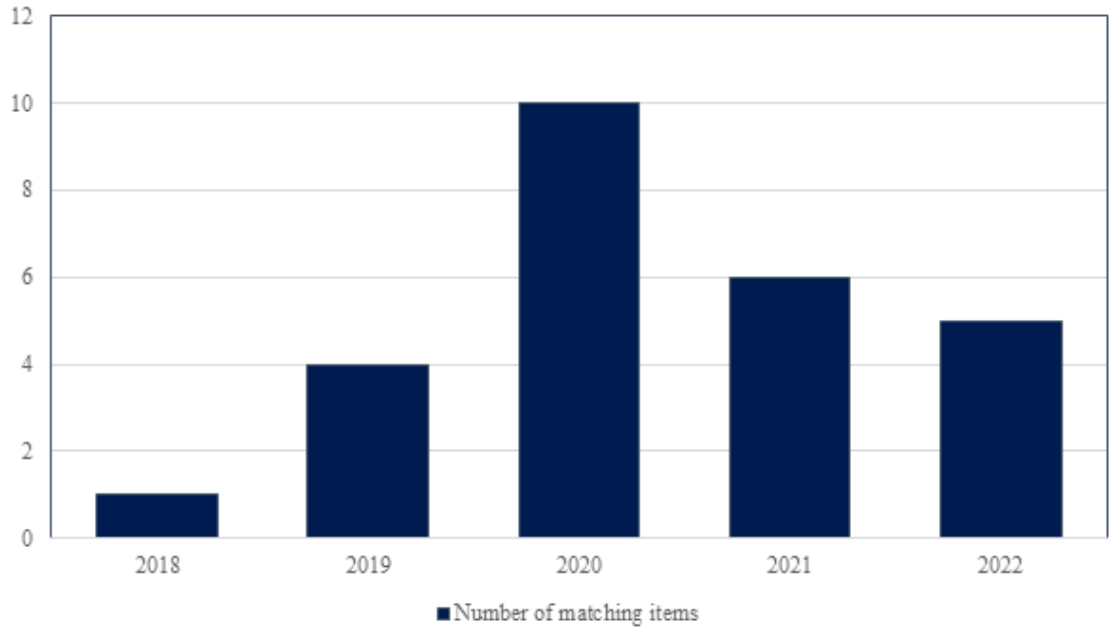
Most of the reviewed articles were published in academic journals, as depicted in Figure 2. To ensure comprehensive coverage of all relevant literature, a supplementary review was conducted using Google Scholar. Figure 3 shows that the majority of articles in the studied time interval were published in 2020. Additionally, most of the papers included in this study were sourced from the Springer and Emerald databases (see Figure 4).

**Figure 2.** Type of Resources




Source: Own Elaboration

**Figure 3.** Time Table of Distribution of Articles

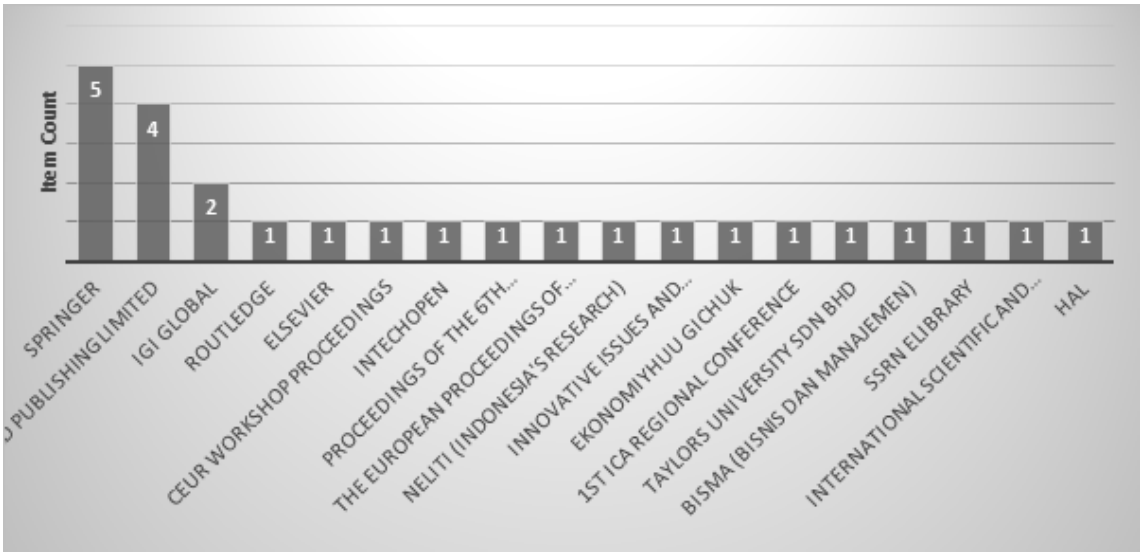



Source: Own Elaboration

Our systematic review included 26 articles representing diverse geographical contexts and sectoral focuses within Tourism 4.0. Geographically, the studies spanned Asia (e.g., Indonesia, Vietnam, Turkey), Europe (e.g., Slovenia, Portugal, Slovakia), as well as review articles with a global scope that were not limited to a specific region. Of these, 61.5% (16/26) adopted a conceptual or review-based approach to examine Tourism 4.0 frameworks and theoretical foundations, while 38.5% (10/26) presented empirical case studies. Sectorally, the articles addressed various domains, including hospitality and hotel management

(34.6%), destination management (19.2%), digital technology applications (30.8%), and business strategy development (15.4%). This distribution reflects a growing global interest in Tourism 4.0, although representation remains uneven across regions and industry segments. Notably, areas such as transportation tourism and emerging markets in Africa and Latin America were underrepresented, highlighting opportunities for future research to address these gap.

**Figure 4.** The Number of Articles by Publishers




Source: Own Elaboration

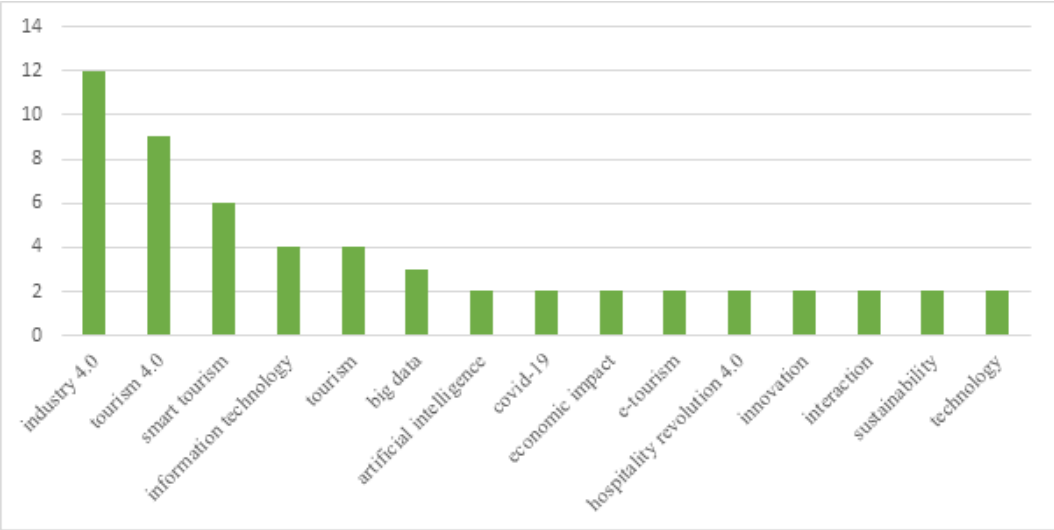
**Table 5.** Publication Statistics

| Journals / Book Chapters / International Conferences | Number of items | Journals / Book Chapters / International Conferences | Number of items |
|---|---|---|---|
| Proceedings of the 6th International Conference on Future Networks & Distributed Systems | 1 | Journal of Hospitality and Tourism Technology | 2 |
| Emerging Transformations in Tourism and Hospitality | 1 | Research Anthology on Cross-Industry Challenges of Industry 4.0 | 1 |
| The European Proceedings of Social Behavioral Sciences | 1 | Consumer behaviour and marketing | 1 |
| Logistics 4.0 and Future of Supply Chains | 1 | Information Technology & Tourism | 2 |
| International Research Journal of Management, IT and Social Sciences | 1 | The Emerald Handbook of ICT in Tourism and Hospitality | 1 |
| Smart Cities Policies and Financing | 1 | International Hospitality Review | 1 |
| Computer Science On-line Conference | 1 | BISMA (Bisnis dan Manajemen) | 1 |
| Smart Systems Integration (SSI) | 1 | Information Technology, Promotion Strategy, Accessibility on Tourist Intention to Visit a Destination | 1 |
| Innovative issues and approaches in social sciences | 1 | International Scientific and Practical Conference on Sustainable Development of Regional Infrastructure | 1 |
| Ekonomiyhuu Gichuk | 1 | Intelligent Systems in Digital Transformation: Theory and Applications | 1 |
| Proceedings of the 1st ICA Regional Conference | 1 | Intelligent Systems in Digital Transformation: Theory and Applications | 1 |
| Asia-Pacific Journal of Innovation in Hospitality and Tourism | 1 | Handbook of Research on Smart Technology Applications in the Tourism Industry | 1 |
| Balkan Economic Review | 1 | | |

Source: Own Elaboration

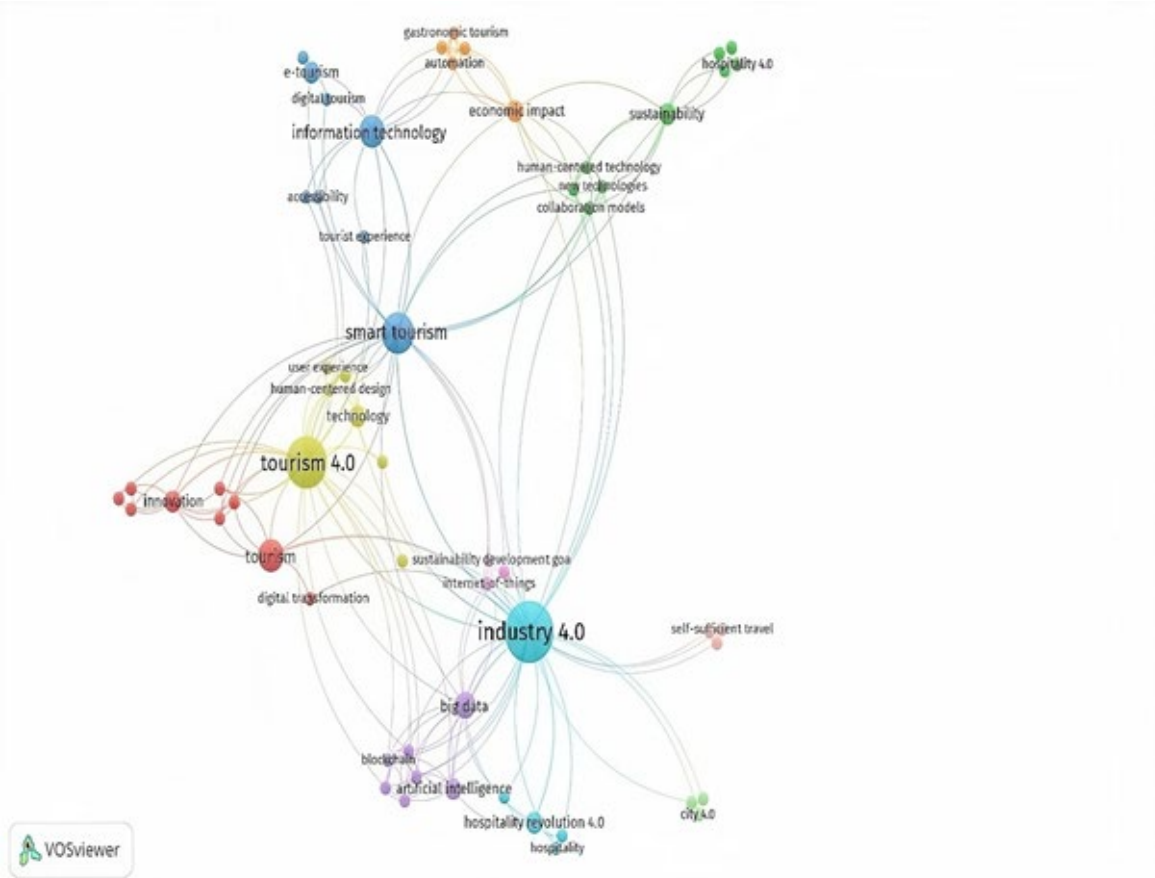
In total, 26 eligible articles contained 69 keywords. Figure 5.a presents the most common keywords found in the abstracts of these articles after applying a noise removal technique. For brevity, only keywords with at least two occurrences were included. As expected, "Industry 4.0" had the highest frequency, followed by related terms such as Tourism 4.0 and smart tourism.

**Figure 5.a.** Occurance of the Most Common Keywords




Source: Own Elaboration

**Figure 5.b.** Occurrence of Keywords in Article Abstract (Co-Occurance=3)




Source: Own Elaboration

In this research, clustering analysis was performed on the keywords, and the results are displayed in Figure 5.b, showing the co-occurrence mapping of keywords. In the figure, nodes represent keywords, with node size indicating keyword frequency and connecting lines revealing co-occurrence relationships. The closer the nodes, the higher the co-occurrence frequency. The strength of the relationship between two nodes is conveyed through the distance separating them; a smaller distance indicates a stronger connection (Van Eck et al., 2010). Keywords are differentiated by color and can be classified into six topics (excluding small clusters).

Upon analyzing the information, it is evident that researchers primarily focus on the following areas in their publications: Industry 4.0, Tourism 4.0, smart tourism, tourism, sustainability, and big data. These words are shown in Figure 5-a as the most common keywords.

The blue cluster in Figure 5-b is mainly centered around the keyword "smart tourism." The other main keywords in this cluster refer to information technology, e-tourism, digital tourism, accessibility, and tourist experience. The green cluster includes five main keywords: hospitality 4.0, sustainability, human-centered technology, new technologies, and collaboration models. The most frequent keyword in this cluster is "sustainability," followed by "hospitality 4.0." The cyan cluster consists of the keyword Industry 4.0, which has the highest frequency among all the keywords. The other main keywords in this cluster are revolution 4.0 and hospitality. The purple cluster is mainly centered around the keyword "big data," with other main keywords including artificial intelligence, blockchain, Internet of Things, and development goals. The olive green cluster consists of keywords such as Tourism 4.0, technology, user experience, and human-centered design. Finally, the red cluster comprises keywords related to tourism, innovation, and digital transformation.

**Figure 6.** Word Clouds Based on Word Frequency in Analysed Papers


Source: Own Elaboration

The word cloud in Figure 6 illustrates the word frequency in the analysed articles, offering a visual summary of the most frequent terms. Word clouds visually represent the size of each word based on its frequency or importance in the analysed text.

## 3.2 Tourism 4.0 – Definition and Scope

This study aimed to answer the research question and conceptualize Tourism 4.0 by reviewing relevant articles. According to the analysis, researchers view Tourism 4.0 as a concept stemming from the fourth industrial revolution, Industry 4.0, characterized by cyber-physical systems (CPS) in manufacturing. Industry 4.0 has revolutionized manufacturing processes, enhancing operational productivity and automating production, leading to the creation of high value-added products and services (Kononova et al., 2020).

In the context of Tourism 4.0, similar goals are pursued within the tourism industry. Tourism 4.0 utilises application sensors to gather data on tourists' behaviours, which is then analysed to create tailored travel experiences (Korže, 2019; Dewi, 2020). This approach allows tourist destinations to implement effective policies that promote efficient, safe, and personalized travel experiences through digital and automation processes (Kononova et al., 2020). Tourism 4.0 is described as a tourism ecosystem built around advanced technology, embracing the fundamental principles of Industry 4.0, including interoperability, virtualization, decentralization, real-time data analysis, and data collection. This approach has transformed production and work methods (Nugraheni et al., 2021).

Scholars often distinguish Tourism 4.0 as a distinct stage in the evolution of tourism, setting it apart from previous concepts such as e-tourism and mobile tourism (Tasya et al., 2019). Some scholars define Tourism 4.0 or Industry 4.0 as the implementation of smart tourism within the tourism sector (Ozturk, 2021). While some define Tourism 4.0 and Industry 4.0 as implementations of smart tourism, others emphasize that both concepts originate from the fourth industrial revolution and are based on smart technologies such as IoT, AR, VR, and AI. However, Tourism 4.0 primarily focuses on the advanced hardware and software components of these technologies, while smart tourism integrates technological, human, and social resources to enhance the quality of life for visitors (Pencarelli, 2020).

Tourism 4.0 fosters collaboration among all participants in the smart tourism ecosystem, leveraging Industry 4.0 technologies to deliver enhanced experiences. Its primary objective is to establish a shared, locally-centered tourism ecosystem that facilitates data-driven strategic planning, seamless communication, and information exchange among all stakeholders. This collaborative platform enables data collection, sharing, and analysis for various strategic activities, aiming to enhance tourists' experiences while minimizing adverse impacts on the local environment (Urbančič et al., 2020).

Industry 4.0-based Tourism 4.0 helps tourism destinations by enabling effective policies through digitalization and automation processes (Kononova et al., 2020). The procedures of the fourth industrial revolution have multiple effects on the tourism industry, aiming to maximize the opportunities presented by Industry 4.0 (Melike et al., 2018). The goal of Industry 4.0 is to offer sustainable and accessible products and services within the tourism sector, promoting seamless integration between tourists and destinations, enhancing the quality of experiences, and delivering personalized offerings. By embracing innovative collaboration and leveraging Industry 4.0 technologies, the perception of tourism and the associated commercial sector is being reshaped (Tasya et al., 2019).

## 3.3 Mapping Key Digital Themes In Tourism 4.0

In the context of the systematic literature review, thematic clustering was employed to categorize the key concepts shaping the digital transformation of the travel and tourism sector. Figure 5-b presents the semantic structure derived from the analysis, highlighting six major clusters: Tourism and Innovation (red), Big Data, Artificial Intelligence, and Blockchain (purple), Smart Tourism and User Experience (blue), Industry 4.0 and the Hospitality Revolution (cyan), Technological Design in Tourism 4.0 (olive green), and Sustainability and Human-Centered Technologies (green). Together, these clusters provide a comprehensive framework for understanding how the digital revolution is influencing and reshaping the future of tourism.

### *3.3.1 Red Cluster – Tourism, Innovation, and Digital Transformation*

The red cluster revolves around the interconnected themes of tourism, innovation, and digital transformation. Innovation in tourism extends beyond service improvements and encompasses the redefinition of business models through digital technologies. Tourism stakeholders increasingly leverage emerging tech-

nologies such as AI, blockchain, IoT and big data analytics to enhance operational efficiency, optimize resource management, and deliver personalized experiences (Urbančič et al., 2020; Bilsen Bilgili et al., 2021).

Digital transformation within the tourism sector signifies the fundamental change in how destinations, businesses, and tourists interact. It encompasses the integration of online booking platforms, smart services, virtual and augmented reality applications, and mobile-based interactions, all aiming to create seamless and hyper-personalized travel experiences (Pencarelli, 2020; Urbančič et al., 2020; Dalkiran, 2022). This technological evolution also plays a crucial role in advancing sustainable tourism. Smart mobility solutions, IoT-based resource management systems, and VR alternatives to physical travel are examples of how digital innovation contributes to environmental conservation and cultural preservation (Peceny et al., 2019; Urbančič et al., 2020).

Despite these advancements, the process of digital transformation in tourism is not without challenges. Issues such as cybersecurity risks, data privacy concerns, technological inequalities, and the digital divide present ongoing obstacles that need to be addressed for inclusive and resilient sectoral growth (Fakhimi et al., 2022). The red cluster thus emphasizes the inseparable relationship between tourism, innovation, and digital transformation, reflecting how the digital revolution continuously redefines the industry's structure and operational logic, ultimately shaping the future of Tourism 4.0.

### 3.3.2 Purple Cluster: Big Data, AI, Blockchain and IoT for Smart Decision-Making

The purple cluster focuses on the integration of big data, AI, Blockchain and IoT within the tourism sector. These technologies form the strategic backbone of data-driven decision-making, which is pivotal in shaping the future of Tourism 4.0. The adoption of these innovations enhances operational efficiency, enriches customer experiences, and enables smart, data-driven solutions for tourism businesses and stakeholders.

#### *Artificial Intelligence: Personalization and Predictive Analytics*

Artificial Intelligence plays a crucial role in personalizing the tourist experience. AI technologies, such as machine learning algorithms and predictive analytics, enable businesses to anticipate customer needs and preferences, thereby offering tailored recommendations and services. AI-powered tools, such as chatbots and virtual assistants, facilitate real-time customer support, enhancing customer satisfaction and streamlining operations (Osei et al., 2020b; Urbančič et al., 2020; Zeqiri et al., 2020; Bilsen Bilgili et al., 2021). For instance, AI is used to predict customer behaviour, allowing for tailored marketing strategies, personalized services, and resource planning. It also helps businesses design investment plans and formulate tourism policies (Urbančič et al., 2020). Hilton Hotels, for example, have implemented AI for personalized concierge services and automated check-ins, significantly improving guest experience and operational efficiency (Korže, 2019; Ozturk, 2021).

#### *Big Data and Smart Systems*

Big data has transformed the way tourism stakeholders understand visitor behaviour. It replaces traditional survey methods by offering a broader and more accurate view of tourist patterns and preferences (Zeqiri et al., 2020). In this context, smart systems, such as smart hotels, integrate big data with other technologies like IoT and robotics to deliver location-aware, personalized services and streamline internal operations (Ramos et al., 2020). These systems use sensors to adapt room settings, automate services, and manage guest interactions dynamically, enhancing the overall visitor experience. By analyzing data from travel platforms and social media, destinations like Barcelona optimize visitor flows, develop targeted promotions, and reduce overcrowding at peak sites (Ozturk, 2021; Dalkiran, 2022). Tourism providers use big data to determine optimal travel times, routes, and destination preferences, helping formulate more effective business strategies (Korže, 2019; Bilsen Bilgili et al., 2021).

#### *Blockchain and Secure Digital Infrastructure*

Blockchain provides a secure, transparent infrastructure for transactions and data management. Blockchain technology ensures secure transactions, data privacy, and transparent management of tourism-related operations. blockchain is effective in reservations, digital payments, identity verification, and

inventory control (Gajdošík et al., 2020; Urbančič et al., 2020). Additionally, the use of NFTs and smart contracts supports new forms of value exchange within the tourism industry, such as loyalty programs and digital ownership of travel-related assets (Peceny et al., 2019).

Blockchain can streamline tourism operations by ensuring secure data storage and reducing reliance on intermediaries. It facilitates encrypted transactions, loyalty programs, and physical asset representation through NFTs. In the context of tourism, blockchain allowing travel agencies to securely book flights and accommodations while sharing customer data with other stakeholders (Peceny et al., 2019; Urbančič et al., 2020). By improving transparency, blockchain fosters trust among stakeholders in international trade (Gajdošík et al., 2020; Fakhimi et al., 2022). Blockchain true power lies in its ability to construct adaptable, trustworthy, and durable systems, offering substantial benefits across the tourism ecosystem (Urbančič et al., 2020).

Real-world implementations further highlight the practical relevance of these technologies. Estonia's national digital ID system and platforms like Winding Tree demonstrate how blockchain can support decentralized bookings without traditional intermediaries. Additionally, tourism-related companies are experimenting with NFTs for event tickets and digital tourism assets, improving traceability, ownership, and customer engagement.

### *IoT and Cloud Computing*

While playing a supportive role compared to AI and big data, IoT significantly enhances Tourism 4.0 by enabling service personalization, improving customer relationship management, and facilitating predictive maintenance. It utilises data from sensors to monitor and minimize tourism's environmental impact by tracking energy and water usage as well as waste production (Osei et al., 2020b; Urbančič et al., 2020). Additionally, IoT supports real-time engagement with tourists through location-based services, offering valuable insights into visitor behavior and preferences (Ramos et al., 2020). The Internet of Services (IoS) complements this by introducing a decentralized framework that enables tourists to access a wide range of online services and engage in digital exchanges. It supports the delivery of software-as-a-service, including development tools, storage, and communication platforms (Pencarelli, 2020; Fakhimi et al., 2022).

Cloud computing, as another pillar of digital infrastructure, simplifies service delivery while reducing IT-related costs. It enables seamless interaction with travel platforms, real-time access to travel content, and the sharing of experiences. By analyzing customer data, cloud platforms allow agencies to offer tailored services that enhance customer satisfaction and improve efficiency, competitiveness, and sustainability in tourism (Zeqiri et al., 2020; Bilsen Bilgili et al., 2021).

These technologies are already being adopted in several smart tourism initiatives. For instance, cities like Singapore use IoT-based sensors for crowd control, environmental monitoring, and location-based marketing. Likewise, cloud-based booking platforms such as Booking.com enable real-time availability updates and seamless communication between service providers and travelers. Together, big data, AI, Blockchain, and IoT form the technological foundation of smart decision-making in Tourism 4.0, enabling more personalized, efficient, and sustainable tourism services.

### *3.3.3 Blue Cluster: Smart Tourism, Immersive Experiences, and Accessibility*

The blue cluster centers on smart tourism, where digital technologies are leveraged to enhance user experience and improve accessibility. Smart tourism is a progressive approach that integrates ICT to create personalized, data-driven travel experiences. It utilises real-time data, sensors, and digital platforms to optimize travel services, making them more efficient and tailored to the needs of individual tourists. This results in a seamless, highly interactive travel experience (Urbančič et al., 2020; Bilsen Bilgili et al., 2021).

Immersive experiences through technologies like VR and AR have significantly transformed how tourists interact with destinations. These technologies allow travelers to engage with destinations in novel ways. For example, VR can simulate visits to remote or inaccessible places, offering an alternative to traditional tourism. This is especially beneficial for cultural and heritage sites that may be too far or fragile for regular tourism, providing educational and sustainable alternatives (Peceny et al., 2019; Urbančič et al., 2020). AR enhances the physical environment by overlaying digital information on real-world objects. For instance, visitors in museums or heritage sites can use AR applications to access detailed information

about artifacts, historical events, and surrounding locations. In cities, AR apps can assist tourists in navigation by providing real-time location-based information, enhancing the overall visitor experience (Ozturk, 2021). Beyond enhancing visitor engagement through immersive technologies, smart tourism also leverages real-time data and connected infrastructures to optimize resource management and destination efficiency.

In addition to enhancing the tourist experience, smart tourism contributes to better resource management in tourism destinations. With the help of IoT-based systems, cities and tourism providers can monitor and optimize resource use, including managing crowd flows, traffic, and even environmental factors such as air quality (Urbančič et al., 2020). For example, cities like Singapore have integrated IoT devices into their urban infrastructure to monitor traffic, crowd control, and air quality, creating a more seamless and efficient travel environment. Similarly, Marriott hotels use smart room technology to adjust lighting, temperature, and entertainment options based on guest preferences, ensuring a personalized and comfortable stay (Korže, 2019; Dalkiran, 2022).

Furthermore, accessibility is a key aspect of smart tourism. Technologies such as mobile apps and wearable devices enable tourists with disabilities or special needs to navigate and engage with destinations more easily. These innovations ensure that tourism is inclusive, offering personalized services to cater to a broader range of visitors (Korže, 2019; Gajdošík et al., 2020).

Overall, smart tourism, powered by immersive technologies like AR and VR, is not just about enhancing tourist experiences, but also about improving efficiency and sustainability, ensuring that tourism grows in a way that meets the needs of the digital age while remaining inclusive and accessible to all.

### *3.3.4 Cyan Cluster: Industry 4.0 and Hospitality Revolution*

The cyan cluster emphasizes the integration of Industry 4.0 technologies in tourism and hospitality. These technologies, including automation, robotics, and cyber-physical systems, are revolutionizing the sector by improving operational efficiency and enhancing guest experiences (Korže, 2019; Zeqiri et al., 2020; Bilsen Bilgili et al., 2021).

Several practical implementations demonstrate how Industry 4.0 technologies are transforming the hospitality sector by enhancing personalization, operational efficiency, and automation. For instance, Marriott Hotels use IoT-based smart room technologies that allow guests to control lighting, temperature, and entertainment settings via mobile applications, ensuring a highly personalized and energy-efficient experience (Korže, 2019; Dalkiran, 2022). Similarly, Alibaba's FlyZoo Hotel employs facial recognition for check-ins and robots for room service, offering guests a fully automated and seamless stay experience. Additionally, AI is being integrated through chatbots like Connie at Hilton Hotels, helping guests with real-time information and personalized recommendations. Data analytics is also playing a significant role in optimizing hotel operations, enabling businesses to adjust pricing dynamically and forecast demand more accurately (Korže, 2019; Urbančič et al., 2020; Bilsen Bilgili et al., 2021).

Industry 4.0 is reshaping tourism and hospitality by enabling smarter, more efficient, personalized, and sustainable services, driving both operational excellence and enhanced guest satisfaction (Nugraheni et al., 2021; Thoi, 2021).

### *3.3.5 Olive Green Cluster: Tourism 4.0, Technological Design, and User Experience*

The olive green cluster focuses on the intersection of Tourism 4.0, technological design, and user experience. It highlights how digital technologies are being integrated into the tourism industry to enhance the overall experience for users, offering a seamless, personalized, and efficient travel journey (Stankov et al., 2020; Zeqiri et al., 2020).

Technological design in tourism involves creating user-friendly, intuitive digital interfaces that improve engagement and accessibility. Smart tourism apps, interactive digital maps, and personalized guides are examples of how technology is used to enhance the user experience (Ramos et al., 2020; Thoi, 2021). These technologies allow tourists to access real-time information, book services, and navigate destinations more efficiently, improving both convenience and satisfaction (Bilsen Bilgili et al., 2019).

Human-centered design also plays a critical role in shaping the tourist experience. By focusing on the needs and preferences of travelers, tourism businesses can create tailored services that make travel more

enjoyable and accessible. For example, personalized mobile apps that suggest activities or restaurants based on individual preferences provide a highly customized experience, increasing satisfaction and encouraging repeat visits (Stankov et al., 2020). Building on these human-centered approaches, emerging technologies like IoT further enhance the connected tourism experience. Moreover, IoT-based systems are used to connect various services and devices in smart cities and accommodations, providing tourists with seamless experiences. For instance, smart hotels enable guests to control their room settings (such as lighting, temperature, and entertainment) through a mobile app, offering convenience and a personalized (Urbančič et al., 2020; Zeqiri et al., 2020).

Thus, the olive green cluster demonstrates how technological and user-centered innovations are reshaping Tourism 4.0 toward greater personalization, efficiency, and accessibility.

### *3.3.6 Green Cluster: Sustainability and Human-Centered Innovation*

This cluster underscores the social, environmental, and economic dimensions of sustainable tourism. Sustainable growth in tourism is essential for mitigating the risks associated with the sharp rise in international travel over the past two decades. Tourism 4.0 presents considerable opportunities to advance sustainable development goals (Ramos et al., 2020), ligning with the United Nations' vision for transformative change within the industry (Peceny et al., 2019). Drawing on a review of the relevant literature, sustainability in the context of Tourism 4.0 is framed around three key dimensions: social, economic, and environmental. These dimensions give rise to three main categories of sustainability drivers: economic benefits, social benefits, and environmental.

#### *A. Economic Advantages*

The rapid evolution of Tourism 4.0 brings significant economic advantages by enhancing service accessibility, increasing destination competitiveness, and optimizing operational processes. The integration of AI and robotics helps address seasonal employment fluctuations and workforce turnover, leading to higher operational efficiency, improved customer service, streamlined supply chains, and expanded digital capabilities. This also creates new employment opportunities (Osei et al., 2020b).

While mass tourism continues to challenge environmental sustainability, stakeholders are turning to smart technologies and digitalization to create innovative, cost-effective, and time-efficient service models (Go & Kang, 2023). Virtual technologies, for instance, offer immersive experiences—such as simulations of historical events and cultural landmarks—while reducing costs and elevating service quality (Thoi, 2021).

Sensors, RFID chips, cyber-physical systems, and IoT play a central role in revolutionizing supply chain processes. IoT enables smarter and more efficient operations, exemplified by the widespread adoption of smart self-service technologies in hotels. These innovations respond to the pressures of mass tourism by enabling experiences that are both economically viable and sustainable. Integrating renewable energy sources into accommodation facilities also supports energy efficiency and the transition to circular economy models, contributing to long-term economic sustainability (Zeqiri et al., 2020).

**Categorization of Economic Benefits:**

Increased Competitiveness: Advanced technologies attract more tourists and strengthen local economies (Gajdošík et al., 2020; Osei et al., 2020b; Thoi, 2021).

Improved Employment and Workforce Efficiency: AI and robotics mitigate seasonal employment issues and improve workforce productivity (Osei et al., 2020a; Osei et al., 2020b; Bilsen Bilgili et al., 2021).

Enhanced Customer Services: Virtual technologies elevate service standards and offer immersive, interactive experiences (Osei et al., 2020a; Bilsen Bilgili et al., 2021).

Cost Reduction and Higher Revenue: Digital technologies enable more efficient service delivery and maximize revenue.

Efficient Supply Chain Management: IoT optimizes logistics and resource use across the tourism sector (Osei et al., 2020b; Zeqiri et al., 2020; Dalkiran, 2022).

Sustainable Operations: Smart systems and renewable energy integration improve energy efficiency and support circular business models (Pencarelli, 2020; Ramos et al., 2020).

Beyond economic benefits, Tourism 4.0 is also driving profound social transformations in the sector.

### *B. Social Advantages*

The emergence of Tourism 4.0 marks a transformative shift in the tourism sector, offering a wide range of social benefits. One of the most prominent is the personalization of services, which not only reduces costs but also significantly improves the customer experience. Digital technologies enable interactive communication and the exchange of creativity between producers and consumers, thereby fostering social and cultural connectedness across regions and countries in the era of the Fourth Industrial Revolution.

Advancements in IoT, smart cities, big data, and cloud computing have enhanced personalization and customer relationship management. For example, hotel rooms are now equipped with tablets or smart TVs that allow guests to customize their environment and receive real-time updates such as flight changes. These technologies also streamline operational tasks and enable predictive maintenance notifications (Urbančič et al., 2020).

Applications of Industry 4.0 simplify travel planning, from room selection to food and beverage preferences, while enabling users to explore destinations virtually (Ramos et al., 2020). Smart robots enhance the travel experience by providing multilingual services via kiosks, mobile devices, social media platforms, and AI-powered tools (Dalkiran, 2022).

Moreover, digital transformation has improved working conditions and created new job opportunities. The demand for digitally skilled professionals is increasing, fostering better livelihoods and promoting social inclusion and cohesion between residents and tourists (Pencarelli, 2020).

**Categorization of Social Benefits:**

Personalization: Tailored services improve efficiency and enhance customer satisfaction (Osei et al., 2020b; Pencarelli, 2020).

Connectivity: Digital technologies and smart devices facilitate creative and cultural exchange (Gajdošík et al., 2020; Pencarelli, 2020).

Improved Customer Experience: Technologies improve tourism experiences through real-time updates, automation, and predictive services (Bilsen Bilgili et al., 2021; Ozturk, 2021).

Job Opportunities: The tourism sector generates demand for skilled digital labor, improving employment conditions (Urbančič et al., 2020).

Social Cohesion: Tourism 4.0 strengthens community relationships and enhances overall quality of life (Pencarelli, 2020; Fakhimi et al., 2022).

These social dimensions underline the broader human-centered potential of Tourism 4.0, highlighting how advanced technologies can not only serve tourists but also empower communities, improve accessibility, and foster inclusive growth.

In addition to economic and social progress, Tourism 4.0 significantly advances environmental sustainability through technological innovation.

### *C. Environmental Advantages*

Tourism 4.0, through the application of Industry 4.0 technologies, presents significant opportunities for advancing environmental sustainability in the tourism sector. Digital tools enhance resource efficiency, reduce energy consumption, and enable better environmental management at both operational and destination levels (Zeqiri et al., 2020).

One key advancement lies in the integration of renewable energy sources into tourism infrastructure, particularly in energy distribution and smart building systems. These systems—supported by smart metering, data analysis, and automation—help reduce carbon emissions and operational costs while maintaining service quality (Pencarelli, 2020). The use of smart energy networks further contributes to optimizing energy distribution and monitoring consumption patterns across tourism facilities (Fakhimi et al., 2022).

Smart buildings utilise intelligent systems such as automated lighting, climate control, smart showers, and energy-saving appliances to minimize environmental impact. For example, smart hotels employ technologies that monitor energy and water use, contributing to conservation efforts and reduced $CO_2$ emissions (Ramos et al., 2020). Additionally, smart meters in kitchens and restaurants help reduce food waste by analyzing consumption and adjusting inventory (Zeqiri et al., 2020).

Water management also benefits from Tourism 4.0 technologies. IoT devices and smart meters provide real-time data on water use, enabling targeted conservation practices—such as irrigation scheduling and laundry optimization—in accommodation facilities and public spaces. These tools are also valuable in monitoring water quality and ensuring efficient usage across large-scale tourism ecosystems (Urbančič et al., 2020; Zeqiri et al., 2020).

Furthermore, virtual and augmented reality technologies reduce the environmental impact of travel by enabling immersive experiences that minimize physical mobility. Virtual visits to cultural or natural sites not only lower emissions but also preserve sensitive environments.

Smart mobility systems offer another layer of sustainability by optimizing public transportation, navigation, traffic flow, and travel assistance. These systems provide eco-friendly alternatives and reduce congestion in popular destinations through real-time data sharing and route optimization (Fakhimi et al., 2022).

**Categorization of Environmental Benefits:**

Sustainable Resource Management: Efficient monitoring and control of water, energy, and waste through IoT and smart meters.

Energy Efficiency: Implementation of renewable energy systems and intelligent infrastructure reduces operational costs and emissions.

Smart Buildings and Infrastructure: Environmentally friendly designs support low-energy tourism facilities (Pencarelli, 2020; Bilsen Bilgili et al., 2021; Fakhimi et al., 2022).

Digital Technologies for Sustainable Transportation: Smart mobility and virtual tourism reduce reliance on physical travel and promote eco-conscious behaviour (Bilsen Bilgili et al., 2021; Ozturk, 2021; Thoi, 2021; Fakhimi et al., 2022).

Pollution Control: Smart systems assist in air and water quality monitoring, recycling management, and emission reduction (Fakhimi et al., 2022).

Tourism 4.0 thus contributes holistically to environmental sustainability by embedding smart, clean, and efficient technologies into all facets of the tourism experience—from resource use and infrastructure to visitor behaviour and transportation systems.

This study has focused on identifying and emphasising the major economic, social, and environmental advantages enabled by Tourism 4.0. While acknowledging the challenges, the intent has been to spotlight the transformative potential of smart technologies in tourism. While Tourism 4.0 delivers substantial sustainability benefits, addressing challenges such as cybersecurity, digital inequality, and environmental risks remains critical.

## 3.4 Challenges and Risks of Tourism 4.0

While many emerging technologies contribute to Tourism 4.0, this study has focused on the most widely implemented and empirically supported innovations to provide a practical and targeted view of their implications. Despite the potential benefits, the literature also highlights several critical challenges and risks associated with the adoption of these technologies in the tourism sector.

Cybersecurity has emerged as a key concern, with increased digital integration exposing tourism systems to potential data breaches and cyberattacks. The vulnerability of centralized data storage and the lack of robust protection mechanisms have been particularly emphasized (Pencarelli, 2020; Hsu et al., 2022). Beyond cybersecurity, ensuring equitable access to digital innovations presents another significant challenge.

Another pressing issue is digital exclusion, which refers to unequal access to digital infrastructure and varying levels of digital literacy across different populations and regions. This digital divide can undermine the inclusive goals envisioned by Tourism 4.0 and potentially widen existing social inequalities (Osei et al., 2020; Pencarelli, 2020; Bilsen Bilgili et al., 2021; Hsu et al., 2022).

Environmental concerns have also been raised. Although Tourism 4.0 technologies can support sustainability, their implementation—particularly the energy consumption and lifecycle of smart devices—poses new environmental challenges. These may conflict with broader sustainability objectives in tourism development (Ramos et al., 2020; Zeqiri et al., 2020) .

Furthermore, the literature identifies the risk of technological dependency, especially for small and medium-sized tourism enterprises. Relying heavily on a limited number of technology providers could

reduce strategic flexibility and create long-term vulnerabilities (Peceny et al., 2019). However, more empirical research is needed to fully understand the extent of these impacts.

To mitigate these risks, scholars have proposed several strategies, including stronger data protection policies, investment in digital literacy and education, and the adoption of sustainable and inclusive technological frameworks. Moreover, supportive public policies are critical to foster an inclusive and sustainable digital transformation in tourism. A balanced approach to the development of Tourism 4.0—one that simultaneously advances innovation while addressing ethical, social, and environmental considerations—is essential for its long-term success (Al-Romeedy, 2024; Rodrigues et al., 2024; Theofanous et al., 2024). Successfully navigating these challenges is essential for realizing the transformative potential of Tourism 4.0.

## 4. Discussion

The global economy is increasingly shaped by digital transformation driven by the Fourth Industrial Revolution. Although the tourism sector is a part of this shift, its adoption of digitalization has been slower due to uncertainties and structural challenges. The COVID-19 pandemic underscored the urgency of pursuing development strategies aligned with sustainability, particularly within the framework of the United Nations' Sustainable Development Goals. Problems such as overtourism, pollution, and economic vulnerability have highlighted the need for smarter, balanced approaches. In this context, advanced digital technologies such as AI and IoT are projected to reshape tourism by enhancing service efficiency, real-time responsiveness, and environmental management (Dalkiran, 2022; Rodrigues et al., 2023). Stakeholders are therefore encouraged to prioritize the adoption of these tools in order to remain competitive and sustainable (Melike et al., 2018).

This study conducted a systematic review to evaluate the current state of research on Tourism 4.0. A descriptive analysis of 26 articles indicates a surge in academic interest, particularly since 2020, yet the literature remains fragmented regarding its definitions, guiding principles, and sustainability implications.

Several countries—including Portugal, Finland, Italy, Spain, Turkey, Slovenia, Thailand, Bali, and Malaysia—have begun integrating the Tourism 4.0 paradigm into national strategies and government publications. Leading examples such as Portugal and Slovenia showcase how practical implementations, including AI and IoT-based systems, can enhance destination management and support long-term sustainability (Korže, 2019; Urbančič et al., 2020).

This paper bridges theoretical frameworks with practical examples, illustrating how digital tools can improve operational efficiency and advance sustainable development goals (Pencarelli, 2020; Zeqiri et al., 2020). Slovenia's Tourism 4.0 project and Portugal's smart tourism strategy illustrate how digital innovations can regulate visitor flows, reduce environmental pressures, and optimize energy use (Ramos et al., 2020; Fakhimi et al., 2022).

To further contextualize the findings, the core research questions are revisited in light of the empirical results obtained through co-occurrence analysis and thematic clustering. Regarding the first question, what are the key concepts of Tourism 4.0 and how does digital evolution impact the industry? The findings reveal that Tourism 4.0 is characterized by the integration of advanced digital technologies such as artificial intelligence, blockchain, big data, IoT, cloud computing, and immersive tools like virtual and augmented reality. These technologies enable the transformation of tourism production, management, and experience, resulting in more personalized services, greater efficiency, and enhanced competitiveness. Digital evolution is reshaping traditional business models and enabling the creation of new, innovative services that meet the evolving needs of tourists.

In addressing the second question, what are the constructive components of Tourism 4.0? The study identifies six major components that constitute the foundation of Tourism 4.0: Tourism and Innovation, Smart Decision-Making, Smart Tourism, Industry 4.0 Transformation, Technological Design, and Sustainability and Human-Centered Innovation. These components together illustrate the multidimensional impact of digital transformation on the tourism sector, including the shift towards data-driven decision-making, the integration of immersive technologies, and the adoption of human-centered approaches to ensure that technological progress aligns with sustainable and inclusive tourism practices.

Finally, regarding the third question, what are the drivers for sustainable development in Tourism 4.0, and how can these drivers be effectively integrated to achieve sustainable outcomes? Sustainability in Tourism 4.0 is driven by three main factors: economic, social, and environmental. Economic drivers include improving operational efficiency, reducing costs, and generating new employment opportunities through digital technologies. Social drivers focus on enhancing personalization, cultural connectivity, and inclusivity, ensuring that tourism benefits all stakeholders. Environmental drivers involve smart resource management, energy-efficient technologies, and the promotion of digital alternatives like virtual tourism to minimize the environmental footprint. To achieve sustainable outcomes, these drivers must be effectively integrated through supportive policies, collaborative frameworks, and the equitable distribution of digital resources to ensure that all stakeholders benefit from the advancements of Tourism 4.0.

Although this study is situated within the Tourism 4.0 framework, the identified emphasis on personalization, social inclusion, and empowerment highlights the relevance of the Tourism 5.0 perspective, which may provide a promising direction for future research focused on the integration of human-centric values and digital innovation in tourism.

The findings are supported by multiple empirical studies. For instance, Osei et al. ( 2020a), (2020b), Ozturk (2021), Bilsen Bilgili et al. (2021) examined the effects of smart technologies on tourism demand and customer experience. Others, including Pencarelli (2020) and Fakhimi et al. (2022), explored the potential of digital innovations to mitigate environmental impacts and improve sustainability during crises such as COVID-19.

This study further identifies technological, organizational, and environmental enablers as crucial to the successful digital transformation of tourism—contrasting with earlier fragmented approaches that analysed these drivers in isolation (Urbančič et al., 2020). Digital tools such as AR, VR, AI, IoT, cloud computing, and blockchain are shown to contribute meaningfully to competitiveness, service personalization, and operational resilience (Gajdošík et al., 2020; Thoi, 2021).

Despite these opportunities, gaps persist in the literature regarding real-world applications and the long-term societal and environmental effects of Tourism 4.0. Many theoretical claims lack empirical validation or fail to address implementation barriers (Thoi, 2021). This study addresses these gaps by examining the practical applications of these technologies.

Future research should focus on the environmental and social impacts of Tourism 4.0, particularly its role in promoting sustainability through digital transformation. Investigating how technologies like AI and blockchain can drive eco-friendly operations and generate socio-economic benefits is essential. Additionally, future studies should explore ethical considerations related to data privacy and the socio-economic effects on local communities, paving the way for innovative, sustainable tourism practices.

Despite the many benefits identified in this study, it is also essential to recognize the accompanying risks and challenges that may hinder the equitable and sustainable implementation of Tourism 4.0. Furthermore, the current study underscores that while the opportunities offered by Tourism 4.0 are vast, they are accompanied by significant challenges. These include cybersecurity threats, ethical concerns regarding data usage, dependence on dominant technology providers, environmental costs of high-tech infrastructure, and issues of digital exclusion—especially in developing regions. Acknowledging these risks is crucial for ensuring that the digital transformation of tourism evolves in an inclusive, ethical, and sustainable manner. Future strategies must therefore balance innovation with digital justice, privacy, and equitable access.

## 4.1 Theoretical Implications

The term "Tourism 4.0" was introduced in 2016 (Ramos et al., 2020), yet there remains no clear consensus on its definition, criteria, and sustainability principles. This study aims to clarify these aspects by presenting comprehensive theoretical insights. Previous research has identified Tourism 4.0 as a driver of innovation in tourism, fostering entrepreneurial ecosystems and involving tourists, service providers, and government stakeholders (Korže, 2019; Peceny et al., 2019; Ramos et al., 2020).

Tourism 4.0 integrates digital technologies and IT infrastructures to create interactive platforms within the tourism industry (Osei et al., 2020a; Osei et al., 2020b; Peceny et al., 2019). This concept extends beyond digitalizing tourism businesses, focusing on enhancing resource efficiency and promoting environ-

mental sustainability by optimizing energy use and reducing waste (Peceny et al., 2019; Urbančič et al., 2020; Zeqiri et al., 2020; Fakhimi et al., 2022).

Existing literature provides empirical evidence supporting the positive impact of Tourism 4.0 on adopting cleaner production methods and eco-friendly operations. Digitalizing operations in the tourism industry aims to create an integrated digital ecosystem and enhance the productivity and competitiveness of tourism destinations, ultimately contributing to sustainable development (Shafiee et al., 2022). To strengthen the theoretical foundation of Tourism 4.0, future research should draw from innovation management, sustainability studies, and digital transformation theories. Developing clear sustainability criteria, while exploring the role of innovation and entrepreneurship, will be key to understanding how Tourism 4.0 can drive the tourism industry's evolution.

## 4.2 Practical Implications

The digitization of tourism is a gradual process that involves interrelated technologies such as cloud computing, big data, and IoT, which together enhance personalized services and connectivity with suppliers (Urbančič et al., 2020; Zeqiri et al., 2020; Peceny et al., 2019). Smart buildings, equipped with sensors and IoT, offer enriched user experiences, while robots streamline communication and services (Zeqiri et al., 2020).

Financial capital is crucial for digital advancements, supporting necessary knowledge and expertise in digital transformation (Osei et al., 2020b). Therefore, countries need well-defined strategic plans to handle the complexities of this transformation. Without these plans, Tourism 4.0 cannot achieve its economic, social, and environmental sustainability objectives.

Tourism 4.0 has often been highlighted for its economic benefits, such as increased productivity and job creation (Osei et al., 2020a; Zeqiri et al., 2020; Thoi, 2021). However, its environmental and social impacts are equally significant. Enhanced resource efficiency, waste reduction, and lower carbon emissions contribute to sustainable outcomes. Furthermore, the integration of technologies in Tourism 4.0 fosters smart city development, where AI and IoT improve urban life, ensuring safety, convenience, and environmental monitoring. Aligning tourism with urban strategies promotes resilience and sustainability.

In addition to enhancing urban infrastructure, technologies like smart grids and smart transportation improve energy use and mobility within cities. Digital platforms facilitate better tourist management, reducing overcrowding at popular sites and promoting a balanced visitor distribution.

With global challenges like environmental degradation in mind, Tourism 4.0 can leverage AI and ICT advancements to address natural resource management in the digital age (Balsalobre-Lorente et al., 2023). The convergence of these technologies supports sustainable tourism, empowering communities and contributing to symbiotic tourism destinations (Ozturk, 2021; Thoi, 2021).

The transformative impact of Industry 4.0 technologies on the tourism sector has become increasingly evident, ushering in a new era of digitalization and connectivity. Our systematic review sheds light on current Tourism 4.0 literature, providing important insights into trends, challenges, and potential advantages.

Strategic Emphasis on Communication Technologies: Stakeholders are urged to prioritize communication technology development and integration of new trends. This aligns with the rapid transformations in the industry, emphasising the need for proactive adaptation to these changes.

Global Adoption of Tourism 4.0 Terminology: The review reveals widespread adoption of the term "Tourism 4.0" in publications and initiatives by governments and policymakers globally. Countries such as Portugal, Finland, Italy, Spain, Turkey, Slovenia, Thailand, Bali, and Malaysia have embraced this terminology (Korže, 2019), signaling a global recognition of the importance of Industry 4.0 in tourism.

Focus on Sustainable Tourism Practices: Addressing sustainability is crucial within the Tourism 4.0 framework. Policymakers and industry leaders must align Tourism 4.0 developments with goals that prioritize not only economic growth but also social and environmental sustainability. However, our review highlights a gap in the literature that needs further exploration of this intersection.

Strategic Planning for Digital Transformation: Developing accurate strategic plans is essential for managing the complexities of tourism's digital transformation. Without proper strategies, the potential for achieving economic, social, and environmental sustainability through Tourism 4.0 is limited. As the review suggests, the long-term economic growth driven by Tourism 4.0 could lead to increased job creation and

sustainable tourism ecosystems. Moreover, optimizing energy and resource consumption directly contributes to enhanced efficiency and reduced environmental impact.

Practical Recommendations: It is critical to provide stakeholders in the tourism sector with actionable insights for implementing Tourism 4.0 initiatives (El Archi et al., 2023). Challenges related to infrastructure development, workforce upskilling, and stakeholder collaboration need addressing. Best practices from regions that have successfully embraced Tourism 4.0 principles offer valuable lessons. Strategic planning must encompass economic, social, and environmental facets to ensure a comprehensive digital transformation. Awareness programs should encourage the incorporation of communication technologies to facilitate the effective implementation of Tourism 4.0 initiatives.

### 4.3 Research Implications

While our systematic review primarily focused on the positive aspects of Tourism 4.0, future research endeavors should delve into the challenges associated with this paradigm shift. Investigating the implications for sustainability, both environmental and social, requires deeper exploration. By addressing these challenges, researchers can contribute to a more comprehensive understanding of the multifaceted impact of Tourism 4.0, thereby informing strategic decision-making and policy development.

Given the dynamic nature of technology, longitudinal studies are essential to track the evolution of Tourism 4.0. Future research should adopt a longitudinal approach to capture the changing landscape, assess sustained impacts, and uncover emerging trends within the tourism industry. This perspective will provide valuable insights into the long-term effects of digital transformation on the tourism sector, enabling stakeholders to adapt and innovate effectively.

Our study hints at the integration of technologies across sectors. Future research can explore the potential benefits and challenges of cross-sector collaboration, offering insights into how different industries can collaborate effectively to enhance overall digital transformation. Understanding the dynamics of cross-sector collaboration in the context of Tourism 4.0 is crucial for fostering synergies and maximizing the potential of interconnected technologies.

A deeper understanding of end-user experiences is crucial for the success of Tourism 4.0 technologies. Future research can delve into user perceptions, preferences, and challenges associated with the adoption of these technologies, ensuring that developments align with the expectations of tourists. By prioritizing user experience studies, researchers can contribute to the creation of more user-centric and effective digital solutions within the tourism industry.

In conclusion, our systematic review not only provides practical insights for industry stakeholders but also highlights critical avenues for future research. By addressing challenges, fostering innovation, and considering sustainability, the tourism sector can maximize the benefits of Industry 4.0 technologies for sustainable and competitive growth. This emphasis on future research directions underscores the importance of continued exploration and adaptation within the evolving landscape of Tourism 4.0.

## 5. Conclusion

This systematic review has highlighted the impact of the fourth industrial revolution on tourism (Melike et al., 2018; Korže, 2019; Tasya et al., 2019), particularly within the context of Tourism 4.0. By systematically reviewing 148 articles from 2016 to 2022 and employing rigorous selection criteria based on the Critical Appraisal Skills Program (CASP) guidelines, we identified 26 high-quality articles, allowing us to achieve our research goals and extract valuable insights. The findings reveal that Tourism 4.0 represents a paradigm shift driven by the digital transformation of the industry, disrupting traditional business models and giving rise to new ones.

As the industry evolves in the digital age, tourism organisations must intelligently address competitive challenges and adapt to new business models to enhance operational effectiveness and overall output (Osei et al., 2020b; Pencarelli, 2020). Furthermore, the emergence of Tourism 4.0 fosters a new type of collaborative engagement (Korže, 2019; Pencarelli, 2020; Urbančič et al., 2020), involving the active participation of local communities, tourists, tourism service providers, and government entities, ultimately creating a more inclusive and sustainable tourism environment.

Tourism 4.0 aligns with the broader objectives of the United Nations' Sustainable Development Goals (SDGs), including fostering economic growth, promoting innovation, and enhancing sustainability within urban and rural communities. By leveraging digital technologies, Tourism 4.0 contributes to the development of sustainable tourism infrastructures, encourages responsible consumption and production patterns, and reduces environmental impacts through more efficient resource use and eco-friendly practices. Additionally, it promotes inclusive growth by creating job opportunities and empowering local communities, while addressing climate change by reducing carbon footprints and encouraging green initiatives.

For industry practitioners, our findings emphasize the necessity of adapting to digital disruption by embracing new business models and enhancing operational efficiency to remain competitive. Policymakers are encouraged to develop frameworks that facilitate this transition by incentivizing innovation and promoting the integration of emerging technologies in the tourism sector. This will support sustained growth, collaboration, and improved service delivery. For government and non-government organizations, fostering a collaborative ecosystem that includes local communities, tourists, and service providers can lead to a more inclusive and sustainable tourism environment. Researchers can utilise these insights to explore the impact of digital transformation on various aspects of tourism, including operational efficiency and social inclusion, while also addressing challenges such as the digital divide and data security.

The practical implications for society revolve around creating a tourism industry that is more sustainable and inclusive, where community engagement and social well-being play central roles. Tourism 4.0 holds great promise in driving economic growth, environmental sustainability, and social equity through the responsible use of technology. However, despite the quality of the studies conducted, numerous research opportunities remain unexplored. The ongoing evolution of Tourism 4.0 presents immense potential for advancing the tourism industry and fostering sustainable development (Peceny et al., 2019; Fakhimi et al., 2022). Therefore, researchers and practitioners must continue to investigate the various dimensions and implications of Tourism 4.0. By embracing digital transformation and collaborative engagement, countries can create a promising future for their tourism industries in terms of environmental, social, and economic development. By providing the necessary infrastructure and conditions, Tourism 4.0 can achieve even greater growth and development.

In navigating the ever-changing landscape of technology and tourism, it is essential to acknowledge the potential challenges and risks associated with Tourism 4.0. Issues such as data privacy, cybersecurity, and the digital divide must be addressed to ensure that all stakeholders can benefit from the digital revolution. Policymakers and industry leaders must collaborate to establish robust regulations and frameworks that safeguard the interests of individuals, businesses, and communities. In embracing digital transformation and collaborative engagement, countries can create a promising future for their tourism industries regarding environmental, social, and economic development. By providing the necessary infrastructure and conditions, Tourism 4.0 can achieve even greater growth and development.

## 5.1 Limitations and Future Research Directions

As we chart the future course of research within the dynamic landscape of Tourism 4.0, it is crucial to address existing gaps and propel the field toward new horizons. Future investigations should prioritize specific topics to deepen our understanding of the dynamics and implications of Tourism 4.0. These topics include exploring the socio-economic impacts on local communities, analyzing the transformative potential of emerging technologies such as artificial intelligence and blockchain in reshaping tourism experiences and operational paradigms, and critically examining the ethical dimensions of data collection, privacy, and digital surveillance in digitalized tourism environments.

For researchers, there is a pressing need to develop and test theoretical frameworks that explain how innovation management theories can guide the adoption of Tourism 4.0. Integrating sustainability principles into these frameworks will be key to achieving long-term benefits. Additionally, practical case studies on regions or businesses that have successfully implemented Tourism 4.0 can provide industry practitioners with actionable insights.

Policymakers and industry leaders should focus on strategic planning that addresses not only the economic benefits but also the social and environmental dimensions of Tourism 4.0. Guidelines must balance

the potential growth of digital tourism with ethical concerns, such as data privacy and security, to protect both businesses and individuals.

Theoretical frameworks play a pivotal role in shaping our comprehension of Tourism 4.0 and guiding its implementation. Future research should investigate how innovation management theories influence the adoption and diffusion of Tourism 4.0 practices across diverse industry contexts. Developing robust theoretical frameworks that integrate sustainability principles into the core strategies of Tourism 4.0 will be essential for ensuring that technological advancements contribute to sustainable and inclusive growth.

Moreover, there is a need to examine the role of smart cities in facilitating Tourism 4.0. Research should explore how urban infrastructure and smart city initiatives can support the seamless integration of Tourism 4.0 technologies, enhancing the overall tourist experience while promoting sustainable urban development.

In addition to theoretical explorations, practical insights are indispensable for industry stakeholders navigating the complexities of implementing Tourism 4.0. Future research should prioritize providing practitioners with actionable case studies and best practices from regions or businesses that have successfully embraced Tourism 4.0 principles. This will facilitate knowledge transfer and informed decision-making, enhancing the effectiveness and sustainability of digital transformation efforts within the tourism industry. Emphasising the importance of strategic planning that encompasses economic, social, and environmental dimensions is crucial for ensuring the comprehensive and sustainable evolution of Tourism 4.0.

Finally, it is important to highlight the need for interdisciplinary approaches in future research. Collaboration among technologists, social scientists, urban planners, and industry practitioners will be crucial in addressing the multifaceted challenges and opportunities presented by Tourism 4.0. By fostering such collaborations, we can ensure that the evolution of Tourism 4.0 is guided by a holistic understanding of its impacts and potential.

By embracing these future research directions, scholars and practitioners can collaboratively advance the field of Tourism 4.0, paving the way for innovative strategies and sustainable practices that harness the full potential of digital technologies within the tourism ecosystem.

While this systematic review offers valuable insights into the digital evolution of the Tourism 4.0 industry, certain limitations may have influenced the findings. Future researchers can build upon this study and explore new avenues to comprehensively address these limitations. One limitation lies in the scope of the selected articles, which—despite efforts to include a diverse range—may have inadvertently excluded relevant studies. Future research could expand the scope by considering a broader range of literature, including industry reports, conference proceedings, and gray literature, to provide a more comprehensive analysis. Additionally, reliance on existing literature may have constrained the depth of insights, suggesting the need for primary research methods such as surveys or interviews to uncover practical implementation insights and challenges associated with Tourism 4.0.

Moreover, while this study primarily focused on the impacts and advantages of Tourism 4.0, future research could delve deeper into sustainability practices and strategies, community engagement, and the well-being of both tourists and local residents. Exploring the practical implementation of Tourism 4.0 technologies in real-world settings and conducting bibliometric analyses to supplement systematic reviews could further enrich our understanding of the field's evolution and trends.

Another important limitation relates to the geographical and sectoral scope of the reviewed literature. The geographical distribution of studies was skewed toward Europe and Southeast Asia, with limited representation from Africa, Latin America, and other developing regions. This imbalance may affect the generalizability of the findings and restrict the applicability of Tourism 4.0 frameworks to diverse socio-economic and cultural contexts. Likewise, the sectoral focus leaned heavily toward hospitality and digital technologies, while niche areas such as sustainable tourism logistics, rural tourism innovation, and community-based ecotourism received comparatively less attention. These gaps underscore the importance of future systematic reviews adopting broader inclusion criteria, incorporating diverse regional perspectives, and utilizing interdisciplinary lenses to capture the full spectrum of Tourism 4.0's global development and its implications across varied sectors.

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