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Review

The Use of Digital Twins to Address Smart Tourist Destinations' Future Challenges

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Abstract: This research aims to conceptualise the use of the digital twins (DT) tool in tourism to address smart tourist destinations' future challenges to enhance tourists' experiences and residents' quality of life through better services developed by DTs. This paper investigated the use of DT technology to tackle the new challenges facing smart tourist destinations (STDs) in terms of urban planning, sustainability, security, marketing, and tourism activities by using data on this topic from expert researchers and public and private organisations. Also, this research adopted a systematic review approach to analyse and illustrate the existing literature on the topic of DTs and their use for STDs, which helped us develop the DT concept in a STD context. The findings of this research reveal that DT technology is emerging as a disruptive technology tool that is being used to improve the management of STDs in terms of their efficiency, safety, sustainability, environmental protection, productivity, and energy consumption. Moreover, DT technology is a nascent tool in the tourism and marketing industries, but its versatility in relation to its capacity to analyse data and predict the behaviour of tourism and business ecosystems to address relevant issues at STDs gives it a key role in the tourism industry. Finally, a new definition of DT technology has been included in this study within a tourism and STDs context, filling the gap in this topic in the tourism industry according to some researchers' suggestions. There are limited scientific publications about DT technology that jointly tackle the DT technology and STDs sphere. Accordingly, this manuscript defines DT technology and provides a new viewpoint of this technology that will help to initiate academic discussions on DT tourism within the context of STDs.

Keywords: digital twins; smart tourist destinations; interoperability; cybersecurity; sustainability

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1. Introduction

Smart tourist destinations (STDs) are constantly undertaking new initiatives and actions to enhance residents' quality of life and tourists' experiences through digital tools [1]. A STD refers to a destination that prioritises technology, innovation, sustainability, accessibility, and inclusivity before, during, and after the tourism cycle to enhance tourists' experiences and residents' quality of life [2,3]. Consequently, the digital collaborative ecosystem and innovative actions are crucial for STDs centred on knowledge flow and sharing information to provide the best services [4]. Indeed, digital twins of STDs have recently attracted much attention as a useful virtual platform to monitor, automate, and optimise their tourism and socio-economic activities [5,6]. A digital twin (DT) is a virtual replica of a city that can be used to simulate and analyse the city's physical and functional characteristics [7]. DT technology allows governments and managers to oversee the performance of a city or company, identify potential threats, and make better-informed decisions about maintenance and the lifecycles of products and services, as well as operational processes. In the tourism industry, this technology can be the difference between the success or failure of an investment of a million euros to enhance the wellbeing of citizens and tourists' experiences at STDs. A STD is understood as a city that combines customised experiences for tourists based on a ubiquity of information and with the support of information and

communication technology (ICT), as well as an accessible space for all that guarantees the sustainable development of the city and residents' needs [1,3].

New forms of STD governance are emerging, supported by DTs, which allows them to manage and monitor performance data, tourism flows, sustainable processes, and potential threats related to their management and technological systems [8]. For instance, metaverse and artificial intelligence (AI) technologies are improving tourists' experiences and residents' quality of life at STDs [9]. It is imperative to develop digital tools like DTs to support government bodies and tourism companies to build a more responsible, sustainable, and resilient future for STDs [10]. The use of the DT tool offers a new opportunity to ensure the competitiveness of STDs in the tourism industry [11] and can help STDs predict future disasters like floods, hurricanes, cyclones, or earthquakes [12,13]. DT technology makes use of real-time data streaming from different technologies such as cloud computing, big data, AI, the internet of things (IoT), machine learning (ML), blockchain techniques, virtual reality (VR), and augmented reality (AR) to optimise, in real time, STDs and organisations' management processes [14–16].

The emergence of DTs boosts the development and sustainability of STDs, as well as their air and ground transport systems [17]. Hence, the future development of STDs focused on DT technologies will provide new and different STD management models [18]. The tourism industry is conditioned by new technologies that provide a range of benefits, such as personalised marketing campaigns, increased productivity, improved customer satisfaction, promoting a city's brand image, or even helping to improve universal accessibility for people with disabilities through communication and information digital channels [19–21]. However, Rahmadian et al. [22] note that DT technology poses significant challenges and concerns surrounding cybersecurity, privacy, and trust with the use of big data, especially in destination marketing organisations (DMOs), tourism activities, and air and ground transport companies. In order to enhance STDs' planning, management, and tourism services, the combination of DT and blockchain technologies enables STDs to build real-time copies of urban landscapes and secure, transparent data management [23].

Singapore, New York (US), Herrenberg (Germany), the New South Wales (Australia), Vienna (Austria), Zurich (Switzerland), Glasgow (Scotland), and even Cambridge and Nottingham (England) have implemented DT technology to more efficiently develop their urban planning, promote a more sustainable tourism model, and be more respectful of the environment. Deng et al. [24] suggest that DT technology facilitates the transformation of the current urban governance paradigm toward STDs. One of the main advantages of the virtual twin tool is that it enables the population to participate in new models of urban planning [13,25].

Notwithstanding, there are limited scientific publications about DT technology that jointly tackle the DT technology and STDs sphere [26]. Even though DT technologies hold great promise for progress, there are many obstacles in the way their transition from theory to practice, including the need to implement DTs in cities and companies, the need for standardised procedures, and the need for efficient methods for system integration and data management in STDs [27,28]. Despite these challenges, DTs transformative impact in urban development is undeniable, and public and private organisations should include this disruptive tool in their operational systems [29]. The idea of the use of DTs in tourism is not well crystallised as of yet [11,30], and it is necessary to enhance new STD models, governance, and communication between DMOs, tourists, and residents [17,31]. Risks and disasters at STDs are becoming ever more unpredictable, and digital tools help mitigate against the debilitating impacts associated with crises, cyberthreats, and disasters. The recent flooding in the city of Valencia (Spain) is a real example of how DT technology could help to save people's lives and predict flood levels in cities. DT technology helps to significantly reduce flood risks through government–citizen collaboration in cities [32,33], as well as to prevent the loss of life and property as a result of catastrophic climatic events in coastal areas [34].

A STD's capacity to respond to a crisis is a litmus test of its resilience. From the point of view of operational and technical management, the implementation of DT technology in STDs is currently used in cybersecurity [35], environmental sustainability [36], recycling [37], urban planning [38], transportation [39], logistics [40], reducing CO2 emissions [41], traffic control [42], climate change mitigation [34], flooding management [32,33], and water and electricity management [43,44]. Thus, DT technology can provide efficient and innovative solutions to address these future challenges and problems in STDs. Diverse sectors' use of DTs offers a variety of perspectives. Since the notion of DTs is focused on different areas in different disciplines, it needs greater clarification in a theoretical context [45], particularly in the tourism industry. Developing a research agenda for digital twin cities will increase knowledge STD's operations, procedures, and upcoming developments [46].

Moreover, Barriceli et al. [7] found that more than half of the papers on the topic of DTs did not define the DT concept, and that most of them were focused on the lifecycles of products and saving costs [47], but not in a tourism and STD context. Accordingly, there still is a paucity of knowledge on the use of DTs to address STDs' future challenges and their implementation in the operational processes and systems of STDs [36]. With this backdrop, this research aims to conceptualise DT tourism to address smart tourist destinations' future challenges to enhance tourists' experiences and residents' quality of life through the development of better services using DTs. Therefore, this manuscript defines DTs and provides a new viewpoint of this technology that will help to initiate academic discussions on DT tourism within the context of STDs. The application of DTs helps STDs attain their commercial and sustainability goals because the use of a virtual scenario provides greater efficiency to production processes, and this digital synergy saves costs and reduces the time to market of products [48]. For instance, Faliagka et al. [49] note that the integration of DTs with STDs' public transport systems helps to build a more intelligent, effective, and robust urban mobility environment.

2. Research Methodology in Order to Enhance the Concept of the Digital Twin

This research adopted a systematic review approach to analyse and illustrate the existing literature on the topic of DT technology and its use in STDs [29], which will help us to develop the DT concept in a STD context. By examining how DTs can create social, environmental, and economic value and well-being within a visited area, this methodology aids in visualising a new scenario for the use of DTs in the travel and tourism industries. It also aims to enhance the travel experience of tourists by promoting sustainable behaviours through DT technologies [50]. Initially, this systematic review considerably helped us to provide different points of view of DTs definitions in this study, and, according to this theoretical perspective, we were able to develop a new DT concept to boost this topic in the travel and tourism literature.

To provide and analyse the most recent information on the topic of DTs, this study focused mainly on studies carried out between 2020 and September 30, 2024, because DT technology has only begun to be applied recently by STDs [36] and companies in the travel and tourism industries [11]. The Web of Science (WoS) database was used to collect the most relevant information related to digital twin and smart tourist destinations in this study. WoS is considered to be one of the three most important databases by researchers who examine tourism and technology activities [29,36,46,51]. The research criteria were based on the following string: "digital twin AND smart tourist destinations" or "digital twin AND smart cities". These were used to search against the title, abstract, and keywords of documents to produce initial insights, only in the English language. Peer-reviewed journal papers, book chapters, and conference proceedings that offered perspectives on the difficulties associated with the difficulties, applications, and theoretical developments regarding the use of DTs in STDs. Hence, the related documents were reduced to 297 documents. China, with 77 documents, is the first country by number of documents published in the period established, followed by the USA (39), England (34), Italy (29), South Korea (25), Australia (18), Spain and India with 15 documents, and France and Germany with 14 documents, respectively.

Furthermore, the three universities that published the most documents in this topic were the University of Cambridge (UK) and the Uppsala University (Sweden) with 10 documents, respectively, and the Egyptian Knowledge Bank Ekb (Egypt) with 7 documents.

This manuscript also presents recent examples of the usage of DTs in STDs and by travel and tourism companies to further illustrate DT technology's potential for use in business operations and predictive analytics in order to enhance tourists' experiences and residents' quality of life. El Archi et al. [51] note that digital technology adoption in sustainable tourist destinations is a complicated and multidimensional issue that calls for cooperation from a range of stakeholders, including local communities, politicians, tourism operators, and technology providers, to boost tourism experiences.

3. Digital Twin: Definitions and Characteristics

From a practical perspective, the idea of a DT was born at NASA in the 1960s through the creation of a living model of the Apollo mission to assess possible risks, make appropriate decisions, and prevent a catastrophic situation [52]. Although DT software is a term created by Michael Grieves in 2002 to examine the life cycle of product management, today, DT technology is being implemented in the development of cloud and telecommunication technologies, and investments in the IoT spearhead the building of platforms that are increasingly sophisticated and interoperable [53]. DT technology is defined by Rantala et al. [54] as a multi-sided platform that can support companies and STD ecosystem activities. DT is a software that can be used to predict system responses before they occur, making it an attractive option for sustainable tourism and STDs [22]. Nevertheless, from an energy and sustainability point of view, Mylonas et al. [15] argue that a DT is a virtual tool that helps to improve STDs' urban planning, mobility, energy usage, and sustainability.

There is no clear and theoretical definition of the DT concept in tourism or in a STD context by researchers and academics, as we can see in Table 1. This table shows different definitions of DT by researchers from different perspectives. One of the main advantages of DT technology is that it allows complex operations within a virtual screen in real time without companies and users being physically present. It is important to highlight that DT technology is not a standalone technology; this digital tool requires a high interoperability and ubiquitous connection between DMOs, governments, tourism and transport companies, experts in cybersecurity, residents, and tourists. Conversely, one of the main disadvantages of creating a DT is the design effort (e.g., the integration of historical data and preventive maintenance), because this needs to be tailored for companies and its high costs need to be integrated into companies' operational systems [55,56].

The use digital technology in STDs provides relevant information for residents and tourists, such as the weather, traffic conditions in real time, special offers and discounts on hotels and tourist attractions, bus routes, bus stop locations, recommended places to visit, or even places not to visit some places for security reasons. According to the theoretical perspective adopted in this study, a DT tool is defined as a virtual representation of a real-world city, company, or process that is used to improve governance, tourism experiences, performance, productivity, sustainability, efficiency, and effectiveness activities by STDs, governments, and companies. Indeed, this iterative tool helps to reduce costs for organisations and provide new business opportunities. A conceptual model of a DT is shown in Figure 1 to illustrate their usefulness per se and potential interactions with STDs, companies, tourists, and residents, in order for readers to better understand disruptive tool. For instance, AI-enhanced digital twin models can simulate and visualise data, helping STDs and organisations better understand the effects and operation of their systems to develop segmented and personalised marketing strategies [2]. Notwithstanding their advantages, the size, diversity, and complexity of cities provide difficulties for DTs and their economic and social implications.

Table 1. Digital twin definitions.

Authors	Different Points of View of Digital Twin's Definitions	Perspectives
Glaessgen and Starge [57]	The DT tool is an integrated multi-physics, multi-scale, probabilistic simulation of a product or system that uses the best available physical models and sensor updates, among others, to mirror the life of its real twin.	A probabilistic simulation tool.
Opoku et al. [45]; Schmitt and Copps [58]	By using predictive analytics, the DT tool can boost productivity and reduce the many issues that organisations face in terms of cost and time.	Software that provides real-time response and improves organisations productivity.
Reim et al. [59]	One kind of digital platform that allows multiple actors to communicate data in order to mimic a physical object is called DTs.	Enhance a product and services through a digital platform.
Bibri et al. [26]; Mazzetto [27]; Peldon et al. [29]	DT is a tool to help enhance the planning of smart city infrastructures thanks to a continuous flow of data between the virtual and physical worlds.	To improve urban planning in smart cities.
Weil et al. [36]	DT is a cutting-edge tool that helps to change the way smart cities' physical systems are developed and managed to enhance their environmental performance.	To enhance environment in the cities.
Park et al. [32]; Roudbari et al. [33]	DT is a digital tool that aids in anticipating changes in the cities' environment and investigating the best course of action (new designs, technologies, or policies) beforehand.	A virtual tool to enhance the STD's performance.
Faliagka et al. [49]	By offering real-time parking availability information, analysing the environmental behaviour of traffic accidents, and enabling effective emergency management, DTs are a crucial piece of technology that will enhance urban mobility in smart cities.	Enhance mobility in the smart cities.
Shahat et al. [46]	Creating a mirrored digital duplicate of a physical system and connecting its data across the course of its life cycle is known as the DT concept.	A digital tool that enhances the city's functions and processes to enhance its realization, operability, and management.
Adamenko et al. [55]	A digital representation of a real-world physical thing is called a "digital twin." This precise replica enhances product design by including all of the attributes, details, and states of the original item.	Enhance the design of products, as well as increase efficiency and reduce costs.
Tao et al. [60]	DT is an effective method for real-time interaction and further convergence between physical space and information space.	Effective information tool.
Armstrong [61]	DT is the virtual representation of a physical place or system across its life cycle.	The city's life cycle.
Zhu et al. [16]	The DT tool displays in real-time the collected data to simultaneously update and modify with its physical counterpart.	A technological tool that monitors and modifies data and information.
Dembski et al. [25]	DT is software that helps to improve the governance in the cities and residents' quality of life.	To improve the governance in the cities and residents' quality of life.

Table 1. *Cont.*

Authors	Different Points of View of Digital Twin's Definitions	Perspectives
Ford and Wolf [12]	The DT tool is a system of ICT sensors that develop data sets integrated into digital twin models that provide a dynamic ability to assess the future impacts of current conditions and strategies in ways that improve decision-making to achieve desired future results.	Help managers make better decisions against future disasters.
Allam and Jones [31]	DT is a virtual representation of the physical and biological worlds through AI, crowd computing, big data, and other communication technologies that help to modify possible errors.	Modify possible errors.
White et al. [13]; Rantala et al. [54]	DT is a digital representation of a physical place, with the aim of improving urban planning.	To improve urban planning.
Deng et al. [24]	DT tools aim to improve the efficiency and sustainability of logistics, energy consumption, communications, urban planning, disaster, building construction, and transportation.	To improve the efficiency and sustainability of STD.
El Marai et al. [62]	DT is a virtual tool that mimics a city in most of its aspects to monitor, analyse, test, and optimise its performance in a digital scenario.	A virtual tool to optimise the STD's performance.
Cureton and Dunn [8]	DT refers to digital replicas of existing and proposed assets to improve management, virtualise testing and maintenance, and maximise efficiency gains.	To enhance the management and efficiency.
Mylonas et al. [15]	DT is a virtual tool that helps to improve urban planning, mobility, energy, and the sustainability of STDs.	A virtual tool to enhance STDs.
Yang and Kim [63]	DT is an application that improves STDs' urban planning.	To improve urban planning.
Piromalis and Kantaros [64]; Ivanov [65]	DT is a digital model that provides an artificial or physical system where sensors are placed to acquire a variety of data regarding different aspects concerning the performance of the system.	Acquire data and information to improve the performance of the system.
Li et al. [17]	DT is software that provides real-time response to the diversified needs of residents, tourists, and organisations.	Software that provides real-time response.
Huang et al. [44]	DT application is a holographic mapping from physical entity to virtual object that analyses the simulation result data, improves the rationality of product production plans, helps promote the further development of the manufacturing industry, and promotes acountry's development towards intelligent.	Promote data and information interoperability.
Kor et al. [14]	DT is a tool that combines real-time and historical data from physics-based models, physical systems, and advanced analytics to produce digital equivalents with high integrity, awareness, and adaptability, allowing planning and construction entities to receive predictive service.	A forecasting tool.
Litavniece et al. [11]	The DT tool is a digital system that mirrors a real object, and its behaviour provides monitoring and decision-making abilities for digital twin users.	A tool that monitors and decision-making abilities by itself.
Ravid and Aharon-Gutman [66]	DT is a conceptual framework for incorporating social aspects into the decision-making process.	To enhance social aspects into the decision-making process.
Rahmadian et al. [22]	DT is software that can predict system responses before they occur, making it an attractive option for sustainable tourism and STD.	Software for predicting future threats.

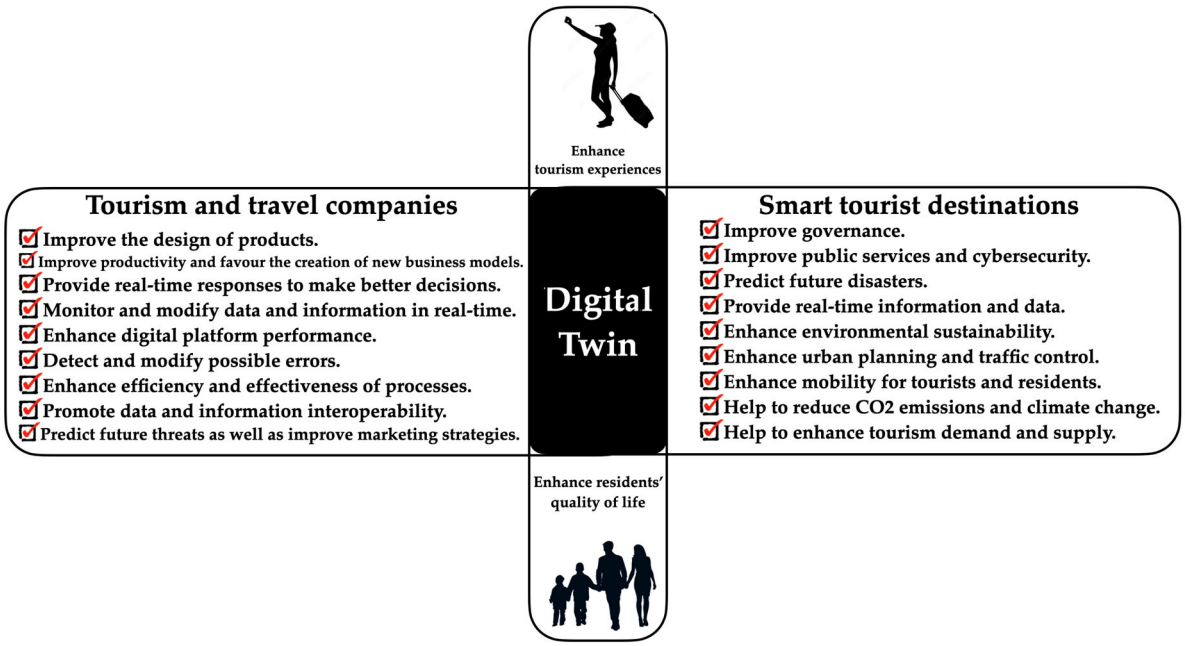

Figure 1. The DT conceptual model. Source: own elaboration.

Predictive maintenance and the performance monitoring of companies and STDs are among the leading use cases for DT technology. For instance, STDs are using DTs as a virtual platform to develop new urban planning, improve quality data governance, develop new marketing strategies focused on tourists' needs, and develop digital business ecosystems, as well as in sharing costs, risks, responsibilities, resources, and skills to improve residents' quality of life and tourists' experiences at tourist destinations.

On the contrary, Yang and Kim [63] found that the effectiveness of DT technology in cities limits residents' participation for the benefit of private companies; in fact, citizens see urban digital twin technology as a platform where private companies sell their products and services. As stated by Ravid and Aharon-Gutman [66], DT technology requires a greater technological and methodological development to improve tourists' experiences and residents' quality of life at STDs. For instance, the STD of Dubai implemented DT technology in public services and transportation, making urban life easier and more dependable for all residents and travellers with the help of precise knowledge and predictive analysis. In the field of STD studies, virtual replicas of STDs have been implemented by DMOs to resolve problems such as environmental pollution and cybersecurity, improve urban planning and transport systems, manage tourist flows, and, very importantly, provide efficient measurements of water resources, all in real time. Such a tool needs multiple networks connected with multiple actors to monitor tourism activities at STDs. Zhu et al. [16] note that the three main characteristics of DT technology are:

1. Real-time analysis: physical and digital data and information are displayed on a virtual screen, which allows STD managers to obtain detailed information on potential incidents through sensors or on new opportunities to improve security, tourism, and transport activities. For example, DTs play a key role in overseeing transport, energy, and utility infrastructure in the Msheireb Downtown Doha (Qatar).
2. Interaction and convergence: physical and digital scenarios interact and converge with real-time data and historical data, enhancing the efficiency, effectiveness, and reliability, of data, as well as its analysis by STD managers. The city of Barcelona in Spain has developed a project named "vCity", based on a DT platform, to provide policymakers with the best ideas, initiatives, urban planning, and services before implementing them in the city, supported by AI technology, data management, and previous simulations.

3. Self-evolution system: a virtual twin tool collects and updates data and information in real time. This tool's physical and digital synergy is continually exploited by DT technology to self-improve and register operating, environment, and transport data, which allows DT software to predict with great certainty what issues might be and where they could occur in its physical counterpart. For instance, in 2024, the Qatari city of Lusail integrated and optimised its urban systems by implementing a DT platform. This central hub integrates data from sensors and IoT devices to provide the real-time monitoring and optimisation of buildings, utilities, and transportation.

Figure 2 shows these three characteristics of DT and how this virtual tool helps DMOs and managers to make better decisions based on data to improve STDs' management and efficiency. For instance, as more and more data are moving from secure on-premises data centres to public and private clouds, the topic of cybersecurity has come to the forefront. Hardware and software security are playing an important role as companies and STDs enter the cloud domain. There are no 100% safe spaces; the risk of a cyberattack is always latent [67].

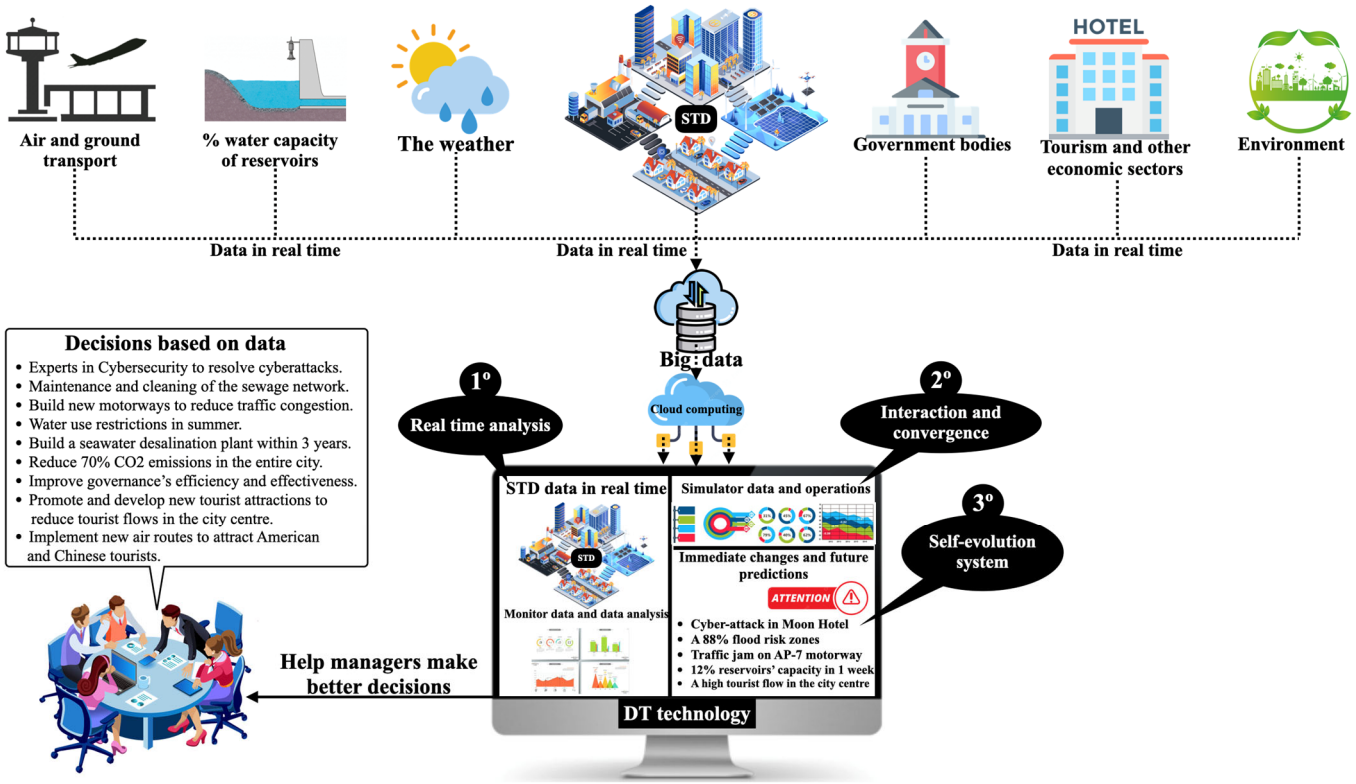

Figure 2. The DT three main characteristics in urban cities, and how this tool helps managers make better decisions based on data. Source: own elaboration from [11,12,14–17,22,24,25,27–29,31–35,44,49,55,59–64,67,68].

With cybercriminals and hackers targeting confidential enterprise data, e-commerce platforms, and governments, end-to-end security business-to-business (B2B) and business-to-consumer (B2C) methods are being examined and monitored with never-before-seen scrutiny and attention. Meanwhile, DT technology can help to optimise the water consumption in tourist destinations such as the Andalusia and Catalonia regions in Spain, as these two regions suffered water use restrictions in 2023. Pérez et al. [68] revealed that the tourism sector increased the water consumption in Spain due to the rising tourism demand. In addition, DT software is also used by STDs to simulate emergency response scenarios, such as to natural disasters and cyberattacks. This software can help STDs to be better prepared for emergencies and respond more effectively when they occur [69].

Other characteristics of DT technology should be emphasized are its capacity improve the management and sustainability of the tourism and hospitality industries of STDs [15]. Moreover, the combination of DT tools with AR, VR, AI, the metaverse, cybersecurity, robotics, and IoT technologies improves visitors' and tourists' experiences in cities, museums, and theme parks, respectively [16,70–72]. The DT technology also offers new opportunities to promote cities' products and services in digital and physical scenarios, because this tool interacts with cities' tourist attraction data and tourists' specific needs, better matching the supply and demand of the destination [11]. Personalised suggestions and recommendations by robots, DTs, and AI platforms improve tourism experiences [2,73]. For instance, the digital interoperability between DMOs and travel and tourism companies allowed by DTs considerably enhances supply of destinations in terms of B2C and B2B [74].

Digital technologies boost the competitiveness and accessibility of STDs and their travel and tourism firms [75]. Access to accessible tourism activities for all at STDs means that DMOs must provide and communicate their products and services through digital and physical channels to residents and tourists, including people with disabilities [21,76]. Azis et al. [77] note that the relationship between technology and tourism activities will help DMOs and tourism organisations understand the competitive advantages of digital technology in tourism practices and incorporate it into strategic means of efficient development and communication [78].

4. How the Digital Twin Tool Relates with Other Technologies and Its Potential in Tourism and Sustainable STD Development

STDs based on DT technologies have broad prospects for economic transformation, urban smart management, and public smart services, allowing residents, tourists, and cities to be better coordinated. DT technology collects data and information from big data and cloud computing platforms to perform various what-if analyses related to geolocation, traffic, environmental sustainability, air quality, noise pollution, tourist flows, or future tourism demand at STDs [30]. In order to anticipate the unique demands of travellers, make it easier to create bespoke itineraries, and provide targeted promotions and marketing campaigns, the STD of Málaga in Spain incorporated DT technology into its marketing plans. This raised the degree of happiness and customisation of the traveller experience in this city. DT technology plays an active and effective role in sharing information between tourists and providing customised information in real time [79]. For instance, the company Marriott International provides virtual tours of Beijing, the Andes, and Rwanda to allow travellers to experience these areas [80].

To cite another example, the city of Cambridge (United Kingdom) implemented DT technology in its system of operations, and this digital tool contributed to improving evidence-informed decision-making by DMO managers [81]. The smart city operation brain (SCOB) management structure is modelled after the concept of a digital twin city, and its functions are: (1) monitor the city's operations coordination; (2) oversee the city's information resource integration and sharing; and (3) develop an open, big-data-based ecosystem of socially focused products and services [82]. To promote better understanding of DT technology in tourism and STD contexts, this research presents a DT tourism scenario and its strong relationship with different actors and activities, which allows it to be more efficient in terms of governance, performance, productivity, effectiveness, and sustainability, as we can see in Figure 3.

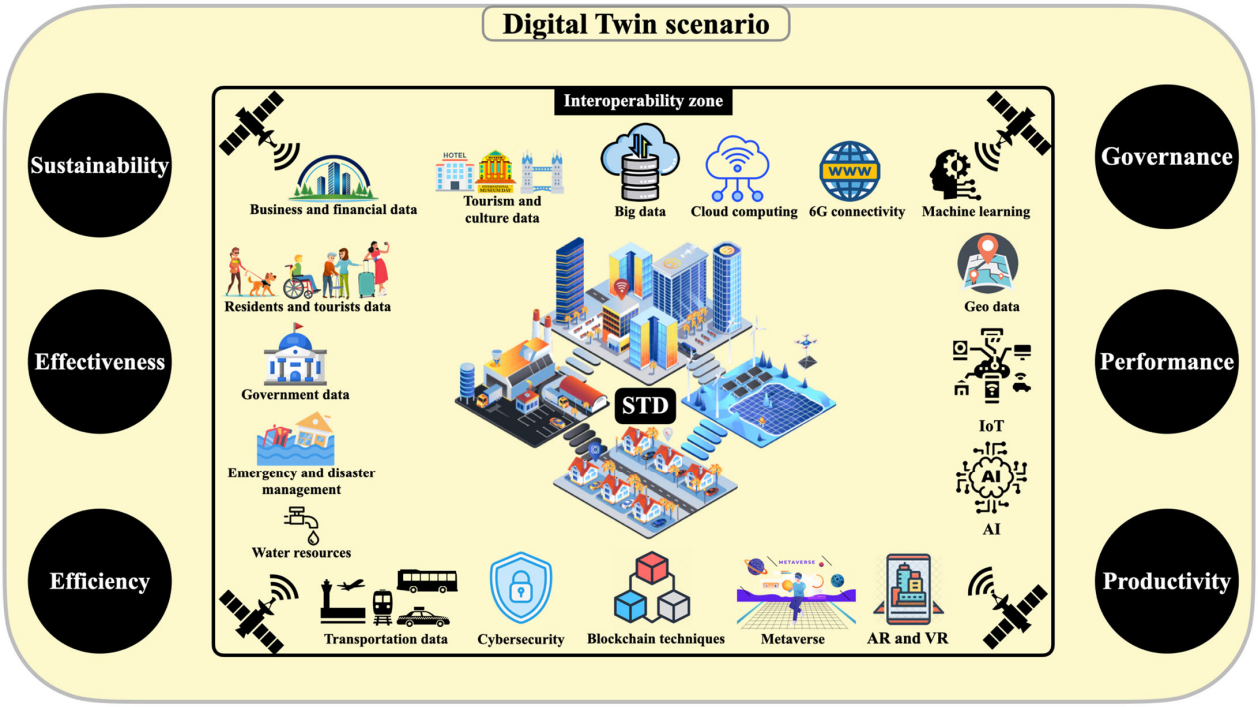

Figure 3. DT tourism scenario in a smart tourist destination. Source: own elaboration from [11,12,14–17,22,24,25,27–29,31–35,44,49,55,59–64,66–69,71–73,75–83].

Moreover, DT technology has the versatility to be combined with other technologies, such as big data, cybersecurity, AI, the metaverse, IoT, blockchain, and geolocation, amongst many others, to provide results and suggestions for managers. Attaran and Celik [83] note that the integration of DT technology with AI and cloud computing will increase consumers' immersive experience levels in the e-commerce sector.

For instance, 6G connectivity will help STDs develop new urban DT models, immersive XR, and mobile holographics [31]. As well, blockchain is an effective tool to share real-time data reliably in e-governance [84]. Kontogianni and Alepis [85] claim that real-time information and services provided by DMOs and tourism companies offer the potential for dynamic engagement with connected consumers in STDs. When a STD wants to monitor tourism, transport, and economic indicators, this needs to include big data and cloud computing storage media to structure data and guarantee private residents' and tourists' information and companies' data against possible cyberattacks.

The fusion of data, information, interoperability, and technology is the keystone of DT technology. In this same line, El Marai et al. [62] suggest that DTs are new emerging technologies that improve efficiency, safety, sustainability, environmental protection, productivity, energy consumption, and management activities in STDs. As stated by Xiang et al. [10], the purpose of a STD is to effectively support and integrate tourism resources in a territory and to improve tourists' experiences as a result. Thus, we recommend that DMOs, organisations, and participants (stakeholders) in the management of STDs develop an interoperable system that may envisage improvements to the existing inventory of products and services; these can be monitored by DMOs. In other words, the design of a touristic supply portfolio must be a city's roadmap to improve tourists' experiences. DMOs need to know why they want to boost the tourism industry in their cities and what global tourism vision they want to cultivate [86]. A DT can be made of an airport, hotel, or cruise ship to replicate a view of operational processes, monitor various assets or key performance indicators (KPIs), and process metrics in the travel and hospitality industry, helping to enhance visitors' experiences and encourage their satisfaction in the city; in fact, Amazon uses this commercial strategy to boost yields and brand loyalty [87].

New technological innovations empower tourism experiences and increasingly allow tourists to co-create value throughout all stages of travel [88]. To minimise the response time to and resolution of incidents by companies will be paramount to satisfying residents' and tourists' experiences in STDs, particularly through communication and information digital channels [89], because, for hotel, restaurant, theme park, commercial airlines, and OTA sectors, time is money. The use of cybersecurity, AR, VR, AI, and IoT technologies facilitates daily activities for residents and tourists and enriches the ecosystem and way of life of STDs [90]. A study carried out by Go and Kang [91] found that the metaverse contains ecosystems formed with user-generated content, economics, and AI activities, encouraging commercial activities by e-commerce tourism companies. Regardless, the implementation of DT technology must be developed with consideration for data privacy and security.

Cybersecurity refers to the security of data and information, particularly of digital users of hotel services, the metaverse, commercial airlines, and online travel agencies (OTAs), which sometimes converge in the use of DT technology. The tourism industry is one of the most vulnerable sectors when it comes to cyberterrorism [92]. Governance in STDs involves the gathering, processing, and sharing of intelligence data, which allows STDs to increase their resilience against terrorism, cyberattacks, and cyberthreats [93,94]. The sustainability of STDs is highly dependent on the implementation of cybersecurity protocols as a preventive tool to ensure the security of B2C and B2B electronic transactions [95]. Indeed, when STDs implement security measures in their operations, DT software needs to be used to aid with ecological, environmental protection, and urban services, with the aim of enhancing the sustainability of the environments in cities through a 3D virtual model [96].

Seventy-five percent of the resources and energy consumption used worldwide are from cities [97]. Therefore, DT technology offers substantial benefits in terms of the efficient use of energy and water, cost savings, and equipment uptime compared with those STDs and companies that do not integrate technology in their operational systems. Thus, STDs, governments, and companies will understand the value of data in their management and what it means for them to address future challenges and strategic choices in the areas of tourism and social policies. With nearly 6 million inhabitants and one of the highest population densities in the world, the city of Singapore is a benchmark in the integration of DTs to improve its governance management and urban planning. Please see this link (https://mindearth.ai/2023/05/18/udt_shaping_the_future_of_smart_sustainable_cities/) (accessed on 2 December 2024) [98] as a real example of DT technology implementation in Singapore.

5. The Management of Tourists' Experiences at STDs Through Digital Twin Tool

DT technology is a nascent tool in the tourism and marketing industries, but its versatility in relation to its capacity to analyse data and predict the behaviour of tourism and business ecosystems to address relevant issues at STDs gives it a key role in the tourism industry. This iterative tool confers the ability to develop new alternatives to existing marketing strategies to promote social and environmental initiatives, the use of customised products and services, and the branding of tourist destinations through the creation of virtual scenarios in which consumers, cities, and companies obtain economic and social benefits. We cannot forget that the multidisciplinary nature of the tourism industry requires continuous access to information by STDs and companies in order to communicate specific information related to their products and services to consumers.

For example, Amazon, Microsoft, Siemens, and General Electric included DT software in their operational systems to develop different organic and inorganic growth strategies, such as product launches, product developments, design marketing strategies focused on consumers' needs, new partnerships, marketing collaborations with different partners to save costs, and increasing cybersecurity, in order to strengthen their offerings in the market [47,99]. Immersive tourism experiences for tourists through the use of VR and AR technologies, monitored by DT tools, are considered a crucial part of the improve-

ment of tourists' experiences by STDs [62]. For example, transportation enabled by DT technology uses machine learning algorithms and real-time sensor data to optimise travel experiences [100]. Zhao et al. [101] suggest that by combining text, images, audio, and multimedia technologies, DT technology can create online virtual reality museums and digital museums that break the limitations of traditional museums. This is truly impossible in a physical museum. In 2030, virtual space experiences will play a role in the intention of tourists to visit physical destinations through the metaverse and DT scenarios [102].

Another benefit of DT technology is how it can help tourists find interactive hotspots and information about the most relevant tourist attractions in cities, or even provide a virtual tour of the most famous sites of a city [103]. The smart city of Gothenburg included DT technology in its management system, and thanks to this digital tool, various urban development projects can be visualised by city managers to simulate and predict future events such as climate change [104].

Hence, for smart innovation like DT technology to succeed in the next generation of STDs, DT technology should become an integral part of the marketing and tourism promotion strategies of STD ecosystems, so that they can interact actively with residents, tourists, and companies. Apparently, STDs are not developing creative marketing campaigns and branding strategies focused on residents' needs and tourists' experiences to promote their strengths and create opportunities to attract international investors and internationalise their brand image across the world [105]. Using DTs for prediction, many AI algorithms are used to design marketing strategies and customised products to increase sales for physical and e-commerce companies; in fact, Alibaba, Amazon, Zepeto, Puma, and Zara use DT technologies to increase their sales and leverage the metaverse as an easily accessed secondary market [106,107]. Simulations of tourists' behaviour and preferences regarding travel routes, trip patterns, and hotel quality can help to improve the development of customised tourist packages [108].

As stated by Augustine [109], the information received from DT technology supports STD managers in making well-versed choices concerning the management of their city and its future tourism supply. The DT technology offers business value for companies and DMOs because it can reduce the time to market for a new product or service, predict and detect quality defects, and improve the punctuality of maintenance services [60]. For instance, DMOs can continuously plan and monitor transportation issues at a destination through DT technologies to reduce CO2 emissions [110], as well as to help tourists optimise their time better during their holidays. According to the ABI Research company [111], cities that implement DT technologies will save an average of $280 billion by 2030. DTs can help a city realise savings across multiple domains, from transportation and safety to infrastructure and energy. However, urban digital twins also offer many other advantages in terms of supporting and improving sustainability, circularity, decarbonisation, tourists' experiences, and the overall quality of urban living. The city of Seattle recently launched its DT platform, which serves as an interactive virtual tour of the city. The DT platform combines cutting-edge technology like VR, AR, and 3D mapping to provide residents and tourists with an immersive experience of the city [112].

6. The Challenges Facing the Adoption of DTs in STDs

The adoption of DT technology, which will present new chances to guaranteeing competitiveness in the tourism sector, will be essential to the development of STDs in the future. This research defines and stages value co-creation through DT technology and the potential opportunities and benefits that are emerging because of it. The real-time analysis and optimisation provided by DT software through data exchange between real and virtual scenarios is advantageous for the tourism and marketing sectors [109]. Indeed STDs and companies that successfully incorporate new technologies into their innovation strategies, such as those regarding business growth, e-commerce, big data, payment methods, security, and connectivity, will obtain new opportunities and competitive advantages against their main competitors [113]. Present and future challenges at tourist destinations like those

relating to flexible and good governance, biodiversity, climate change, CO_2 zero-emissions (known as "decarbonisation"), global tourism plastics initiatives, hotel energy solutions, sustainable consumption (e.g., water and energy) and production (e.g., food and plastic), and sustainable tourism policies have to be applied in all forms of tourism and all types of destinations to ensure the future of the planet's sustainability [114,115]. The adoption of DT technology by STDs enhances energy efficiency and promotes sustainability because this digital tool enables the real-time tracking and analysis of energy consumption by citizens and companies [116].

Even in the midst of this challenging environment, an essential part of our goal in this study is to help researchers and STDs implement new sustainable initiatives through DT technology to improve the sustainability of cities and the tourism industry. The inherent complexity of DT technology and the creation of sustainable cities through physical and virtual integration will provide numerous benefits for residents, tourists, and governments. Today, it is undeniable that transportation has a massive impact on social welfare, tourism experiences, urban sustainability, and STDs [117]. Nonetheless, intelligent transportation systems based on zero-emissions and new electric motor models are being developed, subsequently integrated, and, lastly, validated using DT applications [118]. According to the World Economic Forum (WEF), DT technologies provide a potential solution for governments across the globe to enhance city governance and create a beneficial urban ecosystem for companies and citizens; for example, 25% of new IoT business applications by 2024 will be bundled with DT capabilities, and it was found that 630 tonnes of CO_2 emissions per year can be reduced by the construction of a virtual power plant project that is monitored by a DT tool [119].

Farsi et al. [120] note that the main objective of the use of DT technology by STDs is to enhance the sustainability of destinations, improve the efficiency of systems to reduce CO_2 emissions by transport and logistics activities, reduce the consumption of water and energy in the tourism sector, improve healthcare, and predict future disasters like floods, hurricanes, cyclones, and earthquakes. For instance, DT technology can be an excellent tool to help cities and the air transport and tourism industries reduce their greenhouse gas emissions by 2030 and become climate-neutral by 2050, thus aligning with the European Climate Law and the Paris Agreement. Moreover, the increase in the use of IoT devices in STDs has increased the number of cyberattacks (e.g., malware, phishing, ransomware, amongst many others), which needs to be mitigated through DT technology to ensure data privacy and security [121]. In 2018, four cyberattacks on US natural gas pipelines took place [122], and the implementation of DT technology avoided a repeat of the above cyberattacks through the continuous monitoring of the implemented DTs to improve the detection of malicious threats and actors [123]. The cybersecurity in STDs cannot be ignored because it affects the efficiency and productivity of services provided by STDs and stakeholders. As stated by Florido-Benítez [124], new cyberthreats are emerging in the realm of digital technologies, especially in the tourism industry. Hackers have opportunities to exploit the vulnerabilities of AI, VR, AR, the IoT, blockchain, the metaverse, and DT technologies to launch cyberattacks [125]. However, DT and metaverse technologies focused on STDs, citizens, and good governance will be game changers within cities [126].

7. Conclusions

The nuclear objective of this study was to define DT tourism to address STDs' future challenges in improving tourist experiences and residents' quality of life through providing better services developed by DTs. Moreover, this research also tries to help researchers and STDs implement new sustainable initiatives through the use of DTs to boost the sustainability of cities and the tourism industry. The findings of this study reveal that DT technology is emerging as a disruptive technology tool to improve the management of STDs in terms of their efficiency, safety, sustainability, environmental protection, productivity, and energy consumption. From our point of view, one of the main advantages of DT technology is that it enables the population of a city to participate in new models of urban

planning. If the DT technology is characterised by something, it is its scalability and data prediction, which can be used to improve the management of companies, and can help managers and governments to make better decisions. These findings coincide with those of Wang et al. [127], who found that DT technology allows for the simulation of various city development plans, the early identification of potential operational issues, and the support of decision-making throughout the development of the STD. DTs can also assist in avoiding possible hazards. These findings all point to the great potential of DTs used in STDs. For instance, STDs could leverage DT technologies to make better choices regarding their healthcare infrastructure, deciding where to position hospitals, emergency services, and other resources. The use of DT platforms by STDs enables physical city components to be as modern and functional as they can be, for both residents and tourists.

Moreover, TD technology is also used by STDs to simulate emergency response scenarios, such as natural disasters and cyberattacks; thus, this virtual tool can help STDs develop contingency plans for future catastrophes or cyberthreats. STDs and other cites need to tackle issues such as decarbonisation, traffic management, mobility, climate change, water use, and electricity consumption. However, DT technologies can assist in optimal decision-making by STD managers and companies to tackle the real problems of society, as we mentioned previously. In 2016, the city of Helsinki in Finland implemented DT technology in its operations, management, and oversight systems, improving the governance, mobility, traffic, air quality, energy efficiency, water and electricity consumption, communication, lifecycles of districts, and management of urban development initiatives [128–130]. There is no doubt that the cities capable of leveraging this technology and harnessing its benefits will be the ones that prosper. Apart from technological success, they will become more environmentally, economically, and socially sustainable.

Another important outcome of this study was the finding that DT technology needs to be improved in its application in the marketing and promotion strategies of STDs because there are not studies and reports from public and private organisations that tackle the relationship between DT tourism and marketing and promotion activities. The DT technology should be an integral part of the marketing and tourism promotion strategies of STD ecosystems so that they to interact actively with residents, tourists, and companies. The adoption of DT technologies by cities and companies is changing customer experiences and transforming the operations, sales, and marketing strategies of enterprises. Gothenburg's digital twin (Sweden) provides new digital tourism experiences; this virtual tool shows the city of Gothenburg as an innovative hub, inspires people and companies to visit this smart city, and attracts foreign investment in the city. From a marketing perspective, the DT technology has empowered Gothenburg's brand image across the globe. See this link: (https://youtu.be/kZrgaNVTtkU) (accessed on 1 December 2024) [131].

Finally, we would like to point out that the idea of a STD cannot be conceived as an idyllic, dynamic, and standalone scenario where transferring new technologies improves residents' quality of life and tourists' experiences. STDs require high interoperability between DMOs, stakeholders, and residents and are supported by innovative technologies like DT technology to transform cities and resolve their problems linked to tourism activities, poverty, CO_2 emissions, air and ground accessibility, cybersecurity, pollution, poor environmental conditions, and universal accessibility for people with disabilities.

7.1. Theoretical Contributions

This study contributes to the literature on the adoption of DT technology in STDs, providing a better global vision of this topic for researchers, academics, and public and private organisations, particularly regarding the concept of DT technology. In addition, this manuscript also sheds light on how this iterative tool can enhance tourist experiences and residents' quality of life through the development of better services by DTs. From a theoretical perspective, the findings of the current study relate to how DT technology can be used to support decision-making by managers, can be used by engineering experts to monitor and correct future errors and disasters, and can encourage STDs' management

activities in the context of tourism and marketing activities. Indeed, this study contributes to a better understanding of the potential uses of DT technologies in the travel and tourism industries [132].

Furthermore, this research identified, in the literature review on the application of DTs in STD management, particularly, the difficulty of creating the design of DT platforms for STDs and companies, as a consequence of implementing historical data and preventive maintenance to provide efficient and effective results, as well as the fact that this disruptive technology requires customised processes for use by organisations and has a high cost associated with its integration in companies' operational systems. For instance, STDs' and hotels' operational energy, water requirements, and environmental efficiency are the main challenges that must be addressed by the tourism industry; thus, DT technology needs to monitor and analyse vast amounts of updated data and information to reach this important goal for 2030. The interoperability of updated data and information by public and private organisations, as well as previous models of efficiency and environmental sustainability created by DT technology, must be leveraged and promoted by companies and cities to boost citizens' consciousness of climate change. Even though DTs have enormous untapped potential in companies' operations, this technology has not yet been sufficiently developed and discussed in the travel and tourism sectors [133].

7.2. Managerial Contributions

In addition to its theoretical ramifications, this study's practical consequences make the findings useful from different points of view for STDs, travel and tourism companies, tourists, and residents. First, according to our results, STDs and DMOs should develop personalised services and accessible tourist itineraries and tours for people who are blind and people with reduced mobility through DT technology to enhance their tourism experiences in cities and at tourist attractions. In order to serve a growing number of users with a variety of needs and abilities, including the elderly, those with physical disabilities, and those who are blind, it is imperative that DT technology be used to lower accessibility barriers in metropolitan areas. This will help create a more inclusive society [134]. Second, travel and tourism companies have the possibility to design new promotion and marketing strategies through the use of DTs supported by the metaverse, VR, and AR technologies to attract new clients and stimulate tourism demand in cities. The implementation of digital replicas of travel and tourism companies' products and services on their websites and apps can increase the sales and revenues of companies and STDs [135], as well as help travellers to plan their holidays ahead of time and visit their favourite tourist attractions.

Third and last, from a resident point of view, this study' results show that residents' quality of life can be enhanced by DT approaches, which offer a virtual representation of the urban environment and enable the real-time monitoring, modelling, and analysis of public services and urban systems. For instance, the recent flooding in the Spanish cities of Valencia and Málaga has caused the loss of life (220 people) and damage to property, infrastructure, and crops. National and regional governments can visualise, analyse, and forecast how urban systems will react at the neighbourhood level by simulating future disasters based on various scenarios and hazard levels using an interactive geo-data-frame within the DT methodology. This method improves urban functionality, resilience, and the ability to save lives before future calamities by exposing antecedents and predicting patterns, trends, and correlations at the physical level of each city region [136].

7.3. Limitations and Future Research

One of the limitations of this study was that the search for literature on the DT technology has only been conducted using the databases WoS, Scopus, and Google Scholar. Therefore, future research on the DT topic and its direct relation to STDs should include other databases to provide new documents and different perspectives on this subject. Another limitation of this research is that DT technology is not a standardised digital tool that can be used the same way for all cities and companies. The development of DTs for

a STD or company involves identifying the organisation's specific processes and users' preferences and needs to provide the best results and decisions for managers, or, in the case of the company, offer the best products and services according to consumers' backgrounds. Thus, we must be aware that the implementations of DT technology in a STD and its economic and social results can be totally different in an urban city than a in a sun and beach tourist destination. Consequently, in future research on DT technology and its integration in smart cities, more studies should be carried out to solve these constraints, depending mainly on the type of city and its economic, social, and infrastructure characteristics.

To finish this section, the results suggest that DT technology must be a crucial component of marketing and tourism promotion plans for STD ecosystems in order for them to engage with locals, visitors, and businesses. For this reason, we encourage the development of future studies in this line of research to examine the interaction between the DT virtual tool and marketing strategies and promotion campaigns to stimulate tourism demand and improve STDs' tourism supply.

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References

1. Florido-Benítez, L. Constructing Spanish smart destinations: A new guide for the tourism industry. *Int. J. Tour. Cities* **2024**, *10*, 261–279. [CrossRef]
2. Florido-Benítez, L.; del Alcázar Martínez, B. How Artificial Intelligence (AI) Is Powering New Tourism Marketing and the Future Agenda for Smart Tourist Destinations. *Electronics* **2024**, *13*, 4151. [CrossRef]
3. Wei, W.; Önder, I.; Uysal, M. Smart tourism destination (STD): Developing and validating an impact scale using residents' overall life satisfaction. *Curr. Issu. Tour.* **2024**, *27*, 2849–2872. [CrossRef]
4. Xu, J.; Shi, P.H.; Chen, X. Exploring digital innovation in smart tourism destinations: Insights from 31 premier tourist cities in digital China. *Tour. Rev.* **2024**, in press. [CrossRef]
5. Turcanu, I.; Castignani, G.; Faye, S. On the Integration of Digital Twin Networks into City Digital Twins: Benefits and Challenges. In Proceedings of the IEEE Consumer Communications & Networking Conference (CCNC 2024), Las Vegas, NV, USA, 6–9 January 2024; pp. 752–758.
6. Shirowzhan, S.; Tan, W.; Sepasgozar, S.M.E. Digital Twin and CyberGIS for Improving Connectivity and Measuring the Impact of Infrastructure Construction Planning in Smart Cities. *SPRS Int. J. Geo-Inf.* **2020**, *9*, 240. [CrossRef]
7. Barricelli, B.R.; Casiraghi, E.; Fogli, D. A survey on digital twin: Definitions, characteristics, applications, and design implications. *IEEE Access* **2019**, *7*, 167653–167671. [CrossRef]
8. Cureton, P.; Dunn, N. Digital twins of cities and evasive futures. In *Shaping Smart for Better Cities*; Elsevier: London, UK, 2021; pp. 267–282. [CrossRef]
9. Buhalis, D.; Leung, D.; Lin, M. Metaverse as a disruptive technology revolutionising tourism management and marketing. *Tour. Manag.* **2023**, *97*, 104724. [CrossRef]
10. Xiang, Z.; Stienmetz, J.; Fesenmaier, D.R. Smart Tourism Design: Launching the annals of tourism research curated collection on designing tourism places. *Ann. Tour. Res.* **2021**, *86*, 103154. [CrossRef]
11. Litavniece, L.; Kodors, S.; Adamoniene, R.; Kijasko, J. Digital twin: An approac.h to enhancing tourism competitiveness. *Worldw. Hosp. Tour. Themes* **2023**, *15*, 538–548. [CrossRef]
12. Ford, D.N.; Wolf, C.M. Smart cities with digital twin systems for disaster management. *J. Manag. Eng.* **2020**, *36*, 04020027. [CrossRef]
13. White, G.; Zink, A.; Codecá, L.; Clarke, S. A digital twin smart city for citizen feedback. *Cities* **2021**, *110*, 103064. [CrossRef]
14. Kor, M.; Yitmen, I.; Alizadehsalehi, S. An investigation for integration of deep learning and digital twins towards Construction 4.0. *Smart Sustain. Built Environ.* **2023**, *12*, 461–487. [CrossRef]
15. Mylonas, G.; Kalogeras, A.; Kalogeras, G.; Anagnostopoulos, C.; Alexakos, C.; Muñoz, L. Digital twins from smart manufacturing to smart cities: A survey. *IEEE Access* **2021**, *9*, 143222–143249. [CrossRef]

16. Zhu, Z.; Liu, C.; Xu, X. Visualisation of the Digital Twin data in manufacturing by using Augmented Reality. *Procedia CIRP* **2019**, *81*, 898–903. [CrossRef]
17. Li, X.; Liu, H.; Wang, W.; Zheng, Y.; Lv, H.; Lv, Z. Big data analysis of the internet of things in the digital twins of smart city based on deep learning. *Future Gener. Comput. Syst.* **2022**, *128*, 167–177. [CrossRef]
18. Deren, L.; Wenbo, Y.; Henfeng, S. Smart city based on digital twins. *Comput. Urban Sci.* **2021**, *1*, 4. [CrossRef]
19. Buhalis, D.; O'Connor, P.; Leung, R. Smart hospitality: From smart cities and smart tourism towards agile business ecosystems in networked destinations. *Int. J. Contemp. Hosp. Manag.* **2023**, *35*, 369–393. [CrossRef]
20. Florido-Benítez, L. The accessibility of beaches for blind people and their guide dogs: Accessible tourism and inclusion in Spain. *Tour. Rev.* **2024**, *79*, 719–738. [CrossRef]
21. Florido-Benítez, L. International mobile marketing: A satisfactory concept for companies and users in times of pandemic. *Benchmarking Int. J.* **2022**, *29*, 1826–1856. [CrossRef]
22. Rahmadian, E.; Feitosa, D.; Virantina, Y. Digital twins, big data governance, and sustainable tourism. *Ethics Inf. Technol.* **2023**, *25*, 1–22. [CrossRef]
23. Tyagi, A.K. *Digital Twin and Blockchain for Smart Cities*; John Wiley & Sons, Inc: Hoboken, NJ, USA, 2024.
24. Deng, T.; Zhang, K.; Shen, Z.J.M. A systematic review of a digital twin city: A new pattern of urban governance toward smart cities. *J. Manag. Sci. Eng.* **2021**, *6*, 125–134. [CrossRef]
25. Dembski, F.; Wössner, U.; Letzgus, M.; Ruddat, M.; Yamu, C. Urban digital twins for smart cities and citizens: The case study of Herrenberg, Germany. *Sustainability* **2020**, *12*, 2307. [CrossRef]
26. Bibri, S.E.; Huang, J.; Jagatheesaperumal, S.K.; Krogstie, J. The synergistic interplay of artificial intelligence and digital twin in environmentally planning sustainable smart cities: A comprehensive systematic review. *Environ. Sci. Ecotechnology* **2024**, *20*, 100433. [CrossRef] [PubMed]
27. Mazzetto, S. A Review of Urban Digital Twins Integration, Challenges, and Future Directions in Smart City Development. *Sustainability* **2024**, *16*, 8337. [CrossRef]
28. Tao, F.; Zhang, H.; Zhang, C. Advancements and challenges of digital twins in industry. *Nat. Com. Sci.* **2024**, *4*, 169–177. [CrossRef]
29. Peldon, D.; Banihashemi, S.; LeNguyen, K.; Derrible, S. Navigating urban complexity: The transformative role of digital twins in smart city development. *Sustain. Cities Soc.* **2024**, *111*, 105583. [CrossRef]
30. Raes, L.; Michiels, P.; Adolphi, T.; Tampere, C.; Dalianis, A.; McAleer, S.; Kogut, P. DUET: A framework for building interoperable and trusted digital twins of smart cities. *IEEE Internet Comput.* **2022**, *26*, 43–50. [CrossRef]
31. Allam, Z.; Jones, D.S. Future (post-COVID) digital, smart and sustainable cities in the wake of 6G: Digital twins, immersive realities and new urban economies. *Land Use Policy* **2021**, *101*, 105201. [CrossRef]
32. Park, S.; Kim, J.; Kim, Y.; Kang, J. Participatory Framework for Urban Pluvial Flood Modeling in the Digital Twin Era. *Sustain. Cities Soc.* **2024**, *108*, 105496. [CrossRef]
33. Roudbari, N.S.; Punekar, S.R.; Patterson, Z.; Eicker, U.; Poullis, C. From data to action in flood forecasting leveraging graph neural networks and digital twin visualization. *Sci. Rep.* **2024**, *14*, 18571. [CrossRef]
34. Riaz, K.; McAfee, M.; Gharbia, S.S. Management of Climate Resilience: Exploring the Potential of Digital Twin Technology, 3D City Modelling, and Early Warning Systems. *Sensors* **2023**, *23*, 2659. [CrossRef] [PubMed]
35. Olivares-Rojas, J.C.; Reyes-Archundia, E.; Gutierrez-Gnecchi, J.A.; Molina-Moreno, I.; Cerda-Jacobo, J.; Méndez-Patiño, A. Towards cybersecurity of the smart grid using digital twins. *IEEE Internet Comput.* **2021**, *26*, 52–57. [CrossRef]
36. Weil, C.; Bibri, S.E.; Longchamp, R.; Golay, F.; Lahi, A. Urban digital twin challenges: A systematic review and perspectives for sustainable smart cities. *Sustain. Cities Soc.* **2023**, *99*, 104862. [CrossRef]
37. Preut, A.; Kopka, J.P.; Clausen, U. Digital twins for the circular economy. *Sustainability* **2021**, *13*, 10467. [CrossRef]
38. Ferré-Bigorra, J.; Casals, M.; Gangolells, M. The adoption of urban digital twins. *Cities* **2022**, *131*, 103905. [CrossRef]
39. Feng, H.; Lv, H.; Lv, Z. Resilience to warded Digital Twins to improve the adaptability of transportation systems *Transp. Res. Part A Policy Pract.* **2023**, *173*, 103686. [CrossRef]
40. Marcucci, E.; Gatta, V.; Le Pira, M.; Hansson, L.; Bråthen, S. Digital twins: A critical discussion on their potential for supporting policymaking and planning in urban logistics. *Sustainability* **2020**, *12*, 10623. [CrossRef]
41. Li, B.; Tan, W. A novel framework for integrating solar renewable source into smart cities through digital twin simulations. *Sol. Energy* **2023**, *262*, 111869. [CrossRef]
42. Dasgupta, S.; Rahman, M.; Lidbe, A.D.; Lu, W.; Jones, S. A transportation digital-twin approach for adaptive traffic control systems. *arXiv* **2021**. [CrossRef]
43. Wu, Z.Y.; Chew, A.; Meng, X.; Cai, J.; Pok, J.; Kalfarisi, R.; Lai, K.C.; Hew, S.F.; Wong, J.J. High Fidelity Digital Twin-Based Anomaly Detection and Localization for Smart Water Grid Operation Management. *Sustain. Cities Soc.* **2023**, *91*, 104446. [CrossRef]
44. Huang, J.; Koroteev, D.; Rynkovskaya, M. Machine learning-based demand response in PV-based smart home considering energy management in digital twin. *Sol. Energy* **2023**, *252*, 8–19. [CrossRef]
45. Opoku, D.G.J.; Perera, S.; Osei-Kyei, R.; Rashidi, M. Digital twin application in the construction industry: A literature review. *J. Build. Eng.* **2021**, *40*, 102726. [CrossRef]
46. Shahat, E.; Hyun, C.T.; Yeom, C. City Digital Twin Potentials: A Review and Research Agenda. *Sustainability* **2021**, *13*, 3386. [CrossRef]

47. Broo, D.G.; Schooling, J. Digital twins in infrastructure: Definitions, current practices, challenges and strategies *Int. J. Constr. Manag.* **2023**, *23*, 1254–1263. [CrossRef]
48. Capgemini Research Institute. Reflecting Reality. Digital Twins: Adding Intelligence to the Real World. 2022. Available online: https://prod.ucwe.capgemini.com/wp-content/uploads/2022/05/Capgemini-Research-Institute_DigitalTwins_Web.pdf (accessed on 12 February 2024).
49. Faliagka, E.; Christopoulou, E.; Ringas, D.; Politi, T.; Kostis, N.; Leonardos, D.; Tranoris, C.; Antonopoulos, C.P.; Denazis, S.; Voros, N. Trends in Digital Twin Framework Architectures for Smart Cities: A Case Study in Smart Mobility. *Sensors* **2024**, *24*, 1665. [CrossRef]
50. Aulisio, A.; Pereno, A. Regenerative Design Approach for Twin Transition in Travel and Tourism Sector. In *For Nature/With Nature: New Sustainable Design Scenarios*; Springer Series in Design and Innovation; Gambardella, C., Ed.; Springer: Cham, Switzerland, 2024; Volume 38. [CrossRef]
51. El Archi, Y.; Benbba, B.; Kabil, M.; Dávid, L.D. Digital Technologies for Sustainable Tourism Destinations: State of the Art and Research Agenda. *Adm. Sci.* **2023**, *13*, 184. [CrossRef]
52. Allen, B.D. Digital Twins and Living Models at NASA. 2021. Available online: https://ntrs.nasa.gov/citations/20210023699 (accessed on 15 August 2023).
53. IBM. What is a Digital Twin? 2023. Available online: https://www.ibm.com/topics/what-is-a-digital-twin (accessed on 7 August 2023).
54. Rantala, T.; Ukko, J.; Nasiri, M.; Saunila, M. Shifting focus of value creation through industrial digital twins—From internal application to ecosystem-level utilization. *Technovation* **2023**, *125*, 102795. [CrossRef]
55. Adamenko, D.; Kunnen, S.; Pluhnau, R.; Loibl, A.; Nagarajah, A. Review and comparison of the methods of designing the Digital Twin. *Procedia CIRP* **2020**, *91*, 27–32. [CrossRef]
56. Matei, A.; Cocoșatu, M. Artificial Internet of Things, Sensor-Based Digital Twin Urban Computing Vision Algorithms, and Blockchain Cloud Networks in Sustainable Smart City Administration. *Sustainability* **2024**, *16*, 6749. [CrossRef]
57. Glaessgen, E.; Stargel, D. The Digital Twin Paradigm for Future NASA and U.S. Air Force Vehicles. In *Proceedings of the 53rd Structures, Structural Dynamics and Materials Conference: Special Session on the Digital Twin*; Honolulu, HI, USA, 23–26 April 2012. Available online: https://ntrs.nasa.gov/api/citations/20120008178/downloads/20120008178.pdf (accessed on 14 September 2023).
58. Schmitt, L.; Copps, D. The Business of Digital Twins. In *The Digital Twin*; Crespi, N., Drobot, A.T., Minerva, R., Eds.; Springer: Cham, Switzerland, 2023. [CrossRef]
59. Reim, W.; Andersson, E.; Eckerwall, K. Enabling collaboration on digital platforms: A study of digital twins. *Int. J. Prod. Res.* **2022**, *61*, 3926–3942. [CrossRef]
60. Tao, F.; Cheng, J.; Qi, Q.; Zhang, M.; Zhang, H.; Sui, F. Digital twin-driven product design, manufacturing and service with big data. *Int. J. Adv. Manuf. Technol.* **2018**, *94*, 3563–3576. [CrossRef]
61. Armstrong, M.M. Cheat Sheet: What is Digital Twin? 2018. Available online: https://www.ibm.com/blog/iot-cheat-sheet-digital-twin/ (accessed on 27 September 2023).
62. El Marai, O.; Taleb, T.; Song, J. Road's infrastructure digital twin: A step toward smarter cities realization. *IEEE Netw.* **2021**, *35*, 136–143. [CrossRef]
63. Yang, S.; Kim, H. Urban digital twin applications as a virtual platform of smart city. *Int. J. Sustain. Build. Technol. Urban Dev.* **2021**, *12*, 363–379. [CrossRef]
64. Piromalis, D.; Kantaros, A. Digital Twins in the Automotive Industry: The Road toward Physical-Digital Convergence. *Appl. Syst. Innov.* **2022**, *5*, 65. [CrossRef]
65. Ivanov, D. Conceptualisation of a 7-element digital twin framework in supply chain and operations management *Int. J. Prod. Res.* **2023**, *62*, 2220–2232. [CrossRef]
66. Ravid, R.B.; Aharon-Gutman, M. The Social Digital Twin: The Social Turn in the Field of Smart Cities. *Environ. Plan. B Urban Anal. City Sci.* **2023**, *50*, 1455–1470. [CrossRef]
67. Florido-Benítez, L. Identifying cybersecurity risks in Spanish airports. *CyberSecur. Peer-Rev. J.* **2021**, *4*, 267–291.
68. Pérez, D.M.G.; Martín, J.M.M.; Martínez, J.M.G.; Sáez-Fernández, F.J. An analysis of the cost of water supply linked to the tourism industry. An application to the case of the Island of Ibiza in Spain. *Water* **2020**, *12*, 2006. [CrossRef]
69. Jiang, Y.; Liu, Q.; Zhao, S.; Zhang, T.; Fan, X.; Zhong, R.Y.; Huang, G.Q. Heterogeneous intensity-based DBSCAN (iDBSCAN) model for urban attention distribution in digital twin cities. *Digit. Eng.* **2024**, *2*, 100014. [CrossRef]
70. Anand, A.; Kumar, R.; Pachauri, P.; Jain, V.; Ng, K.T. 6G and IoT-supported augmented and virtual reality-enabled simulation environment. In *Augmented and Virtual Reality in Social Learning: Technological Impacts and Challenges*; De Gruyter: Berlin, Germany, 2023; Volume 3, p. 199.
71. Luther, W.; Baloian, N.; Biella, D.; Sacher, D. Digital Twins and Enabling Technologies in Museums and Cultural Heritage: An Overview. *Sensors* **2023**, *23*, 1583. [CrossRef]
72. Bianchi, V.; Bassoli, M.; Lombardo, G.; Fornacciari, P.; Mordonini, M.; De Munari, I. IoT Wearable Sensor and Deep Learning: An Integrated Approach for Personalized Human Activity Recognition in a Smart Home Environment. *IEEE Internet Things J.* **2019**, *6*, 8553–8562. [CrossRef]
73. Lehtola, V.V.; Koeva, M.; Elberink, S.O.; Raposo, P.; Virtanen, J.P.; Vahdatikhaki, F.; Borsci, S. Digital twin of a city: Review of technology serving city needs. *Int. J. Appl. Earth Obs. Geoinf.* **2022**, *114*, 102915. [CrossRef]

74. Florido-Benítez, L. Bridges: A tourist attraction and iconic element at urban cities' tourism promotion websites. *Int. J. Tour. Cities* **2023**, *9*, 771–787. [CrossRef]
75. Cobanoglu, C.; Dede, P.; Poorani, A. An analysis of skills and competencies of full-service hotel technology managers. *J. Teach. Travel Tour.* **2007**, *6*, 19–35. [CrossRef]
76. Siano, P.; Sarno, D. Assessing the benefits of residential demand response in a real time distribution energy market. *Appl. Energy* **2016**, *161*, 533–551. [CrossRef]
77. Azis, N.; Amin, M.; Chan, S.; Aprilia, C. How smart tourism technologies affect tourist destination loyalty. *J. Hosp. Tour. Technol.* **2020**, *11*, 603–625. [CrossRef]
78. Ma, L.; Liu, C.; Zhan, Y. How smart city construction affects destination tourism efficiency. *Tour. Econ.* **2024**, *30*, 1600–1623. [CrossRef]
79. Ssin, S.; Suh, M.; Lee, J.; Jung, T.; Woo, W. Science Tour and Business Model Using Digital Twin-Based Augmented Reality. In *Augmented Reality and Virtual Reality*; Tom Dieck, M.C., Jung, T.H., Loureiro, S.M.C., Eds.; Springer: Cham, Switzerland, 2021. [CrossRef]
80. Marriott. VRoom Service. The World's First Virtual Reality Travelogs Share Stunning Destinations and Real Travel Stories with Marriott Guests. 2023. Available online: http://framestorevr.com/marriott-vr-postcards (accessed on 1 October 2023).
81. Nochta, T.; Badstuber, N.; Wahby, N. *On the Governance of City Digital Twins—Insights from the Cambridge Case Study*; University of Cambridge: Cambridge, UK, 2019. [CrossRef]
82. Dani, A.A.H.; Supangkat, S.H.; Lubis, F.F.; Nugraha, I.G.B.B.; Kinanda, R.; Rizkia, I. Development of a Smart City Platform Based on Digital Twin Technology for Monitoring and Supporting Decision-Making. *Sustainability* **2023**, *15*, 14002. [CrossRef]
83. Attaran, M.; Celik, B.G. Digital Twin: Benefits, use cases, challenges, and opportunities. *Decis. Anal. J.* **2023**, *6*, 100165. [CrossRef]
84. Li, M.; Shen, L.; Huang, G.Q. Blockchain-enabled workflow operating system for logistics resources sharing in E-commerce logistics real estate service. *Comput. Ind. Eng.* **2019**, *135*, 950–969. [CrossRef]
85. Kontogianni, A.; Alepis, E. Smart tourism: State of the art and literature review for the last six years. *Array* **2020**, *6*, 100020. [CrossRef]
86. Florido-Benítez, L. Increasing Security Levels in the Tourism and Air-Transport Industries Could Enhance African People's Quality of Life and Tourism Demand. *Tour. Hosp.* **2024**, *5*, 713–735. [CrossRef]
87. Antolín Merino, J.A.; Kanthareuben, R. How Digital Twins Can Optimize Travel and Hospitality Operations. 2023. Available online: https://aws.amazon.com/blogs/industries/how-digital-twins-can-optimize-travel-and-hospitality-operations/ (accessed on 12 October 2024).
88. Solakis, K.; Katsoni, V.; Mahmoud, A.B.; Grigoriou, N. Factors affecting value co-creation through artificial intelligence in tourism: A general literature review. *J. Tour. Futures* **2024**, *10*, 116–130. [CrossRef]
89. Florido-Benítez, L. The impact of tourism promotion in tourist destinations: A bibliometric study. *Int. J. Tour. Cities* **2022**, *8*, 844–882. [CrossRef]
90. Alzahrani, N.M.; Alfouzan, F.A. Augmented reality (AR) and cybersecurity for smart cities. A systematic literature review. *Sensors* **2022**, *22*, 2792. [CrossRef]
91. Go, H.; Kang, M. Metaverse tourism for sustainable tourism development: Tourism Agenda 2030. *Tour. Rev.* **2023**, *78*, 381–394. [CrossRef]
92. Kovačić, M.; Čičin-Šain, M.; Milojica, V. Cybersecurity and tourism: Bibliometric analysis. *J. Process Manag. New Technol.* **2022**, *10*, 75–92. [CrossRef]
93. Florido-Benítez, L. Identifying and classifying cyberattacks on airports. *Cybersecurity* **2024**, *79*, 63–79. [CrossRef]
94. Coca-Stefaniak, A.; Morrison, A.M. City tourism destinations and terrorism a worrying trend for now, but could it get worse? *Int. J. Tour. Cities* **2018**, *4*, 409–412. [CrossRef]
95. Florido-Benítez, L. The types of hackers and cyberattacks in the aviation industry. *J. Transp. Secur.* **2024**, *17*, 13. [CrossRef]
96. Li, X.; Luo, J.; Li, Y.; Wang, W.; Hong, W.; Liu, M.; Li, X.; Lv, Z. Application of effective water-energy management based on digital twins' technology in sustainable cities construction. *Sustain. Cities Soc.* **2022**, *87*, 104241. [CrossRef]
97. Liu, D.; Guo, K.; Wang, B.; Peng, Y. Summary and Perspective Survey on Digital Twin Technology. 2018. Available online: https://www.researchgate.net/publication/330638280_Summary_and_perspective_survey_on_digital_twin_technology (accessed on 28 October 2023).
98. Sacyr. Digital Twins to Design the City of the Future. 2023. Available online: https://sacyr.com/en/-/gemelos-digitales-para-diseniar-la-ciudad-del-futuro (accessed on 28 October 2023).
99. Digital Twin Market. Digital Twin Market by application (Predictive Maintenance, Business Optimization, Performance, Monitoring, Inventory Management) Industry (Automotive & Transportation, Healthcare, Energy & Utilities). Enterprise and Geography. Global Forecast to 2028. 2023. Available online: https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html?gad_source=1&gclid=Cj0KCQiAyKurBhD5ARIsALamXaFlPTtOJpYJxFqpByT4nHspQyz9VvZfSvo2u-ioWNamuZhI8EELCVYaAmkoEALw_wcB (accessed on 17 December 2023).
100. Ayyavaraiah, M.; Jeyakumar, B.; Chidambaranathan, S.; Subramaniam, S.; Anitha, K.; Sangeetha, A. Smart Transportation Systems Machine Learning Application in WSN-Based Digital Twins. In *Harnessing AI and Digital Twin Technologies in Businesses*; IGI Global: Hershey, PA, USA, 2024; pp. 356–366. Available online: https://www.igi-global.com/chapter/smart-transportation-systems-machine-learning-application-in-wsn-based-digital-twins/352181 (accessed on 29 November 2024).

101. Zhao, J.; Guo, L.; Li, Y. Application of digital twin combined with artificial intelligence and 5G technology in the art design of digital museums. *Wirel. Commun. Mob. Comput.* **2022**, *1*, 8214514. [CrossRef]
102. Prodinger, B.; Neuhofer, B. Never-Ending Tourism: Tourism Experience Scenarios for 2030. In *Information and Communication Technologies in Tourism 2023*; Ferrer-Rosell, B., Massimo, D., Berezina, K., Eds.; ENTER 2023. Springer Proceedings in Business and Economics; Springer: Cham, Switzerland, 2023. [CrossRef]
103. Singapore Tourism Board. 2024's Most Important Travel Tech Trends. 2023. Available online: https://thenextweb.com/news/2024s-most-important-travel-tech-trends (accessed on 9 January 2024).
104. Cureton, P.; Hartley, E. City Information Models (CIMs) as precursors for Urban Digital Twins (UDTs): A case study of Lancaster. *Front. Built. Environ.* **2023**, *9*, 048510. [CrossRef]
105. Coca-Stefaniak, J.A. Marketing smart tourism cities a strategic dilemma. *Int. J. Tour. Cities* **2019**, *5*, 513–518. [CrossRef]
106. Just-Style Magazine. How Digital Twins Are Shaping the Fashion Industry. 2023. Available online: https://juststyle.nridigital.com/just-style_magazine_mar23/how_digital_twins_are_shaping_the_fashion_industry (accessed on 29 November 2023).
107. Guo, J.; Lv, Z. Application of Digital Twins in multiple fields. *Multimed. Tools Appl.* **2022**, *81*, 26941–26967. [CrossRef]
108. Stavropoulos, P.; Mourtzis, D. Digital twins in industry 4.0. In *Design and Operation of Production Networks for Mass Personalization in the Era of Cloud Technology*; Elsevier: Amsterdam, The Netherlands, 2022; Volume 7, pp. 277–316. [CrossRef]
109. Augustine, P. The industry use cases for the digital twin idea. *Adv. Comput.* **2020**, *117*, 79–105. [CrossRef]
110. Erol, T.; Mendi, A.F.; Doğan, D. Digital Transformation Revolution with Digital Twin Technology. In Proceedings of the 2020 4th international symposium on multidisciplinary studies and innovative technologies (ISMSIT) IEEE, Istanbul, Turkey, 22–24 October 2020; pp. 1–7. [CrossRef]
111. ABI-research. The Use of Digital Twins for Urban Planning to Yield US $280 Billion in Cost Savings by 2030. 2021. Available online: https://www.abiresearch.com/press/use-digital-twins-urban-planning-yield-us280-billion-cost-savings-2030/ (accessed on 7 January 2024).
112. Tiltlabs. Digital Twin Implementation: Transforming Seattle's Urban landscape. 2024. Available online: https://tiltlabs.io/case_studies/digital-twin-for-seattle/ (accessed on 7 November 2024).
113. UNTWO. Accelerating the Adoption of Technologies in the Tourism Value Chain. 2023. Available online: https://www.unwto.org/unwto-awake-tourism-challenge (accessed on 3 October 2024).
114. UNTWO. Sustainable Development. 2023. Available online: https://www.unwto.org/sustainable-development (accessed on 4 December 2023).
115. Florido-Benítez, L. The Priority of Water Consumption in the Spanish Tourism Industry: A Dilemma for Residents and Researchers. *Appl. Sci.* **2024**, *14*, 7125. [CrossRef]
116. Omrany, H.; Al-Obaidi, K.M.; Husain, A.; Ghaffarianhoseini, A. Digital Twins in the Construction Industry: A Comprehensive Review of Current Implementations, Enabling Technologies, and Future Directions. *Sustainability* **2023**, *15*, 10908. [CrossRef]
117. Seuwou, P.; Banissi, E.; Ubakanma, G. The future of mobility with connected and autonomous vehicles in smart cities. In *Digital Twin Technologies and Smart Cities*; Springer: Cham, Switzerland, 2020; pp. 37–52.
118. Bhatti, G.; Mohan, H.; Singh, R.R. Towards the future of smart electric vehicles: Digital twin technology. *Renew. Sustain. Energy Rev.* **2022**, *141*, 110801. [CrossRef]
119. WEF. Global Digital Twin Cities. 2023. Available online: https://www3.weforum.org/docs/WEF_Digital_Twin_Cities_2023.pdf (accessed on 9 January 2024).
120. Farsi, M.; Daneshkhah, A.; Hosseinian-Far, A.; Jahankhani, H. *Digital Twin Technologies and Smart Cities*, Springer: Berlin/Heidelberg, Germany, 2020.
121. Atlam, H.F.; Wills, G.B. IoT security, privacy, safety, and ethics. In *Digital Twin Technologies and Smart Cities*; Springer: Cham, Switzerland, 2020; pp. 123–149.
122. Malik, N.S.; Collins, R.; Vamburkar, M. Cyberattack Pings Data Systems of at Least Four Gas Networks. 2018. Available online: https://www.bloomberg.com/news/articles/2018-04-03/day-after-cyber-attack-a-third-gas-pipeline-data-system-shuts?embedded-checkout=true (accessed on 28 October 2023).
123. Faleiro, R.; Pan, L.; Pokhrel, S.R.; Doss, R. Digital Twin for Cybersecurity: Towards Enhancing Cyber Resilience. In *Broadband Communications, Networks, and Systems. BROADNETS 2021—Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*; Xiang, W., Han, F., Phan, T.K., Eds.; Springer: Cham, Switzerland, 2022; Volume 413, pp. 57–76. [CrossRef]
124. Florido-Benítez, L. The Cybersecurity Applied by Online Travel Agencies and Hotels to Protect Users' Private Data in Smart Cities. *Smart Cities* **2024**, *7*, 475–495. [CrossRef]
125. Saracoglu, D. Metaverse and New Cybersecurity Threats. In *Metaverse. Studies in Big Data*; Esen, F.S., Tinmaz, H., Singh, M., Eds.; Springer: Singapore, 2023; pp. 99–121. [CrossRef]
126. Kuru, K. MetaOmniCity: Towards immersive urban metaverse cyberspaces using smart city digital twins. *IEEE Access* **2023**, *11*, 43844–43868. [CrossRef]
127. Wang, H.; Chen, X.; Jia, F.; Cheng, X. Digital twin-supported smart city: Status, challenges and future research directions. *Exp. Syst. App.* **2023**, *217*, 119531. [CrossRef]
128. Moreno-Munoz, A.; De la Rosa, J.J.G.; Flores-Arias, J.M.; Bellido-Outerino, F.J.; Gil-de-Castro, A. Energy efficiency criteria in uninterruptible power supply selection. *Appl. Energy* **2011**, *88*, 1312–1321. [CrossRef]

129. Hämäläinen, M. Urban development with dynamic digital twins in Helsinki city. *IET Smart Cities* **2021**, *3*, 201–210. [CrossRef]
130. Helsinki. Mobility Lab Helsinki Develops Helsinki's Digital Twin for Mobility. 2022. Available online: https://testbed.hel.fi/en/smart-mobility/mobility-lab-helsinki-develops-helsinkis-digital-twin-for-mobility/ (accessed on 10 January 2024).
131. Gothenburg. Goteverse—The Digital Destination of the Future. 2023. Available online: https://www.youtube.com/watch?v=kZrgaNVTtkU (accessed on 10 January 2024).
132. Hou, H.C.; Lai, J.H.K.; Wu, H.; Wang, T. Digital twin application in heritage facilities management: Systematic literature review and future development directions. *Eng. Constr. Archit. Manag.* **2024**, *31*, 3193–3221. [CrossRef]
133. Omrany, H.; Al-Obaidi, K.M. Application of Digital Twin Technology for Urban Heat Island Mitigation: Review and Conceptual Framework. *Smart Sustain. Built Environ.* **2024**. [CrossRef]
134. Caporusso, N.; Elleman, N.; Cho, S.S. Interface digital twins: Rendering physical devices accessible to people who are blind. In Proceedings of the 2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO), Opatija, Croatia, 28 September–2 October 2020; pp. 982–986. [CrossRef]
135. Zaman, U.; Koo, I.; Abbasi, S.; Raza, S.H.; Qureshi, M.G. Meet Your Digital Twin in Space? Profiling International Expat's Readiness for Metaverse Space Travel, Tech-Savviness, COVID-19 Travel Anxiety, and Travel Fear of Missing Out. *Sustainability* **2022**, *14*, 6441. [CrossRef]
136. Gkontzis, A.F.; Kotsiantis, S.; Feretzakis, G.; Verykios, V.S. Enhancing Urban Resilience: Smart City Data Analyses, Forecasts, and Digital Twin Techniques at the Neighborhood Level. *Future Internet* **2024**, *16*, 47. [CrossRef]