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The digitalization of cultural heritage in Smart City context¹

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Abstract

This paper examines the role of cultural heritage in the development of smart cities, focusing on the role of digital technology in enhancing the preservation, management, accessibility and sustainability of heritage sites. Utilizing a twofold methodological approach that combines a bibliometric analysis and a critical literature review, the study analyzes existing academic papers to evaluate the opportunities and challenges associated with smart technologies—such as Artificial Intelligence (AI), Internet of Things (IoT), and big data—in the preservation, accessibility, and promotion of cultural heritage. Through this dual analysis, key themes emerge regarding the enhancement of citizen engagement, innovative heritage management practices, and the cultural preservation in smart city contexts.

This paper contributes to the discourse on sustainable smart city development by emphasizing the importance of a balanced, heritage-sensitive approach to urban digitalization, advocating for policies that support both technological advancement and cultural integrity aimed at supporting sustainable and inclusive urban development.

JEL classification: O18, O21, O33

Keywords: cultural heritage, smart cities, digitalization.

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1. Introduction

The integration of cultural heritage within the framework of smart cities is gaining increasing attention in urban development research. Smart cities emphasize the use of advanced technologies, such as the Internet of Things (IoT), data analytics, and Artificial Intelligence (AI), to improve urban infrastructure and enhance the quality of life. However, the digitization and preservation of cultural heritage within these technological ecosystems represent an emerging and underexplored area. This study aims to bridge the gap between two interconnected domains: smart city development and cultural heritage management.

While smart city literature has traditionally focused on infrastructure, transportation, energy efficiency, and governance, the role of culture and heritage in these frameworks remains less pronounced. Nonetheless, integrating cultural elements into smart city models is essential for ensuring urban spaces remain vibrant and sustainable, fostering both community identity and tourism. The digitization of heritage - through tools such as Virtual Reality (VR) and Augmented Reality (AR), digital archives, and participatory platforms - offers innovative ways to preserve and promote cultural assets while engaging citizens in new forms of cultural participation.

The aim of the study is to investigate the literature on the digitization of the cultural heritage through the lenses of the smart city. The analysis has a twofold aim. First, it aims to give an overview of the evolution of the studies based on the intersection of these two literatures, with a particular focus on the digitization of the cultural heritage. Second, it wants to identify relevant topics and journals where the debate is vibrant as well as the emerging trends of this promising literature.

This paper provides a critical review of the intersection between smart cities and cultural heritage, focusing particularly on the challenges and opportunities related to digital transformation of cultural heritage. Through a combination of a bibliometric analysis and critical literature review from 1990 to 2023, the study identifies key trends, methodological approaches and future directions in the field. It explores how digital technologies can serve not only as tools for cultural preservation but also as mechanisms for sustainable urban development, highlighting the potential of smart cities to balance technological innovation with cultural and social sustainability.

2. The previous research on Smart City concept and the digitalization of cultural heritage

2.1 Smart City

The smart city literature lacks consensus about its origins; some authors date it back to the 1960s, though most trace its real birth and development to the 1990s (Caragliu and Bo, 2018; Ingwersen and Serrano-López, 2018). Consensus on a clear definition is even more elusive (Cocchia, 2014;

Zubizarreta et al., 2016; Ingwersen and Serrano-López, 2018). The smart city concept encompasses urban automated transportation systems, integrated intercity transport, sustainable energy solutions, and urban planning that includes roads, building construction, infrastructure, and parks. It also involves intelligent homes, apartments, and shopping areas, as well as academic communities. While globally, the smart city concept often focuses on integrating intelligent technologies and AI, it extends beyond digitalization alone (Lee et al. 2014; Ingwersen and Serrano-López, 2018; Ziosi et al., 2022; Gomes and Sedita, 2023). Yet, technology remains central. Several terms have been coined to reflect ICT-driven improvements in modern cities: digital city, intelligent city, and smart city, each illustrating ICT-driven city research and development. This evolution reflects the shift in strategy aimed at improving urban quality of life. Definitions of smart cities have expanded over time, moving beyond technology to include citizen engagement, sustainability, and economic innovation.

This topic spans operational-legislative and theoretical-scientific domains, which are interconnected. The European Union (EU) has consistently developed strategies to foster smart urban growth within metropolitan areas. This commitment extends internationally, with bodies like OECD and EUROSTAT's Oslo Manual (2005) highlighting ICT innovation, offering indicators to assess cities. However, a city's designation as "smart" is not solely determined by the presence of ICT infrastructure (Caragliu et al., 2011). The EU promotes policies supporting the development of smart, resilient cities. Key initiatives include: the Digital Agenda for Europe (2010), promoting digital technologies in urban areas; Smart Cities and Communities (SCC) initiative (2011), which encourages smart city development through investment, knowledge-sharing, and collaboration; the Energy Efficiency Directive (2012), mandating energy efficiency improvements; and the Circular Economy Legislative Package (2018), supporting the circular economy, waste reduction, and product reuse and recycling. Caragliu et al. (2011) analyze European smart cities in depth, examining their traits, developments, and challenges, defining smart cities as integrating ICT into urban infrastructure to improve life quality, resource efficiency, environmental sustainability, and citizen engagement. The strategic use of ICT aims to manage urban resources more efficiently and foster connectivity between citizens and the urban landscape.

Bakıcı et al. (2013) explore Barcelona's smart city initiative through a case study, providing insights into its strategies, processes, and outcomes, which offer lessons for other cities. The authors conclude that Barcelona's success is due to its holistic vision, public-private partnerships, citizen involvement, technological infrastructure, and socioeconomic impact. Zubizarreta et al. (2016) similarly identify these categories through a literature review of smart cities, while Lee et al. (2014) apply a comparative case study to examine San Francisco and Seoul, revealing technology's role in optimizing urban services, managing resources, and enhancing life quality. From transportation

systems to data analytics, technology serves as the backbone of smart city initiatives, increasing urban efficiency, resilience, and sustainability. Using similar methodology, Shelton et al. (2015) analyze smart city initiatives to understand their urban and social impacts, cautioning that smart cities often fail to meet their full potential, advocating for a more critical approach.

Through a systematic review, Cocchia (2014) offers an overview of smart city literature, synthesizing research on "smart" versus "digital" cities and noting the growing prevalence of the term "smart" as a more comprehensive concept that includes sustainability, governance, and quality of life improvements. A smart city integrates technology with strategic planning to achieve economic, social, and environmental benefits, illustrating that not all digital cities are necessarily "smart." Anthopoulos et al. (2016) align with Cocchia's holistic vision, proposing a Unified Smart City Model (USCM) to address the inconsistency in frameworks and provide a comprehensive evaluation tool for policymakers and researchers. Komninou and Mora (2018) emphasize the need for a holistic approach to smart city research, which considers the interplay of technological, social, economic, and environmental factors. They argue that previous research has often focused narrowly, leading to fragmented knowledge and limited understanding. Their paper identifies challenges in smart city research, such as a lack of standardized methodologies, predominance of techno-centric views, and limited attention to social equity. Using critical and systematic reviews, Ricciardi and Za (2015) and Ingwersen and Serrano-López (2018) echo this sentiment, highlighting the need for interdisciplinary collaboration.

Yin et al. (2015) propose an evolution of the smart city concept from the digital and intelligent city. They define the digital city as one where communication, information, and procedures have been digitized to provide access to data on population, resources, environment, and economy. An intelligent city adds a layer of decision-making capability via AI. The smart city incorporates technological infrastructure with data processing for goals such as efficient governance, citizen satisfaction, business growth, and environmental sustainability. Albino et al. (2015) explore smart cities' historical evolution, components, and dimensions, identifying core elements: ICT infrastructure, citizen engagement, environmental sustainability, economic innovation, and mobility. The advent of Big Data and AI, as noted by Allam and Dhunny (2019), has accelerated smart city evolution, providing insights into urban dynamics through vast data from sensors, devices, and platforms. However, challenges regarding data privacy, cybersecurity, equity, and bias persist. Efforts increasingly aim at enhancing citizen well-being through smart healthcare, digital education, and community-driven planning. Ziosi et al. (2022) expand the smart city definition, introducing four dimensions: network infrastructure, post-political governance, social inclusion, and sustainability.

This holistic vision underscores that technology alone cannot solve urban issues, necessitating policy changes and lifestyle shifts.

Sustainability, alongside technology, emerges as a recurring theme, emphasizing that while smart cities leverage technology to enhance efficiency and optimize resources, they often lack a focus on broader sustainability issues like social equity (Ahvenniemi et al., 2017). Martin et al. (2018) highlight tensions in smart-sustainable cities, noting governance, privacy, and equity issues that call for context-specific urban approaches. Ojo et al. (2016), through a comprehensive methodology, stress the importance of technology, governance, and social dimensions in shaping urban development. The 15-Minute City (Moreno et al., 2021) reflects a paradigm shift toward sustainable urbanism, focusing on proximity, accessibility, and community resilience. This model promotes sustainability by minimizing emissions and enhancing quality of life. Gomes and Sedita (2023) argue that technology alone cannot make a city smart; using qualitative methods, they explore the link between new technology and economic growth, well-being, and inclusion.

The concept of smart cities is still under debate. While definitions vary, a smart city broadly involves integrating ICT to enhance urban functions such as transport, energy, and planning. Unlike purely digital or intelligent cities, smart cities emphasize both technology and citizen engagement, addressing sustainability and economic growth.

2.2 Smart City and Cultural Heritage

The concept and literature of smart cities has been largely studied using different methodologies, ranging from the bibliometric analysis (Ingwersen and Serrano-López, 2018; Kominos and Mora, 2018), literature review following different models as systematic or more classical (Cocchia, 2014; Yin et al, 2015; Anthopoulos et al., 2016), case study analysis (Bakıcı et al., 2013; Lee et al., 2014; Shelton et al., 2015), or mixed method analysis (Ojo et al., 2016).

Some of these studies have examined specific aspects of smart cities, such as the role of information technology (Camero and Alba, 2019) and its connection to sustainability (Durán-Sánchez et al., 2017; Ahvenniemi et al., 2017; Ziosi et al., 2022). Su et al. (2015) employed a scientometric methodology to analyse research on construction and building technologies in smart cities, exploring the evolution of research trends, the emergence of key thematic areas, and the interconnections between technological advancements and urban development strategies. Their study highlights how innovation in construction technology contributes to the overall smart city framework.

As already stated, several bibliometric analyses have been developed regarding the Smart City (Ingwersen and Serrano-López, 2018; Kominos and Mora, 2018), considering some specific peculiarities or intersections between the Smart City and other related topics (Ojo et al., 2016).

However, to the best of our knowledge, the interrelation between the Smart City and the digitalization of cultural heritage has not yet been systematically examined through bibliometric analysis or a comprehensive literature review. This gap highlights the need for further investigation into how digital technologies, especially in cultural preservation, are integrated into smart urban frameworks.

One of the topics that appear to be a niche in the smart city literature is the one of the relations with the cultural heritage, which certainly appear central particularly regarding his digitalization, but which however has received less attention.

The integration of technology in cultural and creative endeavours is another crucial aspect highlighted by Caragliu et al. (2011). Therefore, smart city initiatives leverage digital platforms, data analytics and interactive technologies to enhance cultural experiences, support creative industries, and engage citizens in cultural participation. Starting from the Richard Florida's arguments on the role of the creative class in determining long-run urban performance, the paper underscores the intrinsic link between smart cities and the creative class, emphasizing the importance of cultural and creative development in urban planning and innovation. By leveraging technology to enhance cultural experiences and investing in cultural infrastructure, smart cities can enhance their cultural vibrancy and economic competitiveness in the global knowledge economy.

Kourtit (2019) addresses the topic of smart cities and the application of new technologies in connection with cultural heritage observing that our modern society is increasingly characterized by a growing demand for cultural services that are part of an attractive city profile. The paper likely delves into the relationship between cultural heritage preservation and the development of smart cities, examining how digital data analytics can be utilized to achieve both objectives, exploring how digital technologies and data-driven approaches can contribute to the preservation, documentation, and management of cultural heritage sites within urban environments. The paper discusses how smart city initiatives leverage digital data analytics to enhance various aspects of urban life while integrating cultural heritage. This includes strategies for integrating historical and cultural landmarks into smart city planning and development, as well as leveraging digital platforms and tools to engage citizens in cultural heritage conservation efforts. Overall, it likely provides insights into the potential synergies between cultural heritage preservation, smart city development, and digital data analytics, highlighting opportunities for leveraging technology and data-driven approaches to achieve more sustainable and inclusive urban environments.

Magliacani (2022) investigates the organizational processes facilitating public managers in institutionalizing sustainability, accounting and accountability practices in Pavia, an Italian smart city investigating how the pursuit of SDGs poses challenges and opportunities for public management practices, particularly concerning cultural heritage preservation and promotion in the context of smart

city initiatives. The paper likely examines the specific role of cultural heritage within this framework, highlighting its importance as a driver of sustainable development and as a component of a city's identity and quality of life. It discusses how cultural heritage preservation aligns with various SDGs, such as those related to promoting inclusive and sustainable economic growth, fostering resilient and sustainable cities, and preserving cultural diversity and heritage.

3. Methods and data

Following previous literature (Lazzeretti et al., 2022; Nannelli et al., 2023), the methodological approach combines the bibliometric and critical literature review methodologies to explore the evolution of the topic. The bibliometric literature review helps to systematically identify and synthesize the fragmented knowledge of complex and multidisciplinary concepts ensuring a comprehensive understanding of the current research landscape. The critical literature review helps identify key topics that have been widely discussed and outlines a research agenda aimed at addressing the broad and ambiguous issues that emerged from the previous analysis (Paul and Criado, 2020).

In the initial phase of this study, employing a bibliometric approach, data were gathered from the ISI Web of Science database, covering the period from 1990 to 2023. In addition, were followed specific selection criteria: firstly regarding language, to ensure accurate comprehension, only articles published in English were selected; secondly regarding the source, only high-quality, peer-reviewed scientific articles were included; and thirdly regarding the research domain, to align with the study's objectives, articles related to economics, regional economics, and economic geography disciplines (e.g., business, economics, geography, management, social issues, and urban studies) were chosen.

Additionally, both singular and plural forms of relevant keywords were considered to ensure comprehensive search coverage.

Keywords have been selected thanks to the consult of expert scholars in the field and exploratory readings of the literature. The process began by identifying keywords related to smart city concepts (e.g. smart city, smart environment, digitization), followed by those related to cultural heritage (e.g. cultural heritage, intelligent city, historical heritage). Since tourism is a theme that intersects both topics, we decided to retain certain keywords related to tourism without diluting the focus of our research. To achieve this, we included the category 'Hospitality, Leisure, Sport, and Tourism' to ensure that contributions relevant to the tourism and hospitality sector are adequately represented⁵.

⁵ Here is the selection of keywords: “*cultural heritage*” or “*artistic heritage*” or “*historical heritage*” or “*built heritage*” or “*heritage conservation*” or “*intangible heritage*” or “*cultural traditionism*” or “*cultural legac**” or “*cultural identit**” or “*cultural tourism*” or “*historical building*” or “*archeological site**” or “*Artistic Legacy*” or “*historic relics*” or “*monument**” or “*museum*” AND “*smart cit**” or “*smart environment*” or “*digitization*” or “*digitisation*”

The database counts 186, removing duplicates 183. From this database a thorough cleaning was conducted by reading the abstracts (or the entire article when necessary) to exclude papers not aligned with the focus of our research. Following these criteria, the final database comprised 78 articles, forming the basis for the bibliometric review analysis (Cap. 4).

The second step of this study utilizes the findings from the bibliometric analysis to select the papers for a critical literature review. Our objective is to conduct a critical analysis of the intersection between smart cities and cultural heritage, leveraging the selected papers organized into thematic areas as outlined in chapter 5. Through qualitative analysis and in-depth discussion, we aim to highlight potential future developments in the field by evaluating how each study contextualizes the role of digital transformation and technological integration in cultural heritage.

We thoroughly examined the 78 papers identified in the previous step and selected those that provided robust discussions and critical insights into the topic. This selection process ensures that the included articles significantly contribute to the discourse surrounding smart cities and cultural heritage.

From this in-depth reading, we identified 27 articles. In addition, we have included three articles (Romão et al., 2018; Garau, 2020; Lundh Snis et al., 2020) that were not initially identified in the ISI database due to a programming error. These articles contain relevant keywords and all necessary elements, thereby making a significant contribution to the discourse. Including these papers enhances the robustness of our review, ensuring a comprehensive understanding of the subject matter and allowing for a more nuanced exploration of the themes related to smart cities and cultural heritage.

The final number of papers for the critical literature review is 30. Each paper was categorized by theme. Thematic group provides valuable insights into the integration of cultural heritage within the framework of smart cities, focusing particularly on aspects such as technological innovation, tourism, and sustainability. The organization into themes facilitates a more nuanced and critical examination of individual authors' contributions and methodological approaches, while allowing for comparative analysis of similarities and differences within each group.

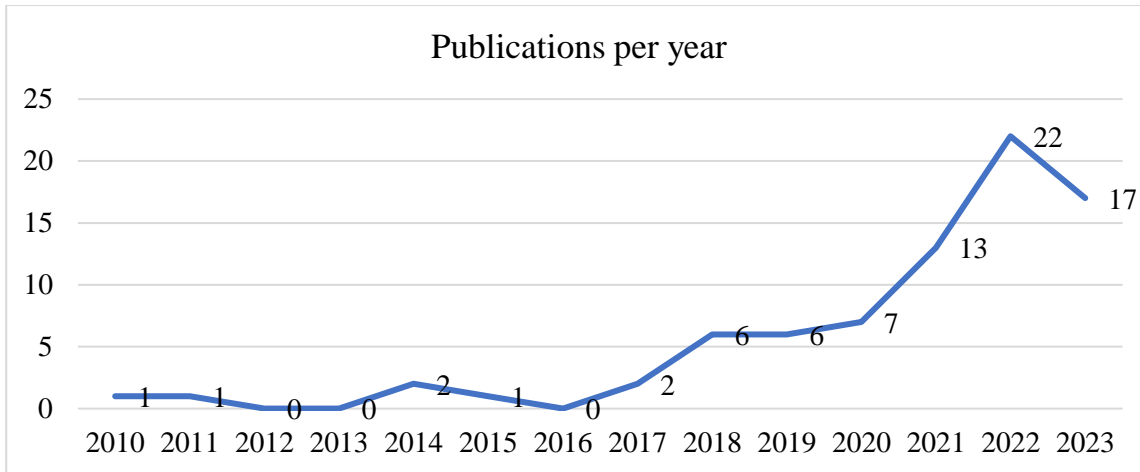
4. The evolution of publications on the digitalization of cultural heritage in smart city context

The preliminary results of the bibliometric analysis examining the intersection of smart cities and cultural heritage within the realm of regional science reveal significant insights into the evolution of this topic over time. Notably, the contributions from the fields of economics and social sciences have

or “gamification” or “digital platform*” or “information communication technolog*” or “digital device*” or “gamification” or “augmented reality” or “virtual reality” or “intelligent cit*” or “digital cit*” or “smart tourism” or “smart sustainability”.

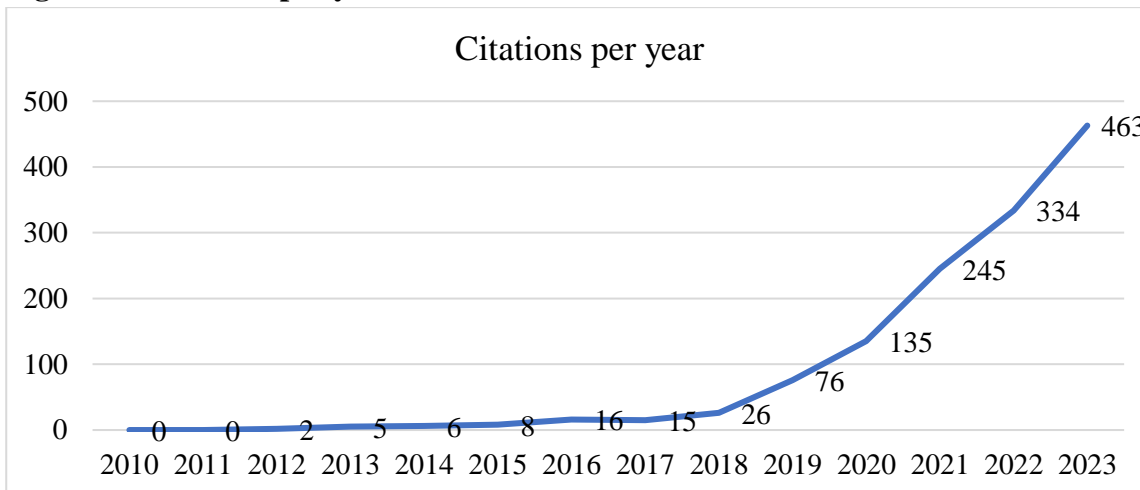
remained relatively modest, underscoring a lag in the academic discourse surrounding these critical areas.

Figure 1 - Publications per year



Source: Author's elaboration

Figure 2 - Citations per year



Source: Author's elaboration

Analysis of the data indicates three distinct phases in the development of studies related to smart cities and cultural heritage. While the foundational literature on smart cities began to surface in the 1990s, the first papers addressing cultural heritage emerged around 2010. This period witnessed a slight uptick in related research, culminating in a first increase in publications beginning in 2018. Furthermore, an additional rise in both the number of articles and citations is evident in the recent years of 2020 to 2023⁶, suggesting that the literature is currently in an early exploration phase. This

⁶ The drop in the number of scientific publications in 2023 may be attributed to the delayed addition of articles to the ISI database. Therefore, this data should be interpreted with caution, as it may not yet fully represent the total publications for that year.

ongoing growth indicates an expanding interest in the intersection of these fields, although it also highlights how the literature remains in its nascent stages and could still be considered as a niche.

Table 1 - Most publishing journals

N.	Journals	N. Of Articles
1	Journal of Heritage Tourism	7
2	Current Issues in Tourism	4
3	Smart Cities	4
4	International Journal of Heritage Studies	3
5	Worldwide Hospitality and Tourism Themes	3
6	European Journal of Tourism Hospitality and Recreation	3
7	European Planning Studies	3
8	Humanities & Social Sciences Communications	3
9	International Journal of Arts Management	3
10	Journal of Urban Technology	3
11	Tourism Review	3

Source: Author's elaboration

Table 1 presents the scientific journals that have predominantly published on the topic. Many scholarly journals that published research papers are concentrated in the field of tourism, accounting for over 20% of the total publications. Consistently, the top two positions are occupied by tourism journals: Journal of Heritage Tourism with 7 publications and Current Issues in Tourism with 4 publications. Following this dominant area, a significant number of journals are dedicated to urban studies and planning. Thus, tied for second place is Smart City journal, also with 4 publications, followed by European Planning Studies with 3 publications. Additionally, there exists a noteworthy subset of journals that focus specifically on cultural heritage and the arts, which further contribute to the diversity of scholarly discourse within these interconnected domains.

Figure 3 highlights the main keywords used by authors who have published on the topic. In this case, we can observe that the top keyword, unsurprisingly defines the two main research area, cultural heritage and smart city. It is evident that, alongside the two central themes that underpin this study, the most frequently encountered keywords are associated with several pertinent concepts. Therefore, the subsequent keywords are related to these research areas and mainly concern innovations and technological development within these fields. These include AR, cultural tourism, innovation, the impact of COVID-19, sustainability and digitalization among others. This assortment of keywords underscores the multifaceted nature of the discourse surrounding the intersection of technology, tourism, and cultural preservation within contemporary urban contexts.

based approach demonstrates how such technologies can bridge the gap between the physical and digital realms, allowing for deeper engagement with cultural heritage. Similarly, Rocio Rueda-Esteban (2022) discusses using technology to reconstruct heritage sites, such as the Abbey of Cluny to offer visitors a more engaging experience. By digitally reconstructing the Abbey, the author demonstrates how visitors can engage with the past in a more interactive and dynamic way, enhancing both educational value and cultural appreciation. This study underscores the potential for digital technologies to go beyond mere preservation, creating new ways for the public to experience and understand heritage.

Nevola et al. (2022) extends this argument by investigating the use of AR to reveal hidden aspects of cultural heritage in Florence. Their research shows how AR can be used to reveal hidden aspects of cultural heritage, such as features of historical sites that are no longer visible or accessible. By overlaying digital content onto the real-world environment, AR can enrich the visitor experience by providing context and insight into aspects of the city's history that would otherwise remain unseen. Nevola (2022)'s study demonstrates that AR not only enhances the visitor experience but also serves as a tool for urban exploration, particularly in cities with rich historical backgrounds such as Florence.

In contrast of these perspectives, both Ocon (2022) and Wagner and de Clippele (2022) focus on the challenges and risks associated with digital preservation. Ocon (2022) critiques the digitization efforts in Southeast Asian cities, questioning whether these processes truly preserve the essence of cultural heritage or merely replace it with a digital surrogate. The author raises concerns about the potential loss of authenticity when cultural heritage is digitized, particularly in contexts where the digital representation might overshadow or misrepresent the original physical artifacts. Ocon's work calls for a more cautious approach to digitization, emphasizing the need to preserve the intrinsic value of physical heritage sites rather than relying solely on digital replicas. Wagner and de Clippele (2022) delve into the legal and ethical challenges surrounding the preservation of digital artifacts. They argue that while digital technologies offer powerful tools for the safeguarding of cultural heritage, they also introduce complex questions about ownership, access, and long-term preservation. For instance, the authors highlight the difficulties of ensuring that digital artifacts remain accessible over time, given the rapid pace of technological change. Moreover, they raise ethical concerns about the potential for digital preservation efforts to commodify cultural heritage, reducing it to a set of data points rather than preserving its cultural and historical significance.

Additionally, the works of Terras et al. (2017) emphasize the value of mass-digitized cultural heritage content in creative contexts, suggesting that such digitization can enhance accessibility and foster new forms of creativity. Fissi et al. (2021) contribute to this discussion by examining the digitalization path of the Opera di Santa Maria del Fiore in Florence, illustrating how such initiatives

respond to contemporary challenges like the COVID-19 pandemic. Salleh and Bushroa (2022) provide a bibliometric analysis on the implementation of digitization technologies in cultural heritage in Malaysia, highlighting trends and gaps in current research. Collectively, these studies emphasize the multifaceted impacts of digital technologies on cultural heritage, underscoring the need for continued exploration in this dynamic field.

In comparing these studies, a clear dichotomy emerges between those that view digital technologies as a tool for enhancing user experiences and those that caution against the potential risks associated with over-reliance on digitization. While the former group emphasizes the ability of VR and AR to bring cultural heritage to life in new and exciting ways, the latter underscores the importance of preserving the authenticity and integrity of cultural heritage in the face of rapid technological change. This tension highlights a critical area for future research: how to balance the benefits of technological innovation with the need to protect the authenticity and cultural significance of heritage sites.

5.2. Digitalization in tourism for cultural heritage

In this set of papers, the discussion shifts to how digital solutions are reshaping tourism management in the cultural heritage context. One of the key technologies contributing to this shift is AR which plays a pivotal role in sustainable development within cultural heritage tourism, as discussed by Cranmer et al. (2022). The authors argue that AR enhances visitor engagement while simultaneously addressing sustainability challenges by offering immersive, low-impact alternatives to traditional tourism. By facilitating virtual interactions with cultural heritage sites, AR reduces the strain on physical resources and encourages more sustainable visitor behaviour. This view aligns with Buonincontri and Marasco (2022), who emphasize that smart technologies like AR not only enhance the visitor experience but also create an *Integrated Experiential Framework* that blends physical and digital elements. The authors suggest that AR can offer more than just entertainment—it provides educational and interpretative benefits that deepen visitors' connection to the heritage site.

Building on these perspectives, Pierdicca et al. (2022) provide a functional analysis of how ICT improve tourism management by optimizing resource allocation and enhancing visitor satisfaction. This focus on technology's functional role is echoed by Yang and Zhang (2022) who explore the potential of smart tourism technologies to create memorable visitor experiences, demonstrating the powerful synergy between digitalization and tourism. Both the studies suggest that digital solutions are indispensable in addressing the evolving needs of tourists, particularly in an increasingly competitive tourism industry.

Similarly, Zhang and Abd Rahman (2022) narrow the focus to millennial engagement with smart museums, highlighting how technology fosters higher levels of visitor satisfaction and loyalty. Their study deepens the broader discussion on how different demographics interact with digitalized cultural heritage, shedding light on the specific preferences and behaviours of younger tourists. In contrast, van Heur (2010) offers a more critical analysis of digitalization in cultural institutions. While acknowledging the many benefits of digital transformation, he warns that this shift can pose significant challenges regarding institutional adaptability and the preservation of traditional practices.

The contrast between a functional perspective (Cranmer et al., 2022; Buonincontri and Marasco, 2022; Pierdicca et al., 2022; Yang and Zhang, 2022; Zhang and Abd Rahman, 2022) and the critical perspectives (van Heur, 2012) highlights a tension in the literature. While digital technologies clearly enhance visitor experiences and promote sustainability, they may also disrupt conventional tourism practices and cultural institution management. This tension is further reflected in the diverse methodologies employed by the authors, which range from quantitative visitor satisfaction surveys to qualitative evaluations of institutional adaptability.

5.3. Tourism flow management and sustainability

This group of papers collectively show how smart technologies, such as AR or VR, can be utilized not only to enhance the cultural tourism experience but also to promote sustainability in managing cultural heritage sites. The central theme across these studies is the dual capacity of smart technologies to enrich the visitor experience and mitigate the environmental and social impacts of mass tourism. This thematic convergence aligns with contemporary discussions about balancing tourism development with heritage preservation, as well as integrating innovative technological solutions for sustainable urban management within smart cities.

Graziano and Privitera (2022) discuss how AR in Italy enhances the attractiveness of cultural sites by offering richer and more immersive experiences, aligning with the before mentioned Nevola et al. (2022) who also stress AR's potential in revealing hidden cultural aspects. Graziano and Privitera (2022)'s case studies illustrate how AR transforms static cultural artifacts into dynamic, interactive experiences, thereby enhancing visitor satisfaction and broadening the appeal of lesser-known cultural sites. Their research emphasizes that such technologies can create a more engaging and educational experience, which, in turn, contributes to the long-term sustainability of cultural tourism by encouraging repeat visits and increasing site visibility.

Frey and Briviba (2022) shift the focus to tourism management proposing strategies to regulate visitor flow and mitigate the negative impacts of tourism on cultural heritage. They propose a series of strategies that employ smart technologies to regulate tourist traffic, particularly in cities facing

excessive visitor numbers. Their study underscores the importance of managing visitor behaviour to mitigate the negative impacts of over-tourism, such as environmental degradation and damage to cultural sites. By using real-time data and smart sensors to monitor and direct tourist flows, Frey and Briviba (2022) demonstrate how smart city technologies can promote sustainable tourism practices, ensuring that cultural heritage is protected for future generations while maintaining high visitor satisfaction. This is in line with previous work by Pantano and Corvello (2013) work which argue that advanced technological innovations can not only promote arts and culture but also play a crucial role in controlling visitor behaviours, thus minimizing environmental degradation and damage to cultural sites. Both studies highlight the need for a more proactive approach to regulating tourism flow in order to protect cultural heritage, ensuring its preservation for future generations.

Further extending this discussion into a broader geographic context, Berjozkina and Kuruvilla (2022) focus on the integration of smart tourism strategies in the Baltic States. Their research emphasizes the role of smart technologies in simultaneously preserving cultural heritage and fostering sustainable tourism growth. They argue that smart tourism - enabled by technologies such as AR, VR and IoT - can create more balanced tourism practices by offering personalized and controlled visitor experiences. This not only enhances the quality of tourism but also alleviates the pressure on heritage sites, aligning with broader sustainability goals in the region. The authors advocate for the adoption of these technologies across other regions to ensure that cultural tourism can be both economically viable and environmentally responsible. Their view on smart tourism, as a balancing mechanism for economic viability and environmental responsibility, aligns with Garau's (2020) perspective on the role of mobile technologies in promoting sustainable and inclusive tourism development.

Panagiotopoulou et al. (2022) contribute to this discourse by highlighting the participatory potential of smart technologies, particularly in involving local communities in managing cultural tourism in historical city centres. They argue that digital platforms can support participatory tourism planning, mediating between the needs of tourists and residents. This perspective complements Garau's (2020) call for mobile technologies that enhance not only tourist experiences but also engagement with local stakeholders. By promoting participatory governance, these technologies help to foster a more inclusive form of tourism management, which ensures sustainability in social and cultural terms, in addition to environmental concerns.

In comparing these studies, a clear divergence emerges between those that focus on enhancing the cultural experience and those that emphasize sustainable management and tourism flow regulation. While both perspectives acknowledge the transformative power of smart technologies, they differ in their primary objectives: one aims to elevate the visitor's immersive experience, while the other is concerned with mitigating the negative impacts of tourism on cultural heritage. This duality illustrates

the multifaceted role of smart technologies in cultural heritage management, acting both as a tool for enriching the visitor experience and as a mechanism for managing environmental and social pressures.

Methodologically, these studies also adopt a blend of qualitative case analyses and strategic planning proposals. This mix of methodological approaches underscores the complexity of applying smart technologies in cultural tourism—requiring both localized, site-specific insights and broader, strategic planning efforts to balance the interests of heritage preservation and sustainable tourism development.

5.4. Smart cities and digital transformation

The final group focuses on the broader integration of smart cities with cultural heritage. Allam and Newman (2018) propose a redefinition of smart cities by integrating culture, sustainability and governance. They argue that cultural metabolism and participatory governance are crucial for a city's smart development, positioning culture as central to urban strategies. This perspective challenges the technocentric view of smart cities advocating for a more holistic approach where technology is a tool to enhance cultural identity and governance, rather than the sole driver of urban progress. Their vision is echoed in various ways across other studies with differing applications. For instance, Agostino and Costantini (2022), while similarly recognizing the significance of digital transformation, focus on its impact within cultural institutions, particularly how digital tools can democratize access to heritage and improve management. Their Italian case study aligns with Allam and Newman (2018)'s argument for cultural integration but operates at a more specific, institutional level. They emphasize that digital transformation can serve as a bridge between traditional heritage and modern technological frameworks.

The work of Sepasgozar et al. (2019) focuses on citizen-centric technology implementation in smart cities and emphasise the predictive modelling of urban technology acceptance. In contrast with Allam and Newman (2018) they are less focused on culture as an essential element and more on how cities can successfully introduce technologies that respond to citizens' needs. Their model suggests a more pragmatic approach, concentrating on the technological adaptation to urban life rather than embedding cultural dimensions in the core of smart city strategies. Gargiulo and Tremiterra (2017) also contribute to this conversation by exploring the intersection between smart cities and competitiveness using Florence as a case study. Like Allam and Newman (2018), they see culture and governance as central to a city's success, particularly in leveraging smart city technologies to enhance urban attractiveness for both residents and tourists. However, they place more emphasis on competitiveness and economic factors, suggesting that digital transformation can improve a city's

global standing. Their work reflects a more market-driven approach to smart city development where smart technologies are seen as a means to enhance urban economic competitiveness.

Magliacani (2019) introduces a sustainability perspective, particularly how the Sustainable Development Goals (SDGs) challenge traditional public management in smart cities. The work is particularly concerned with the balance between cultural preservation and sustainable urban development. Magliacani frames the analysis within the broader context of global sustainability targets, offering a framework that emphasizes the need to preserve cultural heritage while meeting the city's environmental objectives. This perspective highlights that cultural heritage serves both as a valuable asset and a potential challenge in achieving smart, sustainable urban development.

Lundh et al. (2020) takes this further by exploring how historic cities can manage the balance between cultural heritage and smart city transformation. Their focus on stakeholder collaboration in an old town transitioning to a smart city mirrors the participatory governance model proposed by Allam and Newman, but with a focus on managing complex relationships between diverse urban stakeholders. The collaborative approach they advocate highlights the necessity of bringing together government, private entities and citizens to preserve cultural heritage while embracing technological innovations. This more collaborative framework aligns with the inclusive governance models discussed by other scholars, reinforcing the importance of participatory approaches to smart city development. Finally, Romão et al. (2018) contribute to the dialogue by examining how smart cities can balance the needs of both residents and tourists, thus making the city a shared space of interaction. Their structural analysis of urban attractiveness shares thematic similarities with Gargiulo and Tremiterra (2017)'s emphasis on competitiveness, though their focus is more on how smart city technologies can improve the social and cultural dynamics between these two groups. They argue for a common ground in smart city design, where technology enhances both resident quality of life and tourist experience, pointing to a potential convergence of interests within the smart city framework.

5.5. Miscellaneous

This group includes articles that discuss relevant topics which do not fit into the previous four groups. Markellou (2023) discusses cultural heritage accessibility in the digital era within the Greek legal framework, emphasizing regulatory challenges and opportunities. The Greek legal framework, while designed to preserve the integrity of cultural heritage, often lacks the flexibility to fully accommodate emerging technologies. This creates a complex environment where stakeholders must navigate between traditional preservation mandates and the evolving demands of digital access. The discussion of these regulatory challenges raises broader questions about how governments and

institutions across Europe can adapt legal systems to facilitate digital transformations in cultural heritage sectors.

Gatelier et al. (2022), on the other hand, shift the focus toward practical solutions by proposing a business model innovation for cultural heritage attractions, aimed at integrating digital interpretation experiences. Their methodology emphasizes the necessity of reinventing traditional business models to enhance visitor engagement and ensure long-term sustainability of heritage sites. This approach, while still concerned with the preservation of cultural integrity, is more market-driven compared to Markellou (2023)'s regulatory analysis. Gatelier et al. (2022) view digital interpretation technologies as tools to create immersive experiences that both attract tourists and promote deeper engagement with cultural heritage. The balance between commercial viability and cultural preservation is central to their argument, and they propose that technological innovation must be accompanied by sustainable economic models to ensure the continued relevance of cultural heritage in a digital age. The inclusion of digital interpretation is seen as a critical mechanism for revitalizing cultural sites, fostering both educational outcomes and economic benefits.

6. Conclusions

In summary, the intersection of cultural heritage management and smart city development, through the lens of digital transformation, presents both opportunities and complex challenges. The findings from the first part of the study reveal that the digitalization of cultural heritage has been an underexplored area, with no academic attention until 2010. While there has been a gradual increase in research publications since then, it remains a niche field. Although some progress has been made, few studies address the intersection of digitization of cultural heritage and tourism, despite the evident need for a more integrated discourse. This gap is particularly significant for culturally rich cities such as Florence, Venice, and Barcelona, as well as areas with delicate ecosystems like coastal cities and national parks, where the challenges of over tourism intersect with digital heritage management. A deeper understanding of digital processes applied to cultural heritage could help manage the pressures of tourism more effectively in such vulnerable environments.

The increasing incorporation of digital technologies within cultural heritage management marks a pivotal shift in how cultural assets are engaged with and preserved in modern urban environments. As smart cities emerge as hubs of innovation, there is a pressing need to ensure that these advancements do not compromise cultural integrity but rather enhance it. The literature on technology applications in cultural heritage highlights the necessity of an approach that not only utilizes digital tools to enhance user engagement but also safeguards the authenticity and ethical stewardship of heritage assets. This dual emphasis on innovation and preservation underscores the importance of

interdisciplinary collaboration between technologists, historians and policymakers. As smart cities evolve, they must do so with a clear commitment to cultural integrity, suggesting that future smart city frameworks should integrate these two priorities in a balanced manner.

Similarly, the integration of smart technologies into cultural heritage tourism is seen as both promising and challenging. While digital tools such as AR and IoT offer immersive experiences and enable real-time data collection for improved site management, there is an emerging consensus that they should also support sustainable tourism practices. This sustainability focus is reinforced by a growing interest in participatory governance models, which involve local communities in the preservation and management of heritage sites. Empowering communities in this way aligns with the broader smart city goal of fostering inclusive and responsible urban development. Nevertheless, further studies are necessary to understand the long-term effects of community-driven models on heritage preservation, as well as the implications of involving diverse stakeholders in the management of these cultural assets.

Another critical dimension within this body of research is the digitalization of cultural heritage. While there is general agreement on the potential of digital technologies to enhance visitor engagement, opinions differ on their long-term impacts on cultural institutions. Some scholars view digitalization optimistically, seeing AR and smart technologies as transformative tools that modernize heritage experiences. Others, however, express concern that these innovations may undermine traditional practices and restrict the flexibility of cultural institutions. This divergence reveals a gap in the literature regarding the balance between functional enhancements and the preservation of traditional cultural values. Future research must therefore address how digital tools affect the adaptability and resilience of cultural institutions in preserving authentic heritage experiences.

The broader smart city literature, too, reflects a diversity of perspectives on the role of culture within technologically-driven urban strategies. Scholars agree on the need to integrate cultural heritage and sustainability into the concept of smart cities but vary in how this integration should be achieved. While some emphasize participatory governance and the cultural dimensions of smart cities, others focus on pragmatic aspects such as economic competitiveness and technological infrastructure. This divergence highlights that smart city models must extend beyond purely technological solutions, incorporating cultural, social, and governance elements to ensure comprehensive and sustainable urban development. Such an approach is crucial for promoting social equity and maintaining cultural identity within smart cities, especially as urban areas increasingly prioritize technological innovation.

The integration of cultural heritage into smart cities, therefore, reveals several significant trends and directions for future research. A central theme is the need for frameworks that balance the

immersive capabilities of digital tools with the preservation of authenticity in heritage assets. Additionally, the literature emphasizes the value of community participation in heritage management, with digital platforms potentially serving as a bridge between local communities and governance bodies in preserving cultural assets. Furthermore, the debate on the long-term effects of digitalization on cultural institutions suggests a gap in research, particularly regarding how these technologies impact the adaptability of heritage institutions. The consensus also points toward the necessity of holistic smart city strategies that integrate cultural and social dimensions with technological advancements, ensuring that cities remain inclusive and resilient while embracing innovation.

In conclusion, while digital technologies hold substantial promise for enhancing cultural heritage within smart city frameworks, the literature underscores the need to balance technological progress with cultural sustainability. As urban areas increasingly integrate smart technologies, future research should focus on frameworks that balance innovation with preservation. Such frameworks can help smart cities become vibrant, sustainable spaces that honor and uphold their cultural heritage. By fostering both technological advancement and cultural identity, this balanced approach reinforces heritage's role in creating dynamic, resilient urban landscapes.

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