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Research Article

The Role of Geographic Information Systems (GIS) in Participatory Conservation of Heritage Areas

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Abstract: In contemporary heritage management, participatory approaches play a crucial role in identifying and safeguarding values for a diverse range of stakeholders. This inclusive methodology involves professionals, local communities, historians, conservationists, and policymakers in conservation efforts. Successfully addressing challenges in stakeholder engagement is crucial for promoting ownership and stewardship, thereby supporting sustainable conservation efforts. Various methods such as community workshops and collaborative mapping exercises have been adopted. Geographic Information Systems (GIS) have emerged as a valuable tool in facilitating stakeholder participation. This research explores the potential of GIS in participatory heritage conservation. It aims to present principles and considerations to outline the practical application of GIS in engaging communities for heritage conservation. By bridging traditional heritage management practices with contemporary participatory methods, the research aims to enhance inclusive, informed, and sustainable conservation efforts. On this basis, qualitative methods and logical argumentation are used to analyze research content, drawing on qualitative and quantitative data from previous studies. A conceptual model is presented through a literature review, followed by an evaluation of five case studies from Iran, The USA, Finland, Egypt, and Spain that have utilized GIS in participatory planning processes. The research highlights GIS's capability to capture diverse social groups' perspectives on heritage values and priorities using participatory mapping. This integration of community insights empowers stakeholders in decision-making processes, enhancing inclusivity in heritage management and supporting community-driven initiatives for urban heritage preservation.

Keywords: Geographical Information System (GIS), Public Participation Geographical Information System (PPGIS), Participatory Conservation, Heritage Area

Highlights:

- This study explores the pivotal role of GIS in fostering participatory conservation efforts in heritage areas.
- The research offering a framework which outlines key principles for GIS-based participatory conservation.
- Through the evaluation of five diverse case studies, this research showcases the practical considerations of GIS in participatory conservation.

1. Introduction

It has been proven that local stakeholders can support and actively contribute to the success of heritage planning (Li et al., 2020; Mirzakhani et al., 2021). While referring to a wide range of stakeholders in planning historical areas, many world heritage conservation organizations have emphasized the importance of local communities, their traditions, and their way of life (Landorf, 2009, pp. 495–497). For heritage planning, participation can enable consensus in defining heritage significance and values to promote heritage resources for sustainable conservation and development (Huang, 2024). Therefore, participatory heritage planning protects the features and values important to different stakeholders (Foroughi et al., 2023, p. 9). With a proper participatory approach, people can actively participate in planning and find practical, local, and long-term solutions for urban conservation and development programs (Ericson, 2006). Hence, Urban experts have used community-based participatory research for decades, citing benefits such as faster identification of community-relevant research targets, and accelerated transfer of knowledge and findings to the community. Also, researchers from heritage organizations have found that balancing conservation measures with community-based interests will require the participation of people to upgrade their communities to a protected status (Lafreniere et al., 2019, p. 2).

GIS is a technology used for capturing, storing, managing, analyzing, and visualizing geographic data (Huang, 2024) which has been highlighted as essential future knowledge (Humble, 2023). GIS integrates geographical spatial data, such as maps, satellite images, and terrain data, and attributes, such as demographic statistics and land use, to create visual maps and conduct spatial analysis, facilitating a better understanding

of spatial relationships and decision-making (Huang, 2024). The use of GIS in urban planning helps planners in the orderly development of settlements and infrastructure services in an integrated manner (Box, 1999, p. 66). The use of GIS in this field varies depending on the spatial context, its development and design, the analysis and modeling of various ongoing processes, and the relationships between these processes or developments within the space. (Xhafa & Kosovrasti, 2015, p. 85). GIS was established as a support for urban planning in a participatory way (Mollo et al., 2020). On this basis, the Participatory Geographic Information System emerged in the mid-1990s in response to criticisms of GIS regarding its social nature and its effects on society (Mollo et al., 2020). On the other hand, existing academic literature and research increasingly recognize the role of information technologies in cultural heritage (Liu et al., 2024). Coupled with advancements in modern technologies like remote sensing (Agapiou et al., 2015), Artificial Intelligence (AI) (Mishra & Lourenço, 2024), Virtual Reality (VR) (Zhong et al., 2021), 3D modeling, Building Information Modelling (BIM) (Pocobelli et al., 2018), laser scanning (Greenop & Landorf, 2017), and web map services (Puertas-Aguilar et al., 2023), GIS has become integral to advanced and digital conservation practices (Liu et al., 2024) and has started to be considered as an auxiliary tool for heritage conservation (Giannopoulou et al., 2014). This has broadened participation in conservation efforts beyond professional circles (Mollo et al., 2020). as well as in interpreting historical geographical information, thereby enhancing the understanding of the history and cultural background of heritage (Santos et al., 2023).

This study aims to explore the role of Geographic Information Systems (GIS) in facilitating participatory conservation efforts in heritage areas, Hence, the theoretical foundation of this study will delve into the utilization of GIS in both heritage conservation and public engagement. Subsequently, the article will introduce a theoretical framework that highlights key principles crucial for GIS-based participatory conservation. The following section of the study will focus on evaluating five case studies from Iran, the USA, Finland, Egypt, and Spain based on these fundamental principles. Eventually, the insights gained from the case study evaluations will provide support for the theoretical considerations outlined in the study.

2. Literature Review

2.1. GIS & Heritage Conservation

The pioneering GIS, developed by Canadian surveyor R. Tomlinson in 1963, marked the beginning of GIS as an important tool in cultural heritage fields (Liu et al., 2024). Acknowledging cultural heritage as a finite resource imbued with inherent prospects for future investigation has brought to the forefront the significance of GIS in the realm of cultural heritage management (Huang, 2024). GIS is a valuable tool for managing cultural heritage resources (Santos et al., 2023), empowering heritage managers to access, organize, analyze, and retrieve data effectively (Huang, 2024). Its applications include defining protected areas (Tezel et al., 2021), incorporating heritage values into development planning (Brown et al., 2018), and forecasting the impacts of development projects on heritage sites (Ababneh et al., 2019). Archaeologists also utilize GIS for analyzing known cultural resources and predicting the locations of undiscovered heritage assets (Box, 1999) as well as the creation of models showing the main stratification at an archaeological site (Neubauer, 2004).

The role of GIS technology is pivotal in heritage preservation research, enabling the development of dynamic information management systems (Liu et al., 2024) and effectively advancing the sustainable conservation and transmission of heritage resources. It can be used to analyze and assess the impacts of natural and anthropogenic threats on heritage, such as geological disasters, Global Change, and urban expansion, to implement appropriate conservation measures (Huang, 2024). Its use could lead to efficient ideas for urban transformations and relevant plans for using heritage assets, leveraging the existing heritage and territory potentials towards sustainable and smart city development (Giannopoulou et al., 2014). Furthermore, GIS can be utilized for the digital recording and document management of heritage (Santos et al., 2023), integrating spatial and attribute data of heritage sites (Huang, 2024). It also serves as valuable support for recording and classifying elements to be included in HBIM libraries to accurately describe the built heritage to be modeled (Mollo et al., 2020). The evolution of GIS applications in heritage studies, driven by the development of historical urban landscape methodologies, incorporates modern technologies like HBIM and digital preservation techniques to offer a robust tool for understanding, protecting, and managing heritage resources (Santos et al., 2023). Additionally, the creation of thematic maps enhances the system's usability and user-friendliness (Giannopoulou et al., 2014).

In the realm of heritage conservation, Historical GIS (H-GIS) is an interdisciplinary field that merges historical knowledge with GIS expertise (Gregory & Ell, 2007, p. 2). Scholars have acknowledged the value of HGIS-based analyses in reexamining established historical narratives from new vantage points (Knowles, 2016). While previous studies have underscored the significance of HGIS methodology, they have also highlighted a key obstacle facing HGIS research: the substantial time and resource investments needed to construct the requisite geographic datasets (Knowles, 2016; Lafreniere et al., 2019, p. 2; Southall, 2014). When it comes to shaping this data, experts frequently take on a primary role, while the involvement of local communities tends to be minimal. Through the engagement of the general public in the collection and generation of data, a community-participatory strategy within HGIS strives to uphold and protect heritage, history, the environment, and traditions. Ultimately, this approach endeavors to enhance community awareness of their historical legacy through the utilization of location-based technologies (Lafreniere et al., 2019).

2.2. GIS & Public Participation

Since the late 1980s, concerns have been raised in the academic field about the accountability of GIS from political, economic, social and ethical perspectives. In particular, this concern focused on the social implications of how people, space, and the environment are represented in GIS (Stewart et al., 2008, p. 353). The term Public Participation Geographic Information System (PPGIS) was coined in 1996 in the United States of America to describe how GIS technology can support public participation in various programs aimed at the inclusion and empowerment of marginalized populations (Brown, 2012, p. 7). This leads to an equitable citizen-researcher-government partnership and increased trust and empowerment by stakeholder groups (Robinson et al., 2017). Hence, given these foundational concerns about accountability and representation in GIS, the emergence of PPGIS underscores the evolution of participatory methodologies aimed at fostering equity and empowerment within communities.

Participatory Geographic Information System (PGIS), Voluntary Geographic Information System (VGI or VGIS), Public Participation Geographic Information System (PPGIS) and Community Action Geographic Information System (CAGIS) are related terms that describe the processes

of collecting and using non-expert spatial information through a participatory approach with GIS (Brown et al., 2022; Brown & Kyttä, 2014, p. 123; Stewart et al., 2008). The term Voluntary Geographical Information System (VGIS) typically uses citizen-initiated, easy-to-use sampling methods that generate individual cartographic contributions. VGI describe how citizens can use GPS devices to act as "volunteer sensors" and produce collective geospatial knowledge (Sofianopoulos et al., 2024). The ubiquity of user-generated spatial information and mapping applications in VGIS has contributed to the "crowdsourcing" of spatial information, where content is requested from a large group of people, especially an online community (Brown & Kyttä, 2014, p. 126). Crowdsourcing can be a powerful tool for enhancing public participation in urban planning processes. In general, crowdsourcing can be considered as an activity of using the power of the crowd to accomplish a task or to solve a problem (Nummi, 2018). The main goal of CAGIS (Community Action Geographic Information System) is to ensure that community members are allowed to take ownership of research, questions and design, in a way that provides the community with dynamic tools and skills to help Leave it to the decision making in the present and the future. This approach has the potential to create actions that may in turn lead to the refinement of GIS technology and more importantly to community empowerment (Stewart et al., 2008, p. 356). In developing countries, the focus of PGIS has been on social learning and social participation. PGIS is used as a development tool to encourage community identity, and empowerment and build social capital. Promoting social justice and equality is often an implicit goal of this process. In many cases, the participation component is more important than the resulting maps, which are assumed to be the intellectual property of the people and communities that created them (Brown & Kyttä, 2014, p. 125). In contrast, PPGIS may be sanctioned by government agencies, especially in Western democracies, as a more effective tool for engaging in public participation and community consultation in land use planning and decision-making (Brown, 2012, p. 11; Mukherjee, 2015). Nevertheless, despite the nuanced distinctions among them, this paper will collectively regard PGIS, VGI, PPGIS, and CAGIS as synonymous to examine their influence on participatory methodologies in the conservation of heritage areas.

From Brown's point of view, using GIS in participatory planning can lead to identifying spatial features and development priorities, supporting or non-supporting previous decisions, and providing planning alternatives (Brown, 2012, p. 11). These features rely on people's prior experiences in a place identified through participatory mapping (Brown & Kyttä, 2014, p. 127). With participatory mapping, it is possible to combine appreciative knowledge from participants with spatially specific information about physical planning solutions (Brown et al., 2022). Radil and Jiao believe the main advantage of PPGIS is the ability to combine and contextualize quantitative data with community perceptions in a consensus-driven dialogue with stakeholder groups (Radil & Jiao, 2016). Thompson argues that integrated community-based GIS can "inform processes and relationships rather than extract patterns from large volumes of data" (Thompson, 2015). Hence, PPGIS aimed at advancing the level of citizens' involvement in decision-making in urban planning by using online, GIS-based, and interactive maps (Poplin, 2012). This can be a potential tool for plan evaluation, helping identify place-based conflicts among various interests and finding optimised community land use outcomes (Brown et al., 2022).

In summary, the theoretical framework of this research posits that the Main goal of participatory conservation in heritage areas is to facilitate sustainable conservation and development (Ericson, 2006; Huang, 2024). Subsequently, the application of Geographic Information Systems (GIS) in this context can be clarified through four fundamental principles: 1- Integrating spatial and attribute data through digital recording of heritage resources (Huang, 2024; Mollo et al., 2020; Santos et al., 2023); 2- Predicting and assessing potential impacts in heritage areas and providing planning alternatives (Box, 1999; Brown, 2012; Brown et al., 2022; Huang, 2024); 3- Advancing heritage comprehension through the identification of heritage values (Brown, 2012; Brown et al., 2022; Knowles, 2016; Mollo et al., 2020; Santos et al., 2023); 4- Encouraging community identity and ownership through the participatory mapping process (Brown et al., 2022; Brown & Kyttä, 2014; Poplin, 2012; Stewart et al., 2008). Figure 1 illustrates the theoretical framework of this study.

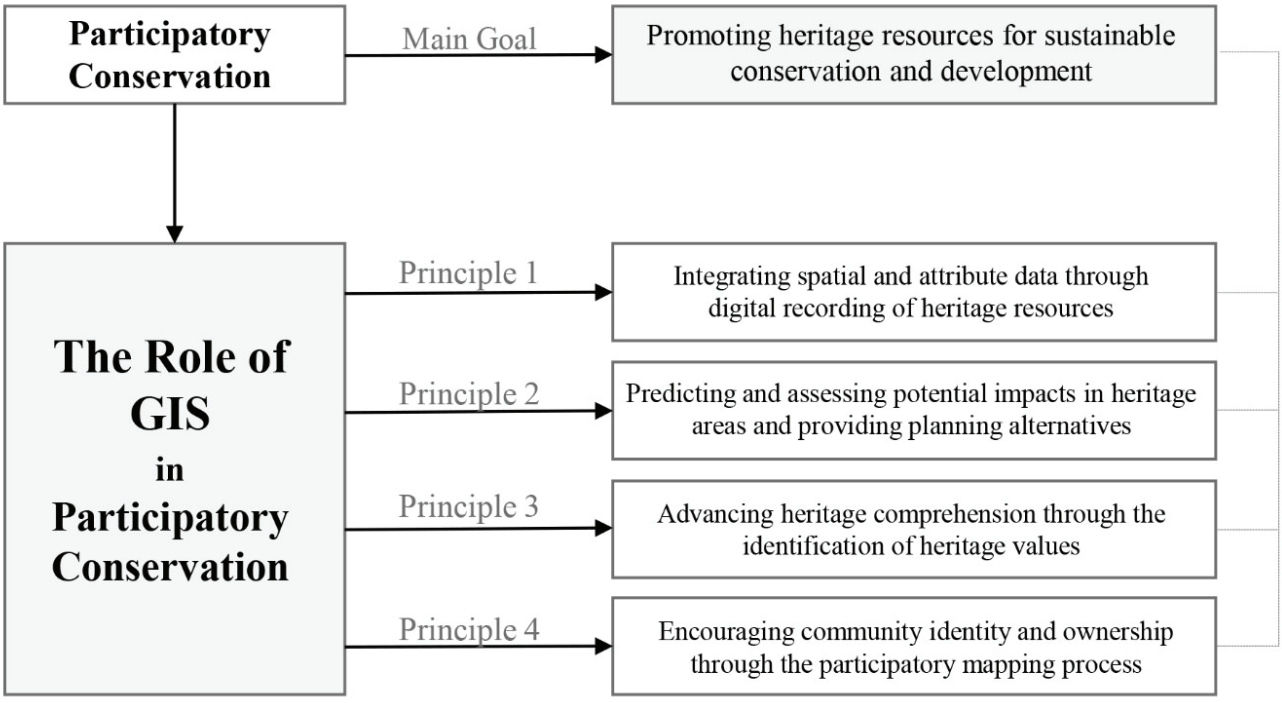

Figure 1. Theoretical framework of the study, highlighting the key principles of GIS in participatory conservation goal

3. Materials and Methods

This study adopts a qualitative approach, employing logical argumentation to analyze pertinent research content and integrating both qualitative and quantitative data from previous studies. After a thorough examination of the theoretical framework, the paper introduces a conceptual model for a literature review, delineating the fundamental principles that underscore the significance of Geographic Information Systems (GIS) in participatory conservation efforts. Subsequently, the paper investigates five case studies that have utilized GIS in participatory planning processes, spanning various contexts including developed and developing countries. Specifically, the case studies draw from previous research on Participatory GIS (PPGIS) in Iran, the USA, Finland, Egypt, and Spain offering a comprehensive exploration of the applications and implications of GIS in participatory approaches. After examining the study studies, their main strategies were extracted (n=20), and subsequently, the most relevant strategies were selected and utilized as research considerations (n=12) following the research's principles.

4. Case Studies

The article seeks to explicate the effectiveness and potential of Geographic Information Systems (GIS) in fostering inclusive and participatory approaches to heritage areas. In light of this, the research evaluates five case studies from Iran, The USA, Finland, Egypt, and Spain that have utilized GIS in participatory planning processes. The selection of the five case studies for this research is grounded in the need to evaluate a diverse array of contexts that encompass both developed and developing countries, thereby providing a comprehensive understanding of participatory conservation practices. By including various heritage areas—such as urban environments, rural landscapes, industrial landscape, religious complexes, and villages—this study captures the multifaceted nature of heritage conservation across different settings. Furthermore, the case studies represent distinct projects with varying objectives, allowing for a nuanced exploration of how specific goals influence conservation strategies. Additionally, the incorporation of various types of strategies utilizing the Public Participatory Geographic Information Systems (PPGIS) approach highlights the adaptability and effectiveness of participatory methods in engaging communities and addressing local heritage concerns. The location of these cases is displayed in Figure 2. Subsequently, an overview of the objectives and strategies within their PPGIS process is presented in Table 1.

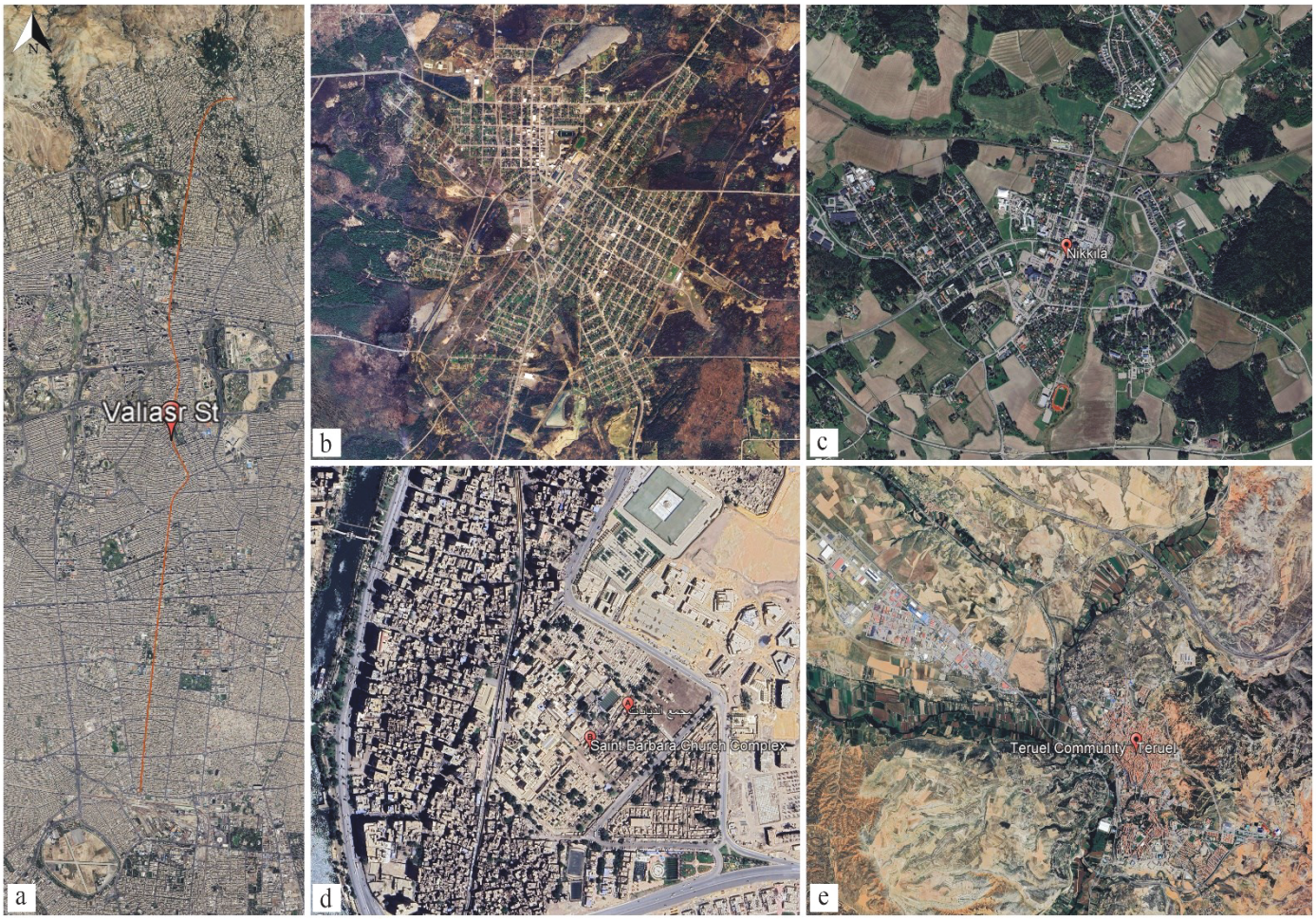

Figure 2. The location of case studies on Google Earth, 2024: **(a)** Valiasr Street, Tehran, Iran; **(b)** Michigan's copper country, Keweenaw Peninsula, USA; **(c)** Nikkilä village, Sipoo, Finland; **(d)** Religious Complex, Old Cairo, Egypt; and **(e)** Teruel rural, Spain

4.1. Valiasr Street, Tehran, Iran

The initial case study focuses on the values embedded in the historical urban landscape of Valiasr Street in Tehran, Iran, intending to prioritise conservation management efforts. It highlights key areas that are critical and imbalanced while evaluating the street's values through the lens of public opinion. Utilizing Public Participation Geographic Information Systems (PPGIS), the study collects and analyzes public perceptions, merging various data sources to produce a thorough spatial analysis. It visualizes the distribution of historical, cultural, social, economic, aesthetic, and natural values as understood by the community. The research seeks to improve public involvement in cultural heritage management and to guide more informed decision-making that honours and safeguards the area's diverse heritage. Additionally, it contributes to the wider discussion on the Historic Urban Landscape approach, stressing the importance of incorporating public perceptions and values into urban heritage management strategies (Andaroodi & Taqipour Anari, 2018).

4.2. Michigan's copper country, Keweenaw Peninsula, USA

The second case study is The Keweenaw Time Traveler (KeTT) project located in Michigan's Copper Country, a historically significant region in copper mining and industrialization in the United States. This project focuses on the development of a public participatory historical geographic information system (PPHGIS). It leverages the region's rich copper mining and industrial history to engage the public in the creation and use of historical geographic information systems (HGIS). By involving the community in classifying building materials, categorizing building uses, and transcribing historical maps, the project has fostered a collaborative environment that enhances the relevance and sustainability of historical data projects. The KeTT project's emphasis on community engagement and its innovative applications, such as the Document Building Material App, Document Building Use App, Transcribe the Map App, and Explore App, have facilitated the collection of over 250,000 classifications and numerous user-submitted stories. The project's collaborative consensus model for data classification ensures accuracy and addresses common challenges in crowdsourcing historical data. The KeTT project's success in maintaining public interest and engagement through outreach efforts under-scores its value as a model for public participatory historical GIS, enriching historical scholarship and promoting a deeper understanding of local heritage (Lafreniere et al., 2019).

4.3. Nikkilä village, Sipoo, Finland

The third case study explores the use of Participatory Public Geographic Information Systems (PPGIS) and social media to crowdsource local knowledge for urban planning in Nikkilä, Finland, aiming to uncover intangible cultural heritage through place-based memories. The "Nikkilä Memories" project compares non-professional knowledge with expert knowledge, revealing valuable insights into the intangible aspects of the built cultural heritage. Utilizing a map questionnaire created with the "Maptionnaire" tool and social media data, the study gathered place-based memories and experiences from local residents, who shared their recollections using the hashtag #muistojennikkilä and a local Facebook group focused on old buildings in Sipoo. This approach bridged the gap between expert evaluations and local values, highlighting the intangible dimensions of Nikkilä's cultural heritage. The findings were used to inform urban planning processes, particularly in the context of the area's ongoing transformation and densification, ensuring that the planning process was more inclusive and culturally sensitive (Nummi, 2018).

4.4. Religious Complex, Old Cairo, Egypt

The fourth case study focuses on the Religious Complex in Old Cairo, Egypt. This complex is significant as it houses sites sacred to three monotheistic religions, making it a unique and rare heritage location. The public spaces within this complex are the subject of the study, which aims to understand how these spaces are used by the public and to evaluate their efficiency. In this project, the researchers conducted an online survey using the Public Participation Geographic Information System (PPGIS) methodology, which involved mapping and rating various items on an interactive map created with ArcGIS. The survey was designed to collect data on how users interact with and perceive the heritage public spaces within the Religious Complex. Also, this survey captured georeferenced information for the precise mapping of opinions and preferences onto the GIS map. The process is used to understand the specific locations within the heritage site that require attention or improvement (Elgobashi & Elsemary, 2021).

4.5. Castellón and Teruel rural, Spain

The fifth case study examines the tangible and intangible aspects of a rural area in Spain, using a digital database to consolidate and visualize findings from the assessment of ten historical urban centers, integrating historical, architectural, and social values to support the Territorial Heritage Action Plan. Focusing on a small region on the east coast of Spain, in the provinces of Castellón and Teruel, the study explores ten municipalities that share common characteristics such as demography, economy, society, problems, and limitations. These areas are notable for their vernacular architecture, reflecting medieval culture and utilizing local materials and construction techniques. The primary goal of the project is to enhance the understanding and preservation of the unique historic environments of these municipalities by employing a GIS-based methodology to accurately catalogue and assess their historical, architectural, and social values. This approach aims to avoid general assumptions and focus on the subtle differences and specificities of the local heritage. Ultimately, the research seeks to reinforce the Territorial Heritage Action Plan (THAP) by integrating these detailed assessments into a digital database, promoting informed and effective heritage management and fostering a sense of collective ownership and responsibility among the local communities (García-Esparza & Altaba Tena, 2020).

5. Results

By evaluating each case study in accordance with the main principles of the theoretical framework (Figure 1), the following insights can be gained; In Valiasr Street, Tehran, Iran, the emphasis was on integrating spatial data by mapping the values that gathered from participants. Also, this case identified areas of imbalance and prioritized conservation efforts via participatory mapping techniques. The project in Michigan's copper country, USA aims to enrich the understanding of the region's history by providing a comprehensive resource and promoting the long-term

sustainability of historical data crowdsourcing through comprehensive public outreach. Additionally, this project facilitates the sharing of personal historical narratives through spatial storytelling by creating an accessible platform for users to interact with historical spatial data. Nikkilä, Sipoo, Finland, emphasized comparing expert opinions with local memories, identifying threats to intangible heritage, and crowdsourcing local knowledge through PPGIS and social media. The Religious Complex in Old Cairo, Egypt, concentrated on identifying key improvement areas and utilizing GIS technology to visualize planning scenarios for increased awareness. Lastly, in Castellón and Teruel rural, Spain, the study involved qualitative analysis of participant values, reinforcing the Territorial Heritage Action Plan, and engaging the community through graphic data collection and participatory activities. Further details regarding the relation between the strategies employed in the case studies and the key theoretical principles are presented in Table 2. Following this, the most pertinent strategies are identified as considerations for the theoretical principles of this study.

Table 1. Clarifying the main objectives of each case study and strategies in their PPGIS process

Case Studies	Main objectives of the project	Main strategies in the PPGIS process
Valiasr Street, Tehran, Iran (Andaroodi & Taqipour Anari, 2018)	● Gather public perceptions and values associated with different segments of Valiasr Street using PPGIS.	● Create detailed maps with georeferenced data and visualize the spatial distribution of various values as perceived by the public.
	● Create a spatial database of historical, cultural, social, economic, aesthetic, and natural values.	● Use GIS tools to identify patterns and clusters of public values by overlaying georeferenced survey data onto urban maps and aerial photographs.
	● Contribute to the broader discourse on the Historic Urban Landscape (HUL) approach by emphasizing the importance of integrating public perceptions.	
Michigan's copper country, Keweenaw Peninsula, USA (Lafreniere et al., 2019)	● Enriching the overall understanding of the region's history as well as providing a more comprehensive resource.	● Facilitating the sharing of personal historical narratives through spatial storytelling.
	● Fostering a sense of ownership and investment among community contributors.	● Classifying historic building materials and uses and transcribing historical notations from maps.
	● Promoting long-term sustainability and success of historical data crowdsourcing projects through comprehensive public outreach	● Creating an accessible platform that allows users to interact with historical spatial data.
Nikkilä village, Sipoo, Finland (Nummi, 2018)	● Uncover the intangible dimensions of Nikkilä's cultural heritage by collecting residents' memories and experiences.	● Utilize the Maptionnaire tool, a map-based questionnaire was created to collect place-based memories and experiences from residents.
	● Study and compare the values that residents and experts place on built cultural heritage objects.	● Encourage residents to share their memories and experiences on social media using specific hashtags.
		● Use social media and other tools to create visual representations of place-based experiences.
Religious Complex, Old Cairo, Egypt (Elgobashi & Elsemary, 2021)	● Determine the needs and preferences of the public regarding the commercial, social, recreational, and cultural activities that could enhance the spaces.	● Use Google Maps as a base map, allowing participants to place and rate items directly on the map.
	● Assess the level of community attachment and sense of place among the users of the heritage public spaces.	● Create placemaking criteria such as Access & Linkage, Comfort & Image, Uses & Activities, and Sociability to evaluate the public spaces within the heritage site.
	● Identify areas for improvement and development that could lead to a better sense of belonging and pride in the place.	
Castellón and Teruel rural, Spain (García-Esparza & Altaba Tena, 2020)	● Deepen the understanding of the unique historical, architectural, and social values, focusing on their vernacular architecture and cultural heritage.	● Involve local residents and stakeholders through structured individual and group interviews, workshops, and heritage days.
	● Cataloging and mapping the tangible and intangible heritage elements, thereby creating a comprehensive digital database.	● Implement Geographic Information System (GIS) technology to create detailed maps that catalog and georeferenced tangible and intangible heritage elements.
	● Foster a sense of collective ownership and responsibility among local communities by involving them in the heritage preservation process.	● Integrate various methodologies, such as the Historic Urban Landscape (HUL) approach and the Historic Area Assessment (HAA), to provide a comprehensive framework for assessing and managing heritage values.

Table 2. Assessment of the PPGIS process in each case study with key principles of the theoretical framework

Case Studies	Principle 1 Integrating spatial and attribute data through digital recording of heritage resources	Principle 2 Predicting and assessing potential impacts in heritage areas and providing planning alternatives	Principle 3 Advancing heritage comprehension through the identification of heritage values	Principle 4 Encouraging community identity and ownership through the participatory mapping process
Valiasr Street, Tehran, Iran (Andaroodi & Taqipour Anari, 2018)	· Collecting the spatial values and distributing them on the GIS map	· Identification of unbalanced areas and Prioritizing conservation management activities	· Redefinition of heritage values based on various stakeholders' opinion	· Participatory activities through engaging various stakeholders
Keweenaw County, Michigan, USA (Lafreniere et al., 2019)	· Utilizing georeferenced historical maps to explore the spatial distribution of heritage resources	· Creating historical spatial data infrastructure (HSDI) to predict planning's results on heritage resources.	· Involving local people in sharing their historical narratives about heritage values.	· Transcribing historical notations through a participatory mapping process.
Nikkilä village, Sipoo, Finland (Nummi, 2018)	· Comparison expert opinions with local people's place-based memories	· Identifying potential threats to elements of intangible cultural heritage	· Collecting local people's place-based memories related to old buildings and places	· Crowdsourcing of local people's knowledge with PPGIS and social media
Religious Complex, Old Cairo, Egypt (Elgobashi & Elsemary, 2021)	· Using a digital map with the placemaking criteria to create a comprehensive understanding of the public spaces	· Identifying key areas that could benefit from improvements or developments, based on public input	· Identifying important tangible and intangible values that are important to the community	· Using GIS technology to visualize different planning scenarios to promote greater awareness
Castellón and Teruel rural, Spain (García-Esparza & Altaba Tena, 2020)	· Qualitative analysis of techniques and materials by mapping the values obtained from participants	· Reinforce the Territorial Heritage Action Plan with an assessment of Historic Urban Cores	· Collecting personal experiences in the form of memories and values through graphic data collection	· Participatory activities through explorative meetings and the celebration of heritage days

The process of identifying strategies as considerations for the research's theoretical principles involves a systematic evaluation of five diverse case studies, each contributing unique insights and methodologies. Initially, the evaluation of these case studies led to the extraction of twenty main strategies, which were subsequently refined to twelve selected strategies that align closely with the established theoretical framework (Figure 3). Each case study, ranging from Valiasr Street in Tehran to rural areas in Spain, provided valuable data on spatial people's values, stakeholder engagement, and the integration of local knowledge through Geographic Information Systems (GIS). The selected strategies for participatory conservation of heritage areas are significantly informed by the contributions of various case studies. In Valiasr Street, Tehran, the focus on investigating and mapping spatial people's values using GIS, engaging stakeholders in participatory activities, and redefining heritage values based on diverse stakeholder opinions highlights the importance of community involvement. Michigan's copper country, USA Utilizes georeferenced historical maps and historical spatial data infrastructure (HSDI) to explore the distribution of heritage resources and predict potential effects on them. This project also Involves local people in sharing their historical narratives about heritage values by transcribing historical notations from maps. Nikkilä Village in Sipoo, Finland, enhances the approach by comparing expert opinions with local people's place-based memories and crowdsourcing local knowledge through PPGIS and social media. The Religious Complex in Old Cairo, Egypt, adds value by identifying key areas for potential improvements and utilizing GIS technology to visualize different planning scenarios, thereby promoting greater awareness. Lastly, Castellón and Teruel Rural in Spain contribute by identifying the personal experiences of inhabitants through graphic data collection and increasing participatory activities via explorative meetings and workshops. The selected strategies, therefore, serve as considerations for this research, facilitating a deeper exploration of how GIS can enhance participatory approaches in heritage conservation and promote sustainable management practices that resonate with community identities and values.

Eventually, the most pertinent strategies of cases are highlighted and presented under each principle of the theoretical framework as considerations (Table 3). In this study on the role of GIS in the participatory conservation of heritage areas, the considerations for each principle play a crucial role in guiding the implementation of GIS tools effectively. The first principle focuses on integrating spatial and attribute data through the digital recording of heritage resources. Considerations such as investigating the spatial people's values, utilizing georeferenced historical maps to explore the spatial distribution of heritage resources, and comparing expert opinions with local people's place-based memories ensure that the data integrated into GIS maps accurately represent the heritage area. The second principle emphasizes predicting and assessing potential impacts in heritage areas and providing planning alternatives. Considerations like prioritizing conservation management activities, creating historical spatial

data infrastructure (HSDI), and Identifying key areas that could benefit from improvements or developments aid in developing effective conservation strategies. The third principle aims to advance heritage comprehension through the identification of heritage values. Considerations such as redefining values based on people's opinions, involving local people in sharing their historical narratives about heritage values, and identifying the personal experiences of inhabitants through graphic data collection contribute to a deeper understanding of the heritage area. Lastly, the fourth principle focuses on encouraging community identity and ownership through the participatory mapping process. Considerations like Using GIS technology to visualize different planning scenarios and promote greater awareness, crowdsourcing local people's knowledge with PPGIS and social media, and increasing participatory activities through explorative meetings and workshops help foster a sense of community involvement and ownership in the conservation efforts.

Figure 3. The process of identifying the most pertinent strategies in accordance with theoretical principles

6. Discussion

The theoretical foundation and case studies presented in this research underscore the transformative potential of Geographic Information Systems (GIS) in facilitating the participatory conservation of heritage areas. One of the key lessons learned is the importance of integrating community values and narratives into heritage management practices. The case studies from diverse geographical contexts illustrate how participatory mapping processes can effectively capture local knowledge and foster a sense of ownership among stakeholders. This integration not only enhances the understanding of heritage values but also informs decision-making processes, ensuring that conservation strategies are aligned with the needs and aspirations of the community. Furthermore, the findings highlight the necessity of employing a multi-faceted approach that combines spatial data with qualitative insights, thereby enriching the conservation discourse and promoting sustainable practices that resonate with local identities. On this basis, the role of GIS is to facilitate the inclusion of diverse community voices and perspectives in the decision-making processes related to heritage management. PPGIS serves as a platform that empowers local stakeholders to actively engage in mapping and expressing their values, preferences, narratives and concerns regarding heritage resources. By utilizing PPGIS, communities can collaboratively identify and prioritize heritage sites, assess potential impacts of development, and contribute to the creation of informed conservation strategies

that reflect their unique cultural and historical contexts. Moreover, this integration allows for a more comprehensive analysis of heritage values, fostering a deeper appreciation of the intangible aspects of cultural heritage.

However, despite the promising applications of PPGIS in heritage conservation, the case studies highlight several shortcomings in their research. A significant limitation is the potential for unequal participation, where certain demographic groups dominate the discourse which skews the understanding of heritage values. Additionally, reliance on technology can create barriers for individuals lacking access to digital tools or skills. The time and resource-intensive nature of data collection and analysis can also pose challenges for smaller communities with limited capacities. Furthermore, the effectiveness of PPGIS can be compromised if community input is not adequately integrated into decision-making processes or if there is insufficient follow-up on the collected data.

Table3. Presenting the main consideration of case studies in the PPGIS process following the theoretical principles

Principles	Considerations
1- Integrating spatial and attribute data through digital recording of heritage resources (Huang, 2024; Mollo et al., 2020; Santos et al., 2023)	1-1 Collecting the spatial values and distributing them on the GIS map (Andaroodi & Taqipour Anari, 2018) 1-2 Utilizing georeferenced historical maps to explore the spatial distribution of heritage resources (Lafreniere et al., 2019) 1-3 Comparison expert opinions with local people's place-based memories (Nummi, 2018)
2- Predicting and assessing potential impacts in heritage areas and providing planning alternatives (Box, 1999; Brown, 2012; Brown et al., 2022; Huang, 2024)	2-1 Prioritizing conservation management activities according to potential impacts (Andaroodi & Taqipour Anari, 2018) 2-2 Creating historical spatial data infrastructure (HSDI) to predict planning's results on heritage resources (Lafreniere et al., 2019) 2-3 Identifying key areas that could benefit from improvements or developments, based on public input (Elgobashi & Elsemary, 2021)
3- Advancing heritage comprehension through the identification of heritage values (Brown, 2012; Brown et al., 2022; Knowles, 2016; Mollo et al., 2020; Santos et al., 2023)	3-1 Redefinition of heritage values based on various stakeholders' opinion (Andaroodi & Taqipour Anari, 2018) 3-2 Involving local people in sharing their historical narratives about heritage values (Lafreniere et al., 2019) 3-3 Identifying the personal experiences of inhabitants through graphic data collection (García-Esparza & Altaba Tena, 2020)
4- Encouraging community identity and ownership through the participatory mapping process (Brown et al., 2022; Brown & Kyttä, 2014; Poplin, 2012; Stewart et al., 2008, 2008)	4-1 Using GIS technology to visualize different planning scenarios and promote greater awareness (Elgobashi & Elsemary, 2021) 4-2 Crowdsourcing of local people's knowledge with PPGIS and social media (Nummi, 2018) 4-3 Increasing participatory activities through explorative meetings and workshops (García-Esparza & Altaba Tena, 2020)

7. Conclusions

In conclusion, this study focuses on the pivotal role of Geographic Information Systems (GIS) in fostering participatory conservation efforts in heritage areas. By integrating spatial and attribute data through digital recording of heritage resources, GIS enables a comprehensive understanding of heritage values and potential impacts, thereby guiding effective conservation strategies. Through participatory mapping processes, GIS facilitates community engagement and ownership, ensuring inclusive and sustainable heritage preservation. The evaluation of five case studies from diverse geographical contexts, objectives, and strategies highlights the effectiveness of GIS in heritage conservation. From Valiasr Street in Tehran, Iran, to rural areas in Spain, each case study demonstrates the importance of integrating community values, assessing potential impacts, identifying heritage values, and encouraging community participation. These considerations, rooted in the theoretical framework of the study, provide a roadmap for leveraging GIS tools effectively in participatory conservation efforts. Moving forward, the findings of this research underscore the significance of GIS in bridging traditional heritage management practices with contemporary participatory methods. By empowering stakeholders in decision-making processes and capturing diverse social groups' perspectives on heritage values, GIS enhances inclusivity in heritage management and supports community-driven initiatives for urban heritage preservation.

Overall, this study contributes to the growing body of literature on the intersection of GIS technology and participatory conservation in heritage areas. The findings of this research demonstrate that Geographic Information Systems (GIS) are essential for enhancing participatory conservation efforts in heritage areas by integrating heritage values, facilitating community engagement, guiding effective conservation strategies, and prioritizing conservation and development measures through participatory mapping and spatial data analysis. In addition to that, the insights gained from the theoretical framework, case study evaluations, and key considerations provide a robust foundation for future research and practical applications of GIS in heritage conservation and urban planning. As heritage conservation continues to evolve in the digital age, the role of GIS in facilitating participatory approaches remains paramount for fostering sustainable and inclusive conservation efforts worldwide. On this basis, future research could focus on assessing the long-term impacts of GIS-based participatory conservation efforts on heritage areas, exploring the scalability of GIS technologies in different heritage contexts such as archaeological heritage, industrial heritage, and modern heritage. Also, it is highly recommended that future research investigates the integration of emerging technologies like AI and VR with GIS in heritage conservation for innovative community engagement.

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References

Ababneh, A., Al-Saad, S., Al-Shorman, A., & AL Kharouf, R. (2019). Land use change at the historical tourist attractions of Umm Qais, Jordan: GIS and Markov chain analyses. *International Journal of Historical Archaeology*, 23, 235–259. https://idp.springer.com/authorize/casa?redirect_uri=https://link.springer.com/article/10.1007/s10761-018-0464-3&casa_token=QC0HzGBRzp0AAAAA:C9mUjb_fs5I13s342vvFHg-iPO7J3wIVfUlElCto86POi0zpfQVxBOymW-uiMw_HtYyYJrO3hUbtxKuV

Agapiou, A., Lysandrou, V., Alexakis, D. D., Themistocleous, K., Cuca, B., Argyriou, A., Sarris, A., & Hadjimitsis, D. G. (2015). Cultural heritage management and monitoring using remote sensing data and GIS: The case study of Paphos area, Cyprus. *Computers, Environment and Urban Systems*, 54, 230–239. https://doi.org/10.1016/j.compenvurbsys.2015.09.003

Andaroodi, E. Taqipour Anari, Z. (2018). Assessment of values in the historical urban landscape of Valiasr Street in Tehran using geographic information system of public participation (PPGIS). *Journal of Fine Arts: Architecture and Urbanism*, 23(2), 75-86. https://doi.org/10.22059/jfaup.2018.234463.671721 (In Persian)

Box, P. (1999). *GIS and Cultural Resource Management: A Manual for Heritage Managers*. UNESCO. https://www.researchgate.net/publication/264048505_GIS_and_Cultural_Resource_Management_a_manual_for_heritage_managers

Brown, G. (2012). Public participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. *Journal of the Urban & Regional Information Systems Association*, *24*(2). http://www.landscapevalues.org/publications/urisa_journal_2012.pdf

Brown, G., & Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Applied Geography*, *46*, 122–136. https://doi.org/10.1016/j.apgeog.2013.11.004

Brown, G., Kyttä, M., & Reed, P. (2022). Using community surveys with participatory mapping to monitor comprehensive plan implementation. *Landscape and Urban Planning*, *218*, 104306. https://doi.org/10.1016/j.landurbplan.2021.104306

Brown, G., Sanders, S., & Reed, P. (2018). Using public participatory mapping to inform general land use planning and zoning. *Landscape and Urban Planning*, *177*, 64–74. https://doi.org/10.1016/j.landurbplan.2018.04.011

Elgobashi, A., & Elsemary, Y. (2021). *REDEFINITION OF HERITAGE PUBLIC SPACES USING PPGIS The Case of Religious complex in Old Cairo*. https://www.researchgate.net/publication/346278671_REDEFINITION_OF_HERITAGE_PUBLIC_SPACES_USING_PPGIS_The_Case_of_Religious_complex_in_Old_Cairo

Ericson, J. A. (2006). A participatory approach to conservation in the Calakmul Biosphere Reserve, Campeche, Mexico. *Landscape and Urban Planning*, *74*(3–4), 242–266. https://www.sciencedirect.com/science/article/pii/S0169204604001033

Foroughi, M., De Andrade, B., Roders, A. P., & Wang, T. (2023). Public participation and consensus-building in urban planning from the lens of heritage planning: A systematic literature review. *Cities*, *135*, 104235. https://doi.org/10.1016/j.cities.2023.104235

García-Esparza, J. A., & Altaba Tena, P. (2020). A GIS-based methodology for the appraisal of historical, architectural, and social values in historic urban cores. *Frontiers of Architectural Research*, *9*(4), 900–913. https://doi.org/10.1016/j.foar.2020.04.004

Giannopoulou, M., Vavatsikos, A. P., Lykostratis, K., & Roukouni, A. (2014). Using GIS to record and analyse historical urban areas. *TeMA-Journal of Land Use, Mobility and Environment*. http://www.serena.unina.it/index.php/tema/article/view/2525

Greenop, K., & Landorf, C. (2017). Grave-to-cradle: A paradigm shift for heritage conservation and interpretation in the era of 3D laser scanning. *Historic Environment*, 29(1), 44–55. https://search.informit.org/doi/abs/10.3316/informit.958198990712870

Gregory, I. N., & Ell, P. S. (2007). Historical GIS: Technologies, Methodologies, and Scholarship. *Cambridge Studies in Historical Geography*. www.cambridge.org

Huang, Y. (2024). Bibliometric analysis of GIS applications in heritage studies based on Web of Science from 1994 to 2023. *Heritage Science*, *12*. https://doi.org/10.1186/s40494-024-01163-y

Humble, N. (2023). Future paths for GIS in K-12 education: A review of possibilities and constraints. *European Journal of Geography*, *14*(3), Article 3. https://doi.org/10.48088/ejg.n.hum.14.3.079.088

Knowles, A. K. (2016). Historical geographic information systems and social science history. *Social Science History*, *40*(4), 741–750. https://www.cambridge.org/core/journals/social-science-history/article/historical-geographic-information-systems-and-social-science-history/2DEE23A21D9DDBC6ABF6DE1A25FC0747

Lafreniere, D., Weidner, L., Trepal, D., Scarlett, S. F., Arnold, J., Pastel, R., & Williams, R. (2019). Public participatory historical GIS. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *52*(3), 132–149. https://doi.org/10.1080/01615440.2019.1567418

Landorf, C. (2009). A Framework for Sustainable Heritage Management: A Study of UK Industrial Heritage Sites. *International Journal of Heritage Studies*, *15*(6), 494–510. https://doi.org/10.1080/13527250903210795

Li, J., Krishnamurthy, S., Pereira Roders, A., & Van Wesemael, P. (2020). Community participation in cultural heritage management: A systematic literature review comparing Chinese and international practices. *Cities*, *96*, 102476. https://doi.org/10.1016/j.cities.2019.102476

Liu, B., Wu, C., Xu, W., Shen, Y., & Tang, F. (2024). Emerging trends in GIS application on cultural heritage conservation: A review. *Heritage Science*, *12*. https://doi.org/10.1186/s40494-024-01265-7

Lopes, P. F., Muñoz, J. M., & Rosa, M. P. (2023). An in-depth look at the application of GIS for industrial heritage documentation. *Conservar Património*, 44, 67–81. https://conservarpatrimonio.pt/article/view/28708
Mirzakhani, A., Turró, M., & Jalilisadrabad, S. (2021). Key stakeholders and operation processes in the regeneration of historical urban fabrics in Iran. *Cities*, *118*, 103362. https://doi.org/10.1016/j.cities.2021.103362
Mishra, M., & Lourenço, P. B. (2024). Artificial intelligence-assisted visual inspection for cultural heritage: State-of-the-art review. *Journal of Cultural Heritage*, 66, 536–550. https://doi.org/10.1016/j.culher.2024.01.005
Mollo, L., Agliata, R., Palmero Iglesias, L. M., & Vigliotti, M. (2020). Typological GIS for knowledge and conservation of built heritage: A case of study in Southern Italy. *Informes de La Construcción (Online)*, *72*(559), 1–7. https://riunet.upv.es/handle/10251/169036
Mukherjee, F. (2015). Public Participatory GIS. *Geography Compass*, *9*(7), 384–394. https://doi.org/10.1111/gec3.12223
Neubauer, W. (2004). GIS in archaeology—The interface between prospection and excavation. *Archaeological Prospection*, 11(3), 159–166. https://doi.org/10.1002/arp.231
Nummi, P. (2018). Crowdsourcing Local Knowledge with PPGIS and Social Media for Urban Planning to Reveal Intangible Cultural Heritage. *Urban Planning*, *3*. https://doi.org/10.17645/up.v3i1.1266
Pocobelli, D. P., Boehm, J., Bryan, P., Still, J., & Grau-Bové, J. (2018). BIM for heritage science: A review. *Heritage Science*, 6(1), 30. https://doi.org/10.1186/s40494-018-0191-4
Poplin, A. (2012). Web-Based PPGIS for Wilhelmsburg, Germany: An Integration of Interactive GIS-Based Maps with an Online Questionnaire. *Urisa Journal*.https://www.semanticscholar.org/paper/Web-Based-PPGIS-for-Wilhelmsburg%2C-Germany%3A-An-of-an-Polin/5a367d3d4823b3a5f5794e4d0eb691a842719393
Puertas-Aguilar, M.-Á., Sipols, A. E. G., & Lázaro-Torres, M.-L. de. (2023). Web GIS to Learn Geopolitics in Secondary Education: A case study from Spain. *European Journal of Geography*, *14*(2), Article 2. https://doi.org/10.48088/ejg.m.pue.14.2.015.031
Radil, S. M., & Jiao, J. (2016). Public Participatory GIS and the Geography of Inclusion. *The Professional Geographer*, *68*(2), 202–210. https://doi.org/10.1080/00330124.2015.1054750
Robinson, J. A., Block, D., & Rees, A. (2017). Community Geography: Addressing Barriers in Public Participation GIS. *The Cartographic Journal*, *54*(1), 5–13. https://doi.org/10.1080/00087041.2016.1244322
Santos, B., Gonçalves, J., Almeida, P. G., & Martins-Nepomuceno, A. M. T. (2023). GIS-based inventory for safeguarding and promoting Portuguese glazed tiles cultural heritage. *Heritage Science*, *11*(1), 133. https://doi.org/10.1186/s40494-023-00976-7
Sofianopoulos, S., Stigas, S., Stratakos, E., Tserpes, K., Faka, A., & Chalkias, C. (2024). Citizens as Environmental Sensors: Noise Mapping and Assessment on Lemnos Island, Greece, Using VGI and Web Technologies. *European Journal of Geography*, *15*(2), Article 2. https://doi.org/10.48088/ejg.s.sof.15.2.106.119
Southall, H. (2014). Applying historical GIS beyond the academy: Four use cases for the Great Britain HGIS. In *Toward spatial humanities: Historical GIS and spatial history* (pp. 92–117). Indiana University Press. https://core.ac.uk/download/pdf/44330820.pdf
Stewart, E. J., Jacobson, D., & Draper, D. (2008). Public participation geographic information systems (PPGIS): Challenges of implementation in Churchill, Manitoba. *Canadian Geographies / Géographies Canadiennes*, *52*(3), 351–366. https://doi.org/10.1111/j.1541-0064.2008.00217.x
Tezel, D., Buyukdemircioglu, M., & Kocaman, S. (2021). Accurate assessment of protected area boundaries for land use planning using 3D GIS. *Geocarto International*, 36(1), 96–109. https://doi.org/10.1080/10106049.2019.1590466
Thompson, M. M. (2015). Public participation GIS and neighbourhood recovery: Using community mapping for economic development. *International Journal of Data Mining, Modelling and Management*, *7*(1), 24. https://doi.org/10.1504/IJDMMM.2015.067632
Xhafa, S., & Kosovrasti, A. (2015). Geographic Information Systems (GIS) in Urban Planning. *European Journal of Interdisciplinary Studies*, *1*, 85. https://doi.org/10.26417/ejis.v1i1.p85-92
Zhong, H., Wang, L., & Zhang, H. (2021). The application of virtual reality technology in the digital preservation of cultural heritage. *Computer Science and Information Systems*, 18(2), 535–551. https://doiserbia.nb.rs/Article.aspx?id=1820-021421000092