# A Scoping Review of Geospatial Strategies for Resilience in Rural Heritage Communities

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***Abstract*:** *Rural communities are increasingly exposed to social, economic, and climatic pressures that threaten their cultural heritage. Although geospatial technology is increasingly used in community planning and cultural heritage documentation, it has the potential in strengthening rural community resilience. Therefore, this interdisciplinary approach is important for understanding how the integration of technology, cultural heritage, and community can contribute to long-term resilience. While geospatial and cultural heritage research are increasing, the integration of cultural heritage digitisation remains rarely systematically investigated. This gap hinders the understanding of technology's application in holistic community development. Therefore, this study aims to identify global research trends related to strengthening rural cultural heritage resilience through geospatial data, to organise methodological and theoretical approaches of existing studies, and to identify gaps based on the analysis results. The research method used is based on a search of the Scopus database and subsequent analysis using a scoping review. The findings identify three main themes: the use of mapping technology in heritage conservation, community-based approaches to developing resilience, and the gap between technological innovation and social empowerment. This study thus contributes to an interdisciplinary understanding and highlights the need for a new framework that connects technology and cultural heritage in a community-centered manner. The findings suggest that future research offers great opportunities to develop more sustainable rural development policies and strategies through community-based geospatial approaches.*

*Keywords: Geospatial, Rural, Rural Planning, Heritage, and Resilience.*

**Introduction**

Rural communities currently face a variety of problems, including social (urbanization, youth migration), economic (decline of traditional industries, lack of jobs), and climatic (floods, landslides, soil erosion) (Neef et al., 2020). The loss of young people poses the risk of destruction or even extinction of cultural heritage, threatening both tangible (buildings, sites) and intangible (traditional knowledge, community identity) heritage (Lampropoulos et al., 2025). Over the past decade, the concept of resilience has been increasingly used in discussions of rural development (Orlando et al., 2025). It refers not only to physical resistance to disasters but also to the capacity of communities to maintain their identity, adaptability, and develop sustainably.

The use of geospatial tools (GIS, remote sensing, UAV, WebGIS, spatial network analysis) is becoming increasingly widespread in planning, environmental monitoring, and heritage conservation (Brandt et al., 2020). This is beneficial for developing communities because it allows for the integration of various data types (ecological, social, cultural), precise documentation (e.g., digital twins of historic buildings), mapping of disaster risks, vulnerability assessments, and the planning of protected areas. Although this technology has proven its worth in urban heritage and environmental planning, its application in the context of rural heritage resilience is still under-researched and rarely systematically investigated (Karahan et al., 2025).

Many studies focus on only one aspect, such as disaster mapping, building documentation, or cultural tourism (Harbiankova et al., 2023; Teng et al., 2025). The focus of the conducted studies rarely holistically connects geospatial technology with the resilience of rural heritage communities. Furthermore, most studies come from developed countries such as East Asia (China) and Europe, while developing countries such as sub-Saharan Africa, Latin America, and Southeast Asia are still underrepresented. This further explains the impact of the methodological gap created by the lack of longitudinal studies or long-term impact assessments, as most studies are merely short-term case studies.

Therefore, an interdisciplinary approach combining knowledge from geosciences, cultural heritage studies, and community resilience is appropriate. This review is necessary because this field is rapidly developing, yet research remains fragmented. Therefore, a scoping review is required to map the selected global research landscape. Its findings should provide more evidence-based recommendations for rural development policies and strategies, and supports communities in using digital technologies to protect their identities and economies.

The objectives of this study are: (1) to identify global trends in the use of geospatial strategies to strengthen the resilience of rural cultural communities; (2) to examine the methodological approaches used by previous researchers; and (3) to identify knowledge gaps and develop future research directions. This study examines current global trends in strengthening the resilience of rural cultural communities through the use of geospatial data and identifies existing gaps through a scoping review analysis.

**Methodology**

This study followed a framework Arksey & O'Malley (2005) that proposed six implementation phases: (1) Formulating research questions, (2) Identifying relevant literature, (3) Electing studies, (4) Mapping data, (5) Summarizing and reporting results, and (6) Conducting expert consultation (optional). Firstly, A research question (RQ) was constructed for this study to fulfill the review process of the collected articles. RQ: "How do geospatial strategies be implemented in enhancing the resilience in rural heritage communities". Next, the articles search process uses Scopus as the main database, with an advanced query method that utilizes AND & OR to expand the search further. The query key in: "TITLE-ABS-KEY (("geospatial" OR "geospatial analysis" OR "spatial data" OR "GIS" OR "remote sensing" OR "geoinformatics" OR "spatial planning") AND ("rural" OR "rural areas" OR "rural communities" OR "rural development" OR "rural planning" OR "villages" OR "rural settlements" OR "remote areas" OR "peri-urban") AND ("resilience" OR "community resilience" OR "rural resilience" OR "climate resilience" OR "adaptive capacity" OR "risk reduction" OR "social vulnerability") AND ("heritage" OR "cultural heritage" OR "intangible heritage" OR "indigenous heritage" OR "heritage conservation" OR "traditional knowledge" OR "cultural identity" OR "local knowledge")) AND PUBYEAR > 2014 AND PUBYEAR < 2026" The code for PUBYEAR was used to limit the publish year from 2015 until 2025 which acted for the relevance of the study. The date for this query was searched on 21st July 2025. Only documents in the form of journal articles were included, while documents such as conference paper, conference reviews, book chapters, reviews, and errata were excluded to really focus on searching for papers that study the geospatial at rural heritage area. 47 articles were identified from the search results after the inclusion and exclusion criteria. All data was exported in CSV format and utilised Microsoft Excel for graph analysis of article counts by year of publication, Top Contributor Country, Top Affiliator, and Subject Areas of Publication. Further selection was made based on the central research question: "How do geospatial

strategies be utilised in enhancing the resilience in rural heritage communities". Articles will be included only if they meet selection criteria, in geospatial rural heritage resilience focus.

**Findings**

**a. Descriptive Result**

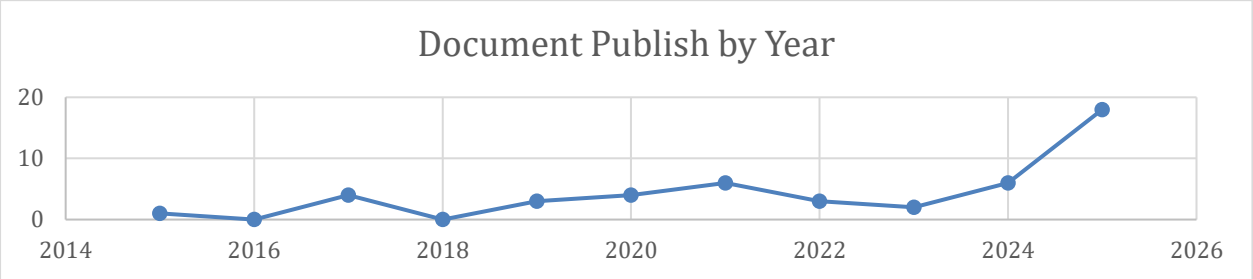


Figure 1: Document Published by Year

The publication trend of 47 articles related to geospatial strategies in rural heritage was minimal and moderate from 2015 until 2023, and then a sharp increase was recorded in 2025, which is the highest in the decade, indicating an increase in global attention towards a holistic approach that combines spatial technology with cultural values and community knowledge to strengthen the resilience and sustainability of rural heritage areas.

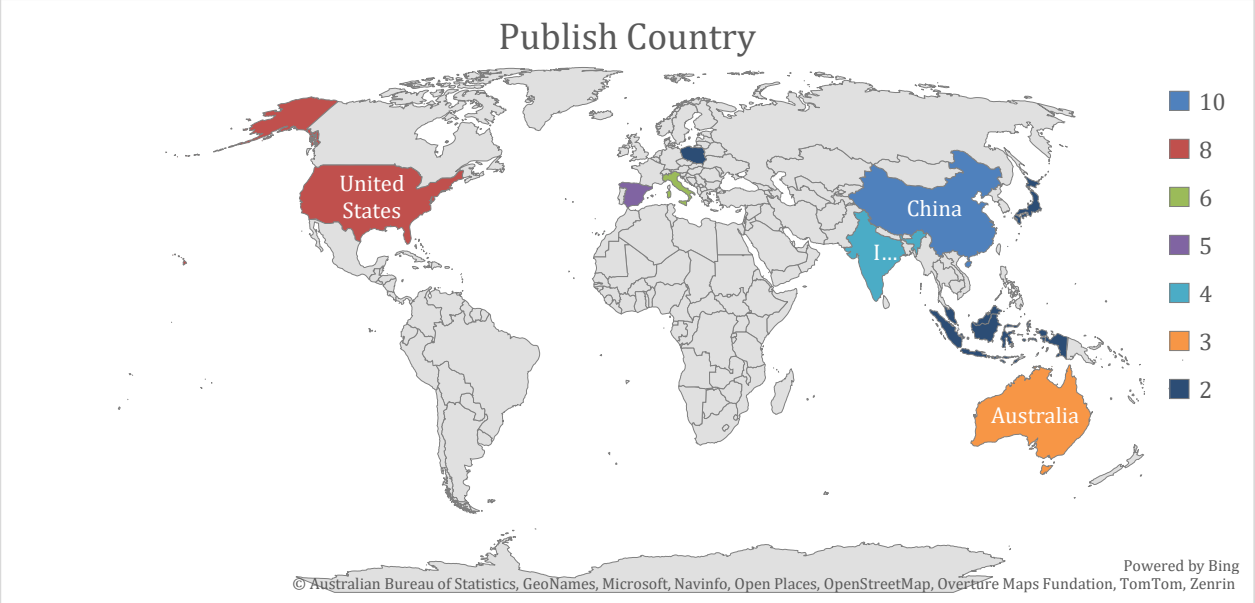


Figure 2: Country Publish Document

Analyzing the top ten countries that contributed the most to this study (47 documents on research on rural digitalization), China recorded the highest number of documents (10). This indicates the participation of researchers from this country who are very active in this research topic. The United States followed in second place with 8 documents each, reflecting the strong American interest in this field. Italy and Spain recorded 6 and 5 documents respectively,

indicating stable but not dominant European participation. India and Australia each had 4 and 3 documents, reflecting a stable research interest in the Asia-Pacific region. Several other countries were involved with only 2 documents, indicating limited but still relevant participation.

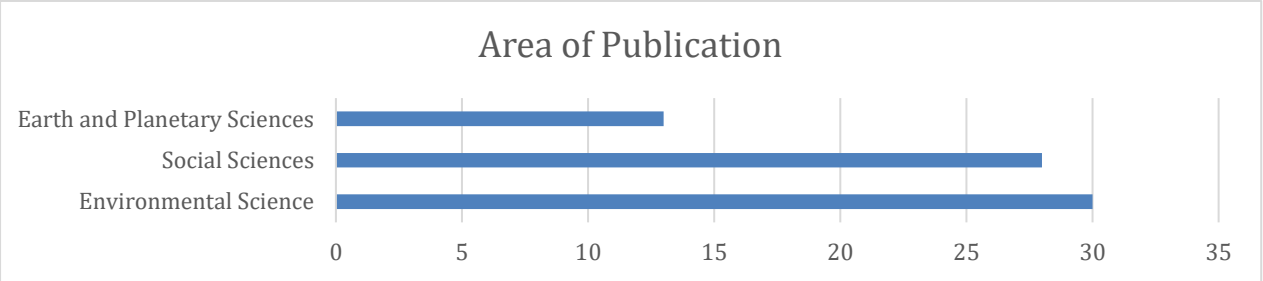


Figure 3: Subject Area of Publication

**b. Overview**

Based on the screening result from 47 related articles, only 12 were selected and the articles are from Burkina Faso, Cambodia, Turkiye, Belize and mostly from China and Europe. Table 1 (below) was constructed to show where the article came from, what methodologies that they used, what are their findings, and the relevance of the article being considered.

Table 1. List of selected articles discuss and study geospatial strategy in rural heritage.

| Author (Date) | Country | Methods | Findings |
|---|---|---|---|
| Ilboudo Nébié & West (2024) | Burkina Faso | Participatory mapping, high-resolution satellite imagery, local stories, historical records | Integration of local knowledge with geospatial data improves understanding of land degradation and adaptation strategies among ethnic groups. |
| Lamprop oulos et al. (2025) | Greece | GIS analysis, stakeholder consultation, socioeconomic assessment | Thematic cultural routes and agritourism initiatives, supported by GIS, boost regional attractiveness and resilience. |
| Orlando et al. (2025) | Italy | GIS, historical cartography, aerial photography | Identified degradation of Baroque villas; proposed a cultural route ("La città delle ville") for heritage-led resilience. |
| Neef et al. (2020) | Cambodi a, Fiji | Participatory mapping, focus group discussions, remote sensing | Blended local and scientific knowledge for flood adaptation strategies. |

| | | | |
|---|---|---|---|
| Harbiankova et al. (2023) | Belarus | GIS mapping, statistical analysis, multidimensional resilience assessment | Cultural heritage preservation strengthens rural settlement resilience across social, economic, and environmental dimensions. |
| Wang et al. (2025) | China | GIS, complex network theory, spatial network analysis | Proposed cluster-based protection framework to enhance connectivity and cultural synergies. |
| Karahan et al. (2025) | Türkiye | UAV photogrammetry, GIS, terrain modeling | Identified degraded terraces; proposed site-specific restoration strategies. |
| Teng et al. (2025) | China, Vietnam | GIS, remote sensing, ecological sensitivity assessment | Integrated TEK with GIS to optimize ecological networks and resilience. |
| Piccinini et al. (2022) | Italy | UAV, TLS, 360º imaging, GIS | Automated GIS extraction of vulnerability parameters for post-disaster recovery. |
| Hidalgo-Sánchez et al. (2024) | Spain | WebGIS, geolocation of cultural assets | Designed cultural itineraries to promote heritage-based rural reactivation. |
| Brandt et al. (2020) | Belize | Participatory GIS (sketch mapping), hot spot analysis, drone imagery | Combined local knowledge with GIS for flood risk management in data-scarce contexts. |
| Zhang et al. (2025) | China | GIS multi-criteria analysis, field surveys | Quantified cultural-ecological value of villages; proposed multi-scale conservation strategies. |

These articles cover a variety of geographical contexts and methodological approaches and address key themes relevant to the research questions. Three main themes are identified: (1) geospatial approaches in heritage conservation, (2) resilience community-based approaches, and (3) integration challenge of technology-social empowerment.

In the context of geospatial approaches in heritage conservation, we can see the digital documentation can be leveraged through precise 3D modeling (digital twins) using drones/photogrammetry (Orlando et al., 2025), the use of satellites for early damage detection, e.g., through risk mapping based on climate, geology, human data, and cultural mapping, whether tangible or intangible (Wang et al., 2025). The nature of this evaluation can be

understood through innovative technology applications. Examples include the use of WebGIS for community access and engagement (Piccinini et al., 2022), analysis of the network of cultural heritage sites, evaluation of criteria for setting conservation priorities, and terrain modeling for disaster risk prevention (Zhang et al., 2025).

Next context is the resilience community-based approaches, which is the Participatory geospatial methods that can empower communities through the combination of scientific and local data, recording traditional environmental knowledge, creating low-cost maps, and prioritizing stakeholder consultation (Hidalgo-Sánchez et al., 2024). In addition, social resilience is built by training communities to learn to use geospatial technologies, which strengthens their heritage identity, preserves historical memory between generations, and all of this indirectly involves communities in a significant way (Brandt et al., 2020; Neef et al., 2020; Wang et al., 2025).

Lastly, the context of integration challenge of technology-social empowerment**.** The power of social technologies was demonstrated by the combination of cutting-edge technology with community engagement, systematic and continuous training, digital platforms for collaboration, and the integration of local information into regional planning (Hidalgo-Sánchez et al., 2024; Wang et al., 2025). However, barriers to the use of social technologies persist due to a lack of technological skills, the difficulty of combining academic and traditional knowledge, unequal access to technology resources and training, and the risk that the technology itself does not fit with local culture (Ilboudo Nébié & West, 2024; Karahan et al., 2025).

**Result and Discussion**

Table 2: Overview of Geospatial in Heritage Conservation

| Similarity | Difference | Gap |
|---|---|---|
| Almost all the selected studies use GIS/UAV to document and map cultural heritage risks. | In Europe (Italy, Spain) the focus is more on heritage conservation and cultural routes, while in Asia (China, Vietnam) the focus is more on ecology and landscape networks. | No long-term studies executed due to the Lack of cost analysis |

Many studies confirm that GIS, UAV, photogrammetry, and WebGIS are not only used for static documentation but also as dynamic tools for the ongoing monitoring and assessment of rural cultural assets (Hidalgo-Sánchez et al., 2024; Karahan et al., 2025; Orlando et al., 2025; Piccinini et al., 2022). The ability of this methodology to create digital twins and risk mapping is consistent with the findings of almost all of the selected studies, albeit in the urban context, as this is still less systematically researched and there is a large gap regarding the different lifestyles of urban and rural residents. The insights gained in the study by Brandt et al. (2020) by combining data from various sources such as climate, geo data, and anthropogenic data enable a more comprehensive risk analysis. This analysis is important for rural cultural heritage areas, which are often exposed to disaster hazards such as floods, landslides, or soil erosion, which can lead to loss and damage (Karahan et al., 2025; Teng et al., 2025). This allows local authorities to plan more proactive mitigation measures, such as establishing protection zones, by prioritizing the restoration of specific sites according to their level of vulnerability. However, even in the production of high-accuracy geospatial data and models, challenges remain that are not addressed in field interventions due to limited financial and technical capacities and weaknesses in disseminating information to local communities.

Table 3: Overview of Resilience through Community-based

| **Similarity** | **Difference** | **Gap** |
|---|---|---|
| The selected studies show that integrating local knowledge and scientific data improves adaptation. | Belize (floods), Burkina Faso (land degradation), Cambodia and Fiji (floods + traditional knowledge). | Lack of long-term cooperation models between the community, government and academic institution. |

Research from Neef et al. (2020) demonstrates that participatory GIS approaches (PGIS) and local knowledge-based mapping enable communities to play a central role in the planning process. This is consistent with the bottom-up theory of resilience building, which emphasizes the active role of communities in developing their own resilience strategies (Ilboudo Nébié & West, 2024). The methodology of combining scientific data and local knowledge increases the legitimacy and credibility of adaptation measures, as observed in flood risk management, water resource management, and disaster recovery (Harbiankova et al., 2023). Furthermore, it has a social impact through geospatial training of local people, which not only builds technical skills but also fosters a sense of ownership of one's heritage and strengthens the continuity of cultural

memory between generations(Harbiankova et al., 2023). The long-term nature of this strategy therefore depends on continued support from relevant agencies, the availability of financial resources for follow-up training, and incentives to ensure community participation.

Table 4: Overview of The Integration Technology and Social Empowerment Challenge

| Similarity | Difference | Gap |
|---|---|---|
| The selected studies emphasize that technology is ineffective without social empowerment. | Industrialised countries (China, Italy) – smaller challenges; developing countries (Belize, Cambodia) – large digital divide. | There is still no standardised global framework for socio-technological integration. |

The integration challenge of technology and social empowerment Although geospatial technology has proven to be able to improve heritage planning and management, the findings of this study emphasize that the real impact is only achieved when the technology is combined with strong social empowerment. From there, the barriers identified based on the analysis are the lack of technical skills among rural communities. This causes a gap between the potential of the technology and its use, reaping the risk of cultural incompatibility when the technology is introduced without an adequate adaptation process (Brandt et al., 2020; Teng et al., 2025). Furthermore, the difficulty of integrating academic knowledge with local wisdom caused by scientific methodologies that do not emphasize cultural sensitivity, resulting in unequal access to knowledge, tools, digital infrastructure, and formal training, which makes the gap between outsiders (academic institutions/research experts) and local communities even wider (Neef et al., 2020). This confirms the global finding that technological innovations that are isolated from the process of social empowerment tend to fail to have a sustainable impact. So, basically, the development of digital collaboration platforms between communities and experts, as well as the adaptation of technology to the local cultural context should be made a mandatory component in the implementation of geospatial strategies.

The analysis revealed a lack of long-term studies examining the impacts of the use of geospatial technology on the resilience of rural cultural heritage communities after the completion of the research conducted there, because the selected studies mostly limited themselves to initial assessments of the effectiveness of specific tools or methods. It is strongly recommended that future research focus on cost-benefit analyses to ensure that the implemented technology is truly applicable in low-income communities (Karahan et al., 2025; Piccinini et al., 2022). The

integration of new technologies such as artificial intelligence (AI) and the Internet of Things (IoT) with GIS should also be encouraged which offer great potential for real-time monitoring and risk prediction for any type of disaster, but it has not yet been sufficiently tested in the context of rural cultural heritage and the technology they employ sometimes is left behind. The findings also identify gaps in the research of new governance models that combine technology, community empowerment, and policy frameworks to ensure the sustainability of rural cultural heritage in the face of globalization and climate change. For example, Cross-border studies demonstrated by Teng et al. (2025) between China and Vietnam that demonstrate cultural heritage surveys often cross political boundaries and therefore require a regional and collaborative approach. So, future research can investigate how geospatial technology can facilitate the management of this transnational heritage in emphasizing the necessary alignment of technology, people, processes, and culture for successful integration.

**Conclusion**

In conclusion, this review found that geospatial strategies play a crucial role in heritage conservation, community empowerment, and rural resilience building. Three main themes emerged from the analysis: (1) Geospatial in Heritage Conservation – GIS, UAV, and WebGIS have proven effective for documentation, risk mapping, and conservation planning; (2) Resilience through Community-Based Approaches – integrating local knowledge with geospatial science strengthens community identity and disaster adaptation; (3) Integration Challenge of Technology and Social Empowerment – technology alone is not enough without social empowerment, ongoing training, and cultural compatibility. This scoping review fills in the gaps by combining methodological approaches, worldwide trends, and upcoming research opportunities. As a result, it supports a broader approach to resilience, covering cultural and social dimensions, not just in terms of the physical context. In addition, it helps policymakers to design technology-based rural development strategies that are more resilient and culturally sensitive. Subsequently, this review also provides insights for local authorities, NGOs, and local communities on how to leverage GIS, UAV, and participatory mapping to adapt to global developments. However, this review is limited to searching the Scopus database only, and only journal articles were taken for analysis, which has the potential to overlook studies from other sources. Furthermore, the geographical coverage of the articles analysed only focused on East Asia and Europe. Suggested future directions for future studies are that studies need to explore AI and IoT in the context of rural heritage, conduct long-term research needed to evaluate the impact of geospatial interventions, produce a globally applicable framework that combines

technological innovation with social empowerment, to ensure more sustainable and widely applicable strategies, and increase cross-border studies since cultural heritage sometimes transcends national boundaries.

**Acknowledgement**

I would like to extend my sincere gratitude to the Universiti Malaya (UM) Global Transformation Research Grant 2024 for providing generous funding for two years to support this programme. I particularly grateful for the professional guidance and continuous support provided by Prof.TPr.Gs.Dr.Norzailawati Mohd Noor for the preparation of this review article.

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