Management of Geospatial Data: Preservation Challenges, Multidisciplinary Approaches, and the Role of Library and Information Science

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ABSTRACT

Purpose Research. This study systematically reviews research on geospatial data preservation, focusing on challenges, solutions, and the role of library and information science (LIS) in ensuring sustainable access. **Research Method.** Using the PRISMA framework, data were collected from the Taylor & Francis (www.tandfonline.com) database. Keywords included *"Geospatial Data Curation", "Archive Geospatial Data",* and *"Geospatial Data Preservation"*. Ninety-five article topics were found discussing geospatial data preservation. After screening, the duplication selection stage, due to combined keywords during the search, language selection and publication range, 10 peer-reviewed articles (2010–2020) were selected for analysis. **Analysis Data.** The selected articles were analyzed thematically, focusing on technical, institutional, and socio-technical dimensions. The analysis also examined the application of FAIR principles (Findable, Accessible, Interoperable, Reusable) and emerging trends like AI for data curation and IoT-generated data integration. **Results.** Findings reveal three main challenges: (1) technical issues like data heterogeneity and technological obsolescence; (2) institutional fragmentation, including inconsistent policies; and (3) the need for LIS professionals to adapt to roles in digital curation and metadata management. Emerging trends highlight the growing importance of interdisciplinary collaboration and innovative technologies. **Conclusions.** The study concludes that a multidisciplinary approach—integrating technical innovation, institutional collaboration, and LIS expertise—is crucial for effective preservation. Recommendations include developing standardized frameworks, enhancing the role of librarians in digital stewardship, and fostering interdisciplinary research. Future studies should explore real-time data preservation and the ethical implications of long-term access.

Keywords: *Geospatial data curation, Geospatial data preservation, Archive Geospatial Data, Library Preservation, Systematic Literature Review*

A. INTRODUCTION

Digital preservation is a set of managed activities to ensure long-term access to digital materials beyond the challenges of media failure and technological change (Digital Preservation Coalition & National Library of Australia, 2012). In this

context, geospatial data occupies a unique position because it combines spatial (latitude, longitude, projection) and descriptive (vegetation, population) information that forms the basis for decision-making in the areas of environment, infrastructure, and disaster (Puntodewo, Dewi, & Tarigan, 2003). Its management relies on Geographic Information Systems (GIS), an integrative framework involving hardware, software, data, and human resources to capture, store, analyze, and visualize location-based information. However, the complexity of geospatial data, such as real-time satellite imagery or crowdsourced GPS data from Internet of Things (IoT) devices, demands preservation approaches that transcend conventional storage solutions.

Despite its importance, geospatial data preservation faces multidimensional challenges. Technically, format heterogeneity, large volumes, and technological obsolescence are major barriers (Kong, 2015a). At the institutional level, the an absence of standardized metadara protocols across sectors (e.g., differences between governmental dan academic GIS databases) (Durante & Hardy, 2015a; Pons & Masó, 2016). Furthermore, most previous research has focused on technical aspects such as database optimization, while institutional, ethical, and financial sustainability dimensions remain underexplored (Stewart, 2012). These gaps indicate the need for a holistic synthesis to bring together the scattered findings in the literature.

This study presents a novelty through a Systematic Literature Review (SLR) approach that integrates multidisciplinary perspectives—information science, geomatics, and public policy—to analyze the evolution of geospatial data preservation research (2010–2020). Unlike previous studies that were limited to technical case studies (Tupas, Lat, & Magturo, 2016; Fernandez-Diaz & Cohen, 2020; Lozić & Štular, 2021), this systematic review identifies general patterns such as the application of FAIR (Findable, Accessible, Interoperable, Reusable) principles and cross-contextual challenges. Temporal analysis is also conducted to understand shifting technological trends, such as the use of AI for data curation and IoT data integration.

The objectives of this study are (1) to map the dominant themes and methodologies in geospatial data preservation research, (2) to analyze the technical, institutional, and socio-technical factors that influence the success of preservation strategies, and (3) to formulate policy recommendations and research priorities. The method used is SLR based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, with data taken from the Taylor & Francis (www.tandfonline.com) database.

Theoretically, this study enriches insights into the integration of digital preservation principles with the complexity of geospatial data while highlighting unexplored research areas, such as real-time data preservation and the impact of privacy regulations. Practically, the synthesis of findings can serve as a guide for archival institutions and GIS developers in designing preservation strategies that are responsive to technological changes. Furthermore, the proposed multidisciplinary analysis framework can be adapted to other complex data domains, such as biomedical or climate, expanding the impact of research across disciplines.

B. METHODS

This study uses a qualitative approach using the Systematic Literature Review (SLR) method. SLR is a rigorous scientific methodology that synthesizes original primary studies to enhance the validity of conclusions and identify reserch gaps. In the context of geospatial data preservation, SLR serves as a critical tool to systematically evaluate existing literature, map evolving trends, and justify future reserch directions. The transparency and reproducibility of SLR guided by protocols such as PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) ensure that findings are methodologically sound and actionable for stakeholders in library science, geomatics, and policy-making. (Moher, Liberati, Tetzlaff, Altman, & Grp, 2009).

The determination of article standards used in this SLR adopts research conducted by Adrian et al. (2016), where in the study, it was found that the procedure for conducting a systematic literature review is divided into three stages, namely planning, implementation, and reporting. The procedure is explained in more detail below:

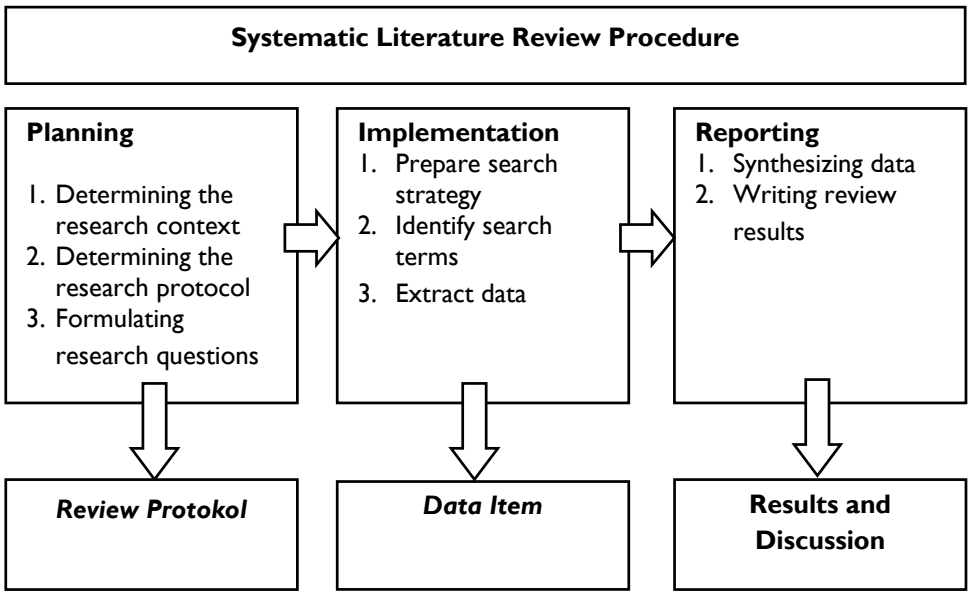

Figure 1. Procedures for conducting a systematic literature review
(Adrian, Abdullah, Atan, & Jusoh, 2016)

Research Questions

The research questions in this systematic review study adopt the PICO (Population, Intervention, Context, Outcome) question framework by (Schardt, Adams, Owens, Keitz, & Fontelo, 2007). The research questions in this study are as shown in the following table:

Table 1: Criteria for research questions with the PICO approach

Criteria	Coverage
Population	People who carry out geospatial data preservation (archivists/librarians/special preservation departments in certain organizations)
Intervention	Preservation that must be carried out by the population
Context	Review of the results of the identification of the implementation of geospatial data preservation practices
Outcome	Preservation of geospatial data discussed (Practices in carrying out geospatial data preservation, suggestions in implementing preservation, factors that influence the implementation of geospatial data preservation, obstacles found, etc.)

Based on Table 1 above, the questions in this study are:

1. What geospatial data preservation is discussed in the article?
2. What factors influence the implementation of geospatial data preservation?
3. What obstacles are found in the article?

Search Strategy

In this study, a systematic review was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach initiated by (Moher et al., 2009) the PRISMA approach is a data search strategy that uses search terms, data sources from online databases, inclusion and exclusion criteria used, assessment of the quality of search results and explaining the results of the data search. This study focuses on research on geospatial data preservation and then the Taylor & Francis database was selected to search for topics on geospatial data preservation. Article searches using combined keywords were conducted to narrow the search results. The combined keywords used were "Geospatial Data Curation", "Archive Geospatial Data", and "Geospatial Data Preservation". Furthermore, publications containing search criteria in the title, combined keywords, and abstract were also included.

Inclusion and Exclusion Criteria

This study adhered to strict inclusion and exclusion criteria to ensure methodological rigour and relevance. We included peer-reviewed articles published in English between 2010-2020 from Taylor & Francis Online database (www.tandfonline.com), focusing specifically on geospatial data preservation. The English language criterion was applied to maintain consistency in analysis and align with the dominant language of scholarly communication in this field (Kitchenham & Charters, 2007). The 2010-2020 timeframe was selected to capture the evolution of preservation challenges during a critical decade marked by technology shifts, such as the adoption of FAIR principles and IoT-driven geospatial data. Articles discussing broader GIS applications without a preservation focus were

excluded to maintain thematic precision, and duplicated publications were systematically identified and removed, retaining only the most comprehensive version (typically journal articles over conference papers). While limiting the search to Taylor & Francis ensured depth in library science and geomatics literature, we acknowledge this may exclude relevant studies from other databases. A limitation addressed in the discussion section. These criteria were designed to balance feasibility with scholarly comprehensiveness, providing a reproducible foundation for future research.

Table 2: inclusion and exclusion criteria set in the study

Inclusion	1. Articles published in English 2. Articles discuss geospatial data preservation 3. Articles are in the Taylor & Francis Online database 4. Articles published between 2010-2020
Exclusion	1. Articles published in languages other than English 2. Articles published outside the 2010-2020 period 3. Articles that have duplicates in the database

Quality Assessment

The quality assessment of search results aims to evaluate the quality of articles and the usefulness of the data obtained (Safira, Salim, Rahmi, & Sani, 2020). The quality assessment of search results is known from predetermined questions where the question has three answer choices and is given a score for each answer where if the answer is Yes = 1; Undecided = 0.5; No = 0 (Adrian et al., 2016). The research questions in this study are below:

Table 3: Assessment Criteria based on Search Results

Tingkat Kualitas	Pertanyaan	Jawaban
P1	Does this article describe current and recommended geospatial data preservation practices?	Yes/Uncertain/No
P2	Does this article describe the drivers of geospatial data preservation practices?	Yes/Uncertain/No
P3	Is this article a "lessons learned from a case study" or an expert opinion report?	Yes/Uncertain/No
P4	Does this article provide information about geospatial data preservation?	Yes/Uncertain/No

C. RESULT AND DISCUSSION

Search Strategy

Based on the search strategy in the Taylor & Francis scientific journal database (www.tandfonline.com), 95 article topics were found discussing geospatial data preservation. Furthermore, after conducting the duplication selection stage due to combined keywords during the search, language selection and publication range

selection, finally 10 articles were obtained that met the inclusion and exclusion criteria and had met the quality assessment based on the search results. The details of the selection of journal articles can be seen in Figure 2 below:

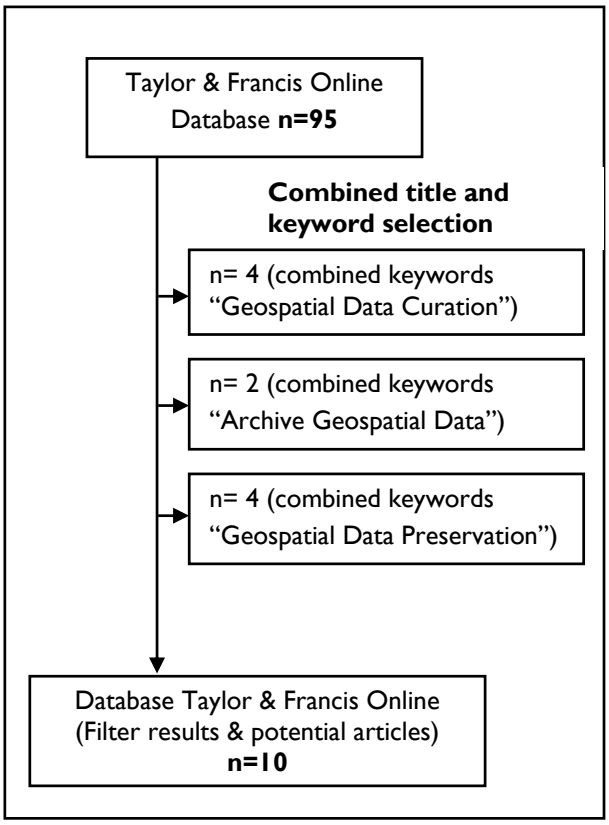

Figure 2: Article selection process flow (Source: Researcher data processing)

Assessment of Search Result Quality

Furthermore, based on the assessment of the quality of search results based on the search result assessment criteria, it is known that the articles that have been analyzed have the lowest values, namely value 3 (1 article), value 3.5 (3 articles) and value 4 (6 articles) as seen in Table 4 and 5

Table 4: Article evaluation results

	Code	P1	P2	P3	P4	Total Value
(Bishop, Grubesic, & Prasertong, 2013)	A1	1	1	0,5	1	3,5
(Khayat & Kempler, 2015)	A2	1	1	1	1	4

(Durante & Hardy, 2015b)	A3	1	1	1	1	4
(Kenyon, Godfrey, & Eckwright, 2012)	A4	0,5	1	1	1	3,5
(Erwin & Sweetkind-Singer, 2010)	A5	1	1	1	1	4
(Clark, 2016)	A6	1	1	0,5	1	3,5
(Kong, 2015b)	A7	1	1	1	1	4
(Trimble, Woods, Berish, Jakubek, & Simpkin, 2015)	A8	1	1	1	1	4
(Porcal-Gonzalo, 2015)	A9	1	1	1	1	4
(Morris, 2010)	A10	1	0,5	0,5	1	3

Table 5: List of Articles that Meet the Assessment Criteria

Code	Author(s)	Title	Method
A1	(Bishop et al., 2013)	Digital Curation and the GeoWeb: An Emerging Role for Geographic Information Librarians	Qualitative
A2	(Khayat & Kempler, 2015)	Life Cycle Management Considerations of Remotely Sensed Geospatial Data and Documentation for Long Term Preservation	Qualitative
A3	(Durante & Hardy, 2015b)	Discovery, Management, and Preservation of Geospatial Data Using Hydra	Qualitative
A4	(Kenyon et al., 2012)	Geospatial Data Curation at the University of Idaho	Qualitative
A5	(Erwin & Sweetkind-Singer, 2010)	The National Geospatial Digital Archive: A Collaborative Project to Archive Geospatial Data	Qualitative
A6	(Clark, 2016)	The Long-Term Preservation of Digital Historical Geospatial Data: A Review of Issues and Methods	Qualitative
A7	(Kong, 2015b)	Exploring Best Management Practices for Geospatial Data in Academic Libraries	Qualitative
A8	(Trimble et al., 2015)	Collaborative Approaches to the Management of Geospatial Data Collections in Canadian Academic Libraries: A Historical Case Study	Qualitative
A9	(Porcal-Gonzalo, 2015)	A Strategy for the Management, Preservation, and Reutilization of Geographical Information Based on the Lifecycle of Geospatial Data: An Assessment and a Proposal Based on Experiences from Spain and Europe	Qualitative
A10	(Morris, 2010)	The North Carolina Geospatial Data Archiving Project: Challenges and Initial Outcomes	Qualitative

Research Question Analysis

1. What geospatial data preservation is discussed in the article?

Table 6 shows the geospatial data preservation discussed in each article, as follows:

Table 6: Preservation of geospatial data discussed

Code	Preservation of geospatial data discussed
A1	a. The role of the geography librarian (GIL) in geospatial data preservation. b. GeoMAPP provides tools for developing long-term archiving business plans.
A2	Four (4) preservation practice recommendations: a. Data selection guidelines. b. Multi-format storage facilities. c. Use of open-source software. d. Understand legal access restrictions.
A3	Data management strategies: a. Leverage existing repositories (e.g., Hydra). b. Use metadata standards (ISO/ArcCatalog). c. Design custom access. d. Collaborate on metadata networks.
A4	a. INSIDE Idaho: Geospatial data repository at the University of Idaho. b. Partnerships with key researchers for data curation.
A5	a. Preservation goals: disaster mitigation and context preservation. b. Not preserving data can also be a realistic strategy (risk of digital decay).
A6	a. Preservation should start at project planning. b. Collaboration of librarians and researchers in data management.
A7	a. Librarians need to be involved from the beginning of the project. b. Best practices: data organization, publication, distribution, and preservation.
A8	a. *The Ontario Council of University Libraries* (OCUL) Canada collaboration through Scholars Portal infrastructure. b. OCUL Map Group enhances geospatial data management capacity.
A9	a. Evaluation of Spatial Data Infrastructure (SDI) in Spain. b. Case study: data life cycle analysis and proposed SDI system.
A10	a. NCGDAP Project: Focus on data acquisition, metadata, and community engagement. b. Challenges: frequency of data collection, repositories, and new initiatives.

2. *What factors influence the implementation of geospatial data preservation?*

Furthermore, Table 7 explains the factors that influence the implementation of geospatial data preservation.

Table 7: Factors influencing the implementation of geospatial data preservation

Code	Factors influencing the implementation of geospatial data preservation
A1	a. The development of GeoWeb and Volunteered Geographic Information (VGI) increases the volume and types of geospatial data. b. The role of the geography librarian (GIL) is changing
A2	a. The availability of relevant and up-to-date metadata is a major challenge. b. Preservation of metadata is as important as the original data.
A3	a. Increasing need for cross-disciplinary access to geospatial data. b. The need for preservation, curation, and metadata services (e.g. GeoHydra at Stanford).
A4	a. Geospatial data is complex and important for multidisciplinary purposes. b. Data management is a priority for academic libraries.
A5	a. The need for data acquisition policies and legal documents to manage content.

	b.	Focus on data at risk and long-term access.
A6	a.	Technological obsolescence threatens the accessibility of historical geospatial data.
	b.	The importance of preservation planning from the beginning of the project.
A7	a.	The exponential growth of spatial data requires effective management.
	b.	The active role of GIS librarians in the data cycle.
A8	a.	Institutional collaboration (e.g., OCUL Geo Community) enhances preservation capacity.
	b.	Shared infrastructure (e.g., Scholars Portal) supports data storage and access.
A9	a.	Recognition of the importance of data preservation and reuse in information management.
	b.	Evaluation of the Spatial Data Infrastructure (SDI) in Spain.
A10	a.	Partnership with a national program (NDIIPP) for the development of preservation infrastructure.
	b.	Focus on data identification, acquisition, and maintenance.

3. What obstacles occurred before or during the practice of geospatial data preservation?

Table 8 below explains what was found in the article.

Table 8: Barriers found in the articles

Code	Barriers found in the articles	Main Barriers
A1	1. Data created by non-institutional individuals (unstructured). 2. Lack of complete metadata. 3. Librarians are less familiar with technical description standards (e.g., projections, coordinate systems).	Data & Metadata Human Resources
A2	1. Increasing public access to DAAC data requires comprehensive documentation. 2. Difficulty managing legacy (old) data. 3. Risk of redundancy of useless data.	Historical Data Documentation
A3	1. Non-persistent URLs, inadequate metadata. 2. ISO 19115/19157 standards have not been optimally implemented. 3. Need for unique identifiers for data layers.	Standards & Interoperability
A4	1. Weak collaboration between researchers and repositories. 2. Data management culture has not been established.	Institutional Collaboration
A5	1. OPAC does not support the complexity of geospatial data. 2. Metadata is often incomplete.	Access Systems Metadata
A6	Complexity of metadata structures for map visualization.	Metadata
A7	1. Challenges of Big Data and Web GIS. 2. Inadequate involvement of GIS librarians.	Technology Human Resources

A8	1. Limited funding. 2. Large data licensing and storage costs. 3. Inter-agency communication barriers.	Finance Infrastructure
A9	1. Poor temporal metadata. 2. Data harmonization is not optimal. 3. Incomplete/low-quality data.	Data Quality
A10	1. Identification of scattered data sources. 2. Repositories do not support data complexity. 3. Low adoption of FGDC standards at the local level.	Data Acquisition Infrastructure

DISCUSSION

Geospatial data preservation is a complex issue that requires a holistic and collaborative approach, considering the challenges that arise from technical, institutional, and socio-technical aspects. The development of technologies such as GeoWeb, Big Data, and Web GIS has brought significant progress in data management but also raises new problems, such as the obsolescence of data formats and infrastructure that is unable to keep up with the growth of data volumes. On the other hand, metadata that is key to successful preservation is often inadequate, both in terms of availability and compliance with international standards such as ISO 19115/19157. Institutional challenges are no less important, where collaboration between institutions—such as that carried out by the OCUL Geo Community—is still hampered by fragmented policies, limited funding, and a lack of awareness of the importance of data management among researchers and data producers.

Technical barriers such as heterogeneity of data formats, large-scale storage requirements, and the inability of access systems (e.g. OPAC) to handle the complexity of geospatial data further complicate preservation efforts. Meanwhile, institutional barriers such as inadequate funding for infrastructure and licensing and lack of collaboration between repositories, researchers, and governments hinder the creation of a sustainable data ecosystem. At the human resource level, librarians' skills in technical descriptions (such as projections and coordinates) and adoption of FGDC (Federal Geographic Data Committee) standards are still low, especially at the local level. This indicates the need for continuous capacity building and training.

To address these challenges, several strategic recommendations can be implemented. At the technical level, the FAIR (Findable, Accessible, Interoperable, Reusable) principle needs to be widely adopted to improve data interoperability. The development of flexible repositories that support multiple formats, such as GeoHydra, is also an important solution. At the institutional level, partnerships between institutions—involving libraries, governments, and universities—need to be strengthened. In contrast, data acquisition policies and legal documents for access rights need to be clearly formulated. Upskilling librarians through training in metadata management and GIS technology, as well as raising researchers'

awareness of the importance of data preservation from the beginning of the project, are also crucial steps.

The implications of these findings are not only practical but also theoretical. Theoretically, this study reinforces the need to integrate digital preservation principles with the unique needs of geospatial data, especially in the context of Big Data and the Internet of Things (IoT). Practically, archival institutions need to invest in cloud storage infrastructure and AI-based curation tools, while policymakers should encourage the harmonization of metadata standards across sectors. For the future, further research is needed to address real-time data preservation, the impact of privacy regulations such as GDPR, and ethical issues related to crowdsourced data ownership (VGI) and long-term access.

Critical points that need further development include the gap between theory and practice, especially in the implementation of ISO 19115/19157 standards and FAIR principles that are still limited to certain research. The role of librarians also needs to transform from physical collection managers to data stewards, which requires increased technical competency and specific certification for GIS librarians. In addition, sustainable funding models—such as open access schemes or government support—need to be tested and developed. At the same time, community-based repositories can be a solution to reduce reliance on expensive infrastructure.

Thus, geospatial data preservation is not just a technical issue but also includes institutional, cultural, and ethical challenges that require cross-disciplinary synergy, long-term commitment, and collaboration between various stakeholders. These efforts are not only important to ensure the sustainability of geospatial data, but also to support research, policy-making, and sustainable development in the future.

E. CONCLUSION

The exponential growth in geospatial data utilization across sectors has created complex preservation challenges that demand a multi-stakeholder response. Our findings reveal that effective long-term management requires addressing three interconnected dimensions: technical infrastructure, institutional frameworks, and collaborative networks. While technical solutions like format standardization and AI-driven curation are crucial, they must be supported by policy reforms and capacity building among information professionals. Key insights from the study include:

1. The critical role of collaborative models (exemplified by Ontario's OCUL GeoCommunity) in overcoming resource limitations
2. The growing urgency to develop specialized repositories with standardized documentation protocols
3. The underappreciated importance of socio-technical factors in preservation success

For practitioners, these findings underscore the need to move beyond traditional archival approaches. Map librarians and data curators must now cultivate technical competencies in emerging technologies while advocating for institutional support. Policymakers, meanwhile, should prioritize funding for

preservation infrastructure and mandate interoperability standards across Spatial Data Infrastructure initiatives. The study's limitations point to valuable directions for future research:

1. The rapid evolution of blockchain and distributed ledger technologies for geospatial provenance tracking
2. Ethical implications of preserving sensitive location data under evolving privacy regulations
3. Comparative analysis of preservation frameworks across different geopolitical contexts

Ultimately, safeguarding our geospatial heritage will require sustained collaboration between researchers developing innovative solutions, professionals implementing best practices, and policymakers creating enabling environments. As the volume and complexity of geospatial data continue to grow, the insights from this study provide both a warning about current gaps and a roadmap for building more resilient preservation systems. The challenge is substantial, but so too is the opportunity to shape a future where geospatial knowledge remains accessible and actionable across generations.

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