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Geospatial Information and Artificial Intelligence (AI): Opportunities and Challenges for Map/GIS Libraries

Keywords: *Map/GIS libraries, artificial intelligence, GeoAI, spatial data literacy, geospatial metadata, literature review*

Summary: *Map/GIS libraries manage large volumes of digital or hybrid heterogeneous geospatial materials, historical maps, metadata, and digital records. They perform a variety of specialized functions related to the cataloging, metadata and classification, reference and user support, discovery and search services, collection development and management, instruction and user education, geospatial preservation, and geospatial research data management. These areas are increasingly affected by the rapid advancement of artificial intelligence (AI). While AI has attracted growing attention across library and information science, its implications for the specific service context of Map/GIS libraries remain underexplored. Given the limited research in this area, this paper explores the role of AI in Map/GIS libraries, focusing on how AI technologies (including machine learning, large language models (LLMs) and generative AI) are reshaping each of these core library functions. Methodologically, the study relies on a literature review of international bibliography published primarily between 2020 and 2025, across the fields of library and information science, Map/GIS libraries, and AI research. Results demonstrate that AI has substantial opportunities for Map and GIS libraries in all the above essential functions and services. Furthermore, the literature review highlights significant challenges related to skills, technical requirements and AI ethical use. Finally, the study suggests that Map/GIS librarians are the most qualified professionals to guide and instruct patrons in the use and implementation of AI tools in their daily lives considering that they are pioneers in the adoption of new technologies aiming the provided services improvement.*

Introduction

Geographical information is heading to a new phase in which AI is transforming the collection, interpretation, visualization, and use of spatial data, pushing geoscience and GIS beyond traditional automation toward intelligent reasoning, knowledge discovery, and scalable analysis of large spatial datasets (Mai et al. 2025; Li Shao and Zhang 2020). This convergence supports applications such as remote sensing, cartography, urban computing, and spatial prediction, combining geospatial science with machine and deep learning methods (Mai et al. 2025). Map/GIS libraries are moving from print-based map collections to digital hubs for geospatial information that support service analysis and collection planning while they have been a source of successful collaborations (Paige and Finn 2025). Relevant research studies on AI in libraries demonstrate that these technologies are already in active use, changing cataloging, classification, metadata creation, retrieval, reference services, and user support; yet, their implementation is still different and is usually dependent on institutional strategy, infrastructure, and staff's qualifications (Esh and Ghosh 2024).
In the above framework, due to their institutional role, Map/GIS libraries are most appropriately situated (indeed the sole responsible party) to serve as a connecting point between users in need of reliable geographical information, geo-literacy support, practical guidance, and ge-

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ospatial AI tools (Borgohain Bhardwaj and Verma 2024). Nevertheless, this interaction additionally brings along more complex ethical and technological challenges, including heterogeneity, fairness, privacy, interpretability of models, data quality, bias, and lack of training data (Fernholz et al. 2025; Mahmud 2024). The paper seeks to examine the integration of AI technologies into seven core Map/GIS library functions and services: *Cataloging and Classification, Reference & User Support, Collection Development & Management, Discovery & Search Services, Geospatial Preservation, Instruction & User Education, and Geospatial Research Data Management (RDM)*. For this goal to be accomplished, an international literature review conducted in the fields of AI research, Map/GIS libraries, and library and information science based on articles published primarily between 2020 and 2025.

This research is organized into the following sections to accomplish its goals: To comprehend the relationship between AI, GIS, and Map/GIS libraries, a conceptual framework is initially developed. The paper then explores various AI implementations across critical Map/GIS library services and functions, documenting the adoption and practical integration of these technologies. Some case studies of AI in Map/GIS libraries are presented while both challenges in the application of AI in Map/GIS libraries and challenges to the adoption of AI by Map/GIS libraries are discussed. As the Map/GIS librarian has a key role in the adoption of AI into the library environment, its evolving role is discussed further. After the discussion of the findings and the directions for future research, the conclusions summarize the key insights of the paper.

AI, GIS, and Geographic Libraries: A Conceptual Framework

There is a relation between AI, GIS, and Map/GIS libraries, which relies not only on the alignment of three different but yet fundamentally interconnected fields. This synthesis reflects the utilization of novel technological tools in library settings as well as a major shift in how geographical information is organized, curated, managed, accessed, and exploited.

AI is one of the fastest-growing fields, and it is already generating over a trillion dollars a year in revenue (Russel and Norvig 2021:19). Rich and Knight (1991:3) simply define AI as "*the study of how to make computers do things which, at the moment, people do better.*" It constitutes a broad and multidisciplinary field of computer science concerned with the development of computational methods, models, and algorithms. These models are capable of performing tasks that have traditionally required human cognitive abilities, including learning, reasoning, pattern recognition, decision-making, and natural language understanding (Tecuci 2012; Dwivedi et al. 2021). Contemporary advances in AI have been driven primarily by developments in Machine Learning[1] (ML), Deep Learning[2] (DL), Natural Language Processing[3] (NLP), and Computer Vision[4] (CV). A major turning point in the development of the field has been reached lately with the spread of Generative Artificial Intelligence[5] (Gener-

[1]ML can be considered the subfield of AI that concerns the extraction of information from example data in order to enable computer systems to learn specific tasks and improve their performance (van den Brandhof et al. 2023).

[2]DL discovers intricate structure in large data sets by using the backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer (LeCun Bengio and Hinton 2015).

[3] A subfield of AI that aims to enable computers to understand, analyze, generate, and transform human language (Martinez 2010).

[4]A field of AI concerned with the automatic interpretation and processing of visual data, such as images and videos, to perform tasks including object recognition, classification, detection, and scene understanding (Conwell et al. 2024).

[5] A subset of Artificial Intelligence and Deep Learning that generates novel content (including text, images, audio, video, and source code) by learning the underlying patterns, structures, and probability distributions of training data (Shoitan et al. 2026).

Conference Proceedings, ISSN 2459-3893
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AUTH CartoGeoLab, 2026

ative AI). Built upon Large Language Models[6] (LLMs) and other foundation models, Generative AI enables the generation, interpretation, and synthesis of textual, visual, and multimodal content, thereby substantially expanding the range of applications of AI across scientific, educational, and information management domains. The rapid advancement of AI has brought about structural transformations across social, economic, and technological domains in the twenty-first century. Machine learning and deep learning technologies (including large language models) have established themselves as new systems that augment human cognition and decision-making by enabling rapid analysis of large-scale datasets (Kijewski Ronchi and Vayena 2025; Falegnami et al. 2024).

In the library environment, these technologies are already being used to automate cataloguing, generate metadata, classify information resources, develop information retrieval systems, and support users through intelligent assistants and conversational systems (Engel et al. 2025; Boateng 2025; Corrado 2021). At the same time, Geographic Information Systems (GIS) constitute the core technological environment for collecting, storing, organising, analysing, visualising, and disseminating spatial data (Kirilenko 2022). Geospatial information differs from other forms of information in that each object is linked to a specific location in geographic space and is often accompanied by temporal, thematic, and descriptive attributes. GIS is a key tool in many scientific disciplines, such as geography, urban planning, environmental management, archaeology, and the humanities, due to its capacity to integrate data from many sources and formats (Kuhn 2012).

Geospatial Artificial Intelligence (GeoAI), an interdisciplinary field that uses machine learning, deep learning, and computer vision algorithms to automatically identify spatial patterns, classify satellite imagery, extract geographic features, predict spatial phenomena, and support complex decision-making processes, has emerged as a result of the ongoing growth in the volume and complexity of geospatial data (Dyke 2026; Mai et al. 2025; Li et al. 2024). We can describe the relationship between AI, GIS, and Map/GIS libraries as a three-part conceptual scheme based on the previous discussion: AI adds intelligent processing for analysis, automation, and knowledge production, while GIS provides the infrastructure for organising and managing spatial information. Lastly, the institutional environment where these two technologies are converted into established services for the implementation, distribution, and access to geospatial knowledge is represented by the Map/GIS library (Fig.1).

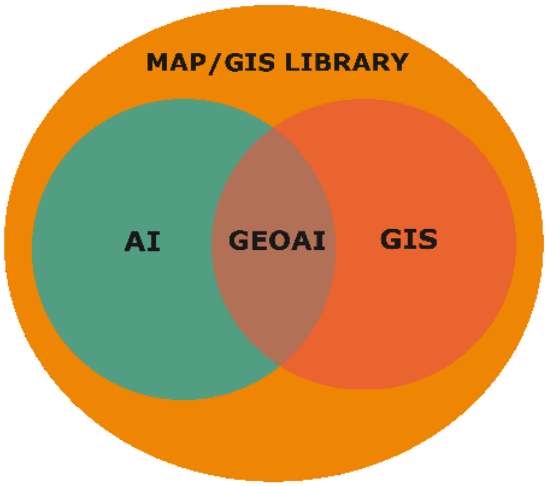


Fig.1: Three-part conceptual scheme: AI, GEOAI and GIS in the framework of the Map/GIS library

In response to this viewpoint, the library serves as a link between the user, geospatial collections, and cutting-edge technology infrastructures, providing data quality, interoperability, open access, respon-

[6] LLMs are a type of artificial intelligence system trained on large volumes of data that can generate and understand human-like language. LLMs are made up of a large number of parameters (varying from billions to trillions), allowing them to handle complex language understanding and creation (Pillai and Tanev 2026).

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sible use of AI applications, and appropriate use of geographic data and its sources. This conceptual approach also affects the connections linked with Map/GIS librarianship.
Standard information retrieval is evolving into a geographical discovery process, and traditional cataloging is moving toward integrating dynamically produced metadata created and enhanced by algorithms. These days, users interact with intelligent systems that comprehend the spatial, temporal, and semantic context of their query rather than just using keywords to search for a map. This shift provides the theoretical context for the possibilities, difficulties, and forthcoming advances covered in the article's sections that follow.

Applications of AI in Map/GIS Libraries

The unique and highly specialized tasks carried out by Map/GIS libraries are becoming increasingly influenced by the rapid development of AI. The retrieved literature indicates that by accelerating text recognition, georeferencing, and metadata development, AI is creating new opportunities for historical maps and analog spatial data (Kim et al., 2023; Li et al., 2021; Bahgat and Runfola 2021). It is also associated with faster access, more personalized support, automated cataloging, and smarter geospatial service chains, alongside growing concerns about ethics, privacy, skills, and infrastructure (Torres Jr. and Peñaflor 2026; Jyoti 2024).
Across the studies examined, seven functional areas emerge as the ones most systematically and repeatedly affected by AI in Map/GIS library contexts: *cataloging, metadata and classification*, *reference and user support*, *discovery and search services, collection development and management, instruction and user education, geospatial preservation, and geospatial research data management*. These areas recur consistently as the dominant themes across reviews, case studies, and professional guidance documents issued by library and geospatial-data organizations and were therefore adopted as the organizing framework for this review (Jyoti 2024; Corrado 2021; Schreur 2020; American Library Association 2026; Association of College and Research Libraries 2025; International Federation of Library Associations and Institutions 2025). This section presents the findings of a literature review conducted on scholarly publications in LeapSpace database[7] (formerly Elsevier's ScienceDirect.ai) from 2020 to 2025 concerning the impact of AI on these seven functional areas. LeapSpace was not used as a replacement for the critical assessment of sources; rather, it was used strictly to locate relevant scholarly publications. The author independently selected the sources that were eventually included in the article after critically evaluating their scholarly quality, relevance, and compatibility with the study's goals. For each area, the relevant literature was examined in order to identify the extent to which AI-based methods and tools have already been integrated into practice. The results were organized into a summary table, structured according to the seven functional areas outlined above. In particular the AI applications that have been documented as being utilized in libraries are listed in a different column for each function/service, and the bibliography supporting them is provided in the final column (Table 1). The findings for each area are then discussed in more detail below.

LIBRARY FUNCTION/SERVICE	AI IMPLICATION	BIBLIOGRAPHY
Cataloging and Classification	Automates metadata extraction and creation	Jabeen 2025; Mahmud 2024; Corrado 2021; Schreur 2020
	OCR	
	Subject indexing	
	Improves speed and consistency	
	Linked-data workflows	

[7] LeapSpace is a research-grade AI-assisted workspace that blends responsible AI and trust indicators with the most comprehensive collection of peer-reviewed, publisher-neutral full-text and abstracts as metadata as well as indexed in Scopus and participating publishing partners, including both subscription and open access sources. The Greek academic community has access to LeapSpace under Heal-Link's consortium agreements.

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Reference & User Support	Chatbots	Abutayeh 2025; Chen and Chang 2025; Liu, Li, and Kazazi 2025; Barsha and Munshi 2024; Mansourian, and Oucheikh 2024; Nawaz 2021
	RAG systems	
	Multi-layered reference	
	Personalized assistance	
	24/7 availability	
	Intelligent geospatial data discovery	
	ChatGeoAI framework (Llama 2) converts natural-language queries into executable GIS code, enabling geospatial analysis by non-specialists	
Collection Development & Management	Automated track of new releases across major spatial data portals	Ajakaye 2025; Vahdat, Badard, and Pouliot 2025; Petit and Vuillerme 2025; Basak et al.2024
	Semantic similarity models compare new dataset descriptions against existing collection holdings	
	AI can analyze circulation and usage patterns to support collection development and resource allocation	
Discovery & Search Services	NLP-driven search	Adewojo and Dunmade 2024; Mahmud 2024; Jyoti 2024; Bubinger and Dinneen 2024; Halilali et al. 2022
	Semantic search	
	Personalized recommendations	
	Intelligent gateways	
	AI-enhanced access to digital collections, especially large-scale historical data	
Geospatial preservation	AI supports long-term access, metadata quality and digital preservation strategies	Ailakhu 2024; Sun et al. 2024; Jaillant and Caputo 2022
	AI improves curation, reuse and management of born-digital/historical records	
	Workflow/metadata tools support interoperability and reproducibility for long-term preservation	
Instruction & User Education	Intelligent tutoring and adaptive learning for GIS/map literacy	Bridges et al. 2025; Jhariya and Bajpail 2025; Anna, Novian and Ismail 2023; Andrews, Ward and Yoon 2021
	Learning analytics for instruction and assessment	
	AI-enhanced programming/makerspace initiatives	
	Personalized, differentiated resource guidance	
	Generative AI for instructional material creation (tutorials, rubrics, datasets)	
	Natural language interfaces lowering technical barriers in workshops	
Geospatial Research Data Management (RDM)	AI-assisted metadata templates	Guy, Zhang, and Truong 2025; Zareef and Jabeen 2025; Griffin and Janz 2024; Hackett and Kim 2024
	AI tools partially automate preparation of ISO 19115or FGDC	
	Supportive layer embedded within library workflows	
	LLMs generate draft metadata for existing research data	
	Policies, standards, and sustainability practices are necessary foundations for any AI-supported geospatial RDM approach	

Table 1: AI Implications for key functions/services in Map/GIS Libraries

Map/GIS libraries are being transformed from storage-and-access infrastructures into intelligent service environments because of AI. The strongest effects appear in reference work, discovery, metadata production, and workflow automation. Particularly, for ***reference and user support*** in library settings, AI-enhanced reference systems can combine retrieval-augmented generation and graph-based methods to deliver tiered support for different user needs (Chen and Chang 2025). Related applications include chatbots and virtual assistants that support user guidance and access to information resources more broadly (Abutayeh 2025; Nawaz 2021; Barsha and Munshi 2024). A major source of difficulty in geospatial reference has always been the inadequacy of standard keyword-based searches for spatial data portals. Researchers and general users alike who do not know the controlled vocabulary of a given

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AUTH CartoGeoLab, 2026

catalog, or who describe their needs in everyday language rather than technical terms, frequently fail to retrieve relevant datasets even when they exist. Recent research proposes LLM-powered, intent-aware discovery frameworks that interpret natural language queries semantically and match them against heterogeneous geospatial data catalogs moving toward what researchers describe as intelligent geospatial data discovery that captures user intent more effectively than keyword matching (Liu Li and Kazazi 2025). Similarly, the ChatGeoAI framework, built on the Llama 2 large language model, enables users to issue natural language requests and receive executable GIS code for analysis within environments such as QGIS, effectively lowering the technical barrier to geospatial analysis for non-specialist users (Mansourian, and Oucheikh 2024).

AI is also changing ***cataloging, metadata, and classification***. Reviews of library cataloging and metadata creation show that machine learning and natural language processing can improve efficiency, consistency, and depth in metadata work, although the supporting evidence remains more optimistic than experimental at this stage (Corrado 2021). Even so, these techniques already support automatic metadata extraction, subject determination, classification, indexing, and OCR-based processing, reducing human workload across cataloging tasks (Mahmud 2024). Reflecting this trajectory, AI-driven cataloging is gradually moving from experimentation toward fuller integration in some libraries, even as broader empirical validation is still catching up (Jabeen 2025). In light of these advances in metadata and classification, the combination of linked data and AI further supports improved resource representation on the semantic web (Schreur 2020).

In Map/GIS libraries, AI is particularly crucial for ***search and discovery services***. It enhances resource discovery, custom suggestions, and search capabilities, including intelligent retrieval across sophisticated geospatial datasets (Adewojo and Dunmade 2024). Semantic reasoning, independent workflow composition, and knowledge discovery are used by intelligent GIS services to facilitate improved access to scattered geospatial information. Geospatial service discovery, service orchestration, and AI-enabled assistants may minimize technical obstacles and enhance the retrieval of complex geospatial data, according to related research (Jyoti 2024; Halilali et al. 2022).

AI is revolutionizing ***collection development and management*** by increasing the analytical, predictive, and efficient nature of these jobs. Librarians can use circulation data, usage trends, and user behavior as guidance for acquisition and selection choices, resulting in collections that are more closely aligned with real demand (Ajakaye 2025; Basak et.al. 2024).

AI is being utilized to proactively find new acquisition candidates in addition to making decisions based on current usage patterns. Major spatial data portals, such as national open data repositories, regional spatial data infrastructures, and scientific data archives, may now be tracked by automated monitoring technologies, which can also identify datasets that match collection scope profiles. By using semantic similarity models to check new dataset descriptions against current collection holdings, these tools go beyond basic keyword alerts identifying potential gaps, redundancies, or high-priority acquisitions (Vahdat Badard and Pouliot 2025; Petit and Vuillerme 2025).

Instruction and user education have become one of the most visible and valued functions of Map/GIS libraries, and AI is now expanding this educational role in two distinct but complementary ways: by enhancing what is taught and by transforming how it is taught. With respect to content, intelligent tutoring systems and adaptive learning platforms can support spatial reasoning and guide users through GIS software training while also enabling remote and self-paced approaches to map literacy education (Bridges et al. 2025). More broadly, intelligent educational systems and learning analytics allow instructors to refine both instructional design and assessment, adapting content to the progress and needs of individual learners. Alongside this shift in instructional design, libraries increasingly integrate AI-enhanced programming and making opportunities, such as hands-on workshops and digital literacy initiatives, which extend beyond traditional reference and instruction services (Andrews, Ward and Yoon 2021). Beyond shaping instructional content, AI is also changing how GIS librarians design and deliver instruction. Generative AI tools can assist in creating instructional materials (e.g., tutorial scripts, dataset descriptions, exercise datasets, and assessment rubrics) at significantly greater speed than manual authorship (Anna, Novian and Ismail 2023). At the same time, natural language interfaces to GIS software lower the technical barrier for workshop participants, potentially allowing instruction sessions to move more quickly from tool mechanics to deeper engagement with spatial analysis concepts. Taken together, these developments indicate that AI is reshaping the delivery of educational

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services in GIS libraries, enabling a shift towards more differentiated instruction whereby both the content delivered and the process of delivering it can be tailored to the specific competencies and goals of each user (Jhariya and Bajpail 2025; Baker 2025).

Another important area where AI is starting to exert a significant impact on Map/GIS libraries is *geospatial preservation*, which supports long-term access, enhances metadata quality, and expands digital preservation techniques for spatial and historical materials (Ailakhu 2024). According to the literature, AI can improve the reuse and management of archival and cultural data by accelerating the curation of both born-digital and historical records (Jaillant and Caputo 2022). Particularly in geospatial contexts, related workflow and metadata technologies enhance interoperability and reproducibility, both of which are conditions that are essential to long-term preservation (Sun et al. 2024).

The literature on ***Geospatial Research Data Management (RDM)*** presents a more comprehensive perspective, distinguishing between explicitly documented AI applications and potential applications inferred from related practices. AI assistance in this space can be viewed, based on the available literature, as a supportive layer embedded within library workflows for curation, metadata, preservation, discovery, and research data services (Hackett and Kim 2024). This support becomes evident at several distinct points in the workflow. At data creation, AI-assisted metadata templates can prompt researchers to capture required elements, e.g., coordinate reference systems, geographic extent, attribute definitions, and data lineage, during or immediately after data collection, when this information is most readily available (Guy, Zhang, and Truong 2025; Griffin and Janz 2024). At deposit, AI tools can partially automate the preparation of ISO 19115 or FGDC-compliant metadata records from researcher-supplied documentation, with library staff reviewing and completing the records; and for existing datasets requiring retrospective documentation, LLMs can generate draft metadata from associated publications, data dictionaries, or project reports (Corrado 2021). These technical gains, however, do not stand apart from the broader concerns of the field: studies on digital curation and RDM continue to place strong emphasis on policies, standards, and sustainability, all of which are elements that would be critical to any AI-supported approach to geospatial data (Zareef and Jabeen 2025).

However, these advances come with familiar constraints: data quality, privacy, ethics, infrastructure, and staff skills (Kausika and van Altena 2025; Barsha and Munshi 2024; Jyoti 2024). For that reason, the literature does not support a simple "automation replaces librarians" view; instead, it points to a redesign of library work toward oversight, curation, instruction, and responsible AI governance (Kautonen and Gasparini 2024; Barsha and Munshi 2024). Overall, AI is most likely to reshape map/GIS libraries by making them more discovery-driven, metadata-rich, and workflow-automated a shift that changes how library work is carried out, even as it leaves the underlying human responsibility for interpretation and ethical judgment firmly in place (Engel et al. 2025; Li et al. 2025).

Case Studies of AI in Map/GIS Libraries

The international literature reflects a diverse range of AI applications addressing different services and functions within Map/GIS libraries and related institutions, spanning digitization, cataloging, reference provision, discovery, collection management, and professional education. The Royal Danish Library, through the Postcard project, in order to digitize approximately 350,000 topographic postcards dating from 1887 to the 1990s from across Denmark, developed and implemented AI to make this special collection available to the wider public (Scupola 2025). Taniguchi (2024), in his study, examined the feasibility of creating MARC 21 bibliographic records based on RDA standards using ChatGPT (GPT-4). The selected examples encompassed a wide variety of resource types beyond books, including maps, sheet music, sound recordings, microforms, electronic resources, and serial publications. The results revealed promise in ChatGPT's ability to create MARC 21 bibliographic records, indicating that it could be used as a tool to assist human catalogers. The above is one of the many articles in the international literature that explore the AI application to library cataloging work since the public release of ChatGPT in 2022 (Engel et al. 2025). Turning to reference and user support, the case of the Hakka Literary Museum illustrates the application of RAG and GraphRAG frameworks to deliver multi-tiered reference services, enabling real-time web scraping and faster, more in-depth responses to subject-based queries (Chen and Chang 2025). With respect to discovery and search services, the Library of Congress's Geography and Map Division has employed the multimodal CLIP model to gener-

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ate embeddings for over 562,000 maps and to implement exploratory search methods encompassing natural language, visual, and multimodal inputs, indicating that CLIP's primary function in this context is to support discovery and interactive search (Mahowald and Lee 2024); in a similar vein, a study conducted across the top 100 US university libraries reports the adoption of intelligent retrieval and recommendation technologies to support retrieval, reference, guided-tour, and ID-recognition services (Guo et al. 2025). AI solutions have been used in the field of collection development and management to help ease the administration and organization of collections with the goal of minimizing routine tasks and assisting in selection, acquisition, regular inventory, weeding, and evidence-based decision-making (Ajakaye 2025). Ultimately, the B-Wheel model, which is based on the Bauhaus way of teaching design, provides an example from Scandinavian libraries regarding instruction and user education. It focuses on the development of AI capabilities within academic libraries and, consequently, on staff training and assistance (Kautonen and Gasparini 2024). While combined, the above examples point out that the use of AI in Map/GIS libraries is neither isolated nor consistent but rather represents a complex trend that is gradually changing essential library operations throughout the whole service range.

Application Challenges and Adoption Barriers of AI in Map/GIS Libraries

Challenges in the Application of AI in Map/GIS Libraries

The literature indicates that although AI has tremendous amounts of potential to support Map/GIS libraries, privacy, ethical, and organizational issues continue to constrain its implementation (Bradley 2022). Several studies highlight a related set of practical barriers, including data quality issues, integration with legacy systems, and the need for new skill sets among library professionals (Mahmud 2024). These challenges are related to the fact that AI integration frequently necessitates stronger digital infrastructure, compatibility with current systems, and technical capacity, while GIS and geospatial services rely on standardized metadata, shared schemas, and interoperable platforms (Jabeen 2025). The literature frequently reveals that AI systems are vulnerable to recurrent issues, such as incomplete data, poor interoperability, and limited reproducibility. This dependence on trustworthy metadata, standardized documentation, and traceable workflows makes data quality and provenance a particularly persistent limitation (Mahmud 2024; Corrado 2021). Beyond these technological worries, ethical issues (such as bias, discrimination, disinformation, and algorithmic opacity) add an additional layer of danger, especially when generative AI generates outputs that are convincing but incorrect or when black box systems influence user access and decision making (Kavak 2024). Therefore, the key question for Map/GIS libraries is not whether AI can be used but rather whether it can be implemented with strong governance, transparent and open procedures, and an adequate level of human oversight (Lo 2023).

Challenges to the Adoption of AI by Map/GIS Libraries

Beyond these application-level limitations there is a particular set of issues that are related to institutional adoption of AI itself. As an example, map/GIS libraries operating under resource constraints are facing challenges such as lack of funds, shortage of expertise, weak professional networks, and lack of institutional support (Asim et al. 2023). In practice, many libraries face gaps in staff capacity, training, infrastructure, and policy that collectively affect the progress of adoption and undermine the conditions for its responsible implementation (Jabeen 2025).

The Evolving Role of the Map/GIS Librarian in the AI Era

Despite a systematic examination of the international literature conducted for this study, no professional association specifically dedicated to Map/GIS librarianship has yet been found to offer formal guidance on the responsible use of AI. In the absence of such a dedicated framework, this study draws on the broader recommendations of the American Library Association (ALA) (ALA 2026) and the International Federation of Library Associations and Institutions (IFLA 2020), alongside the wider

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international literature, which together converge on a consistent set of expectations: a Map/GIS librarian should develop AI literacy, prompt engineering, geospatial data curation, ethical judgment, and workflow automation skills in order to use AI tools effectively in map and geospatial services.
The skills required to effectively use and apply AI are not a standalone skill and the literature links its successful adoption to the enhancement of skills such as technical fluency, ethical judgment, metadata expertise, and instructional capacity (Oladokun Abduldaya and Akanbiemu 2025). In light of the above, some of the critical skills required for the effective use and application of AI include the following:

- **AI literacy**: AI literacy can be understood under four basic aspects: understanding AI, applying AI, evaluating and creating AI, and using AI ethically and responsibly considering their societal implications as well (Lo 2024; Ali and Richardson 2025). It is anticipated that librarians will utilize AI tools critically and methodically, expanding beyond simple awareness (Khan et al. 2025). This expectation aligns with IFLA's request that libraries encourage AI literacy and awareness among staff and users, as well as the ALA's emphasis on thorough staff training regarding the usage and consequences associated with AI. (ALA 2026; IFLA 2020).
- **Prompt engineering**: Writing concise, iterative prompts for AI systems and instructing others on how to do the same is known as prompt engineering. Output quality is significantly impacted by prompt quality, especially in reference and instructional contexts (Lo 2023).
- **Metadata and cataloging**: Metadata and cataloging skills involve using AI to support subject analysis, classification, and metadata creation while ensuring accuracy. AI can increase productivity, but human evaluation is still necessary for metadata work to guarantee accuracy and contextual relevance (Mahmud 2024; Corrado 2021). This is consistent with the role IFLA anticipates for libraries in search and discovery, classification, and content production enabled by AI (IFLA 2020).
- **Spatial data curation**: Organizing, maintaining, disseminating, and publishing geospatial data across the whole data life cycle is known as spatial data curation. Map/GIS librarians are increasingly expected to contribute to data-intensive research rather than only managing map collections (Bishop and Larsen 2025).
- **Geospatial analysis and GIS tools**: Working effectively with GIS software, spatial data, and geospatial processes is a key component of geospatial analysis and GIS tools expertise. Technical GIS knowledge that goes beyond standard library skill sets is becoming more and more necessary for Map/GIS library positions (Plassche 2022).
- **Ethics, privacy, and bias awareness**: The ability to critically evaluate the ethical implications of AI-generated outputs, including concerns about bias, privacy, transparency, copyright compliance, and responsibility, is referred to as ethics, privacy, and bias awareness. Studies examining the application of AI in library settings continue to identify ethical concerns as one of the most common issues. (Sousa 2025; Adewojo and Dunmade 2024). This consideration aligns with IFLA's focus on reducing algorithmic bias and preserving intellectual freedom, as well as the ALA's recommendations on data ownership and patron privacy protection. (ALA 2026; Ali and Richardson 2025).
- **Instruction and training**: Teaching users how to utilize AI technologies ethically in research and information literacy contexts is part of instruction and training. Map/GIS librarians are especially qualified to teach AI literacy in conjunction with geospatial literacy (Schmidt Fruehauf and Beman-Cavallaro 2025). This reflects IFLA's recommendation that libraries play an active role in advancing AI literacy through user education (IFLA 2020).
- **Workflow automation and data handling**: Workflow automation and data handling involve using AI to streamline repetitive tasks and support research workflows. AI is most commonly framed as a tool for efficiency, though it simultaneously reshapes librarians' professional roles (Hassan and Becker 2025). This corresponds to IFLA's identification of AI-supported decision-making analytics, such as resource allocation, as an emerging library role (IFLA 2020).

The strongest profile is thus a hybrid one: a Map/GIS librarian who combines geospatial and data expertise with AI literacy, prompt design, ethical judgment, and teaching ability will be better prepared than one who focuses on tool use alone (Schmidt Fruehauf and Beman-Cavallaro 2025). This hybrid

Conference Proceedings, ISSN 2459-3893
Editors: A.Tsorlini, C. Boutoura
AUTH CartoGeoLab, 2026

profile is notably consistent with the combined vision set out in the ALA and IFLA documents discussed above, which likewise frame the librarian's role in the AI era not as the mastery of any single technical skill, but as a broader stewardship function spanning data protection, ethical oversight, and user education (ALA 2026; IFLA 2020). Developing this kind of stewardship, however, is unlikely to come from theoretical knowledge alone: evidence on AI in librarianship suggests that practical, hands-on training matters more than purely theoretical instruction (Mannheimer et al. 2024).

Discussion

In the present study, we undertook a literature review of the international scholarship published between 2020 and 2025, with a view to investigating issues relating to the introduction and use of AI in Map/GIS libraries and the management of geographic information. To this end, a conceptual framework for AI, GIS, and Geographic Libraries was first developed, providing the theoretical grounding for the analysis that followed. Building on this framework, we then identified a range of applications emerging from the literature in relation to specific actions and services undertaken by map libraries, before documenting concrete instances of AI implementation across library settings. We then turned to the application challenges and adoption barriers associated with AI in map/GIS libraries, which informed our final examination of the evolving role of the map/GIS librarian in the AI era. The applications reviewed and the case studies presented reveal a recurring pattern: AI adoption in Map/GIS libraries tends to cluster around a number of core functions such as cataloging and metadata generation, reference and discovery services, collection management, and geospatial data curation rather than constituting a uniform or centrally coordinated strategy. The Library of Congress use of the multimodal CLIP model for map retrieval (Mahowald and Lee 2024), the creation of MARC 21 records through the ChatGPT use of the (Taniguchi, 2024), and the application of RAG and GraphRAG to provide multi-level reference services at the Hakka Literary Museum (Chen and Chang 2025), all bring up unique operational challenges. However, all of them, come to the same conclusion that AI is being developed as a tool that supports existing professional practices and workflows rather than as a replacement for librarianship knowledge. This finding aligns closely with the conceptual framework outlined above, which likewise treats AI as a set of tools operating in interaction with, rather than in substitution for, established library and GIS competencies. A recurring pattern in the applications and case studies examined in the literature is the trade-off between effectiveness and reliability. AI is constantly mentioned as tools for reducing repetitive workloads, whether in the field of cataloguing (Taniguchi 2024), collections management (Ajakaye 2025), or search services (Guo et al. 2025). Nonetheless, human verification still has an important role to play, especially in the accuracy of metadata and quality of subject analysis. This trend is in line with the aforementioned challenges, where data quality, origin, and interoperability have been recognized as long-term constraints (Mahmud 2024; Corrado 2021). These findings in combination suggest that the introduction of AI in Map/GIS libraries does not replace professional oversight but rather redefines it: librarians are now regarded as the professionals who verify and curate the output of AI, as opposed to just be its initial producers. The challenges in the AI implementation such as privacy, governance gaps, and resource constraints (Bradley 2022; Kavak 2024; Lo 2023; Asim et al. 2023) also highlight the institutional parameter that goes beyond technical constraints. This interpretation is reinforced by the aforementioned guidelines of the ALA (2026) and IFLA (2020) which assign the responsibility of the librarian not only in the technical management but also in the long-term stewardship and maintenance of data protection, ethical supervision and user education. Jabeen's (2025) confirms that the responsible implementation of AI is limited by the availability of staff, their level of training and the absence of clear policies.
The immediate professional response to the challenges mentioned above is to add to the Map/GIS librarian's existing skill profile the competencies that arise with the adoption of GeoAI, e.g., GeoAI literacy, prompt engineering, geospatial data curation, ethics, instruction, and workflow automation skills. While the focus on guidance and AI literacy supports IFLA's (2020) recommendation for libraries to take the lead in promoting AI literacy, the emphasis on ethics, discrimination, misinformation, and awareness of biases confronts the management challenges already indicated.

Conference Proceedings, ISSN 2459-3893
Editors: A.Tsorlini, C. Boutoura
AUTH CartoGeoLab, 2026

Thus, the "hybrid profile" that was previously described in this study is not solely a theoretical notion but rather an interpretive framework that directly results from certain risks and gaps that are clearly noted throughout the article.

Limitations of the present study

This research is subject to several limitations that should be noted. The literature review conducted for this study did not identify specific guidelines for the implementation of AI in Map/GIS libraries from professional associations related to Map/GIS librarianship. Therefore, the proposed competency framework discussed in the paper is drawn from the guidelines of the associations of the broader library community and the relevant literature (ALA 2026; IFLA 2020). This in itself is a finding of the study, but it also limits the specificity of the proposed recommendations. Second, the case studies reviewed are mainly captivated from large, well-resourced institutions (e.g., Library of Congress, Stanford, Royal Danish Library) which may limit the generalization of the findings to smaller or resource-constrained libraries. Third, the literature reviewed is concentrated within the past five years, reflecting the regency of generative AI adoption but also meaning that longer-term outcomes and impacts remain, as yet, undocumented.

Future research

With regard to the aforementioned considerations future research in the field should be include: a. A thorough and comprehensive research based on robust scientific methods of the use of AI in Map/GIS libraries. b. The development of Map/GIS librarian AI Competencies document similar to the one that Map and Geospatial Information Round Table (MAGERT) of the American Library Association (ALA) conducted for the Map/GIS librarian: *"Map, GIS and Cataloging/Metadata Librarian Core Competencies*[8]*"*, c. long term research that examines the impact of the AI on the ongoing evolution of the Map/GIS librarian's professional identity and workload.

Conclusions

GeoAI evolution has begun to affect the way geographic information is produced, processed, maintained, distributed, and retrieved, thereby affecting the way Map/GIS libraries carry out their fundamental service mission. The bibliographic research conducted in the international bibliography of the last five years revealed a common ground among the scientific communities of AI, GIS, and Map/GIS librarianship regarding the opportunities in the roles and services of Map/GIS libraries: expanding collection reach, accelerating metadata creation, scaling discovery services, enriching instruction, improving research data documentation, and amplifying advocacy impact. Equally significant are the identified challenges such as the risk of quality loss in cataloguing assisted by AI, alongside with the potential replacement of references and bibliographies with incorrect or false substitutes. Furthermore, differences in the adoption and use of GeoAI by academic institutions and organizations lead to differences in the benefits gained while its limitations in spatial reasoning and areas' adequate geographic representation continue to be significant research challenges. However, as mentioned above, these challenges do not constitute an argument against engaging with AI. On the contrary, they document the need for all efforts to exploit the potential of this technology to be conducted in alignment with the core professional values of the Map/GIS library community, namely accuracy, equity, openness, and service. The adjustment of GeoAI as a recognized field of library practice suggests that the Map/GIS library community is already responding to the current phase of transformation. Therefore, what lies ahead is to convert this commitment into concrete service improvements, common professional standards, and ongoing support for a geospatial AI ecosystem that can serve the whole range of scholarly communities supported by Map/GIS libraries. However, the fact that Map/GIS librarians currently have little guidance for selecting between competing systems, assessing their accuracy for specialized geospatial applications, or identifying their limitations for particular types of collections and user

[8] https://www.ala.org/sites/default/files/educationcareers/content/careers/corecomp/corecompspecial/magertcorecomp2008.pdf

Conference Proceedings, ISSN 2459-3893
Editors: A.Tsorlini, C. Boutoura
AUTH CartoGeoLab, 2026

communities, however, makes this assignment challenging. This paper highlights that the evaluation, selection, validation, and adoption of GeoAI tools across the full range or even critical areas of a Map/GIS library's services and operations exceed, in most cases, the capabilities of a single organization. Consortial approaches to GeoAI assisted cataloging, shared training datasets for geospatial metadata models, and collectively developed AI literacy curricula for teaching are practices that could significantly multiply the capacity of individual Map/GIS libraries while distributing the costs of experimentation and quality assurance more equitably across the community.
Ultimately, the Map/GIS librarian, at the intersection of geospatial expertise, information science, and AI, remains the key player in the responsible use of GeoAI, ensuring that the technologies involved are accurate, equitable, and meaningfully aligned with the needs of the communities that Map/GIS libraries serve.

AI Declaration
AI technology (ChatGPT4.0 and Claude Sonnet 5) was utilized solely for grammatical correction and language editing purposes during the drafting of this manuscript. The final content was thoroughly reviewed and approved by the author.

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