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BIG DATA IN THE GIS ECOSYSTEM FOR PLANNING IN VIETNAM: CURRENT APPLICATIONS AND FUTURE DIRECTIONS

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Abstract

The ongoing digital transformation has positioned big data and the geographic information system (GIS) ecosystem as essential platforms for spatial analysis, forecasting, and decision support in regional and provincial planning. This paper examines the characteristics and roles of big data within the GIS ecosystem and evaluates its current application in Vietnam in comparison with international experiences. The study employed a synthesis and analysis of secondary sources, including scientific publications, policy reports, and legal documents. The findings show that integrating big data into GIS supports planning analysis and improves the quality of planning formulation and adjustment, and enhances transparency in planning management. Despite these advantages, Vietnam continues to face notable challenges, particularly in technological infrastructure, human resource capacity, and multi-level data integration. Addressing these issues is vital for maximizing the potential of geospatial big data. Based on these insights, the paper proposes solution-oriented directions and development pathways toward building a coherent and sustainable GIS-based big data ecosystem that supports the modernization of planning practices.

Keywords: Big Data; Gis Ecosystem; Planning; Digital Transformation

I. Introduction

Big data is fundamentally transforming approaches to spatial management and analysis. When being integrated into the geographic information system (GIS) ecosystem, big data not only expands the scale and speed of information processing but also supports planning, analysis, and decision-making processes (Zou et al., 2024). With its characteristics of massive volume, rapid update, high diversity, and continuous

dynamics, big data provides a foundation for GIS ecosystems to effectively support regional planning, provincial planning, and planning management.

Globally, several pioneering models demonstrate this potential, such as the Virtual Singapore project, the City Brain system in China, and urban WebGIS platforms in New York and Chicago. These experiences highlight how the integration of big data and GIS ecosystems can generate breakthroughs in analyzing, coordinating, and disseminating planning information.

In Vietnam, the adoption of Big Data in GIS ecosystems has been closely associated with the national digital transformation agenda and ongoing planning reforms. Projects such as the National Planning Information Portal, regional and provincial planning databases, and local WebGIS platforms (e.g., Hanoi, Ho Chi Minh City, Quang Ninh) represent important progress.

As of late 2024, most provinces and centrally governed cities had completed the formulation of their Provincial Plans for 2021–2030 and digitized the associated datasets in accordance with Circular No. 04/2023/TT-BKHDT. These datasets have been integrated into the National Planning Information Portal, covering multiple thematic layers such as land use, technical and social infrastructure, population, resources, and environment.

In addition, several localities such as Hanoi, Ho Chi Minh City, and Quang Ninh have developed WebGIS platforms to disclose planning information and facilitate interaction with citizens and businesses. Nevertheless, practical implementation has revealed persistent issues, including inconsistencies in map scales, uneven digital infrastructure capacity, and a shortage of professionals capable of advanced Big Data exploitation. These issues are considered from a data integration and interoperability perspective rather than through advanced spatial harmonization or multi-resolution modeling approaches.

This study aims to analyze the characteristics and roles of big data within GIS ecosystems, evaluate the current state of application in Vietnam in relation to international experiences, and to identify major challenges. Based on these insights, the authors propose development directions to build a coherent and sustainable geospatial big data ecosystem to effectively support regional and provincial planning and planning management in the digital transformation era.

II. Methodology

This study employed a synthesis and analytical approach based on secondary sources, including published scientific literature, sectoral reports, and the current legal framework in Vietnam. These materials were systematically reviewed and cross-checked to clarify theoretical foundations, establish the regulatory context, and identify the current status of big data applications within GIS ecosystems for planning and planning management.

In addition, the research incorporated an examination of selected planning databases to illustrate practical applications. Specifically, provincial planning datasets from Nghe An, Quang Binh, Hanoi, and Ho Chi Minh City, as well as the regional planning

database of the Northern Midland and Mountainous Region, were analyzed (Hanoi People's Committee, 2024 and Ho Chi Minh City People's Committee, 2024 and People's Committee of Nghe An Province, 2023 and People's Committee of Quang Binh Province, 2023). These datasets were assessed in terms of structural design, thematic layers, and compliance with standardization requirements under Circular No. 04/2023/TT-BKHDT, as well as their integration into the National Planning Information Portal. Insights gained from these case studies provided concrete evidence to complement the literature review and served to highlight key challenges and development orientations for establishing a coherent geospatial Big Data ecosystem in Vietnam.

III. Applications of big data in the GIS ecosystem for planning in Vietnam

Since the enactment of the 2017 Planning Law, Vietnam has accelerated planning reform based on large-scale digital data (National Assembly of Vietnam, 2017). In contrast to the fragmented system of previous decades, current planning processes are increasingly unified across regional and provincial levels, supported by integrated multi-sectoral databases. Decree No. 58/2023/ND-CP and Circular No. 04/2023/TT-BKHDT have established the legal and technical foundations for the development of the National Planning Database, which now functions as the backbone of a multi-level GIS ecosystem (Ministry of Planning and Investment of Vietnam, 2023). This ecosystem is designed to manage, analyze, and share geospatial data at an unprecedented scale, thereby enabling more coherent, transparent, and evidence-based planning practices.

At the regional level, big data is integrated across all 14 mandated sectors—including land, infrastructure, population, resources, environment, and socio-economic development—from every province within the region. Such integration enables planners to prepare comprehensive regional plans that capture cross-provincial synergies and inter-sectoral linkages. The Northern Midland and Mountainous Regional Plan for 2021–2030 serves as a representative example: it consolidated extensive multi-sectoral datasets to identify regional development hubs, design economic corridors, and align spatial development strategies with ecological and environmental protection requirements (Ministry of Planning and Investment of Vietnam, 2023). Other regional plans have adopted similar approaches, leveraging big data to analyze demographic dynamics, assess environmental risks, and plan infrastructure networks. Collectively, these practices demonstrate how integrated geospatial datasets can strengthen spatial coordination and promote balanced development across provinces.

At the provincial level, big data has become the cornerstone of Provincial Plans for 2021–2030 with a vision to 2050. By late 2024, most provinces and centrally governed cities had completed their plans, digitized and standardized planning datasets across all 14 mandated sectors, and uploaded them to the National Planning Information Portal (Fig.1).

Fig. 1. National Planning Information Portal of Vietnam, providing access to national, regional, provincial, urban–rural, and sectoral planning datasets (source: qhqg.cgis.asia, accessed September 2025).

This portal provides a unified platform for data sharing and interoperability, allowing seamless integration between provincial and national datasets. Crucially, the standardization required under Circular No. 04/2023/TT-BKHDT ensures compatibility in terms of coordinate systems, data formats, and metadata structures, thereby facilitating cross-provincial comparison and integration, which is demonstrated in Figure 2. As a result, big data at the provincial level functions not only as a tool for preparing and managing individual plans but also as a fundamental building block for national-scale spatial analysis, monitoring, and policy evaluation.

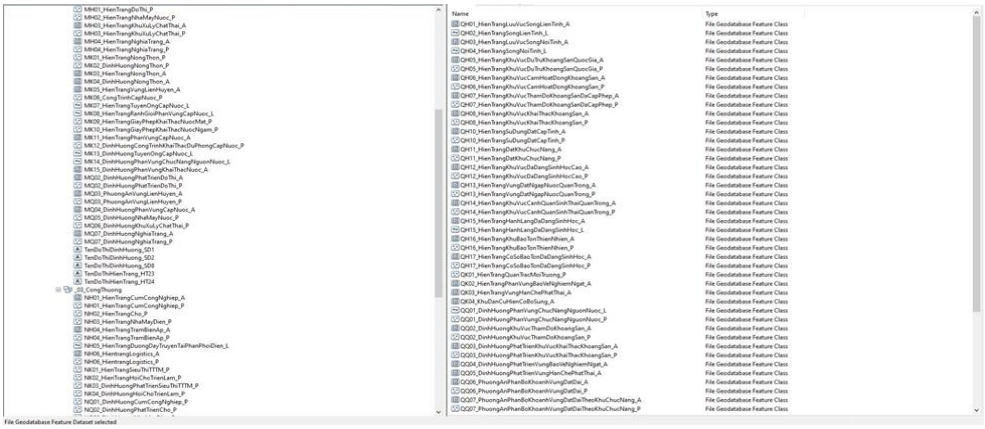

Fig. 2. Structure of provincial planning geodatabase.

At the local level, several cities and provinces have pioneered the development of WebGIS platforms to enhance accessibility and transparency in planning. Hanoi has launched an online planning information system that enables residents to access zoning maps and planning documents, as in Figure 3; Ho Chi Minh City has established a multi-layer spatial data portal to support infrastructure and land-use management; and Quang Ninh has deployed an integrated GIS platform to oversee resources, infrastructure, and tourism development. Collectively, these initiatives illustrate a broader transition from

static, paper-based disclosure toward dynamic, online platforms powered by real-time data streams. By combining planning databases with big data analytics, local WebGIS systems not only improve transparency and facilitate public participation but also equip decision-makers with timely, evidence-based insights for more effective planning and management.

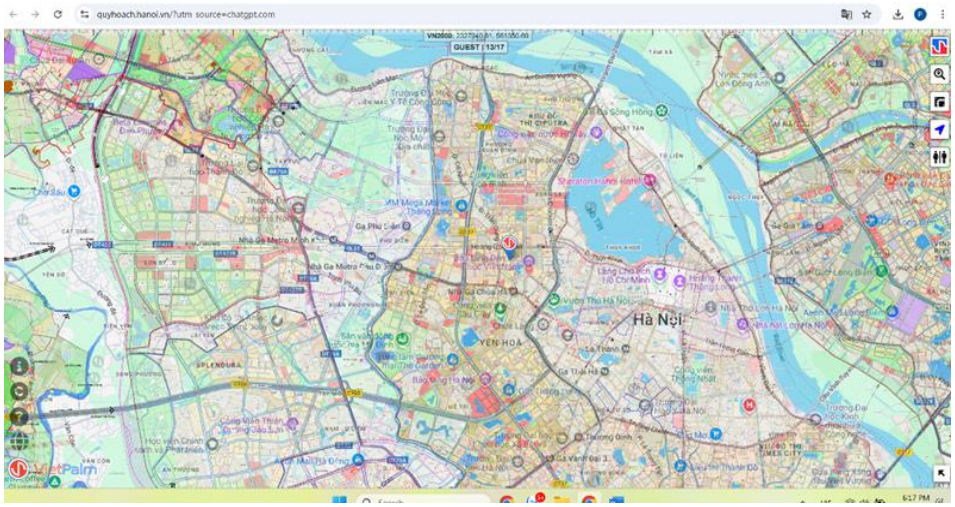

Fig. 3. WebGIS platform of Hanoi for online planning disclosure. Source: Hanoi Planning Portal (quyhoach.hanoi.vn), accessed September 2025.

Taken together, these applications show that Big Data has begun to transform Vietnam's planning system in multiple dimensions. The integration of 14 mandated sectors into regional and provincial plans has fostered a more coherent and multi-sectoral approach to spatial development. At the same time, the growing capacity for forecasting and cross-regional analysis has allowed planners to simulate scenarios such as climate change adaptation, urban expansion, or infrastructure demand. The expansion of WebGIS platforms has also contributed to better governance and transparency by making planning information more accessible to citizens, businesses, and other stakeholders. Beyond these advances, the establishment of shared technical standards and digital databases has laid the groundwork for a gradual shift toward sustainable, data-driven, and participatory planning practices.

Nevertheless, important challenges remain. Limitations in digital infrastructure, shortages of skilled human resources, and gaps in data governance continue to constrain the full potential of Big Data in Vietnam's GIS ecosystem. Overcoming these barriers will be crucial if the country is to align its planning practices with international standards of integrated and transparent spatial governance. This study does not address computational complexity or system scalability. As it focuses on system-level assessment, technical issues related to large-scale data processing are beyond the scope of this paper. These issues will be addressed in future research.

Table 1: Applications of big data on GIS-based planning in Vietnam

Planning level	Big data application	Key outcomes
Regional	Integrated datasets across 14 sectors (land, infrastructure, population, resources, environment, socio-economy, etc.) with large volume and multi-provincial sources	Integrated regional planning across 14 sectors, enabling multi-sectoral linkage and synchronization within the GIS ecosystem
Provincial/city	Provincial planning databases covering 14 sectors, standardized under circular no. 04/2023/tt-bkhdt and updated on the national planning information portal	Integrated provincial planning across 14 sectors, ensuring interoperability from local to national levels within the GIS ecosystem
Local/webgis	Online webGIS platforms integrating planning data of 14 sectors, supporting real-time access and updates	Public disclosure and management of integrated 14-sector planning, enhancing transparency and community participation

Despite the significant progress made in integrating Big Data into the GIS ecosystem for regional and provincial planning in Vietnam, the implementation process continues to face multiple challenges.

From a technical perspective, although coordinate reference systems, digital map formats, and data encoding have been standardized under Circular No. 04/2023/TT-BKHDT, differences in territory size, boundary shape, and especially map scales among provinces remain problematic. In practice, although datasets are standardized to the VN-2000 coordinate system, integration across provinces remains challenging due to variations in spatial resolution and levels of detail. These inconsistencies are often addressed through manual or semi-automated matching processes, such as aligning transportation networks or adjusting administrative boundaries. A common approach is to use larger-scale (higher-resolution) datasets as reference layers. However, such practices remain largely ad hoc and are not governed by a unified technical framework, which may affect data consistency and the reliability of cross-regional spatial analysis. As a result, datasets produced at different scales may lead to inconsistencies in detail and resolution when integrated into regional or national systems, thereby complicating cross-regional analysis and reducing the reliability of large-scale spatial assessments.

In practice, GIS analyses in planning are typically performed within defined planning boundaries (e.g., spatial overlay for land-use consistency checks), rather than across the entire national dataset. Consequently, the computational load remains moderate and depends on the size and level of detail of the selected area.

In Vietnam, current GIS-based planning systems are primarily implemented using centralized database architectures, supporting data integration, storage, and analysis across administrative levels. However, as data volume increases or multiple users

access the system concurrently, performance may be affected due to the limitations of centralized architectures, particularly for spatial queries and analysis operations.

Planning databases are standardized using the VN-2000 coordinate system and referenced to the national geospatial base database or other standardized sources such as satellite imagery and OpenStreetMap, ensuring consistency in spatial reference and topology. Any deviations from the base data are not accepted and must be corrected before integration. For attribute data, in addition to requirements on accuracy, completeness, and timeliness, consistency and logical coherence between data fields must also be ensured (e.g., infrastructure classification following standardized categories). However, when integrating datasets from multiple sources and provinces, minor discrepancies may still arise due to differences in data sources, update times, and local classification practices. These discrepancies are generally limited and are controlled through data validation procedures and dedicated tools with defined tolerance thresholds, but may still affect the consistency of cross-regional analyses and should be considered in planning applications.

With respect to infrastructure and human resources, digital capacity in many provinces is still insufficient. The absence of large data centers, shared cloud platforms, and high-speed transmission networks limits the ability to process and analyze massive datasets. At the same time, most planning and technical staff are only trained in basic GIS operations and lack skills in data science, spatial data mining, and artificial intelligence. As a result, there is a considerable gap between the availability of standardized datasets and the actual ability to exploit them for in-depth analysis and forecasting.

In terms of the legal and institutional framework, although the Planning Law, Decree No. 58/2023/ND-CP, and Decree No. 13/2023/ND-CP on personal data protection have established important foundations, regulations on access rights, inter-agency data sharing, and information security remain incomplete (National Assembly of Vietnam, 2017). Sensitive issues such as anonymization of personal data and responsibilities for managing and sharing spatial data have yet to be clarified, which constrains the development of an open, transparent, and secure data ecosystem.

Another important challenge relates to social accessibility. While some provinces have developed WebGIS platforms to disclose planning information, coverage and usability remain uneven. Many citizens and businesses still face difficulties in accessing or using online planning data due to limitations in digital infrastructure, technical literacy, or user-friendly system design. As a result, the full potential of Big Data in enhancing transparency and community participation in planning has yet to be realized.

Looking ahead, several strategic directions are essential to overcome these barriers. One important direction is to strengthen investment in digital infrastructure at both regional and local levels, including regional data centers, cloud-based platforms, and high-speed communication networks, in order to ensure sufficient capacity for storing and processing large datasets. Equally important is the development of interdisciplinary human resources through practice-oriented training programs that link universities, research institutes, government agencies, and enterprises, thereby creating a workforce that can bridge the gap between technology and planning practice. In parallel, the refinement of national technical standards remains a priority, especially to address

issues of inconsistent map scales and to enhance cross-regional interoperability. Finally, data-sharing mechanisms should be designed to be transparent, open, and secure, protecting citizens' rights while encouraging private sector and community participation in the development of data-driven applications.

In summary, the challenges of applying Big Data in the GIS ecosystem in Vietnam are concentrated not only in infrastructure and human resources at the local level, but also in technical and legal frameworks at the national scale, as well as in the accessibility of planning data for citizens and businesses. Addressing these issues in a coordinated manner will allow Vietnam to fully harness the potential of Big Data, gradually building a modern, transparent, and sustainable GIS ecosystem that supports planning, spatial governance, and the development of smart cities.

IV. Conclusion

This study confirms that the integration of Big Data into the GIS ecosystem is an inevitable trend in the era of digital transformation (Hamamurad et al., 2022, and Goodchild, 2018). It provides not only a technical foundation for analysis, forecasting, and decision support, but also reshapes approaches to spatial planning and planning management. In Vietnam, recent practice has demonstrated initial achievements, including the establishment of a unified National Planning Database and the deployment of WebGIS platforms in several provinces and cities (Phuong et al., 2023). These developments have improved forecasting capacity, enhanced the quality of planning formulation and adjustment, and increased transparency in governance.

Despite this progress, the implementation process continues to face significant limitations. The lack of uniformity in digital infrastructure, inconsistencies in map scales and levels of detail across provinces, and shortages of qualified human resources are constraining the effective exploitation of Big Data. These weaknesses reduce the capacity for cross-sectoral and cross-regional analysis and limit the potential of Big Data to serve as a strategic instrument for real-time planning and spatial governance.

Future progress will require attention to multiple dimensions. Strengthening digital infrastructure such as regional data centers, cloud computing platforms, and high-speed communication networks remains fundamental for handling large and complex datasets. Equally crucial is the development of an interdisciplinary workforce with expertise in data analytics, spatial data mining, and artificial intelligence, enabling the transformation of Big Data into actionable knowledge for planning. At the same time, the legal and technical framework for data sharing, interoperability, and security must be further refined to create a transparent and reliable environment that fosters collaboration between public institutions and private stakeholders.

The findings of this study provide both scientific and practical contributions to the modernization of spatial planning in Vietnam. Future research should explore advanced models that combine Big Data and artificial intelligence within GIS, as well as conduct comparative international studies to clarify contextual specificities and enhance the generalizability of results. Such directions will help establish Big Data more clearly as a cornerstone of integrated planning, while offering valuable policy insights for sustainable urban development and spatial governance.

Conflict of Interest:

The authors declare that there is no conflict of interest regarding this article.

References

I. Goodchild, M. "Annals of GIS." *Reimagining the history of GIS*, 2018, vol. 24, pp. 1–8. 10.1080/19475683.2018.1424737

II. Government of Vietnam. *Decree No. 13/2023/ND-CP on personal data protection*, 2023, Government of Vietnam, Hanoi, Vietnam, URL: https://vanban.chinhphu.vn/?pageid=27160&docid=207759.

III. Government of Vietnam. *Decree No. 58/2023/ND-CP detailing a number of articles of the Planning Law*, 2023, Government of Vietnam, Hanoi, Vietnam, URL: https://vanban.chinhphu.vn/?pageid=27160&docid=208476

IV. Hamamurad, Q.H., N. Mat Jusoh, and U. Ujang. "ISPRS International Journal of Geo-Information." *Factors that affect spatial data sharing in Malaysia*, 2022, vol. 11, no. 8, pp. 446. https://doi.org/10.3390/ijgi11080446

V. Hanoi People's Committee. *Explanatory report of Hanoi Capital Planning for the period 2021–2030, vision to 2050*, 2024, Hanoi People's Committee, Hanoi, Vietnam, URL: https://dbndhanoi.gov.vn/Files/portal/DinhKemTinBai/2024-03/1%20240317%20-%20BCTT%20QH%20Th%E1%BB%A7%20%C4%91%C3%B4%201.2_K73MdQbvyESr0bmd.pdf.

VI. Ho Chi Minh City People's Committee. *Explanatory report of Ho Chi Minh City Planning for the period 2021–2030, vision to 2050*, 2024, Ho Chi Minh City People's Committee, Ho Chi Minh City, Vietnam, URL: https://chinhphu.vn/?pageid=27160&docid=212234&tagid=1&type=1.

VII. Ministry of Planning and Investment of Vietnam. *Circular No. 04/2023/TT-BKHDT on requirements for content and technical specifications of planning database dossiers*, 2023, Ministry of Planning and Investment of Vietnam, Hanoi, Vietnam, URL: https://thuvienphapluat.vn/van-ban/Xay-dung-Do-thi/Thong-tu-04-2023-TT-BKHDT-yeu-cau-noi-dung-va-ky-thuat-cua-co-so-du-lieu-ho-so-quy-hoach-571327.aspx

VIII. Ministry of Planning and Investment of Vietnam. *Explanatory report of the Northern Midland and Mountainous Regional Planning for the period 2021–2030, vision to 2050*, 2024, Ministry of Planning and Investment of Vietnam, Hanoi, Vietnam. URL: https://chinhphu.vn/?pageid=27160&docid=211408

IX. National Assembly of Vietnam. *Law on Planning No. 21/2017/QH14*, 2017, National Assembly of Vietnam, Hanoi, Vietnam, URL: https://thuvienphapluat.vn/van-ban/Xay-dung-Do-thi/Luat-quy-hoach-322935.aspx.

X. People's Committee of Nghe An Province. *Explanatory report of Nghe An Provincial Planning for the period 2021–2030, vision to 2050. 2023*, People's Committee of Nghe An Province, Vinh, Vietnam, URL: https://nghean.gov.vn/quy-hoach-tinh-nghe-an-thoi-ky-2021-2030-tam-nhin-den-nam-2050/bao-cao-tong-hop-quy-hoach-tinh-nghe-an-thoi-ky-2021-2030-tam-nhin-den-nam-2050-626765.

XI. People's Committee of Quang Binh Province. *Explanatory report of Quang Binh Provincial Planning for the period 2021–2030, vision to 2050*, 2023, People's Committee of Quang Binh Province, Dong Hoi, Vietnam, URL: https://vanban.chinhphu.vn/?pageid=27160&docid=207743&gidzl=AujHKCqD8a0daLDGpXGWG2UGM5BNGI4GFv9IKjP39qHhm55MXK4Z46B600FPHtSHDCS60p7Uia0dnmmWGm.

XII. Phuong, L.T.M., B.H. Phong, and T.T. Anh. "E3S Web of Conferences" *Improving performance of Geographic Information Systems (GIS): A case study on Nghe An (Vietnam) province planning*, vol.403,2023, 03004, 10.1051/e3sconf/202340303004

XIII. Zou, L., Y. Song, and G. Cervone. "Annals of GIS." *Geospatial big data: theory, methods, and applications*. 2024, vol. 30(4), pp. 411–415, 10.1080/19475683.2024.2419749