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Strengthening Urban Governance through Address Standardization

A Transitional Information System Approach in Indonesia

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Abstract: Unstructured, narrative-based addressing systems in many developing countries fragment spatial data management and hinder effective urban governance. Although Indonesia has formally established a national standard for urban and rural addressing (SNI 9037:2021), implementation remains limited, resulting in inconsistent, non-geocoded, and non-interoperable address records. Strengthening address standardization is therefore essential to improve public service delivery, spatial data integration, and national data interoperability. This study proposes a web-based address information system designed as a transitional mechanism to support the gradual implementation of standardized addressing without immediately eliminating locally embedded address practices. Using Mantrijeron subdistrict in Yogyakarta City as a case study, we develop a dual-schema geospatial database and a hybrid search mechanism that link existing community-based addresses to standardized formats. The results show that the system maps descriptive local address queries to standardized, spatially referenced building records. The transitional dual-system model allows local governments to promote address standardization while maintaining operational usability during the transition period. A usability evaluation indicates strong user acceptance among initial users, although readiness for broader implementation remains to be established. We conclude that effective address standardization in developing contexts may benefit from adaptive and inclusive digital strategies. Rather than imposing abrupt top-down reforms, transitional information systems can facilitate gradual compliance with national standards while strengthening urban governance and supporting the One Data Indonesia framework.

Keywords: urban governance; address standardization; address information system; geocoding.

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1. Introduction

Indonesia comprises 514 cities and regencies across 38 provinces, yet almost all of them lack a geocoded, standardized address system compatible with national standards. Standar Nasional Indonesia 9037:2021 tentang Pengalamatan di Perkotaan dan Perdesaan [Indonesian National Standard 9037:2021 on Urban and Rural Addressing] (SNI 9037:2021), issued by the Badan Standardisasi Nasional [National Standardization Agency] in December 2021, has not been widely disseminated and therefore remains only partially implemented at the local level. This situation results in continued reliance on address records that are narrative-based, spatially unverifiable, and structurally incompatible with the data-integration requirements of the Satu Data Indonesia [One Data Indonesia] initiative, established under Peraturan Presiden Republik Indonesia Nomor 39 Tahun 2019 tentang Satu Data Indonesia [Presidential Regulation of the Republic of Indonesia No. 39 of 2019 on One Data Indonesia]. This infrastructure gap is not merely technical: it constitutes a governance failure with direct consequences for public service delivery, property tax administration, emergency response coordination, and spatial planning under the regional and detailed spatial planning framework—the Rencana Tata Ruang Wilayah [Regional Spatial Plan] (RTRW) and Rencana Detail Tata Ruang [Detailed Spatial Plan] (RDTR)—governed by Peraturan Pemerintah Republik Indonesia Nomor 21 Tahun 2021 tentang Penyelenggaraan Penataan Ruang [Government Regulation of the Republic of Indonesia No. 21 of 2021 on the Implementation of Spatial Planning].

Urban expansion and dynamic population growth continue to reshape the physical and socioeconomic landscape of cities, requiring local governments to continuously improve the effectiveness, efficiency, and responsiveness of urban governance (Distor & Khaltar, 2022; Tong & Qiu, 2020). In Indonesia, these spatiotemporal transformations are particularly evident in rapidly developing areas such as the Yogyakarta urban region (Dewa et al., 2025). As urban morphology, or city structure, becomes increasingly complex, local governments face growing challenges in managing administrative services, spatial planning, and public service delivery. In this context, effective governance increasingly depends on reliable spatial data infrastructures that enable evidence-based policymaking and coordinated institutional action.

The regulatory architecture governing address data in Indonesia spans multiple policy domains. At the highest level, Undang-Undang Republik Indonesia Nomor 4 Tahun 2011 tentang Informasi Geospasial [Law of the Republic of Indonesia No. 4 of 2011 on Geospatial Information] establishes the Badan Informasi Geospasial [Geospatial Information Agency] as the national authority for geospatial reference data, including large-scale topographic base maps at a scale of 1:5,000 for urban areas, which constitute the spatial reference framework for any geocoded address system. The spatial planning hierarchy, governed by Government Regulation No. 21 of 2021, mandates that the RTRW and RDTR define the administrative and land-use boundaries within which address systems must operate. At the data-governance level, Presidential Regulation No. 39 of 2019 requires all government data—including address records—to conform to standardized formats, complete metadata, and interoperable structures accessible through national and regional data portals. The administrative coding framework is further specified in Peraturan Menteri Dalam Negeri Republik Indonesia Nomor 58 Tahun 2021 tentang Kode, Data Wilayah Administrasi Pemerintahan, dan Pulau [Regulation of the Minister of Home Affairs of the Republic of Indonesia No. 58 of 2021 on Administrative Area Codes, Administrative Area Data, and Islands], which provides the authoritative coding structure down to the village (kelurahan or desa) level and the neighborhood tiers

below it, the Rukun Tetangga [neighborhood unit] (RT) and Rukun Warga [community unit] (RW). Despite this regulatory scaffolding, no national mechanism currently mandates or supports local governments in transitioning from existing informal address formats to SNI 9037:2021-compliant records, creating a persistent implementation gap between policy intent and administrative reality.

Address information is a fundamental component of administrative governance, serving as the basis for identification, service delivery, and spatial planning. In governance studies, urban governance refers to the process of collective decision-making involving state and non-state actors in managing urban functions (Pierre, 1999; Rhodes, 1996). A sociotechnical governance approach is essential for understanding how address information systems (AIS) interact with administrative practices and the social fabric of local communities. Grounded in the intellectual framework mapped by Song et al. (2023), this perspective holds that technological change is a primary driver of institutional transformation. By viewing technology and social structures as mutually constitutive rather than independent (Hughes et al., 1987; Jasanoff, 2004), the framework positions the AIS not merely as a software platform but as an active governance instrument—one that must be designed in alignment with, and in response to, the very social structures it is meant to serve. Whereas many countries have long established and consistently implemented standardized addressing systems (Bui & Tran, 2019; Choi & Lee, 2018; Christen et al., 2004; Cortes et al., 2021), the situation in Indonesia differs significantly: SNI 9037:2021 was issued only recently, and its dissemination and implementation remain limited.

As a consequence, address formats across regions remain inconsistent and inaccurate and often do not follow a standardized structure (Sutanta et al., 2020, 2022). This lack of uniformity hampers efforts to develop geocoded address databases, which are essential for building reliable spatial information systems. Without standardized, georeferenced address data, it is difficult to establish an integrated address information system capable of interoperating with other national information systems that support development planning and public services.

Within urban governance, a standardized AIS is more than a technical tool. It is a strategic instrument supporting fair and efficient public services. A reliable addressing system lets local governments manage taxation, optimize logistics, coordinate emergency response, and target social assistance. More importantly, it connects administrative systems to citizens' spatial realities, thereby reducing service inequality and improving accountability (Abdul Rahman et al., 2022; Klaus et al., 2023; Monir et al., 2021). The contribution of web-based geospatial information systems to the quality of local governance has also been documented in diverse Indonesian contexts, including the development of integrated village information systems (Budiantoro et al., 2023) and the digitalization of regional public service management (Mislawaty et al., 2022), reinforcing the case for adaptive digital solutions in strengthening administrative capacity.

Despite its importance, the move to standardized addressing remains a major challenge in many developing countries, where informal addressing practices rooted in culture and community predominate (Kipkemoi & Ngare, 2025; Malaainine & Lechgar, 2021). From a sociological and anthropological standpoint, addressing systems are far from neutral, objective utilities; rather, they serve as highly contested city-texts through which communities actively construct, negotiate, and attribute meaning to urban space (Gutiérrez-Mora & Oto-Peralías, 2022). Localized address expressions are therefore not merely technical or administrative shortcomings but

symbolic infrastructures that encode distinct social identities and reflect the cultural capital embedded in daily community life (Rose-Redwood et al., 2024). Informal systems rely on local semantics, landmarks, and community narratives instead of street-based numbering (Dumedah, 2021; Javidaneh et al., 2020). This is especially true in Indonesia, where people use village boundaries, hamlet names, or descriptive narratives to identify locations. National address-writing standards are not yet widely implemented (Sadewo & Sutanta, 2021; Sutanta et al., 2016, 2020, 2022, 2023).

Local addressing practices carry significant socio-cultural value. Yet their unstructured nature limits geocoding accuracy and reduces interoperability with government systems, creating a critical information gap between formal administrative data and lived spatial realities. When government systems disregard how citizens describe space, inefficiencies result. National initiatives such as Satu Data Indonesia consequently face implementation barriers (Jahani Chehrehbargh et al., 2024; Rachmat et al., 2024).

Previous studies have tested technological solutions to similar challenges, including natural language processing and addressing reforms in various countries (Bui & Tran, 2019; Choi & Lee, 2018; Cortes et al., 2021; Guermazi et al., 2022; Kipkemoi & Ngare, 2025; Malaainine & Lechgar, 2021). In Indonesia, some projects indicate that geocoded addresses assist village administration and that web-based maps support standardized address management (Aprinia & Sutanta, 2024; Sadewo & Sutanta, 2021). To our knowledge, however, no integrated, transitional AIS—that is, a system that simultaneously preserves community-based address formats and links them to a standardized geocoding database within a single operational platform—has yet been developed and implemented in Indonesia. Existing efforts remain limited to geocoding exercises or standalone standardization projects without an adaptive dual-recognition mechanism (Kesuma & Sutanta, 2025). This constitutes a critical gap that the present study directly addresses.

Rather than replacing existing practices, urban governance may benefit from an inclusive data strategy that bridges local addressing with standardized spatial data. This bridging approach shifts governance toward adaptability and responsiveness. It honors community-based identities while meeting requirements for interoperable, coordinate-based databases. Although prior studies have explored technological and policy approaches to address standardization, limited attention has been given to adaptive integration models that allow informal and standardized address systems to coexist within a unified governance framework over a defined transition period.

The novelty of this research lies in two explicit contributions that distinguish it from prior studies. First, it proposes a transitional dual-system model—in contrast to the replacement-oriented approaches prevalent in the literature—in which community-based addresses and SNI 9037:2021-compliant standardized addresses are simultaneously maintained as first-class data within a single operational platform; it is, as far as we are aware, among the first such models developed and tested in Indonesia. Second, it develops a three-level search algorithm (exact substring matching, full-text search, and similarity-based fuzzy matching) specifically designed to accommodate the format heterogeneity of Indonesian addresses—a challenge not adequately resolved by prior geocoding studies in developing-country contexts.

To address this need, we propose a web-based AIS to harmonize local community addresses with national standards. Mantrijeron subdistrict in Yogyakarta City—known for its dense historical settlements and rapid urban growth—was chosen as a

case study. We aim to develop a system that bridges existing, non-standardized addresses and to analyze how this approach strengthens inclusive governance and supports local data integration.

2. Methods

This research focuses on developing an AIS platform to harmonize two addressing paradigms—the traditional and the standardized—within Mantrijeron subdistrict. The development process was conducted as a governance-oriented technological intervention to improve the integration of community-based addressing practices with standardized administrative spatial data.

The system was developed using a structured software development life cycle based on the waterfall model, which provides a systematic and sequential framework for translating governance needs into functional information-system components (Balaji & Murugaiyan, 2012; Ragunath et al., 2010). The waterfall model was selected because its staged process enables clear documentation of requirements derived from administrative stakeholders and allows incremental refinement aligned with public service needs (Pargaonkar, 2023). Each development phase—requirements analysis, system design, implementation, and evaluation—was conducted sequentially, with iterative improvements informed by user and local-government feedback.

In the requirements analysis, system needs were gathered from stakeholders, including community members, the village head, and RW representatives. This ensured that the system design matched both administrative goals and community practices. The analysis surfaced five main requirements: (1) support for two address formats (existing and standardized), (2) address mapping via an interactive map, (3) unified display of address information, (4) public access, and (5) address search to aid administration and services.

To bridge the two addressing paradigms, the study uses analytical methods and system frameworks. The focus is on designing the AIS architecture and building algorithms to link unstructured addresses to standardized formats. Spatial data from local and standardized sources are integrated into a geospatial database, enabling interoperability and supporting governance-focused data use.

2.1. Study Area and Data Acquisition

The research was conducted in Mantrijeron subdistrict, Yogyakarta City, which comprises three urban villages (kelurahan): Gedongkiwo, Suryodiningratan, and Mantrijeron, as illustrated in Figure 1. The subdistrict was selected as the study area on four explicit criteria. First, it exhibits high address-format heterogeneity, with community-based address expressions coexisting alongside partially standardized administrative records—a condition representative of dense urban settlements across Indonesian cities. Second, Yogyakarta City has an established RDTR that provides a georeferenced administrative boundary framework consistent with Government Regulation No. 21 of 2021, enabling alignment between the AIS spatial database and the formal spatial planning hierarchy. Third, Yogyakarta's status as a special region—Daerah Istimewa Yogyakarta [Special Region of Yogyakarta], governed under Undang-Undang Republik Indonesia Nomor 13 Tahun 2012 tentang Keistimewaan Daerah Istimewa Yogyakarta [Law of the Republic of Indonesia No. 13 of 2012 on the Special Status of the Special Region of Yogyakarta]—provides an institutional context in which local government has higher-than-average administrative data-management capacity, making it a favorable environment for

testing a transitional governance instrument. Fourth, prior research in adjacent urban villages in Yogyakarta (Aprinia & Sutanta, 2024; Sadewo & Sutanta, 2021) provides a comparative baseline for evaluating the technical approach. The wide variation of address formats shaped by local socio-cultural practices, alongside emerging standardized administrative requirements, makes Mantrijeron a representative case for understanding the broader challenges local governments face in integrating community-based address information into formal administrative systems.

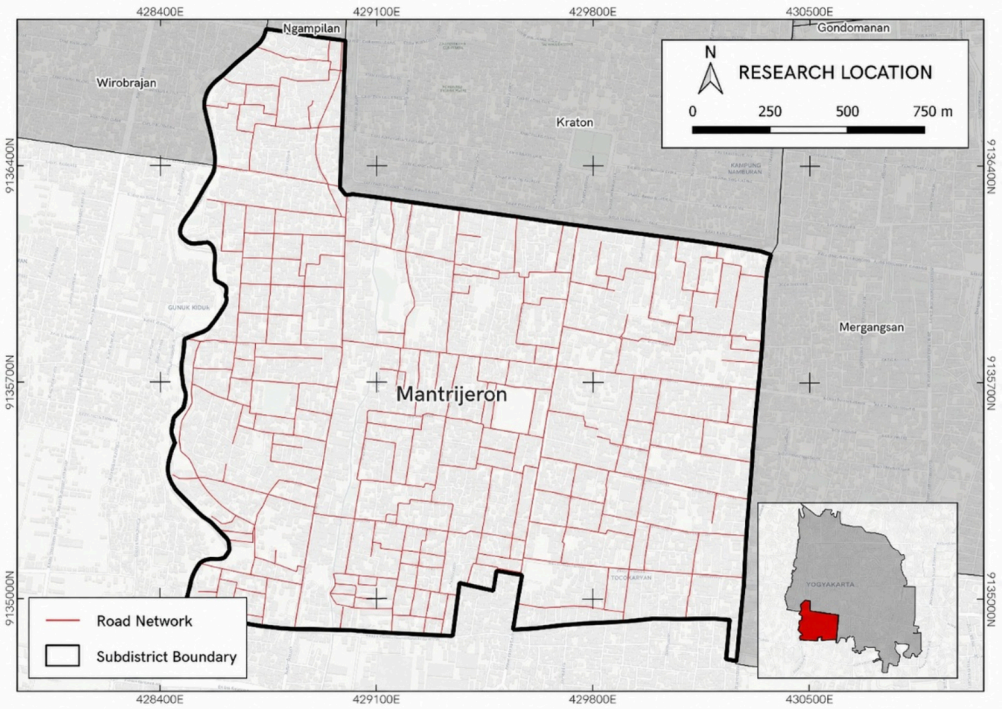

Figure 1. Research Location

Source: *The authors, using base data from the Yogyakarta City Land and Spatial Planning Office.*

Data collection involved two primary datasets. First, the existing-address data are a localized dataset collected through an address survey conducted in Mantrijeron subdistrict in 2024. Second, the standardized addresses were derived from a standardization process carried out in accordance with SNI 9037:2021. Additional datasets—administrative boundaries, the road network, and land parcels—were obtained from the Yogyakarta City Land and Spatial Planning Office.

2.2. Address Data Integration Approach

This research adopts an adaptive integration approach to harmonize existing community-based addresses with standardized administrative address formats. Rather than replacing existing address expressions, the approach enables both addressing paradigms to coexist within a unified spatial database structure.

The integration process involves three main steps. First, existing address records were harmonized with standardized administrative components in accordance with the national addressing standard. Second, address information was spatially linked to building polygons to enable geospatial referencing of address locations. Third, a retrieval mechanism was developed to allow users to search address information using either standardized administrative references or commonly used community-based address descriptions.

This integration framework enables descriptive address queries commonly used by residents to be associated with standardized spatial records, thereby improving interoperability between community-generated spatial information and formal government datasets.

2.3. Development of the Address Information System

The development of the AIS operationalizes the conceptual system design into a functional platform that supports address-data integration and administrative services. The system was developed to bridge standardized and existing address formats within a single integrated application environment, enabling local governments to manage heterogeneous address information more effectively.

To operationalize the integration framework, a web-based AIS was developed to manage and visualize address information within a unified geospatial platform. The system adopts a client–server architecture that integrates spatial databases with interactive web-mapping technologies.

The AIS enables users to visualize address information on an interactive map, search for addresses using keywords or administrative-boundary filters, and retrieve address attributes associated with building features. The system supports both existing community-based addresses and standardized address formats, allowing users to view both representations simultaneously.

Spatial visualization enables users to interact with address information through an interactive web-based map interface. Spatial layers and address information are displayed using tiling, which improves system performance by allowing large volumes of spatial data—such as thousands of building polygons—to be rendered efficiently on the user's device without compromising responsiveness.

To support administrative data exploration, the system incorporates interactive map functionality through event-based user interactions. When a user selects a building feature on the map, the system retrieves detailed spatial and attribute information using the Web Feature Service protocol. The retrieved information is then presented in an interactive information panel, enabling users to view the address attributes associated with the selected building.

This visualization mechanism allows address information to be accessed intuitively, supporting the verification, spatial referencing, and information retrieval needed for local-government administrative processes and public information services.

The address-search algorithm is the core functional component of the AIS, enabling users to retrieve address information across heterogeneous addressing formats. The algorithm was designed to address inconsistencies between standardized administrative addresses and community-based address expressions, thereby supporting more inclusive access to spatial information within local-government services.

The search mechanism processes user queries by combining keyword inputs with administrative-boundary filters (RW, hamlet, village, and subdistrict). This dual approach allows users to locate addresses using either formal administrative references or commonly used local descriptions. To accommodate variation in address-writing structures, the system applies a three-level search strategy, executed simultaneously across street and lane names, standardized addresses, and existing-address datasets:

a. *Exact substring matching*, which identifies direct matches using a case-insensitive comparison to ensure accurate retrieval when address formats align with stored data.
b. *Fuzzy matching*, which uses similarity-based comparison to accommodate spelling variations or typographical errors frequently encountered in informal address usage.
c. *Full-text search*, which analyzes semantic relationships among address terms to identify contextually relevant results even when word order differs.

Search results are ranked by relevance: exact matches receive the highest priority, followed by semantically relevant results, and finally similarity-based matches. To maintain responsiveness and ensure efficient service delivery, the algorithm limits output to the most relevant results, preventing excessive server load while providing users with accurate address suggestions.

Through this approach, the AIS enables flexible address retrieval that accommodates both standardized administrative formats and locally used address expressions, thereby reducing barriers to accessing spatial information and improving administrative usability.

2.4. System Evaluation

System evaluation was conducted to assess the usability and user acceptance of the AIS as a public-facing digital service. The evaluation involved an online usability survey distributed to system users. A total of 36 respondents participated, comprising three purposively selected groups to ensure demographic and functional diversity: (1) members of the general public who currently reside or have previously resided in Mantrijeron subdistrict, representing the primary end-users of the public-facing address-search service; (2) neighborhood and community administrative officials (RT and RW chairpersons and kelurahan staff), representing the key institutional actors who use and validate address data in local administrative workflows; and (3) staff of the Yogyakarta City Land and Spatial Planning Office, representing the governmental technical users responsible for maintaining the spatial-data infrastructure that underpins the system. All respondents had direct familiarity with the addressing landscape of Mantrijeron subdistrict, through either residency or professional responsibilities, ensuring that usability judgments reflected grounded, context-specific experience.

The evaluation employed usability testing based on the framework proposed by Quesenbery (2004), which defines usability in terms of five key dimensions, commonly referred to as the 5Es: effective, efficient, engaging, error-tolerant, and easy to learn. Respondents assessed their experience using the system through a Likert-scale questionnaire. According to Sekaran and Bougie (2016), the Likert scale measures user perception by capturing levels of agreement or disagreement across a five-point range: strongly disagree, disagree, neutral, agree, and strongly agree. The evaluation statements were designed to represent each usability criterion and to assess how effectively the system supports address searching, spatial-information access, and overall user interaction. Table 1 presents the evaluation statements for each usability dimension.

Table 1. List of Usability Test Statements

Code	Statement	Usability Aspect
P1	This system provides easy-to-understand address information	Effective
P2	The system can perform address searches	
P3	The features you need are available in the system	
P4	The system loads quickly when first accessed	Efficient
P5	Address searches can be performed quickly	
P6	Address information can be accessed quickly	
P7	The system is attractive and visually appealing	Engaging
P8	The coloring of each layer is appropriate and easy to understand	
P9	I would be willing to use this system again in the future	
P10	The system does not experience errors or crashes during use	Error-tolerant
P11	Address searches can be performed without errors	
P12	The features in the system work properly	
P13	I can use this system easily	Easy to learn
P14	The system's layout makes it easy to understand the main functions	
P15	I do not need help to understand the main functions	

Source: *Compiled by the authors.*

3. Results and Discussion

The AIS was successfully developed as a web-based platform integrating existing community-based addresses with SNI 9037:2021-compliant standardized address data within a unified dual-schema geospatial database. The implementation integrates functional components—use-case structures, workflow processes, database relationships, and system architecture—into an operational platform supporting address-data management and public information services.

The system was developed to ensure accessibility and usability for a wide range of users, enabling both standardized and existing address searches, visualization of spatial address attributes, basemap customization, and compatibility across multiple devices and web browsers. Beyond technical implementation, the AIS serves as a governance-support tool, facilitating the integration of heterogeneous address information and improving access to spatial data for both government officials and the public. The following sections present the system's operational features and discuss their implications for urban governance and public service delivery.

3.1. Implementation of the Address Information System

The AIS provides an interactive web-based interface that enables users to visualize address information and associated spatial features. The system can be accessed through various devices, including desktop computers and mobile devices, ensuring accessibility for both administrative users and community members.

Upon accessing the platform, users are presented with an interactive map that displays multiple spatial layers, including buildings, land parcels, road networks, and points of interest. The building layer serves as the primary dataset, linking each building polygon with both standardized address information and locally used address expressions.

Users can interact with spatial features directly on the map to retrieve detailed address information. When a building is selected, the system displays comprehensive address attributes—including the standardized address (Alamat Sesuai Standar), the existing address (Alamat Existing), the object name (Nama

Objek) where available, the neighborhood unit (RT) and community unit (RW), the hamlet (kampung), the village (kelurahan), the subdistrict (kecamatan), the province, and the postal code—as shown in Figure 2. This feature allows users to verify address information visually and improves transparency in accessing spatial administrative data.

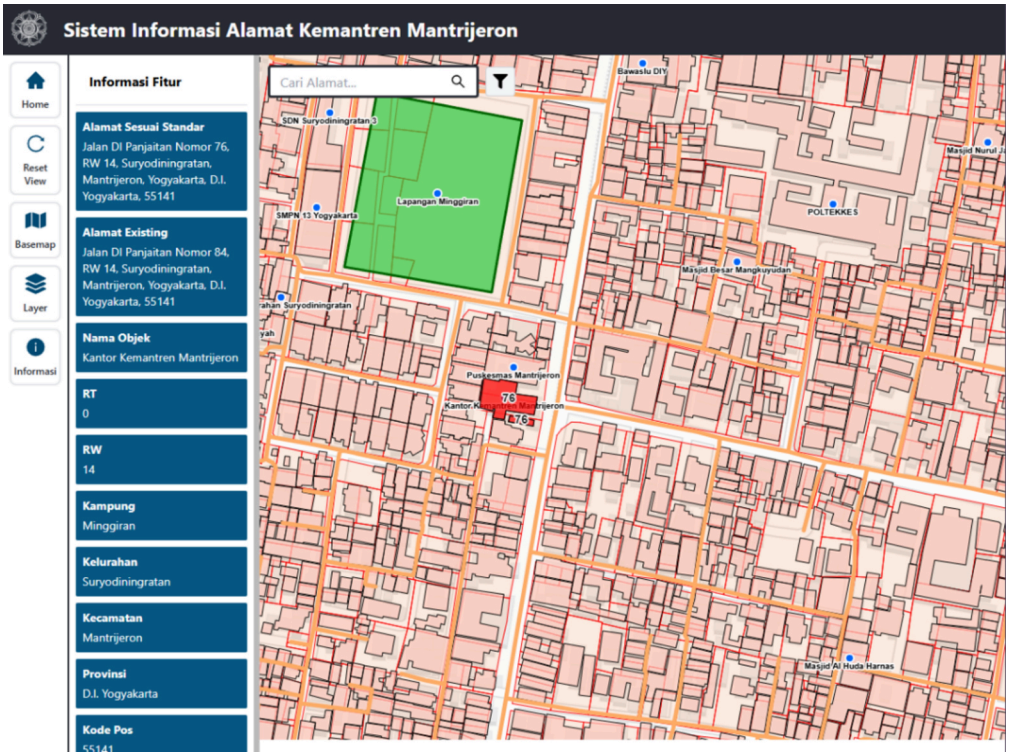

Figure 2. Address Attribute Panel

Source: The authors.

From a governance perspective, this integrated visualization supports administrative verification and helps local officials interpret spatial relationships among buildings, parcels, and infrastructure. By linking address information with spatial features, the system enhances data consistency and improves the reliability of location-based administrative services.

3.2. Address Retrieval

One of the core functions of the AIS is its ability to retrieve address information using both standardized and community-based address expressions, as presented in Figure 3. The system allows users to search for addresses using keywords or administrative-boundary filters.

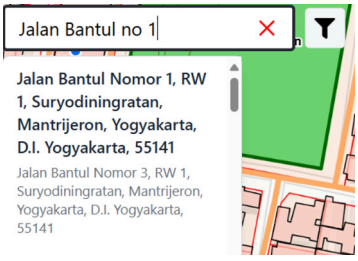

Figure 3. Address Search Bar

Source: The authors.

When users—such as RW administrators or community members—enter an unstructured existing address, the system automatically associates the input with its corresponding standardized administrative address. This bridging mechanism allows locally used address expressions to remain usable while simultaneously connecting them to formal government datasets.

The search process combines multiple matching techniques—exact matching, full-text search, and similarity-based matching—enabling the system to accommodate variations in spelling and address structure commonly found in informal address formats. Queries retrieve data stored within the integrated database environment and return spatially referenced results.

The operational performance of this feature demonstrates the practical feasibility of integrating socio-cultural spatial information with formal administrative datasets. Rather than replacing existing practices, the system enables coexistence between community knowledge and state administrative structures, thereby supporting inclusive urban governance and improving access to spatial-information services.

In addition to keyword-based searches, the system provides administrative-boundary filters that enable users to refine address searches according to government administrative units. Available filtering options include the subdistrict, village, hamlet, community unit (RW), street, and alley levels. These filters were designed to align the system with the administrative structures commonly used in local governance processes.

The filtering mechanism operates hierarchically: selections made at higher administrative levels automatically constrain the available options at lower levels. For example, when a user selects Suryodiningratan Village, subsequent filters—such as street or neighborhood options—are dynamically limited to features located within that administrative area. This hierarchical filtering supports more accurate spatial navigation and reflects how administrative data are typically organized in local-government operations.

When users apply filters without entering search keywords, the system automatically zooms to and highlights the spatial features corresponding to the selected administrative area, as illustrated in Figure 4. This functionality enables users to explore spatial information by jurisdictional boundary, which is particularly useful for administrative verification and area-based planning.

Address suggestions also adapt dynamically to the selected filters. For instance, when Kampung Danunegaran is selected, the system generates address suggestions limited to that area. If both filters and keywords are applied simultaneously, the results display only addresses matching both criteria. This combined filtering mechanism enhances search precision while supporting administrative workflows that rely on territorial classification.

Such functionality aligns with the way administrative data are typically organized in local-government institutions and therefore supports spatial verification and area-based planning. Through these mechanisms, the AIS enables flexible address retrieval while maintaining consistency with standardized spatial datasets. This capability is particularly important in contexts where informal addressing practices remain widely used by residents.

3.3. Usability Evaluation

The usability evaluation indicates high user acceptance of the AIS. The average scores across the five usability dimensions ranged from 4.17 to 4.38, indicating that

respondents perceived the system as effective, efficient, and easy to use. The summarized results are presented in Table 2.

Table 2. Usability Test Results

	Effective	Efficient	Engaging	Error-Tolerant	Easy to Learn
Average Score	4.37	4.28	4.17	4.30	4.38

Source: Usability survey, data processed (2024).

Overall, respondents agreed that address searches and system functions operated reliably, that the system demonstrated satisfactory loading performance, and that the interface was easy to understand. These findings suggest that the AIS is not only technically functional but also acceptable and usable for community users, indicating readiness for broader implementation within local administrative contexts.

Beyond usability performance, the evaluation results reveal important implications for local governance and public service delivery. Historically, limitations in recognizing locally used addresses created information asymmetries between government administrative systems and community spatial practices, often leading to inefficiencies in service provision. The AIS addresses this gap by enabling inclusive spatial-data integration. In the sociology of urban governance, the involvement of RT and RW heads and kelurahan staff in the AIS represents a shift toward participatory smart urban governance. Their roles extend beyond operational data entry; they are key actors who bridge the tension between the government's top-down digital standardization and the organic, grassroots spatial reality (Mustika Rani & Malau, 2025). By codifying dynamic local knowledge into formal platforms, these actors help ensure that the city's spatial governance remains adaptive, transparent, and rooted in the community's social needs (Aldhi et al., 2025; Jiang, 2021).

First, the system supports improved public service delivery. By enabling users to retrieve both community-expressed and SNI-compliant addresses for the same building, the AIS reduces the information asymmetry between how citizens describe their location and how government systems record it. This has direct implications for the accuracy of service delivery in logistics, emergency response, and administrative correspondence—areas where unstructured addressing has been shown to cause measurable delays (Abdul Rahman et al., 2022). It should be noted, however, that these governance-improvement claims are grounded in the system's structural design and regulatory alignment rather than in direct empirical measurement of administrative outcomes. Longitudinal evaluation with government users—assessing actual reductions in response time, error rates, or service-delivery failures attributable to address ambiguity—represents a critical research gap that future studies must address.

Second, by linking address records to georeferenced building polygons, the AIS creates a spatial linkage between address information and parcel data that is, in principle, compatible with land and property-data frameworks. The potential application of this linkage to property-tax administration under Undang-Undang Republik Indonesia Nomor 1 Tahun 2022 tentang Hubungan Keuangan antara Pemerintah Pusat dan Pemerintahan Daerah [Law of the Republic of Indonesia No. 1 of 2022 on Fiscal Relations between the Central Government and Regional Governments] warrants further investigation but is beyond the scope of this study.

The bridging approach demonstrated in this study shows that compliance with national data-interoperability initiatives—such as the One Data Indonesia framework—can be achieved without replacing culturally embedded addressing

practices. Instead, adaptive integration allows local knowledge and administrative standards to coexist, supporting more inclusive and context-sensitive governance. Theoretically, this model can be understood as an expression of adaptive governance (Folke et al., 2005), in which institutional arrangements are incrementally adjusted to local realities while progressively converging toward national standards. This positioning distinguishes the AIS from top-down standardization models and provides a normative basis for its broader replication in other Indonesian districts facing similar challenges.

3.4. Comparison with Prior Studies

To contextualize the contribution of this study, we are aware of no prior integrated, transitional AIS that combines dual-recognition of community-based and standardized address formats and that has been developed and deployed in Indonesia. Comparisons can therefore be drawn only with partial or technically oriented prior efforts. Studies by Sadewo and Sutanta (2021) and Aprinia and Sutanta (2024) in Yogyakarta demonstrated the technical feasibility of geocoded-address creation but did not develop a publicly accessible retrieval interface that accommodates unstructured community address queries.

At the international level, Malaainine and Lechgar (2021) showed, in Casablanca, that conventional geocoding algorithms fail in informal addressing contexts but did not propose a unified platform retaining both systems. Bui and Tran (2019), in Vietnam, developed conditional random field models for address standardization, but their approach replaces local formats rather than preserving them alongside standardized records. The AIS presented here differs from all these approaches by treating community-based addresses as first-class data persistent in the database—not as noise to be converted and discarded. This distinction is precisely what enables the transitional governance model and makes replication relevant to other Indonesian districts.

3.5. Limitations

This study acknowledges four principal limitations. First, implementation was confined to a single subdistrict (Mantrijeron) within Yogyakarta City, a context with relatively high administrative capacity compared with most Indonesian local governments; generalization to lower-capacity contexts requires replication studies. Second, the usability evaluation involved 36 respondents at an early deployment stage, precluding conclusions about long-term user adoption at scale. Third, all claims about governance benefits—including improved emergency-response coordination, logistics efficiency, and property-tax administration—are based on the system's structural design and regulatory alignment rather than on direct empirical measurement; longitudinal evaluation with government users is needed to validate these claims. Fourth, no participatory data-update mechanism has yet been developed, meaning that the accuracy of address data over time depends on institutional initiative from the local government rather than on community-driven maintenance.

4. Conclusion

The development of the Address Information System (AIS) in Mantrijeron subdistrict demonstrates the technical and administrative feasibility of bridging community-based addressing practices with standardized government address systems. The study shows that harmonization between socio-cultural addressing traditions and

formal administrative data can be achieved through interoperable spatial information systems rather than by replacing existing local practices. This approach enables locally meaningful address expressions to remain functional while simultaneously supporting standardized data management.

This study contributes to both theory and practice. Theoretically, it operationalizes the concept of adaptive governance by translating principles of institutional flexibility and local responsiveness into a tangible information-system design through a dual-schema database and a multi-level search mechanism. It also extends sociotechnical governance perspectives by illustrating how digital systems can be designed to accommodate, rather than override, community spatial knowledge and addressing practices.

From a governance perspective, the Address Information System reduces the information asymmetry between citizen-generated spatial knowledge and government administrative datasets. The dual-address approach enables existing and standardized addresses to coexist, supporting more inclusive public service delivery, improved spatial-data consistency, and enhanced administrative capacity. The findings further demonstrate how local governments can operationalize national data-interoperability initiatives, including the One Data Indonesia framework, through adaptive and context-sensitive digital solutions. In this regard, the dual-address mechanism can be viewed as a transitional governance instrument that facilitates progressive address standardization while maintaining operational continuity and public acceptance.

Despite these contributions, the study was implemented at a single-subdistrict scale, and the anticipated governance benefits have not yet been evaluated through long-term operational use. Future research should therefore examine implementation at broader administrative scales and assess its effects on government performance, service delivery, and data governance. Further development may also incorporate participatory data-update mechanisms and locally adapted natural-language-processing capabilities to enhance data sustainability, user engagement, and participatory urban governance.

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