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Developing a WebGIS-based spatial information system integrating historical data to map cultural heritage buildings in Palopo

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Abstract. The preservation of cultural heritage buildings in Palopo City faces significant challenges due to rapid urbanization and the absence of robust spatial and historical documentation systems. This study aims to develop a WebGIS-based information system integrated with multi-criteria analysis as a foundation for determining conservation priorities. The research methodology combines a descriptive-qualitative approach with quantitative analysis using Multi-Criteria Decision Analysis (MCDA). The empirical assessment covered 17 cultural heritage buildings in Palopo City, comprising royal and sacred heritage assets, colonial public buildings, military and administrative facilities, and public service buildings. Data were collected through literature review, field surveys, and in-depth interviews with experts, including cultural heritage specialists, architects, and civil engineers, to establish the weights of 17 assessment criteria adapted from international standards and national regulations. Each building's score was calculated by multiplying the expert-assigned weights with field condition assessments, producing a classification of conservation priorities. MCDA results classified three buildings as high priority, four as medium-high priority, and ten as medium priority. The results were then integrated into a WebGIS platform that interactively displays location maps, historical narratives, architectural attributes, and conservation scores. The system serves not only as a medium for documentation and public education but also as an evidence-based decision-support tool for government, academics, and local communities in preserving the cultural heritage of Palopo City.

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Keywords: Cultural Heritage; Conservation Prioritization; Multi-Criteria Decision Analysis; Spatial Information System; WebGIS

1. Introduction

The preservation of cultural heritage buildings is crucial for safeguarding cultural values amid the pressures of urbanization and the commercialization of urban spaces, which often neglect historical legacies [1–3]. In the midst of rapid urban development and the commodification of city space, historic buildings are frequently marginalized or even demolished, as they are perceived to lack economic productivity. Yet, well-preserved heritage sites can serve as vital assets for education, tourism, and local pride [4–6]. These buildings represent more than physical assets; they are symbols of identity and education that reinforce intergenerational connections [7,8]. Many countries have adopted preservation policies through conservation regulations, protection zoning, and economic incentives, as exemplified by UNESCO's World Heritage Sites program. Cities such as Kyoto, Prague, and Granada demonstrate that cultural preservation can coexist with modern development, providing a foundation of values that enrich urban life and strengthen society's collective narrative [9–11].

In Palopo City, which bears the legacy of the Luwu Kingdom and occupies a strategic role in South Sulawesi's history, numerous historic buildings of great significance remain, such as the Kedatuan Palace, Jami Mosque, and Pniel Church [12]. Unfortunately, most of these buildings have not been systematically mapped, and their historical documentation is dispersed across various sources without integrated management. This condition hampers preservation efforts, limits public education, and weakens the integration of historical values into urban development policies.

With advances in technology, the application of WebGIS-based spatial information systems offers a strategic opportunity to document, visualize, and disseminate information on cultural heritage buildings [13–16]. WebGIS enables the presentation of spatial data and historical narratives in an interactive, accessible format, usable across sectors, from government agencies, researchers, and cultural communities to the wider public [17–20]. However, Palopo currently lacks a digital platform that integrates spatial and historical data in a unified system.

This study aims to formulate a preliminary framework for developing a WebGIS-based spatial information system integrated with historical data, as a strategic step to support the preservation of cultural heritage buildings in Palopo City. The findings are expected to provide an initial foundation for expanding the system and to inform urban planning policies that are sensitive to historical and cultural perspectives. Preserving cultural heritage buildings is a prerequisite for maintaining urban identity, collective memory, and sustainable spatial quality. In Palopo, with its deep ties to the Luwu civilization, data on the location, physical condition, and historical narratives of heritage buildings remain fragmented across archives, literature, and local knowledge without standardized documentation. This fragmentation leaves many heritage assets vulnerable to neglect amid urban development pressures, while both

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government and the public lack a reliable medium to access a comprehensive “big picture” of the city’s heritage.

This gap necessitates a platform that not only maps coordinates but also links spatial layers with historical data and spatial planning policies. The proposed WebGIS integrates building attribute databases (age, materials, condition), historical evidence (photographs, archives, oral histories), and regulatory contexts (RTRW/RDTR, protected zones) into a single interface. The outcome is a single source of truth that can be utilized across stakeholders, government, researchers, communities, and the public, for evidence-based decision-making.

Operationally, the research begins with field inventory and verification, georeferencing of historical maps/archives, and the design of a data model that bridges technical building attributes with historical metadata. An open-source stack was chosen to ensure cost sustainability and ease of replication. Data curation mechanisms were established through standardized input (forms, attribute schemas), quality control (consistency and duplication checks), and versioning, thereby providing a clear audit trail for every update.

The urgency of this study lies in the rapid pace of land-use conversion and physical degradation, which outpaces conventional data collection cycles. Without an integrated spatial-historical inventory, licensing and development decisions risk disregarding heritage values. The WebGIS serves as an early warning system (e.g., notifications of high-value buildings located within development corridors) as well as a decision-support tool for setting conservation priorities, delineating protection zones, and formulating adaptive scenarios at both site and district scales. Another critical dimension is public literacy and participation. The interactive map interface enables citizens to recognize the heritage value of their surroundings, while curated crowdsourcing opens channels for updating information that was previously siloed. Community engagement, such as through the Palopo Heritage Society, is embedded from the upstream phase (data model design, ground-truthing) to the downstream phase (dissemination and education), ensuring that data flows do not stop at project close-out but continue as a practice of shared governance (co-governance).

Previous studies have demonstrated the usefulness of GIS, WebGIS, and StoryMap platforms for documenting, visualizing, and disseminating cultural heritage information. For example, Malinverni et al. developed a GIS-based StoryMap for Chan Chan, Peru, to communicate tangible and intangible archaeological heritage through a web-based storytelling interface [21]. Similarly, Howland et al. showed that ArcGIS StoryMaps can transform archaeological datasets into accessible narratives for public engagement, education, and heritage interpretation [22]. Other studies have also developed interactive thematic maps and WebGIS platforms to organize heritage records, multimedia content, spatial layers, and historical information for public exploration and knowledge dissemination [23,24]. These studies confirm the value of digital mapping and story-based visualization in heritage communication. However, many existing approaches remain primarily oriented toward documentation, visualization, storytelling, or public access, and do not explicitly connect the digital interface

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with a conservation-priority framework that integrates heritage significance, physical condition, risk exposure, legal status, and spatial planning instruments.

Therefore, the novelty of this study does not lie merely in mapping cultural heritage buildings through a web-based platform, but in integrating WebGIS with a multi-criteria conservation assessment and a historical-regulatory database for urban heritage governance. In the Palopo case, the proposed framework links building coordinates, historical narratives, architectural attributes, legal designation documents, spatial-planning information, and MCDA-based conservation priority scores within a single system. This integration is intended to shift the role of WebGIS from a descriptive story map into a spatial decision-support tool that can assist government agencies, researchers, heritage communities, and the public in identifying conservation urgency, comparing heritage assets, and aligning preservation actions with urban planning policies.

Palopo is positioned in this study as a case context for examining how small and medium-sized cities can develop a more integrated and replicable approach to digital heritage governance. Rather than presenting the platform as a final or universal model, this study offers an initial framework consisting of a data model, assessment workflow, WebGIS interface, and conservation-priority logic that can be further refined, validated, and adapted in other resource-constrained urban contexts.

2. Methods

To address the research problems that have been formulated, this study adopts an interdisciplinary approach [25–27], combining spatial analysis, historical inquiry, and principles of regional planning. This approach is intended to capture the complexity of cultural heritage buildings not only from their physical characteristics and spatial locations but also from their historical significance and their interconnections with the dynamics of urban space. The methods employed include field surveys for the identification and verification of cultural heritage buildings, in-depth interviews with key informants, historical literature review, and spatial mapping using Geographic Information System (GIS) technology.

This study employs a descriptive-qualitative approach enriched with quantitative analysis through multi-criteria weighting. The approach was selected to provide a comprehensive understanding of the condition, values, and urgency of preserving cultural heritage buildings in Palopo City, not only from a spatial perspective but also from historical, architectural, social, and technical-structural dimensions.

The data collection process was carried out in several stages. First, literature review and document analysis were conducted to examine cultural heritage regulations, spatial planning documents (RTRW/RDTR), historical archives, and previous studies. Second, field surveys were undertaken to inventory building locations, verify physical conditions, and document cultural heritage sites through photographs. The field survey covered 17 cultural heritage buildings in Palopo City. Based on their dominant heritage character and present use, the assessed assets

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comprised four royal and sacred heritage assets, three colonial public or religious buildings, eight military and administrative facilities, and two public service or official residence buildings. For each building, the survey recorded geographic coordinates, photographs, physical condition, current function, architectural attributes, legal status, and risk-related contextual information. Third, in-depth interviews were conducted with experts in their respective fields, namely cultural heritage specialists, architects, and civil engineers. These interviews were aimed at deriving weights for each assessment criterion, which were then applied in the analytical process.

The determination of weights was conducted using an expert judgment mechanism. Cultural heritage experts assessed historical, social, and communal values; architects evaluated aesthetic quality, authenticity, and architectural integrity; while civil engineers examined structural conditions, material vulnerabilities, and technical risks that may affect conservation. The results of these assessments were synthesized into weights for 17 evaluation criteria adapted from the Burra Charter, UNESCO guidelines, and national regulations.

Data analysis employed the Multi-Criteria Decision Analysis (MCDA) approach. Each building was evaluated against the 17 criteria, with scores obtained from field surveys and expert interviews multiplied by the assigned weights. The final conservation priority score for each building was calculated using a weighted-sum model:

$$MCDA_j = \sum_{i=1}^{17} W_i \times S_{ij}$$

where $MCDA_j$ represents the final conservation priority score of building j, W_i represents the expert-assigned weight of criterion i, and S_{ij} represents the field assessment score of building jfor criterion i. The final score was interpreted on a normalized 0–100 scale.

The normalized scores were then classified into conservation priority labels using distribution-based thresholds: scores of 72 and above were classified as high priority, scores from 70.00 to 71.99 as medium-high priority, scores from 60.00 to 69.99 as medium priority, and scores below 60.00 as low priority. This process produced a conservation priority value for each building, which was then visualized in the form of tables, radar charts, heatmaps, and thematic maps.

The final stage of the research was the integration of results into a WebGIS system. Spatial data on building locations were combined with historical narratives, architectural attributes, and conservation priority scores for interactive visualization. The WebGIS is expected to serve as a comprehensive information source that can be utilized by government agencies, academics, cultural communities, and the general public as a basis for decision-making in the preservation of cultural heritage buildings in Palopo City.

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The problem-solving strategy was operationalized through the development of an initial WebGIS prototype capable of visualizing both spatial and historical-narrative data interactively. The system is designed not only as a documentation tool but also as a medium for education, policy advocacy, and public engagement in heritage preservation.

This research adopts an interdisciplinary approach, integrating three main domains: Urban and Regional Planning, Cultural Heritage Conservation, and Geospatial Information Technology. Such an approach enables a comprehensive understanding [28–30] of cultural heritage buildings, not merely as physical objects within the urban space, but also as entities with historical, architectural, social, and spatial values, and how these can be effectively managed and presented through a web-based spatial information system.

3. Result and analysis

3.1. Determination of criteria

The analysis was conducted to assess and determine conservation priorities, for which it was necessary to establish evaluation criteria. The determination of a building's significance generally rests on four dimensions, historical, aesthetic/architectural, scientific/technological, and social/communal, as formulated in the Burra Charter [31], which defines cultural significance as aesthetic, historical, scientific, and social/spiritual values, while emphasizing the principle of caution in relation to change. This framework has been widely adopted by Historic England through its Conservation Principles, which formalize four core values: evidential, historical, aesthetic, and communal. For listing decisions, the dimensions of rarity/uniqueness and typological representativeness are emphasized in the DCMS Principles of Selection for Listed Buildings and elaborated further in the Listing Selection Guides. These five criteria (A1-A5) form the "value foundation" that must first be assessed before conservation strategies are formulated.

Second, the quality of meaning must be supported by integrity, completeness, and preservation of attributes that convey cultural value, as defined in the most recent UNESCO Operational Guidelines, as well as authenticity, which encompasses design, materials, workmanship, layout, function/tradition, location, and setting, as emphasized in the Nara Document on Authenticity [32]. In practice, these two criteria (B6-B7) act as quality gatekeepers, ensuring that priorities or interventions do not compromise the material evidence or the significance of place.

Short-term action needs are determined by physical condition, deterioration trends, and multi-hazard risks. The Heritage at Risk program outlines methodologies for assessing condition, vulnerability, and statistical risk across asset types, while the Resource Manual: Managing Disaster Risks for World Heritage (UNESCO/ICCROM/ICOMOS/IUCN) provides a framework for risk reduction assessment and the development of disaster risk management (DRM) plans for cultural heritage. For climate-related risks, the Climate Vulnerability Index (CVI) offers a rapid assessment of exposure, value sensitivity, and impacts on communities,

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and has been applied in several sites (e.g., Sukur Cultural Landscape) (CVI, n.d.; ICOMOS Nigeria, n.d.). From this body of literature, criteria C8-C9 capture technical condition and urgency, while D10-D12 address natural hazard exposure, land-use change pressures, and emergency response capacity and accessibility.

Table 1. Heritage assessment criteria and key references.

Cluster	Code	Criteria	Key References / Sources
A. Significance (Value)	A1	Historical value	[31,33,34]
	A2	Architectural / aesthetic value	[35–38]
	A3	Social–communal value	[35,39,40]
	A4	Scientific / technological value	[36,37,41]
	A5	Rarity / uniqueness & typological representativeness	[36,37,41,42]
B. Integrity & Authenticity	B6	Integrity (wholeness)	[36,37,42,43]
	B7	Authenticity	[32,39,42]
C. Condition & Urgency	C8	Physical / material / structural condition	[44,45]
	C9	Deterioration trend & urgency of intervention	[44–46]
D. Risk & Vulnerability	D10	Exposure to natural hazards (flood, fire, earthquake, etc.)	[44,46,47]
	D11	Anthropogenic pressure / land-use change	[43,48,49]
	D12	Emergency access & response capacity	[43,44]
E. Policy, Zoning & Governance	E13	Protection status / legal designation	[35,43]
	E14	Compliance with zoning & spatial planning	[43,47]
	E15	Governance, permitting & legal accessibility	[34,48]
F. Public Benefit & Feasibility	F16	Public benefit (education, identity, sustainable tourism)	[34,50,51]
	F17	Technical–financial feasibility & reversibility (incl. stakeholder support)	[41,44]

For conservation priorities to be actionable and impactful, there must be alignment across policy, zoning, governance, public benefit considerations, and feasibility. In Indonesia, Law No. 11/2010 on Cultural Heritage provides the legal foundation for designation and preservation, while Ministerial Regulation of Education, Culture, Research, and Technology No. 17/2024 establish a cultural heritage zoning system (zone typology, authority, designation, monitoring-evaluation), thereby reinforcing criteria E13-E15. To integrate all criteria transparently and in an auditable manner, multi-criteria decision analysis (MCDA) approaches, such as AHP or MAVT, are widely employed in conservation prioritization or adaptive reuse. The principle of minimal intervention, as stated in the Burra Charter, continues to serve as a normative reference when considering alternative actions [38,42].

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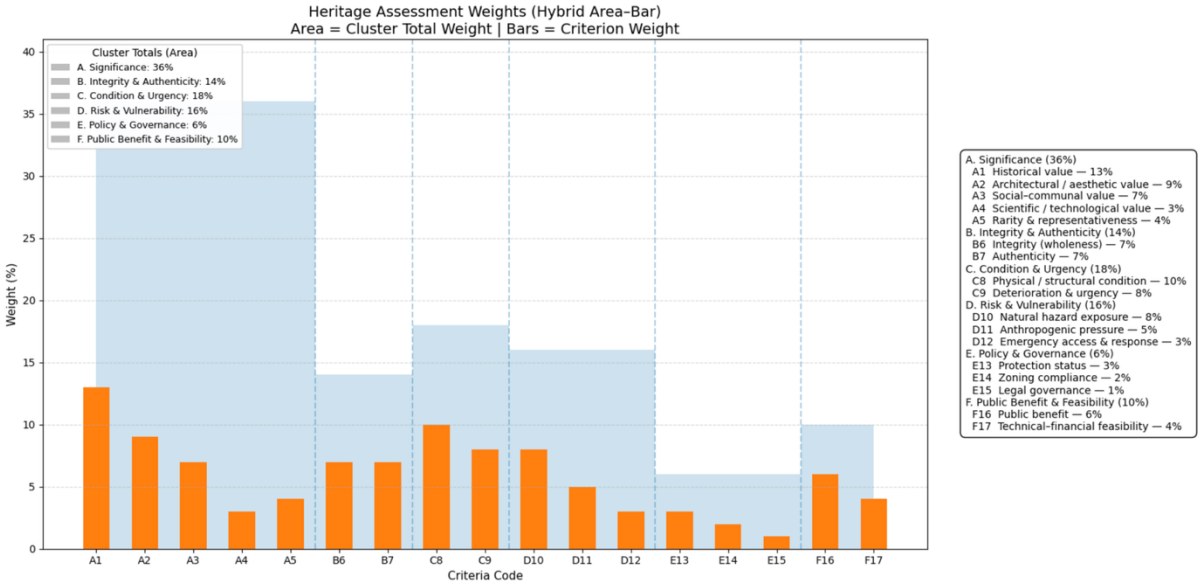


Figure 1. Weighting 17 criteria.

3.2. Cultural heritage building assessment

The 17-criteria assessment of the Palopo City Department of Culture Office indicates a medium conservation priority. This is primarily driven by its high historical value (A1) as a late-colonial government building that has remained in continuous use to the present, as well as its recognizable colonial architectural character (A2), despite the replacement of certain elements, particularly windows and openings, which has reduced authenticity (B7) and left integrity (B6) at a moderate level. The social-communal (A3) and scientific/technological (A4) values are considered moderate, given that the building's main function is administrative. Its rarity/representativeness (A5) is also moderate: the building is representative, though not unique, within the central urban corridor. In terms of condition, both physical state (C8) and deterioration trends (C9) are rated as moderate: the building remains active and functionally maintained, yet the age of materials and past modifications necessitate preventive maintenance. Strong drivers of conservation priority arise from high exposure to natural hazards (D10) and urban land-use change pressures (D11) in Palopo's city center; conversely, accessibility and emergency response capacity (D12) are relatively good, thus lowering urgency. From a governance perspective, formal protection status is already in place, which reduces urgency (E13 low). However, zoning compliance (E14) and legal/governance coordination (E15) still require reinforcement through stronger inter-agency collaboration. Finally, public benefit (F16) and technical-financial feasibility (F17) are both considered moderate, suggesting that a phased conservation program, focused on façade restoration, management of openings and drainage, and adaptive guidelines, would be feasible to implement, maintaining the area's identity without disrupting its administrative function.

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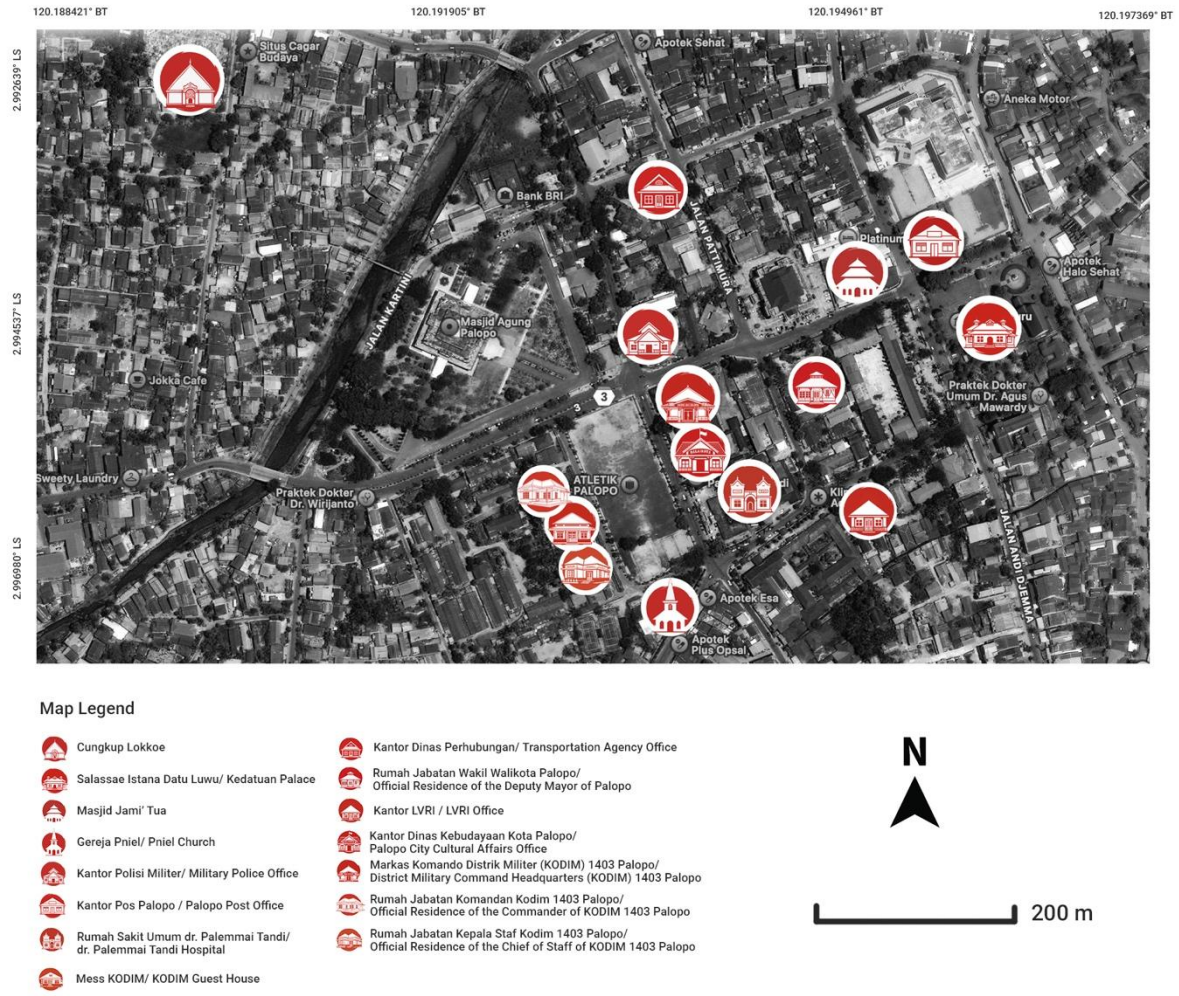


Figure 2. Map of heritage buildings in Palopo City.

The application of the 17-criteria assessment across heritage assets in Palopo reveals a differentiated yet coherent pattern of conservation priority. Overall, assets with strong historical narratives, sustained social functions, and symbolic value consistently emerge as higher priorities, while buildings that remain operational but have undergone functional adaptation tend to occupy medium to medium-high positions. This indicates that conservation urgency in Palopo is not solely driven by age or architectural quality, but by the interaction between significance, risk exposure, and contemporary urban pressures. Sacred and royal heritage assets, such as Istana Datu Luwu, Masjid Jami Tua, Sumur Mattirowalie, and Cungkup Lokkoe, demonstrate the highest priority profiles. These sites score strongly on historical value (A1), social-communal value (A3), and rarity/representativeness (A5), reflecting their deep integration into collective memory, ritual practices, and local identity. Their radar profiles form wide and balanced polygons, signaling both high significance and high vulnerability. In

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these cases, conservation priority is reinforced not only by symbolic importance but also by ongoing use that continuously reproduces cultural meaning.

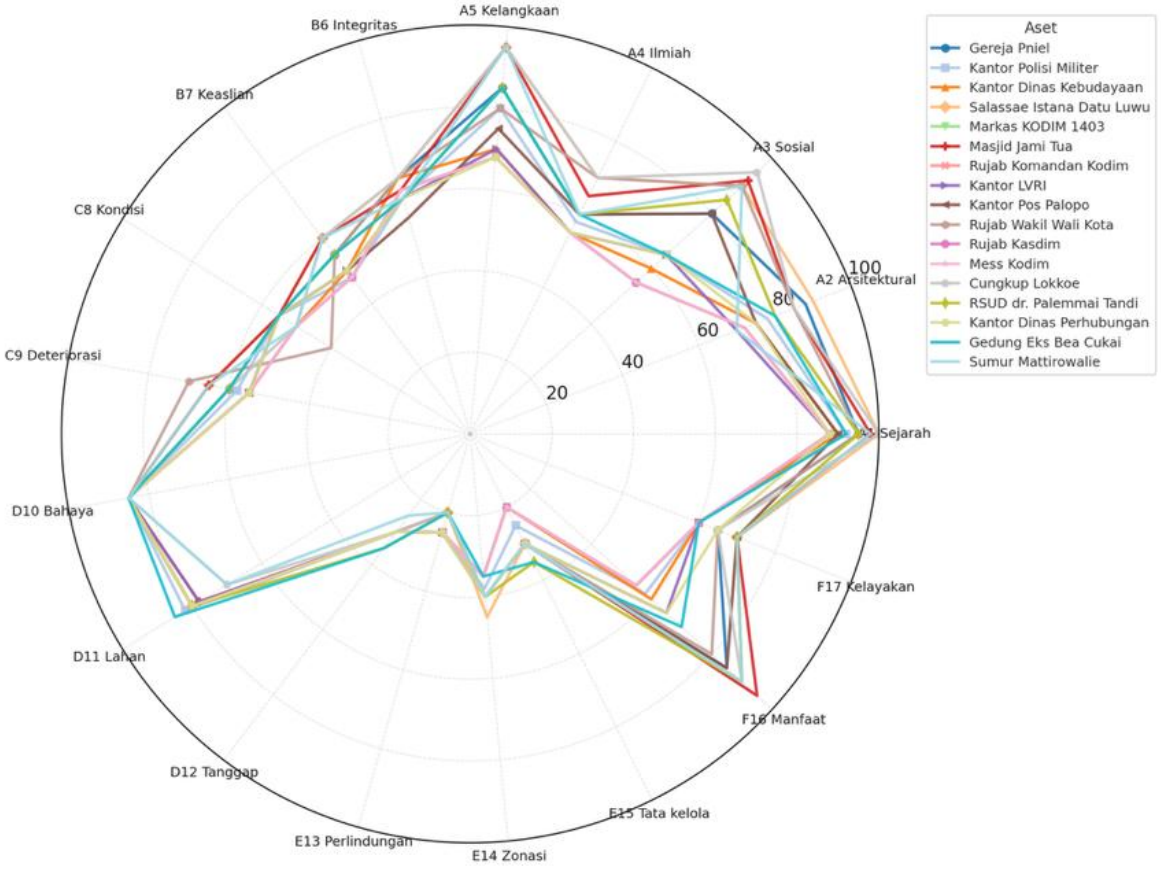


Figure 3. Overlay of 17 criteria across all buildings.

Public colonial buildings, including Pniel Church, the Palopo Post Office, and the Former Customs Office, also register relatively high conservation priorities. Their strength lies primarily in historical (A1) and architectural values (A2), with colonial massing, façade rhythms, and typological clarity still legible. However, these assets show noticeable contraction in authenticity (B7), largely due to material replacements, functional upgrades, and operational requirements. Despite this, their continued use sustains social relevance and public benefit (F16), positioning them as strong candidates for adaptive conservation rather than strict restoration. Military and official government assets, such as KODIM headquarters, military residences, LVRI Office, and other administrative buildings, tend to cluster within the medium to medium-high priority range. Their historical value (A1) as part of Palopo's military and administrative landscape remains evident, yet architectural value (A2) and rarity (A5) are generally moderate, reflecting more standardized building typologies. In these cases, integrity (B6) is often preserved at a basic level, while authenticity (B7) declines due to operational adaptations, modern materials, and spatial reconfiguration.

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Across almost all assessed buildings, risk and vulnerability emerge as a unifying driver of urgency. High exposure to natural hazards (D10), particularly flooding, humidity, and in some locations landslide risk, combined with strong pressure from land-use change (D11) in Palopo's central urban corridor consistently elevate conservation priority. This pattern suggests that urban dynamics, rather than intrinsic heritage value alone, are a critical factor shaping conservation urgency in rapidly growing secondary cities. In contrast, access and emergency response capacity (D12) generally score well and therefore contribute little additional urgency. Most assets remain accessible and functional, even during peak activities or ceremonial events. Similarly, formal protection status (E13) is already in place for many sites, which tends to lower regulatory urgency. However, this does not eliminate conservation challenges, as zoning compliance (E14) and, more importantly, governance coordination (E15) remains uneven across asset types.

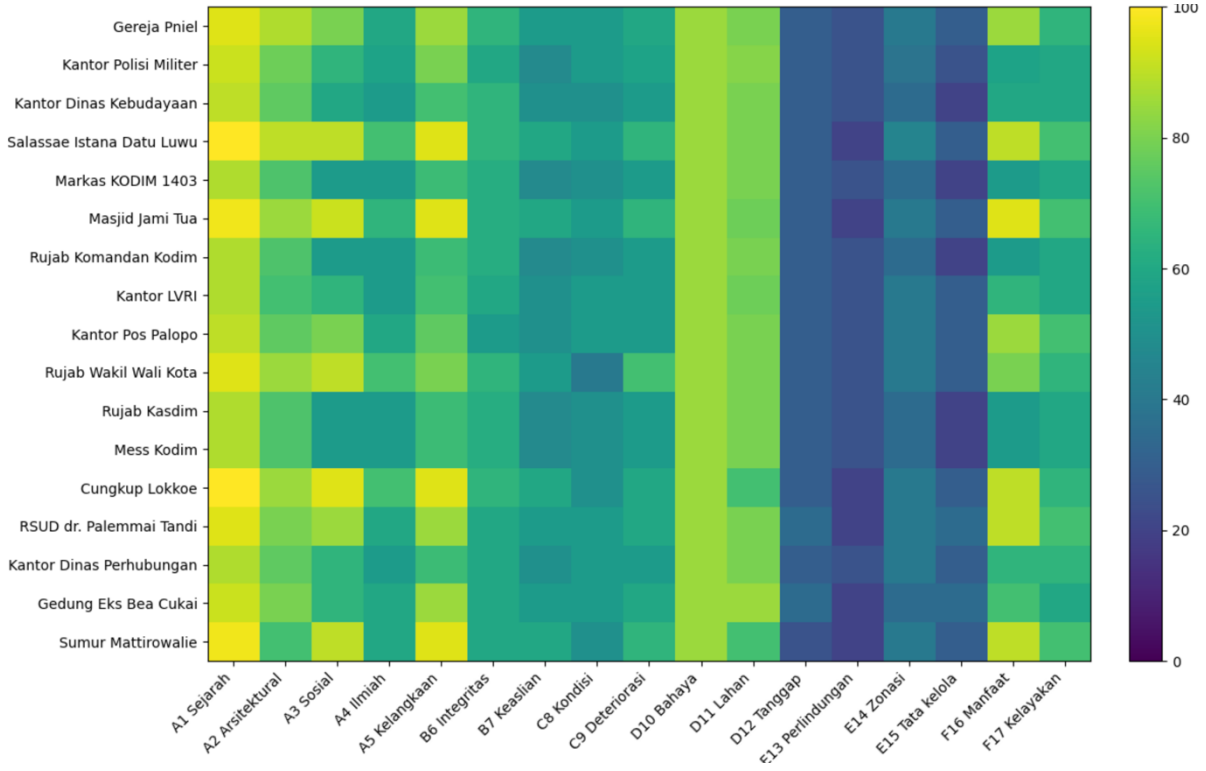


Figure 4. Heatmap of the 17 assessment criteria across 17 heritage buildings.

To make the MCDA results more explicit, the weighted scores were aggregated into a final conservation priority score for each building. Table 2 presents the ranking, MCDA score, and conservation priority label of the 17 assessed heritage buildings in Palopo City. The table complements the heatmap by translating the 17-criteria assessment into a comparable quantitative priority score for each asset.

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Table 2. MCDA-based conservation priority scores of cultural heritage buildings in Palopo City.

Rank	Heritage building	MCDA score	Priority label
1	Salassae Istana Datu Luwu	74.45	High
2	Masjid Jami Tua	73.62	High
3	Cungkup Lokkoe	72.65	High
4	Gereja Pniel	71.02	Medium-high
5	RSUD dr. Palemmai Tandi	70.85	Medium-high
6	Rujab Wakil Wali Kota	70.85	Medium-high
7	Sumur Mattirowalie	70.49	Medium-high
8	Gedung Eks Bea Cukai	67.61	Medium
9	Kantor Pos Palopo	67.55	Medium
10	Kantor Polisi Militer	65.54	Medium
11	Kantor Dinas Perhubungan	64.76	Medium
12	Kantor LVRI	64.09	Medium
13	Kantor Dinas Kebudayaan	63.90	Medium
14	Markas KODIM 1403	62.22	Medium
15	Rujab Komandan Kodim	62.22	Medium
16	Rujab Kasdim	62.22	Medium
17	Mess Kodim	62.22	Medium

Table 2 shows that three buildings were classified as high priority, four buildings as medium-high priority, and ten buildings as medium priority. The highest scores were recorded for Salassae Istana Datu Luwu, Masjid Jami Tua, and Cungkup Lokkoe, indicating that royal and sacred heritage assets occupy the strongest conservation priority group. These assets combine high historical value, strong social-communal significance, rarity, and continuing cultural relevance. Medium-high priority buildings include Gereja Pniel, RSUD dr. Palemmai Tandi, Rujab Wakil Wali Kota, and Sumur Mattirowalie, which retain important historical and public values but show more varied levels of authenticity, functional adaptation, and risk exposure. The remaining ten buildings were classified as medium priority, suggesting that they require preventive maintenance, documentation, monitoring, and stronger governance coordination rather than immediate large-scale restoration

Governance-related issues are particularly evident in buildings with overlapping institutional responsibilities, such as military facilities, hospitals, and port-related structures. While legal protection exists, effective conservation depends on sustained coordination between municipal authorities, central government agencies, customary institutions, and asset managers. Weaknesses in E15 thus emerge as a structural constraint, potentially limiting the translation of high conservation priority into concrete action. Finally, the assessment highlights a generally favorable outlook for phased and preventive conservation. Public benefit (F16) is high for most high-priority assets, especially in terms of education, identity reinforcement, and cultural tourism, while technical-financial feasibility (F17) is mostly rated moderate to good. This indicates that conservation in Palopo is less constrained by feasibility than by prioritization and coordination. Assets with more “expanded” assessment profiles

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require immediate and integrated intervention, whereas those with more compact profiles are well suited to gradual, preventive strategies aligned with ongoing use and urban management.

The results of the 17-criteria assessment are subsequently integrated into the spatial information system palopoheritage.id, thereby strengthening the functionality of the WebGIS platform as both a public heritage knowledge portal and a continuously updated digital archive. The home page of the system presents an interactive WebGIS interface, in which all heritage buildings are visualized on a map or aerial imagery with unique symbols for each asset. By clicking on a symbol, users can access preliminary information, including the building's address, site area, a brief narrative description, and representative photographs. A hyperlink is also provided to redirect users to a dedicated page containing more detailed information. The "Buildings" page displays a comprehensive repository of all listed heritage structures, incorporating historical narratives and high-resolution photographs that are freely downloadable for academic, professional, or public use. The "Our Team" page introduces the research and technical team responsible for developing the system, documenting the process from conceptual design through to implementation and launch. Furthermore, the "Decrees" page archives official government documents establishing the legal designation of cultural heritage buildings in Palopo City, which can likewise be downloaded as open-access resources.

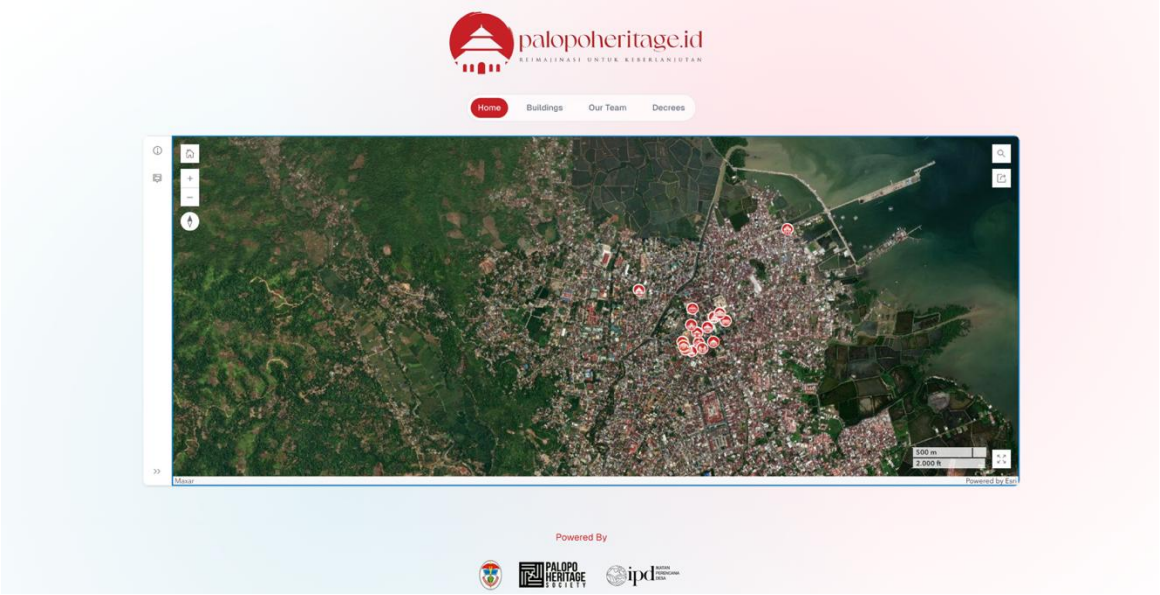


Figure 5. Homepage interface of palopoheritage.id.

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Figure 6. Sample documentation of cultural Heritage buildings in Palopo City.

3.3. Discussion

The findings of this study directly address the research objectives outlined in the Introduction, namely to establish a structured and operational framework for prioritizing urban heritage conservation by integrating cultural values, risk exposure, and governance conditions. The 17-criteria assessment demonstrates that conservation priority in Palopo is shaped not by a single dominant factor, but by the interaction between heritage significance, environmental and urban risks, and institutional capacity. This supports the growing consensus in heritage studies that conservation decision-making must move beyond fabric-focused assessments toward multi-dimensional, value- and risk-informed approaches [34,41]. From the perspective of

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heritage value theory, the consistently high priority assigned to sacred and royal assets reflects the central role of historical (A1), social-communal (A3), and rarity/representativeness (A5) values. Previous studies emphasize that social and associative values often outweigh purely architectural or aesthetic considerations, particularly in contexts where heritage remains embedded in everyday practices and ritual life [40,52]. The results confirm that heritage significance in Palopo is strongly relational: buildings and sites derive urgency from their continuing role in sustaining collective memory, identity, and social cohesion, aligning with the concept of living heritage widely discussed in contemporary conservation theory [53]. At the same time, the assessment reveals systematic reductions in authenticity (B7) among public colonial buildings and operational facilities. Rather than contradicting heritage value theory, this pattern reinforces scholarly arguments that authenticity should be understood as a negotiated and context-dependent attribute rather than a static condition [35,39]. Functional adaptation and material replacement, while diminishing material authenticity, often sustain use value and social relevance, thereby preserving other dimensions of significance. This finding supports values-based conservation frameworks that advocate adaptive management strategies instead of strict material restoration, especially in active urban contexts [34].

The prominence of risk-related criteria, particularly exposure to natural hazards (D10) and pressure from land-use change (D11), highlights the explanatory power of risk-based conservation. According to ICCROM's risk management model, conservation priority should be determined by the probability and magnitude of value loss rather than by condition alone [44,45]. In Palopo, flood risk, humidity, and rapid urban transformation emerge as cross-cutting drivers of urgency across almost all asset categories. This finding aligns with studies showing that in tropical and coastal cities, environmental hazards increasingly dominate heritage vulnerability profiles [46,47]. Interpreted through the lens of urban resilience, these results suggest that heritage assets function as sensitive indicators of broader urban stress. Urban resilience literature conceptualizes cities as socio-ecological systems exposed to both acute shocks and chronic stresses [54]. The expansion of D10 and D11 across radar profiles indicates that heritage in Palopo is deeply entangled with the city's capacity to absorb and adapt to climate-related hazards and land-use pressures. Consequently, conserving heritage assets also contributes to strengthening cultural resilience by maintaining identity, continuity, and place attachment, dimensions increasingly recognized as integral to resilient urban systems [49,50].

The governance findings further reinforce theoretical insights from both risk-based conservation and urban resilience frameworks. Although many assets possess formal protection status (E13), weaknesses persist in coordination, permitting, and inter-institutional collaboration (E15). Previous research demonstrates that legal designation alone rarely ensures effective conservation unless supported by governance capacity, stakeholder engagement, and adaptive management mechanisms [35,43]. The Palopo case exemplifies this gap, particularly for assets under complex institutional control, such as military facilities, hospitals, and port infrastructure. When compared with international studies, the results are

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broadly consistent with research conducted in other historic cities in Asia and the Global South. Similar patterns have been reported in studies from Southeast Asia and South Asia, where social value, risk exposure, and urban development pressures jointly shape conservation priorities [51,55]. However, a notable distinction in Palopo lies in the intensity of land-use pressure affecting medium-sized cities, suggesting that heritage vulnerability is not exclusive to metropolitan centers but is increasingly pronounced in rapidly transforming secondary cities.

Overall, this study contributes to theory-driven heritage planning by empirically demonstrating how heritage value theory, risk-based conservation, and urban resilience can be operationalized within a single assessment framework. The findings underscore that conservation priority is a dynamic outcome of value recognition, risk anticipation, and governance capacity. By bridging these theoretical strands, the study offers a transferable approach for integrating heritage conservation into broader urban planning and resilience strategies, particularly in developing-country contexts experiencing accelerated urban change.

4. Conclusions

This study addresses its primary objective by demonstrating that the integration of spatial, historical, and regulatory data within a WebGIS environment provides a scientifically robust and operational framework for urban heritage governance in small- to medium-sized cities. By moving beyond fragmented inventories and static mapping practices, the proposed system advances current knowledge through the conceptualization of a living spatial–historical platform that links heritage values, physical condition, risk exposure, and planning instruments into a single decision-support structure. Scientifically, the study contributes by operationalizing heritage value theory and risk-informed conservation within a spatial planning context, translating abstract assessment criteria into actionable prioritization levels that can be directly aligned with zoning and development control frameworks. Practically, the framework demonstrates how WebGIS can function not only as a documentation tool, but as an early-warning and evidence-based decision system that supports multi-stakeholder coordination and adaptive conservation planning. The results indicate that such integration enhances transparency, comparability, and policy relevance in heritage management, particularly in rapidly urbanizing contexts where institutional capacity is limited. Future work will focus on expanding asset coverage, refining metadata standards and quality-control protocols, and implementing automated prioritization and monitoring modules, including periodic condition updates and risk-scenario testing, to further validate and scale the system's applicability across comparable urban contexts.

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