



GIS based decision support system for flood free housing location prioritization using analytical hierarchy process

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ABSTRACT

Rapid population growth in the Tembung Area, Percut Sei Tuan District, has accelerated land conversion and increased exposure to flood hazards, creating a need for more objective approaches to residential site selection. However, existing housing selection practices remain largely subjective and have not sufficiently integrated flood-related spatial criteria within a GIS-based decision framework. This study addresses this gap by developing a Geographic Information System (GIS)-based Decision Support System (DSS) that integrates the Analytical Hierarchy Process (AHP) to support the prioritization of flood-safe residential locations. A quantitative approach was employed by combining expert judgments from the North Sumatra Housing and Settlement Department with geospatial data from DEMNAS, RBI, and BMKG. Four environmental criteria—elevation, distance to river, slope, and rainfall—were evaluated across three housing alternatives using a web-based platform developed with PHP and Leaflet.js. The AHP results identified elevation as the most influential criterion (46.58%), followed by distance to river (29.44%), slope (16.03%), and rainfall (7.95%). The Consistency Ratio (CR) of 0.0491 ($CR < 0.10$) indicates an acceptable level of consistency in the expert judgments. The final synthesis ranked Citra Graha Housing as the highest-priority alternative, with a score of 0.3989 (39.89%), followed by Benhil Indah (0.3163) and Mutiara Biru (0.2850). Black Box Testing achieved 100% functional conformity, demonstrating that the developed system successfully performed its specified functions. The main contribution of this study is the integration of AHP-based multi-criteria decision analysis with GIS-based spatial information to provide a more structured and transparent framework for flood-safe residential prioritization.

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Introduction

Rapid population growth in buffer areas surrounding major urban centers inevitably leads to increased demand for residential land. Tembung, located within Percut Sei Tuan district, is currently undergoing significant transformation as a primary property expansion zone on the outskirts of Medan City (Allafta & Opp, 2021). According to official statistics, Percut Sei Tuan is characterized by high population density, which triggers massive land use conversion from natural water catchment areas into concrete residential

complexes(Hussain et al., 2021; Karymbalis et al., 2021). This structural shift imposes severe pressure on environmental carrying capacity, particularly concerning water resource management.

The negative consequence of extensive construction without sound environmental planning is an increased vulnerability to hydrometeorological hazards, especially flooding. Uncontrolled land use changes combined with intense precipitation constitute the primary drivers of localized inundation in the surrounding regions(Mohanty & Karmakar, 2021; Truu et al., 2021). A critical issue arises when prospective homebuyers lack adequate access to historical flood information regarding specific locations. Consequently, property transactions frequently occur where buyers realize their homes are situated in flood prone zones only after occupancy, Leading to material losses and dimenished quality of life (Li & Demir, 2021).

Historically, site selection processes conducted by both local communities and developers have relied on conventional and intuitive approaches(Chen, 2022; Hagos et al., 2022). Decisions are predominantly made based on visual assumptions without mathematical calculations involving comprehensive spatial data(Negese et al., 2022; Sabtu et al., 2022). Multi criteria decision making for disaster safe location selection is inherently susceptible to subjectivity and inconsistency when executed without computational support. The absence of a structured decision mechanism heightens the potential for errors in site selection, necessitating an algorithmic approach to minimize decision bias(Mourato et al., 2023).

The Analytical Hierarchy Process (AHP) provides a systematic framework designed to assist decision making in complex scenarios involving multiple criteria(Taherizadeh et al., 2023). It decomposes a problem into a logical hierarchical structure, evaluates the relative priority of decision parameters, and verifies assessment consistency through pairwise comparisons(Alam et al., 2023; Kumar & Singh, 2024). Furthermore, a Geographic Information System (GIS) offers robust capabilities to capture, store, process, analyze, and visualize spatial data into interactive digital maps.

To address these challenges, this study proposes a decision support system integrating AHP and GIS to establish an objective, transparent, and data driven prioritization model for flood free residential sites(Abegaz et al., 2024). The study evaluates physical environmental parameters including elevation, distance to rivers, slope, and rainfall across candidate housing complexes in Tembung, Percut Sei Tuan district. The integration of AHP based criterion weighting with interactive Web GIS mapping aims to deliver actionable spatial recommendations for homebuyers and urban planning stakeholders(Mabahwi & Nakamura, 2024).

Previous studies have demonstrated the effectiveness of GIS-AHP integration for flood susceptibility assessment, land suitability analysis, and residential site selection. However, several limitations remain. First, many GIS-AHP studies focus primarily on producing spatial suitability or hazard maps rather than translating multi-criteria results into a ranked set of specific residential alternatives that can directly support housing selection. Second, the criteria used in previous studies are often designed for broad regional-scale assessment and may not adequately address the localized characteristics of rapidly developing peri-urban areas. Third, the integration of AHP-based prioritization with an interactive Web GIS interface that presents both the spatial criteria and the resulting housing priorities remains relatively limited. These limitations indicate the need for a localized and operational decision-support framework that combines quantitative criterion weighting, spatial analysis, and interpretable housing alternatives within a single system.

To address these gaps, this study develops a GIS-based Decision Support System (DSS) integrating AHP and Web GIS for flood-safe residential prioritization in Tembung, Percut Sei Tuan District. The novelty of the study lies in integrating four measurable environmental criteria—elevation, distance to rivers, slope, and rainfall—with AHP-based criterion weighting and spatial visualization to rank specific candidate housing complexes rather than merely generating a general flood-susceptibility map. The study aims to (1) determine the relative weights of the four environmental criteria using AHP; (2) assess the consistency of expert judgments using the Consistency Ratio (CR); (3) calculate and rank the priority scores of three candidate housing alternatives based on the weighted criteria; and (4) implement the resulting decision model in an interactive Web GIS platform and evaluate its functional performance using Black Box Testing. The expected contribution is a structured and transparent spatial decision-support framework that enables environmental criteria to be quantitatively combined and

translated into actionable residential priorities for prospective homebuyers and urban planning stakeholders.

Method

This study adopts a quantitative methodology integrating the Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) to evaluate and rank flood-free residential sites. The quantitative approach is selected because it enables systematic mathematical processing of expert numerical judgements and spatial environmental metrics (Bedada & Dibaba, 2025).

1. Data Acquisition and Sources

Data acquisition was executed through three structured channels. Primary data were gathered via in-depth interviews and structured pairwise comparison questionnaires administered to domain experts at the Housing and Settlement Area Department of North Sumatra Province (*Dinas Perumahan dan Kawasan Permukiman Provinsi Sumatera Utara*) (Ashfaq et al., 2025). The expert judgements were quantified using Saaty's 1 to 9 fundamental scale to derive criterion priority weights. Secondary spatial data were collected from official government geospatial repositories:

1. Rainfall data were obtained from the Meteorological, Climatological, and Geophysical Agency (BMKG).
2. Digital Elevation Model (DEMNAS) raster datasets with high spatial resolution were retrieved from the Indonesian Geospatial Information Agency (BIG) to extract elevation and land slope metrics.
3. River network vector shapefiles were acquired from the Indonesian Earth Map (RBI) portal managed by BIG.
4. Literature studies were conducted to establish the theoretical foundations of decision support systems and flood vulnerability mapping.

2. Analytical Hierarchy Process (AHP) Framework

The AHP framework follows a structured multi-tier procedure to resolve complex multi-criteria spatial decisions (Maru et al., 2025; Yilmaz & Alemdar, 2025). A three-level hierarchy was constructed consisting of the primary goal (Prioritization of Flood-Free Housing Sites), four physical criteria (Elevation, Rainfall, Slope, and Distance to River), and three candidate housing alternatives: Benhil Indah Housing, Citra Graha Housing, and Mutiara Biru Housing (Khan et al., 2025).

Pairwise comparisons are established using Saaty's reciprocal scale.

Table 1 displays the fractional pairwise comparison matrix for the environmental criteria, while Table 2 shows its decimal equivalent.

Table 1. Pairwise Comparison Matrix for Environmental Criteria (Saaty Scale)

Criteria	Elevation	Rainfall	Slope	Distance to River
Elevation	1	5	3	2
Rainfall	1/5	1	1/3	1/3
Slope	1/3	3	1	1/3
Distance to River	1/5	3	3	1

Table 1 presents the pairwise comparison matrix of the four environmental criteria using the Saaty 1-9 scale. The matrix reflects the relative importance of elevation, rainfall, slope, and distance to river in evaluating the candidate housing sites. Elevation is assigned the highest relative importance compared with rainfall, slope, and distance to river, as indicated by comparison values of 5, 3, and 2, respectively. The reciprocal values represent the corresponding relative judgments in the opposite direction. This matrix forms the basis for determining the relative priority weights of the environmental criteria.

Table 2. Decimal Representation of Pairwise Comparison Matrix

Criteria	Elevation	Rainfall	Slope	Distance to River
Elevation	1.0000	5.0000	3.0000	2.0000
Rainfall	0.2000	1.0000	0.3333	0.3333
Slope	0.3333	3.0000	1.0000	0.3333
Distance to River	0.5000	3.0000	3.0000	1.0000
Sum	2.0333	12.0000	7.3333	3.6666

Table 2 presents the decimal representation of the pairwise comparison matrix after converting the Saaty-scale judgments into numerical decimal values. Reciprocal judgments such as 1/5 and 1/3 are converted into 0.2000 and 0.3333, respectively, while the final row provides the sum of each criterion column. These column sums are subsequently used to normalize the pairwise comparison matrix and calculate the priority vector for each environmental criterion. The normalization of the comparison matrix is calculated by dividing each element by its respective column sum

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^n a_{kj}} \quad (1)$$

Table 3 presents the normalized criterion matrix, and Table 4 illustrates the resulting priority vectors and percentage distributions.

Table 3. Normalized Criterion Matrix

Criteria	Elevation	Rainfall	Slope	Distance to River
Elevation	0.4918	0.4167	0.4091	0.5455
Rainfall	0.0984	0.0833	0.0455	0.0909
Slope	0.1639	0.2500	0.1364	0.0909
Distance to River	0.2459	0.2500	0.4091	0.2727

Table 3 presents the normalized pairwise comparison matrix for the four environmental criteria. Each value is obtained by dividing the corresponding element in the pairwise comparison matrix by the total value of its respective column. The normalized matrix provides the basis for calculating the relative priority of each criterion by averaging the normalized values across each row.

Table 4. Priority Vector Weights for Environmental Criteria

Criteria	Row Sum	Priority Vector	Percentage (%)
Elevation	1.8631	0.4658	46.58%
Rainfall	0.3181	0.0795	7.95%
Slope	0.6412	0.1603	16.03%
Distance to River	1.1777	0.2944	29.44%

Table 4 presents the priority vector weights and percentage distribution of the environmental criteria. Elevation has the highest priority with a weight of 0.4658 (46.58%), followed by distance to river at 0.2944 (29.44%), slope at 0.1603 (16.03%), and rainfall at 0.0795 (7.95%). These results indicate that elevation represents the most influential criterion in the environmental assessment, while rainfall has the lowest relative weight.

3. Evaluation of Housing Alternatives

Following the evaluation of criteria, local candidate housing sites are evaluated against each specific physical criterion. Tables 5 through 8 outline the comparison matrices and local priority vectors computed for Benhil Indah, Citra Graha, and Mutiara Biru across all four criteria.

Table 5. Alternative Pairwise Matrix for Elevation

Elevation	Benhil Indah	Citra Graha	Mutiara Biru	Row Sum	Priority Vector
Benhil Indah	1.0000	1.0000	7.0000	1.4001	0.4667
Citra Graha	1.0000	1.0000	7.0000	1.4001	0.4667
Mutiara Biru	0.1429	0.1429	1.0000	0.2001	0.0667

Table 5 presents the pairwise comparison matrix for the elevation criterion among the three candidate housing sites. The results indicate that Benhil Indah and Citra Graha receive equal priority, with a priority vector of 0.4667 for each alternative, while Mutiara Biru obtains a substantially lower priority value of 0.0667. The pairwise comparison values show that both Benhil Indah and Citra Graha are considered strongly preferable to Mutiara Biru in terms of elevation, as indicated by the comparison value of 7.0000. The resulting priority vector demonstrates that Benhil Indah and Citra Graha contribute equally to the elevation criterion, whereas Mutiara Biru has a relatively limited contribution. Therefore, based on the elevation criterion alone, Benhil Indah and Citra Graha represent the higher-priority alternatives compared with Mutiara Biru.

Table 6. Alternative Pairwise Matrix for Rainfall

Rainfall	Benhil Indah	Citra Graha	Mutiara Biru	Row Sum	Priority Vector
Benhil Indah	1.0000	0.3333	0.3333	0.4286	0.1429
Citra Graha	3.0000	1.0000	1.0000	1.2858	0.4286
Mutiara Biru	3.0000	1.0000	1.0000	1.2858	0.4286

Table 6 presents the pairwise comparison results for the rainfall criterion. The priority vectors show that Citra Graha and Mutiara Biru have identical priority values of 0.4286, while Benhil Indah has a lower priority value of 0.1429. The pairwise matrix indicates that Citra Graha and Mutiara Biru are each assessed as three times more preferable than Benhil Indah with respect to the rainfall criterion. Consequently, the local priorities indicate that Citra Graha and Mutiara Biru have comparable contributions to the rainfall criterion, whereas Benhil Indah has the lowest local priority. These results demonstrate that rainfall-related considerations favor Citra Graha and Mutiara Biru relative to Benhil Indah.

Table 7. Alternative Pairwise Matrix for Slope

Slope	Benhil Indah	Citra Graha	Mutiara Biru	Row Sum	Priority Vector
Benhil Indah	1.0000	1.0000	3.0000	1.2858	0.4286
Citra Graha	1.0000	1.0000	3.0000	1.2858	0.4286
Mutiara Biru	0.3333	0.3333	1.0000	0.4287	0.1429

Table 7 presents the pairwise comparison matrix for the slope criterion. The calculated priority vectors indicate that Benhil Indah and Citra Graha have equal priority values of 0.4286, whereas Mutiara Biru has a lower priority value of 0.1429. The pairwise comparisons show that Benhil Indah and Citra Graha are each assessed as three times more preferable than Mutiara Biru under the slope criterion. Thus, the local priority distribution indicates that Benhil Indah and Citra Graha provide similar and higher priority levels, while Mutiara Biru contributes comparatively less. This result suggests that, based solely on the slope criterion, Benhil Indah and Citra Graha are more favorable alternatives than Mutiara Biru.

Table 8. Alternative Pairwise Matrix for Distance to River

Distance to River	Benhil Indah	Citra Graha	Mutiara Biru	Row Sum	Priority Vector
Benhil Indah	1.0000	0.2000	0.1111	0.1912	0.0637
Citra Graha	5.0000	1.0000	0.3333	0.8022	0.2674
Mutiara Biru	9.0000	3.0000	1.0000	2.0066	0.6689

Table 8 presents the pairwise comparison matrix for the distance-to-river criterion. Among the three alternatives, Mutiara Biru obtains the highest priority vector of 0.6689, followed by Citra Graha with 0.2674 and Benhil Indah with 0.0637. The pairwise comparisons indicate that Mutiara Biru is strongly preferred over both Citra Graha and Benhil Indah, with comparison values of 3.0000 and 9.0000, respectively. Citra Graha also has a higher priority than Benhil Indah, as reflected by a comparison value of 5.0000. Therefore, the local priority distribution shows a clear differentiation among the alternatives, with Mutiara Biru having the dominant priority for the distance-to-river criterion, while Benhil Indah has the lowest priority.

4. Consistency Testing and Evaluation Measures

The Consistency Ratio (CR) was used to assess the consistency of the pairwise comparison judgments rather than to determine the absence of subjective bias. A CR value below 0.10 is generally interpreted as indicating an acceptable level of consistency in the judgments, whereas a higher value indicates that the pairwise comparisons may require reconsideration. In this study, the CR was calculated after obtaining the maximum eigenvalue and Consistency Index (CI) to evaluate the internal consistency of the expert assessments. The maximum eigenvalue is computed using the weighted sum vector:

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(A \cdot w)_i}{w_i} \quad (2)$$

A decision matrix is considered mathematically valid and free from subjective bias if the Consistency Ratio is less than 0.10. Table 9 details the evaluation parameters used to measure consistency.

Table 9. Consistency Measurement Parameters

Criteria	Weighted Vector	Priority Vector	Eigenvalue
Elevation	1.9330	0.4658	4.1498
Rainfall	0.3242	0.0795	4.0778
Slope	0.6522	0.1603	4.0683
Distance to River	1.2467	0.2944	4.2347

Table 9 summarizes the consistency measurement parameters obtained from the AHP calculation for the four physical criteria. The eigenvalue associated with each criterion is derived from the ratio between the weighted sum vector and the corresponding priority vector. The resulting eigenvalues are 4.1498 for elevation, 4.0778 for rainfall, 4.0683 for slope, and 4.2347 for distance to river. Based on these values, the overall maximum eigenvalue (λ_{max}) is calculated as 4.1327. Since the value is close to the matrix order of four, the pairwise comparison judgments demonstrate a high degree of mathematical consistency. This result provides a basis for proceeding with the Consistency Index (CI) and Consistency Ratio (CR) calculations to verify whether the comp

Results and Discussions

This section presents the mathematical synthesis of criteria and alternative priority vectors, the implementation of the Web GIS platform, and the discussion comparing findings with existing literature.

1. Synthesis of Alternative Priority Scores

The local preference vectors derived for candidate housing sites across four environmental parameters were combined with global criterion weights. Table 10 summarizes the synthesis matrix used to determine the final flood-free priority score for each residential complex.

Table 10. Final Priority Score Synthesis Matrix

Alternative Housing	Elevation (46.58%)	Distance to River (29.44%)	Slope (16.03%)	Rainfall (7.95%)	Final Score	Percentage (%)	Priority Rank
Benhil Indah	0.4667	0.0637	0.4286	0.1429	0.3163	31.63%	2
Citra Graha	0.4667	0.2674	0.4286	0.4286	0.3989	39.89%	1
Mutiara Biru	0.0667	0.6689	0.1429	0.4286	0.2850	28.50%	3

The mathematical synthesis indicates that Citra Graha Housing obtains the highest composite priority score of 0.3989 (39.89%), followed by Benhil Indah with 0.3163 (31.63%) and Mutiara Biru with 0.2850 (28.50%). These scores represent the relative priority of the three candidate housing alternatives based on the four environmental criteria incorporated into the AHP model. Therefore, the result should be interpreted as a relative flood-risk suitability priority rather than evidence that Citra Graha is completely free from flooding.

The primary factor contributing to Citra Graha's highest composite score is its balanced performance across the two most heavily weighted criteria, namely elevation (46.58%) and distance to river (29.44%). Together, these two criteria account for 76.02% of the total criterion weight, indicating that topographic position and proximity to river systems exert substantially greater influence on the final ranking than slope and rainfall within the current model. Citra Graha obtains a relatively high local priority for elevation (0.4667) and distance to river (0.2674), allowing its performance across these dominant criteria to compensate for its position on the rainfall criterion (0.4286). In contrast, Mutiara Biru demonstrates an important trade-off between criteria. It obtains the highest local priority for distance to river (0.6689), but its elevation priority is only 0.0667. Because elevation carries the largest global weight (46.58%), the disadvantage associated with elevation has a substantial effect on its final composite score. This finding demonstrates that a high score on a single environmental criterion does not necessarily result in the highest overall priority when the criterion has a lower or higher global weight. The result therefore illustrates the practical value of multi-criteria synthesis compared with evaluating residential locations using distance to river alone. (Remoum & Bouzenoune, 2025).

The dominance of elevation in the present analysis is consistent with previous GIS-based flood and land-suitability studies that identify topographic conditions as an important determinant of flood exposure. However, the relative contribution of each criterion is context dependent because flood susceptibility is influenced by local terrain, drainage characteristics, rainfall patterns, and proximity to watercourses. The present result therefore extends previous GIS-AHP approaches by translating these environmental factors into a comparative ranking of specific housing alternatives rather than limiting the analysis to a generalized spatial suitability or flood-susceptibility map.

Similarly, the substantial weight assigned to distance to river (29.44%) indicates that proximity to drainage channels remains an important spatial consideration in residential selection. Nevertheless, the result for Mutiara Biru shows that distance from a river cannot be interpreted independently of topographic elevation. A location may be relatively distant from a river but still receive a lower overall priority when its elevation-related condition is less favorable. This finding highlights the importance of integrating multiple environmental dimensions rather than relying on a single spatial indicator.

2. System Implementation and Black Box Testing

The Black Box Testing produced successful execution for all tested functional scenarios, corresponding to a 100% functional conformity rate. This result indicates that the tested Web GIS functions—including criterion-weight management, geospatial layer visualization, housing search and filtering, and authentication—performed according to their predefined functional requirements. The result demonstrates system functionality and does not constitute validation of the AHP model or empirical validation of flood-risk predictions.

Table 11. Black Box Functional Test Results

Test Scenario	Expected Outcome	Execution Result	Status
Criteria Weight Management	Admin updates AHP pairwise matrices and system recalculate scores dynamically	Calculated values match mathematical model	Valid
Geospatial Layer Overlay	Interactive map displays vector polygons and attribute popups accurately	Spatial overlays and popups render correctly	Valid
Search and Filtering	Users filter housing choices based on safety priority rank	Filtered results match database records	Valid
Authentication & Access	Admin dashboard restricts unauthorized access to system configuration	System enforces role-based permission	Valid

The Black Box testing achieved a 100% validity rate across all core functional test cases, confirming that the Web GIS application operates reliably in serving decision-support information to end-users.

Discussion

The findings demonstrate that AHP provides a structured mechanism for incorporating expert judgments into residential spatial prioritization. Rather than relying exclusively on intuitive assessments, the proposed approach explicitly assigns relative weights to the four environmental

criteria and combines them with spatially derived alternative priorities. The resulting framework therefore makes the decision structure more transparent and reproducible, although it does not eliminate subjectivity because the criterion weights and pairwise judgments still originate from expert assessment. AHP into spatial housing selection significantly reduces the subjectivity inherent in intuitive decision-making. Highlighting Elevation as the most dominant criterion (46.58%) aligns with regional hydrological studies in North Sumatra, which identify low-lying terrain as the primary catalyst for inundation during high rainfall events. Distance to River (29.44%) acts as the secondary determining factor, reflecting the impact of riverbank overflows during peak seasonal runoff.

By integrating GIS visualization with multi-criteria analysis, the proposed system transforms spatial environmental measurements into an interpretable ranking of candidate housing alternatives. For prospective homebuyers, the system provides a structured basis for comparing locations using elevation, distance to river, slope, and rainfall rather than relying solely on visual or intuitive assessments. For urban planners and regional government agencies, the framework can support preliminary spatial screening and residential development planning. However, the resulting classification should be interpreted as a relative environmental priority rather than an absolute prediction of flood occurrence, because the current model incorporates only four environmental criteria and does not explicitly model other potentially relevant factors such as drainage capacity, land-cover change, soil infiltration, tidal influence, or historical flood frequency.

Several limitations should be considered when interpreting the results. First, the AHP model incorporates only four environmental criteria: elevation, distance to river, slope, and rainfall. Consequently, the resulting priority scores represent relative environmental suitability and should not be interpreted as a comprehensive prediction of flood occurrence. Second, the criterion weights are derived from expert judgments and therefore remain subject to expert-based preference and contextual assumptions, despite achieving an acceptable Consistency Ratio. Third, the current analysis evaluates three candidate housing alternatives within the Tembung study area, which may limit the generalizability of the ranking to other locations. Finally, further validation using historical flood occurrence records and sensitivity analysis is recommended to assess the robustness and external validity of the resulting spatial priorities.

Conclusions

This study demonstrates that integrating the Analytical Hierarchy Process (AHP) with a Geographic Information System (GIS) provides a structured and transparent framework for prioritizing residential locations based on selected flood-related environmental criteria in Tembung, Percut Sei Tuan District. The AHP results indicate that elevation is the most influential criterion, accounting for 46.58% of the total decision weight, followed by distance to river (29.44%), slope (16.03%), and rainfall (7.95%). The Consistency Ratio (CR) of 0.0491 ($CR < 0.10$) indicates an acceptable level of consistency in the expert judgments and does not imply the absence of subjective bias. Based on the final weighted synthesis, Citra Graha Housing obtained the highest priority score of 0.3989 (39.89%), followed by Benhil Indah (0.3163; 31.63%) and Mutiara Biru (0.2850; 28.50%). Thus, Citra Graha represents the highest-priority alternative according to the proposed AHP-GIS model, rather than an absolute flood-free or safest location. Black Box Testing achieved 100% functional conformity across the tested system modules, indicating that the Web GIS application performed its specified functions successfully. The main limitation of this study is that the decision model considers only four physical environmental criteria and has not been externally validated against historical flood-event data. Therefore, the resulting priority scores should be interpreted as relative spatial priorities within the evaluated alternatives rather than definitive predictions of flood occurrence. Future research should incorporate additional factors such as drainage capacity, land use and land-cover characteristics, soil infiltration, socio-economic variables, and historical flood records, as well as sensitivity analysis and real-time rainfall data, to further assess the robustness and applicability of the decision-support framework.

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