

Land Use Suitability Analysis for Urban Spatial Planning and Development of Barisal Metropolitan City and Surroundings Using Geo-Factors Multi-Criteria Analysis

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Abstract: Urban growth in Bangladesh demands sustainable spatial planning to manage unplanned expansion and environmental risks. This study assesses land use suitability for urban development in Barisal Metropolitan City using a GIS-based Multi-Criteria Analysis (MCA). Spatial geo-factors such as geomorphology, terrain, foundation suitability, inundation, subsidence, and earthquake hazards were analyzed using the Analytical Hierarchy Process (AHP) for weighting. The integrated GIS analysis produced a land suitability map with five classes, showing 66% of the area as low suitability (Class IV). The results highlight limited foundation strength and high earthquake risk, emphasizing the need for proper engineering solutions and geo-spatial integration in sustainable urban planning.

Keywords: Geo-factors, Land use suitability, Multi-Criteria Analysis (MCA), Analytical Hierarchy Process, Sustainable development goals.

Introduction

Urban growth and infrastructure development in Bangladesh are progressing rapidly, particularly in regional cities like Barisal, which are increasingly facing the challenges of unplanned expansion. Such unregulated urbanization can result in inefficient land use, vulnerable infrastructure, and significant environmental hazards. To address these issues, this study conducts a comprehensive assessment of land use suitability for sustainable spatial urban development planning in Barisal Metropolitan City and its surroundings. The objective is to identify optimal zones for future expansion by incorporating geospatial analysis and decision-support methodologies.

Methodology

This approach integrates Geographic Information Systems (GIS) with Multi-Criteria Analysis (MCA). GIS provides a platform for spatial data management, analysis, and visualization. MCA allows us to systematically evaluate and weigh various geo-factors influencing land use suitability. By combining these

techniques, we can generate a comprehensive and objective suitability map.

The study adopts a structured methodological framework integrating GIS and MCA, particularly the Analytical Hierarchy Process (AHP), to evaluate spatial data layers. The process involves the following key steps:

Study area and data collection

Barisal Metropolitan Area, including its peripheral regions, is selected for this analysis. There are several geo-factors, including

Geomorphic Map – Identifies terrain features.

Digital Terrain Model (DTM) - terrain elevation.

Bearing Capacity – Determines if land can support structures.

Local PGA Map – Assesses ground motion intensity.

Seismic Soil Class – Categorizes earthquake susceptibility.

Liquefaction, Inundation & Subsidence – Identifies risk-prone zones.

Criteria selection and standardization

Each criterion was standardized using a common scale (typically 1–5 or 0–1), depending on its suitability for urban development. These factors are carefully selected based on their impact on urban development and the specific context of the study area.

Weight assignment through AHP

Weights were assigned to each criterion using the AHP technique (Saaty, 1980), which involves linear approach based on expert input.

Weighted overlay analysis in GIS

The weighted spatial layers were overlaid using a GIS-based raster analysis. The final suitability index was calculated using the formula (Voogd, 1983).

$$Suitability\ Index\ (SI) = \sum (W_i \times W_{ij})$$

Where, W_i is the weight of criterion i and W_{ij} is the standardized score of criterion i .

Results and discussion

The resulting map is classified into five suitability classes, I to V, with $SI > 0.8$, $SI\ 0.8 - 0.6$, $SI\ 0.6 - 0.4$, $SI\ 0.4 - 0.2$, and $SI < 0.2$ (Figure 1).

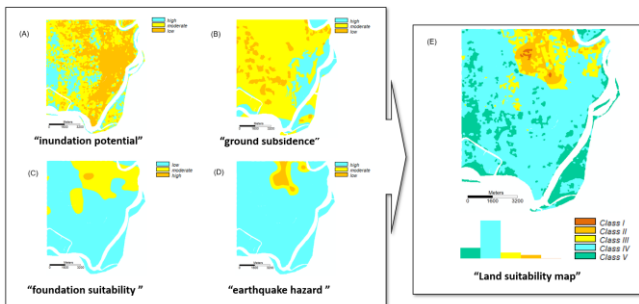


Figure 1, Geo-factors inundation potential (A), ground subsidence (B), foundation suitability (C) and earthquake hazard (D) of Barisal area. E: Land suitability map with histogram showing relative terrain class areas.

The analysis revealed that approximately 66% of the study area falls under Class IV, indicating low suitability and requiring special engineering measures. The study area shows low foundation suitability for heavy infrastructure and comparably high earthquake hazard (liquefaction). Although vast areas have low inundation potential and moderate subsidence trends. Proper engineering methods, techniques, and design should be considered for heavy infrastructure development.

The suitability analysis further revealed a spatial disparity in development potential. The northern and central zones of Barisal city show higher suitability due to relatively stable terrain and established infrastructure (Figure 2). In contrast, southern and peripheral regions, particularly near riverbanks and floodplains, are more vulnerable and less suited for expansion without significant investment in land stabilization and flood control.

Implications for urban planning

The findings of this study provide valuable insights for policymakers, urban planners, and local authorities. By identifying areas with high development potential, urban expansion can be directed in a more sustainable and cost-effective manner. The classification also allows planners to avoid or mitigate risks associated with environmental hazards like flooding, thereby

reducing infrastructure vulnerability. This GIS-MCA approach is adaptable and can be replicated for other cities in Bangladesh facing similar challenges.

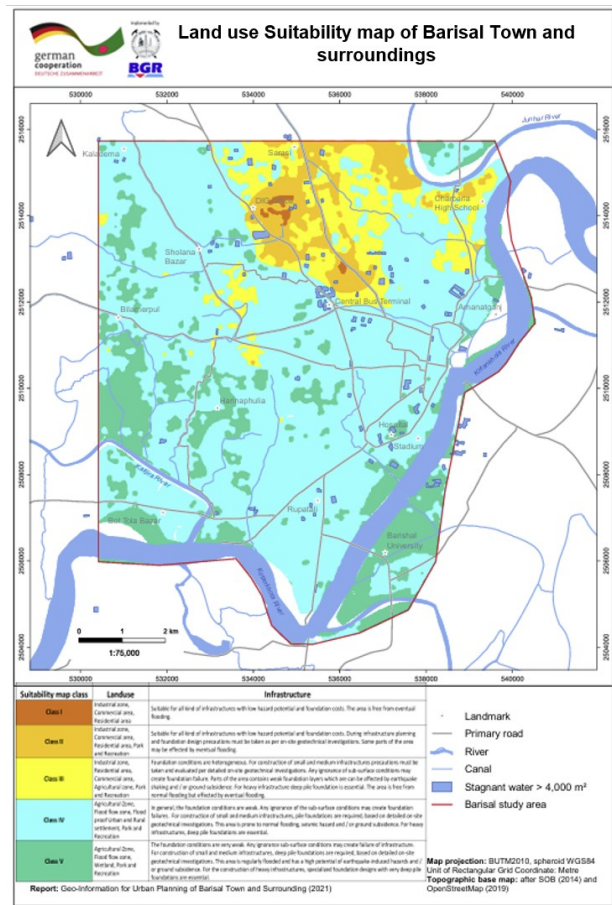


Figure 2, Land use Suitability map of Barisal town and Surroundings.

Conclusion

This study demonstrates the effectiveness of integrating GIS and Multi-Criteria Analysis for assessing land suitability in Barisal Town. The results offer insights into sustainable, risk-sensitive urban planning, while future inclusion of socio-economic and climate data could further improve the model.

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