



GIS-BASED MULTI-CRITERIA WEIGHTED-OVERLAY ANALYSIS FOR LAND-USE SUITABILITY

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Abstract— These days, decisions regarding land suitability analysis, especially for urban areas are assisted by GIS and other multi criteria weighing techniques. Land as a resource needs a well-organized and careful considerations in using and managing it. The existing regional bus terminals of Asmara are old and lack necessary services. Their location, which is near and inside the UNESCO nominated heritage site presents a challenge for reconstruction. For the future, construction of new and modern bus terminal that overcomes the existing problems and satisfies the demand is certain. This research is aimed to select the optimum sites for a new regional bus terminal for Asmara city through the use of Multi-Criteria Overlay (MCO) within Geographic Information Systems (GIS). In this study, first, the overlay analysis is done by considering equal weight for factors and then, expert views on the factors is used to obtain weights of factors by the Analytical Hierarchical Process (AHP). The GIS environment was used first to eliminate the sites where future development should not be considered, then rank the suitability of those areas where future development is possible. The resulting suitability maps generated by AHP and equal weighting were compared and AHP found to give more reliability

Index Terms - GIS, AHP, Overlay, UNESCO, land use, suitability analysis

I. INTRODUCTION

Land suitability analysis (LSA) is technique used for assessing the compatibility of land for a specific use. Multi-criteria overlay (MCO) integrates various factors like slope, proximity, and land cover into a suitability map. Land

suitability analysis (LSA) in GIS traditionally assigns equal weights to various criteria like slope or soil type. This method simplifies analysis while ensuring all criteria contribute equally to the final land suitability map. Using Analytic Hierarchy Process (AHP) for land suitability analysis within GIS allows decision-makers to assign weights to different criteria, enabling a more nuanced evaluation and creation of suitability maps reflecting prioritized factors. This research will demonstrate how MCO in QGIS can be used to assess potential locations for bus terminals. By comparing the results of AHP and equal weighting in MCO, insights can be gained into the sensitivity of the suitability analysis to different weighting schemes.

II. PROBLEM STATEMENT

The current bus terminal in Asmara is outdated and no longer meets the needs of a growing population. Selecting a suitable location for a new terminal requires a comprehensive evaluation that considers various factors impacting passenger experience, operational efficiency, and urban development. This research aims to compare two weighting approaches in the decision-making for replacing the bus terminal:

Analytic Hierarchy Process (AHP): This method allows decision-makers to assign weights to critical criteria (e.g., accessibility, land cost, environmental impact) based on their relative importance.

Equal Weight Criteria: This approach assigns equal importance to all pre-defined criteria, simplifying analysis but potentially overlooking the varying significance of factors.

III. OBJECTIVE AND SCOPE

This research will investigate the use of Multi-Criteria Overlay (MCO) within Geographic Information Systems (GIS) to compare two factor-weighting methods; AHP and Equal weight for land suitability analysis applied in selecting location for a new bus terminal. The effectiveness of AHP (Analytic Hierarchy Process), which allows weighting of criteria based on importance will be compared against a method of assigning equal weight to all suitability criteria. A spatial suitability model in GIS incorporating factors like accessibility, slope, environmental impact, and operational efficiency will be developed. By comparing the resulting suitability maps generated by AHP and equal weighting, it is aimed to identify which method provides a more robust and informative decision-making framework for selecting the optimal location for the new bus terminal.

IV. METHODOLOGY

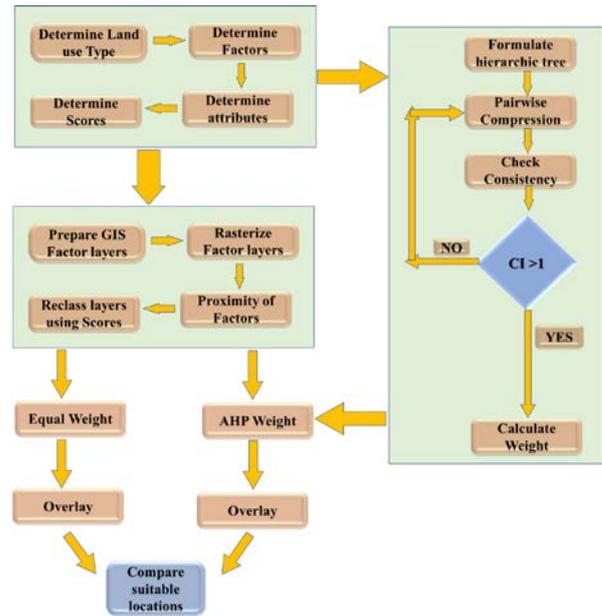
Previous research on land suitability analysis for various urban development projects provides a valuable foundation. However, this study delves deeper into the specific criteria relevant for bus terminal location selection. Literature on urban transportation planning and passenger needs are consulted to identify factors like:

- Accessibility to different transport modes (bus routes, rail lines)
- Proximity to population centers
- Availability of land for terminal construction and future expansion
- Potential environmental impacts of the new location
- Slope
- Restricted areas like forests and water bodies.
- Major utility lines that may cross development site.

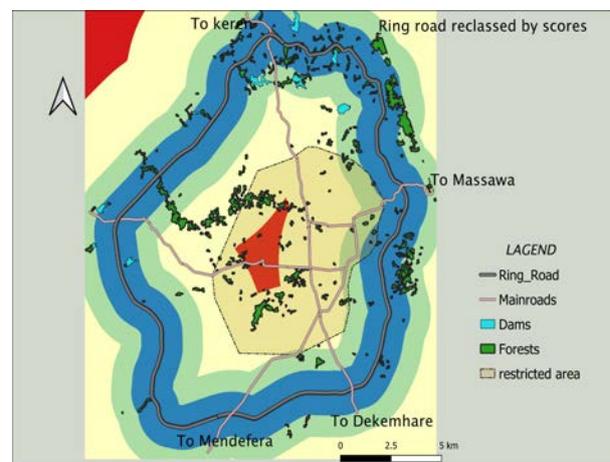
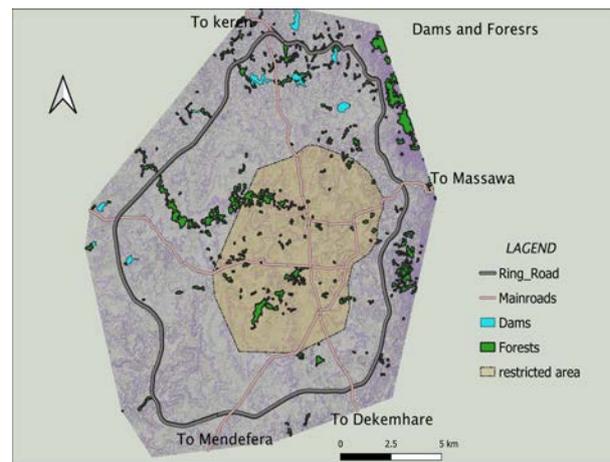
The Analytic Hierarchy Process (AHP) is a widely used method for weighting criteria in multi-criteria overlay decision making (MCO). It facilitates the structured comparison of criteria, allowing decision-makers (e.g., city planners, transportation authorities) to assign weights based on their importance for the specific project. This ensures that factors critical for a well-functioning bus terminal, such as accessibility to public transport hubs or proximity to major roads, are appropriately prioritized in the suitability analysis. The

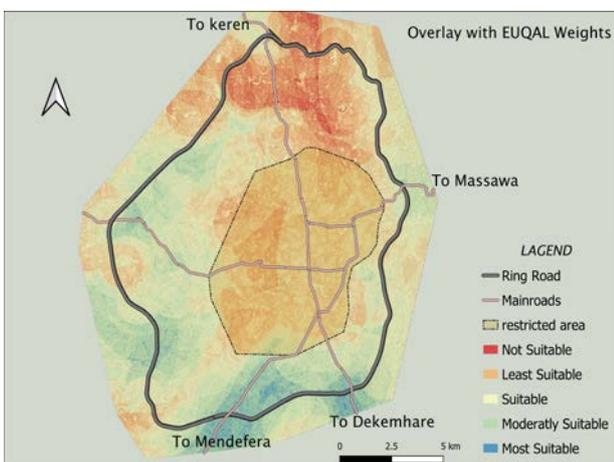
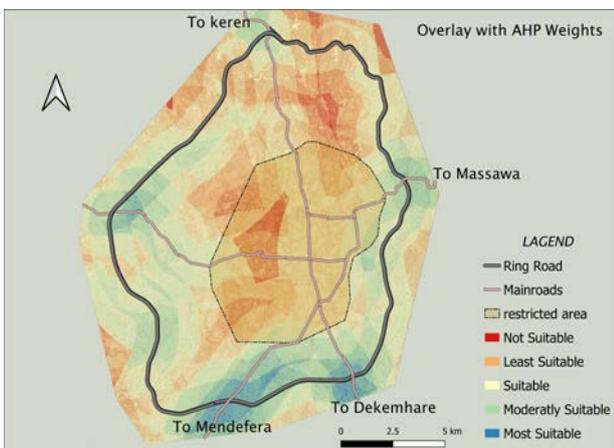
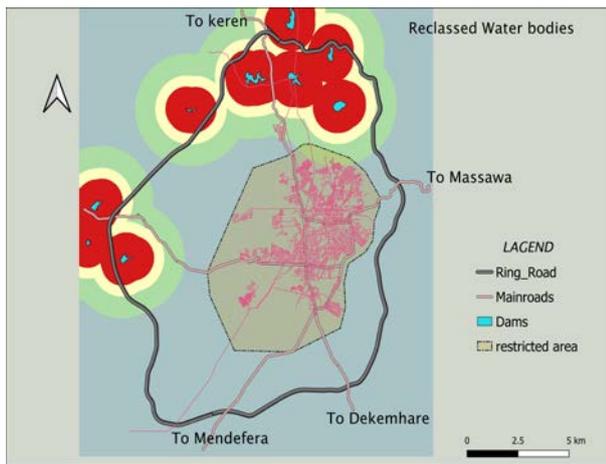
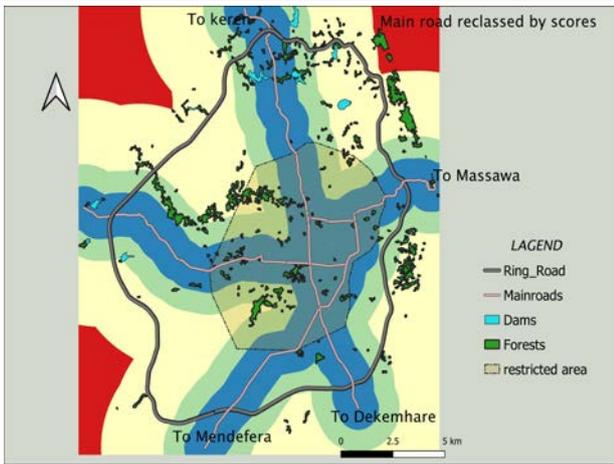
following table was adopted to compare factor's importance in weight calculation.

V. METHODOLOGY FLOW CHART



VI. ANALYSIS AND DISCUSSION





The results of GIS-based MCO by using weights from AHP and equal weights were compared. When the factors used with equal weight, the site for bus terminal found to fall in only one region, which is a junction of ring road and main road at the southern part of Asmara. The results from weight by AHP gave locations greater than two along the ring road that effectively avoid places that need protection and reasonable proximity to access the downtown. Comparatively speaking, GIS-based MCO with weights from AHP provides a more technological, convenient and precise way for bus terminal site selection than equal weight criteria. It combines spatial and non-spatial data to construct visualized information that can be easily understood and analyzed by decision makers. By using such illustrative maps, decision makers can obtain very accurate solutions for problems.

VII. CONCLUSION

In this study, the optimal site for new bus terminal found to be along the proposed Asmara ring-road, which proves that the result from GIS method is relatively practical. The accuracy is further witnessed by the location falling in reasonably enough buffer from forests and water bodies which otherwise would have been affected by it. The slope is convenient for construction and in a range to minimize the cost of construction. The major utility lines were effectively avoided from crossing the site by relatively enough buffer.

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