

Original Article

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## Locating high-rise buildings with emphasis on skyline theory and transit-oriented development (tod): a case study of hamedan city

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### Abstract

This study aims to identify suitable locations for high-rise development in Hamedan City by integrating the principles of Skyline Theory and Transit-Oriented Development (TOD). Two main groups of criteria were analyzed: functional criteria (accessibility, proximity to public transport, land-use mix, walkability/bikeability, and parking availability) and visual criteria (view, diversity in form and appearance, and height). The research employed a combined Analytic Hierarchy Process and Geographic Information System (AHP-GIS) approach, using expert evaluations and spatial data layers. The results indicated that Beheshti Town, with a weight of 0.431, has the highest potential for high-rise development, while Golan (0.310) and Haji (0.258) neighborhoods stand in the next ranks. Findings revealed that accessibility to public transportation and preservation of visual corridors are the most influential factors in site selection. The integration of TOD and Skyline Theory establishes a balanced framework that supports both functional efficiency and visual harmony in urban form. Ultimately, the outcomes provide practical insights for municipalities and urban planners to regulate high-rise construction and promote sustainable urban development in both the historical and modern contexts of Hamedan.

### Keywords

High-rise development  
Public Transportation Accessibility  
Skyline  
Spatial Criteria  
Transit-Oriented Development (TOD)  
Urban site selection  
Urban visual landscape

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## 1. Introduction

In recent decades, the growing trend of high-rise development in cities, alongside horizontal expansion and physical sprawl, has led to excessive land consumption and the emergence of environmental and management challenges (Rennie Short, 2013; Al-Kodmany et al., 2022). This situation has underscored the pressing need to develop effective strategies for the optimal siting and design of tall buildings. Since the 1970s, approaches such as smart growth, New Urbanism, and Transit-Oriented Development (TOD) have been introduced as key models to control horizontal expansion and improve the efficiency of inner-city land use (Zarabi et al., 2011). These approaches, by emphasizing the connection between land use and transportation systems, promote balanced density, mixed-use development, and enhanced public accessibility, providing a solid foundation for placing tall buildings (Knowles et al., 2020; Wood, 2022).

However, the rapid and unplanned expansion of neighborhoods has resulted in undesirable changes and deterioration in their quality and cohesion. Careful site selection, planning, and design based on principles and regulations, coordination with surrounding areas, and the creation of active and desirable urban spaces are essential considerations in tall building design. In this context, urban development guided by the TOD approach has been considered an effective solution to enhance urban quality of life and identify areas needing improvement (Kumar, 2018).

Tall buildings are not only iconic elements of the city skyline but also play a key role in redefining the spatial structure of modern cities. Research reveals that the quality of these buildings' interaction with their surrounding environment and urban landscape significantly impacts visual perception and urban identity (Karimimoshaver & Winkemann, 2018). In this regard, "skyline theory," focusing on three aesthetic, visual, and semantic dimensions, offers a conceptual framework for assessing how high-rise development impacts the urban landscape and legibility (Karimimoshaver et al., 2021; Kheir Al-Kodmany, 2013).

Still, the definition of a tall building varies across different texts and depends on social and urban contexts (Pishgar & Mohammadi, 2020). Such differences highlight the importance of considering local characteristics in analyzing high-rise development. While in some global cities tall towers symbolize

growth, in many historic cities such as Hamedan, these structures can threaten the human scale, cultural landscape, and spatial justice (Ajzae Shokoohi & Razaghian, 2015). On the other hand, high-rise construction can improve urban services per capita, create visual corridors, and establish city landmarks, despite its negative consequences such as increased population density, transportation disruptions, and obstructed urban views (Anabestani et al., 2015).

In recent years, new debates around spatial justice and smart cities have been added to urban planning discourse. These approaches focus on optimal space management, equitable access, and the use of smart technology for sustainable development, indirectly influencing high-rise policies. Therefore, the location of tall buildings should be considered not only based on physical and visual criteria but also on spatial justice and accessibility (Abagheri Mahabadi et al., 2024; Shirooyehpour et al., 2024; Soleymani et al., 2024).

Choosing suitable sites for tall buildings is crucial for sustainability and the quality of the urban environment. Although such structures can contribute to organizing urban spaces by preventing horizontal growth, improving service per capita, and creating visual corridors, without scientific site selection and strict design regulations, they can cause problems like excessive density, disruption to the transportation system, shadowing, gentrification, and damage to the urban landscape (Ali & Al-Kodmany, 2012: 384). Therefore, attention to physical, visual, and environmental dimensions in the site selection process for tall buildings is fundamental for balanced and sustainable urban growth.

In Hamedan, which faces population growth and land limitations, high-rise development has accelerated recently, leading to problems such as excessive density, gentrification, shadowing, and urban landscape disruption (Shafiei Dastjerdi et al., 2022). To address this, it is important to adopt an integrated approach combining TOD principles and skyline theory to manage tall construction. While benefiting from the advantages of compact development, this approach can prevent visual and spatial anomalies, thereby improving urban livability.

Under such circumstances, tall buildings are typically constructed in locations with good access to public transportation networks and pedestrian routes, aligning with TOD principles and helping to reduce traffic, pollution, and energy consumption. Integrating TOD principles with skyline considerations offers an

effective solution to balance spatial efficiency, visual quality, and urban identity. This research focuses on these frameworks to identify effective criteria for site selection for tall buildings in Hamedan and to prioritize areas suitable for high-rise development. The findings aim to provide an analytical model for evaluating urban high-rise development and support better-informed decisions by urban managers and planners to enhance livability and city character. The main objectives are:

- 1) Prioritizing effective criteria for high-rise development across Hamedan's different areas;
- 2) Identifying the most suitable zones for tall building development based on TOD and skyline characteristics.

## 2. Literature Review

High-rise development, as one of the most significant physical phenomena in contemporary cities, has consistently received the attention of researchers in

architecture, urban design, and urban planning. This approach, on the one hand, responds to increasing population density and urban land limitations; on the other hand, due to its profound impacts on urban character, spatial justice, and livability, it creates fundamental challenges in the urban planning system. Recent studies have examined high-rise development from various dimensions, including economic, physical, environmental, visual, and social perspectives. However, the methodical site selection for tall buildings, especially when considering Transit-Oriented Development (TOD) theory and skyline theory, has not been frequently studied simultaneously. Table 1 presents a systematic review of key domestic and international research in this area, clarifying the conceptual evolution and the existing analytical methods, as well as establishing the position and innovation of the present research within this context.

**Table 1: Review of previous research on tall building site selection with emphasis on tod theory and skyline**

No.	Researcher (Year)	Main Focus	Key Findings	Direct Relevance to Present Research
1	Ali & Al-Kodmany, 2012	Examining the consequences of high-rise development at the urban scale	Unplanned high-rise development leads to congestion, traffic, and environmental problems.	Emphasizes the necessity of precise spatial planning in tall construction projects.
2	Azizi & Motevaseli, 2012	Impact of tall buildings on Mashhad's character and landscape	High-rises reduced legibility and visual harmony in the urban landscape.	Demonstrates the necessity of visual control and skyline proportion in urban development.
3	Anabestani et al., 2015	Using AHP and ANP methods for locating high-rises in Mashhad	Land slope and price are determining factors in site selection.	Provides a model for applying multi-criteria decision-making models, similar to the present research.
4	Kumar, 2018	Examining the role of TOD in sustainable urban development	TOD is a tool for reducing car dependency and improving the quality of life.	Provides a theoretical support for the transit-oriented development approach in the present research.
5	Karimimoshaver & Winkemann, 2018	Analysis of skyline from aesthetic and semantic perspectives	The semantic dimension has the greatest effect on the perception of urban landscape quality.	Provides a theoretical basis for integrating visual components with spatial criteria.
6	Karimimoshaver et al., 2020	Locating high-rises using network and visual analysis	Visual components and height are the most important indicators in site selection.	Emphasizes the necessity of attention to perceptual dimensions alongside functional indicators.
7	Knowles et al., 2020	Analytical review of TOD theory in large cities	TOD facilitates balanced density, mixed-use, and sustainable mobility.	Theoretical support for the transit-oriented section of the present research.

No.	Researcher (Year)	Main Focus	Key Findings	Direct Relevance to Present Research
8	Tara et al., 2021	Examining the view obstruction and skyline distortion caused by towers	Surrounding density is more effective than height in view obstruction.	Confirms the importance of precise placement in tall building site selection.
9	Puspitasari, 2021	Visual analysis of towers in Jakarta using GIS	View density and distance between towers are key factors in landscape quality.	Provides a model for analyzing the visual impact of tall buildings in Hamedan.
10	Dervishi & Sadeghi, 2022	Analysis of high-rise development in Tabriz with a spatial justice approach	Towers led to traffic, shadowing, and violation of neighboring rights.	Demonstrates the necessity of principled site selection in dense Iranian fabrics.
11	Ahlfeldt & Barr, 2022	Economic analysis of tower construction in dense cities	Land price and market density are the main drivers of vertical development.	Strengthens the economic dimension in urban site selection models.
12	Al-Kodmany et al., 2022	Developing the TB-TOD model (combining high-rise development and TOD)	This combination resulted in reduced car dependency and increased land productivity.	Provides a theoretical foundation for integrating the TOD approach with high-rise development in the present research.
13	Shafiei Dastjerdi et al., 2022	Analysis of high-rise development in Hamedan	The rapid growth of towers has disrupted the landscape and transportation.	Provides a local empirical basis for the necessity of research in Hamedan.
14	Ibrahim et al., 2023	TOD site selection in Alexandria using GIS and SMCA	Areas with high potential for sustainable development were identified.	Confirms the efficiency of spatial analyses in evaluating tall building locations.

Based on the previous research review, existing studies can be categorized into three main themes:

1. **Studies with Physical and Functional Approaches:** In this category of research, the primary focus has been on quantitative and technical indicators, such as density, land price, slope, accessibility, and urban infrastructure. Although these studies play a crucial role in determining suitable zones for high-rise development, they have neglected the perceptual, visual, and identity-related dimensions of cities. Thus, many high-rise projects, despite their appropriate spatial locations, result in visual anomalies and reduced urban legibility.

2. **Studies with Aesthetic and Perceptual Approaches:** Another group of studies has focused on the visual and aesthetic impacts of tall buildings. These studies have examined the concept of “skyline” as an indicator of urban legibility and identity; however, they have often lacked analytical connection with functional indicators and land use. Thus, they have emphasized the “landscape” aspect of the issue without a clear answer to how to integrate these criteria into the site selection process.

3. **Studies with Integrated and Interdisciplinary**

**Approaches:** In recent years, some studies have attempted to integrate Transit-Oriented Development (TOD) approaches with high-rise development considerations. These investigations represent an important step toward the convergence of functional and visual domains; however, they have mostly studied cities that differ structurally and culturally from Iran’s historical cities, such as Hamedan. Therefore, their results cannot be directly adapted to local contexts. Synthesizing the above three themes reveals that:

- Most previous research has adopted a one-dimensional approach, focusing either on technical and economic variables or on visual and perceptual aspects.
- The integration of functional principles of Transit-Oriented Development (TOD) with visual and aesthetic considerations of the skyline constitutes a gap that has rarely been examined in existing literature.
- At the national level, research on tall building site selection has primarily been conducted in cities such as Mashhad, Tabriz, and Tehran, while the city of Hamedan, with its distinctive historical, cultural, and topographical characteristics, lacks an indigenous

model for guiding high-rise development location and management.

Therefore, the present research aims to fill this scientific gap by integrating two key perspectives, "TOD" and "skyline," within an analytical model for the city of Hamedan. This study is innovative not only methodologically (combining Analytic Hierarchy Process with spatial data) but also in its approach (simultaneous analysis of functional and visual dimensions), and can provide an indigenous and applicable model for other Iranian cities.

### 3. Materials and Methods

This research was designed based on the integration of the Analytic Hierarchy Process (AHP) multi-criteria decision-making method and spatial multi-criteria analysis within a Geographic Information System environment (AHP-GIS) to determine the relative weights of criteria from experts' perspectives, conduct spatial assessment, and generate suitability maps for tall building site selection in Hamedan. The research process consisted of three main stages:

1. Identifying criteria and extracting their weights using the AHP method based on questionnaire items and expert judgment;
2. Preparing and preprocessing spatial layers corresponding to each criterion and normalizing them in the GIS environment;
3. Weighted overlay of normalized layers to produce the final suitability map, and conducting sensitivity analysis and validation.

#### 3.1. Criteria Identification and Expert Population

In the first step, based on library studies and preliminary investigations, effective criteria for tall building site selection were identified. These criteria were classified into two main groups: criteria related to Transit-Oriented Development (TOD) theory, including access and accessibility, cycling and walking capability, parking availability, mixed-use development, and proximity to public transportation networks; and criteria related to skyline theory, including view,

diversity in form and appearance, and height. These indicators were selected based on the theoretical principles of TOD and skyline theory, as well as using previous studies on high-rise development.

In the second stage, a questionnaire with 20 items was designed for data collection. The number of questionnaires was determined to ensure diverse perspectives, manage data optimally, reduce time and resource constraints, and improve precision in information gathering. These 20 items covered criteria related to two main axes: Transit-Oriented Development (TOD) and skyline theory. The expert population for this research consisted of 12 specialists from urban planning, architecture, and urban design fields who were selected based on purposeful sampling and their related experience in urban development projects in Hamedan. The professional experiences of these individuals ranged from 10 to 25 years. The expert population sampling was conducted using the Delphi method based on expert judgment. Evaluation and pairwise comparisons of criteria by experts were performed using a 9-point scale, and the data were processed in Expert Choice software to extract final weights (all pairwise comparisons had an inconsistency ratio of less than 0.10).

#### 3.2. Study Area and Alternatives

The analysis specifically focused on three neighborhoods in Hamedan: Beheshti Township, Golan neighborhood, and Haji neighborhood. These three neighborhoods were selected based on two key criteria:

1. Differences in physical and historical characteristics (new versus old fabric);
2. Level of access to public transportation networks and urban infrastructure.

The hierarchical structure of research criteria and sub-criteria, which serves as the basis of AHP analysis, is illustrated in Figure 1. In the next step, the weighting results derived from this structure were used in the integrated AHP-GIS model to complete the spatial analysis of tall building site selection in Hamedan.

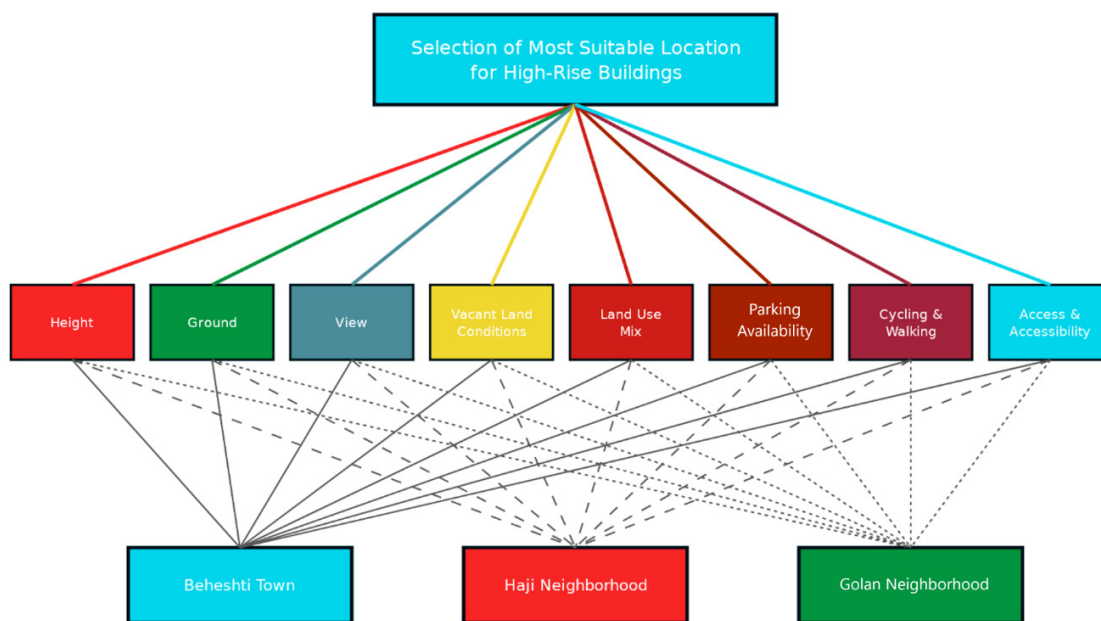


Figure 1. Hierarchical structure of the research criteria

### 3.3. Application of the Integrated AHP–GIS Model in High-Rise Building Site Selection

To enhance the spatial validity of the analysis, the criteria weights extracted from AHP (via Expert Choice) were applied to their corresponding spatial layers within a GIS environment. The process was executed as follows:

1. Data Collection: Spatial data were extracted from open sources (OpenStreetMap) for the road network, service points, land use, and transport stations. DEM data for calculating views and topography were sourced from SRTM/ALOS. The urban boundary was obtained from OSM/Master Plan references.
2. Raster Conversion and Overlay: All vector layers were converted to rasters with a uniform resolution (30x30 meters) to ensure weighted additivity.
3. Defining Suitability Direction and Normalization: Each layer was linearly normalized based on its suitability direction (higher-is-better or lower-is-better) to scale each pixel's value to the range [0, 1]. For the "less better" criteria (e.g., distance to a station), the distance was first calculated, then the value was inverted and normalized.

Linear Normalization Formula:

$$\frac{R_{min} - R}{R_{min,max} - R} = R_{norm} \quad \text{Positive Criteria}$$

$$R - R_{max} = R' \quad \text{Negative Criteria}$$

4. Applying Weights and Weighted Summation: The weights extracted from AHP were applied to the

normalized layers, and a weighted sum was calculated:

$$R_{i,norm}(x,y) \times w_i \sum_{i=1}^n = Suitability(x,y)$$

If the analysis for the TOD and Skyline groups were performed separately, group suitability would first be calculated and then combined with the final group weights:

$$Suitability_{skyline} \times W_{skyline} + Suitability_{TOD} \times W_{TOD} = Suitability_{final}$$

5. Classification and Priority Extraction: The final suitability map was classified using the Jenks Natural Breaks method into qualitative intervals (Very High, High, Medium, Low, and Very Low). The three zones with the highest frequency and area in the "High" and "Very High" classes were reported as proposed priorities.

6. Sensitivity Analysis and Validation: To verify the validity of the results, a sensitivity analysis was conducted by adjusting the weights of key criteria by  $\pm 10\%$  and  $\pm 20\%$  and observing the impact on the ranking of the areas. Additionally, a correlation comparison was performed between the non-spatial AHP results and the mean suitability values calculated for each zone using Spearman's rank correlation coefficient (Spearman's rho).

### 3.4. Tools and Software

Spatial processing and map production were conducted using QGIS (version 3.x), along with GDAL/OGR tools and various related plugins. Numerical processing and scripting were performed in Python,

using the rasterio, numpy, and geopandas libraries. Furthermore, AHP calculations and weight extraction were executed using Expert Choice.

### 3.5. Case Study Description

Hamedan is the fourteenth most populous and twenty-third largest province in the country. It is located between 33°59' and 35°48' North latitude and 47°34' and 49°36' East longitude, comprising 10 counties, 25 districts, 30 cities, 73 rural districts, and 1210 villages. The city of Hamedan, situated on the north and east-facing slopes of the Alvand Mountains, has dense soils and relatively high humidity. Hamedan is the oldest city in Iran and one of the most ancient in the world. Figure 2 shows the location of Hamedan city (Statistical Center of Iran, 2011).

In this article, three areas of Haji, Golan, and Beheshti Town are examined as priority options for the construction of high-rise buildings. These areas, due to their geographical features and historical background, have high potential for implementing Transit-Oriented

Development (TOD) principles. Geographically, these zones are located at a lower elevation than their surrounding areas. This feature gives them a prominent status in terms of urban views and landscape, making them the points with desirable prospects of the skyline and city profile. Such a feature is crucial in the siting and design of towers, as it can not only enhance residents' quality of life but also mitigate problems like shadowing and unwanted visual intrusion. In addition to these advantages, the Golan and Haji areas are recognized as historical fabrics of Hamedan and hold a special place in the city's social and economic structure due to their proximity to the traditional bazaar. With a valuable cultural and historical heritage, these areas require extra attention in the urban development process. Applying TOD principles in these fabrics not only helps preserve their historical and cultural identity but also paves the way for improved accessibility, enhanced urban dynamism, and better quality of life for residents. Figure 2 displays the location of these three areas within the urban structure of Hamedan.

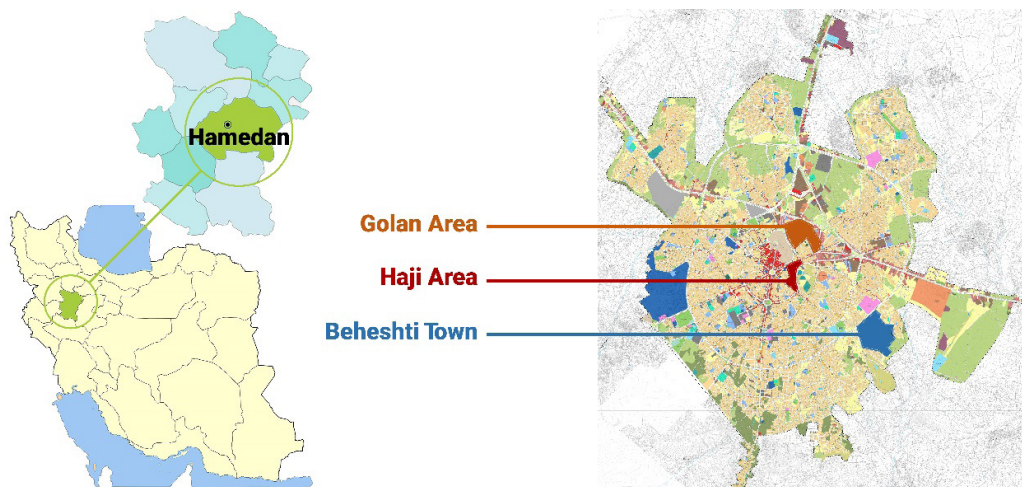


Figure 2: Study area

## 4. Findings

The research findings indicate that the study areas are prioritized not only based on physical and functional indicators but also on visual and perceptual factors. Consequently, decision-making regarding the location of tall buildings requires a simultaneous understanding of spatial efficiency (such as access and land-use mix) and visual quality (such as view and height). Thus, combining the results of the two approaches, TOD and skyline, provides urban planners with a comprehensive picture of each neighborhood's capabilities.

### 4.1. Analysis of Hierarchical Results (AHP)

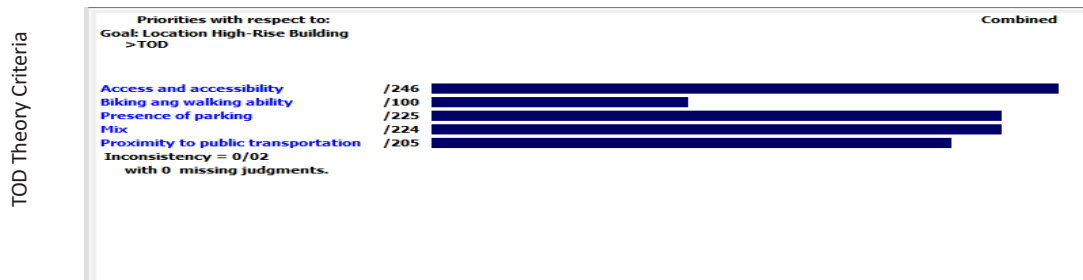
Considering the selected criteria from the two approaches of Transit-Oriented Development (TOD) and skyline theory, the Analytic Hierarchy Process (AHP) enables a precise comparison and weighting of the indicators. The results from this analysis serve as a basis for identifying the relative importance of each criterion and prioritizing the study areas in Hamedan. In this stage, in addition to determining the weight of each indicator, the contribution of each selected area to achieving the desired model of high-rise

development is examined. The following table provides as the starting point for a detailed analysis of the a summary of the weights and ranking of the criteria, findings.

**Table 2: Summary of weighting and prioritization of site selection criteria for tall buildings in hamedan based on ahp**

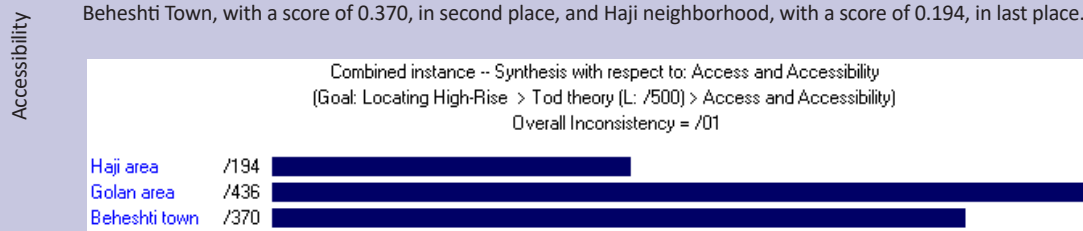
Indicator	Description and Figure
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In Figure 3, the importance of each criterion from the TOD theory perspective is obtained using Expert Choice software. The weight of each criterion indicates its importance in the decision-making process.



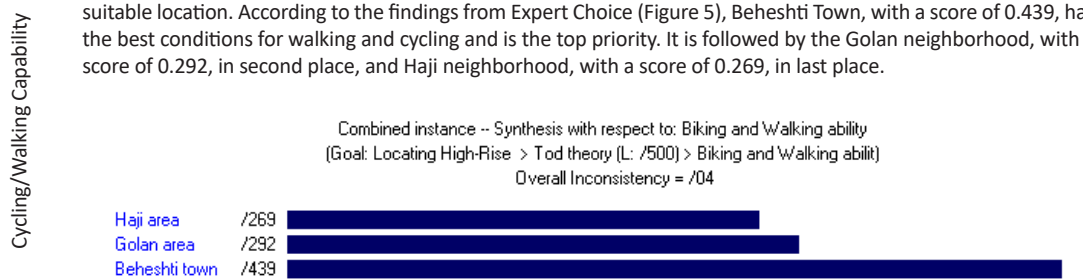
**Figure 3: Prioritization of tod criteria for siting tall buildings**

The AHP results show that the weight of this criterion is 0.246, the highest value among the TOD indicators, emphasizing its vital importance for the success of high-rise projects. This suggests that considering access quality in planning and design can play a significant role in enhancing urban quality of life and achieving sustainable development. According to data extracted from Expert Choice (Figure 4), among the three neighborhoods studied, the Golan neighborhood, with a score of 0.436, ranks highest in terms of access and is the top priority. It is followed by Beheshti Town, with a score of 0.370, in second place, and Haji neighborhood, with a score of 0.194, in last place.



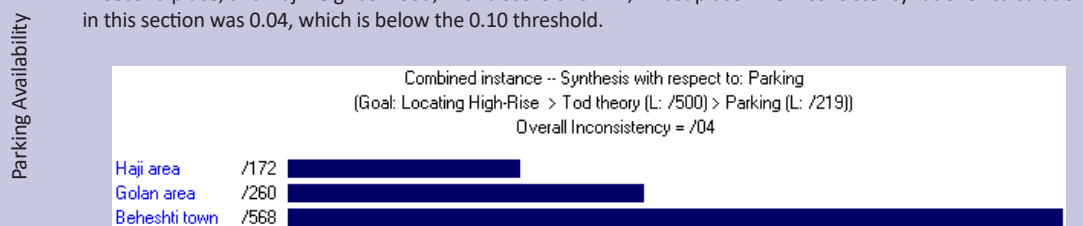
**Figure 4: Prioritization of areas based on accessibility criterion**

The AHP results show that the weight of this criterion in the overall model is 0.100, indicating its relatively less importance compared to other TOD indicators; however, even this small contribution can be decisive in selecting a suitable location. According to the findings from Expert Choice (Figure 5), Beheshti Town, with a score of 0.439, has the best conditions for walking and cycling and is the top priority. It is followed by the Golan neighborhood, with a score of 0.292, in second place, and Haji neighborhood, with a score of 0.269, in last place.



**Figure 5: Prioritization of areas based on cycling and walking capability criterion**

The AHP findings reveal that among the options considered, Beheshti Town, with a score of 0.568, has the highest priority in terms of parking capacity and potential. It is followed by the Golan neighborhood, with a score of 0.260, in second place, and Haji neighborhood, with a score of 0.172, in last place. The inconsistency ratio for calculations in this section was 0.04, which is below the 0.10 threshold.



**Figure 6: Prioritization of areas based on parking criterion**

Indicator Description and Figure

Land-Use Mix

The AHP results indicate that among the options studied, the Golan neighborhood has the highest priority for land-use mix with a score of 0.436. It is followed by Haji neighborhood, with a score of 0.366, in second place, and Beheshti Town, with a score of 0.197, in last place. The inconsistency ratio for this section is reported as 0.02, which is well below the 0.10 threshold.

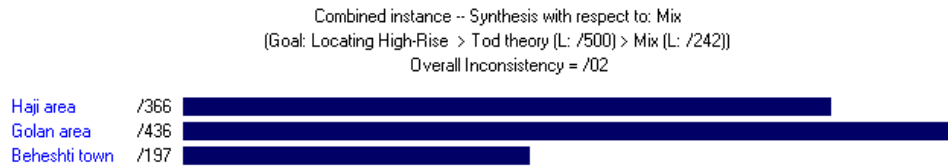


Figure 7: Prioritization of areas based on land-use mix criterion

Proximity to Public Transport

The AHP results show that among the options considered, Haji neighborhood has the highest priority for proximity to public transport with a score of 0.371. It is followed by the Golan neighborhood, with a score of 0.331, in second place, and Beheshti Town, with a score of 0.298, in third place. The inconsistency ratio for this section is reported as close to zero, well below the 0.10 threshold.

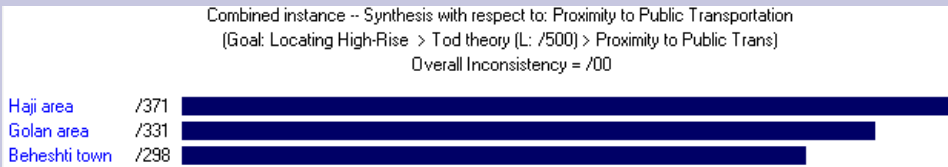


Figure 8: Prioritization of areas based on proximity to public transport criterion

The AHP results indicate that, among the indicators studied, View has the highest priority, with a score of 0.453. It is followed by Diversity in Form and Appearance, with a score of 0.344, in second place, and Height, with a score of 0.203, in third place. The inconsistency ratio for this section is reported as 0.00174, significantly lower than the 0.10 threshold.

Skyline Criteria



Figure 9: Prioritization of skyline criteria for siting tall buildings

View Criterion

The AHP results in this section indicate that, among the areas studied, Beheshti Town has the highest priority, with a score of 0.727. It is followed by the Golan neighborhood, with a score of 0.160, in second place, and finally, Haji neighborhood, with a score of 0.113, in third place. The inconsistency ratio for this section is calculated to be 0.04, which is below the 0.10 threshold.

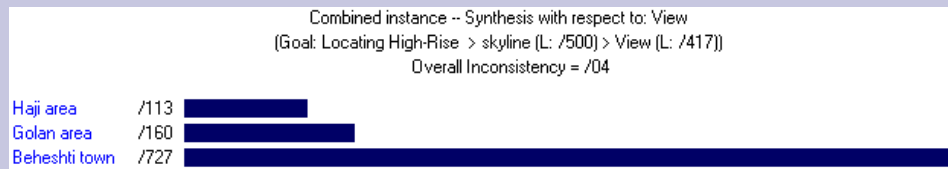


Figure 10: Prioritization of areas based on the view criterion

Indicator Description and Figure

Diversity in Form and Appearance Criterion

Beheshti Town has the highest priority in “Diversity in Form and Appearance” with a score of 0.350. It is followed by the Golan neighborhood, with a score of 0.330, in second place, and Haji neighborhood, with a score of 0.320, in the lowest rank. The inconsistency ratio for this section is reported as 0.00, which is much lower than the 0.10 threshold.

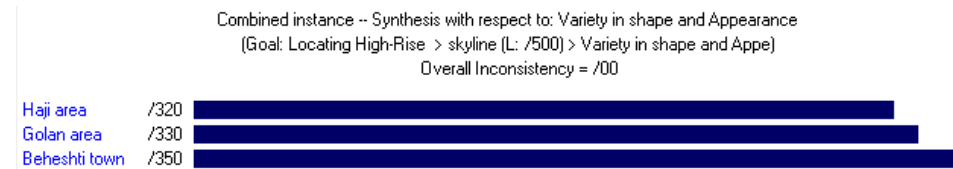


Figure 11: Prioritization of areas based on diversity in the form and appearance criterion

Height

Beheshti Town achieves the highest priority in the height indicator with a score of 0.666. It is followed by the Golan neighborhood, with a score of 0.169, in second place, and Haji neighborhood, with a score of 0.166, in third place. The inconsistency ratio for this section is 0.00, indicating perfect consistency in the experts’ judgments in this comparison.

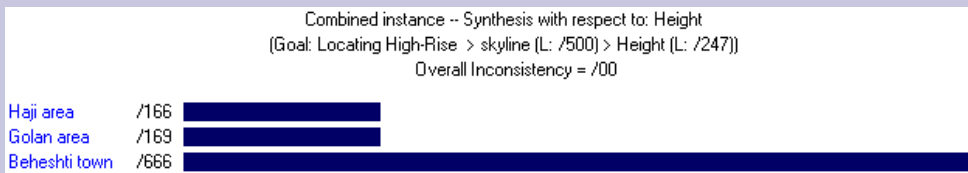


Figure 12: Prioritization of areas based on height criterion

Prioritization of Areas

The three study areas, including Haji neighborhood, Golan neighborhood, and Beheshti Town, are compared based on these two integrated approaches. The results show that Beheshti Town has the highest priority with a score of 0.431. It is followed by the Golan neighborhood, with a score of 0.310, in second place, and finally, Haji neighborhood, with a score of 0.258, in the lowest rank. The inconsistency ratio for this section is reported as 0.01, which is below the 0.10 threshold.



Figure 13: Prioritization of areas based on skyline theory and TOD for siting tall buildings

The analysis results show that Beheshti Town is at the top of the locational priorities due to its favorable access to transportation networks, presence of open lands, and potential for physical development. This finding aligns with the principles of TOD theory, as concentrating development in areas with balanced density and strong connections to public transport leads to reduced car dependency and enhanced urban dynamism (Kumar, 2018; Knowles et al., 2020). From a visual perspective, this neighborhood, due to its lower elevation than the surrounding heights and its good views of the city skyline, favorably meets the indicators of Skyline theory. This aligns with the findings of Karimimoshaver & Winkemann (2018) regarding the decisive role of the visual dimension in the quality of urban landscape. In contrast, although the historic fabrics of Golan and

Haji have significant scores in terms of land-use mix and proximity to public transport, their physical limitations, the age of the fabric, and high population density reduce the possibility of physical intervention. Therefore, any high-rise development in these areas must be accompanied by an urban regeneration approach, respect for neighborhood rights, and preservation of historical identity. A comparative analysis of the findings reveals that functional and visual variables mutually influence locational decision-making; thus, a sole focus on technical indicators (such as access or parking) without attention to visual quality can decrease the skyline harmony and landscape legibility. This result is consistent with the research of Al-Kodmany et al. (2022) and Tara et al. (2021), which emphasizes the necessity of integrating quantitative and perceptual

analyses in locational decision-making. Therefore, the findings of the present research, while confirming the hypothesis of integrating the TOD and Skyline theories, emphasize the importance of a multi-dimensional analysis for locating tall buildings in historical cities like Hamedan, where the balance between physical development and spatial identity guarantees the sustainability and legibility of the urban image.

#### 4.2. Spatial and Integrated Analysis (AHP-GIS)

To enhance the accuracy and spatial interpretability of results derived from the Analytic Hierarchy Process (AHP), the Geographic Information System (GIS) was used for the integration and spatial analysis of data. This methodological combination, while overcoming the limitations of purely numerical analysis, provides the means for spatial display and evaluation of locational priorities.

##### Preparation of Spatial Data

In this stage, all identified criteria in the two main groups of Transit-Oriented Development (TOD) theory and skyline theory were prepared as separate layers in the GIS environment. The layers for TOD criteria included access and accessibility, cycling and walking capability, parking availability, land-use mix, and proximity to the public transportation network. Spatial data for these indicators were collected from public sources, such as Hamedan's base maps, transportation network data, and field surveys, and were converted to a uniform raster format. In the second group of criteria, the skyline theory, layers for view and landscape, building heights, and diversity of urban form and appearance were generated in the GIS environment. The View layer was extracted from Viewshed Analysis based on a Digital Elevation Model (DEM) to identify areas with open views and suitable urban prospects. The height layer was obtained from building maps and data registered with the Hamedan municipality and was classified in a normalized range of 0 to 1. Finally, the diversity of form layer was calculated as a visual diversity index using the ratio of building surface area to volume and changes in physical rhythm in each area.

##### Normalization and Weighting of Layers

To co-scale the data, all layers were normalized to a range of 0 to 1, with higher values indicating greater suitability for the placement of high-rise buildings. The weight of each criterion was derived from the numerical AHP results calculated using Expert Choice

software and was assigned to the corresponding layer in the GIS environment. The final weighting was based on two main groups of criteria: TOD-related criteria accounted for 55% of the total weight, while skyline-related criteria accounted for 45%. This balance of weights reflects the importance of both functional and visual factors in locating high-rise buildings.

##### Layer Integration and Production of Final Suitability Map

After weighing the layers, the integration process was performed using the Weighted Overlay method in the ArcGIS environment. This method allows for the linear combination of normalized layers based on specified weights and is considered one of the most common Spatial Multi-Criteria Evaluation (SMCA) techniques. The output was the final Suitability Map, which shows the fitness level of each area in Hamedan for high-rise building development. The map was divided into five main classes: Very Low, Low, Medium, High, and Very High. Figure 13 displays the spatial distribution of suitability.

##### Analysis of Spatial Results

Based on the integrated map (Figure 13), the spatial distribution of suitability shows that large parts of Beheshti Town fall into the "High" and "Very High" classes; consequently, this area is identified as the most suitable location for high-rise building development. Following that, the Golan neighborhood, with a weight of 0.310, is in second place, and Haji neighborhood, with a weight of 0.258, is in third place. The obtained results are consistent with the numerical results from AHP and demonstrate that integrating the GIS has strengthened the validity of the numerical results and spatial transparency of the findings.

From the TOD theory perspective, Beheshti Town, with its proximity to major public transport axes, easy access to the road network, and potential for mixed-use development, has the highest capacity for accommodating high-rises. On the other hand, the historical fabric of Golan and Haji neighborhoods, due to physical constraints, narrow streets, and cultural and visual sensitivities, requires precise height control and adherence to urban landscape regulations. These findings suggest that integrating functional indicators (such as access and land-use mix) with visual indicators (such as diversity in form and appearance) can create a balance between efficiency and urban identity.

##### Sensitivity Analysis and Stability of Results

To evaluate the validity of the integrated model, a sensitivity analysis was performed with  $\pm 10$  and  $\pm 20\%$

changes in the weights of key criteria. The results showed that despite minor changes in local scores, the overall order of priorities remained unchanged, and Beheshti Town consistently maintained the highest level of suitability. This stability against changes in weights indicates the logical coherence and reliability of the spatial model. Furthermore, the overall Consistency Ratio (CR) in all comparisons was less than 0.1 (in the final integration, it was 0.01), which indicates high precision in the experts' judgments and the validity of the analysis process.

### Analytical Summary

Overall, integrating the AHP method with GIS could provide a practical tool for urban decision-making while enhancing the accuracy and interpretability of the results. The spatial results indicate that high-rises should not be located solely based on economic or physical indicators; rather, the principles of Transit-Oriented Development (TOD) and Skyline Theory should be considered simultaneously. The findings of this section can assist Hamedan's urban managers in formulating sustainable development policies, controlling density, managing the urban landscape, and preserving the historical identity.

## 5. Discussion

In this research, suitable locations for constructing high-rise buildings in Hamedan were prioritized, combining two theoretical frameworks: Transit-Oriented Development (TOD) and Skyline Theory. The main objective was to identify effective indicators for creating a balance between functional efficiency and visual quality in the city's vertical developments. The results from the Analytic Hierarchy Process (AHP) showed that among the criteria examined, variables related to TOD theory, such as accessibility, land-use mix, and parking availability, had the largest share in determining optimal locations for high-rise construction. In contrast, criteria related to skyline theory, such as view, diversity of form, and height, played a more significant role in assessing the urban landscape and visual harmony.

As shown in Figure 3, the criterion of access and accessibility (with a weight of 0.246) holds the highest importance among the evaluation indicators, signifying that direct access to the public transport network and major urban routes is the most crucial prerequisite for siting high-rise buildings. This is consistent with the principles of TOD theory, as the greater the residents' access to public transportation, urban services, and

pedestrian paths, the lower the dependency on private cars, thereby strengthening environmental sustainability and the efficiency of urban transportation.

The two criteria of parking availability (0.225) and land-use mix (0.224) are ranked second in importance, with nearly identical weights. Parking availability is effective in reducing congestion, organizing traffic flow, and enhancing urban environmental quality. Conversely, land-use mix, by consolidating residential, commercial, and service activities within one zone, leads to reducing unnecessary trips, increasing social interactions, and enhancing urban dynamism, which is a cornerstone of sustainable development in TOD theory.

Proximity to public transport stations (0.205) is also significant, emphasizing that mere public access to the transport network is insufficient; rather, a short physical distance and direct connection to main stations play a decisive role in the success of high-rise projects. This criterion represents the operational dimension of the "accessibility" indicator and is referred to as a "location-based criterion" in TOD literature.

The lowest weight of walkability and cyclability (0.100) reflects the actual conditions in Hamedan, where pedestrian- and bicycle-oriented infrastructure is not yet well-developed, and the culture of using these modes of transport is at a lower level. This indicates that although pedestrian-centric design is a fundamental principle in the theoretical framework of TOD, in the local context of Hamedan, physical and behavioral limitations have hindered its full realization. Overall, the analysis of the results indicates that the weighting of criteria in Hamedan is more influenced by the current state of infrastructure and citizen behavior patterns than by the universal principles of TOD. In the following, the main criteria of these theories are analyzed and evaluated separately to explain how they influence the siting of high-rise buildings.

### 5.1. Accessibility

Access to public transport stations and other urban services is considered the primary factor in the siting of high-rise buildings. According to the findings from the combined AHP and GIS analyses, the Golan neighborhood scored highest due to its proximity to the public transportation network, connected street structure, and quick access to service centers. In contrast, the Haji neighborhood performed the

weakest due to its dense fabric, narrow streets, and greater distance to transport stations. These differences suggest that access to transport infrastructure is not only a functional criterion but also contributes to the quality of urban life and the realization of TOD principles. Indeed, the easier the access and the more cohesive the network connections, the lower the dependency on private cars and the greater the socio-economic dynamism in the area. Therefore, in Hamedan's urban policy-making, developing public transport axes adjacent to developable fabrics, such as the Golan, should be prioritized to enable the optimal placement of high-rise buildings.

### 5.2. Cyclability/Walkability

The results show that although the "walkability and cyclability" criterion has a lower weight compared to other TOD indicators, it plays a fundamental role in achieving urban sustainability and enhancing environmental quality. The combination of AHP data and GIS maps indicates that Beheshti Town has the greatest potential for complying with TOD principles due to its more regular network of local streets and the possibility of upgrading pedestrian-oriented infrastructure. In contrast, historical neighborhoods, such as the Golan and Haji, show weaker performance due to physical constraints and the lack of safe cycling paths. These results suggest that in Hamedan, pedestrian- and bicycle-centric approaches have not yet been institutionalized as key variables of urban development. Therefore, urban planners should consider the development of pedestrian networks and safe cycling routes as part of long-term TOD policies, so that high-rise developments can take shape in a human-centered and sustainable context.

### 5.3. Existence of Parking

According to the findings, Beheshti Town performs better in terms of capacity for creating structured and underground parking. This advantage is due to its more open physical layout and lower overall density. In contrast, the Golan and Haji neighborhoods face limitations in developing parking infrastructure due to the high density, narrow streets, and a compact historical fabric. Nevertheless, the results indicate that, although the parking criterion is secondary in TOD theory, it remains crucial in medium-sized cities like Hamedan because of car-dependent travel patterns. Therefore, it is recommended that future

high-rise projects incorporate smart parking management solutions such as shared multi-story garages, smart reservation systems, and underground spaces to meet functional needs while adhering to urban sustainability principles.

### 5.4. Land-Use Mix

Land-use mix is a key pillar of TOD theory that helps improve urban dynamism and reduce unnecessary trips. The analysis suggests that the Golan neighborhood, with a higher score, is most aligned with land-use mix principles due to its proximity to the traditional bazaar, the presence of diverse commercial and service activities, and high population density. The Haji neighborhood, with a similar but more limited structure, ranks second, and Beheshti Town, due to its predominantly residential nature, stands in third place. From an analytical perspective, these findings indicate the challenge of misalignment between high-rise policies and single-use patterns in some new areas of the city. To align high-rise projects with the TOD approach, "Guided Mixed-Use" policies should be applied in zones like Beheshti Town to enhance complementary commercial and service activities at the local scale while maintaining demographic balance.

### 5.5. Proximity to Public Transport

Proximity to the public transportation network, both spatially and functionally, is one of the key indicators in siting the high-rise buildings. The results show that the Haji neighborhood scored highest due to its more direct access to bus and taxi stations, as well as its proximity to the city's arterial routes. The Golan neighborhood also ranks second due to its acceptable access to the transportation network, while Beheshti Town ranks third due to its distance from main stations. These findings highlight that locating tall buildings adjacent to transport stations can reduce traffic pressure, increase the use of sustainable transportation modes, and enhance urban connectivity. Therefore, high-rise development should be planned simultaneously with the strengthening of the public transport network to maintain a balance between physical density and urban mobility capacity.

### 5.6. Skyline Criteria

In the realm of skyline assessment, three main criteria, "View," "Height," and "Diversity in Form and Appearance," were identified as determining factors. The integrated analysis reveals that the view indicator

carries the most weight, as it directly impacts the legibility and beauty of the urban landscape. Following that, diversity in form and appearance ranks second, and height ranks third. This reflects a shift in approach from quantitative to qualitative high-rise development; that is, it is not just height that matters, but how the building interacts with the skyline. This finding is consistent with the theoretical foundations of skyline, emphasizing the necessity of visual harmony and avoiding clutter in urban profiles. Overall, integrating visual criteria with the functional indicators of TOD provides a basis for cohesive and identity-rich vertical developments.

### 5.7. View Criterion

The analysis of the view criterion indicates that Beheshti Town has the highest visual potential for the placement of high-rise buildings. Its topographical position, expansive views of natural landscapes, and adequate distance from historical zones contribute to minimizing any negative impact on the overall cityscape. In contrast, the Golan and Haji neighborhoods are considered lower priorities due to their proximity to historical fabrics and restricted sightlines. This finding highlights the importance of coordinated height planning in maintaining views of important landmarks while minimizing visual obstructions in both historical and natural landscapes. It is recommended that future designs incorporate view and landscape studies into the high-rise permitting process to maintain visual harmony in Hamedan's skyline.

### 5.8. Diversity in Form and Appearance Criterion

"Diversity in Form and Appearance" reflects the quality of architectural design and the harmony of volumes in the skyline. The findings show that Beheshti Town scored highest on this criterion due to its more open lands, recent renovations, and greater design freedom. The Golan neighborhood follows, with a slight difference, in second place, while the Haji neighborhood has the least diversity due to its historical fabric and limitations on form alteration. These results suggest that controlled diversity in facade designs and architectural forms can help increase visual legibility and prevent monotony in the skyline. Therefore, it is recommended that urban design regulations for new areas, such as Beheshti Town, be developed based on principles of "harmony in diversity" to strengthen the city's visual identity.

### 5.9. Height

The "height" is a key criterion in determining the physical capacity and spatial organization of a city. The analysis of combined data reveals that Beheshti Town has the highest potential for locating tall buildings concerning structural stability, distance from historical zones, and technical feasibility. The Golan and Haji neighborhoods follow with a small difference. The findings highlight that although height is an inherent characteristic of high-rise development, in the absence of visual and contextual considerations, it can lead to landscape clutter. Therefore, in urban development policies, height regulations must be formulated in proportion to the view capacity, landform, and urban infrastructure of each area to establish a balance between spatial efficiency and visual harmony.

### 5.10. Prioritization of Areas

The combination of the two theoretical frameworks, TOD and skyline, in this research has enabled a comprehensive assessment of suitable locations for high-rise development. The final AHP-GIS analysis results indicate that Beheshti Town ranks first with a weight of 0.431, followed by the Golan neighborhood, with a weight of 0.310, and then by the Haji neighborhood, with a weight of 0.258. This prioritization reflects the superiority of Beheshti Town in terms of physical capacity, favorable access, and potential for creating a cohesive skyline. At the same time, the Golan neighborhood is recommended for the next phase of development due to its commercial dynamism and suitable access. In contrast, Haji neighborhood is a lower-priority option due to physical and historical constraints. The integration of these two theories shows that achieving sustainable development is only possible with a balance between functional efficiency and visual quality. Therefore, it is proposed that Hamedan's urban planners use the combined TOD-Skyline model as a decision-making framework in future high-rise projects.

### 5.11. Implementation Challenges of the Combined TOD–Skyline Model in Hamedan

Although the results of this research showed that integrating the Transit-Oriented Development (TOD) theory and the skyline theory can provide a comprehensive framework for siting high-rise buildings in Hamedan, the practical implementation of this model in the city's real context faces several executive challenges. These challenges arise from institutional,

physical, social, and managerial dimensions and, if ignored, can prevent the achievement of sustainability goals and visual coherence for the city.

#### Institutional and Managerial Challenge

One of the most significant implementation barriers is the lack of coordination among urban planning, transportation, and architectural institutions. Currently, policies related to high-rise construction, urban transport regulations, and urban landscape considerations are formulated in separate institutions, lacking structural coherence. This results in decisions on siting and issuing building permits without a comprehensive assessment of transport capacity and visual impacts. Creating a coordinated mechanism among the municipality, the Department of Roads and Urban Development, and the Cultural Heritage Organization is one of the prerequisites for realizing the combined TOD-Skyline model.

#### Physical and Infrastructural Challenge

The historical and dense fabric of Hamedan's central neighborhoods, especially in the Golan and Haji areas, limits the implementation of some TOD indicators such as pedestrian-oriented networks, cycling paths, and structured parking. Additionally, in many neighborhoods, the road network fails to absorb the traffic generated by tall buildings. On the other hand, public transport infrastructure in some peripheral areas, such as Beheshti Town, has not yet reached a desirable level. Therefore, the development of this model requires a revision of detailed plans and an upgrade of urban infrastructure capacity, especially along axes with high-rise potential.

#### Economic and Investment Challenge

Developing TOD-based high-rise projects often requires significant investment in transportation infrastructure and the organization of public spaces. On the other hand, investors are more inclined to build in areas with quick economic returns, not necessarily in locations that are more desirable in terms of access or urban landscape. This mismatch between short-term economic interests and sustainable development goals is one of the main obstacles to realizing the proposed model. Creating financial incentives and supportive policies for investment in TOD priority areas can be an effective way to reduce this gap.

#### Cultural and Social Challenge

One of the key considerations in implementing the combined model is the social acceptance of high-rise construction in traditional fabrics. In neighborhoods like Haji and Golan, high-rise buildings can lead to

visual and identity conflicts with the historical fabric, provoking negative reactions from residents. In such situations, only a design that is in harmony with the skyline and respects the human scale can prevent social conflicts. Therefore, it is imperative to incorporate participatory processes and dialogue with the local community as part of urban policy-making in high-rise projects.

#### Supervisory and Urban Design Regulation Enforcement Challenge

Weakness in supervising the enforcement of design regulations and the lack of precise standards for controlling the urban landscape are other existing challenges. Height regulations in Hamedan's detailed plan are rarely based on view and landscape studies. The result is the emergence of buildings that sometimes distort the city's skyline. Therefore, developing design regulations based on visual and functional indicators and mandating landscape impact assessments before issuing building permits are executive necessities.

In summary, implementing the combined TOD-Skyline model in Hamedan necessitates an integrated and interdisciplinary approach that goes beyond traditional planning methods. Without reforming the institutional structure, upgrading transport infrastructure, public participation, and precise supervision of urban design, this model will remain merely a theoretical framework. Therefore, it is proposed that the Hamedan municipality, by creating a specialized working group for sustainable high-rise development composed of experts in urban design, transport, economics, and cultural heritage, should chart the executive path for realizing this model in future urban development plans.

## 6. Conclusion

The present research was conducted to identify optimal locations for high-rise buildings in Hamedan, based on the two theoretical frameworks of "Transit-Oriented Development (TOD)" and "Skyline Theory." In this study, the effective functional and visual criteria for the placement of high-rise buildings were identified and prioritized using the Analytic Hierarchy Process (AHP) method combined with spatial analysis (GIS). The findings showed that criteria related to accessibility, land-use mix, and proximity to public transport are the main pillars for realizing TOD principles and have the greatest impact on optimal siting. In contrast, criteria related to the skyline, such

as view, diversity of form, and height, play a decisive role in maintaining visual quality, landscape legibility, and physical harmony.

The final results from integrating two frameworks showed that Beheshti Town, with a weight of 0.431, is the most suitable area for sustainable high-rise development in Hamedan. This area includes superior conditions in terms of physical capacity, favorable access to urban networks, and the potential for design harmonious with the skyline. Following that, the Golan neighborhood, with a weight of 0.310, is ranked second due to its active historical and commercial fabric, as well as its central location. Haji neighborhood, with a weight of 0.258, is in the third priority due to physical limitations, dense fabric, and a lack of public transport infrastructure.

The significance of these results lies in showing that high-rise development, when integrated with TOD principles and skyline regulations, can shift from a physical threat into an effective tool for enhancing the quality of life, increasing urban sustainability, and preserving visual identity. Theoretically, this research contributes to the existing literature by clarifying the relationship between urban transport performance and landscape quality in locational decision-making. Practically, it can serve as a foundation for revising high-rise and urban design policies in cities with similar characteristics.

However, the present research also faced limitations. First, the lack of precise spatial and transport data at the neighborhood level in Hamedan led to analyses based on secondary data and expert estimates. Second, the limited number of participants in the AHP process (20 specialists) may not fully reflect the diversity of viewpoints. Additionally, due to the theoretical nature of the research, the economic and social dimensions of high-rise development were not scrutinized. It is suggested that future research intensify the spatial accuracy of analyses by applying real transportation data and multi-criteria modeling in a GIS environment, and that the economic and social dimensions of high-rise development be examined simultaneously.

In terms of policy-making, the results of this research can provide practical guidance for urban management in Hamedan and other similar cities in integrating high-rise policies with transport system and urban landscape regulations. It is recommended that:

1. The Hamedan municipality redefines high-priority zones in the detailed plan and develops special Urban Design Guidelines to control height, density, and

building form in these areas.

2. The urban transport organization facilitates the realization of TOD principles by developing bus networks and transit stations adjacent to areas with high-rise potential.

3. The architecture and urban planning commissions prevent skyline clutter by mandating visual and view impact assessments in the issuance of building permits.

4. Finally, by creating a specialized working group for sustainable high-rise development composed of experts in urban design, transport, urban economics, and cultural heritage, the executive path for realizing the combined TOD-Skyline model can be charted in future urban development policies.

For future research, it is also recommended that studies utilize more advanced models, such as (MCDM-GIS), (Fuzzy-AHP), and (Machine Learning-GIS), for spatial analysis and simulate different vertical development scenarios over a long-term horizon. Also, examining the socio-cultural impacts of high-rise development on citizens' perception of landscape and urban identity can open a new horizon in sustainable urban planning.

Overall, this research showed that an integrated view of high-rise development can not only optimize urban performance but also align with strengthening the visual profile, identity, and sustainability of the city. This approach can serve as a model for other Iranian cities seeking a balance between vertical development and preserving their identity and cultural structure.

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