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Study and Analysis of Lands for Physical Development of Coastal Cities Based on Geotechnical Criteria (Case Study: Bandar Abbas)

A. Khatibi[1], M. Amiri[2]*, M. Faghihi[3]

[1] Faculty of Engineering, Islamic Azad University of Qeshm Branch, Qeshm Island, Iran.
[2] Faculty of Engineering, University of Hormozgan, Bandar Abbas, Iran.
[3] Research Center of Islamic legislative Assembly, Tehran, Iran.

ABSTRACT: Determining suitable lands for urban development is one of the most important and complex decisions of city managers. The main approach of the present study is to determine suitable lands for the physical development of Bandar Abbas, to achieve which, one of the effective components including geological criteria (6 sub criteria), geotechnical (13 sub criteria) and environmental (4 sub criteria) Was used. ANP method was used to weight the criteria. After creating the information layers, fuzzy operators AND, OR, SUM, Product, gamma 0.9, gamma 0.7, and gamma 0.5 were used to superimpose the criteria. OLS was used to select the best operator to show suitable lands for urban development and the clustering of neighborhoods was done by K-mean method. The results showed that the weights of geotechnical, environmental, and geological criteria were 0.584, 0.280, and 0.135, respectively. The results of OLS showed that among the fuzzy operators, the SUM algebraic operator had the highest correlation with the research criteria and provided the best map for determining urban development lands. The results of K-mean method showed 4 clusters for urban development of Bandar Abbas. In the first cluster, 53.6% (30.5 km2) of the lands located in the eastern and northeastern regions of Bandar Abbas, are quite suitable for the physical development of the city. 30.7% (17.5 km2) of suitable land is located in the northwestern part; About 13.1 percent (7.5 km2) of unsuitable land and 2.4 percent (1.4 km2) of completely unsuitable lands. Therefore, the lands located in the east-northeast and then northwest are the most suitable lands for the construction and physical development of Bandar Abbas.

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1- Introduction

Coastal areas offer favorable conditions for human settlement, agriculture, tourism, industry, transportation, and communication on a global scale. These areas are dynamic ecological resources that support economic and social activities [1]. Currently, approximately 3.8 billion people reside within 200 kilometers of coastal lines, and projections indicate that this number will double by 2050 [2, 3]. Given the projected population growth and potential for socioeconomic development in coastal areas, it is crucial to identify suitable locations for the physical expansion of coastal cities [4, 5]. Therefore, managers and experts utilize various environmental and geographical factors to identify lands that are suitable for the development of coastal cities. Urban geology in coastal areas is one such parameter that influences the selection of lands for city construction and physical development [6]. Due to limited availability of suitable land, urban constructions in coastal areas often involve multistoried buildings and apartments, making it critical to consider geotechnical issues and soil structure [7]. Selecting lands with appropriate geotechnical and geological parameters can be challenging in coastal areas where the groundwater level is often high and the substrate soil has plasticity properties. Improper substrate and soil conditions in lands earmarked for urban development can lead to geotechnical hazards such as soil liquefaction, landslides, and subsidence, resulting in irreversible damage to urban infrastructure. Therefore, ensuring the safety of construction projects is of paramount importance for urban development, especially in coastal areas worldwide. Urban development without proper geotechnical studies can result in significant costs in the future. Therefore, geotechnical studies can provide a valuable model for urban planners to make informed decisions.

While most urban studies focus on barren lands, land value, and distance from environmental barriers for city development, this study also considers the vertical development of Bandar Abbas due to the environmental constraints on horizontal expansion. Therefore, this study aims to examine the geotechnical properties of lands suitable for urban development and propose an optimal growth trajectory for Bandar Abbas, taking into account the geotechnical aspects of construction and development of

*Corresponding author's email: amirii@hormozgan.ac.ir

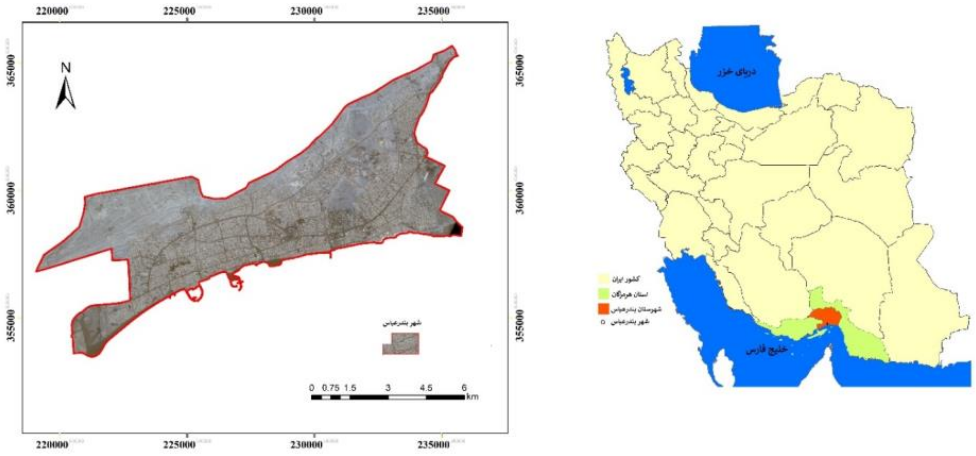

Fig. 1. The geographical situation of the studied area (Bandar Abbas)

technical structures.

2- Materials and methods

The geology of Bandar Abbas is characterized by the Aghajari formation, which consists of marl-silt sandstone rocks that have eroded in high areas and sedimented in low-lying areas, resulting in marl-sandy layers. Bandar Abbas is located in an area that is part of the central Iran region to the north, the high Zagros structural area to the west and northwest, the Zagros fold structural area to the east, the Mokran area to the southeast, and the Persian Gulf to the south.

The city of Bandar Abbas is situated on the northern latitude of 26° and 58 minutes and eastern longitude of 55° and 88 minutes from the Greenwich meridian. It has an urban area of approximately 5323.5 hectares according to the master plan. The southern and northern boundaries of Bandar Abbas are defined by the sea, serving as a natural and limiting edge from the south, and high heights that act as a natural barrier from the north. The average elevation of the city above sea level ranges from 0.6 to 4 meters.

Bandar Abbas is surrounded by natural features such as the sea to the south, high heights to the north, the airport and aerial station to the east, and naval facilities to the west. The city has seen significant growth due to its economic potential as an economic hub in Iran and increasing tourism, resulting in an influx of population. However, the geotechnical properties of the area, including the soft soil with clay and fine-grained sand on the Persian Gulf coast, the high depth of underground water, and the potential for liquefaction due to numerous faults, pose challenges for urban development and construction.

Considering the environmental limitations of horizontal development due to natural and man-made barriers, this study aims to evaluate the geotechnical properties of the lands suitable for urban development and select an optimal growth trajectory for Bandar Abbas, taking into account the construction and development of technical structures, as well as the potential for liquefaction and other geotechnical hazards.

3- Results and discussion

3- 1- Geological Criteria The geological

criterion consisted of six sub-criteria. Pearson correlation analysis revealed that geological formations had the highest correlation with other sub-criteria. This parameter was found to have a significant relationship with soil texture, depth of the earthquake, and slope of land. Additionally, a significant correlation (at a 99% confidence level) was observed between the depth of earthquakes that occurred in Bandar Abbas over the past 50 years and soil texture, geological formations, and faults (Table 1).

According to the results of the weighted criteria and sub-criteria based on ANP, the slope of lands and surface topography were found to be the most important factors in identifying suitable lands for urban development in Bandar Abbas, with weights of 0.357 and 0.284, respectively. The study revealed that urban construction is not feasible in areas where the subgrade slope is more than 10%. The increased slope in Bandar Abbas leads to higher land levels, making these high-height areas unsuitable for urban development. However, lands with a slope of 2-10% are deemed suitable for this purpose.

4- Conclusion

After conducting geotechnical studies using borehole drilling to assess soil and subgrade properties in subsurface layers, including soil density, granulation, liquefaction risk, and resistance against construction loads on foundations, the following results were obtained:

Four clusters for development were identified based on the results of the geotechnical studies.

The first cluster, located in the east and northeast of Bandar Abbas, comprises 53.6% (30.5 km^2) of land that is suitable for the city's physical development.

The second cluster, located in the northwest of the city,

Table 1. Correlation between geological sub-criteria based on Pearson correlation coefficient

	Soil texture	Geological formations	Fault	Depth of earthquake	Slope	Topography
Soil texture	1					
Geological formations	0.684**	1				
Fault	-0.003	0.068	1			
Depth of earthquake	0.472**	0.383**	-0.420**	1		
Slope	-0.263*	-0.334**	0.010	-0.146	1	
Topography	0.154	0.096	-0.010	0.029	-0.068	1

includes 30.7% (17.5 km^2) of suitable land.

Approximately 13.1% (7.5 km^2) of land was deemed improper for urban development.

Therefore, the lands in the east and northeast areas are identified as the most geotechnically suitable lands for the construction and physical development of Bandar Abbas City.

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