KPU International Journal of Engineering & Technology
Volume 4, Issue2, Sep. 2024
e-ISSN:2790-0819, p-ISSN:2790-0800

Date Received: 2024-07-13
Date Accepted: 2024-08-28
Date Published: 2024-09-30

Investigation and Development of Urban Green Space Using AHP Model and GIS Platform: Case of District 13th, Kabul City

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Abstract

Nowadays, one of the fundamental problems in cities, especially in third-world countries, is the lack of urban green spaces. Urban green space is one of the land uses its distribution and location within the city had a particular importance. One of the criteria for measuring and determining sustainable cities is the availability of a minimum per capita green space. The thirteenth District of Kabul City is one of the areas that does not have the appropriate distribution of green space, meaning that the amount of urban green space in this area is not comparable to its population. This article investigates, analyzes, and presents an appropriate pattern for the optimal distribution of urban green space in this district, considering factors such as population, communication network, existing green spaces, and lands with the potential to create urban green space at the district level. The research method was descriptive-analytical and data collection was based on library studies and field research. In this study, the combination of the Analytical Hierarchy Process (AHP) model and GIS has been used to find the best location for park construction.

Keywords: Urban green space, 13th district, Analytical Hierarchy Process (AHP) model, GIS Program.

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1. Introduction

Spatial planning policies in cities and the need for more housing have led to a reduction in people's access to green spaces [1]. Green space is a part of the physical extent of a city that can have specific functions [2]. With the increase in population and urban development, humans have gradually moved away from nature, and overpopulation, intervention in the natural environment, and the creation of man-made environments have increased the needs of human beings in terms of environmental, physical, and spiritual aspects. To meet these needs, urban residents have created gardens and artificial green spaces within cities [3]. Among these, green spaces play a fundamental role as an integral part of cities' unique structures in their metabolism and can have serious consequences if they are lacking [4]. Nowadays, the concept of cities without effective green spaces in various forms is no longer imaginable. The consequences of urban development and the complexities of their environmental problems have made the existence and expansion of green spaces inevitable for cities forever [5]. The importance of green spaces within cities is such that it is mentioned among the top 5 important urban uses. The importance of this use has increased significantly since the rapid and unprecedented expansion of urban uses after the Industrial Revolution [6]. Unfortunately, the creation and development of urban green spaces have always faced problems and shortages, including the lack of urban regulations and laws and the determination of standard green space per capita, which has led to the presentation of statistics ranging from 7 to 50 square meters per capita by various organizations. This is while unofficial statistics suggest a recommended green space per capita of around 9-8 square meters in our country, Afghanistan. The global standards for green spaces recommended by the United Nations are around 52-20 square meters per citizen [7].

In this study, using information obtained from books, articles, existing maps of the study area, and documents providing information about the study area, the thirteenth district of Kabul City has been examined in terms of having urban green spaces. Then, considering the current situation and using the Analytic Hierarchy Process (AHP) method, criteria for the area have been taken into account. Later, by combining these criteria with the GIS environment, the desired result, which is the development of urban green spaces in the thirteenth district of Kabul city, has been achieved.

2. Literature Review

In the field of site selection for the development of urban green spaces using a combination of the Analytic Hierarchy Process (AHP) model and GIS, limited research has been conducted in various countries. Some of the related cases that can be mentioned in this regard are:

In a study, the spatial variability of the availability of adequate sites for the development of urban green amenities in Noida city was examined. Multi-criteria assessment of potential locations has been accomplished using the Analytical Hierarchical Process coupled with geospatial technology. Urban land use, physiographic factors (slope and elevation), accessibility (proximity to roads), and presence of grey, green, and blue amenities (Normalized Difference Built-up Index, Normalized Difference Vegetation Index, and proximity to water bodies, respectively) are the seven key criteria used to

derive the final green space suitability map. A total of 46.47 % of the land was found to be in the category of highly and moderately suitable for greening the city, highlighting the potential of developing different forms of green spaces in the area. Such holistic city-scale analysis of the availability of potential sites for green space development can be utilized by the city administrators and urban planners for future land use planning and improving the distribution and spatial connectivity of the green spaces in the city with the common goals of better health, a cleaner environment, and climate change mitigation [8].

Another study presents a comprehensive assessment of urban green space (UGS) suitability in the Taif region of Saudi Arabia using a geographic information system (GIS) combined with a multiple-criteria decision-analysis-based analytic hierarchy process (AHP). The integration of various morphologic, topographic, climatic, and land use/land change (LULC) maps provided a robust framework for evaluating the suitability of UGSs. The Taif region demonstrated fair suitability for UGS development across 56.4% of its total area. However, large areas of barren land in the central and northeastern parts were rendered unsuitable for UGS development, while the southwestern part showed higher percentages of good and excellent suitability. This study highlights the importance of considering the visibility and awareness aspects of UGS planning, as it serves as a visual reminder of the value of nature in urban settings. The results obtained by this research may help managers and decision-makers with future planning for GI areas in the Taif region [9].

In Afghanistan, some research has been done about this issue. For example, research that was recently done in the fourth district of Kabul city, which has a population of 350,000 people, with a low per capita number of urban inner parks, and the reason for this is the increase in population, excessive growth of construction, and lack of proper management of urban inner parks. The purpose of this research is to analyze the spatial distribution of urban inner parks based on social justice, how to optimally distribute parks with an emphasis on sustainable development, and to provide a suitable and comprehensive model for locating this type of land use in other areas of Kabul. In this regard, after determining the influential indicators in the location of urban inner parks, weighting them using the AHP model and integrating the weighted indicators in the GIS environment has been done and suitable areas for the construction of new parks in the area of study were obtained [10].

In this research, similar to previous studies in this field, efforts have been made to investigate and understand the presence and distribution of urban green spaces in the thirteenth district of Kabul. Later, based on the current conditions and situation of this area, how to develop green spaces at the district level will be addressed.

3. The Value of Green Space

Green space is the foundation of a healthy population and economy in any city [11]. Urban green spaces and parks not only provide a suitable place for people to spend their leisure time and serve as recreational areas, but they also prevent many aspects of unbalanced and unplanned urban development. Nowadays, due to the carcinogenicity of the urban environment, the credibility and importance of urban green spaces and parks

have increased [12]. Studies have shown that many people use green spaces and parks most during stressful times, and these spaces have positive psychological and emotional effects on individuals [1].

Increasing green space has the potential to reduce the undesirable effects of urbanization and make cities more attractive for living [13]. The development of green spaces and the issue of easy access to them in deprived urban areas increase interactions and ultimately ensure urban sustainability. Providing green space near residential areas is referred to as a health policy in urban planning, as easy access and proximity to green space lead to a 25% increase in the health of citizens [14].

Allocating urban land to green space for recreation and nature experience improves the quality of life for citizens [15]. While in the past, green spaces were mainly limited to beautifying the environment, today their functions within cities have expanded significantly into three main categories: ecological, urban structural, and social-psychological functions [16].

3.1. Ecological Function of Green Space

This function primarily helps improve ecological conditions and reduce pollution. The most important impact of green spaces in cities is their ecological functions, which give meaning to cities as human ecological environments, counteracting the negative effects of technological expansion and improper use, and increasing the quality of life in cities [5]. Therefore, it is essential that green spaces are properly located in terms of climate and predominantly utilize trees and shrubs in their design [17].

Creating green space is one of the most effective ways to control environmental pollution, including air, water, and soil pollution, providing a healthier environment for humans. Therefore, abundant plant cover is considered one of the most suitable and effective methods for combating environmental pollution [18].

3.2. Urban Structural Function of Green Space

The urban structural division affects the function of urban green space, with various service uses integrated into different urban divisions such as neighborhoods and regions [19]. Green space is perceived as an integral part of the urban structural body, forming the construction or fabric of the city in harmony with the urban fabric division, taking on the role of city edge, spatial separation, and road network decoration [18].

3.3. Social-Psychological Function

Green spaces bring natural environments into the urban environment, transforming harsh and artificial city structures into soothing and invigorating environments. Green spaces establish a strong relationship between social members and the natural environment, making the city more habitable and tolerable. This is fundamental for a society that aims to be more sustainable. Therefore, the social effects of green space can be summarized as: 1. Better social interaction among citizens, 2. Socialization and leisure activities, 3. Dissemination of values and thoughts. In terms of psychological aspects, suitable green spaces in cities lead to physical well-being, mental tranquility, increased productivity, and improved quality of life [20].

4. Research Methodology

The research method used in this study is descriptive-analytical. Data collection was carried out in two forms: library and field research. In the first stage, available sources such as books, articles, theses, maps, and documents about the area under study were reviewed to gain a good understanding of the area and to obtain the criteria and regulations related to urban green spaces. After identifying the necessary aspects and criteria for the 13th district, the Analytical Hierarchy Process (AHP) was used to prioritize these criteria based on their importance. Then, these criteria were introduced into the Geographic Information System (GIS) to produce spatial maps for a better understanding of the area. Finally, using both AHP and GIS processes, efforts were made to identify the most suitable location for the optimal development of green spaces in this area. Finally, by visiting the appropriate site, the most suitable location in terms of position, area, and land use for urban space development in the 13th district was determined.

5. Study Area

5.1. Thirteenth district of Kabul City

The thirteenth district of Kabul City is one of the western districts of Kabul City, where more than 90% of the development and construction is unplanned and organic. This district has 13 Gozars (Neighborhoods), each with a maximum of 1000 households. The area of this district is approximately 46.6 square kilometers, with an estimated population of around 290,010 people [21].

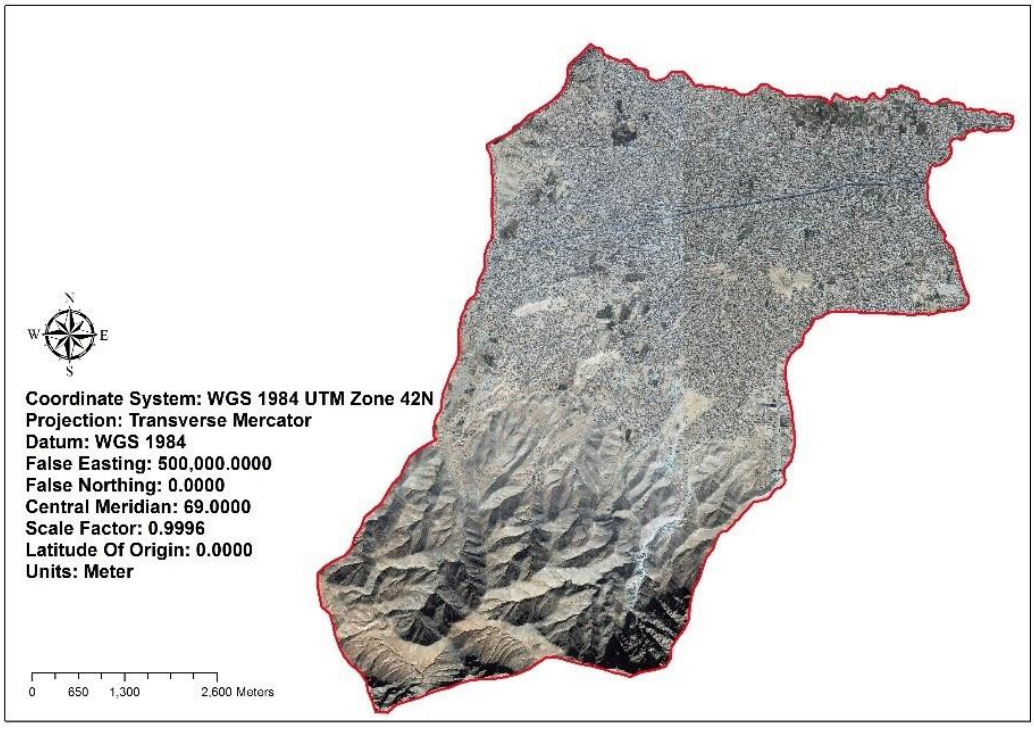


Fig. 1. Kabul City, 13th district

5-2. Land Use and Population Density in the 13th District of Kabul

The predominant land use in this district is residential, including high-rise, medium-rise, and low-rise housing categories. Additionally, there are commercial and mixed-use areas such as markets, companies, and salons in this district [21]. Furthermore, recreational, religious sites, parks, and green spaces are also present. The population density in this area is considered based on the figures within the framework of Kabul's urban design(KUDF), with a minimum population of 0-19 people and a maximum population of 265-373 people per section.

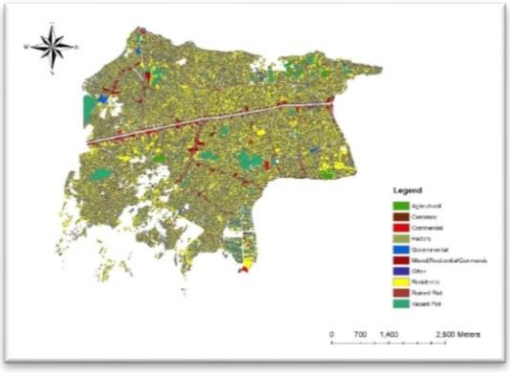


Fig. 2. Land use, 13th district

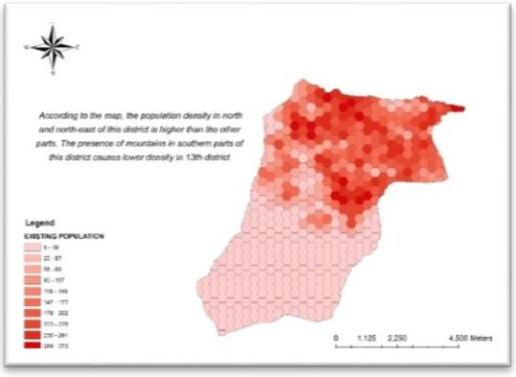


Fig. 3. Population Density, 13th district

5.3. Green Spaces in 13th District of Kabul

The Thirteenth District of Kabul City is one of the areas lacking recreational parks with the necessary facilities and equipment. There is a strong need for parks and public green spaces in this area. Currently, there are only two green areas, Tappeh Katah Belandi, and Koh-e Chihel Dukhtaran, with minimal tree planting, which have been recognized by the Kabul Municipality as parks.

Table 1. Kabul Municipality, Department of Greening, GIS office

No	Name	District	Area/m^2
1	Katah Belandi Hill	13th District	91939.7
2	Koh-e Chihel Dukhtaran	13th District	163379.7

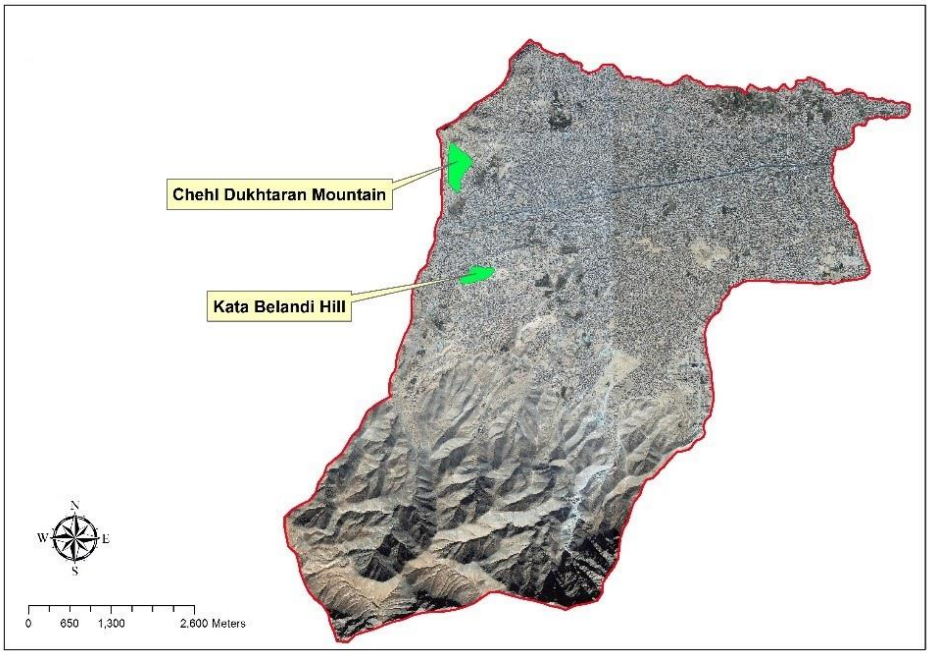


Fig. 4. 13th district green space (Authors)

Considering the population size, the area of green spaces, and the quality of green spaces in this district, there is a noticeable need for the construction of new parks with better recreational facilities and improved green spaces. Therefore, there is a need to identify new locations for park construction in the 13th district of Kabul City.

6. Spatial Distribution or Locating Urban Green Spaces

Parks and green spaces, as one of the important land uses that a significant population interacts with, allocate considerable levels of urban space to themselves. They face challenges such as shortages, inappropriate distribution according to population needs, lack of adjacency considerations, and some other challenges. Analyzing the spatial distribution of parks and urban green spaces, which play a role in the continuity of people's quality of life, is a complex and relatively closed process that requires greater attention during spatial planning.

The overall goal of this location analysis is to find the best site for constructing a park in the 13th district of Kabul City. To achieve this, the Geographic Information System (GIS) program and multi-criteria decision-making methods such as the Analytical Hierarchy Process (AHP) have been utilized.

For the precise and accurate execution of the location analysis process, criteria should be considered for guiding or determining the location selection process to identify the best site for construction. Four criteria have been considered for determining the best location for a park in the 13th district of Kabul City:

1. Distance from existing parks
2. Distance from corridors (economic corridors)
3. Terrain slope

4. Proximity to agricultural lands

Other criteria can also be considered for locating a park within a specific area, such as population density. However, since the thirteenth district of Kabul city has mostly grown in a non-planned manner, population density in this area is almost similar in all parts, with low to moderate population density in most areas. In addition, the fourth criterion considered, which is the proximity to agricultural lands, indicates that the location should be on lands with low population density or even zero population density. Therefore, there is no need to consider population density as a criterion because each area should be evaluated based on its specific conditions.

6.1. Distance from Existing Parks

The park location project is considered for areas deprived of recreational parks. Therefore, areas with access to parks are not included in the selected areas. Existing parks have been chosen as a criterion for locating new parks in the 13th district.

6.2. Distance from Economic Corridor

The economic corridors, or high-value economic corridors, usually host commercial activities and have high land prices. Therefore, building a park in these areas results in both economically costly and considered inappropriate use of space. Parks are recommended to be located in areas with lower land prices, making the economic corridor an important criterion in the site selection project.

6.3. Terrain Slope

Understanding the terrain in terms of slope and elevation is crucial in planning, especially when the area includes mountains and hills. Areas with steep slopes are not recommended for the construction of recreational parks. As the 13th district of Kabul city contains mountains, this criterion has been chosen as a condition in the site selection project. Therefore, all areas with a slope greater than 25% in this district are excluded from the selection.

6.4. Proximity to Agricultural Lands

As mentioned in the economic corridor criterion, the construction of a new park should incur the lowest possible cost. Therefore, the most suitable option is to build the park on agricultural lands, as they can be more easily converted to other land uses compared to other types of land.

7. Analytical Hierarchy Process (AHP)

The AHP method is one of the most practical decision-making tools for ranking a set of options based on multiple criteria. This method is based on pairwise comparisons and the most important aspect is to extract the weight of each criterion from a pairwise comparison matrix. As four criteria have been considered for site selection, AHP has been used to assign weights to each of these criteria.

Table 2. Analytical Hierarchy Process (Authors)

Criteria	Distance from Existence Parks	Distance from Corridor	Slope	Proximity to Agricultural Fields	Geo-Mean	Criteria's Weight	Percentage
Distance from Existence Parks	1	0.5	0.33	0.25	0.450	0.095	10%
Distance from Corridor	2	1	0.2	0.33	0.757	0.159	16%
Slope	3	2	1	0.5	1.346	0.277	28%
Proximity to Agricultural Fields	4	3	2	1	2.213	0.467	46%

8. Geographic Information System (GIS)

A model is a simplified representation of reality. In this regard, the ArcGIS software based on its Model Builder environment provides a suitable visual platform for various spatial modeling. This modeling, based on graphical representation, can be easily done in the Model Builder environment without the need to learn the relevant programming language. Through the use of available commands and tools, models can be easily created, edited, and managed in this environment. Furthermore, Model Builder can be introduced as a visual programming language for various spatial modeling tasks. In other words, Model Builder has a visual programming language for creating relationships between commands in geospatial processes. Geospatial processing models document spatial analysis and data management processes [22].

Here, Model Builder has been used to execute a location-allocation project, which is shown in the diagram below.

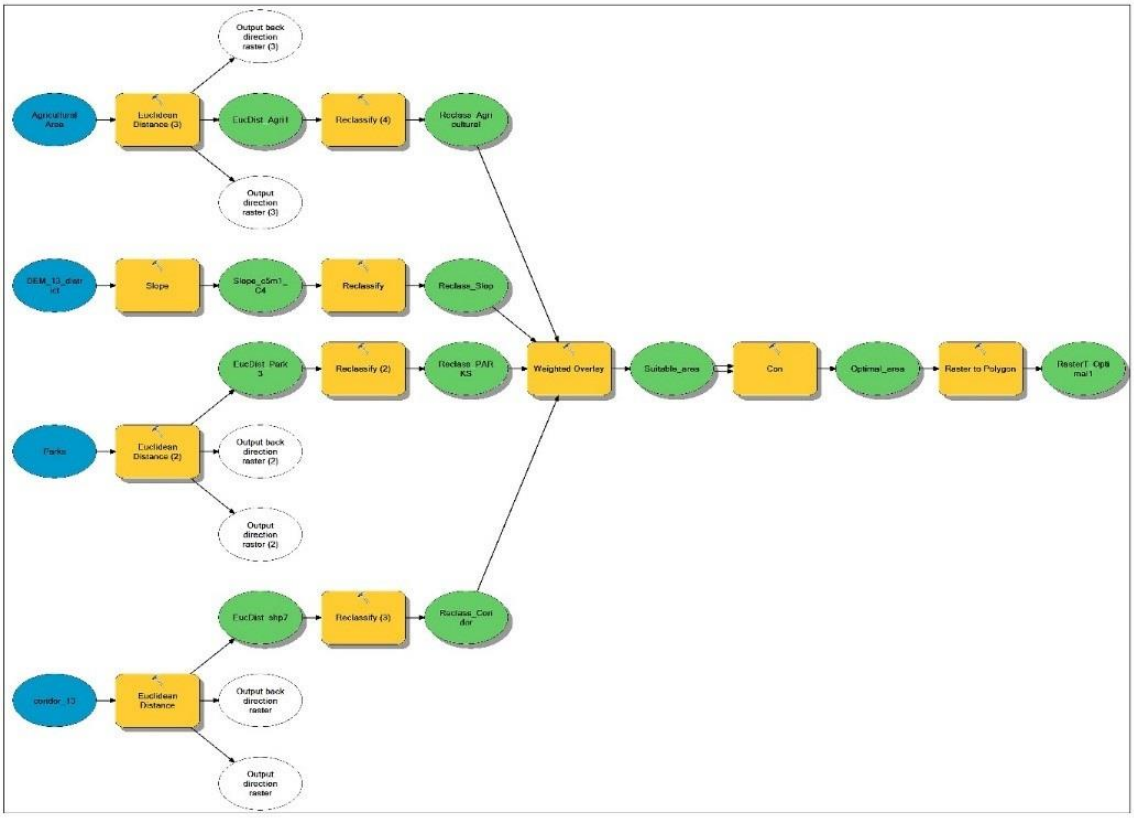


Fig. 5. Model Builder Diagram (Authors)

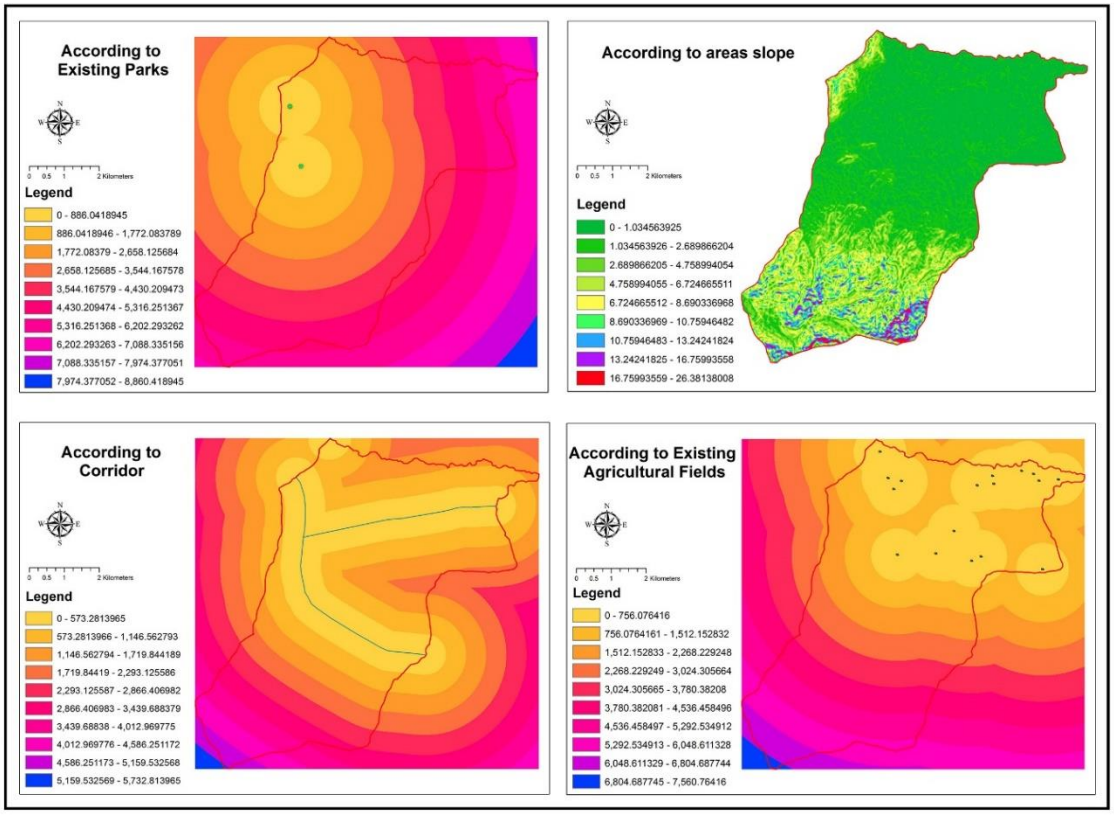


Fig. 6. Integration of AHP results with GIS environment and the obtained maps from each criterion (Authors)

9. Integration of (AHP) Results with GIS Environment

After determining the weight of each criterion, the criteria are introduced to the GIS environment in Model Builder so that analysis and maps of these criteria can also be obtained in the GIS environment.

Once all criteria have been determined, we divide the criteria into different classes or categories. If we divide the areas into nine classes, each class has a specific importance and value that can be considered as weighting or valuing each criterion. This process determines the value of areas based on different criteria, meaning it determines the importance of areas based on their distance from or proximity to the existing criteria.

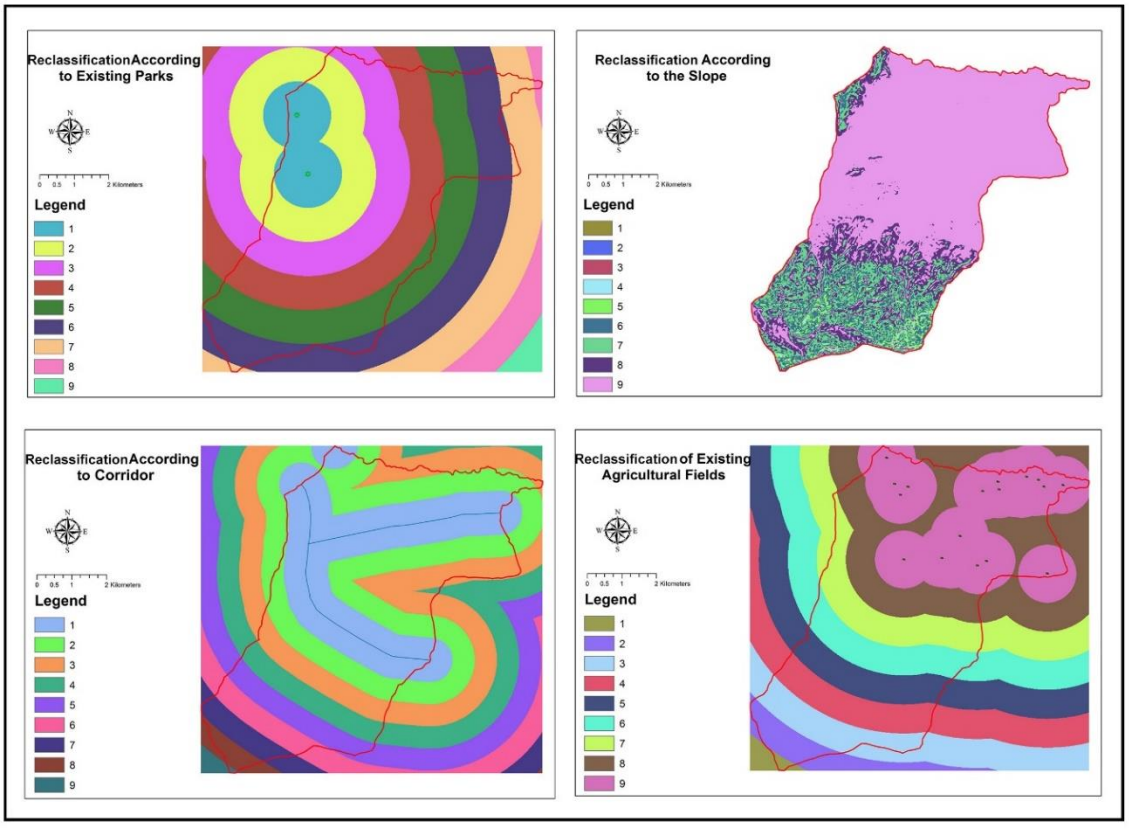


Fig. 7. Reclassification of each criterion to indicate the value of the lands for each of them (Authors)

After all criteria have standardized weights, precise location allocation is still not achieved. Therefore, the next step is to use a Weighted Overlay. In this step, all criteria are overlaid on top of each other and combined.

The criteria are considered individually and the most suitable site for the construction of a recreational park is identified.

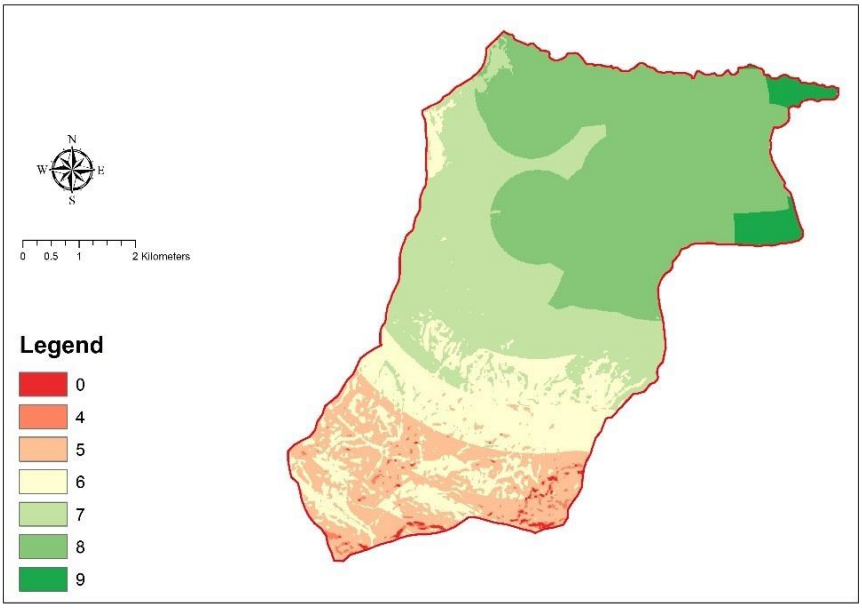


Fig. 8. Finding suitable areas for parks according to all criteria (Authors)

In the above plan, the best areas for constructing a Park are indicated with dark green, which held the value of nine according to standardized weights. However, our data is in raster format and cannot be displayed on an aerial image of the desired area. Therefore, it should be converted to the vector data. To do this, in the GIS environment, the "Raster to Polygon" option converts the raster data to vector data.

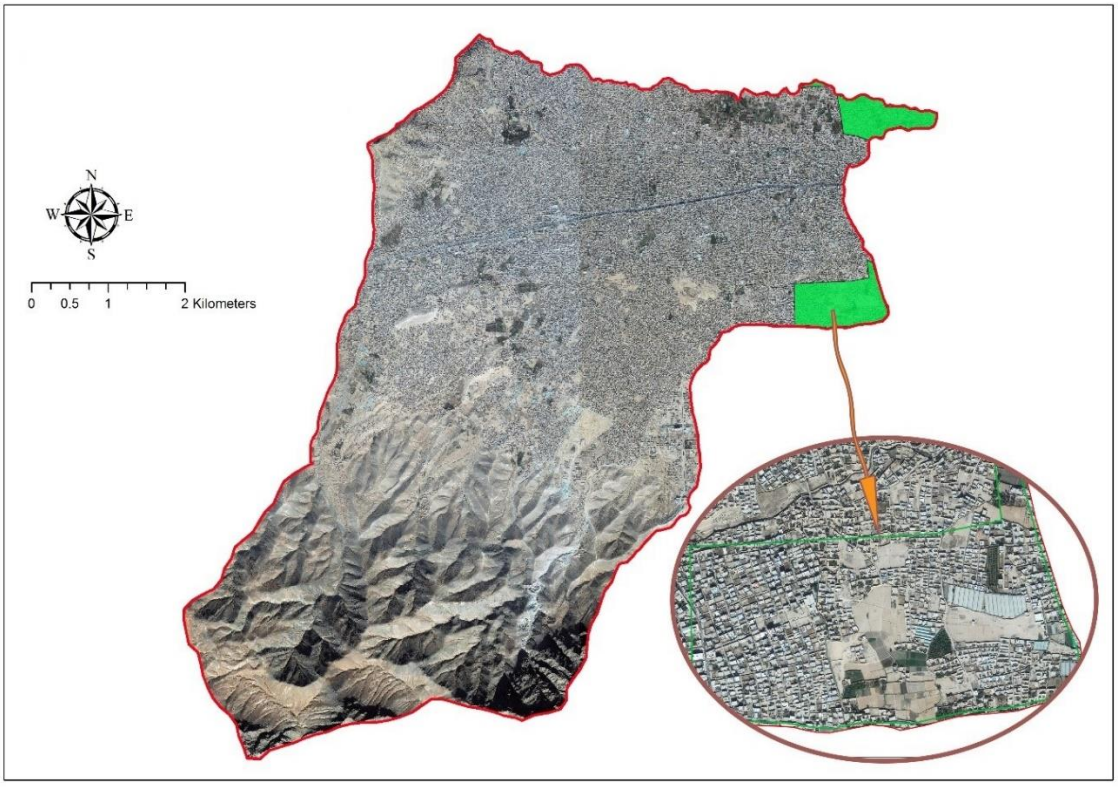


Fig. 9. Showing suitable area for park construction on a satellite image (Authors)

The selected areas are large and cannot be precisely designated as specific locations for park construction. Therefore, the selected areas need to be closely checked to determine the best location with the most suitable area for building a park.

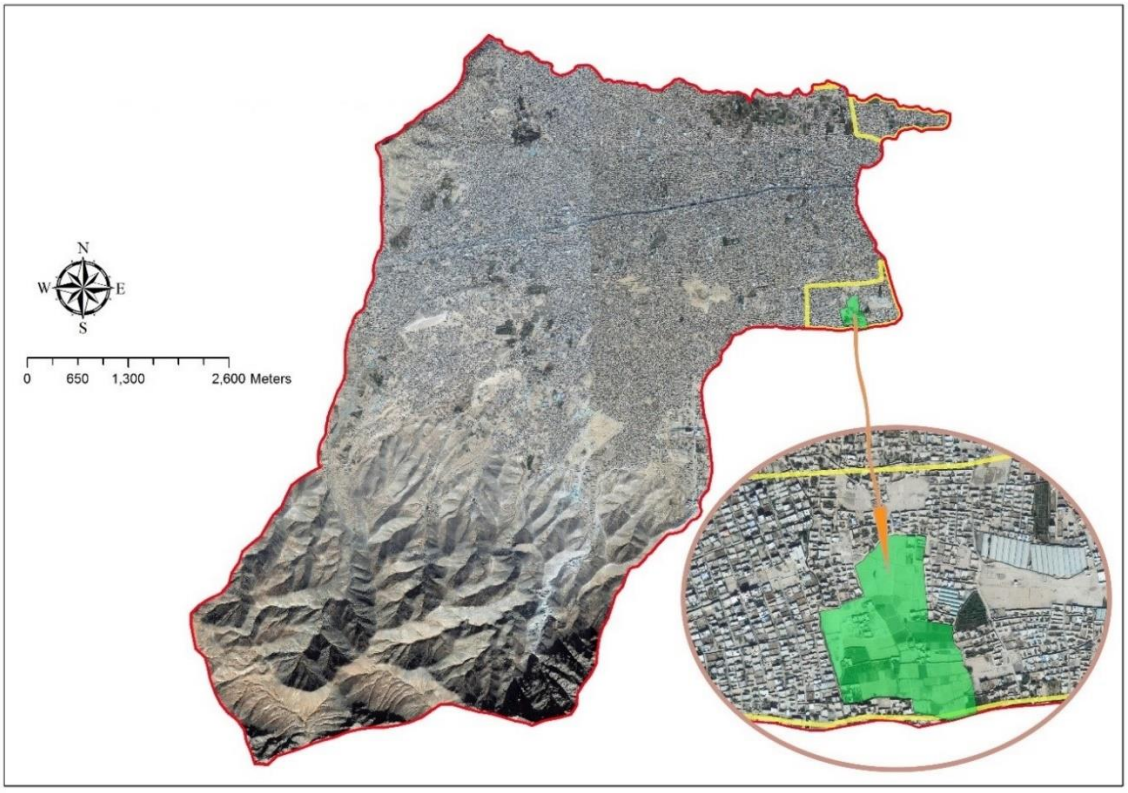


Fig. 10. Positioning the exact location for park construction in selected areas (Authors)

The selected area for constructing a park in the 13th district of Kabul City has an area of 94,209 square meters and is considered among the district parks. The area of district parks ranges from 50,000 to 100,000 square meters, with a radius of influence of 2,000 meters and a capacity of 3,000 people at a time [23].

This area is mostly used for agriculture and is at a distance from existing parks, corridors, and areas with buildings; meaning all the criteria considered in the Analytical Hierarchy Process (AHP) model have been met, and the most suitable location for park construction has been identified accordingly.

10. Conclusion

Urban green space is a part of urban open spaces that consist of natural or artificial areas with trees, shrubs, flowers, grass, and other plants that are managed and maintained by humans according to regulations, laws, and relevant expertise to improve the living conditions, habitat, and well-being of urban residents and non-rural population centers [20]. In the 13th district of Kabul, a total of 255,319 square meters of land has been designated for park construction. However, practical work on it has not been carried out fundamentally. Only several trees have been planted in this area and have not been fully completed, and the facilities and equipment required for parks are also not present in these areas. If these two areas designated for parks were constructed fundamentally and standard, the shortage of urban green space would still be a problem for the 290,010

residents in this area. This study has endeavored to use the Analytical Hierarchy Process (AHP) model and Geographic Information System (GIS) software to identify a suitable location for the development of urban green space in the 13th district of Kabul. In the Analytical Hierarchy Process analysis, four criteria were considered to obtain the most suitable location, and location-allocation was carried out accordingly in the GIS environment, which is the best location for park construction in this area.

Conflicts of interest

All authors declare that they have no conflicts of interest to disclose.

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Authors Profile



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