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Assessment of Urban Land Suitability Analysis for Public Park Planning

Sungmin Cho

Ph.D., Professor, Dept. of Landscape Architecture, Honam University, 120 Honamdaegil Gwangju, S. Korea.

E-mail: mincho@honam.ac.kr

Abstract

One of the most time consuming issues in a city development is the identification of suitable areas for urban infrastructures and proper land uses. Suitability analysis is the process and procedures to find the best available land in given area -that is, the ability of a system to select the needs of users in land use. This paper studied the usage of Geographic Information System technique and methods for the selection of the most appropriate sites for public park in the city of Gwangju. GIS was used as a standard technique to find the best available sites for development in urban areas. For this cause, digital elevation model and spatial data were used to produce different thematic layers by using software Idrisi. Criteria for finding the suitable site for park development were decided to evaluate the land and the followings 4 criteria were selected: on land with less than 3 degrees in slope, outside a 200m buffer around lakes, on land currently designated as forests, and 20ha or greater in size. To meet and measure each criterion, distance and context operators were applied to reclassify the importance of certain weight and Boolean images were generated to meet the criteria. These weights and maps has been combined using ArcGIS tools and the final map was prepared showing the most suitable sites. We may assist city planners and government officials in future development of public facilities including parks and related land use plans at urban level and act as to ensure proper land use planning and management of the urban areas.

Key words*: Suitability Analysis, Urban Development, Boolean Images. Criteria, GIS*

1. Introduction

A public park and recreational areas are essential elements in a city that play an important role for outdoor activities for the people in the community as they can generate economic and social values while promoting a healthy lifestyle of the people. That is, open public parks and areas are important places in neighborhoods for public recreational use, destinations for walking, exercising, and releasing energy, irrespective of socio-demographic backgrounds [1-2]. A park is an open space and area of natural, semi-natural, or planted space for human activities and recreation or for the protection of wildlife and natural habitats. Therefore, open and green spaces in a city are valuable components of urban environments and they can improve and ameliorate micro climates, reduce air pollution, and alleviate heat island effects, provide comfortable recreational space

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Corresponding Author: mincho@honam.ac.kr
Tel: +82-62-940-5504, Fax: +82-62-940-5617
Associate Professor, Department of Landscape Architecture, Honam University, Korea

for residential areas and contribute to sustainable urban environments [3-4]. Parks in the cities play significant aspects of urbanized ecosystems and provide a variety of environmental and social services for enhancing life values for the people in the urban areas [5]. Public parks and recreational areas can be classified by their specific demands and requirements as urban public parks play an essential role to preserve biodiversity within urban vicinities. Development of public facilities including urban parks has been impacted by the rapid urbanization and population influx to major cities since the end of 20th century.

These days, the development of public parks and recreational areas for highly populated cities is a challenge for the local authorities because of the limited land availability and its values are becoming the major challenge for the provision of public parks within urban areas. The conversion of natural land into urban usability service is obvious due to the change of the rural centers into metropolitan cities [6]. Identifying a suitable site for development of an urban area is one of the most appraising task of planning. Site suitability is the technique to understand the quality of an existing site and also the factors that determine the location for an certain activity. This technique consists of detailed investigation of the land cover and also the ongoing processes of the site, that characterize it. The outcome of a site suitability analysis is a complete display of the optimum suitable areas of consideration for a certain facility, while removing the unsuitable or undesired sites. Certain factors have of higher importance in determining the solution for a facility than others. The process of selecting a suitable area for some specific purposes should be based on an achievement of set of criteria selected. The processes include the mapping approaches by using Geographic Information System (GIS) and processing of the geo-database and various planning objectives to find its alternative usage [7]. Before GIS, which is a computerized method that helps to determine suitability analysis was widely used in the late 20th century, landscape designers and city planners carried out suitability analysis processes by laying transparencies over the maps of the present conditions. These days, GIS and remote sensing techniques can be applied to find a land for parks and other family-oriented recreational areas. The process of overall suitability for a certain urban use can be obtained by using a weighted system of the various aspects. GIS applications offer approaches which can facilitate easy and faster remodeling of small changes for a criteria to produce results in the form of maps for presentation [8]. GIS tools allow users to get the results by forming geospatial queries on the spatial information and edit the data obtained to form maps to present the outputs of all the operations. These techniques of site suitability require measurements that are to be regenerated to values that are common and are to be converted to the final selection of the site [9]. The purpose of this research was to find the best available areas specifically for the development of public park by conducting suitability analysis on a particular land parcel by using GIS. In this research, an Analytic Hierarchy Process (AHP) framework as a multi-criteria decision approach of integrating with GIS was carried-out to indicate different parameters for selection of a suitable site of public parks. AHP is the most frequently used method for determining weight values for different layers by comparing each criterion against the other criteria which will help in deciding suitable site and AHP is widely used in a systematic method to guide decision-makers in making decisions to solve the problems based on priorities [10-11]. Idrisi software was used for calculating the weights from alternative scenarios and selection criteria. The objectives of this research were divided into the followings: (a) to find the best suitable area for public park development in the metropolitan city, (b) to generate a suitability map showing the degree of suitability for a particular purpose at any location, (c) to assess distance and context operators to combine Boolean images.

2. Research Area and Methods

The research area is the city of Gwangju, which is located in a geographic basin with high mountains to the east—especially Mudeungsan mountain which has a peak elevation of 1,140 meters, and open plains to the west. Located in the metropolitan sphere, it offers a pleasant housing environment and great potential for development. Over 70% of the area consists of mountains, with valleys and streams. Youngsan river, the source of the water supply for the metropolitan region, preserves the city's beautiful natural landscape. Gwangju was chosen as it is the metropolitan city which has plenty of undeveloped land to be developed as public parks compared to other major cities. It is believed that the presence of sufficient green space areas and public parks with adequate accessibility in the city contribute to the happiness of the citizens towards a sustainable quality of life.

The base map of research area is shown in Figure 1. It is said that Gwangju is the origin of the traditional Korean culture and is home to Korea's long history and culture. It is located at the southern part of Korea and South Korea's 6th largest city.

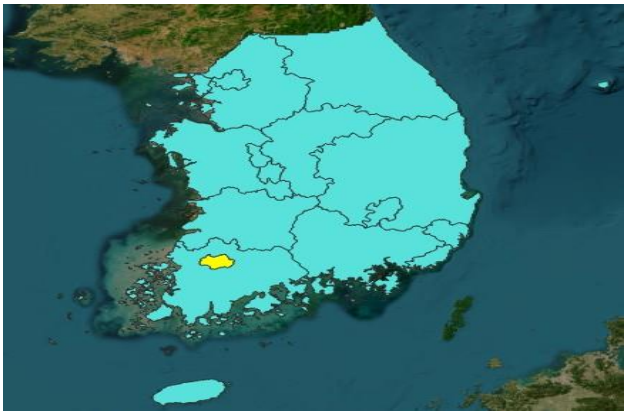


Figure. 1: Image of study area.

3. Materials and Method

The spatial and non-spatial data for the study area was collected from the city planning department. Land use and land cover maps were acquired and topo sheet of 1:50,000 scales was used to create digital elevation model which was used to generate the slope map. Satellite data of high resolution has been used along with road proximity map to classify land use and land cover types. To find all areas suitable for the location for park development site in the city, one important factor was that the site should be on fairly level ground with a certain size. The city officials were concerned that the city's several lakes be protected and have specified that no artificial facility be within 200 meters of any lakes. Additionally, it was needed to consider not only all land available for development but also forested land was available. Figure 2 shows the procedures to analyze the spatial data types and criteria to find the sites suitable for park development. Four criteria are as follows: a) on land with slopes less than 3 degrees, b) on land currently designated as forest, c) outside a 200m buffer around lakes, d) 7ha or greater in size.

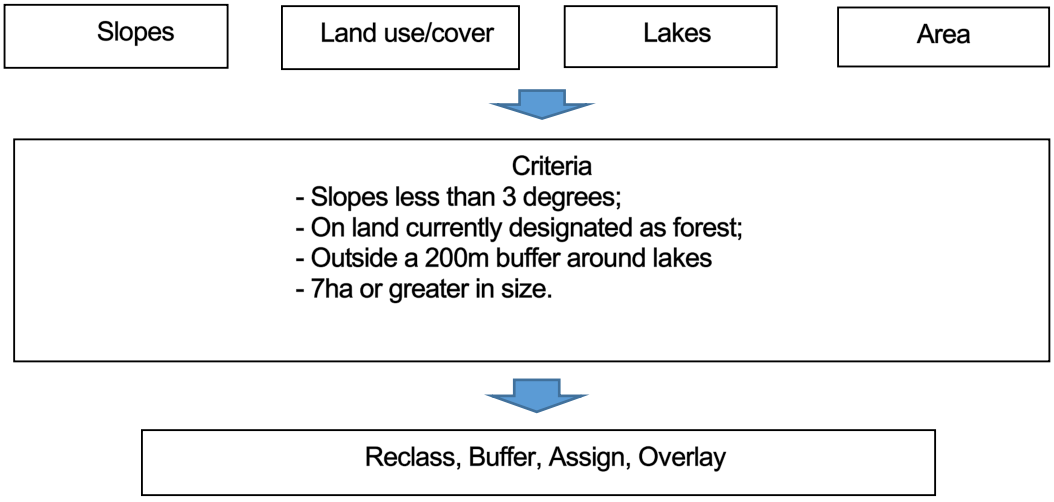


Figure. 2. Procedures and Criteria selected for suitability analysis using spatial data.

Besides above four criteria, road accessbility, population density of the area and geological format ion of the land were considered for the spatial analysis. Two groups of analytical operations, distan ce and context operators were applied. Distance operators calculate distances from some feature or s et of features. In a raster environment, they produce a resultant image where every pixel is assigne d a value representing its distance from the nearest feature. There are many different concepts of di stance that maybe modeled, Euclidean or straight line, distance is that we are most familiar with. C ontext operators determine the new value a pixel based on the values of the surrounding pixels to i dentify contiguous groups of pixels [12]. To achieve suitability analysis, it was required to put som e values for each criteria as per the requirement for the development of the urban region. Boolean i mages were combined using overlay module to yield a final map that showed the sites that met all the specified criteria. Different criteria were required to develop a ratio matrix and the pairwise com parison matrix was developed using scale of weights shown in Table 1. These pairwise comparabilit y were taken as the inputs and the outputs obtained are the relative weights.

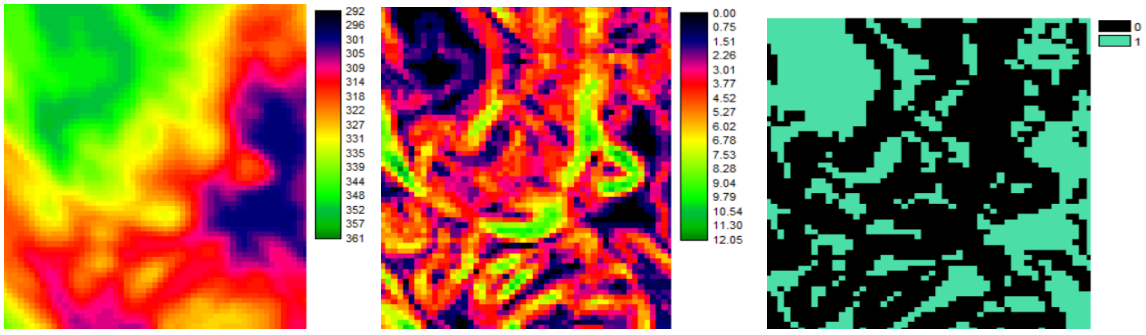
Table 1: Table of pairwise comparison on 5 point weighting scale.

Importance of Intensity	Description	Suitability Class
1	Equal to moderate importance	Low
2	Moderate importance	Moderate
3	High importance	High
4	Strong importance	Strong
5	Very strong importance	Very High

4. Results and Discussion

The first criterion was to find the land with slopes less than 3 degrees. For this criterion, a Bool ean image for the areas meeting this criterion was produced. To create the Boolean image, digital e levation model was used to create slope image with all slope values and then the image was used

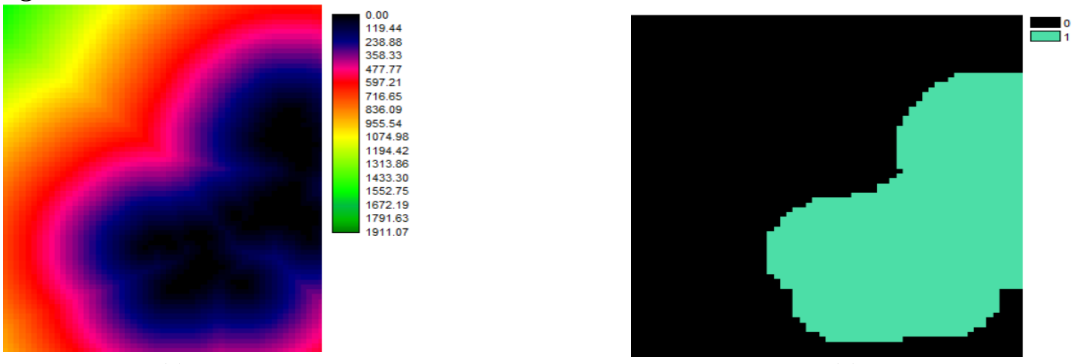
for a reclassification to isolate only those slopes that met the criterion. In the final Boolean image, new value of 1 was assigned to all values from 0 to just less than 3 degrees and the value of 0 t o all those values equal to or greater than 3 degrees. Figure 3 shows the Boolean image of slopes with value of 0 and 1. Figure 3(a) is a image of digital elevation model and 3(b0 is the image of slope calculated from DEM. Figure 3(c) is the final Boolean image with values of 0 and 1.



(a) **(b)** **(c)**

Figure 3. Boolean image of slope by using digital elevation model with values of 0 and 1.

The second criterion to find the park construction area was that suitable areas must be outside 20 0m buffer zone around the lakes. A buffer zone is an area that falls within a certain distance of a particular feature or set of features. The Boolean image of buffer zone should contain the value of 1 for all pixels that are further than 200m from lakes and the value 0 for all pixels that are within 200m of lakes. In planning the analysis for this step, it was needed to calculate distance from lak es and to isolate set of those distances. To produce the image needed, distance and buffer modules required as input an image in which the target features from which distances should be calculated h ave non-zero values and every other pixel has the value of 0. By using distance module, each pixel distance from the target was calculated and a new image in which each cell value was the shortes t distance from that cell to the nearest feature and distance surface of continuous representation of distance was acquired. On the other hand, buffer module produced a categorical, rathe than continuo us, image. Buffer module set the feature image and used 200m as the buffer width and assigned th e value of 0 for the lakes and 1 for the areas outside the buffer zone. Figure 4 shows the Boolean image of buffer zone created with distance operator with value of 0 and 1. Figure 4(a) is the ima ge showing the distance from the lakes and (b) is the Boolean image of buffer zone created from distance image.



(a) **(b)**

Figure. 4. Boolean image of buffer zone created with distance operator with values of 0 and 1.

For the land use criterion, reclass module was performed to find forested land. The fourth and la st condition to account for in the analysis is that suitable sites mush have an area of 7ha or more. For this procedure, three Boolean images, one for each of the previous criterion, were combined int o one final Boolean image that showed those areas where all three conditions were met. These diff erent maps created based on the criteria were converted to raster data format as they were less cum bersome than vector data format. To get the final site suitability map, these classified raster data m aps were processed in the raster calculator of ArcGIS tool and the weights were multiplied accordin gly. Figure 5 shows the final image of selected area for possible park development image of slopes with value of 0 and 1.

Figure. 5. Final image of selected area for park development.

All four scenarios were calculated and then combined to determine potential suitable land areas. T he weighted overlay values of all 4 criteria including the distance and context operators produced th e suitability map for the public park. The total area of 1.23% was ranked by a suitability value 5, which is the most suitable areas, and 5.61% of the land was ranked by a suitability value 5, and 5 7.2% was ranked by a suitability value 4. Selection of the priority was given to areas with the hig hest suitability value and in regards to land availability, the proposed new public park area was abo ut 24.8ha.

5. Conclusion

In the design and development of city public park, it is important to fully combine the sunny side and the shady side and carefully consider the park space which not only bathes in the sunshine, but also avoids the strong cold wind according to the actual terrain. Designers also carefully allocate plants and land plots to create a beautiful and pleasant micro-environment for all seasons. Also, terrain and slope are very important criteria in site suitability as the need of accessibility and usage of park mainly relied on the flat road network within a city. The land suitability analysis was performed with different spatial data and images were produced in the raster format. The raster data model was the more suitable technique because the structure of raster data is grid cell based, which can easily delineate suitable sites than vector model. Raster data facilitated the user in carrying out a weighted overlay on numerous layers. The generated maps of given criteria were standardized using pairwise comparison matrix known as analytical hierarchy process. Analytical hierarchy process is the most frequently used method for determining weight values for different layers by comparing each criterion against the other criteria which will help in deciding suitable site. The weights of factors and parameters were calculated easily for land suitability with the Idrisi software. Computed weights were calculated with GIS

through spatial layers and produced land suitability maps, and proposed different sites around the city for public parks. In the end, suitable areas were selected though reclass, assign, and overlay procedures for public parks in the city. Finding an optimal location for diverse uses and services in a city is in high demand to increase quality of life. Especially, the urban parks which are green with plants and most open public spaces of cities play important role to improve the social, cultural, and environment-friendly conditions of the people in urban areas. Public parks and gardens have gained a lot of attention along with the growth of an area and the population of the urban regions in many countries. Various polices and strategies have been applied and used to develop public parks properly throughout the urban environments. This approach and land suitability analysis approach was useful to determine suitable land site in urban areas. Selecting the optimal location is not the only important consideration in the city planning process. This study may assist city planners and government officials in future development of public facilities including parks and related land use plans at urban level and act as to ensure proper land use planning and management of the urban areas.

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