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Introduction of a Method for Locating New Urban Forest Parks using Multi-criteria Analysis and GIS Approaches

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ABSTRACT: Urban parks and green spaces are one of the applications that their distributions are very important in the city. Accordingly, the necessity of constructing green spaces including parks and urban forest and selecting new locations for plantations in cities are coming vital. The multi-criteria analysis comprises three steps including initial selection stage, suitability stage and feasibility stage. In the initial selection stage, the possible areas for urban forest parks are evaluated and the areas which takes the suitable points are selected for the next stage. The criteria are weighted by experts before they ranked in the next stage. Afterwards, the regions with the highest score and suitability are entered in feasibility stage and evaluated. Finally, the areas with the highest scores are selected for the construction of urban forest parks. MCA flexibility in setting the criteria for each area based on the conditions and characteristics of the area is important.

Keywords: urban forest parks, urban forestry, locating, multi-criteria analysis (MCA), urban planning.

INTRODUCTION

Around the world, countries are increasingly moving towards urbanization. In the next few years, 50 percent of the world's population will live in urban areas (Konijnendijk, 1999). In 2012, about 71.4 percent of the Iran population lives in urban areas (Statistical Center of Iran, 2012). In the recent decades, as a result of industrialization phenomena such as rural-urban emigration, invasion of urbanization to the capital and industrial centers, mass and population density phenomenon in urban centers have caused problems such as, air and noise pollution which resulted in physical and psychological injuries on the residents of these cities. Iran is one of the developing countries which is going to step on the road to economic and social development facing with many problems. The necessity to develop; besides maintaining and preserving green spaces for many reasons are being more evident and are increasingly attracting more attention by the people and authorities. Urban forests as one of the important urban elements play an important role in the utility and amenity space of the cities. Thus, by accepting the tremendous value of trees in today's urban life, planning to fix the problem is inevitable. Urban forest parks as the most important part of urban forests play an important role in implementing its functions (Barzehkar, 2005). Based on the definition, urban forest parks are described as a green space within the city or its margins, which is manifested as forest parks, green belt or green space with suitable vegetation trees (Irani and Razi, 2005). These lands are located within or adjacent to the cities (natural or artificial made) and must have beautification, environmental and ecological functions of green spaces and at the same time have the recreational application. Urban forest parks are an integration of forest parks and urban parks that are equipped with environmental, recreational, entertainment, cultural and educational functions. Therefore, an urban forest park is defined according to the following features:

- It should be located in the urban land areas.
-It should have environmental and ecological applications of green spaces.
-It should have aesthetic features of creating landscape.
-It also should have the recreational application (Irani and Razi, 2005).

The advantages and functions of urban forests could be classified as the four categories of ecological, economic, beautification, social and cultural functions. One of the most important objectives of urban forestry is the development of tree's vegetation in the cities and around them in order to achieving different environmental, social and public welfare goals. However, in addition to obtaining the social and environmental goals, economic benefits from urban forests is also considered today.

The latter is implemented with the goal of making the cost minimum and gaining the maximum profit through the calculation of ecological and social benefits of urban forestry, and quantifying them (Barzehkar, 2005). In this study, two research methods of multi-criteria analysis for locating new urban forests implemented by Gul *et al*., 2006 and Elegem *et al*., 2002, was followed and adapted in order to introducing a novel method for locating new urban parks.

MATERIALS AND METHODS

Multi-criteria analysis (MCA) is a decision-making method and tool for solving complex multi criteria problems which have different aspects of qualitative and quantitative in a decision-making process. MCA approach is used for setting priorities when there are multiple targets in a decision-making problem (Mendoza *et al*., 1999). Multi-criteria analysis comprises three different stages: initial selection stage, suitability stage and feasibility stage. As the stages go down with the process, the number of potential sites for urban forest parks are minimized, according to the stages shown in Fig. 1. In each stage, the criteria, sub-criteria (if any exists) and indicators affecting the locating of urban forest parks are selected (Gul, 2006).

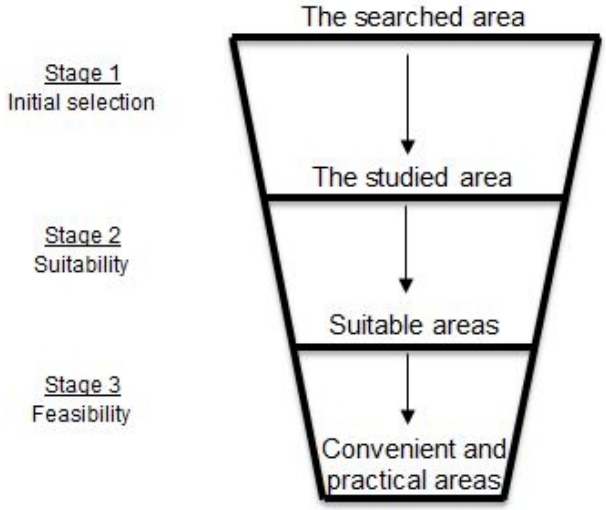

Fig.1. The three stages of multi-criteria analysis (Van Elegem *et al.*, 2002).

This stage consists of two parts. The first part is an elimination process in which the underdeveloped regions like open areas, reforestation, forest and agricultural lands residues are considered to create urban forests. The other areas which are in low space, beyond the development of the city and proper for the other applications are excluded from the investigation. In the Initial selection stage, the selected areas in the first part are evaluated according to the criteria shown in Table 1 (Gul, 2006).

Table 1: The main criteria, indicators and scores used in the initial selection stage.

The main criteria	Indicators	Scores
Location	in the city center Far from downtown In the border city	3 2 1
Area	Low Medium High	1 2 3
Ownership	Governmental Privately	3 1
The existence of protected areas	Yes No	3 1
Used by organizations and other departments	Yes No	3 1
Limiting structures (such as highways, factories, airports, railways)	None Less than two limiting structure More than two-limiting structure	3 2 1

Each indicator receives a score ranging from 1 (the lowest importance) to 3 (the highest importance).

These criteria have been selected based on previous studies, especially Gul *et al*., 2006 and Elegem *et al*., 2002. Potential areas of urban forest parks should be large enough to make the potential of different usage from them (Gul and Gezer, 2004). This is important especially when considering the importance of recreation aspect of urban forest parks. Larger areas provide more space for recreation, without loss of planting trees opportunity and degradation of flora and fauna (Serin, 2004). Moreover, larger areas provide more privacy for urban lands and make more connection between the other green spaces (Van Elegem *et al*., 2002). Generally speaking, privately-owned lands, have more limitation than the government owned lands. The existence of restrictions on land usage, leads to the acquisition of a lower score for the lands. Those areas that don't meet the certain scores (e.g. half points possible) are excluded from MCA eligibility stage.

Suitability Stage: The initial areas selected in the initial selection stage are then assessed in terms of suitability for the construction of urban forest parks. In this stage, the areas are evaluated based on three aspects of recreational, ecological and structural. Criteria, sub-criteria (if any exists) and indices for each aspect are shown in Table 2 (recreational aspect), Table 3 (ecological aspect) and Table 4 (structural aspect).

Regarding to the discrepancies in the importance of criteria in different areas, the opinions of local experts should be used in order to determine the relative importance and weight of each aspect and criteria. Weighting aspects is the dominant part of a MCA which is often performed using information from local experts (Dodgson, 2000; Nijkamp *et al*., 1990; Van Elegem *et al*., 2002; Janssen, 2001). If the discrepancies between the opinions are high, the sensitivity analysis is used for the unequal weighting of the aspects (Rajaeifar 2013).

Recreational suitability aspect: Urban forest parks are getting more interest due to their recreational potential (Konijnendijk, 1999; Gulez, 1992). Recreational opportunities should be considered with accessibility, visitor density, natural, cultural and theoretical values and leisure facilities. The close recreational areas are more valuable than faraway areas due to convenient access for the visitors (Lindhagen, 1996; Roovers *et al*., 2002). The standard and ideal time for residents' access to the urban forest parks by walking, is about 15 to 30 minutes (Serin, 2004). Urban Forest Parks must provide recreational opportunities for tourists (Gul and Gezer, 2004).

Table 2: The main criteria, indicators and scores used in the field of recreational suitability stage.

The main criteria	Sub criteria	Indicators	Scores
Population	In the radius of the influence sphere	High population	3
		Medium population	2
		Low population	1
Access	Type of Communication Ways	Highway	3
		main Street	2
		Auxiliary road	1
	Number of main Communication Ways	Two or more	3
		One	2
		None	1
	Duration to access by walking	Low	3
		Medium	2
		High	1
Tourism centers	Number In the radius of the influence sphere	High	3
		Medium	2
	Tourism population covered	Low	1
		High	3
		Medium	2
		Low	1
Educational Centers	Number In the radius of the influence sphere	Low	3
		Medium	2
		High	1
Existence of scenic values		More than one type value	3
		One type value	2
		None	1
existence of the Recreational facilities		Yes	3
		No	1
Distance from the Existing park		High	1
		Medium	2
		Low	3

Each indicator receives a score ranging from 1 (the lowest importance) to 3 (the highest importance).

Therefore, natural, cultural, historical and scenic resources are very important. Existence of scenic natural values in urban forest parks could have a positive effect on the recreational tourism activities both mentally and physically. Dwyer (1983) suggests that citizens prefer recreational landscape that includes a combination of forests, scattered trees, pastures and water lakes. This diversity in the points has found to occur for scenic values more than the others.

Ecological suitability aspect: Urban forests can play an important role in the development of biological and ecological quality of the urban areas. Biological and ecological quality, such as improving the climate, saving energy, reducing noise, improving air and water quality, carbon storage and sequestration are the examples of many advantages that trees provide (Miller, 1997; Harris *et al*., 2004).

Table 3: The main criteria, indicators and scores used in the field of ecological suitability stage.

The main criteria	Sub criteria	Indicators	Scores
water sources	Access to water resources	High	3
		Medium	2
		Low	1
The vegetation	Type of Coverage	Forest cover	3
		Tree cover	2
		shrub and herbaceous plants Cover	1
	The diversity of plant species	High	3
		Medium	2
		Low	1
soil texture	Surface soil	Loamy soil	3
		Sandy, clay loam	2
		Clay and hydromorphic	1
Distance from the facilities and factories		Low	1
		Medium	2
		High	3
air pollution		Up	3
		Medium	2
		Low	1
Noise Pollution		Up	3
		Medium	2
		Low	1
The topography	Height	Low	3
		Medium	2
		Up	1
	Slope	Flat (less than 10%)	3
		Medium (10% to 30%)	2
		High (more than 30%)	1
	Direction	South	3
		East and West	2
		North	1

Each indicator receives a score ranging from 1 (the lowest importance) to 3 (the highest importance).

Structural suitability aspect: Urban forest parks could be used as a border for a city and therefore prevent the spreading of residential areas in the regions of interest. Also, construction of these spaces among undeveloped lands in residential areas could prevent joining them together and urbanization of these areas. Another important function of urban forest parks is establishing of ecological linking between other green spaces. Moreover, the urban forests can improve the structure of the urban landscape in different ways and form a sound and visual protection to improve the privacy of the residents (Anderson, 1993). Regions which have lower fragmentation and limiter structures could gain more points for the construction of urban forest parks.

Each selected area from the initial selection stage is evaluated in accordance to the criteria in the three described aspects.

In each area, the scores of each aspect are multiplied by its related weight and added together in order to finalize the calculations of suitability.

Feasibility stage: In cases where two or more areas similarly receive the maximum scores, feasibility stage is used. In this stage, the criteria, sub-criteria and indices for determining the possibility of accepting the urban forest parks by land use sectors (Rajaeifar 2015a,b) such as agriculture, conservation, urban development, industry and transportation are evaluated according to the criteria shown in Table 5. Moreover, the possibility of achieving to the construction of forest parks in urban areas are evaluated , by assessing forestry projects in process, construction costs and possibility of using green space in urban development program.

Table 4: The main criteria, indicators and scores used in the field of structural suitability stage.

The main criteria	Indicators	Scores
The ability to create border for urban areas	More than 3 border 2 or 3 borders Less than 2 border	3 2 1
The ability to create privacy against joining residential areas	More than 3 privacy 2 or 3 privacy Less than 2 privacy	3 2 1
The ability to communicate or corridor between urban green spaces	more than 3 Communication or corridor 2 or 3 Communication or corridor less than 2 Communication or corridor	3 2 1
The ability to improve the quality of urban landscape	Yes No	3 1
The degree of continuity	High Medium Low	3 2 1

Each indicator receives a score ranging from 1 (the lowest importance) to 3 (the highest importance).

Table 5: The main criteria, indicators and scores used in the aspect of feasibility stage.

The main criteria	Sub criteria	Indicators	Scores
Acceptance by other land uses	Acceptance by the agriculture sector	Yes Rather No	3 2 1
	Acceptance by the Department of Conservation of Nature	Yes Rather No	3 2 1
	Acceptance by the housing sector	Yes Rather No	3 2 1
	Acceptance by industry sector	Yes Rather No	3 2 1
	Acceptance by the transportation sector	Yes Rather No	3 2 1
The ability of area ownership and Afforestation in the short term		Yes Rather No	3 2 1
Afforestation projects existing		Yes Rather No	3 2 1
Take advantage of the green space in urban development program	Number In the radius of the influence sphere	Yes Rather No	3 2 1
Potential cost to create infrastructure		Low Medium High	3 2 1

Each indicator receives a score ranging from 1 (the lowest importance) to 3 (the highest importance).

RESULTS AND DISCUSSIONS

In the initial selection stage, areas that have the potential for constructing urban forest parks are selected and scored based on the initial selection criteria. In case of the obtaining certain scores (e.g. half of the possible scores), the areas are entered to the stage of suitability. In the suitability stage, the scores of each areas in each aspect (recreational, ecological and structural) are multiplied by its own weight (which is calculated based on the questionnaires and expert opinions). The sum of these scores, determines the score of each area in the suitability stage. Two or more areas that similarly receive the maximum scores in the suitability stage, are entered to the feasibility stage. Total scores in this three stages (initial selection, suitability and feasibility), is calculated from the sum of score for each area. The area that receives the most score is selected as the most convenient area for establishing an urban forest park.

CONCLUSIONS

Suitability techniques are essential for consciously decision making and empowering the local planners and decision makers to analyze the important interactions. Multi-criteria analysis is a flexible and practical way to facilitate the process of selecting suitable for the urban forest parks establishment. The input information from local experts and survey of citizens to choose the criteria on multi-criteria analysis and also the use of local experts to determine weighting coefficients, provide a model that could be used to adapt for different cities to create a multi-criteria analysis for urban forest parks locally.

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