Site selection for local forest park using analytic hierarchy process and geographic information system (case study: Badreh County)

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ABSTRACT: Today, entertainment and recreation are essential to human. Therefore, the development and construction of forest parks to attract the tourists generate income, leisure, relaxation and resources conservation. In this study, suitable areas for local forest park determined in Badreh County-Ilam province using analytic hierarchy process (AHP) and geographic information system (GIS). At first, the hierarchy of the evaluation process created and criteria and sub-criteria weights obtained using experts opinions. Then, The GIS layers were created for each of the sub-criteria. Finally, the final map of suitable areas for Forest Park prepared using weighted Linear Combination (WLC) technique in GIS environment. The results showed that 2765.6 ha of study area has first class potential (high suitable), 15794.1 ha has second class potential (moderate), 30537.5 ha has third class potential (low) and 7930.5 ha has four class potential (no suitable).

Keywords: local forest park, AHP, GIS, Badreh

INTRODUCTION

Ecotourism has a strict connection with sustainable tourism. Sustainability depends on the relationship among tourism and environment reference. Suitable management for ecotourism development is essential in order to conserve and maintain the biological richness of the area as well as economic upliftment of the local people. In addition, ecotourism can be defined as an opportunity to promote the values in the protected areas and to finance related stakeholders (Ok, 2006). In this respect, ecotourism evaluation should be regarded as an important tool for sustainable development of tourism in any area (Ceballos-Lascurain, 1996). In addition Ecotourism and recreation play an important role on human life and improve physical and psychological state of human (Gul and Gezer, 2004).

One of the important types of ecotourism is recreation and outing in natural and forest areas that considered as convenience and recreation resources for humans (Lynn and Brown, 2003). Organic and forest locations considered as recreational spaces which have persistently received a greater significance for fairly some time? (Lynn and Brown, 2003).The main effects of green spaces, including Forest Parks, are their ecological functions. Other effects of green spaces are leisure and recreation, positive psychological effects, reducing of air pollution, oxygen production, and wind control (Majnunian, 1995). Therefore forest parks with recreational facilities can have an important role in providing recreational needs (Majnunian, 1995). Parks are classified into two major categories: providing of recreation, services to society and conservation of natural values (Maruani and Amit-Chen, 2007). Parks and green spaces also can control the extreme temperatures in residential areas and provide a healthy residential area environment (Barbosa et al, 2007).

Badreh County located in I lam province in western of Iran has not forest park; therefore the most suitable sites must be selected to develop an forest park. Hence, the main objective of this paper is to identify and evaluate Badreh County by finding the most suitable site to locate a new urban forest park based on an integrated GIS multi-criteria evaluation technique. As GIS-based MCDM becomes one with the most helpful techniques for spatial planning and management (Joerin et al, 2001; Karnatak, et al, 2007; Chen et al, 2010), the request for tools supporting collaborative decisions have spiraled over the last decade (Chen et al, 2010).
An introduction to this field can be found in Malczewski (1999), who contributed to bridging the gap between geographical information systems (GIS) and multi-criteria decision making (MCDM) methods such as analytical Hierarchy process (AHP) (zucca et al, 2008). In this study, a GIS-based AHP was used to determine land suitability for parks, which has been a very useful method over the years. GIS plays a vital role in planning for many decades of land-use suitability mapping and modeling (Malczewski, 2004; Malczewski, 2006; Karami et al, 2012) One of the most useful applications of GIS for planning and management is the land use suitability mapping and analysis (McHarg, 1969; Babaie-Kafaky etal., 2009; Farajzadeh and Karami, 2004; Collins et al, 2001).

AHP is a well known technique that decomposes a decision making problem into several levels in such a way that they form a hierarchy with unidirectional hierarchical relationships between levels. The top level of the hierarchy is the overall goal of the decision problem. The following lower levels are the tangible and/or intangible criteria and sub-criteria that contribute to the goal (Saaty, 1994). This paper addresses a scientific approach to determine suitable land for healthy residential area development. This approach will help in revision of policy and preparation of development plans in the study area and for other area as well.

MATERIALS AND METHODOLOGY

Study area

The study area is Badreh region that located in Ilam province, western Iran with latitude from 33˚ 29’ 27” to 33˚ 8’ 45” north, and longitude from 46˚ 47’ 21” to 47˚ 14’ 50” east (Fig. 1). Badreh covers about 57028 ha that is placed on the Zagros Mountains. The average annual rainfall is about 528.3 mm and the average annual temperature is 20.95 °c. The climatic condition is semi-arid with cold winters based on Ampereje method. The common characteristics of this area are: forested hills, limestone bedrock, deep litho-soil, fair to good vegetation cover, and sharp slope with rill and sheet erosion.

METHODOLOGY

AHP was used to evaluate the priority weight of each criteria and sub-criteria (parameters). AHP and the Geographic Information System (GIS) are an integrated technique used to assess suitable land use for forest parks in Badreh County. Determination of suitable areas for new urban Forest Park, took place in three main steps:

Determination and assessment of criteria and sub-criteria

in order to evaluate and allocate suitable areas for different land uses, a set of criteria must be developed (Belfor, 2003; Karami, 2010). Therefore, in first step, the most important criteria and sub criteria that effect on site selection for urban forest parks were determined. AHP was used for this purpose. AHP is a useful technique for solving multi-criteria problems. The AHP uses pair wise comparison to allocate weights to the elements of each level, measuring their relative importance by using Saaty’s (1-to-9) scale, and finally calculates global weights for elements at the bottom level. The method also calculates a consistency ratio (CR) to verify the coherence of the judgments, which must be about 0.10 or less to be accepted. Mathematical foundations of the AHP can be found in Saaty (1994, 1996).
AHP method is conducted in three stages: 1) creating hierarchical structure of the problem that is the most important part of AHP (Cimern et al., 2007), 2) Calculation of the criteria and sub-criteria weight using expert’s judgments (Saaty, 1980) and 3) survey of judgments consistency, consistency ratio (CR) of judgments should be less than 0.1 (Dey and Ramcharan, 2008).

In this study criteria and sub criteria were selected according to similar studies (Bukenya, 2000; Gul et al., 2006; Barzekar, 2006; zucca et al., 2008; Shirvani, 2009; lawal et al, 2011; Jalilvand et al., 2011)). Natural conditions of the study area and experts opinions. Then, developed questionnaires were distributed among experts. Experts used pairwise comparisons and Saaty’s scale to assess the importance of criteria and sub criteria. The weights of layers (sub-criteria) in each questionnaire and inconsistency rate for each judgment were calculated using Super Decision software. The inconsistency rate of each judgment should be less than 0.1 to be accepted for assessment. Then, the layers weights of each questionnaire s were averaged and the final weight was calculated for each sub-criteria of evaluation.

**Sub-criteria Maps**

In this step, map of each sub-criterion was prepared using GIS. Sub-Criteria maps form an output regarding to evaluated criteria and sub-criteria identification stage. This follows right after input of information to GIS (acquisition, reformattin, geo-referencing, compiling as well as documenting related data) saved in graphical and tabular type, manipulated and analyzed to acquire desirable info. Generally, with the help of numerous GIS techniques, a base map of the study area is created and utilized to produce a number of sub-criteria maps. Each sub-criterion is represented on a map as a layer in GIS. Every map represents one sub-criterion and can be known as a thematic layer or data layer. They signify way in what the attributes are distributed in space and how they assist in achieving the objectives. In other word, a layer represents a set of alternative places for a decision. The alternatives are divided into a number of classes or are assigned values to represent the level of preference of the alternative upon given criterion, which helps an individual to visualize many less and more desirable alternatives.

Having prepared Digital Elevation Model (DEM) map of study area; slope, aspect and elevation maps with a scale of 1:50,000 were obtained in GIS environment. Forest Density, soil and petrology maps obtained from Department of Natural Resources of Ilam Province. Erosion rate Map was prepared using GIS and EPM model that calculate erosion rates in the four categories including severe erosion, moderate, low and very low. Map of distance from water resources (springs and rivers) was produced using topography map. For mapping the distance from the recreational attractive; first, recreational resources of the area including archaeological sites, waterfalls, most beautiful caves, shrines and etc were identified using topography map and GPS. Then, map of distance from recreational attractive was generated in four categories using Buffering. Distance maps from negative factors (livestock and poultry farms, industrial sites, etc.), roads and residential areas were generated using topography map, GPS and Buffering in GIS environment.

Maps classification was conducted based on the natural conditions of study area, previous studies and expert opinions.

**Weight assigned to maps and generation of suitability map**

At this stage, ever single map was combined with its own weight using weighted linear combination (WLC) technique in GIS environment (Santa-riviera et al., 2008). In weighted linear combination (WLC) procedure, factors and parameters (Vi) are multiplied by the weight of the suitability parameters (Wi) to get composited weights and then summed. WLC is a straight forward linear method calculating composite weights. This function multiplies and sums up the layers to produce suitability maps for parks. Therefore, the weighted linear technique (Mendoza, 1997; Mohit and Ali, 2006) was applied to generate a suitability map by the following formula and the final map of suitable area for local Forest Park production (Chandlo et al, 2011).

\[ E = \sum_{i=1}^{n} w_i \cdot v_i \]

Where: \( w_i \) = relative importance or weight of factors/parameters i, \( v_i \) = relative weight of parameters i and \( n \) = total number of parameters related to the study.

**RESULT**

AHP was used to evaluate the priority weight of each criteria and sub-criteria (parameters). AHP and the Geographic Information System (GIS) are an integrated technique used to assess suitable land for local forest park in Badreh County. In This study, to assess the potential of Badreh County for selecting suitable forest park locations, 12 factor (sub-criteria) including Slope, Aspect, elevation, erosion rate, petrology, soil type, forest density, distance from water, distance from residential areas, distance from recreational attractive,
distance from the road and distance from the negative factors in three criteria including geomorphology, environmental and socio-economic were used.

Based on the results of the criteria and sub-criteria assessment, distance from the water resource with a weight equal to 0.267265 was the most important in this evaluation and slope, forest density and distance from recreational attractive layers were the much important respectively. Table 1 shows the results of the hierarchy creation, the importance of the sub-criteria (layer) and layer classification.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Weight (Wi)</th>
<th>Layers classification</th>
<th>No suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>environmental</td>
<td>Distance from Resources water (M)</td>
<td>0.267265</td>
<td>High</td>
<td>300 - 600</td>
</tr>
<tr>
<td>Social Economic</td>
<td>Forest density</td>
<td>0.1488</td>
<td>Moderate (25-50%)</td>
<td>Poor</td>
</tr>
<tr>
<td>Geomorphology</td>
<td>Distance from roads (KM)</td>
<td>0.02468</td>
<td>0 - 3</td>
<td>3 - 6</td>
</tr>
<tr>
<td></td>
<td>Distance from Residential areas (KM)</td>
<td>0.041065</td>
<td>0 - 3</td>
<td>3 - 6</td>
</tr>
<tr>
<td></td>
<td>Distance from negative factors (KM)</td>
<td>0.06624</td>
<td>9 &lt;</td>
<td>6 - 9</td>
</tr>
<tr>
<td></td>
<td>Distance from Recreational attractive (KM)</td>
<td>0.084025</td>
<td>0 - 3</td>
<td>3 - 6</td>
</tr>
<tr>
<td>Slope (percent)</td>
<td>0.1922</td>
<td>0 - 12</td>
<td>12 - 25</td>
<td>25 - 45</td>
</tr>
<tr>
<td>Aspect</td>
<td>0.07326</td>
<td>Western</td>
<td>Northern</td>
<td>Southern</td>
</tr>
<tr>
<td>Elevation (M)</td>
<td>0.039325</td>
<td>500-1000</td>
<td>Northern</td>
<td>Southern</td>
</tr>
<tr>
<td>Erosion</td>
<td>0.02131</td>
<td>Very low</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>Soil type</td>
<td>0.02387</td>
<td>Deep with few rock particles</td>
<td>Deep with more rock particles</td>
<td>Shallow with many rock particles</td>
</tr>
<tr>
<td>Petrology</td>
<td>0.01796</td>
<td>Lime stones</td>
<td>Alluvial fan</td>
<td>Alluvial soils</td>
</tr>
</tbody>
</table>

In next step, required maps derived from reorganization of biological and ecological resources of the study area. These maps include distance from water resources, vegetation cover, distance from roads, distance from residential areas, distance from negative factors, distance from recreational attractive, slope, aspect, elevation, erosion rate, soil type and petrology.

The major result of this study is suitable areas map for local forest park locations (Fig. 2) that classified in 4 categories. The results showed that 2765.6 ha of study area (4.85%) has potential for first class (high suitable), 15794.1 ha (27.7 %) 30537.5 ha (53.54%) potential for second (moderate) and third (low) class, respectively.7930.5 ha (13.91%) has potential for fourth class (no suitable) (table 2).

Figure2. Map of suitability for local forest park of the study area
Table 2. area of different classes in map of suitability for local forest park of the study area

<table>
<thead>
<tr>
<th>Class (suitability)</th>
<th>Area (hectare)</th>
<th>Area (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2765.59</td>
<td>4.65</td>
</tr>
<tr>
<td>Moderate</td>
<td>15794.11</td>
<td>27.7</td>
</tr>
<tr>
<td>Low</td>
<td>30537.50</td>
<td>53.54</td>
</tr>
<tr>
<td>No suitability</td>
<td>7930.51</td>
<td>13.91</td>
</tr>
</tbody>
</table>

**DISCUSSION AND CONCLUSIONS**

In this study, analytic hierarchy process was used to optimal site selection for the potential urban forest park in the study area, based on the AHP. Criteria and Sub-criteria were determined and prioritized. Results of the experts' opinions indicated that the four-factor including distance from water resources, slope, forest density and distance from recreational attractive were the major factors in this area to optimal sites selection for the potential urban forest park. Results of Gul et al. (2006), Shirvani (2009) and Karami (2010) studies showed that distance from water resources is most important factor in recreational evaluation. This factor has the greatest influence on recreational potential and the areas where have the minimum distance from the water, have a higher value. The slope is important limiting parameter in planning of the recreational (Makhdooom, 2010; Barzekar, 2010), So that in Makhdooom's model (Makhdooom, 2010) and Jalilvand et al. (2011) study is the most important factor and Maximum utility for physical development funded in lower slope (Gul et al, 2006; Karami, 2010). Regarding to slope factor, study area has potential to planning for all types of outdoor recreation and ecotourism activities. Regarding to importance of forest density for recreational evaluation in many studies (Farajzadeh and Karami, 2004; Barzekar, 2006; Shirvani, 2009; Karami, 2010; Kumari et al, 2010), in this study used as important factor, too. Vegetation mapping results showed that more than half of the study area has forest cover, which shows good potential for the creation of the park. Regarding to areas which are closed to attractive sources that have a higher value and demand for recreation (Shirvani, 2009; Karami, 2010), in this study, distance from attractive and recreational resources (caves, ancient and holy places and etc) were considered for the evaluation and locating recreational forest park and areas with a minimum distance from attractions (less than 3 km) were evaluated as the best class. Field visit showed that these areas have a higher demand for outdoor recreation.

The results of the study area evaluation for forest park site selection showed that about 33% of the study area has good to excellent (class I and II) potential for urban forest park. According to the suitability map for the park, the central region of the study area has more capability than other regions. In fact, about 5% (2765.59 ha) of the study area has excellent potential for park establishing. These areas include areas forest cover that surrounding water resources. It can be because of weight and importance of water resources in the study area for developing new forest park. Approximately 14% of the study area hasn't suitability including regions with southern aspect, height elevation, less water resources and most steeper area. This area has slope of more than 100%, higher altitudes and includes rocky protrusions.

Since, the AHP is the logical way to compare options and select the best option according to all effective parameters, it can create the regulatory framework for collective participation in decision making and generate best decisions regarding to prioritization criteria and sub-criteria are using expert's opinions. In studies of Babai-Kafaki (2009), Jalilvand et al. (2011) and Karami et al. (2012) also expert's opinions were used for comparison using AHP. AHP has been proved to be a flexible and practical tool to select areas for local forest park in study area. This can be due to participation of experts and officials in the determination of the criteria and sub criteria using AHP. In addition, GIS could be utilized to support spatial decision-making, since; it has excellent capabilities for dealing with spatial issues. Solving a complex multiple criteria problem without spatial analytical and visualization tools could be computationally challenging, if not impossible. Therefore, this study can provide a framework for the planning process using GIS and AHP for Badreh County planning and its Results can be useful in the planning of local forest park and future land use planning in study area.

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