

**Land suitability assessment using ANP in a GIS environment for
Tourism Development Site (Case study: Lavasan-e Kuchak Rural
District, Tehran province, Iran)**

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Abstract

The selection of a tourism development site involves a complex array of decision criteria that may have interdependence relationships within and between them. This study assessed the possibility of establishing natural tourism development site in Lavasan-e Kuchak Rural District (Tehran province) in Iran by using analytic network process (ANP) in a geographical information system (GIS) environment. ANP and the overlaying process were done on GIS. Using 10 information layers in three main criteria including Site Feature, Infrastructures & Services, and Risk & Sensitive Areas, the land suitability map was produced and reclassified into 5 scored divisions from least suitable to most suitable areas. The results showed that about 15.87 of the area of Lavasan-e Kuchak Rural District is most suitable for establishment of tourism development.

Keywords: Tourism Development, Geographical information system (GIS), Site selection, ANP, Lavasan-e Kuchak Rural District

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Introduction

Today, Tourism is considered one of the world's largest industries that supporting more than 258 million jobs worldwide and generating some 9.1% of global Gross Domestic Product (GDP)[1]. Evaluating and selecting a suitable tourism development site has become one of the most critical issues for the tourism industry. Location decision has drawn increasing attention from academic and business communities in the past two decades. It has been well recognized that selection of a facility location has important strategic implications because a location decision will normally involve a long-term commitment of resources[2].

Geographic information systems (GIS) and multicriteria evaluation (MCE) techniques are the most common tools employed to solve site selection problems. However, each suffers from serious shortcomings. GIS is a great tool for handling physical suitability analysis. However, it has limited capabilities of incorporating the decision maker's preferences into the problem solving process. MCE is the proper tool for analyzing decision problems and evaluating alternatives based on a decision maker's values and preferences[3].

Analytic network process(ANP) is a Multi Criteria Evaluation (MCE) method that is a generalization of the analytic hierarchy process (AHP). These two models were proposed by Saaty[4]. Analytic Network Process (ANP) can help the decision makers to translate a number of variables and the relationships between them into manageable units of information. ANP has the capability to evaluate physical processes such as sustainable tourism using expert opinion to make the best selection among the variables under consideration. Recently, geographic information systems (GIS) integrated MCE models have been widely applied to environmental planning and engineering issues. The result of the ANP will be integrated into Geographic Information System (GIS) environment. GIS can be regarded as a tool that eases the mapping of Natural Tourism

Site's(NTS) conditions, which is useful in varied monitoring and assessment capacities. In addition to this, the predictive capability of modeling provides a thorough statistical framework for directing management activities by enabling characterization of NTS at any point on the landscape. Spatial data can be used to explore conflicts and assist decision-making. GIS can play a role in examining the suitability of locations for proposed developments, identifying conflicting interests and modeling relationships. Systematic evaluation of environmental impact is often hampered by information deficiencies. GIS seems particularly suited to this task. Hence, the strength of sustainable tourism planning can be enhanced by a GIS based Analytic Network Process.

One of the first studies of GIS in tourism planning is discussed by Berry (1991) in the US Virgin Islands. Using three models he defined conservation areas, ecological research areas and areas of residential and recreational development while, a fourth model was used for conflict resolution among competing uses[5]. Hakimi et al. (2011) used multi-criteria evaluation method and GIS as a practical instrument to evaluate the suitability of Guilan Province coast of Iran for sustainable tourism destinations. In order to select destination of sustainable coastal tourism using Analytical Hierarchy Process (AHP) and GIS, three distinct procedures were exercised, namely: Using GIS to generate information layers; GIS was used to analyze layers of information in order to determine primary coastal tourism sites by Boolean logics.; and lastly the utilization of GIS to analyze layers of information in order to determine priority of sustainable coastal tourism destination with AHP[6]. Similarly, Boyd and Butler (1993) demonstrated the application of GIS in the identification of areas suitable for ecotourism in Northern Ontario, Canada. At first, a resource inventory and a list of ecotourism criteria were developed. At a next stage GIS techniques were used to measure the ranking of different sites according to the set criteria and therefore, identify those with the 'best' potential[7]. Minagawa and Tanaka (1998) used GIS to locate areas suitable for tourism development at Lombok Island in Indonesia. The main objective was to propose a methodology for a GIS based tourism planning. Using map overlay and multi-criteria evaluation, a number of potential sites for tourism development were

identified[8]. Williams et al. (1996) also used GIS to record and analyze tourism resource inventory information in British Columbia, Canada. He developed a tourism capability map which indicates areas of high, moderate and low capability for specific tourism activities[9]. Boers and Cottrell (2007) used GIS in sustainable tourism infrastructure planning, which involves three phases: a visitor segmentation phase, a zoning phase and a transportation network planning phase[10]. Bunruamkaew and Murayam (2011) used GIS and AHP to identify and prioritize the potential ecotourism sites in Surat Thani Province, Thailand. He used four steps to produce site suitability map for ecotourism and these are: finding suitable factors to be used in the analysis; Assigning factor priority to the parameters involved; Generating land suitability map of ecotourism; and determining ecotourism potential areas[11].

Looking at the previous studies, they only utilized Analytic Hierarchy Process (AHP) of Multi-Criteria Evaluation (MCE) on dealing with tourism issues. However, AHP has been criticized to be insufficient in handling complex decision problems like sustainable tourism. AHP considers elements to be independent of all others, which rarely occurs in real life situation. For this reason, the AHP technique has been widely condemned[12]. In general, AHP's failure is attributed to the fact that, the weight of each criterion is independent of the evaluations of the available alternatives with respect to this criterion, which is caused by the way, in which the method derives these weights from decision-makers. ANP which is a more general form of the Analytic Hierarchy Process (AHP) in Multi Criteria Evaluation (MCE) will provide a significant benefit to sustainable tourism planning. ANP can model complex decision problems where AHP is not sufficient. ANP allows interaction and feedback within clusters (inner-dependence) and between clusters (outer-dependence) [13]. Like in many real world situations ANP considers elements to be interdependent to each other thus making accurate predictions. ANP provides a thorough framework to include clusters of elements connected in any desired way to investigate the process of deriving ratio scale priorities from the distribution of influence among elements and among clusters[14]. The Analytic Network Process through feedback can better capture the complex effects of interplay in human

society and subsequently guides to the best choice in a way that matches the common sense.

According to ANP advantages, some scholars use methods which utilized ANP and GIS on dealing with tourism issues. Aminu et al (2013) presents an approach based on an integrated use of GIS, ANP and Water Quality Index (WQI) for sustainable tourism planning in a wetland environment[15]. Eldrandaly and AL-Amari (2014) proposed decision making framework in which expert systems (ES), and geographic information systems–based multicriteria evaluation techniques (Analytical Network Process and fuzzy quantifiers-guided ordered weighted averaging operators (GIS-based ANP-OWA)) are integrated systematically to facilitate the selection of suitable sites for building new tourism facilities[16]. Therefore, This study aims to make the best selection among the factors responsible for Natural Tourism Sites(NTS) using ANP and translate the result of ANP into spatial models using GIS techniques.

2. Area of the study

Lavasan-e Kuchak Rural District is a rural district (dehestan) in Lavasanat District, Shemiranat County, Tehran Province, Iran. At the 2011 census, its population was 6, 036. its geographical coordinates are 35° 49' 30" North, 51° 46' 58" East(Fig. 1). Lavasan has been acknowledged as one of the most beautiful natural attractions in Tehran province. are famous attractions which there are several natural tourism attraction such as Barg-e Jahan, Afjeh, Dasht-e Havij in Lavasan-e Kuchak Rural District.

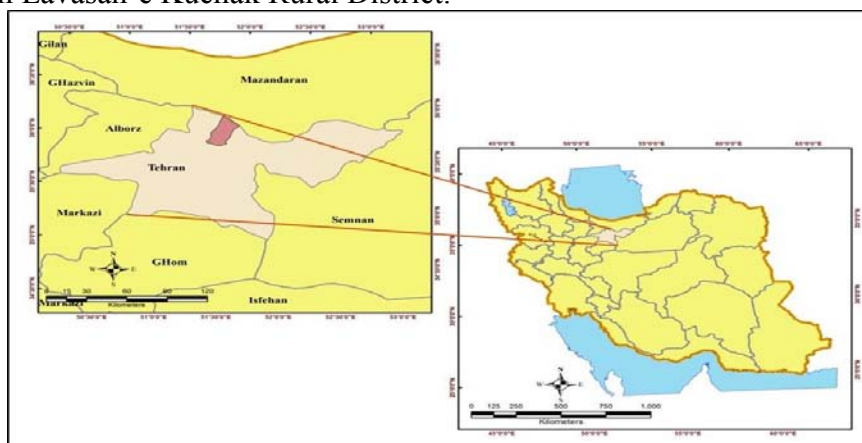


Fig. 1 Location Lavasan-e Kuchak in Iran

3. Materials and methods

3.1. Methodology

The goal in a site selection exercise is to find the best location with desired conditions that satisfy predetermined selection criteria[17]. The selection process attempts to optimize a number of objectives in determining the suitability of a particular site for a defined Natural Tourism (NT) Sites. The process of NT site selection is shown in Fig. 2.

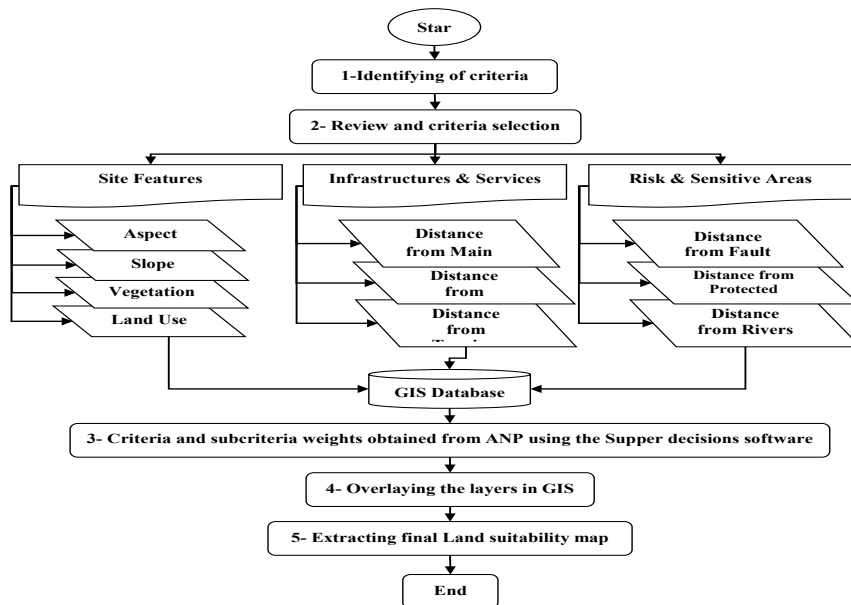


Fig. 2 The overall process of NT site selection in ANP method

First (in step 1), criteria was gathered; if some information for site selection was not available, an attempt was made to consider the most influential technical, economic, and environmental parameters. In step 2, using local conditions, a literature review and the opinions of experts, different criteria were reviewed and 10 criteria were selected in three main groups. These were the most important criteria for selecting suitable sites and establishing NT and are shown in Fig. 2 and explained in Table 1. Ten information layers were prepared and converted to a raster format. Preliminary spatial analyses were performed on them to implement ANP in the GIS and to establish a database. In step 3, ANP was used to weight the criteria. Overlaying

was done using GIS in step 4 and, finally, the land suitability map was reclassified into five equally scored zones from least suitable to most suitable in step 5. The GIS datasets of the 10 criteria were collected from sources shown in Table 1.

Table 1 List and description of criteria for NTs site selection

Cluster	Criteria	Sources
Site Features	Aspect	Iran's DEM (National Cartographic Center of Iran (NCC))
	Slope	Iran's DEM (National Cartographic Center of Iran (NCC))
	Vegetation	Forests, Range and Watershed Management Organization
	Land Use	Forests, Range and Watershed Management Organization
Infrastructures & Services	Distance from Main Road	National Cartographic Center of Iran (NCC))
	Distance from Settlement	National Cartographic Center of Iran (NCC))
	Distance from Tourism Sites	Cultural Heritage, Handcrafts and Tourism Organization
Risk & Sensitive Areas	Distance from Fault	Geological Survey of Iran(GSI)
	Distance from Protected Areas	Department of Environment (Iran)
	Distance from Rivers	Ministry of Energy

3.2. ANP

ANP is an extension of the AHP; indeed, it is the general form of the AHP. These two models are proposed by Saaty [4]. AHP is a well-known technique that breaks down a decision-making problem into several levels in such a way that they form a hierarchy with unidirectional hierarchical relationships between levels[18] but ANP is a nonlinear structure with bilateral relationships (Fig. 3).

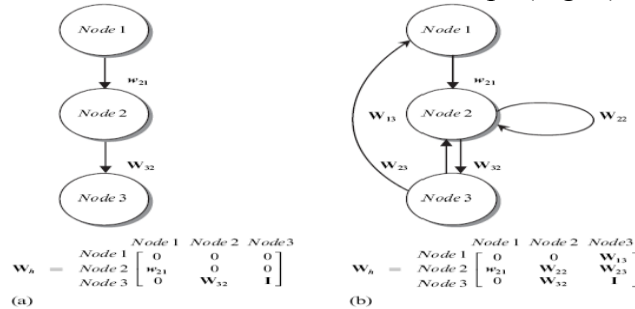


Fig. 3 Structural difference between a) a linear Hierarchy; b) a nonlinear network

So the main innovation of the ANP is its network structure, which enables interactions between elements situated in different clusters and dependencies between the elements in the same cluster to be taken into account[12, 19]. In this paper, ANP is used to obtain the weight of the criteria. The application steps of ANP can be described in the following steps.

Step 1: As mentioned above, the first step is to construct a conceptual model and to determine relationships between/among clusters and nodes. The conceptual model (Fig. 4) is constructed and the relationships (shown by arrows in the conceptual model) between/among clusters, and nodes are determined.

Step 2: Criteria are compared, using Super Decisions software (Fig. 5), in the whole network in order to form an unweighted supermatrix by pairwise comparisons (the same as the AHP). In this phase, decision makers compare two elements. Pairwise comparisons are made with the grades ranging from 1–9 [20]. A reciprocal value of each number is used to express the inverse comparison. The values of pairwise comparisons are allocated in the comparison matrix and local priority vector is derived from eigenvector. Consistency of pairwise matrix like the AHP must be less than 0.1 [21].

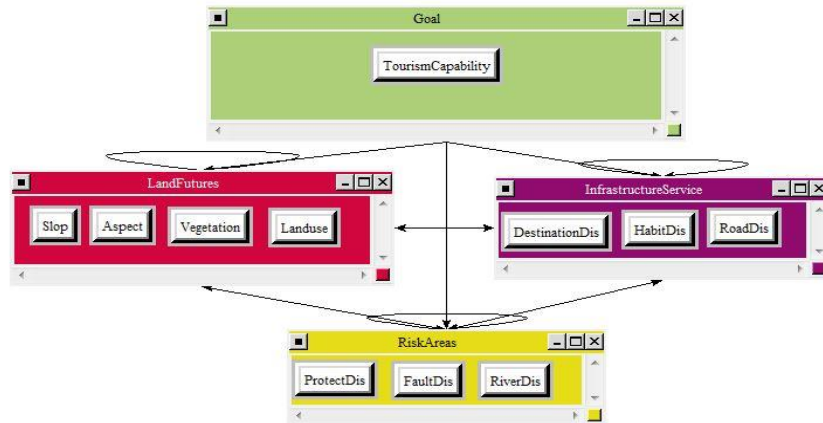


Fig. 4 conceptual model of NT site selection in ANP

1. Landuse	>=9.5	9	8	7	6	5	4	3	2	2	3	4	5	6	7	8	9	>=9.5	No comp.	Slop
2. Landuse	>=9.5	9	8	7	6	5	4	3	2	2	3	4	5	6	7	8	9	>=9.5	No comp.	Vegetation
3. Slop	>=9.5	9	8	7	6	5	4	3	2	2	3	4	5	6	7	8	9	>=9.5	No comp.	Vegetation

Fig. 5 Pairwise comparisons in super decisions software

Step 3: The weights obtained from the previous steps are introduced into the supermatrix that includes the entire network components and represents their inter relationships. In this step, supermatrix is called the initial supermatrix. Equation (1) shows the general form of the supermatrix:

$$W = \begin{matrix} & \begin{matrix} C_1 & C_2 & \dots & C_n \\ e_{11} \dots e_{1m_1} & e_{21} \dots e_{2m_2} & \dots & e_{n1} \dots e_{nm_n} \end{matrix} \\ \begin{matrix} C_1 \\ e_{11} \\ e_{12} \\ \vdots \\ e_{1m_1} \\ C_2 \\ e_{21} \\ e_{22} \\ \vdots \\ e_{2m_2} \\ \vdots \\ C_n \\ e_{n1} \\ e_{n2} \\ \vdots \\ e_{nm_n} \end{matrix} & \begin{bmatrix} W_{11} & W_{12} & \dots & W_{1n} \\ W_{12} & W_{22} & \dots & W_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ W_{n1} & W_{n2} & \dots & W_{nn} \end{bmatrix} \end{matrix}$$

C_k is the kth cluster ($k=1, 2, \dots, N$) which has n_k elements denoted as $e_{k1}, e_{k2}, \dots, e_{knk}$. A matrix segment, W_{ij} , represents a relationship between the ith cluster and the jth cluster. Each column of W_{ij} is a local priority vector obtained from the corresponding pairwise comparison, representing the importance of the elements in the ith cluster on an element in the jth cluster [22]. The new obtained matrix is known as the weighted supermatrix.

Step 4: The cluster weights should be calculated in this step in order to weigh the initial supermatrix. When the cluster weight matrix has been obtained, the initial supermatrix can be weighted by multiplying the cluster weights matrix by an initial supermatrix [12]. The new obtained matrix is known as the weighted supermatrix.

Step5: The final step consists of multiplying the weighted supermatrix n times by itself until the limit supermatrix is reached. Some super matrices may have a cyclicity effect. As a result, two or more final limit super matrixes may be obtained. The main property of the limit supermatrix is that its columns are equal and represent the global.

4. Results and discussion

This research will produce a model based on an integrated use of GIS and ANP for natural tourism development. The model will have three sub-models(Clusters), namely: Site Feature Model, Infrastructures & Services Model, and Risk & Sensitive Areas Model. According to methodology, Input data layers was produced natural tourism site selection(Fig. 6). Figure 6 is based on information from Tables 1 to prepare input layers and convert them to raster format.

After establishing a database, Super Decisions software [23] was used for ANP to obtain the final weights; the final weights of the criteria for ANP are shown in Table 2. By applying the weights in Table 2, overlaying was done in GIS and a land suitability map was obtained.

Table 2 The final weights for criteria land suitability assessment (Lavasane-e Kuchak Rural District)

Criteria	Weight	Rank
Distance from Tourism Sites	0.616409	1
Distance from Protected Areas	0.142433	2
Land Use	0.094525	3
Distance from Fault	0.034329	4
Distance from Rivers	0.032908	5
Aspect	0.032319	6
Vegetation	0.023317	7
Distance from Settlement	0.010256	8
Slope	0.009674	9
Distance from Main Road	0.00383	10

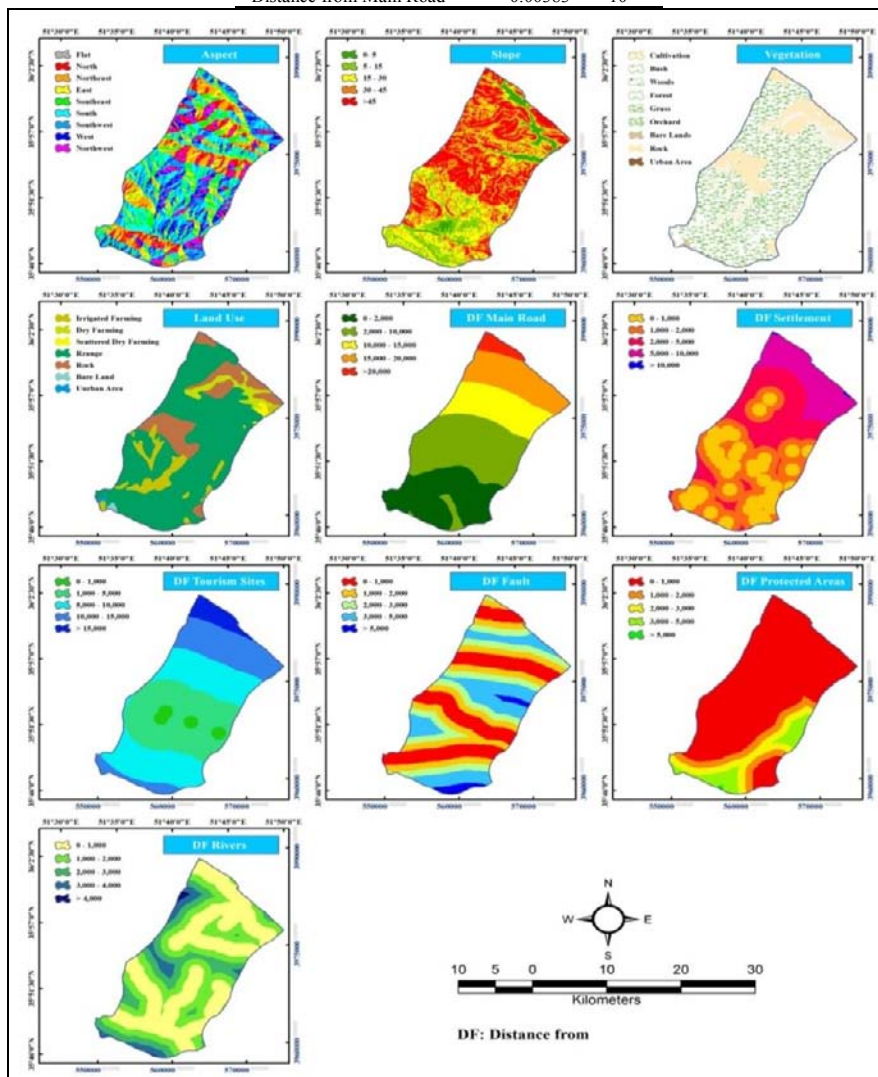


Fig. 6 Input data layers in natural tourism site selection (Lavasane-e Kuchak Rural District)

The final zoning maps of the ANP models were reclassified and are presented in Fig. 7. Table 3 shows the five zones derived from ANP model. Distribution of weights in the ANP model (Table 3) are oriented toward the center divisions (moderately suitable, highly suitable). Although high classes (Extremely suitable, High suitable) are located in center of Lavasan-e Kuchak Rural District, area where important tourism villages (such as Barg-e Jahan, Afjeh, Kond ‘Olyā, and Kond Soflá) located there.

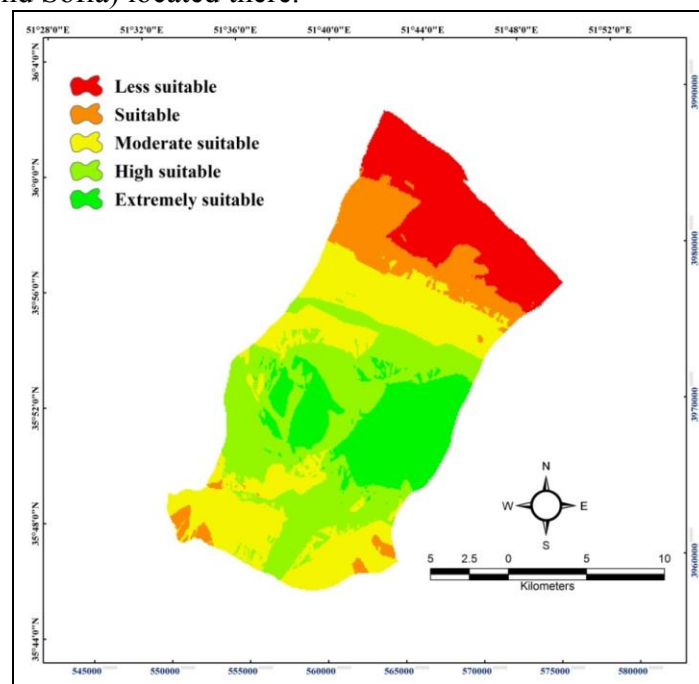


Fig. 7 Land suitability maps in ANP (Lavasane Kuchak Rural District)

Table 3 The areas of classes of final land suitability map (Lavasane Kuchak Rural District)

Classes	Area (km ²)	Area (%)
Less suitable	60396	16.35
Suitable	42561	11.52
Moderate suitable	105419	28.54
High suitable	102335	27.71
Extremely suitable	58597	15.87
Total	369307	100

5. Conclusions

The tourism development site selection process has become increasingly complex because of the plethora of environmental laws and regulations as well as the greater public awareness and

involvement in the zoning and environmental issues. GIS and MCE are very vital efficient tools for solving sitting problem. However, each of these tools has its own limitations and drawbacks in solving such problem. The integration of these techniques eliminates these limitations and provides the decision maker with an innovative approach to sitting problem. Although many recent publications discussed the application of MCE and GIS in a variety of sitting problems, only a few of them are related to tourism development site selection problems.

This paper presents a new decision making framework in which GIS and ANP are integrated systematically to handle tourism development site selection decisions. According to the type of the proposed tourism facility, an expert system is used to define the recommended sitting criteria and the interdependence relationships within and between them.

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