Pollution, 2(2): 163-181 , Spring 2016
DOI: 10.7508/pj.2016.02.006
Print ISSN 2383-451X Online ISSN: 2383-4501
Web Page: https://jpoll.ut.ac.ir Email: jpoll@ut.ac.ir

Optimization of Recreational Site Selection Using Multi Criteria Evaluation and Functional Relationship Diagram (Case Study: Miankaleh Wildlife Sanctuary)

Masoodi, M.[1*], Salman Mahiny, A.[2], Mohammadzadeh, M.[3] and Hamed Mirkarimi, H.[3]

1. MSc. Graduate in Environmental Science, Gorgan University of Agricultural and Natural Resources, Gorgan, Iran
2. Associate Professor, Faculty of Environment Science, Gorgan University of Agricultural and Natural Resources, Gorgan, Iran
3. Assistance Professor, Faculty of Environment Science, Gorgan University of Agricultural and Natural Resources, Gorgan, Iran

Received: 31 Oct. 2014 Accepted: 22 Dec. 2015

ABSTRACT: Today, ecotourism is a major tourist activity around the world. It is based on environment potential through which suitable utilization and conservation of sites under management practices including considering accurate planning, potential, and peoples' preferences are realized. The present study was conducted to determine people's recreational preferences using questionnaires to evaluate the ecotourism potentials (recreational activities that choice in questioner by visitors) for site selection and land use planning, and to analyze the functional relationships among zones in the MianKaleh wildlife sanctuary, south of the Caspian Sea in Mazandaran and Golestan Provinces of Iran. Recreational preferences of people were found to be bird watching, swimming, camping, sightseeing, horse riding, and boating. Multi Criteria Evaluation was used to assess the ecotourism potential. For land use planning, the Multi Objective Land Allocation function included environmental suitability maps, zone weighting, and a set of desirable areas for each zone. Post processing functions (filters, zone size, and distance to other zones) and functional relationship diagrams were applied to amend the zoning maps. The functional relationship diagram concept was applied to the amended maps for optimizing access and identifying the relationships among zones. Overall, the results revealed that MCE and MOLA methods are capable of evaluating and zoning the wildlife sanctuary. Furthermore, post-processing and functional relationship diagrams were effective in selecting recreational sites. The results of this research revealed the recreational potential of MianKaleh wildlife sanctuary. Land planning for ecotourism can now be implemented using the results of this study that will upgrade the conservation status in the area.

Keywords: ecotourism, functional relationship diagram, land use planning, MCE, MOLA.

INTRODUCTION

Ecotourism known as a form of sustainable tourism expected to contribute to both conservation and development (Tsaur and Lin, 2006; Bunruamkaew and Murayama, 2011). Ecotourism is more than the well-known definition by Ceballos-Lascura´ (1996) in as ʽtravelling to relatively undisturbed natural areas' for its biological and cultural features. It is about the preservation of the environment and promoting tourism such that the tourist

*Corresponding Author: Masoodi_m65@yahoomail.com

does not harm the environment. It has the potential to be a prosperous industry while providing for ecologically sustainable development in any region that has a unique natural environment (Courvisanos and Jaina, 2006). Ecotourism can therefore be defined as an opportunity to promote certain values in protected areas and to finance related stakeholders (OK, 2006).

Appropriate management for ecotourism development is essential in order to maximize positive impacts and minimize negative impacts on all aspects of tourism. This will help conserve and maintain the biological richness of the areas and provide opportunities for ecotourism management (Courvisanos and Jaina, 2006). Unfortunately, due to inadequate environmental assessments and audits, many ecotourism destinations tend to be both hazardous and self-destructive (Tsaur and Lin, 2006). Ecotourism evaluation and site selection should be regarded as important tools for the sustainable development of tourism in protected areas (Ceballos-Lascurain, 1996). The goal of zoning and site selection exercises is to find the optimum location that satisfies a number of predefined criteria (Healey and Ilbery, 1990). The process of site selection typically involves two main phases: screening (identifying a limited number of candidate sites from a broad geographical area given a range of selection factors) and evaluation (Vahidnia and *et al*., 2009).

Land evaluation is the process of predicting the potential use of land on the basis of its attributes. A variety of analytical methods are used to make these predictions (Rossiter, 1996). Traditional methods of GIS site selection and evaluation are based on the transformation of effective layers into classified maps, for example, through use of a Boolean model (Louviere *et al*., 2000). The Boolean model, however, has defects such as giving equal value to all suitable areas regardless of their position in reference to their factors (Hajehforooshnia *et al*., 2011). A few studies have been implemented on evaluating and zoning protected areas in Iran, and nearly all of them are based on Boolean logic using either the MacHarg or Makhdoum method (Makhdoum, 2001).

Recent developments in the Geographical Information System (GIS) have led to significant improvements in our capability for decision-making processes in land allocation and environmental management using Multi Criteria Evaluation (MCE) (Caver, 1991). MCE refers to the concepts, approaches, models, and methods that aid an evaluation (expressed by weights, values or intensities of preference) according to several criteria (Barredo, 1996) which ultimately may lead to better decision-making (Shahadat *et al*., 2009). MCE also is an effective tool for multiple criteria decision-making (Malcewski, 2006). The purpose of MCE is to investigate a choice among a number of possibilities from multiple criteria and multiple objectives (Cover, 1991), MCE is most commonly achieved by one of two procedures: The first involves Boolean overlay whereby all criteria are reduced to logical statements of suitability and then combined by means of one or more logical operators such as intersection (AND) and union (OR). The second is known as weighted linear combination (WLC) wherein continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average (Eastman, 2003). Unlike the Boolean operations, WLC is a compensatory method in the sense that a low score on one suitability criterion can be compensated by a high suitability one another (Eastman *et al*., 1995).

The capabilities of GIS and MCE for spatial decision making have been used in several studies (Sun and Mersey, 2001; Gul *et al*., 2006; Kumari *et al*., 2010; Mahiny *et al*., 2007) are examples of studies that have used MCE and GIS for land evaluation.

After determining suitability maps with MCE, conflicted activities and zones should be solved, so high suitable activities or zones would allocate to specific area. Multi Objective Land Allocation (MOLA) which uses a decision heuristic to resolve conflicts is proper method for this case. MOLA provides a procedure for solving multi-objective land allocation problems for cases with conflicting objectives (Eastman, 2003).

So, MCE and MOLA methods enable decision makers to evaluate the relative priorities of protected areas based on a set of preferences, criteria, and indicators and provide a procedure for solving multi-objective land allocation problems for cases with conflicting objectives. Geneletti and Duren (2008) studied a national park in Italy and, by identifying the spatial factors affecting different zones, used the MOLA function to zone the area. Hajehforooshnia *et al*. (2011) used MCE and MOLA to evaluate and zoning the Ghamishloo wildlife sanctuary in Iran. This study is one of the few studies that use MCE and MOLA for zoning protected areas in Iran.

This research attempts to evaluate environmental and recreational capabilities in Miankaleh Sanctuary using a Spatial Decision Support System (SDSS) which includes an approach in MCE named Weighted Linear Combination (WLC) and MOLA integrated with GIS. The reasons for the popularity of these methods are that they are easy to implement within the GIS environment using map algebra operations, and the methods are easy-to-understand and intuitively appealing to decision makers. Also, WLC approach is an averaging technique that softens the hard decisions of the Boolean approach and avoids the extremes. In fact, given a continuum of risk from minimum to maximum, WLC falls exactly in the middle; it is neither risk-averse nor risk-taking (Eastman, 2003).

Manual approach known as the functional relationship diagram was used to optimize site selection. The functional relationships diagram is a manual approach to recreational facilities planning. It delineates the optimal relationships between activities and facilities (U.S. Army Corps of Engineers, 1998) The zoning method (MOLA) per se suffers from shortcomings such as negligence of neighborhood and expert views in zoning the area. The functional relationships diagram consists of analyzing the interactions between facilities and activities to determine whether a given pair of uses spots need to be linked or separated in order to function properly and be compatible (U.S. Army Corps of Engineers, 1994; Ruthledge, 1985).

Generally this automatic evaluation and zoning processes through GIS can avoid subjectivity in terms of defining the zones, and consequently can avoid the conflicts between conservation and local development. With regard to the availability of methods for automatic evaluation and zoning of protected areas, few cases exist in Iran in which an improvement from the manual map overlay method has been exercised. This study exemplifies the advantages of using automatic MCE and MOLA method for planning protected area in Iran.

With an environmental evaluation of Miankaleh wildlife sanctuary, this study intends to provide a proper approach for identifying and selecting sites for various recreational activities and zones.

Figure 1 shows the process of recreational site selection and zoning of the area.

MATERIALS AND METHODS

Study area

MianKaleh wildlife sanctuary is located in Mazandaran Province and in Behshahr city to the north of Iran and south of Caspian Sea. It is bounded by latitudes 36˚ 46' 36" to 36˚ 57' 26" N and longitudes 53˚ 24' 28" to 54˚ 2' 2" E. that covers an area of

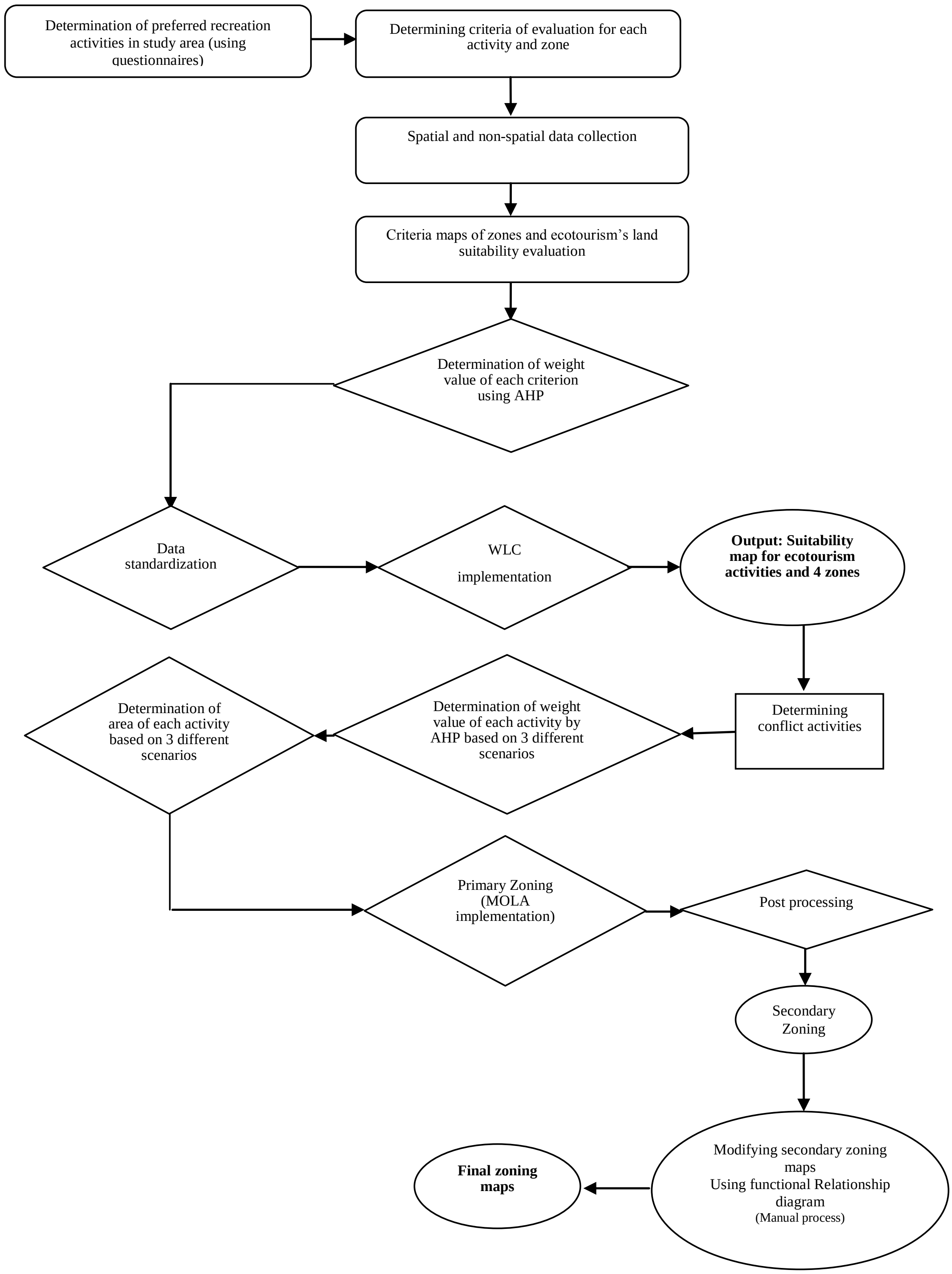


Fig. 1. Structured framework of Multi Criteria and Multi Objective Decision making process

approximately 68800 hectares. Elevation of the area is 25 meter below sea level. The area is completely flat (Department of Environmental Conservation, 2002) and well known for its landscape beauty and rich collection of diverse plants and animals. This Sanctuary appears to have many attributes needed for the successful development of ecotourism. Vegetation cover, birds, and native people living in the vicinity all increase the value of the area for case study to demonstrate the application of the methodology. A map of the MianKaleh wildlife sanctuary and its location is shown in Figure 2.

The boundary of the area was provided from Department of Environmental Conservation and was modified considering study objectives (requirements of recreation activities specially swimming and boating (e.g. maximum sea depth for Swimming and Boating are considered to be 3 m and 6 m respectively) and bathymetric layer.

Map preparation and basic information layers

Data used in this study were collected from a variety of sources (Table 1); layers showing land use and access routes were corrected using a satellite image (Landsat ETM^+, 2009) and control points were determined by field surveys. An interpolated bathymetric layer was prepared using Isobaths layers and SPLINE method. SPLINE is an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

Table 1. List of data and original sources (data acquisition)

Data	Source
Digital Elevation Model (DEM), Original boundary	Department of Mapping
Isobaths or depth contours -Vegetation type-Land use Soil texture, Accessibility routes	MianKaleh wildlife sanctuary Management Plan, Department of Environmental Conservation
Landsat satellite image	Sensor ETM^+ 2009
Vegetation cover (Vegetation density)	NDVI Index
Natural and cultural attractions	Field Survey with GPS
Distribution of birds and wildlife	Field Survey and interviews with local experts

Areas of Scenic beauty in the landscape

Attraction points were located for areas of scenic beauty. Coordinates for some of these points (cultural or natural attractions such as monuments and the Elm Grove) were determined using GPS and other features such as seashore and swamps were extracted from available maps. Then, those points without a view were discarded and a map showing combinations of attractions and accessibility, was determined (Sirusi, 2011).

After collection of information a database was prepared for further modifications such as Geo-referencing. Lacking data were obtained using satellite images and control points, and pixel size of all layers were standardized at 30 meters. All maps and images were transformed into Universal Transverse Mercator (UTM) projection.

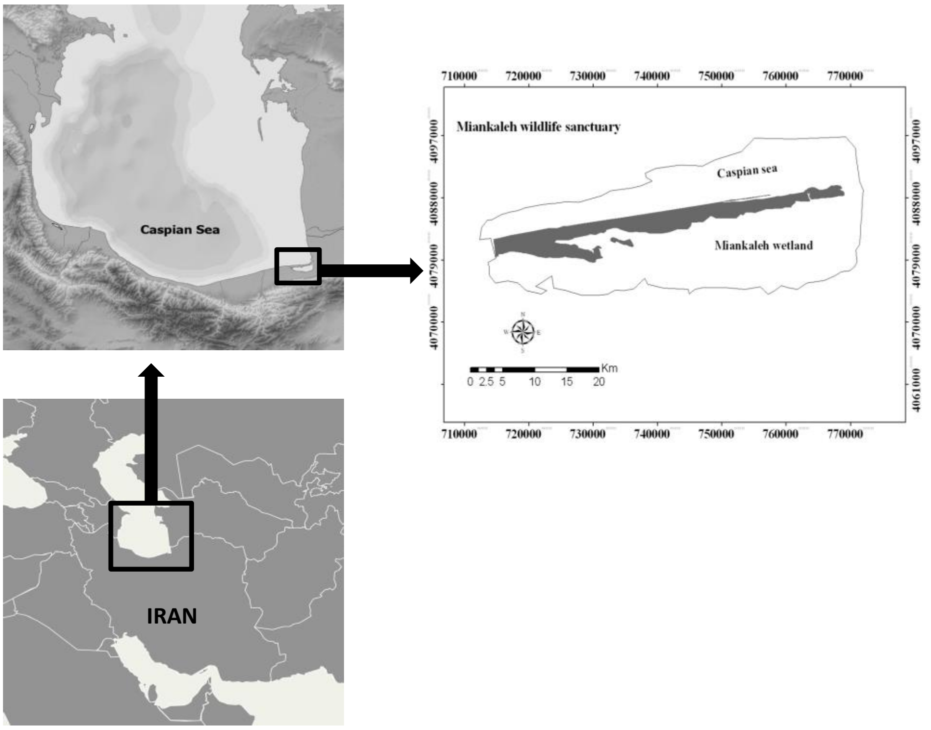


Fig. 2. Location of MianKaleh wildlife sanctuary

METHODOLOGY

In this research multiple criteria are aggregated into a single evaluation score for each decision alternative, namely recreation activities and four zones being as; strict nature reserve zone, conservation zone, rehabilitation zone and cultural zone according to the weighted linear combination (WLC). Weighted linear combination (WLC) is considered as the most straightforward and the most often employed method of MCE for land suitability analysis (Malczewski, 2004). It involves standardization of the suitability maps, assigning the weights of relative importance to the suitability's maps, and then combining the weights and standardized suitability maps to obtain an overall suitability score (Hanbali *et al*., 2011). It has traditionally dominated the use of GIS as a decision support tool (Malczewski, 2006). The WLC method employs the following 4 steps: 1. Objective determination, 2. Criteria determination, 3. Standardization of criteria and 4. Weighting criteria.

The objective was to apply a variety of recreational activities within a study area. So the first step was to determine recreational activities applicable to the MianKaleh wildlife sanctuary; this was determined using expert opinion in accordance with local conditions and people's preferences. Fourteen recreational activities were selected as follows: bird watching, swimming, nature photography and filming, sightseeing, horse riding, boating (paddle), fishing, resting, research, camping, cultural and sightseeing, picnics, cycling, and hunting. In order to rank selected activities, questionnaires were selected in data collection methods. Each questionnaire included twenty one multiple choice and rank order questions which were about recreational priorities and preferences among visitors. There were also some questions about personal information of respondents e. g. age, sex, city, etc. The respondents were chosen randomly to covers all ages.

After three visits covering three seasons (spring, summer, and fall) and distribution of 150 questionnaires, the six top ranked activities were selected from visitors' preferences. Visitors' preferences were determined by Eq. (1) (Masoodi *et al*., 2010).

$$X = \left[\left(\frac{n_i - n_{\min}}{N} \right) * n_i \right] + \left[(W_R) * R \right] \quad (1)$$

where X is preference of recreational activity, n_i is the number of people per rank i, $n_{i\ min}$ is the least number of people that determine rank i for any activity, R is rank, w_R is weight of the rank, and N is the total number of people (samples). Also, weight of ranks (W_R) was determined using the fuzz rank between 0 to 1 values.

Finally, the six highest preferences of recreational activities were: bird watching, swimming, camping, sightseeing, horse riding and boating. After determination of objectives and preferred activities, analysis was done to determine influential criteria affecting each zone by reviewing resources and expert opinions. A criterion is some basis for a decision that can be measured and evaluated. It is the evidence upon which an individual can be assigned to a decision set (Eastman *et al*., 1995). Criteria can be two kinds: factors that show suitability of an alternative and those constraints that show no suitability (Eastman, 2006). In this study, with the exception of six recreational activities, four zones including strict nature reserve zone, conservation zone, rehabilitation zone and cultural zone were evaluated and located. Criteria applicable to six activities and other zones are shown in Table 3.

For WLC evaluation, based on formula 2 (Eastman *et al*., 1995; Eastman, 2003, 2006), each factor was multiplied to its corresponding weight and then these sums were multiplied to the product of constraints and a suitability map was acquired for each use (Giordano and Riedel, 2008).

$$S = \sum W_i X_i \prod C_j \quad (2)$$

where *S* suitability, W_i weight of factor i, X_i fuzzy value of factor i, C_j constraint j, Π product (Multiplication sign).

The MCE method which used in this study required that all factors be standardized. The criteria maps were each originally measured in a different scale so factors needed to be standardized to a suitable and uniform rating scale before combination using the formulas above (Eastman, 2003). Standardization transforms the disparate measurement units of factor maps into comparable suitability values (Eastman, 2003; Mahiny and Gholamalifard, 2006). The Fuzzy set membership was applied to standardize the factors. This method also provided a useful means of dealing with uncertainty as a result of imprecise boundaries between suitability classes (McBratne and Odeh, 1997). This approach attempts to turn the artificially crisp and clear-cut criteria of the Boolean approach into real-life continuous criteria that express a degree of suitability and enables decision makers to evaluate the relative priorities of conserving the area (Hajehforooshnia *et al*., 2011). Fuzzy set membership functions provides the option of standardizing factors to either a 0-1 real number scale or a 0-255 byte scale. This latter option is recommended because the MCE module has been optimized for speed using a 0-255 level standardization. Importantly, the higher value of the standardized scale must represent the case of being more likely to belong to the decision set (Eastman, 2003). In order to implement fuzzy sets for standardizing criteria maps, it is essential to determine Membership functions shape and type and variables threshold values (effective range). Fuzzy sets which used in this study were monotonically increasing, monotonically decreasing and symmetric functions in Linear, Sigmoid (or S shape) and user defined shapes. Fuzzy membership functions which used in this research have shown in Table 3.

A constraint serves to limit the alternatives under consideration constraints classify the areas into two classes:

unsuitable (value 0) or suitable (value 1).

Factor weighting in MCE gives priority to criteria and is measured by decision makers from weights given to criteria and sub-criteria. The Analytical Hierarchy Process (AHP) method was used to weight factors (Saaty, 1980). After gathering AHP questionnaires, evaluations for final weight of criteria and inconsistency index were calculated using the AHP method. To ensure the credibility of the relative significance used, AHP also provides measures to determine inconsistency of judgments mathematically Saaty (1980) suggests that if consistency ratio (CR) is smaller than 0.10, then degree of consistency is acceptable. Consistency ratios for the factors relevant to each zone and activity are given in Table 2.

Combinations of criteria were implemented using Idrisi software through WLC method. In this study suitability map for each zone and activity is the final output of WLC method. Each map has a range of values as the standardized factor maps that were used. After providing Strict Nature Reserve suitability map from WLC, range of values was stretched to 0-255, then higher values (217-255) considered as Strict Nature Reserve zone.

Generally parameters which are important in determining Strict Nature Reserve zone are also effective in providing conservation zone, but the later includes lower range of values. It is more often to locate conservation zone as a buffer around Strict Nature Reserve zone, so human impacts will be minimized automatically. Therefore a 200 m buffer was used to determine conservation zone from Strict Nature Reserve zone which was provided previously. The outcome zone was combined with an arbitrarily zone with 215-217 range of values, so the final conservation zone will be uniform. It is notable that conservation zone's extent could be increase with inutile areas after site selection for all zones and activities.

As in this study cultural zone has just one factor, formula 2 is not a proper way to gain suitability so a 500 m buffer for each cultural site was used for cultural zone extraction.

Also for determining rehabilitation zone, rehabilitation suitability map was stretched to 0-255 range of values then higher values (150-255) considered as the rehabilitation zone.

Table 2. The inconsistency index for the zones and activities

Zones	Inconsistency value of AHP
Strict nature Reserve	0.06
Rehabilitation	0.06
Bird watching	0.04
Swimming	0.05
Camping	0.06
Sightseeing	0.08
Horse riding	0.04
Boating	0.05

Land use planning by MOLA

Multi Objective Land Allocation (MOLA) modeling was used to allocate an area of the MianKaleh wildlife sanctuary for each zone. A multi-objective land allocation procedure was undertaken to assign a zone to each land unit, it also provided a procedure for solving MOLA problems for cases with conflicting objectives (Eastman, 2003). It was also used to determine a compromise solution in an attempt to maximize the suitability of land for each objective with respect to its assigned weights. It then reclassifies the ranked suitability maps to perform first stage allocations, to check for conflicts and then to allocate conflicts based on a minimum-distance-to-ideal-point rule using the weighted ranks. The first step was to use the RANK module to rank cells in each suitability map. This prepared data for use with the MOLA procedure and had the additional effect of standardizing the suitability of each map using a non-parametric histogram equalization technique. RANK orders the cells in a byte binary image. Its primary application is in decision making where a specific area (or number of cells) is required

Table 3. Factors, effective ranges and standardization function

Criteria		recreational activity								
	Factors	**birding**	**Swimming**	**Camping**	**Viewing scenery**	**Horse riding**	**Boating**	**Strict Nature Reserve**	**rehabilitation**	**cultural**
1	**Distance from water resource**	≥100m Liner decreasing	≥100m Liner decreasing	≥100m-2000m≥ Liner decreasing	≥100m Liner decreasing	≥100m-2000m≥ Liner decreasing	≥100m Liner decreasing	Not used	Not used	Not used
2	**Distance from aquatic plant**	Not use	≥50m Liner increasing	Not use	Not use	Not use	≥50m Liner increasing	Liner decreasing	Not used	Not used
3	**Soil**	Not use	Not use	**High suit:** Y. D & O.D[1] **Not suit:** ZM & swamp	Not use	**High suit:** Y. D & O.D **Not suit:** ZM &Swamp	Not used	**High suit:** SH-k & ZM[2] **Moderate suit:** Y. D & O.D	Not used	Not used
4	**Vegetation cover**	Marginal to high Liner increasing	Not used	Marginal to high Liner decreasing	Marginal to high Liner increasing	Marginal to high Liner decreasing	Not used	Liner increasing	Not used	Not used
5	**Plant type**	Not used	Not used	**High suit:** Alnus sabcordata &Ar.ts **Moderate suit:** Sa.so+sa.he **Not suit:** Pu.gr, pu.gr+ra.pe,pu.gr+rh.pa, w.p> 50cm, w.p< 50cm ju.ma+ju.ca, ju.ac	**High suit:** Alnus subcordata **Moderate suit:** Pu.gr, pu.gr+ra.pe,pu.gr+rh.pa **Marginal suit:** other types	**High suit:** Ar.ts, ju.ma+ju.ca, ju.ac **Moderate suit:** Alnus sabcordata. Sa.so+sa.he, w.p< 50cm **Not suit:** Pu.gr, pu.gr+ra.pe,pu.gr+rh.pa, w.p> 50cm	Not used	**High suit**: Alnus subcordata **Moderate suit:** Pu.gr, pu.gr+ra.pe,pu.gr+rh.pa, Ar.ts	Not used	Not used
6	**scenic beauties**	Not used	Not used	Not used	≥100m-300m≥ S symmetric	Not used	Not used	Not used	Not used	Not used
7	**Water depth**	Not used	1-3.5m depth Liner decreasing	Not used	Not used	Not used	1-6 m depth Linear symmetric	Not used	Not used	Not used
8	**Distance from roads**	≥100m Liner decreasing	≥100m Liner decreasing	≥100m Liner decreasing	≥100m Liner decreasing	≥100 m Liner increasing	≤100m Liner decreasing	≥250-m Liner increasing	250m≥ S decreasing	Not used
9	**Distance from Settlement**	100 m≥ Liner decreasing	≥100m Liner decreasing	≥100m Liner decreasing	≤100m Liner decreasing	100m≥ Liner decreasing	≤100m Liner decreasing	≥250m Liner increasing	250m≥ **S** decreasing	Not used
10	**Distance from cultural sites**	100 m≥ Liner increasing	Not use	≥100m-1000m≥ Liner increasing	≥100m Liner decreasing	≥200m Liner increasing	Not used	Liner decreasing	Not used	≤500m S decreasing
11	**Land used**	**High suit**: pasture **Moderate suit**: jungles & rangeland, wet land with cover **Marginal**: salt land with cover& arid land **Not suit:** gardens	Not used	**High suit**: rangeland& arid land **Moderate suit:** pasture, salt land with cover **Not suit**: gardens, wet land with cover	**High suit:** jungles & rangeland **Moderate suit:** pasture & salt land with cover **Marginal suit:** farms & wet land with cover &gardens	**High suit:** arid land &rangeland, **Moderate suit:** salt and wet land with cover **Marginal suit:** pasture & jungles **Not suit**: farms and waters	Not used	Not used	Not used	Not used
12	**Distance from Livestock**	≥100m Liner increasing	Not used	≥100m Liner increasing	≥100 m Liner increasing	≥100 m Liner increasing	Not used	≥250m Liner increasing	≤250m **S** decreasing	Not used
13	**Distance from aquatic**	≥100m Liner increasing	Not used	≥100m Liner increasing	≥100 m Liner increasing	≥100 m Liner increasing	Not used	≥250m Liner increasing	≤250m **S** decreasing	Not used
14	**Distance from facilities**	≤100m Liner decreasing	≥100 m Liner decreasing	≥100m Liner decreasing	≥100m Liner decreasing	≥100 m Liner decreasing	≥100m Liner decreasing	Not used	≤250m **S** decreasing	Not used
15	**Distance from birds distribution**	≥150m -1500m≥ Liner decreasing	≥150m Liner increasing	≥250 Liner increasing	≥m150-1500m≥ Liner decreasing	≥200m Liner increasing	≥250m Liner increasing	Liner decreasing	Not used	Not used
16	**Distance from aquatic habitat**	Not used	≥50m Liner increasing	Not used	Not used	Not used	≥250 m Liner increasing	Liner decreasing	Not used	Not used
17	**Distance from farms**	Not used	Not used	Not used	Not used	Not used	Not used	Not used	≤250m S decreasing	Not used
18	**Distance from shore**	Not used	Liner decreasing	Not used	**S** decreasing	Not used	Liner decreasing	Not used	Not used	Not used

1. Young dunes & Old dunes or Regosol soils
2. Shah– Kileh & Zaqhmarz that they mean: Saline alkali soil & Hallo hydro morphic soil

required that contains the best, or worst, cells according to some index. By ranking cells and then reclassifying the result, a specific number of the best or worst ranks can be determined (Eastman *et al*., 1995). The second step was to submit ranked suitability maps to the MOLA procedure. In addition to suitability map inputs, objectives' weights and required areas for each zone were entered into the model.

In this study, after the creation of 10 suitability maps by MCE, conflicting zones were identified. Among the six zones identified for recreational activity, bird watching and viewing scenery were determined as not conflicting and activities of horse riding with camping, and swimming with boating (paddle) were determined as conflicting. Also all recreational activities were not in conflict with four zones as the strict nature reserve zone, the conservation zone, the cultural zone and the rehabilitation zone which had fixed and unchangeable locations and were not considered in the MOLA model. Accordingly, among recreational activities except that of bird watching and viewing scenery, for which maps were needed prior to consideration in the model, others were prepared as MCE primary maps, considered in the model and finally five suitability maps were prepared as follows: suitability maps of boating, swimming, bird watching and viewing scenery, horse riding, camping.

Three scenarios were used to determine weights and areas of objectives and MOLA was performed according to the three defined scenarios as listed below:

1. Prioritizing uses (conflicted activities) in terms of their natural potential (sum of area of pixels with values over 200 were determined as desirable areas).

2. Prioritizing zones in terms of peoples' preferences, for which AHP weights were used so that each zone's weight multiplied by natural area (obtained in previous section), specified an area for each activity.

3. Prioritizing zones according to experts' comments.

For this scenario three general criterions were considered, as follows: the natural potential of a region for a zone, predictions for future (uses likely to be established in the future) and guidance (based on society's needs and areas in which usage should be established). So, conflicted activities were ordered and ranked according to each criterion (Table 4).

Multiplying total score of any activity, which is shown in table 4, in area of that activity, results in tertiary scenario area of any activity which is needed as input for MOLA.

For instance, total score for boating is 5+5+4 or 93%, so required area for this activity in this scenario is: %93×36530 =339756 pixel or 30578.12 hectare.

Acquired weights from AHP and determined area for all uses (conflicted activities) in each scenario are shown in Tables 5-7 considering their scenarios and areas (two bird watching and viewing scenery usages were added due to having no conflicts and considered in the model as one layer).

Table 4. Ordering criteria in order to determine zone areas (Expert comment scenario)

Natural potential	Rank	Future prediction	Rank	guidance	Rank
Boating	5	Boating	5	Camping	5
Swimming	4	Bird watching and Viewing scenery	4	Boating	4
Bird watching and Viewing scenery	3	Swimming	3	Horse riding	3
Horse riding	2	Camping	2	Bird watching and Viewing scenery	2
Camping	1	Horse riding	1	Swimming	1
Total	15		15		15

Table 5. AHP Weights and natural potential areas.

Recreational Activities	AHP weight	Area (ha)
Boating	0.376	32879.7
Swimming	0.215	21665.52
Bird watching and Viewing scenery	0.215	3357
Horse riding	0.121	44969
Camping	0.074	353.88
Inconsistency	0.007	

Table 6. AHP Weights and Experts Comments Areas

Recreational Activities	AHP weight	Area (ha)
Boating	0.472	30578.12
Swimming	0.158	11482.72
Bird watching and Viewing scenery	0.260	2014.57
Horse riding	0.059	177.876
Camping	0.096	187.55
Inconsistency	0.01	

Table 7. AHP Weights and Public Scenario areas

Recreational Activities	AHP weight	Area (ha)
Boating	0.119	3912.68
Swimming	0.281	6088
Bird watching and Viewing scenery	0.353	1185.24
Horse riding	0.174	78.24
Camping	0.073	25.83
Inconsistency	0.03	

MOLA was performed after determining weight and area for each zone in each scenario. Tolerance and threshold for each zone were set to be 10 pixels. The MOLA was run in IDRISI GIS software. Results of MOLA modeling determined primary zoning.

Post-processing and Functional relationships diagram

A post-processing operation was done according to various zone concepts such as filters, zone size and distance. Filter changes the values of all pixels in an image, based on each pixel's original value and those of its neighbors. The filter used in this study was MODE (3*3). The MODE filter assigns the most common value to the center pixel of the kernel. For evaluations of distance between some of land uses with conflicts, a one pixel buffer of about thirty meters was allowed between zones. Finally, three zoning maps were obtained, one for each scenario. These maps were combined independently with following zones: strict nature reserve, conservation, rehabilitation and cultural and then secondary zoning maps were obtained.

One disadvantage of MOLA is that it makes no consideration of the juxtaposition of zones in practical reality in terms of access between zones and other facilities such as water resources or access routes. Therefore, the functional relationship diagram was used to locate activities to modify maps derived from MOLA.

This process consisted of analyzing interactions between facilities and activities to determine whether a given pair needed to be linked or separated in order to function properly compatibly. These diagrams organized facilities into ideal arrangements, based on considerations of their interdependence.

In fact, functional relationship diagram shows relationship orientation among users and the best position for uses in comparison to others regardless of their position as a picture (Ruthledge, 1985). In this research, using functional relationship diagram basics, recreational spots with best relationship orientation were picked and others were deleted. Ultimately, final zoning maps were obtained.

In summary, seven general instructions which were defined for modifications and post-processing are listed below:

- Other zones cannot intrude into the strict nature reserve zone,
- Strict nature reserve zones should always have a buffer in the shape of a conservation zone,
- Recreational zones are extendable if there is ecological potential for them in the area,
- Strict nature reserve zone is dominant over all other uses,
- Specified recreational spots should be manageable in terms of shape and area,
- Livestock routes and pedestrian paths in an area should never be changed to accommodate a jeep route or road access,
- In choosing recreational spots, those with the best access to other recreational activity zones should be chosen and consideration of access and entrances should not compromise strict nature reserve zones.

RESULTS

In this study preferred activities of MianKaleh wildlife sanctuary determined according to visitor's opinion and for complementary study four zones (strict nature reserve, conservation, rehabilitation and cultural) were studied and allocated in that area. Due to the expert's opinions, appropriate criterions (and also fuzzy set membership and effective ranges) for any activities and zones determined, and then weighted with AHP method. In order to attain suitability maps, after weighting and standardizing criteria, WLC method was implemented in Idrisi software. Multi criteria land suitability maps for zones and activities are shown in Figure 3.

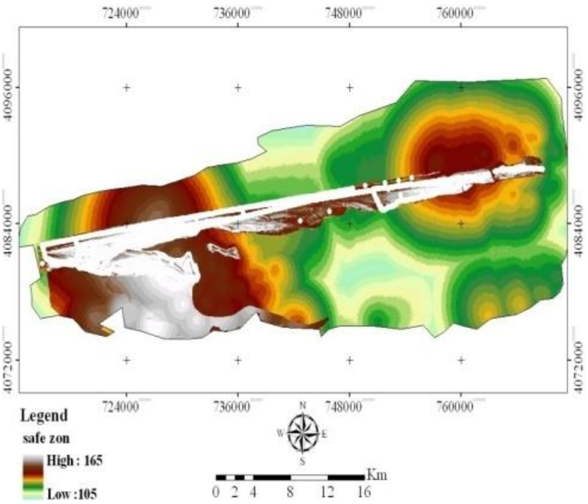
Land use planning through MOLA

Initial zoning for recreational activity according to land use was determined from the results of MOLA following combination analysis. The zoning map (before post processing and functional relationship diagram) of each scenario (natural potential, people preference and experts comment) is shown in Figure 4.

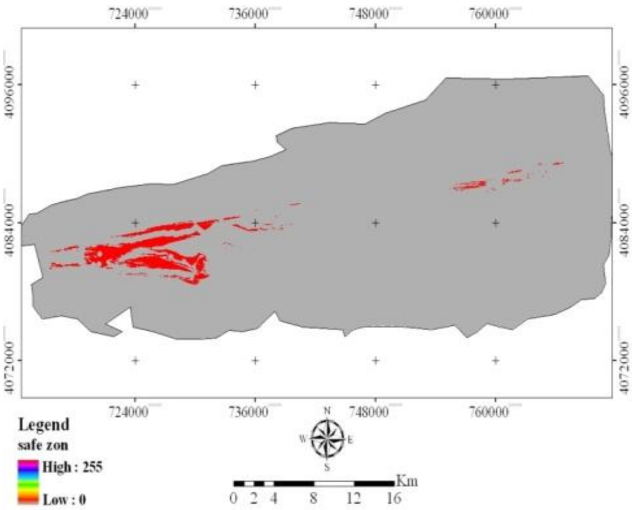
After zoning and land allocation, no value areas were allocated to the conservation zone. The overlapped areas of the three obtained maps from the three scenarios determined that the total strict nature reserve zone and conservation zones had the highest percentage of land area followed by those of boating, swimming and bird watching respectively.

Results of modifications of zoning maps after the post-processing operation and performing functional relationship concept are shown in Figure 5.

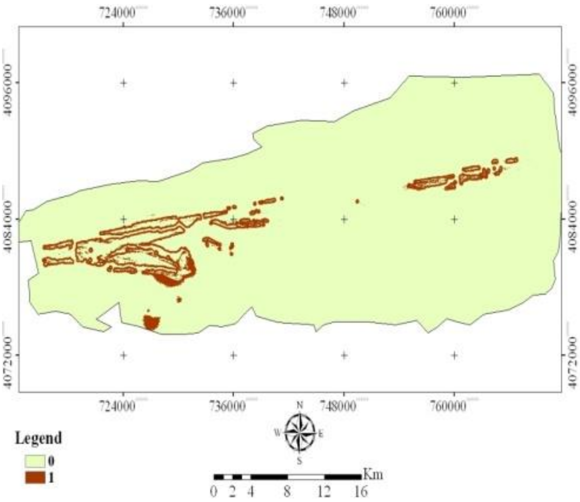
After modification, zoning maps were modified based on the three scenarios as shown in Figures 2, 3 and 4. The following comparison graphs were used to show quantitative changes of zones among areas before and after post processing (Fig. 6).



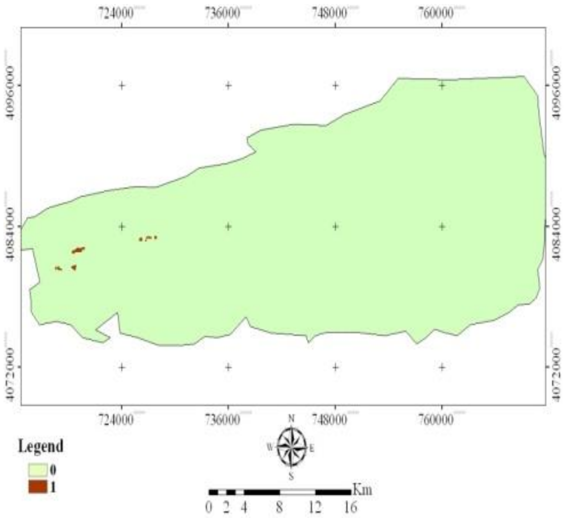
A) Suitability Map for Strict Nature Reserve Zone



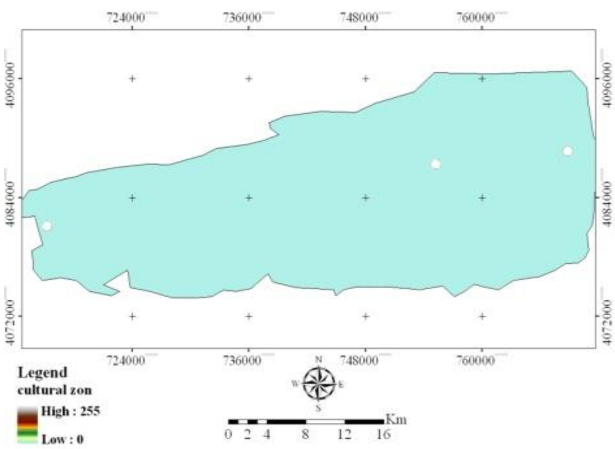
B) Strict Nature Reserve Zone



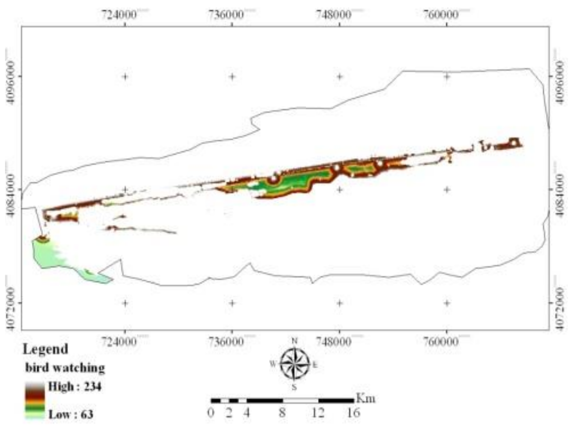
C) Conservation Zone



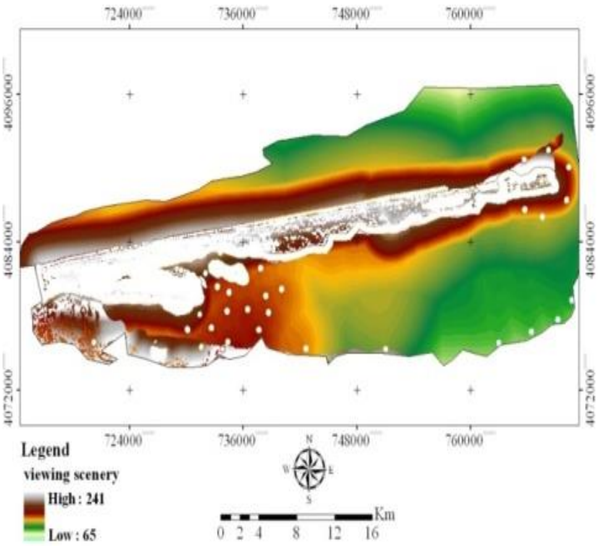
D) Rehabilitation Zone



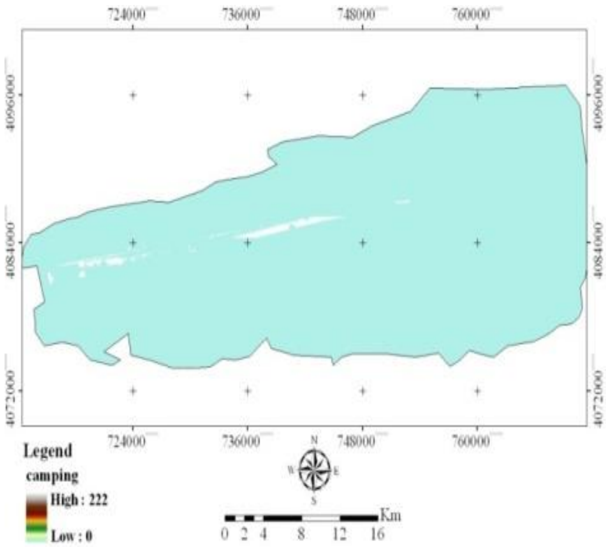
E) Cultural Zone



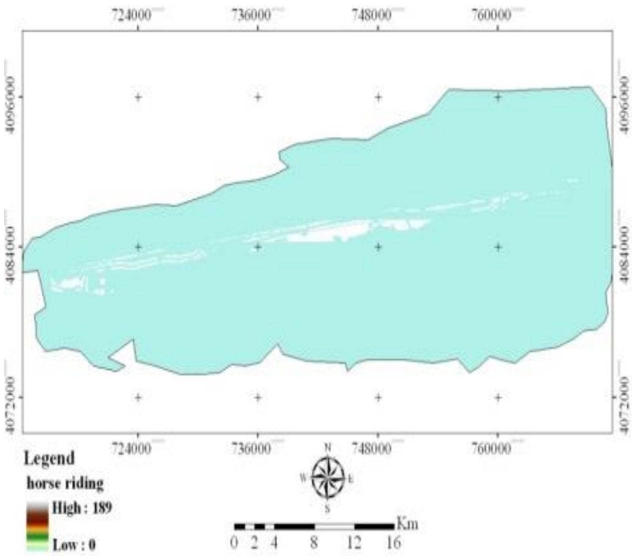
F) Suitability Map for Bird Watching



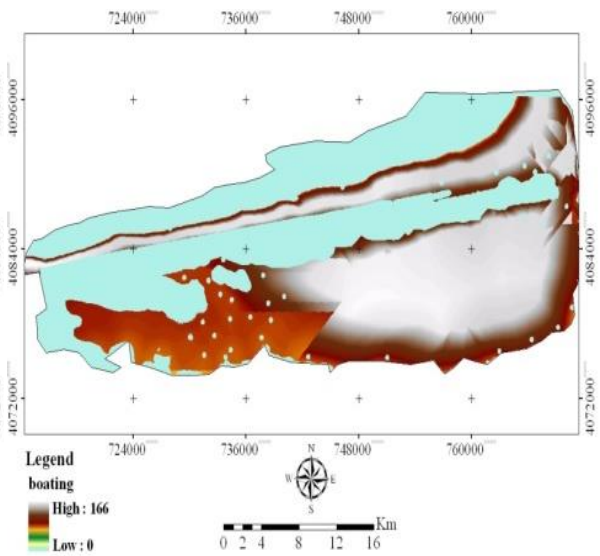
G) Suitability Map for view scenery



H) Suitability Map for Camping

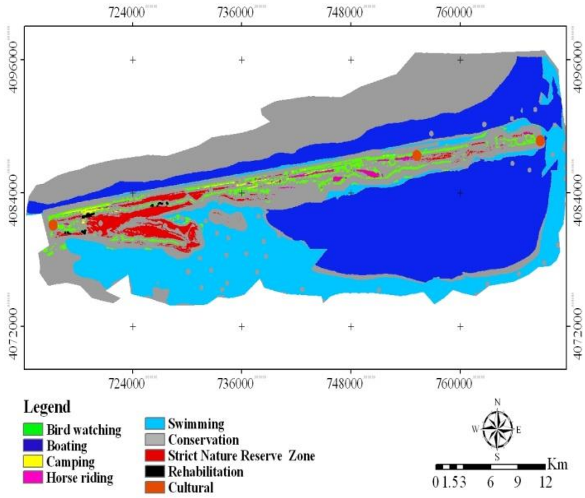


I) Suitability Map for Horse riding

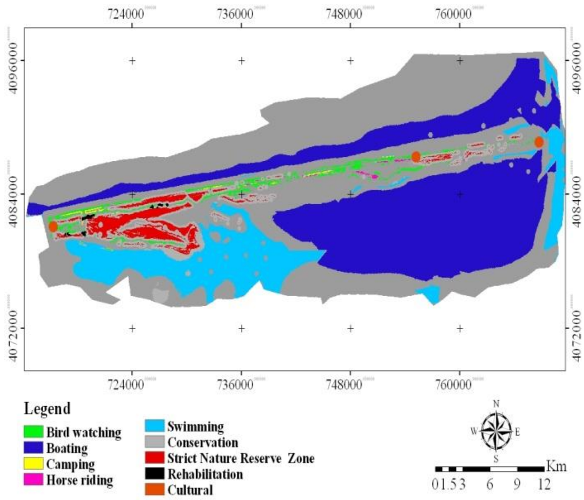


J) Suitability Map for boating

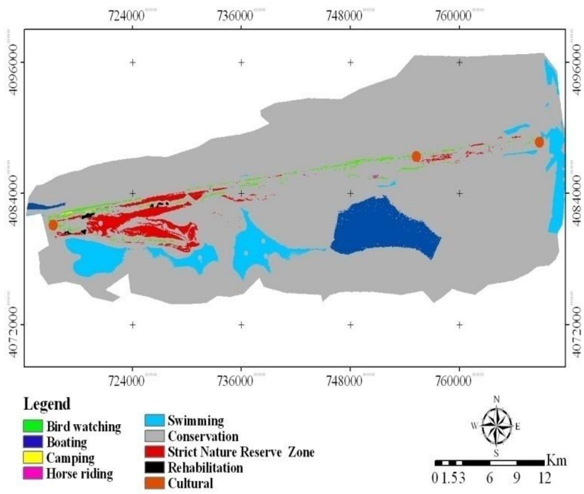
Fig. 3. Produced map through the MCE method



A) A)Zoning map According to Ecological Potential scenario

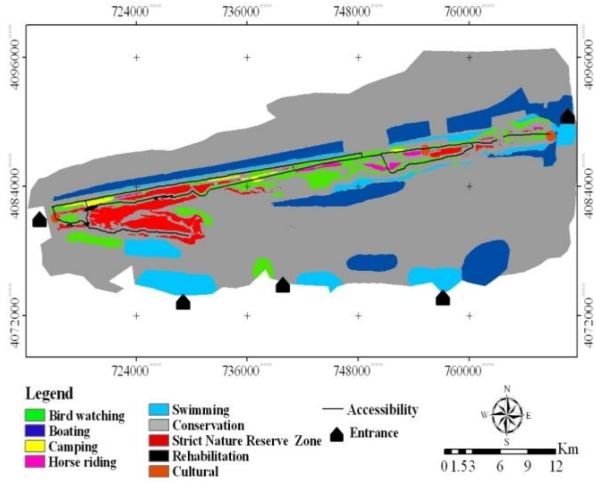


B) Zoning map According to Experts scenario

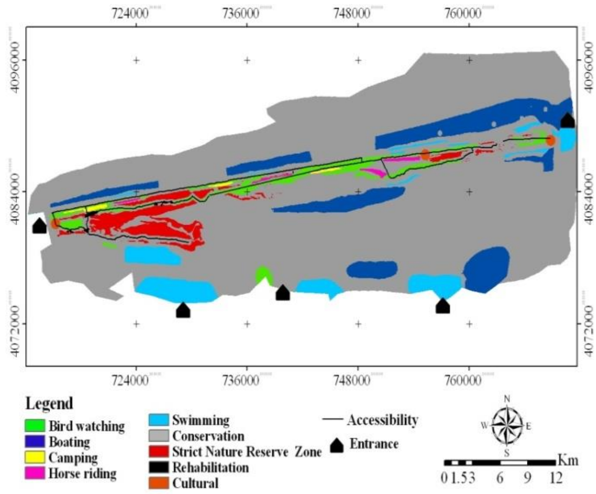


C) Zoning map According to public scenario

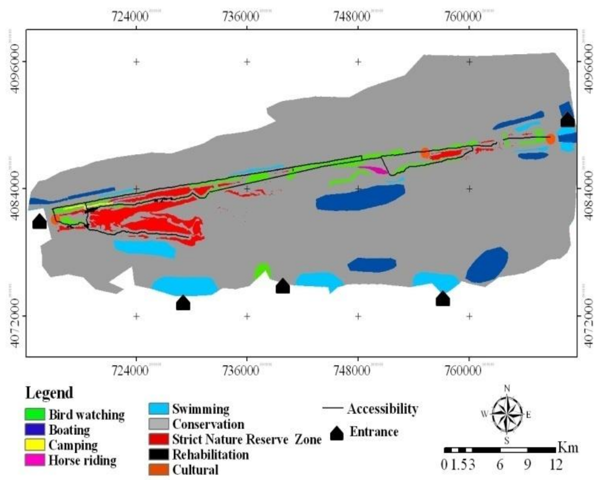
Fig. 4. Zoning maps by MOLA method



A) Zoning map According to Ecological Potential scenario

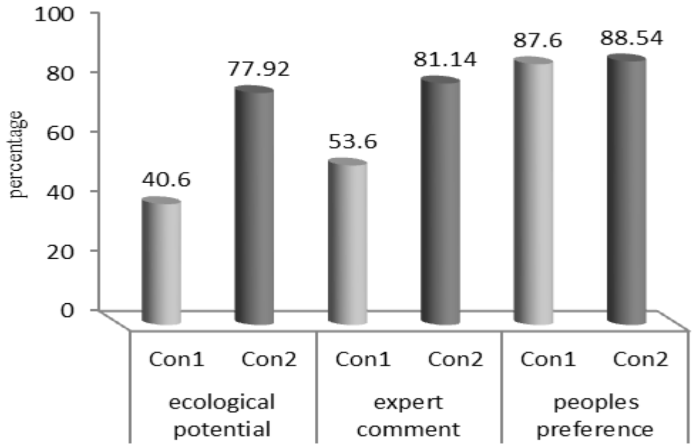


B) Zoning map According to Experts scenario

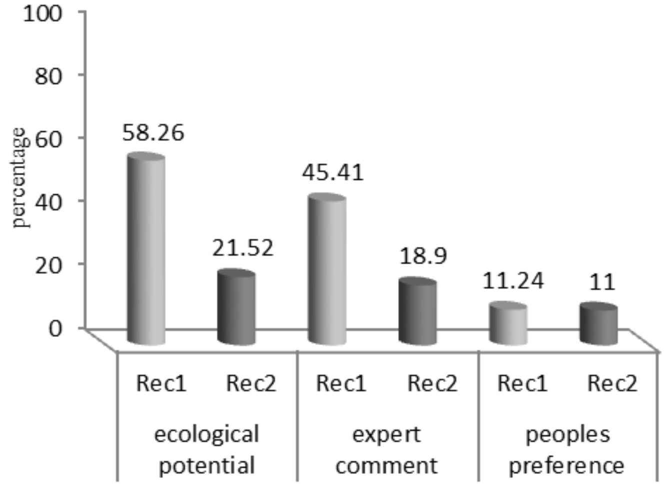


C) Zoning map According to public scenario

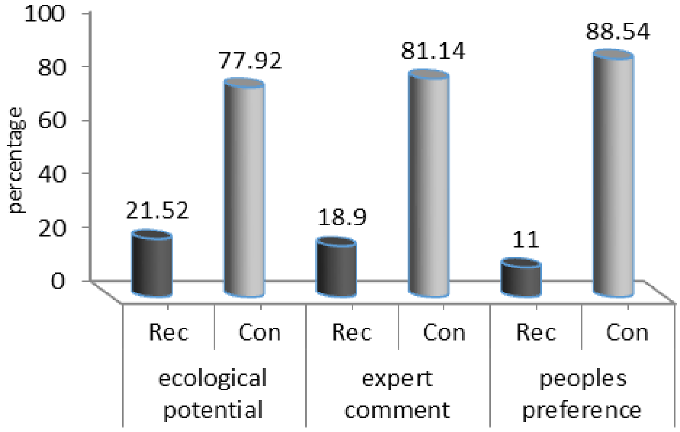
Fig. 5. Zoning map after post processing and application of functional relationship diagram concept



A) Comparison of area for recreation and Conservation zones in the 3 scenarios (after Post-Processing)



B) Comparison of area of recreation zone in the 3 scenarios (before and after Post-Processing)



C) Comparison of area of Conservation zone in the 3 Scenarios (before and after Post-Processing) meaning of Con 1 and Con 2 is total area of both Strict Nature Reserve and conservation zones before and after post processing also meaning of Rec 1 and Rec 2 is total area of 6 recreational activity zones before and after post processing

Fig. 6. Comparison of zones in areas

DISCUSSION AND CONCLUSION

Provision of recreational facilities without proper planning and outlining is more damaging than benefiting the environment and the users. Hence, it is necessary to consider all planning needs and also public demands and opinions in resource management (Rosa *et al*., 2005; Petrosillo *et al*., 2006; Mohammadzadeh, 2008). Evaluation of recreational activities is essential when developing any region effectively. This foresight and planning will also serve to prevent wastage of financial and human resources. In this study, questionnaires were used to determine recreational opportunities and then the MCE method was used for environmental evaluation. Through this GIS-MCE approach, an effective framework for land evaluation was presented, the selection of evaluation factors and the identification of a suitable range for each factor had a direct influence on the results.

The WLC approach used for layer combination is an averaging technique that softens the hard decisions of the Boolean approach and avoids extremes. In fact, given a continuum of risk from minimum to maximum, WLC falls exactly in the middle; it is neither risk-averse nor risk-taking (Eastman, 2003). The WLC decision rule allows the user to specify a set of weights representing the relative importance of criteria according to user preferences. The weight of a criterion defines its impact on compensatory aggregation.

Then the MOLA routine was used to locate each activity and to solve multi objective conflicts. The result of land use planning by the MOLA routine shows definitions of spatial limitations such as area for any zone in terms of manageability. This research shows that MOLA provides a flexible tool for land allocation, thus input variables of a model such as weights and areas can be adjusted and modified according to priority. The results indicate that although factors and their weights strongly influenced land allocation, objective prioritization seems to have had the most significant impact; it means a higher priority objective will be land allocated before a lower one even if the land is more suited to the latter objective. The best results are achieved with carefully identified land use criteria that will then produce accurate criteria maps and use a flexible but objective approach to criteria weighting and objective prioritization. A disadvantage of the MOLA routine is the salt and pepper noise (Eastman, 2003) like results. Therefore the map that is produced needs to be processed more. The post-processing operation used in this study applied filters to remove single pixels and small and scattered spots. Some changes were also made by manual correction based on each zone's potential map to correct the zones' size and shape.

Another disadvantage of MOLA is its inattention to neighborhood and access between recreational zones and other facilities such as water resources or access routes. Therefore, functional relationship diagram principles were used to optimize site selections. A functional relationship diagram was used to analyze function of the recreational activities in terms of optimum access to facilities, entrances and to other recreational zones and to solve conflicts between neighboring zones. Since zoning maps are prepared according to a region's ecological potential, all zones are located in an area with the most appropriate potential, so in this method it was only necessary to additionally consider spots with the best access and suitability in relation to adjacent land uses among other determined MOLA spots. As an example, camping and horse riding should not be adjacent to one another because this may disturb visitors engaged in bird watching. Therefore, a distance of at least 30 meters (one pixel) was recommended between these two zones. This operation was applied to all three MOLA maps for each of the three scenarios and finally the best spots were chosen for zoning (Fig. 5).

Changes in allocations for zones in all three scenarios showed similar trends. It is clear that the strict nature reserve zone was assigned the greater extent of land area (Fig 6A), but this was the reverse for recreational zones (total area of 6 recreational activities; Fig. 6B). This could be the result of considering protection of the location and the ecological value of the region and consideration of the need to maintain its biodiversity. Figure 6C shows the minimum extent of land for a recreational zone for public access and the maximum extent in terms of ecology, as determined by MOLA evaluation and post-processing.

Generally, zoning of the MianKaleh wildlife Sanctuary shows more than 77% (based on different scenarios) of the area was allocated to strict nature reserve and conservation zones. This extent should not be decreased because in the area, unique features and pressure on land from residents, roads, and installations dictates this figure to ensure its safe conservation.

Results of the survey showed the potential for recreational activities in MianKaleh wildlife Sanctuary and the suitability of its condition as an ecotourism attraction (more than 11% of the total area based on different scenarios especially ecological potential). Other considerations are those of; level of interest for potential visitors and high ecological potential, so accurate planning for ecotourism could meet the targets set out for land management that could also facilitate better protection of the region.

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