EQA - International Journal of Environmental Quality
ISSN 2281-4485 - Vol. 40 (2020): 19-30
Journal homepage: https://eqa.unibo.it/

published by

A GIS-based quantitative model for land use planning in Larestan County, Iran

Masoud Masoudi*, Parviz Jokar, Elias Ramezanipour

1 Department of Natural Resources and Environmental Engineering, Shiraz University, Iran

* Corresponding author e-mail: masoudi@shirazu.ac.ir

Article info
Received 25/1/2020; received in revised form 23/4/2020; accepted 10/5/2020.
DOI: 10.6092/issn.2281-4485/10433
© 2020 The Authors.

Abstract

Land use planning involves making decisions regarding the use of land resources with the primary aim of achieving the best use of land for maximum food production and profit. The main goal of this research is to evaluate the land use and natural resources for future sustainable land planning using GIS. So, in this study, the Iranian ecological evaluation model was used for the analysis the ecological and resources maps of the study area. First of all, ecological capability maps of different land uses including forestry, agriculture, range management, environmental conservation, ecotourism and development of village, urban and industry were developed by overlaying geographical maps based on Boolean overlay method (as a Multi-Criteria Evaluation Method) in GIS for the Township. The final step of this research was the prioritization of land uses considering the ecological and socio-economic characteristics (by distributing questionnaire to 46 experts (of the study area using a quantitative model. Results shows the maximum area of proposed uses is 65.1% that is related to range management showing this land use has high potential and socio-economic demands in study area. While minimum area of proposed uses is related to Rainfed farming.

Keywords
boolean theory, land-use planning, modified model, GIS, Larestan County

Introduction

In many countries, land resources are being used with an increasing intensity to meet the needs of growing populations. Increasing demands for food and increasing material expectations have led to the urgent need for the optimization of land resources (Dent and Young, 1981; Kutter et al., 1997; van Lier, 1998; FAO, 1993; Jozi, 2010; Jokar and Masoudi, 2016). According to the Food and Agriculture Organisation (FAO, 1993), land use planning involves making decisions regarding the use of land resources with the primary aim of achieving the best use of land for maximum food production and profit. This is often driven by the needs of future generations in terms of productivity and environmental sustainability. However, sustainable land management is a very complex and challenging concept, encompassing biophysical, socioeconomic and environmental issues that must be viewed as part of an integrated system (FAO, 1976). Therefore, effective land management information and land evaluation are prerequisites to achieving optimum utilization of available land resources for production of particular importance to developing countries (Nwer, 2005).

Furthermore, the most current and future challenge facing the development of land use is how to ensure the sustainability of land resources through efficient exploitation of what is available. Again, due to rapidly increasing population and urbanization, arable land needs to be evaluated in order to achieve self-sufficiency and reduce vulnerability to food insecurity (FAO, 2011).

To sustain land uses, special attention needs to be given to spatial models that can illustrate stronger linkages between data derived from land characteristics and land use, which can predict land suitability management. Similarly, Al-Mashreki et al. (2011) suggest that increasing food production for self-sufficiency and national economic growth could be met through systematic survey of the soils, evaluating land use

The journal is hosted and mantained by ABIS-AlmaDL. Works are licensed under CC BY 4.0

DOI: 10.6092/issn.2281-4485/10433

options and formulating land use plans based on local peculiarities, but which are viable economically, socially acceptable and environmentally friendly.

In ecological evaluation, GIS is quickly becoming data management standard in planning the use of land and natural resources (Makhdoom, 2001; Prato, 2007; Makhdoom et al., 2009; Abu Hammad and Tumeizi, 2010; Barzani and Khairulmaini, 2013; Jafari and Bakhshandehmehr, 2013). Virtually all environmental issues involve map–based data, and real world problems typically extend over relatively large areas (Nouri and Sharifipour, 2004). Actually a geographical information system (GIS) is used for geography patterns (Pauleit and Duhme, 2000; Bojo´rquez-Tapia *et al.,* 2001; Biswas and Baran Pal, 2005; Peel and Lloyd, 2007; Steinitz, 2014). Also, GIS is an indispensable tool for land and resource managers (Swanson, 2003; Gandasasmita and Sakamoto, 2007; Oyinloye and Kufoniyi, 2013). In GIS-based methods like MCE, quantitative criteria are evaluated as fully continuous variables rather than collapsing them to Boolean constraints (e.g., WLC (weighted linear combination), OWA (ordered weighted averaging)) (Malczewski, 2004; Fallahshamsi, 2004; Sanaee *et al.* (2010); Oyinloye and Kufoniyi, 2013; Kumar and Biswas (2013), Pourkhabbaz et al (2014). In weighted linear combination method, maps are combined together based on linear weighting. In this method, areas can be classified according to varying degrees of suitability. The OWA is extension and generalization of the WLC. This method is a weighted sum with ordered evaluation criteria (Sanaee et al., 2010; Kumar and Biswas, 2013; Pourkhabbaz et al., 2014).

The overall aim of this study is to develop and modify a land evaluation technique and assessment of ecological and socio-economic for land use planning in Larestan County, Iran.

Materials and Methods

Larestan County with an area of 17736 km^2 as largest Township is located in the Fars province and Southern parts of Iran (Fig 1). Larestan city is located between geographical longitude 54° 20´ E and geographical latitudes 27° 40´ N. This area has an arid and warm climate.

Figure 1. *Position of Larestan in Fars Province and Iran.*

DOI: 10.6092/issn.2281-4485/10433

The data in this paper are included in two types 1) numerical numerical and descriptive data and 2) thematic maps, but mainly in the map format (vector) with mostly semi-detailed scale (1:50000 scale) for the GIS analysis. All such relevant data (based on table1) were obtained from the local and main offices and institutes of the Ministries of Agriculture and Energy and the Meteorological Organization of Iran. Also some soil samples and field data also were gathered during field work to check and improve the maps and reports used, wherever needed. The different kinds of maps were used in this research to determine the ecological resources of the area under study were Digital Elevation Model (DEM), slope and aspect, soil data, erosion, geology, iso-precipitation (iso-hyetal), iso-thermal, iso-evaporation, climate, canopy percentage and type and in addition to water resources data.

This research was done based on two main parts include:

I. Ecological capability evaluation for different uses.

II. Prioritizing the different land uses.

For ecological capability evaluation for different uses (step I), a systematic method known as the Iranian ecological evaluation Model based on Boolean model (FAO, 1976; Burrough *et al.,* 1992; Davidson *et al.,* 1994; Makhdoom, 2001; Baja *et al.,* 2006; Amiri *et al.,* 2010) was used for the analysis of maps in relation to the ecological and socio-economic resources of the study area. Boolean model (as a MCE Method) is an overlay method which combines parameters based on AND (intersection) and OR (union) operators in GIS. Different ecological capability models of the Iranian ecological evaluation model based on ecological data were used to evaluate ecological capability of different land uses including forestry, agriculture, range management, environmental conservation, ecotourism and development of village, urban and industry (Makhdoom, 2001). We can classify an area based on these models to different capability classes. Ecological capability classes for forestry, agriculture, range management, environmental conservation, ecotourism and development of village, urban and industry are 7, 7, 4, 3, 3 and 3, respectively. The best capability class is class one and the worst capability class is the last class in each model. The good and moderate ranges were shown in table 1. In order to identify the effective criteria for every use in the study area, they were based on literature review and previous studies (Makhdoom, 2001; Fallahshamsi, 2004; Makhdoom et al., 2009).

It should be noted that in table 1, good and moderate classes are listed based on influence on every use. Also, poor and none suitable classes have been excluded due to their unimportant role in classification.

Indicators	Class	Forestry (classes 1-4)	Agriculture & range management (classes 1-4)	Ecotourism (intensive) (classes 1-2)	Development (classes 1-2)
Elevation(m)	Good	0-1000			400-1200
	Good to Moderate	0-1000			0-400, 1200-1800
	Moderate	0-1400			
	Mostly moderate	400-1800			
Slope (%)	Good	0-25	0-5	0-5	0-12
	Good to Moderate	0-35	5-8	5-15	12-20
	Moderate	0-45			
	Mostly moderate	0-55	8-15		
Climate and Precipitation (mm)	Good	>800	Warm & moderate (Mediterranean to humid)		501-800
	Good to Moderate	>800	Warm & moderate & cold (Semi-arid to humid)		51-500, >800
	Moderate	>500	Warm & moderate & cold & very cold (Arid to humid)		
	Mostly moderate	>500			

DOI: 10.6092/issn.2281-4485/10433

Indicators	Class	Forestry (classes 1-4)	Agriculture & range management (classes 1-4)	Ecotourism (intensive) (classes 1-2)	Development (classes 1-2)
Temperature (°C)	Good	18-21		21-24*	18.1-24
	Good to Moderate	18-21		18-21, 24-30	24.1-30, <18
	Moderate	<18, 18-30			
	Mostly moderate	<18, 18-30			
Sunny days*	Good to Moderate			>15	
	Moderate			7-15	
Relative humid (%)	Good to Moderate				40.1-70
	Moderate				<40, 70-80
Soil Texture & Type	Good	Brown soil and forest semi humid to loam clay texture	Clay, loam clay, humus	usually moderate	moderate(often)
	Good to Moderate	Brown soil and forest semi humid to loam clay texture	Clay, loam clay, humus clay, sandy loam clay, sandy clay loam, clay loam, loam	Coarse, light, heavy	light(often)
	Moderate	Brown soil to clay loam texture	clay loam, loam sand, loam clay sand, clay loam sandy, sand		
	Mostly moderate	Brown rendezina to clay loam texture, regosols brown soil, litosols to sand loam texture	Clay, loam clay, clay loam, loam		
Drainage	Good	Moderate to perfect	perfect	Good	Good
	Good to Moderate	Moderate to good	good	moderate to poor	moderate
	Moderate	Rather incomplete to good	Moderate to incomplete		
	Mostly moderate	Rather incomplete to Moderate			
Depth	Good	Deep	Deep	Deep	Deep
	Good to Moderate	Deep	Moderate to good	Semi deep	Semi deep
	Moderate	Moderate to good	Low to Moderate		
	Mostly moderate	Moderate to good			
Structure	Good	Granulating fine to moderate, a bit Gravel, Evoluted	Granulating fine to moderate, none Gravel, Evoluted, low erosion	Perfect evolution	Slight erosion to Granulating Moderate and Perfect evolution
	Good to Moderate	Granulating fine to moderate, by Gravel, Evoluted	Granulating fine to moderate, none Gravel, Evoluted, low to moderate erosion	moderate evolution	moderate erosion to Granulating Fine, Coarse and moderate evolution
	Moderate	Granulating fine to moderate, by Gravel, Evoluted	Granulating moderate to coarse, by Gravel, moderate Evolution, moderate erosion		
	Mostly moderate	Granulating fine to moderate, by Rubble, low to moderate Evolution			

DOI: 10.6092/issn.2281-4485/10433

Indicators	Class	Forestry (classes 1-4)	Agriculture & range management (classes 1-4)	Ecotourism (intensive) (classes 1-2)	Development (classes 1-2)
Fertility	Good	perfect	perfect	Good, Moderate	Good,
	Good to Moderate	Good	Good	Low	Moderate
	Moderate	Moderate to good	Moderate	-	-
	Mostly moderate	Low to Moderate		-	-
Canopy Cover (%)	Good	>80		Forest lands (With canopy cover of >50%)	0-25
	Good to Moderate	60-80		Forest lands (With ca-nopy cover of 5-50%)	26-50
	Moderate	50-70			
	Mostly moderate	40-60			
Annual Growth (m^3)	Good	>6			
	Good to Moderate	> 6			
	Moderate	> 5			
	Mostly moderate	> 4			
Quantity of Water for everyone (Lit/day)	Good		6000-10000 **	> 40	<225
	Good to Moderate		4000-6000	12-39.9	150-225
	Moderate		3000-5000		
	Mostly moderate		To 3000		

Table 1. *Moderate and good classes for every use (* in springer & summer seasons; ** m^3/ha).*

In the next step, after producing ecological capability maps, the land use map was prepared. To prioritize the different land uses (step II), the model consists of four scenarios in each land unit including: a) present land utilization of the study area, b) economic needs of the study area, c) social needs of the study area and d) ecological needs of the study area. First scenario to make its ranking was evaluated using current land use. But for other scenarios (b, c and d) a questionnaire was prepared to ask from experts of study area to rank different land uses for each scenario based on their knowledge and experience from study area. Questionnaire filling is a good method especially for finding socio-economic needs of an area that depends on many things like: socio-political characteristics, population composition, relative earning conditions, immigration condition, present land utilization, agriculture and animal husbandry conditions, hygiene, health, education and other public services.

The above socio-economic information helped the experts for ranking of utilizations in economic and social scenarios (Fallahshamsi, 2004; Hamzeh et al., 2014). The questionnaire sample distributed among experts was shown in table 2.

It should be noted that 46 experts were identified from related organizations for different land uses (e.g. urban, agricultural offices and etc.) and based accessibility to them. Average of results helped us to rank different land uses for each scenario.

So, all land uses are ranked for each scenario and then are scored from 10 to lower base on their ranks and ecological capability. For example if in one scenario, rank of forestry is third place and its ecological capability is class two in a land unit; its score in first step is given 8 and then one score is lowered for its capability reduction (class two) that makes its score number 7 for forestry in the land unit. It should say that this one point reduction for forestry in three other scenarios is

DOI: 10.6092/issn.2281-4485/10433

repeated because of one place of reduction compared to first class of ecological capability. If ecological capability class is class three, the reduction in each scenario would be two.

		LAND USE						
		Development	Ecotourism	Conservation	Rainfed farming	Rangeland	Forest	Irrigated farming
SCENARIO	Scenario b							
	Scenario c							
	Scenario d							

Table 2. *The questionnaire sample distributed among experts.*

To achieve a systematic analytical model, all maps layers are in vector format in the ArcGIS software environment. These maps were operated using ArcGIS 9.3 and the appropriate utilization of each land unit was determined and prioritized. The appropriate utilizations are those that have higher sum of scores among used scenarios. Many of the units were seen fit for two appropriate uses. Hence, selecting the best utilization for the area is based on socio-economic status of the area and consistency of land uses and current land use, too.

The important modifications in this paper are explained below:

- ***Land capability evaluation.*** It is necessary to say some modifications in the process of work were done like no preparation of environmental units (such as the Iranian ecological evaluation model). Actually, in this research, current method of systemic analysis for preparation of environmental units was not utilized for assessing the ecological capability maps and land use planning of quantitative model. It may be used only for assessing the small areas with low diversity (e.g. small watershed). Hence, for assessing the larger areas (e.g. large watersheds, counties and provinces), preparation of environmental units eliminate a lot of information used in the ecological capability models. So, in the present study all indicator maps related to different ecological capability models were overlaid in GIS.

- ***Land use prioritizing.*** Other modifications in the process of work done for assessing the land use planning model included:

a) Prioritization of each use was based on the highest score derived after summing the scenarios› scores (ecological, economic, social, area) (Makhdoom, 2001). Also, it was considered suitable capability for the use with highest score (this point does not do in Iranian ecological evaluation method).

b) To use current land-use map in assessment mainly due to the socio-economic compulsions of the population especially in rural area. Also, we hold the following land utilizations in the end of land-use planning process:

1) Irrigated lands with suitable capability.

2) Settlement lands (urban, rural and industrial area).

3) The Forest lands with canopy cover more than 25% and those with conservational role.

4) Lake and river bed.

Finally, land use planning maps of Larestan County were developed considering the ecological and socio-economic characteristics of the area. Process for evaluation included the following steps presented in Figure 2.

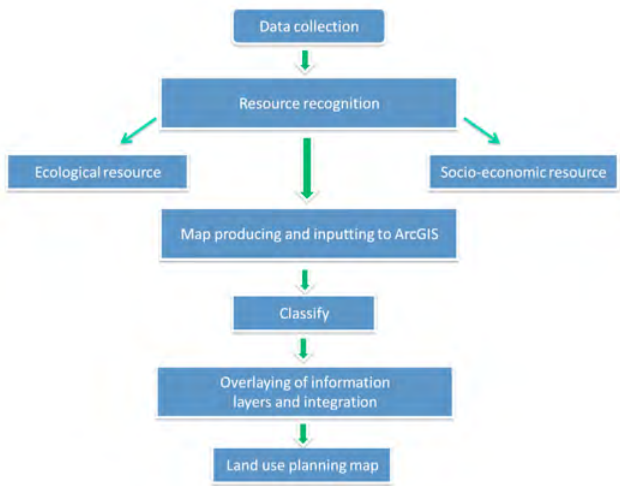

Figure 2. *Process of evaluation.*

Results and Discussion

In this study for each model the related indicators were overlaid. Then land capability maps were accessed. The capability maps are shown in Figures 3 to 8 and percent of area for different ecological capabilities of land uses is observed in Table 3.

DOI: 10.6092/issn.2281-4485/10433

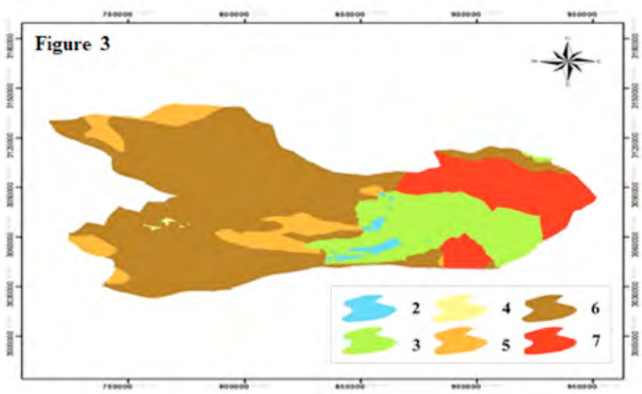

Figure 3. *Land capability classification map for irrigation agriculture.*

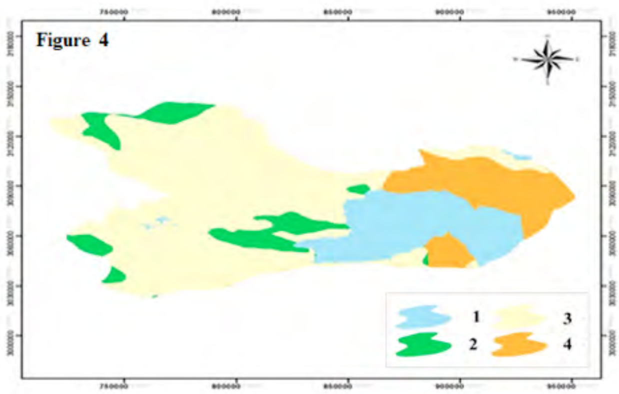

Figure 4. *Land capability classification map for range management and dry farming.*

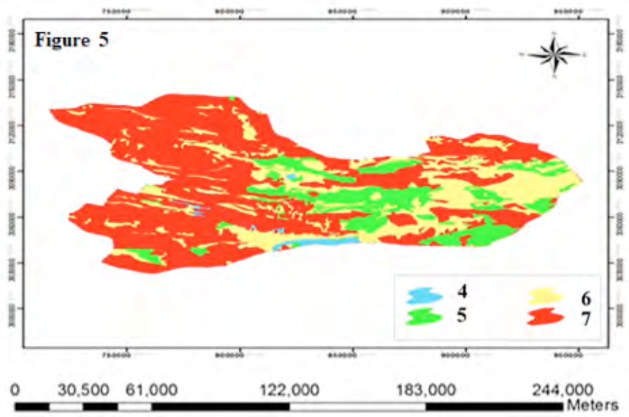

Figure 5. *Land capability classification map for forest.*

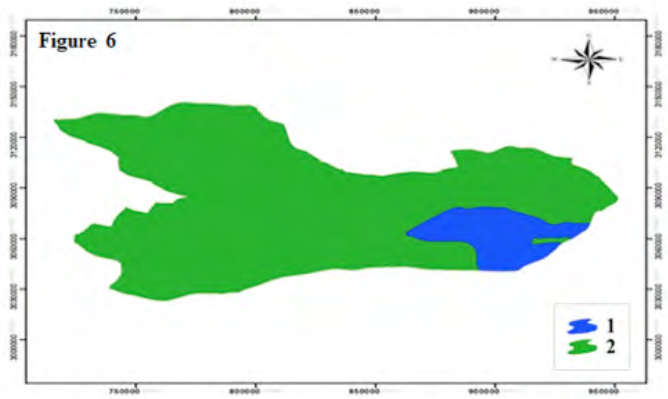

Figure 6. *Land capability classification map for environmental conservation.*

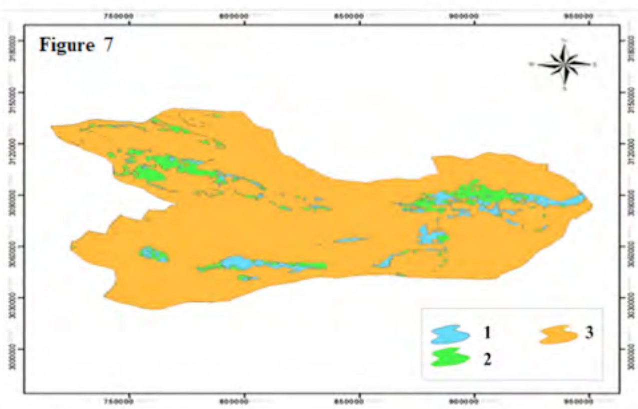

Figure 7. *Land capability classification map for ecotourism (intensive).*

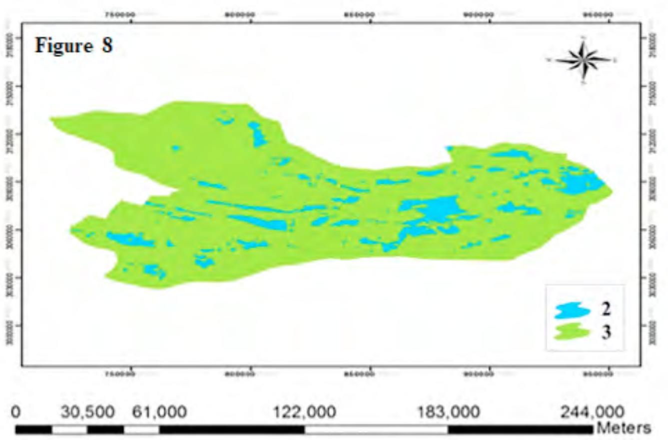

Figure 8. *Land capability classification map for urban, rural and industrial development.*

DOI: 10.6092/issn.2281-4485/10433

Table 3 shows percent of area for different ecological capability classes of land uses. For agriculture use, minimum and maximum areas are related to class 4 (0.14%) and class 6 (58.65%) respectively. Class 1 also was not seen. For Range management & dry farming uses, minimum and maximum areas are related to class 2 (8.92%) and class 3 (58.59%) respectively. For forest use, minimum and maximum areas are related to class 4 (1.25%) and class 7 (58.39%) respectively. Classes 1-3 also were not seen. For Conservation use, minimum and maximum areas are related to class 1 (9.75%) and class 2 (90.25%) respectively. For ecotourism use, minimum and maximum areas are related to class 1 (4.34) and class3 (89.53). For development use, minimum and maximum areas are related to class 2 (13.09%) and class 3 (86.90%) respectively. Class 1 also was not seen.

Land type	class	Percent of area
Irrigated Agriculture	2	1.19
	3	16.71
	4	0.14
	5	8.93
	6	58.65
	7	14.37
Range management & dry farming	1	18.02
	2	8.92
	3	58.59
	4	14.46
Forestry	4	1.25
	5	15.41
	6	24.95
	7	58.39
Conservation	1	9.75
	2	90.25
Ecotourism	1	4.34
	2	6.12
	3	89.53
Development of urban, rural and industry	2	13.09
	3	86.90

Table 3. *Percent of area for different ecological capabilities of land uses.*

Also, results of uses ranking are seen below:

***Area scenario*:** Range > Conservation > Irrigated farming > Forest > Development > Rainfed farming > Ecotourism.

Ecological scenario: Conservation > Development > Rainfed farming > Range > Ecotourism > Irrigated farming > Forest.

Economic scenario: Development > Irrigated farming > Rainfed farming > Ecotourism Conservation > Range > Forest.

Social scenario: Development > Conservation > Ecotourism > Irrigated farming > Rainfed farming > Range > Forest.

Land use	Capability						
	1	2	3	4	5	6	7
Forest	-	-	-	7	3	-1	-5
Ecotourism	25	21	17	-	-	-	-
Development	-	31	27	-	-	-	-
Irrigated farming	-	25	21	17	13	9	5
Range	28	24	20	16	-	-	-
Rainfed farming	27	23	19	15	-	-	-
Conservation	33	29	-	-	-	-	-

Table 4. *Sum of scores for different land uses based on capability classes and 2 scenarios method.*

DOI: 10.6092/issn.2281-4485/10433

Table 4 also shows sum of scores for different land uses based on capability classes and 4 scenarios method in the study area. As can be seen, Conservation and development are more important (higher scores) than other uses in study area based on sum of scores in 4 scenarios method. The land capability maps were then overlaid and land use planning map (Fig. 9) by quantitative approach was assessed.

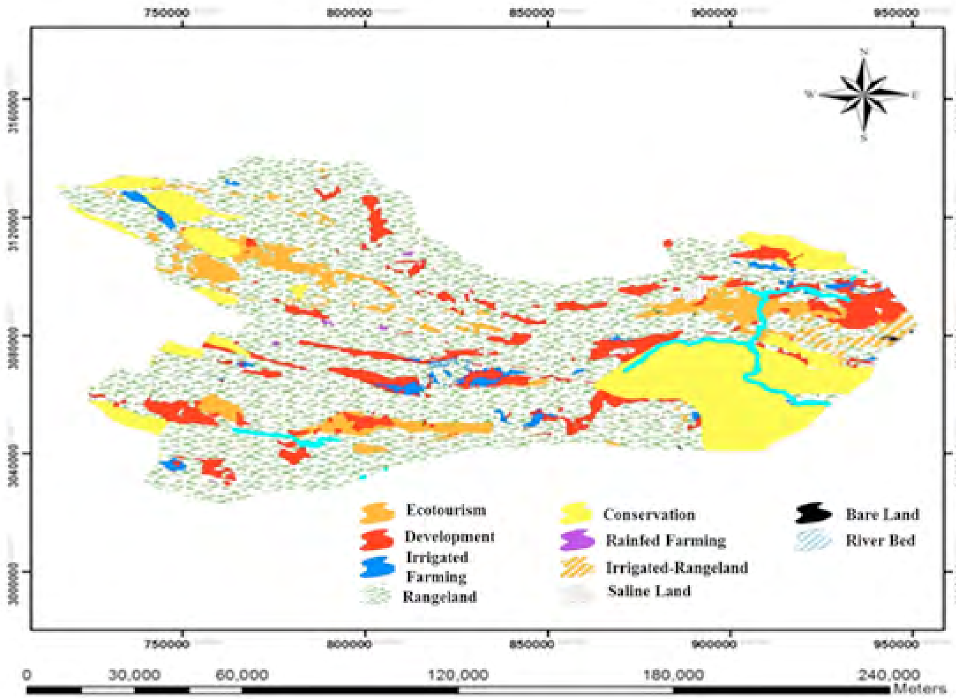

Figura 9. *Land use planning map.*

Table 5 also shows percentage of area in current land use and proposed land use maps. The main results of this comparison indicate that current land use area is more than proposed area for Forest, irrigated and range management and it is showing these land uses are located more than their capabilities in the study area. While current land use area is less than proposed area for Ecotourism, development, environmental conservation, and rainfed showing these land uses are located less than their capabilities in the study area. Also Fig. 9 and Table 5 shows the maximum area of proposed uses is 65.1% that is related to range management showing this land use has high potential and socio-economic demands in study area. While minimum area of proposed uses is related to Rainfed farming.

Land Type	Percent of Proposed land use	Percent of Current land use
Forest	-	2.6
Ecotourism	6.5	-
Development	10.3	0.4
Irrigated farming	1.5	8.3
Range	65.1	79.9
Rainfed farming	0.8	0.2
Conservation	14.1	-
Irrigated farming- Range	1.1	-
River bed	0.3	0.3
Saline land	0.2	3.4
Bare Land	0.1	4.9
Sum	100	100

Table 5. *Comparison of land percent in current land use and proposed land use maps.*

DOI: 10.6092/issn.2281-4485/10433

Current land use planning in Iran by Iranian evaluation Quantitative model has some problems like difficulties in assessment of ecological and socio-economic information used in related scenarios. Also it is possible because of sum of scores derived from different scenarios; current model may prioritize land use without ecological capability or recommended changing urban land cover to a pasture. Therefore the main goal of this study was to solve these problems and develop and modify the current quantitative method of Iranian ecological Model (Makhdoom, 2001) to evaluate better land use planning in Iran.
Lack of elementary classes in each model (e.g. class 1 in the model of urban development) is caused by the strict method of Boolean logic. The use of the Boolean logic theory to land evaluation methods has been criticized by many authors (Burrough et al., 1992; Davidson et al., 1994; Baja et al., 2006; Amiri et al., 2010). In the classic methods like the FAO model for land evaluation (FAO, 1976) using maximum limitation, makes the classification quite strict. Because, in Boolean logic, only one index with lower effect is enough to reduce the suitability of lands from highly suitable classes to not suitable classes.
Babaie-Kafaky et al (2009) showed if the importance of the multiple-use of Zagros forests is not recognized in forest management, the forests will lose many of the recreational, natural ecosystem characteristics and countless values.
Amiri et al (2010) utilized two methods for assessing the ecological capability of forestry in Mazandaran Province. Their findings after using the conventional Boolean Model revealed that there are categories 3, 5, 6, and 7 of forest capability in the area. Our research is in agreement with them, from a Boolean perspective.

Conclusions

In summary, a key element in this study was the use of multi-criteria methods integrated with a Geographic Information System. This integration of the study enabled the evaluator to produce specific land information maps for each land utilization type. Generally, it should be noted that current research implemented reforms in Iranian ecological evaluation model. Since, proposed model has higher functionality for land use planning. Iranian ecological evaluation model and current modified Iranian ecological evaluation model also were evaluated in Firuzabad, Jahrom and Darab Townships in southern Iran (Asadifard, 2015; Masoudi and Jokar, 2016; Masoudi et al., 2017); after validation of two models, results showed that the modified model has higher accuracy for land use planning in these regions. Generally, the results of this study are suggested to managers and other stakeholders according to this land management study.

Acknowledgements
The authors are thankful to those governmental offices of Iran, for providing the data, maps and reports for this land use planning work.

References

ABU HAMMAD A., TUMEIZI A. (2010) Land Degradation: Socioeconomic and Environmental Causes and Consequences in the Eastern Mediterranean. Land Degrad. Develop., 23:216-226. Doi: 10.1002/ldr.1069

AL-MASHREKI M.H., AKHIR J., RAHIM S.A., LIHAN K., HAIDER A.R. (2011) GIS-based sensitivity analysis of multi-criteria weights for land suitability evaluation of sorghum crop in the Ibb Govemorate Republic of Yemen. Journal of Basic and Applied Scientific Research, 1(9):1102-1111. ISSN 2090-424X.

AMIRI M.J., SALMAN MAHINI A., JALALI S.GH., HOSSEINI S.M., AZARI DEHKORDI F. (2010) A Comparison of Maps Overlay Systemic Method and Boolean-Fuzzy Logic in the Ecological Capability Evaluation of No.33 and 34 Watershed Forests in Northern Iran. Environ Sci., 7:109-124. (In Persian).

ASADIFARD, E. (2015) Landuse Planning in Firuzabad Township Based on Modifying Method of Current Model Using GIS. M.Sc. Thesis, Faculty of Agriculture, Shiraz University.

BABAIE KAFAKY, S., MATAJI, A. AND AHMADI SANI, N. Ecological Capability Assessment for Multiple-Use in Forest Areas Using GIS-Based Multiple Criteria Decision Making Approach. Am J Environ Sci. 2009; 5: 714-721. Doi: 10.3844/ajessp.2009.714.721

BAJA S., CHAPMAN D.M., DRAGOVICH D. (2006) A conceptual model for defining and assessing land management units using a Fuzzy modeling approach in GIS Environment. Environ Manage., 29:647-661. Doi: 10.1007/s00267-001-0053-8

BISWAS A., BARAN P.B. (2005) Application of fuzzy goal programming technique to land use planning in agricultural system. Omega, 33:391–398. Doi: 10.1016/j.omega.2004.07.003

DOI: 10.6092/issn.2281-4485/10433

BOJO´RQUEZ-TAPIA L., DI´AZ-MONDRAGO N.S., EZCURRA E. (2001) GIS-based approach for participatory decision making and land suitability assessment. Int J Geogr Info Sci., 15:129-151. Doi: 10.1080/13658810010005534

BURROUGH P.A., MACMALLIN R.A., VAN DEURSEN W. (1992) Fuzzy classification methods for determining land suitability from soil profile observations and topography. J Soil Sci., 43:193-210. Doi: 10.1111/j.1365-2389.1992.tb00129.x

DAVIDSON D.A., THEOCHAROPOULOS S.P., BLOKSMA R.J. (1994) A land evaluation project in Greece using GIS and based on Boolean and Fuzzy set methodologies. Int J Geogr Inf Syst., 8:369-384. Doi: 10.1080/02693799408902007

DENT D., YOUNG A. (1981) Soil Survey and Land Evaluation. George Allen & Unwin, London, 278 pp.

FALLAHSHAMSI H.R. (2004) Economic Evaluation of Different Land uses in Kalibar - chai Forest -covered Watershed, Using Linear Programming and Geographical Information Systems", Ph.D. Thesis Report, Natural Resource Faculty, Tehran University, Karaj. (In Persian)

FAO - Food and Agriculture Organization of the United Nations (1976) A framework for land evaluation. Soils Bulletin 32, Soil resources development and conservation service land and water development division, Rome, 87 p.

FAO - Food and Agriculture Organization of the United Nations (1993) Guidelines for Land Use Planning. Soil Resources, Management and Conservation Service, Rome, 96 p.

FAO (2011). Food Security in Libya. An Overview, World Food Programme . Food and Agriculture Organization 36.

GANDASASMITA K., SAKAMOTO K. (2007) Practical application of a land resources information system for agricultural landscape planning. Landscape Urban Plan., 79:38–52. Doi: 10.1016/j.landurbplan.2006.03.002

HAMZEH S., MOKARRAM M., ALAVIPANAH S. K. (2014) Combination of Fuzzy and AHP methods to assess land suitability for barley: Case Study of semi-arid lands in the southwest of Iran. Desert, 19:173-181. Doi: 10.22059/JDESERT.2014.52346

JAFARI R., BAKHSHANDEHMEHR L.(2013) Quantitative mapping and assessment of environmentally sensitive areas to desertification in central Iran. Land Degrad. Develop., 27 (2):108-119. Doi: 10.1002/ldr.2227

JOKAR P., MASOUDI M. (2016) Land suitability of Urban and industrial Development by a proposal model (A case study: Jahrom Township, Iran). Journal of Environmental Studies, 42:135-149.

JOZI S.A. (2010) Evaluation of Ecological Capability using Spatial Multi Criteria Evaluation Method (SMCE) (Case study: Implementation of Indoor Recreation in Varjin Protected Area-Iran).International Journal of Environmental Science and Development, 1: 273-277. ISSN: 2010-0264.

KUMAR M., BISWAS V. (2013) Identification of Potential Sites for Urban Development Using GIS Based Multi Criteria Evaluation Technique. A Case Study of Shimla Municipal Area, Shimla District, Himachal Pradesh, India. Journal of Settlements and Spatial Planning, 4(1):45-51.

KUTTER A., NACHTERGAELE F.O., VERHEYE W. H. (1997) The new FAO approach to land use planning and management, and its application in Sierra Leone. ITC journal, 3(4):278-283.

MAKHDOOM M. (2001) Fundamental of Land Use Planning. Tehran University Press, Tehran. 289 p. (In Persian).

MAKHDUOM M., DARVISHSEFAT A., JAFARZADEH H., MAKHDOM A. (2009) Environmental Evaluation and Planning by Geographic Information System. University of Tehran. 304p. (In Persian)

MALCZEWSKI M. (2004) GIS-based land-use suitability analysis: a critical overview. Progress in Planning, 62:63–65. Doi: 10.1016/j.progress.2003.09.002

MARANI BARZANI M., KHAIRULMAINI O.S. (2013) Desertification risk mapping of the Zayandeh Rood Basin in Iran. J. Earth Syst. Sci., 22:1269–1282. ISSN: 0253-4126.

MASOUDI M., JOKAR P. (2016) Suggestion the Proposed Model of EMOLUP, with New Approach in Land Use Planning (Step Two: Prioritizing for Different Land Uses). Environmental Studies, 14(2): under publication (In Persian).

MASOUDI M., JOKAR P., SADEGHI M. (2017) Land Use Planning using a Quantitative model and Geographic Information System (GIS) in Darab County, Iran. Journal of Materials and Environmental Sciences, 8(8):2975-2985. ISSN: 2028-2508.

NOURI J., SHARIFIPOUR R. (2004) Ecological Capability Evaluation of Rural Development by Means of GIS. Iran J Environ Health Sci Eng., 1:81-90.

DOI: 10.6092/issn.2281-4485/10433

NWER B. (2005) The application of land evaluation technique in the north-east of Libya. Published PhD thesis, Cranfield University, Silsoe.

OYINLOYE M., KUFONIYI O. (2013) Application of IKONOS Satellite Images in Monitoring of Urban Land use Change in Ikeja, GRA, Lagos, Nigeria. IJESI. 2:1-10. ISSN (Online): 2319 –6734.

PAULEIT, S. AND DUHME, F. GIS Assessment of Munich's Urban Forest Structure for Urban Planning. J Arboric. 2000; 26: 133-141. ISSN 0278-5226.

PEEL D., LLOYD M. (2007) Neo-traditional planning. Towards a new ethos for land use planning? Land Use Policy, 24:396–403. DOI: 10.1016/j.landusepol.2006.05.003

POURKHABBAZ H.R., JAVANMARDI S., FARAJI SABOKBAR H.A. (2014) Suitability Analysis for Determining Potential Agricultural Land Use by the Multi-Criteria Decision Making Models SAW and VIKOR-AHP (Case study: Takestan-Qazvin Plain). J. Agr. Sci. Tech., 16:1005-1016.

PRATO T. (2007) Evaluating land use plans under uncertainty. Land Use Policy, 24:165-174. Doi: 10.1016/j.landusepol.2006.02.003

SANAEE M. FALLAH SHAMSI S.R., FERDOWSI ASEMANJERDI H. (2010) Multi-criteria land evaluation, using WLC and OWA strategies to select suitable site of forage plantation (Case study; Zakherd, Fars). Rangeland, 4:216-227. (In Persian)

STEINITZ C. (2014) Which Way of Designing? Geodesign by Integrating Design and Geospatial Sciences.

SWANSON E. (2003) Geographic information system (GIS) information enhanced land use planning. Michigan Center for Geographic Information Department of Information Technology.

VAN LIER H. (1998) The role of land use planning in sustainable rural systems. Landscape Urban Plan., 41:83–91. Doi: 10.1016/S0169-2046(97)00061-3