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Land Use Planning using a Quantitative model and Geographic Information System (GIS) in Darab County, Iran

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Abstract
Land use planning is a science that determines the type of land use through studying the ecological character of the land as well as its socio-economic structure. The primary objective of this study is to evaluate the land use and natural resources for future sustainable land planning using GIS as a tool. So, In this study, a systematic method known as the Makhdoum Model was used for the analysis of maps in relation to the ecological and resources of the studied area. First, 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 study was the prioritization of land uses considering the ecological and socio-economic characteristics of the study area using a quantitative model. The results of the evaluation indicated that the maximum area of proposed uses is 33.2% that is related to irrigation agriculture showing this land use has high potential and socio-economic demands in study area. While minimum area of proposed uses is related to dry farming.

1. Introduction
Land-use planning is the systematic assessment of land and water potential, alternatives for land-use and economic and social conditions in order to select and adapt the best land-use options [1]. This definition embraces the systematic approach of possibilities for different land-uses in the future, and also the (felt) need for changes and the willingness to execute the plan all present land-use planning is caught up between two seemingly contradictory dimensions: ecological conservation and economic existence. Both dimensions are, in some way or another, related to sustainability in land-use planning, sustainability as a goal is often criticized as being vague and a paradox. The conflicting problem of economic development and ecological conservation is often mentioned: ‘‘we cannot save the environment without development and that we cannot continue to develop anywhere unless we save the environment [2].
In other hand, Unplanned and ungoverned development is one of the main problems in developing countries. To achieve sustainable development goals, evaluation of ecological capability as a basic study and foundation of land use planning, is a requisite action to accomplish development process in accordance with environmental capabilities. Besides, human-nature relation has achieved the real understanding of "human with nature" notion with gradual disappearing of old thoughts of "human on nature [3].
Arid and semi-arid lands cover more than 70% of Iran and are very prone to desertification [4, 5]. As a result of the following factors, land degradation and desertification have accelerated in Iran during the recent decades: first, the population has doubled over the last 25 years (since 1979); second, increased agricultural and pastoral products have forced people to use land extensively or convert forest and rangelands to cultivated land; third, overuse of wood and plants as fuel for household cooking and heating, and use of natural regulations tend to denude the soil and intensify the desertification [6]. Abu Hammad and Tumeizi [7] investigated the socioeconomic factors and causes of land degradation (e.g. population growth and urbanization, poverty, overgrazing, pollution, biodiversity, erosion) in the eastern part of the Mediterranean region. Results revealed a significant land use change from agricultural and natural vegetation to urbanized areas due to the high population increase during the last 80 years.
In this regard, land use planning is a kind of long-term planning that considers the land as a determined factor in supplying development goals. Land use planning based on regulations with permanent and suitable return view,

according to the qualitative and quantitative capabilities and talents for different use of human from the land shall render type of utilization. Thus waste of natural resources and ruining of the environment will be stopped.
In ecological evaluation, GIS is quickly becoming data management standard in planning the use of land and natural resources. Virtually all environmental issues involve map–based data, and real world problems typically extend over relatively large areas [8]. Actually a geographical information system (GIS) use to access for geography patterns [9] as well as Nowadays, GIS has become an indispensable tool for land and resource managers [10].
Land use, in general, consists of the coordination of the relation between humans and the land and their activities on the land for the proper and long-term use of provisions for the betterment of the material and spiritual condition of the society over time. Land planning requires extensive infrastructural research and keeping the economic condition of the area under study in mind. It can be undeniably stated that land use planning of an area without considering the socio-economic condition of that area is virtually impossible [11, 12, and 13]. While a part of an area in theory possibly has the potential for a certain use, it may be practically impossible to implement. Hence, one must base the ecological potential of an area for a certain use on the socio-economic ability of that area in addition to its ecological conditions. On the other hand, the lack of necessary knowledge of land potential and the irrational use of the land by humans bring about further reduction of land resources. In other words, the sustainable development or best use of the land will be carried out by assigning the land use zones on the basis of capability, compatibility, use of proper technology and measures to protect environmental degradability [14].
Bojo´rquez-Tapia *et al* [15] presenting a GIS-based multivariate application for land suitability assessment with a public participation base is also a typical case. Oyinloye and Kufoniyi [16] analyzed the urban land use change, 2000 and 2010 IKONOS are used in a post classification comparison analysis to map the land use changes and identify the conversion process in Ikeja, GRA, Lagos. The results showed increase in commercial land uses between the same periods. Also, the application of urban satellite images with higher ground resolution was found to be effective in monitoring the land use changes and providing valuable information necessary for planning and research.
Peel and Lloyd [17] consider four contemporary challenges facing land use planning practice, and suggest that a new ethos for land use policy making is emerging. Biswas and Baran Pal [18] in the District Nadia, West Bengal, investigated that how fuzzy goal programming can be efficiently used for modeling and solving land-use planning problems in agricultural systems for optimal production of several seasonal crops in a planning year. Gandasasmita and Sakamoto [19] addressed a multi-criteria analysis approach to agricultural landscape planning. This case study was conducted in the Cianjurwatershed, West Java, Indonesia. Results showed that proposed agro-ecological land-use was planned under which the land-utilization types would not cause more than tolerable soil loss, would be at least marginally suitable with regard to land resources quality, and would be economically feasible.
Current land use planning in Iran by Makhdoom Quantitative Method 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 in current model; a land use without ecological capability is prioritized or part of city is recommended to change to a pasture. Therefore the main goal of this study is to solve these problems and develop and modify the current quantitative method of Makhdoom Model to evaluate better land use planning in Iran.

2. Materials and methods

2.1. *Study area*

Darab County with an area of 1172 km^2 is located in the Fars province and southern parts of Iran (Fig 1). Darab city is located between geographical longitude 54° 33´ E and geographical latitudes 28° 47´ N and with the mean height 1180 meter. This area is located in mountainous area of Zagros and has a semi-arid climate.

2.2. *Data analysis*

In this study, a systematic method known as the Makhdoom Model [11] was used for the analysis of maps in relation to the ecological and socio-economic resources of the study area.

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.

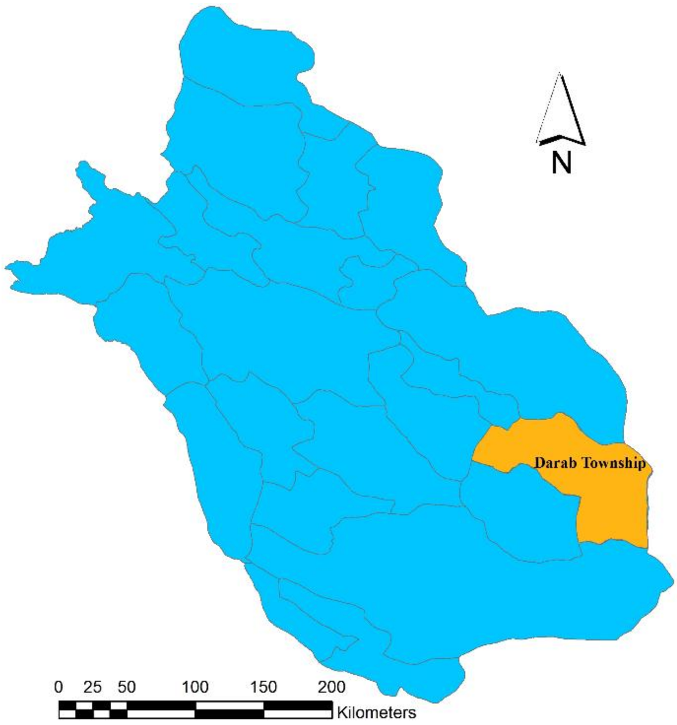

Figure 1: Position of Darab in Fars Province

These data for this study have been gathered from the records and reports published by the different departments of the Ministries of Agriculture and Energy and the Meteorological Organization of Iran. 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.

Table 1: Moderate and good classes for every use.

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	-		-
Temperature (°c)	Good	18-21	-	21-24[1]	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[2]	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, itosols 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	Low to Moderate	-	-

[1]in spring & summer seasons
[2]in spring & summer seasons

		good			
	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	-	-	-
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 canopy 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 (Lit/day/person)	Good	-	6000-10000[3]	>40	<225
	Good to Moderate		4000-6000	12-39.9	150-225
	Moderate		3000-5000	-	-
	Mostly moderate		To 3000	-	-

[3] m^3/ha

Different ecological capability models of Makhdoom method 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 [11]. 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 [11, 20].

In the next step, after producing ecological capability maps, the land use map was prepared. 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 d) ecological needs of the study area. 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 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.

First scenario to make its ranking was evaluated using current land use. But for other scenarios 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. In this study, 53 experts in different studied land uses in related organizations and offices of study area filled out questionnaires. Average of results helped us to rank different land uses for each scenario. Questionnaire filling is a good method especially for finding socio-economic needs of an area that depends to 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. On the other hand expertism evaluation of socio-economic of agriculture and natural resources and other utilizations make study very difficult.

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

It is necessary to say some modifications in the process of work were done like no preparation of environmental units and using current land use map. 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. Other modifications in the process of work done for assessing the land use planning model included:

a) Prioritization of each use was done based on the highest score derived after summing the scenarios' scores (ecological, economic, social, area) [11]. But, it should be considered appropriate (suitable) capability for the utilization with highest score.

b) To use current land use map in assessment mainly because of the socio-economic compulsions of the population especially in rural area. Like to 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) Dense forests with taking into consideration of compatibility of uses (e.g. conservation).
4) Lake and river bed.

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

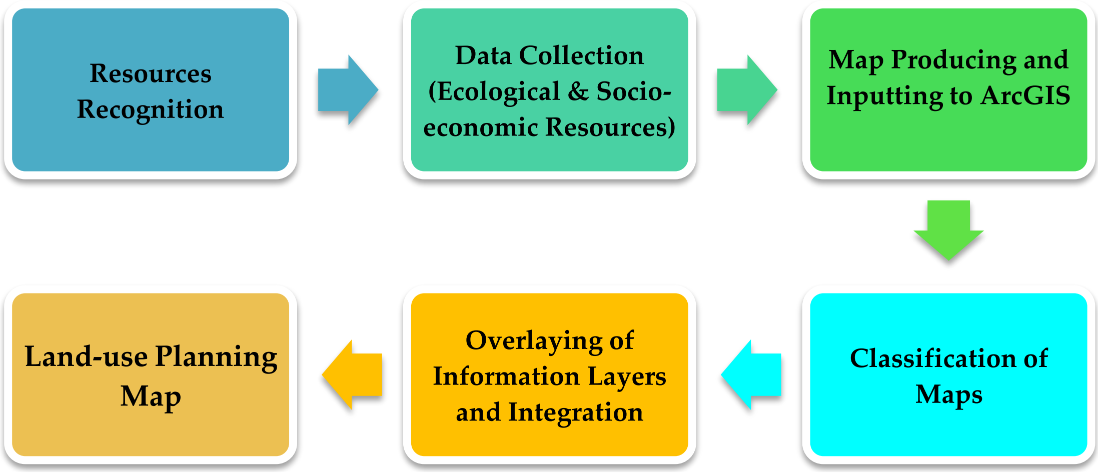

Figure 2: Process of evaluation.

3. 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 2.

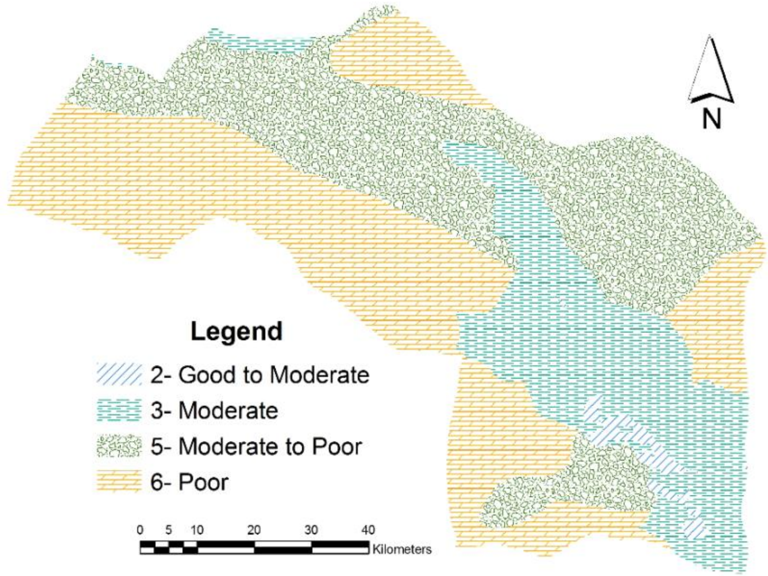

Figure 3: Land capability map for irrigation agriculture.

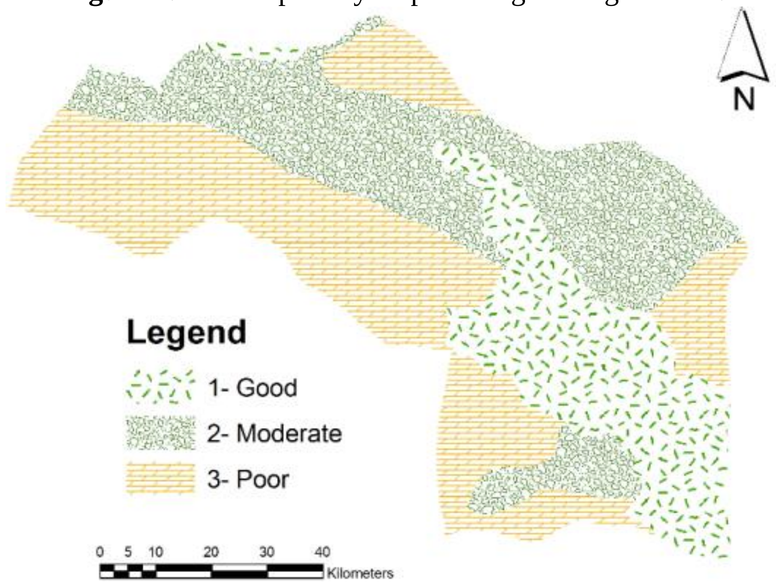

Figure 4: Land capability map for range management and dry farming.

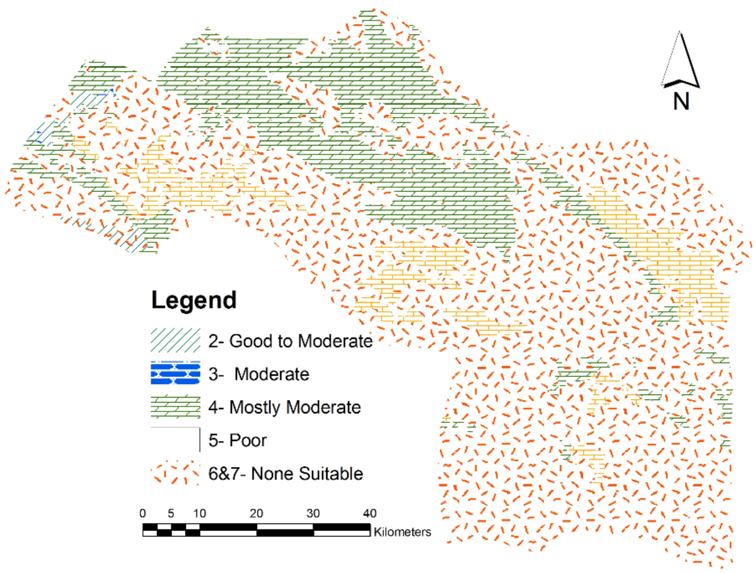

Figure 5: Land capability map for forestry.

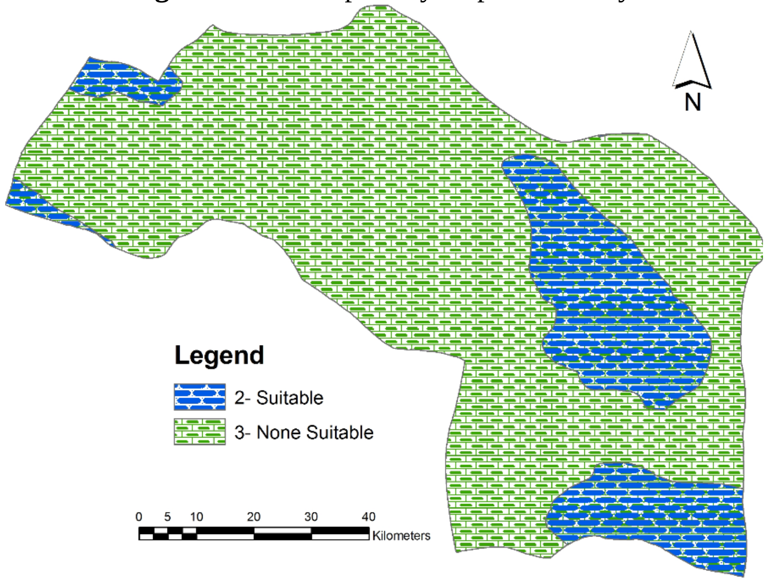

Figure 6: Land capability map for environmental conservation.

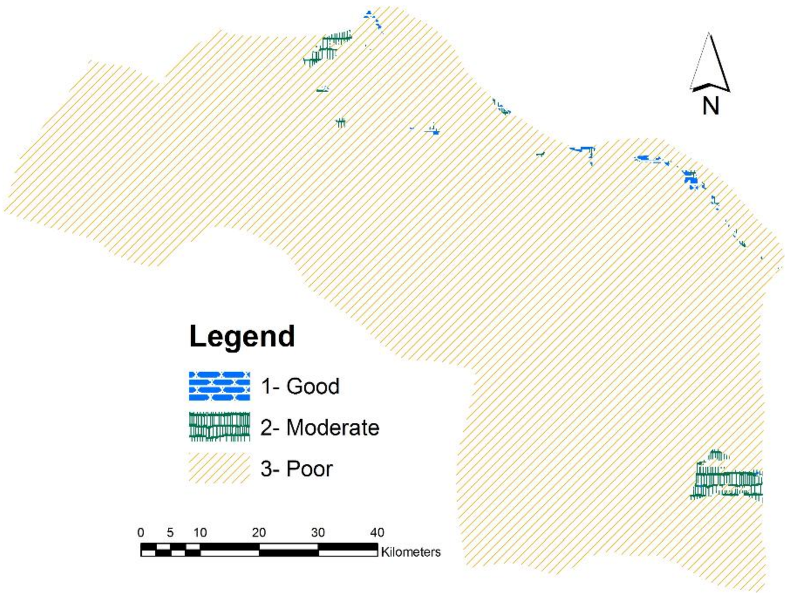

Figure 7: Land capability map for ecotourism (intensive).

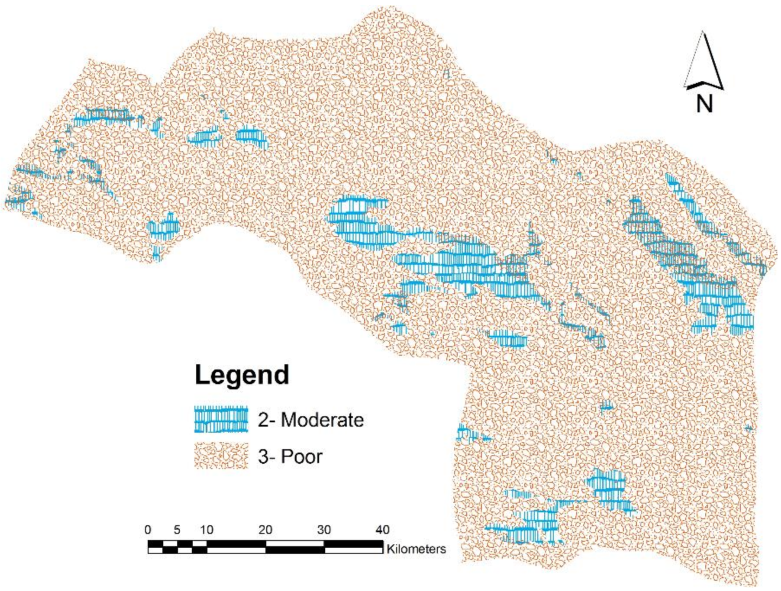

Figure 8: Land capability map for urban, rural and industrial development.

Table2: percent of area for different ecological capabilities of land uses.

Land Type	class	Percent
Agriculture	2	1.53
	3	21.95
	5	34.75
	6	41.77
Range management & dry farming	1	23.5
	2	35.1
	3	41.4
Forestry	2	0.95
	3	0.03
	4	20.82
	5	8.29
	6	16.44
	7	53.45
Conservation	2	21.08
	3	78.91
Ecotourism	1	0.29
	2	1.3
	3	98.41
Development of urban, rural and industry	2	11.03
	3	88.96

Then land capability maps were overlaid and land use planning map (Fig. 9) by quantitative approach was assessed. A comparison of land percent in current land use and proposed land use maps is observed in Table 3. The main results from this comparison indicate that current area is more than proposed area for forestry and range management showing these land uses are located more than their capabilities in the study area. While current area is less than proposed area for urban, rural and industrial development, irrigated and environmental conservation showing these land uses are located less than their capabilities in the study area. Also Fig. 9 and

Table 2 show the maximum area of proposed uses is 33.2% that is related to irrigation agriculture showing this land use has high potential and socio-economic demands in study area. While minimum area of proposed uses is related to dry farming.

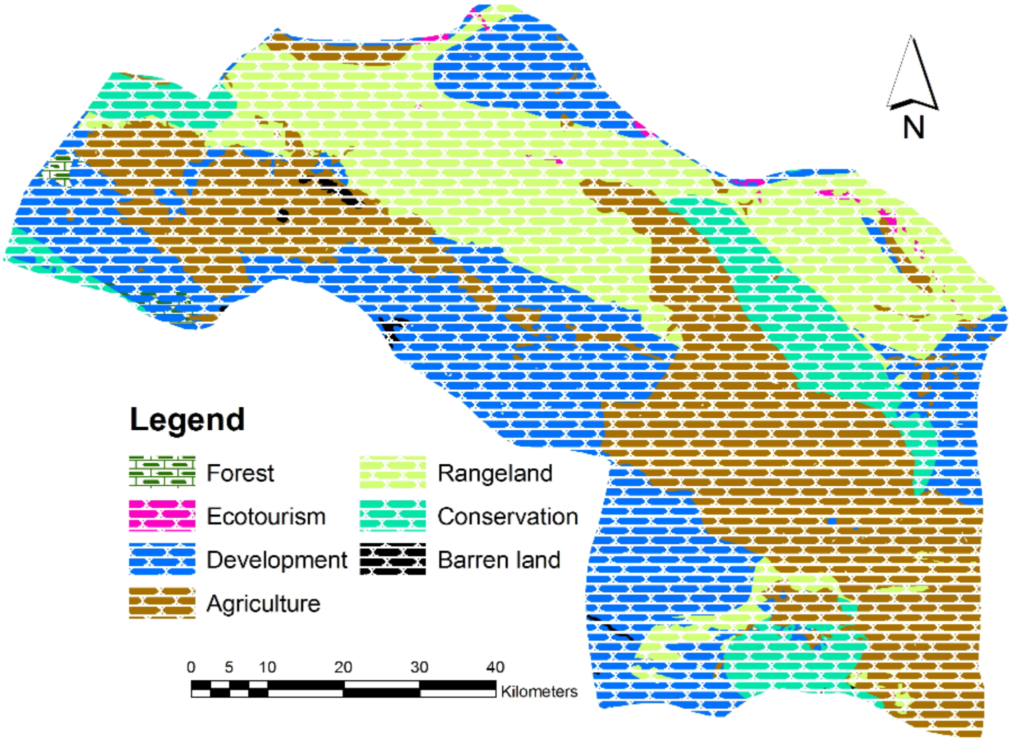

Figure 9: Land use planning map

Table 3: comparison of land percent in Current land use and proposed land use maps.

Land Type	Percent of Current land use	Percent of Proposed land use
Forestry	18.95	0.57
Ecotourism	-	0.28
Urban, rural and industrial development	0.12	32.6
agriculture Irrigation	12.82	33.2
Range management	66.49	24.42
dry farming	0.05	-
Environmental conservation	-	8.65
Saline land	0.89	-
Bare land	0.65	0.37

Conclusions

Cause of land degradation can be divided into natural hazards, direct causes, and underlying (indirect) causes. Direct causes are unsuitable land use and inappropriate land management practices, for example cultivation in steep slopes [21]. All these activities have to be controlled by local natural resources offices based on the capacity of natural vegetation cover and land use planning [21, 22, and 23].Based on the results obtained from this paper, the minimum and maximum percentages of the final maps of land use planning are dry farming and irrigation agriculture, respectively. With Boolean approach, a parameter is sufficient to lead to a lower class[24, 25, 26, 27and28].Amiri et al [27] 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.Babaie-Kafaky et al [29] 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.

Through examining the prepared land planning maps, we determine that we cannot only use environmental units for just a single purpose; the potential exists for multiple uses. However, in any one unit, no more than a single type of utilization can, ultimately, be implemented [11]. In units where there are no socioeconomic limitations, the priority is with the one demonstrating the highest potential [30].The priority of land use in some of the units is determined based on political needs, and the possibility for changing it does not exist [31]. In some units where one use has no advantage over another and from the priority point of view are close, multiple uses may be proposed [11].

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