GIS application for land evaluation and planning of Hamadan province for agricultural activity

Mahdi.Reyahi khoram *, Dr M.Shariat** ,Dr A. Azar ***

*Doctoral student in environmental management, faculty of Environment, science and research branch, Islamic Azad Univ in Tehran
And Educator in jihad-e agriculture education complex in Hamadan province,
P.O.BOX: 14515-775,Tehran, Iran. E-mail: phdmrk@yahoo.com

** Prof of department of environmental management, faculty of Environment, science and research branch, Islamic Azad Univ in Tehran, P.O.BOX: 14515-775,Tehran, Iran. E-mail: mahmood_shariat@hotmail.com

***Associate prof of Tarbiat modarres Univ in Tehran
E-mail: AZARA@Modares.ic.ir

1 Abstract

Considering that land is an important property and all economic resources as well as development activities are concentrated on it; therefore, it is required to carry out long term and scientific land evaluation.
Land evaluation is a form of land classification, which predicates the behavior of land use systems, that is, specific land area under specific uses.
Geographical Information System (GIS) is the combination of spatially referenced data, appropriate computer hardware and software, and users competent to employ the data and technology to solve problems. GIS is typically used to store and analyse extensive information in a map-based format. Considering GIS powers for integrating georeferenced data, and the possibility of the complex analyses connected with attribute information and graphic information, GIS is the best suitable system for land evaluation.
The Province of Hamadan located in the west of Iran, covers 19493 square kilometers and is 320 kms from Tehran. Due to the low investments in industrial activity, the development of the area is built upon the improvement of agriculture, while the real land evaluation of the region is not yet studied thoroughly.
In this research, at the first step the Makhdoum's model (Makhdoum 2001) is introduced, and then Hamadan province, from agricultural point of view and capabilities of the lands to fullfill agricultural activities, and range management is evaluated and then these capabilities are categorized in to 9 classes using Makhdoums model. In this research, we have used Geographic Information System (GIS) with a scale of 1/250000 .The software used is Arc View (version 3.2a), with the UTM projection. In this evaluation we have used eleven data layers of digital map in the model. These layers include: over-all slope, climatological condition, present erosion status, the amount of water capacity, temperature, relative humidity, the sensitive planting areas, the value of the protective plant species, precipitation, the rate of fodder/hectare, and the vegetation cover. For evaluation, we have utilized McHark method of Maps overlay (McHark 1969). The results of this research are as follow:

1 - about 31.6 percent of Hamadan province area has the slope that is steeper than 12 percent.
2- since we have used Makhdoum's model and data analyses in this model based on Systematic Analysis, therefor, different environments were showed on the map, each of which holds its own Micro ecosystem with its specific ecological potential capability.
3- following the processing of the information, the capability of the land was showed on the map in different types of land uses.
4- According to the results, the extent of wet agricultural land, dry agricultural land and the extent of the rangelands were introduced.
5- final results showed some limitations of the ecological capability of Hamadan province for agricultural activities in some areas. These limitations should be considered for improvement programs of the province.

2 Introduction

According to the statistics and the information available, annually over two billion tones of the best quality soil of the watershed in our country erode. Annually, 1,000,000 hectares of the land of our country change to the deserts and the rate of the destruction of the jungles is estimated to be equal to 360 square meters per second, the underground water tables in most plains of the country is also decreasing.
The Province of Hamadan covers 19493 square kilometers, is located in west of Iran, is 320 km from Tehran and the population is about 1.6 million people. Due to the low investments in industrial activity, the development of the area is built upon the improvement of agriculture.
According to that using Makhdoum's model in this research, at first it is necessary to produce Makhdoum's model.
Makhdoum's model: In fact, Makhdoum's model is a linear, multi unknown quantity model to evaluate and recognize the potentials and capabilities of the land for agriculture objectives. This model was presented by professor. Majeed F. Makhdoum, the chair man of Environmental planning & management Department, faculty of environment in Tehran university in 2001.

In this model, 28 parameters, related to different factors, or related to 28 informational layers were used and each informational layer was consisted of several classes. The condition of the layers and the classes is briefly presented in table (1). In this model, the capabilities of the lands in agriculture and range management are defined in selection 9, where each selection is explained by using a formula. Considering that different parameters are used in designing these parameters, each formula denotes the characteristics of that selection. These formulas are as follows:

$$F_1 = Cl[cd(4,5,6,7,8)] + Wc(1,2) + So(1,2) + Ct(2,3,4) + Ch(2,3,4) + dsm(1,2) +$$
$$Es(1,2) + Ps_1(1) + Ph(2) + Pg(1,2) + Pd(1) + Ps_2(1) + Pf(1) + Pdr(1) +$$
$$Phg(1,2) + Pte(7,8,10,12) + H(10) + \Pr(13) + Cvt(3) +$$
$$Ha(2,3) + Si(5,8)$$

$$F_2 = Cl[bcd(4,5,6,7,8)] + Wc(1,2,3) + So(1,2,3) + Ct(1,2,3,4) + Ch(2,3,4) + dsm(1,2) + Es(1,2) + Ps_1(1) + Ph(2,3) + Pg(1,2,3) + Pd(1,2,3) + Ps_2(1) + Pf(1) + Pdr(1,2) + Phg(1,2) + Pte(4,7,8,9,10,12) + H(10) + \mathrm{Pr}(13) + Cvt(3) + Ha(2,3) + Si(5,8)$$

$$F_3 = Cl[abcd(2,3,5,6,7,8)] + Wc(1,2,3) + So(1,2,3) + Ct(1,2,3,4,5) + Ch(1,2,3,4) + dsm(1,2,3) + Es(1,2) + Ps_1(1,2) + Ph(1,2,3) + Pg(3,4) + Pd(2,3,4) + Ps_2(1,2,3) + Pf(2,3,4) + Pdr(1,2,3,4) + Phg(1,2,3) + Pte(1,2,3,4,5,6,7,8,9,10,11,12) + H(10) + \mathrm{Pr}(13) + Cvt(3) + Ha(2,3) + Si(5,8)$$

$$F_4 = Cl[bcd(3,4,5,6,7,8)] + Wc(4) + So(1,2,3,4) + Ct(2,3,4) + Ch(2,3,4) + dsm(1,2) + Es(1,2) + Ps_1(1,2) + Ph(1,2) + Pg(1,2,3) + Pd(1,2,3) + Ps_2(1,2) + Pf(1,2,3) + Pdr(1,2) + Phg(1,2) + Pte(4,7,8,10,12) + H(10) + \mathrm{Pr}(13) + Cvt(3) + Ha(2,3) + Si(5,8) + Cp(4,5,6,7)$$

$$F_5 = Cl[abcd(2,3,4,5,6,7,8)] + Wc(4) + So(1,2,3,4) + Ct(1,2,3,4,5) + Ch(1,2,3,4) + dsm(1,2,3) + Es(1,2,3) + Ps_1(1,2,3) + Ph(1,2,3) + Pg(3,4) + Pd(3,4) + Ps_2(1,2,3) + Pf(2,3,4) + Pdr(3,4) + Phg(1,2,3) + Pte(1,2,3,4,5,6,7,8,9,10,11,12) + H(10) + \mathrm{Pr}(13) + Cvt(3) + Ha(2,3) + Si(5,8) + cp(3,4,5,6,7)$$

$$F_6 = Cl[abcd(2,3,4,5,6,7,8)] + Wc(4) + So(1,2,3,4,5) + Ct(1,2,3,4) + Ch(1,2,3,4) + dsm(1,2) + Es(1,2) + Ps_1(1,2,3) + Ph(1,2,3) + Pg(1,2,3,4) + Pd(1,2,3,4) + Ps_2(1,2) + Pf(1,2,3) + Pdr(1,2) + Phg(1,2) + Pte(1,2,3,4,6,7,8,9,10,11,12) + H(10) + \mathrm{Pr}(8,13) + Cvt(3) + Ha(2,3) + Si(5,8) + Cp(4,5,6,7) + Dg(1) + Ba(4,5) + Vg(1) + Rc(1,2) + Rac(1,2,3) + Vf(1,2,3)$$

$$F_7 = Cl[abcd(2,3,4,5,6,7,8)] + Wc(4) + So(1,2,3,4,5) + Ct(1,2,3,4,5) + Ch(1,2,3,4) + dsm(1,2,3) + Es(1,2,3) + Ps_1(1,2,3) + Ph(1,2,3) + Pg(3,4) + Pd(3,4) + Ps_2(1,2,3) + Pf(2,3,4) + Pdr(3,4) + Phg(1,2,3) + Pte(1,2,3,4,6,7,8,9,10,11,12) + H(10) + \mathrm{Pr}(8,13) + Cvt(3) + Ha(2,3,4) + Si(5,7,8) + Cp(3,4,5,6,7) + Dg(2) + Ba(3,4,5) + Vg(2) + Rc(3,4) + Rac(3,4) + Vf(1,2,3)$$

$$F_8 = Cl[abcd(1,2,3,4,5,6,7,8)] + Wc(4) + So(5,6,7,8) + Ct(1,2,3,4,5) + Ch(1,2,3,4) + dsm(1,2,3) + Es(1,2,3) + Ps_1(2,3) + Ph(1,2,3,4) + Pg(3,4) + Pd(3,4,5) + Ps_2(1,2,3) + Pf(3,4,5) + Pdr(3,4) + Phg(1,2,3) + Pte(1,2,3,4,6,7,8,9,10,11,12) + H(10) + \Pr(8,13) + Cvt(3) + Ha(1,2,3) + Si(4,5,7,8) + Cp(2,3,4,5,6,7) + Dg(3) + Ba(1,2,3,4,5) + Vg(2,3,4) + Rc(2,3,4) + Rac(4) + Vf(1,2,3,4)$$

$$F_9 = Cl[abcd(1,2,3,4,5,6,7,8)] + Wc(4) + So(7,8,9,10) + Ct(1,2,3,4,5) + Ch(1,2,3,4) + dsm(1,2,3,4,5) Es(1,2,3,4,5,6,7) + Ps_1(3,4) + Ph(1,2,3,4) + Pg(1,2,3,4) + Pd(5) + Ps_2(3,4) + Pf(4,5) + Pdr(4,5) + Phg(1,2,3,4) + Pte(1,2,3,4,6,7,8,9,10,11,12) + H(1,2,3,4,5,6,7,8,9,10,11,12) + \Pr(8,13) + Cvt(1,2,3) + Ha(1,2,3,4,5) + Si(1,3,4,5,6,7,8) + Cp(2,3,4,5,6,7) + Dg(3) + Ba(1,2,3,4,5) + Vg(2,3,4) + Rc(3,4,5) + Rac(4) + Vf(1,2,3,4,5)$$

In these formula:

W_1 : favorite areas for number one wet farming
W_2 : favorite areas for number two wet farming
W_3 : favorite areas for number three wet farming
D_1 : favorite areas for number one dry farming
D_2 : favorite areas for number two dry farming
R_1 : favorite areas for number one rangeland
R_2 : favorite areas for number two rangeland
R_3 : favorite areas for number three rangeland
R_4 : favorite areas for number four rangeland
$Cl[abcd]$: climatological condition (in 32 class)
Wc: the amount of water capability as cubic meter per hectare (in 4 class)
So : over - all slope as percent (in 10 class)
Ct : Air temperature (in 5 class)
Ch : relative humidity as percent (in 4 class)
Cp.: Ave precipitation as mm/yr. (in 7 class)
DSM: Electrical conductivity as Deci Siemens per meter (in 5 class)
Es: soil Erosion by water (in 7 class)
Ps_1 : soil maturation (in 4 class)
PH: soil acidity (in 4 class)
Pg.: soil classification (in 4 class)
Pd: soil depth as cm (in 5 class)
Ps2: Topsoil stoniness as percent (in 4 class)
Pf : soil fertility (in 5 class)
Pdr: soil drainage (in 5 class)
Phg: Hydrologic soil group (in 4 class)
Pte: Topsoil texture (in 13 class)
H: geohydrology (in 12 class)
Pr: protected areas (in 13 class)
Dg: the rate of fodder as kg per hectare (in 4 class)

layer	1	2	3	4	5	6	7	8	9	10	11	12	13
Cl*	*	*	*	*	*	*	*	*	*	*	*	*	*
wc	+10000	6000-10000	6000-3000	-3000	-	-	-	-	-	-	-	-	-
So	0-2	2.1-5	5.1-8	8.1-12	12.1-15	15.1-20	20.1-25	25.1-40	40.1-65	+65	-	-	-
Ct	-18	18.1-21	21.1-24	24.1-30	+30.1	-	--	-	-	-	-	-	-
Ch	-40	40.1-60	60.1-80	80.1-100	-	-	-	-	-	-	-	-	-
Cp	-50	51-200	201-500	501-800	801-1200	1201-2000	+2001	-	-	-	-	-	-
dsm	-4	4-8	8.1-18	18.1-22	+22	-	-	-	-	-	-	-	-
Es	NO. E	-.25	.25-.70	+.70	Rill Erosion	Gully Erosion	Aluvial Erosion	-	-	-	-	-	-
Ps_1	Mature	Semi mature	In maturation	Non mature	-	-	-	-	-	-	-	-	-
Ph	4.2-6	6.1-7	7.1-8.5	8.6-10	-	-	-	-	-	-	-	-	-
Pg	Vrry fine	fine	medume	Coarse	-	-	-	-	-	-	-	-	-
Pd	+180	121-180	61-120	31-60	-30	-	-	-	-	-	-	-	-
Ps_2	2-15	16-50	51-90	+90	-	-	-	-	-	-	-	-	-
Pf	Very good	good	medume	Poor	Very poor	-	-	-	-	-	-	-	-
Pdr	perfect	Good-medume	Medume-imperfect	Imperfect –poor	Poor	-	-	-	-	-	-	-	-
Phg	A	B	C	D	-	-	-	-	-	-	-	-	-
Pte	sand	Loamy dand	Sandy loam	Loam	Silt loam	silt	Sandy clay loam	Clay loam	Silty clay loam	Sandy clay	Silty clay	clay	Litosol
H	River dry bed	Food plain	fault	Marn (I) and (II)	River dry bed-fault	River dry bed - marl	Foodplain - fault	Food plain-marl	Fault-marl	others	Saline formations	****	-
Pr	Reserve area forest	Natural forest park	Arteficial forest park	Natural park	National park	Wildlife refuge	Natural monuments	Protected area	Biospher reserves	Wordly inheritance	Ancient relics	Historical and cultural sits	Other
Dg	500	350-499	250-349	-250	-	-	-	-	-	-	-	-	-
Ba	10-14	5-9	2-5	-	-	-	-	-	-	-	-	-	-
Vg	76-100	51-75	26-50	6-25	1.1-5	0-1	-	-	-	-	-	-	-
Vf	Annual or biennial plants	Permanent herbaceous plant	Woody plant	shurb	wood	-	-	-	-	-	-	-	-
Si	mongrove	creek	wetland	savanna	bank	dene	forest	others	-	-	-	-	-
Cvt	**	***	others	-	-	-	-	-	-	-	-	-	-
Ha	excelent	usual	poor	vulneral	vulnerable	-	-	-	-	-	-	-	-
Rc	Excelent	good	fair	poor	Very poor	-	-	-	-	-	-	-	-
Rac	**2**	**1**	**.5**	**.25**	-	-	-	-	-	-	-	-	-

** : after will discuss*

*** : plant species such as Taxus baccata , Buxus hyrcanus , Acer hyrcanum , Cupressus sempervirens var.horizontalis , Sorbus torminalis*

**** : Juniperus polycarpus , Biota orientalis , juiperus , Rhizophora mucronata , Quercus cinerascens , Prunus aviom , Quercus persica , piruscommunis*

***** :sensitive formation on erosion*

Table (1) :summery of makhdooms model and its parameters

BA : biodiversity (in 3 class)
Vg: vegetation cover as percent (in 6 class)
VF: type of plant growth (in 5 class)
Si: the sensitive plant areas (in 8 class)
Cvt: The value of the protective species (in 3 class)
Ha: habitat trend (in 5 class)
Rc: range condition (in 5 class)
Rae: range carrying capacity (in 4 class)

In Makhdoum's model, Demartunne's method, which was verified by Dr. Khalili, has been used to classify it according to the climates. The difference between Demartunne's method and its verified version is that in its verified one, the effect of the height from the sea free level has been regarded in the calculations.

$$A = \frac{P}{T + 10} \qquad (1)$$

in this equation :
A :Aridity index values
P : mean annual precipitation as mm/yr
T: mean annual Air temperature 24h as c^o

In climate classification of Demartunne's method there are seven classes, and by using Demartunne's method, index of "A" has been calculated, and the type of the climate is defined according to that (see Table2).

Climat type	Aridity index values
Arid	-10
Semiarid	10-19.9
Mediterranean	20- 23.9
Subhumid	24 - 27.9
Humid	28 - 34.9
Very humid	+35

Table 2 :classification of climatological condition in DeMartonnes method

Formula (1) is known as Demartunne's Formula. According to this formula, whenever the annual mean of the rain increases in an area, Demartunne's index increases simultaneously. In other words, the above mentioned area is heading to become humid. Furthermore, if the annual temperature decreases in a specific area, consequently, Demartunne's index will increase; i.e. the area is heading toward becoming humid (see Table 2).
In this formula, the effect of temperature decreasing in mountain regions, will cause the Demartunne's index in these regions increase to a Very humid, which may turn these regions to be considered as Very humid regions. Since this conclusion is not correct, Dr. Ali Khalili, the professor of Natural Resources College of Tehran's University, verified Demartunne's formula, trying to match it to Iran's climates. According to this revise, the climate nature in Demartunne's system is defined by using a two- letter combination, where each letter stands for one standard. The first part or letter, "A_i" is

Demartunne's index. There is only a small difference, because of the arid condition in the deserts of Iran; the arid parts will be divided to two parts; very arid parts, and desert arid parts. The second part or the letter "m_j" is the standard of temperature, which is distinguished by considering the mean of the least temperature in the weather of the coldest months of the year (see Tables 3 and 4).

Mean MIN air temperature at coldest month per year as C	Climatological group	m_j
<-7	Very cool	a
-7 - 0	Cool	b
0-5	Moderate	c
+5	Warm	d

Table 3 : application of m_j coefficient for modified DeMartonne method by Ali Khalili

Therefore, the revised system of Demartunne is comprised from four groups of climates and eight types of climate and totally they include 32 categories of climates. The maps of Iran's climates are prepared and presented according to this method.

Aridity index values	A_i	Typs of climate
0-4.9	1	Very arid
5-9.9	2	Desert arid
10-19.9	3	Semi arid
20-23.9	4	Mediterranean
24-27.9	5	Subhumid
28-34.9	6	humid
35-54.9	7	Very humid (I)
+55	8	Very humid (II)

Table 4 :application of A_i coefficient for modified DeMartonne method by Ali Khalili

3 Methodology

land evaluation of Hamadan province is not yet studied thoroughly. In this research, Hamadan province, from agricultural point of view and capabilities of the lands to fulfill agricultural activities and range management is evaluated, using the Geographical Information system (GIS).
This research started from the beginning of March 2003 in Hamadan Province, and took 12 months. The process of land evaluation in this research is presented in three parts.
A - collecting information: collecting information was fulfilled in two ways, one by library studying where information resources, libraries, companies, research institutes, and ministries were needed for digital information. Then we tried to update the collected information by desert patrolling and analyzing and collocating comparison of natural conditions of the lands.
B - Analyses: The characteristics and environmental parameters of each area are various, and these characteristics can define an ecological system. Therefore, the important aspect of the survey is the evaluation of the land and

studying and analyzing the environmental characteristics, which is a very hard task. Consequently, using this model to accelerate the recognition of the parameters and the analyses of the data is inevitable. In this research, this model has been used to analyze the data and to be specific Makhdoum's model has been used.

C - Evaluation: What is meant by evaluation is the ecological capability in determining or forecasting the potential capability or type of natural usage of the land. Although methods such as check list, Matrix, Network, and overlay Method have been used to environmental impact assessment, In this research overlay Method (McHark 1969) has been used to evaluate the capability of the land. Also in this research, Geographical Information System (GIS) has been used to evaluate the land as a main tool .The software used is Arc View (version 3.2a) with the UTM projection and scale was 1/250,000.

After preparation the above-mentioned layers, we tried to unite the projection system of all of the layers and the projection system was select (UTM). All layers were on the scale of 1/250,000. Meter is defined for the software system as the unit of the scale and the unit of the map.

Following the preparation of the layers, each eleven layers accompanied with the base layer of the province itself were presented in a file in Arc View, and the related classification of information was done according to the applied model. In the second step, the above mentioned layers were changed from its vector data to raster data by using convert to gird command, and to the next analysis in Arc View soft ware. In addition, the amount of the cell sizes was selected to be ten meters. This selection caused the operation to be very exact. Then for each parameter motioned above in the model, Map Query (MQ) was considered. Later, the extent of interfering over lapping of the cases was analyzed by using multiple MQ's. In this analyze, it became clear that only two selections out of nine selections related to the model over lapped each other. These two selections included selections of two number wet farming areas and three number wet farming areas, after land studying, where it was decided that these covering be considered as related to two number wet farming areas. Consequently, the above vastness of the lands was deleted from three number wet farming.

4 results

The results of this research are presented in two parts.

1- The collected information: in this research, 11 Geographical information System (GIS) layers have been used to evaluate, on the basis of the classifications used in Makhdoum's model. The titles of these layers are presented in table (5). Furthermore, related information of these layers includes the followings.

A -Climate condition (Cl). As we mentioned already, in the above mentioned model 32 categories were considered for the layer of the climate, but in Hamadan Province there are only 8 categories.According to the information collected, about 68.4percent of the province is classified as very cool-semi Arid (see Table 5).

B - Relative humidity (ch). Considering that Hamadan Province is too far from the sea and its rainfall is limited, its relative humidity mean is low annually. According to the available information, the maximum relative humidity in Bahar area is equal to 55 percent, and the minimum relative humidity is in Malayer area, is equal to 45 percent. Therefore, in the above-mentioned model, there are 4 classes for the layers of relative humidity, while there is only one

class in Hamadan province (see Table 6).

C- The rate of fodder/hectare (Dg). Considering the poor pastures of the province, there are only the classes of 3 & 4 of this layer, and this indicates that the pastures of the province are too poor (see Table 7).

D - The precipitation's (Cp). The annual precipitation in the studied area is limited too, to the extent that its maximum rate was in Bahar area with 372 mm., and its minimum rate was in Razan area with 274 mm. Therefore, there are 7 classes considered for the layer of precipitation, while in Hamadan province there is only one class (see Table 8).

E - Soil erosion by water (Es). According to the information, only 5 information layers out of 7 are concerned with the erosion in the province, where there is no gully erosion or alluvial erosion there (see Table 9)

NO.	Climatological condition	CODE	%	NO.	Category	CODE	%
1	Very cool- very arid	a1	0	17	Moderate - very arid	c1	0
2	Very cool- desert arid	a2	0	18	Moderate - desert arid	c2	0
3	Very cool-semiarid	a3	68.4	19	Moderate - semi arid	c3	0
4	Very cool-Mediterranean	a4	14.3	20	Moderate - Mediterranean	c4	0
5	Very cool-subhumid	a5	2.3	21	Moderate - subhumid	c5	0
6	Very cool-humid	a6	2.8	22	Moderate -humid	c6	0
7	Very cool -Very humid(I)	a7	0.9	23	Moderate - Very humid(I)	c7	0
8	Very cool-Very humid(II)	a8	0	24	Moderate - Very humid (II)	c8	0
9	Cool -very arid	b1	0	25	Warm -very arid	d1	0
10	Cool - arid	b2	0	26	Warm - desert arid	d2	0
11	Cool -semi arid	b3	6.2	27	Warm - semiarid	d3	0
12	Cool - Mediterranean	b4	4.3	28	Warm - Mediterranean	d4	0
13	Cool -subhumid	b5	0	29	Warm - subhumid	d5	0
14	Cool -humid	b6	0.8	30	Warm -humid	d6	0
15	Cool - Very humid(I)	b7	0	31	Warm - Very humid (I)	d7	0
16	Cool - Very humid (II)	b8	0	32	Warm - Very humid (II)	d8	0

Table (5) : Hamadan climatological condition based on modified DeMartonne method by Ali Khalili

F- Temperature (Ct). Basically Hamadan province is located in the cold regions of country, and therefore, according to the information and the statistics, the annual mean temperature in the Kabootar Ahang region is equal to 9.5°c, and in Malayer region is 13.5°c. Annual mean temperature in all of the regions of the province is less than18 °c. Therefore, 5 classes are

Area %	Ch (%)	Code NO
0.0	-40	1
100.	40.1-60	2
0.0	60.1-80	3
0.0	80.1-100	4

Table (6) : characteristics of Ch in Hamadan province

Area %	Dg (Kg/hc)	Code NO
0.0	500	1
0.0	350-499	2
2.8	250-399	3
97.2	-250	4

Table (7): characteristics of Dg in Hamadan province

Area %	Cp (mm/yr)	Code NO
0.0	-50	1
0.0	51-200	2
100	201-500	3
0.0	501-800	4
0.0	801-1200	5
0.0	1201-2000	6
0.0	+2000	7

Table (8): characteristics of cp in Hamadan province

Area %	Es (%)	Code NO
26.8	NO Erosion	1
28.3	-0.25	2
22.7	0.25-0.7	3
15.4	+0.7	4
6.8	Rill Erosion	5
0.0	Gully Erosion	6
0.0	Aluvial Erosion	7

Table (9): characteristics of Es in Hamadan province

Area %	Ct (C^o)	Code NO.
100	-18	1
0.0	18.1-21	2
0.0	21.1-24	3
0.0	24.1-30	4
0.0	+30.1	5

Table (10): characteristics of Ct in Hamadan province

Area %	Wc (M^3/ hc)	Code NO.
0.0	+10000	1
17.4	10000-6000	2
34.7	6000-3000	3
47.9	-3000	4

Table (11): characteristics of Wc in Hamadan province

alocated to the temperature in the above-mentioned model,while in Hamadan province there is only one class(see Table 10).

G-Water capacity (Wc). Our region contains limited surfaces of water, and therefore a great part of the water necessary for the province is supplied from the underground water. Also, because of the extra usage of this water the levels of the underground water of all of the plains of the province are minus. According to this model, 4 classes are considered for the water capacity, while in Hamadan province there is only three classes (see Table 11)

H - The sensitive plant areas (Si). As it was mentioned, Hamadan province is too far from the sea and that the province does not have of Mangrove, creek, Savanna areas, and dene. On the other hand, in Makhdoum's model bank areas and other areas are put by each other. Therefore these two areas are combined with each other in this research. The forests of the province cover 35,000 hectares, while there are few wetlands, some of which become dry in

summer times. In this research, the importance of the protection of the natural resources and the environment value of the forests and wetlands is considered, and we have tried to show this subject in evaluating the land to a great extent, although the forests and wetlands of the province are too limited. In this model, there are 8 layers considered to the sensitive plant areas, while in Hamadan province there are only three layers (see Table 12).

I - Over-all slope (So). In Makhdoum's model, the over all slope is classified in 10 classes, while the information collected show that in the province, the slope classes of 3, 7, 9, and 10 are not available. Also, the information showed that 31.6 percent of the province lands have a slope more than 12 percent (see Table 13).

J - The value of the protective species (Cvt) as we mentioned already, the wood coverage of the province is far less than the province itself. The tree species of the first layer in the province are not present, and the tree species of the second layer in the province are found in Nahavand woodlands to a limited degree. Therefore in this model, there are 3 classes for the layer of sensitive plant areas, while there are two classes in the province (see Table 14).

Area %	Si	Code NO
0.0	Mangrove	1
0.0	creek	2
0.2	Wetland	3
0.0	Savanna	4
0.0	Bank	5
0.0	Dene	6
1.2	Forest	7
98.6	Other	8

Table (12): characteristics of Si in Hamadan province

Area %	So (%)	Code NO
20.2	0-2	1
34.2	2.1-5	2
0.0	5.1-8	3
14	8.1-12	4
9.6	12.1-15	5
7.3	15.1-20	6
0.0	20.1-25	7
14.7	25.1-40	8
0.0	+65	10

Table (13): characteristics of So in Hamadan province

K- Herbage density (Vgo). Concerning the layer of herbage density, fortunately, all of the classes forecasted in the model are available in the area, although they are very limited in some of classes (Table 15).

2- The results of the evaluation: According to this model and considering the information collected in Hamadan province, there are no favorite areas for number one wet farming, there are no favorite areas for number one dry farming and in the province, there are no favorite areas for number one and number two range management.

According to this model, favorite areas for number two wet farming in Hamadan province is equal to 70,000 hectares (3.6 percent of the province), favorite areas for number three wet farming is equal to 500.000 hectares (25.7 percent of the province), favorite areas for number two dry farming is equal to 300.000 hectares (15.5 percent of the province), favorite areas for number three range management is equal to 13.000 hectares(less than 0.7 percent of the province), and the favorite areas for number four range management is

Area %	Cvt	Code NO
0.0	*	1
0.12	**	2
99.88	other	3
: plant species such as Taxus baccata , Buxus hyrcanus , Acer hyrcanum , Cupressus sempervirens var.horizontalis , Sorbus torminalis* *:Juniperus polycarpus , Biota orientalis ,juiperus,Rhizophora mucronata, Quercus cinerascens , Prunus aviom , Quercus persica , piruscommunis*		

Table (14): characteristics of Cvt in Hamadan province

Area %	Vgo (%)	Code NO
0.003	76-100	1
2.767	51-75	2
2.233	26-50	3
14.642	6-25	4
0.415	1.1-5	5
79.940	0-1	6

Table (15): characteristics of Vgo in Hamadan province

Layer	Dg Kg/hc	Vgo %	Cp mm/yr	Cvt	Si	Ch %	Ct °C	Wc M^3/hc	Es	Cl	So %
1	500	76-100	-50	*	Mangrove	-40	-18	+10000	0	a1	0-2
2	350-449	51-75	51-200	**	creek	40.1-60	18.1-21	10000-6000	-0.25	a2	2.1-5
3	250-349	26-50	201-500	Other	Wetland	60.1-80	21.1-24	6000-3000	.025-0.70	a3	5.1-8
4	-250	6-25	501-800	–	Savanna	80.1-100	24.1-30	-3000	+0.70	a4	8.1-12
5	-	1.1-5	801-1200	–	Bank	–	+30.1	–	RILL. E	a5	12.1-15
6	–	0-1	1201-2000	–	Dene	–	–	–	GULLY. E	a6	15.1-20
7	–	–	+2001	–	forest	–	–	–	ALUVIAL .E	a7	20.1-25
8	–	–	–	–	other	–	–	–	–	a8	25.1-40
9	–	–	–	–	–	–	–	–	–	b1	40.1-65
10	–	–	–	–	–	–	–	–	–	b2	+65
11	–	–	–	–	–	–	–	–	–	b3	–
12	–	–	–	–	–	–	–	–	–	b4	–
13	–	–	–	–	–	–	–	–	–	b5	–
14	–	–	–	–	–	–	–	–	–	b6	–
15	–	–	–	–	–	–	–	–	–	b7	–
16	–	–	–	–	–	–	–	–	–	b8	–
17	–	–	–	–	–	–	–	–	–	c1	–
18	–	–	–	–	–	–	–	–	–	c2	–
19	–	–	–	–	–	–	–	–	–	c3	–
20	–	–	–	–	–	–	–	–	–	c4	–
21	–	–	–	–	–	–	–	–	–	c5	–
22	–	–	–	–	–	–	–	–	–	c6	–
23	–	–	–	–	–	–	–	–	–	c7	–
24	**: plant species such as Taxus baccata , Buxus hyrcanus , Acer hyrcanum , Cupressus sempervirens var.horizontalis , Sorbus torminalis* ***: plant species such as Juniperus polycarpus , Biota orientalis , juiperus , Rhizophora mucronata , Quercus cinerascens , Prunus aviom , Quercus persica , piruscommunis*								–	C8	–
25									–	D1	–
26									–	D2	–
27									–	D3	–
28	–	–	–	–	–	–	–	–	–	d4	–
29	–	–	–	–	–	–	–	–	–	d5	–
30	–	–	–	–	–	–	–	–	–	d6	–
31	–	–	–	–	–	–	–	–	–	d7	–
32	–	–	–	–	–	–	–	–	–	d8	–

Table (16) : the summery of makhdooms model that using in this study

NO	Vgo	Dg	Cvt	Si	Ch	Ct	Cp	Wc	Es	Cl	So %
1	76-100	*	*	*	*	-18	*	*	NO	a3	0-2
2	51-75	*	**	*	40.1-60	*	*	10000-6000	-0.25	a4	2.1-5
3	26-50	250-349	–	wetland	*	*	200-500	6000-3000	0.25-0.70	a5	*
4	6-25	-250	–	*	*	*	*	-3000	+0.70	a6	8.1-12
5	1.1-5	–	–	*	–	*	*	–	Rill E	a7	12.1-15
6	0-1	–	–	*	–	–	*	–	*	b3	15.1-20
7	–	–	–	Forest	–	–	*	–	*	b4	*
8	–	–	–	Others	–	–	–	–	–	b6	25.1-40
9	–	–	–	–	–	–	–	–	–	*	40.1-65
10	–	–	–	–	–	–	_	–	–	*	+65

**:this class not found in Hamadan province*
***:plant species such as Juniperus polycarpus , Biota orientalis , juiperus , Rhizophora mucronata , Quercus cinerascens , Prunus aviom , Quercus persica , piruscommunis*

Table (17) : detail of data layers that using in this research

equal to 106.000 hectares(about 54.5 percent of the province).All of these locations are shown on the map(see Table 18).

Area %	Land use based on Makhdoum's model	Code. NO
0.0	favorite areas for number one wet farming	W1
3.6	favorite areas for number two wet farming	W2
25.7	favorite areas for number three wet farming	W3
0.0	favorite areas for number one dry farming	D1
15.5	favorite areas for number two dry farming	D2
0.0	favorite areas for number one range management	R1
0.0	favorite areas for number two range management	R2
0.7	favorite areas for number three range management	R3
54.5	favorite areas for number four range management	R4

Table (18) : summery results of evaluation in this research

5 conclusion

according to the evaluations, Hamadan province has limited potentials for wet farming activities, to the extent that there is no favorite area for number one wet farming, furthermore, wet farming areas number two in Hamadan province is limited and the basic reason is the cold weather, and climate conditions in the province. Dry farming in Hamadan province faces a lot of limitations, which accompanies such agriculture with a very high risk. This

risk is because of the low possibility of precipitation in the months of April and May. Also, Hamadan province is too poor in its pastures and favorite area for number one and number two range management can not be founded. This is because of low relative humidity of the weather, limited precipitations, extra grazing of the animals, coldness of the weather and because of the bad use of the pastures and the some shortage of pasture management. Therefore these findings show that Hamadan province faces a lot of limitations in executing agricultural and range management, and it is necessary to pay attention to these limitations, and the development plans be arranged considering them.
Since Geographical Information System (GIS) and digital data has been used in this research, the task of analyzing the information has been done carefully. The usage of GIS facilities, and the related software's, paves the way to eliminate the possible errors, and to update the information in a very short

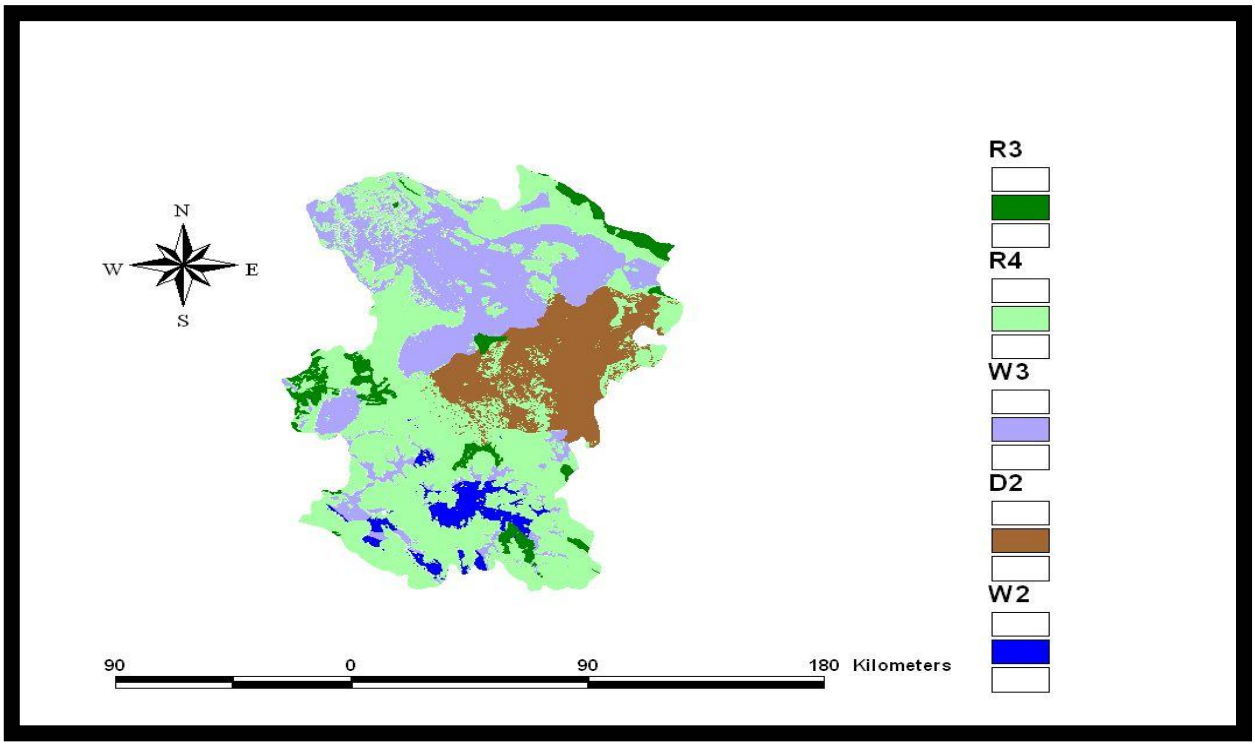

Figure (1): Results of Evaluation

time. Also, it will become possible to store the information in a small space and presenting them in different shapes, which is a very important aspect in evaluation process. The evaluation in a manual manner and without GIS is often long and boring, and there is the possibility for errors in a high degree.

6 Recommendation

At the end of this research the following items are presented as recommendation :
1 - Because of the limitations of the province, it is recommended to allocate the lands to farming the strategic crops such as wheat, barley, and oil seeds and other crops such as vine crops and salad crops be planted in hydroponics units.

2 - Considering the limited resources of water in the province it is recommended to farm those crops which need much water (such as forage crops) as dry farming and those crops which need less water as wet farming.
3 - We recommend doing researches about planting some corps that matches the capability of the province, and that the optimized corps will be presented.
4 - We recommend having a better use of the natural resources, and regarding the interests of the next generations from these resources, training's be given to farmers, so that they get familiar with the principles and executing of sustainable agriculture.
5 - Considering the importance of protecting natural resources such as the pastures, it is recommended to raise the income of the peasants, which this in turn will stop them in grassing their cattle there.
6 - It is recommended to run appropriate management of the pastures and to take the necessary precautions such as declaring a timed program for grazing the cattle and limiting that.
7 - We recommend to protect soil and water resources by studying and executing watershed projects, which this will stop the erosion of water to a great extent.

7 Acknowledgement

We would like to present the regards of the editors of this research from all of esteemed people who cooperated with us and gave us the necessary information. Also, we would like to thank all of the friends who helped us in collecting this work of research, such as Mr. Majid hokmi, Mr. Manoochehr Asaee, and Mr. Abbas Karami.

8 References

[1] A.J.Smyth , Dumanski ,˝ An international fromwork for evaluating sustainable land management,˝ Food and Agriculture Organization Of the United Nations ,Rome Italy, 1993.

[2] Brandon R. Bottomley, B.A.,˝Mapping Rural Land Use & land cover change in caaroll county,˝ university of Arkansas ,USA, 1998 .
available at:
http://www.cast.uark.edu/local/brandon_thesis/

[3] David G . Rossiter ,˝ Advanced Elective : quantified Land Evaluation ,˝ ITC , Netherlands , 2001.
available at:
www.itc.nl/~rossiter/teach/qle/qle2001.pdf

[4] FAO ˝salt affected soils and other management ˝FAO , NO ; 39

[5] FAO ˝ agro-ecological zoning ˝ FAO soils bulletin 73 ,Food and Agriculture Organization Of the United Nations , Rome Italy,1996.

[6] FAO ,˝Afromwork for land evaluation ,˝FAO soils bulletin 32 ,Food and Agriculture Organization Of the United Nations , Rome Italy,1981.

[7] FAO ,"Land evaluation for development ,"Food and Agriculture Organization Of the United Nations , Rome Italy,

[8] FAO,"Terminology for integrated resources planning and management ,"Food and Agriculture Organization Of the United Nations , Rome Italy,1998.

[9] FAO ,"Guidelines for land-use planning ,"FAO Development series 1, Food and Agriculture Organization Of the United Nations , Rome Italy,1993.

[10] FAO,UNEP ,"The future of our land ,"FAO and UNEP ,1999.

[11] Farshad Nourian and Mr. Ali Jahani (Iran),"Multi-Criteria Evaluation of Land use Effects on Environment using Quantitative Methods in GIS: The Talighan Basin (Iran) ,"Department of Urban and Regional Planning, Faculty of Fine ArtUniversity of Tehran, Tehran, Iran .
available at:
http://www.gisdevelopment.net/aars/acrs/1999/ts14/ts14612pf.htm

[12] Hermann Kaufmann, Sabine Chabrillat and others ," SAND - A Hyperspectral Sensor for the Analysis of Dryland Degradation
available at:
http://www.gfz-potsdam.de/pb1/pg5/research/projects/sand/sand_paper2.htm

[13] H.N.van lier, C.F.jaarsma, C.R..Jurgens, a.j.de buck ", sustainable and landuse planning ", Elsevier science , b.v, Netherlands, 1994.

[14] iftikhar Ahmad , Franklin Greenaway ," GIS Application for land planning and managementin montserrat , west Indies ,"2002.
available at:
www.ing.unitn.it/~grass/conferences/GRASS2002/proceedings/proceedings/pdfs/Ahmed_Iftikhar.pdf

[15] J.Boardman,I.D.L .Foster and J.A.Dearnig "soil erosion of agriculture land ",john wiley &sons , USA, 1990.

[16] Jef EMBRECHTS ," upland development programme in southern Mindanao field manual for Agro Ecological Zoning ,"MAY 2000.
available at:
http://www.udpmindanao.org/pdfdocs/Manual%20Operations%20of%20AMIS%20in%20South%20Cotabato.PDF

[17] Karen C.Hanna , R.Brain culpepper ", GIS in site design ", . john wiley &sons , USA , 1998.

[18] Kurt Fedra , Enrico Feoli ,"GIS Technology and spatial Analysis in coastal zone Management ,"
available at:
www.sustdev.org/journals/others/iczm/03.171.pdf

[19] Kumar rasija ,́ biodiversity principles and conservation ,́ Agrobios , India, 2002.

[20] Ludovico biagi ,Maria Antonia Brovelli , Marco Negretti ,́ Environmental thematic map predication and easy probabilitic classification ,́ procceding of open source GIS - GRASS users conference , Trento Italy , 2002.
available at:
www.blackwell-synergy.com/links/doi/10.1111/ j.1467-9671.2004.00181.x/abs/

[21] Makhdoum.Majid .F ,́ Degradation Model: A Quantitative EIA Instrument, Acting as a Decision Support System (DDS) for Environmental Management
available at:
http://www.environmental-center.com/magazine/springer/00267/20300151.pdf

[22} Mcharg,I.L ",Design with nature ,"published for the American musium of natural history,1971

[23] N.M.Awan &Muhammad latif ,́ environmental assessment and management of irrigation and drinage projects ,́ Lahore , 1993.

[24] P.A.Burrough ́ principles of Geographical information systems for land resourses assessment ́oxford university press, 1996.

[25] scott mitchell , Ferco casillage , cristina tague ,́ Advantages of open source GIS to improve spatial environmental management ,2002.
available at:
ww.ing.unitn.it/~grass/conferences/GRASS2002/proceedings/
proceedings/pdfs/Mitchell_Scott.pdf

[26] steve ventura ,́ GIS - Enhanced land use planning in dane county, wisconcin ,́wisconcin university
available at:
www.ncgia.ucsb.edu/varenius/ppgis/papers/ventura.html

[27] The working Grup on land use planning for the Asian -pasific Region ,́ Experiences of land use planning in asian projects ,́ Colombo , 1996.

[28] TOM turner ́ ́ land scape planning and environmental impact desigen 2 ñd edition ,T.J.International LTD,padstow, 1998.

[29] Working Group on Integrated Land Use Planning,́ land use planning methods,strategies and tools Germany , 1999.