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Qualitative land suitability evaluation of the Khajeh research station for Wheat, Barley, Alfalfa, Maize and Safflower

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Land suitability assessment was conducted for irrigated wheat , barley, alfalfa, maize and safflower in Khajeh research station of Tabriz in East Azarbaijan by using of Simple Limitation method (SLM), Limitation Method regarding Number and Intensity (LMNI) and parametric (PM) such as square root and storie methods. According to results obtained of applied method, a climate characteristic of the region was high suitable (SI) for safflower, moderately suitable (S2) for wheat, barley and alfalfa and marginally suitable (S3) or non-suitable classes (N2) for maize. In this study economic factors have been excluded and moderate management has been assumed. Results also confirmed that the most critical limitation factors for determined crops include OC, salinity, sodicity alone, or in combinations, however, in safflower suitability evaluation CEC can be added to these factors. Therefore for irrigated wheat (salinity and sodicity) for barely (OC, salinity and sodicity) for alfalfa and maize (climate, OC and salinity) and for safflower (OC, salinity and CEC) are the main limitation factors with different limitation degree. Overall, salinity and OC are the most important limiting factors. Qualitative evaluation of land for barely, wheat and alfalfa in both SLM and LMNI mainly showed S2-S3suitability classes based on climate, OC, salinity and sodicity, while in parametric square root method with effect of minimum factor rating and square root of other factors, the suitability classes are S3 and in some case N1 or N2. Also results for maize (N1-N2) and safflower (S3-N) in parametric method are different from SLM and LMNI. Therefore cultivation of irrigated wheat, barley, alfalfa can be recommended respectively.

Keywords: Climate, OC, salinity, sodicity, CEC

Natural resource is considered of the most valuable assets in a country. Appropriate use, non-scientific and regardless of nature ecological power are the most destructive factors of Natural resource. Land suitability evaluation is the process of assessing the suitability of land for specified kinds of use. Land suitability classification is the process of appraisal and grouping, of specific types of land in terms of their absolute or relative suitability for a specified kind of use. Ayobi et al (2000). were conducted qualitative land suitability evaluations for the main crops of an area Isfahan north using FAO method. This study proved that results of physical evaluation by parametric method (square root) were similar to those obtained Simple Limitation method.

91% of developing countries (not including China) have potential to dry farming on 2573 million ha which is a considerable area, compared to 757 million ha of irrigated land (FAO 1991). Most Iran's areas are located arid to semiarid climate with an average annual precipitation of about 250 mm, so the problem of optimum land use is highly relevant. Wheat, barley, alfalfa, maize and safflower are among main crops commercially generated in Iran's rich agricultural areas and also in the East &West Azerbaijan provinces, where their production depends largely on climate, soil, and topography. In different areas of Iran, land suitability was evaluated for some of crops in order to find an optimum use for each land unit by Ghasemi Dehkordi (1994), Sarvari and Mahmoudi (2001), Jafarzadeh and Atabakazar (2004), Jafarzadeh et al. (2005 a,b), Jafarzadeh and abbasi (2006), and Shahbazi and Jafarzadeh (2004).

Materials and methods

Studying site

The study area, Soil and Water Conservation Research Station of Khajeh (between longitude 46º35′ and 46º40′E, latitude 35º08′ to 35º12′N), is located in 30 and 60 km of Tabriz and Ahar, respectively. This station covers an area of 250 hectares (14). The region has a semi-arid and cold continental climate with an average annual rainfall of 220 to 270 mm (14). The altitude of the region is about 1550 m above sea level. climate characteristic needed to assess land suitability (including temperature, rainfall, relative humidity, etc.) were provided from Ahar metrological station which average annual rainfall is about 272.7 mm with mean annual temperature of 10.48^{0}C (Table 1). While other families of crop (including chenopodiaceae, alliaceae, papilionaceae, labiatae, etc) cultivated in this area, wheat is prevalent culture (Malekian 2005). The region is surrounded by mountains, hills and piedmonts. To obtain accurate and reliable soil data, 8 representative soil profiles in different land units (1-8) based on overall slope percentage used for more detail soil survey. Explanation of soil profile (Table 2), samplings and analysis were performed using standard terminology (soil survey staff 1993). The soils were classified by Ebadpour (2000) in term of USDA classification system (soil survey staff 2006) so that were assigned to the Aridisols order, calcids and gypsids suborders (Table 3). With respect to the map originated of soil temperature and moisture regimes of Iran, the soil temperature and moisture regimes of the area were recognized as mesic and aridic, respectively. It should be noted that, in the process of qualitative land suitability evaluation, there are several factors such as physical soil characteristics (texture, structure, stones, profile depth, $CaCO_3$ status and gypsum status), the fertility characteristics not easy to correct (apparent cation exchange capacity (CEC), sum of exchangeable base cations pH in H_2O, organic carbon) and the salinity and alkalinity (Table 2) which can have dramatically impacts. Properties associated with land qualities such as the moisture and oxygen availability and the foothold for root development depend considerably on the soil texture, the content of coarse fragments and stones, the soil depth and structure. Coarse particle such as gravel and cobbles at the soil surface is a barrier for tillage practical and consequence water and food absorption. Experience has shown that for most crops, effective root zone depth in crop production is of 90 to 100 cm. thus, annual crops mainly produce their root system density within the upper 100 cm, while in most tree crops; root system density is concentrated at greater than 150 cm soil depths. Using depth-weighting up to the depth 1 m for annual crops and up to 1.5 m or up to an impermeable layer for perennial crops, the textural classes applied for land suitability evaluation were reevaluated. As the gypsum content in the root zone is higher than 25% and the mean lime and gypsum content decreases with depth within the top 30 cm layer, then the lime and gypsum content in the soil was evaluated for this upper 30 cm only. In the other cases, the recalculated lime and gypsum content, using depth-weighting factors, was taken. The apparent CEC (ACEC) of the B horizon, or at 50 cm depth for A–C profiles, or just at the lithic or paralytics contact if this was present within 50 cm from the surface, was calculated as the weighted average of the sum of the exchangeable Ca, Mg and K, taking into account pH and organic matter (OM) in the upper 25 cm of the soil. In the irrigated land, salinity and alkalinity evaluation was made for the 100 cm depth from the soil surface, while the salinity evaluation for annual crops with shallow root systems was calculated as a weighted average of the upper 50 cm only.

Land suitability evaluation

The plant needs were expressed in a tables in term of climate, landscape and soil information according to Sys et al. (1993). These tables have an important role in the qualitative land suitability evaluation for wheat (*Triticum spp*. L.), barley (*Hordeum vulgare* L.), alfalfa (*Medicago sativa* L.), maize (*Zea mays* L.) and safflower (*Carthamus tinctorius* L.) through the study the actual soil characteristics and qualities with the plant needs. Based on obtained information about topography, soil, climate, and suitability evaluation methods, simple limitation method, limitation method regarding number and intensity, and parametric methods (storie and square root methods) were selected and the land suitability class for crops was determined. (Sys et al. 1991 a, b).

Simple limitation method (SLM)

The simple limitation method implies that the crop requirement tables are made for each land utilization type. Land classes are determined according to the most limiting characteristics. The advantage of this method is its simplicity and there is no overlap and interaction between, so many features can be used in evaluating (4,6 tahr ahar). The previous scientist used The simple limitation method for qualitative land suitability determination of five soil series in South-Western Nigeria for crops such as maize, rice and cassava, cultivated under rainfed conditions (Osie 1993).

Limitation method regarding number and intensity of limitations

In this method land classes are defined in term of number and intensity of limitations. Firstly, climate class identifies, so, the climatic characteristics, are divided to 4 groups: radiation, temperature, rainfall and humidity. To determine the climatic suitability class which is then used as the corresponding limitation level, the most severe limitation determine in each of this groups and subclass and climate limitation level according to table. This method is more difficult than SLM, but the approach is more accurate, because it considers the land with several limitations of the same level as belonging to a lower-class land than that with only a single limitation of the same level.

Parametric methods (PM)

In The parametric land evaluation different characteristics obtained a numerical scale and if a characteristic is appropriate for crop so it receive the maximum rate (normalised as 100%) and if the same characteristic have limitation, it get a less rate. Finally, the climatic index, as well as the land index, is calculated from these individual ratings. In our case, the indices were calculated following two alternative procedures:

The Storie method (Storie 1976):

The index was taken as a product of individual ratings:

$$I = A \times \frac{B}{100} \times \frac{C}{100} \times 100 \quad \times \ldots\ldots$$

Where *I* *is* index (%) and *A*, *B*, *C* etc. describe ratings allocated to different characteristics (%).

Square-root method (Khiddir 1986):

$$I = R_{\min} \times \sqrt{\frac{A}{100} \times \frac{B}{100} \times 100 \times ....}$$

Where *I* is index (%), *R*min – minimum rating (%), *A*, *B*, *C* etc. – remaining ratings (%).

Results and discussion

The suitability is largely a matter of producing crop yield with relatively low inputs and also a matter of crop needs and the influence of soil and site characteristics upon the crop (Vink's 1960). The identification and delineation of land with desirable attributes are two important stages in finding a land suitable for a specific crop. In this study, after analyzing soil samples, the requirements of wheat, barley, alfalfa, maize and safflower summarized by Sys et al. (1993) were used. After that the simple limitation method (SLM), the limitation method regarding number and intensity (LMNI), and the parametric methods (the storie and the square-root methods) were applied. Land suitability classes were determined (S1 or highly suitable with production of 80-100%of optimum, S2 or moderately suitable or 60 to 80% of optimum,S3 or marginally suitable or 40-60% of optimum and N or non suitable (N1& N2). Economic factors were kept out and moderate level of management was supposed. Different methods results showed limitation factors of OC, salinity and sodicity alone, or with together. While in safflower suitability evaluation, CEC can be added to these factors. Therefore for irrigated wheat, salinity and sodicity, for barely OC, salinity & sodicity, for alfalfa and maize climate, OC & salinity and for safflower OC, salinity and CEC are main limiting factors with different limitation degree. In general salinity and OC are the most important limiting factors. The results obtained by the parametric square-root method are probably more realistic, as suggested by comparison with other reports (Movahhedi Naeni 1993; Ghasemi Dehkordi 1994; Mahmoudi 2001; Jafarzadeh and Atabakaza 2004; Shahbazi and Jafarzadeh 2004, Jafarzadeh et al. 2005a, b; Jafarzadeh and Abbasi 2006) in which different methods were applied in different Darts of country for the same crops. The parametric square-root method suggests that the region of the Khaje research station possesses optimal climatic condition for irrigated barley and safflower, indicating for this case a high suitability class (Sl), While the climatic conditions during the growing cycle make the region only moderately(S2) suitable for wheat and marginal (S3) for maize. The results of evaluation of soil properties suggest that the lands in the regions belong to land classes between moderately suitable (S2) and non-suitable (N2). This result can be obtained by either of the two limitation methods (SLM or LMNI) and also by the parametric square-root method. The Storie method suggests that practically all lands belong to the marginal to non suitable (s3-n2) classes (Tables 4 and 5), witch, however, is an unrealistic result. The square-root method indicates that the units are non-suitable (N1-N2) for maize only. Based on the results (especially those from the square root-method),the priority crops for the area studied turn to be wheat and barley (first), alfalfa(second) and safflower (third), for which the region belongs to mainly marginally suitable class or 40-60 % of their optimal production for wheat, barley and alfalfa.

Table 1. Climatic characteristics from the Ahar meteological station

Monthly Temperatures (0C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max.mean	2.6	3	8.8	16.3	20.9	25.5	17.7	27.1	24.6	17.8	11.5	5.5
Min.mean	-5.5	-5	-0.8	2.3	8	11.8	15.2	14.9	10.8	6.3	1.6	-2.3
Absol.max	15.6	17.4	21	26.5	30.2	34.2	36.4	36.4	35	29	22.5	17
Absol.min	-19	-20.5	-17.5	-11	-4	6	8	7.4	4	-2.5	-16.6	-19
Mean monthly temperature	-1.5	-0.6	4	10.3	14.5	18.7	21.5	21	17.7	12	6.6	1.6
Meat monthly Rainfall(mm)	18.4	19.2	38.9	42.7	14.4	29.4	5.3	9.1	9	33	31.1	22.2
Mean relative humidity (%)	68.7	69.7	67.4	60.7	59.8	56.3	51.4	55.8	56.1	62.1	61.5	67.5
Sunshine hours	4.74	5.15	5.13	6.29	7.57	9.1	9.59	8.82	8.08	6.16	5.36	4.36
Potential ET(mm)	26.7	35.6	55.8	95.6	131	171.8	191.4	179.6	138.2	85.6	50.6	34.3
1/2ETp(mm)	13.35	17.8	27.9	47.8	65.5	85.9	95.7	89.8	69.1	42.8	25.3	17.15

Table 2. Analytical characteristics of representative soil for land units of the study area

Land unit	Horizon	Depth	C (%)	Si (%)	S (%)	Text class	pH	OC (%)	Caco$_3$ (%)	ECe (dS/m)	CEC (Cmol+/kg)	Gravel (%)
1	A	0-16	39	38	23	CL	7.1	0.92	21	21.3	19.8	nl
	B_{k1}	16-33	33	29	38	CL	7.5	0.68	19	12.05	18.4	-
	B_{k2}	33-61	38.3	49	12.7	SiCL	7.1	0.54	21.4	13.19	16.05	-
	C_{k1}	61-100	42.3	48	9.7	sic	7.2	0.78	18.3	12.79	19.1	-
	C_{k2}	100-140	43.8	46	10.2	sic	7.1	0.51	16	12.6	16.5	-
2	A	0-10	30.4	48	21.6	sil	7.4	0.98	23.9	14.45	17.01	12
	B_{k1}	10-41	28.4	51.4	20.2	CL	7.2	1.34	21.5	7.36	19.8	nl
	B_{k2}	41-79	28.4	40	31.6	CL	7.4	0.48	22.7	3.45	15.59	-
	B_{k3}	79-115	29.8	38	32	CL	7.2	0.42	23.8	2.4	18.4	1.6
	B_{k4}	115-145	30.8	38	33	CL	7.1	0.39	24.9	2.2	16.1	-
3	A	0-13	35.3	41	23.7	CL	7.6	1.45	21.7	7.34	18.9	-
	B_{k1}	13-37	35.3	43	21.7	CL	7.5	0.68	20.3	13.4	15.59	-
	C_{k1}	37-80	30.3	44	35.7	CL	7.4	0.39	19.2	19.16	14.17	0.5
	C_{k2}	80-122	31.6	45	23.4	CL	7.3	0.3	17.7	18.59	12.7	0.8
4	A	0-13	21.6	38	40.4	L	7.5	1.86	17.8	2.66	13.7	1.8
	B_{k1}	13-40	20.3	38	41.7	L	7.5	0.57	18.2	2.32	12.4	4.6
	B_{k2}	40-62	24.3	42	33.7	L	7.5	0.58	21.27	2.88	21.2	2.6
	$2B_{Y}$	62-94	18	19	63	SL	7.7	0.45	15.3	2.76	9.92	34.5
	$3B_{K1}$	94-105	9.8	24.2	66	SL	7	0.42	18.7	2.72	7.08	59
	C_{Y}	105-142	10	23	67	SL	7.2	0.4	16	2.72	10.7	20.1
5	A	0-8	16.4	41	42.6	L	7.1	0.45	17.7	1.8	9.8	3.7
	B_{k1}	8-34	16.6	25.8	57.6	SL	7.2	0.45	18.2	1.91	12.6	9.35
	B_{k2}	34-60	17	33.4	49.6	L	7.4	0.35	21.2	3.1	15.1	4.6
	C_{k}	60-110	16.7	38.2	45.1	L	7.5	0.34	20.1	3	16.4	3.2
6	A	0-12	30.4	30	39.6	CL	7.3	0.68	19.1	4.04	18.02	0.7
	B_{k1}	12-48	34.4	30	35.6	CL	7.3	0.6	19.01	3.6	17.8	4.8
	B_{k2}	48-115	29.6	32	38.4	CL	7	0.65	18	4.36	18.01	1.5
7	A	0-14	10	37	53	L	6.9	0.97	12.2	1.72	10.3	10.4
	B_{Y1}	14-59	10	28	62	SL	7	0.39	11.2	1.84	7.9	35.3
	B_{Y2}	59-90	11	33	56	L	7.6	0.39	3.4	1.95	11.4	42.5
	C_{Y1}	90-115	11	34	55	SL	7.5	0.25	12.1	1.73	5.7	40.7
	C_{Y2}	115-125	20	32	48	L	7.5	0.20	12.2	1.8	7.01	22.1
8	A	0-9	29	31	40	CL	7.4	0.65	19.1	1.89	7.8	38.09
	B_{Y1}	9-42	10	46	44	L	7.3	0.09	19.2	1.75	10.9	39.8
	B_{Y1}	42-72	10	39	51	L	7.4	0.09	9.6	1.14	8.02	39.5

C (clay), Si (silt), S(sand). Text.class(USDA textural class): L (loam), SL (sandy loam), SIL (silt loam), Sicl (silt clay loam), all estimated by the hydrometer method. Oc (organic carbon), ECe (electrical conductivity of saturated soil paste extract), CEC (cation exchange capacity).

Table 3.Families of representative soils in the study area (Ebadpour2000)

Representative Profile in land units	Soil family (Soil Taxonomy)
1	Fine, mixed, active, calcareous, mesic, Typic Haplocalcids
2	Fine, mixed, active, calcareous, mesic, Typic Haplocalcids
3	Fine, mixed, semiactive, calcareous, mesic, Typic Haplocalcids
4	Fine-silty, mixed, active, calcareous, mesic, Typic Haplocalcids
5	Fine, mixed, semiactive, calcareous, mesic, Typic Haplocalcids
6	Fine, mixed, active, calcareous, mesic, Typic Haplocalcids
7	Lomy-skeletal, mixed, active, calcareous, mesic, Typic aplocalcids
8	Lomy-skeletal, mixed, active, calcareous, mesic, Typic aplocalcids

Table 4. Land suitability classes of the study area for barely, wheat, Alfalfa based on different methods

Profiles	Barley				Wheat				Alfalfa			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	S3f	S3f	N2	N1	S2c	N2n	N2	N2	N2n	N2n	N2	N2
2	S2c	S2c	N1	S3	N2n	S2c	N1	S3	N2n	N2n	N1	S3
3	S2c	S2c	S3	S3	N2n	S2c	N2	S3	S2c	S2c	N1	S3
4	S2c	S2c	N1	S3	S2c	S2c	S3	S2	S2c	S2cs	S3	S2
5	S3f	S3f	S3	S3	S2c	S2c	S3	S3	N2f	N2f	N2	N2
6	S2c	S3fn	S3	S3	N2n	S2c	N2	S3	S3sfn	S3sfn	N2	N2
7	S2c	S2c	S3	S2	S2c	S2c	S3	S3	S3fn	S2cf	S3	S2
8	S3cf	S3cf	N2	N1	S3s	S3s	N2	N2	S3cf	S3cf	N2	N2

Table 5. Land suitability classes of the study area for maize, safflower based on different methods

Profiles	Maize				Safflower			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	N2n	N2n	N2	N2	N2n	N2n	N2	N2
2	N2n	N2n	N2	N2	N2n	N2n	N2	N2
3	S3cn	S3cn	N2	N2	S3f	S3f	N2	N1
4	S3c	S3c	N2	N1	S2f	S2f	N1	S3
5	S3cf	S3cf	N2	N1	S2f	S2f	N2	N1
6	S3c	S3c	N2	N1	S3f	S3f	N2	N1
7	S3c	S3c	N2	N1	S3f	S2f	N2	S3
8	S3csf	S3csf	N2	N1	S3f	S3f	N1	S3

Conclusion

The study leads to the following conclusion.

1. Generally, the area highly suitable (S1) from the climatic point of view (c) for Safflower and barley, moderately suitable (S2) for wheat and alfalfa and Marginally suitable (S3) for maize.

2. The soil fertility characteristics (f), the salinity and alkalinity conditions (n) and, in some cases, the soil physical characteristics (s) make the lands in the area marginally suitable (S3) or even non-suitable.

3. Based on the parametric square-root method, which seems to be the best, the cultivation of irrigated wheat and barley can be recommended, but the majority of the region is non-suitable for maize and alfalfa with safflower.

4. Limitations are posed mainly by the high gravel content, high pH low organic matter and high salinity and alkalinity, either alone or in combination. The picture is principally same for all suborders (Gypsids or Calcids) and great groups (Hapologypsids, Calcigypsids or Hapolocalcids) in the area.

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