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Qualitative Evaluation of Land Suitability for Principal Crops in the Gargar Region, Khuzestan Province, Southwest Iran

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Abstract: Here a land suitability evaluation study for key productions of the region, including wheat, alfalfa, maize and barley, covering an area of 15831 ha was carried out in the region. Using the findings of the semi-detailed soil studies for this area, 2 soil families and 8 soil series in 2 physiographic units was identified. Physiologic requirements of each crop were also determined and rated based upon the proposed methods (Parametric methods and Simple limitation method). Qualitative evaluation was carried out by means of simple limitation and parametric methods (Storie and Root Square Method) and comparing land and climate characteristics with crop needs. The index obtained for barley, wheat and alfalfa was higher in comparison to that developed for maize. Limiting factors in different crop yield in the region along with climatic variables included soil physical properties, especially its carbonate contents, soil salinity and drainage. From the two methods used i.e., simple limitation and parametric methods (Storie and Square root methods), the latter (Square root methods) produced more realistic results in respect to the existing conditions of the region.

Key words: Land suitability evaluation, parametric methods (storie and square root method), simple limitation methods, land series

INTRODUCTION

Considering the rapid growth of the world populations, which is in its turn a limiting factor to the arable lands around the world, the dire need for effective and efficient application of the croplands have been felt more than ever. Sustainable agriculture would be achieved if lands be categorized and utilized based upon their different uses (FAO, 1983, 1984). Qualitative evaluation of the land suitability consists of determination of the land use for particular applications regardless of yield fulfillment and socio-economic issues (FAO, 1976, 1983, 1984, 1985). In this view, FAO (Food and Agriculture Organization) took a stride in its Soils Bulletins No. 32, 42, 48, 52 and 55 by introducing various methodologies based upon the above framework.

In their research in the Province of Ben Slimane, Morocco, Yasmina *et al.* (2001) carried out the qualitative land evaluation for crop production and fruit-bearing trees under rainfed and irrigated conditions. By the use of the parametric method, they showed that much of the croplands of the region were in critical conditions the most limiting factors of which including soil texture, soil depth and drainage. The main crops of the area were wheat, barely, pea, bean and onion.

Ljusa and Pajovic (2002) investigated the Land suitability for rainfed agriculture in the province of Larache, Morocco. The study area was characterized by crops which were separated into three groups as food crops (maize, sugarcane, chickpea, potato, tomato, green pepper, onion, sunflower and wheat), fodder crops (barley, sorghum and alfalfa) and tree crops (citrus and olives), all with different agricultural management. The methodology used for the evaluation refers to the Sys *et al.* (1991) parametric method based on land evaluation framework for rainfed agriculture. The main step of this methodology was matching land characteristics against crop needs, giving in that way suitability rating for each land characteristic. After suitability analysis for rainfed agriculture, all crops could be separated into two groups; the first one where there are crops good for this kind of agriculture and the second one can't grow without good moisture condition. In the first group are presents the main of the difference crops: maize suitable in the whole agricultural part; sugarcane suitable in the northern and southern reliefs; potato suitable in the southern reliefs; sunflower suitable in the northern and southern reliefs; wheat suitable in the northern reliefs and in the valley; barley suitable only in the northern reliefs; citrus suitable in small parts in the

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northern and southern reliefs and olives suitable in the valley and in the southern reliefs. For almost all crops any kind of irrigation is necessary for increasing suitability class. Other crops like chickenpea, tomato, green pepper, onion, sorghum and alfalfa belong to group of crops, which are not recommended for rainfed agriculture.

Francesco *et al.* (2003) conducted land evaluation of Thies Region, Senegal, for crops such as maize, sorghum, pea, sesames, etc. The evaluation showed that the northern part of the region contained suitable (S_1) or relatively suitable (S_2) lands for all the crops under study while in northwest part along the shoreline the croplands were unsuitable (N_1 and N_2) which was due to the domination of sandy soils. The study also indicated that from 60387 ha of the studied lands, 12522 ha were highly suitable (S_1) for all the crops, 31540 ha were relatively suitable (S_1) and 16325 ha were totally unsuitable (N_1 and N_2).

Sokol *et al.* (2004) used parametric (square root) method and conducted a research on Oud Rmel Catchment of Tunisia on wheat, barely, sorghum, potato, etc. The most influential limiting factor to the study area were found to be land slope, coarse-grained soil texture of the area, dominant existence of stones and aggregates, alkaline pH and the excessive amount of the soil carbonate calcium.

Njiki *et al.* (2005) performed a land evaluation project for Shouyang County in Shanxi Province, China, in which maize, soybean, potato, sunflower, wheat as well as tree crops were studied. For this purpose, land suitability classification was carried out using parametric method and the consequent land suitability maps were prepared for crops under traditional and mechanized cultivations.

Dunshan *et al.* (2006) investigated the land suitability for agricultural crops in Danling county-Sichuan province, China-using the Sys's parametric evaluation system. The final aim of this evaluation is to facilitate farmers in choosing the best crop to be cultivated (for small areas) and decision makers in planning the rural development (for large areas). Several crops were analyzed; in particular, the suitability for rice was compared to the one for other summer crops like sweet potato and maize. A comparison between wheat and rape was carried out since these are the more common crops to be rotated with rice. The more widespread tree crops, like orange and loquat, were also included in the analysis as well as mulberry tree which is becoming more widespread due to the growth of the silk market. The evaluation of some cash crops that do not currently grow in the agricultural landscape of Danling county was carried out too in order to gain an indication about future productivity of the area.

Al-Areba *et al.* (2007) evaluated the land suitability for key agricultural crops in Essaouira Province, Morocco. The principal crops cultivated in the study area were barley, maize, onion and wheat which are the main source of subsistence for the families in *Essaouira*. Olive is the main perennial crop. The aim of this evaluation was to find out which parcels of land may best support the different crops commonly grown by the local farmer based on the physical and chemical properties of the soils in the study area and recommend these results to the local stakeholder for an increase in yield. Suitability maps were produced for each specific crop. In general, the evaluation class for the crops suitability ranges from moderately suitable to permanently not suitable. This is due to the different condition that the crops require for their developments in the local area in question. Barley and wheat are the most important crops for the economy and subsistence of the families in the region since most families earn their livelihoods from the cultivation of these crops. Livestock farming constitutes a significant financial reserve for the majority of the farmers. The animals also take advantage of the leftovers of cropfields after the harvest. These areas have limitations due to the presence of coarse fragments and rock outcrops, poor drainage, steep slope, high $CaCO_3$ content and texture which are considered to be important factors since they determine the capacity for the penetration of the roots and the capacity to retain water and nutrients.

The main objective of this research is to evaluate and compare land suitability for principal crops (including wheat, alfalfa, maize and barley) based on the parametric evaluation methods (Storie and Square root method) and simple limitation methods for Gargar Plain, Khuzestan Province, Iran.

MATERIALS AND METHODS

The present study was conducted in an area about 15831 ha in Gargar Plain, Khuzestan Province, Southwest of Iran during 2008. The study area is located 50 km northeast the city of Ahwaz, 31°38' to 31° 49' N and 48°57' to 49°07' E. This area has an arid climate with a mean annual rainfall of 295 mm and minimum and maximum relative humidity of 33 and 69%, respectively. The mean annual temperature is 24.8 C°. The warmest month of the year is Tir (June-July) with a maximum temperature of 46.1°C while the coldest month of the year is Dey (late October to early January) when the minimum temperature is as low as 7.1°C. The annual evapo-transpiration has been measured as 2150 mm (KWPA, 2005). Geologically, the alluvial nature of the region has been developed into a sediment-dominated environment and seems to belong to the sediments of a recent geological era (KWPA, 2006).

Common agricultures in the region include fall growth of irrigated wheat, barley, maize and alfalfa. The agriculture in the area uses traditional to semi-mechanized techniques and equipment. The power supply is

Table 1: Growth periods and development stages of crops in the study area

Crop	Initial stage	Development stage	Mid-season stage	Late season stage
Wheat	20 (day) 13 Dec-23 Nov	55 (day) 6 Feb-14 Dec	65 (day) 13 Apr-7 Feb	15 (day) 27 Apr-14 Apr
Maize	15 (day) 10 Aug-27 Jul	40 (day) 19 Sep-11 Aug	33 (day) 22 Oct-20 Sep	34 (day) 25 Nov-23 Oct
Barley	20 (day) 13 Dec-23 Nov	55 (day) 6 Feb-14 Dec	65 (day) 13 Apr-7 Feb	15 (day) 27 Apr -14 Apr
Alfalfa	75 (day) 4 Apr-27 Jun	80 (day) 26 Jun-5 Apr	80 (day) 16 Sep-27 Jun	85 (day) 11 Dec-17 Sep

Table 2: Values of different characteristics in defining different phases of each soil series

	Degree of limitation				
Characteristics	Without	Slight	Moderate	Sever	Very sever
Salinity (Ds/m)	<4	8-Apr	16-Aug	16-32	>32
Alkalinity (SAR)	<6.5	6.5-13	13-18	18-24	>24
Drainage	Well drained	Moderately drained	Imperfectly drained	Poorly drained	Very poorly drained

*Data have been prepared and used as per the Plant Requirements Table (Givi, 1997) and Guidelines for Description of Soil Profiles (Iranian Soil and Water Research Institute Bulletin No. 758)

Table 3: Qualitative land suitability classes for the different land indices

Symbol	Definition	Land index
S_1	Highly suitable	75.0-100
S_2	Moderately suitable	50.0-75
S_3	Marginally suitable	25.0-50
N_1	Currently not suitable	12.5-25
N_2	Permanently not suitable	0.0-12.5

usually tractors. Gargar River is the main water resource to the region where gravity irrigation is predominant. According to the available data, the growth periods and development stages for the crops in the region include initial stage, development stage, med-season stage and late season stage (Table 1).

The properties of the above croplands to be considered in the present study included climatic characteristics (including relative humidity, temperature and sun radiation during different phases of plant growth), topography (including soil slope) and soil (including soil depth, soil texture, gypsum and lime contents, soil salinity (EC) and alkalinity (ESP), drainage and percentage of aggregates). Also, Properties of soil fertility such as Cation Exchange Capacity (CEC), percentage of basic saturation (PBC), organic mater (OM%) and soil acidity (pH) were considered in terms of soil fertility. Sys *et al*. (1991) suggested that soil characteristics such as OM% and PBS do not require any evaluation in the arid regions while clay CEC rate usually exceeds the plant requirement without further limitation, thus, only soil acidity (pH) has been considered sufficient in any assessment of the soil fertility.

According to the particular semi-detailed studies of the region, samples were taken from each soil series profiles and laboratory analysis were carried out based upon the conventional methods of the Iranian soil and water research institute methodologies and the following properties were measured by due methods: soil acidity by electrometric method by using a pH meter, electrical conductivity by conductivity-meter, soil texture by agitator and hydrometer, lime settlement rate by titration method, gypsum by sediment measurement by using acetone, cation exchange capacity by replacing of the exchangeable sodium ions with ammonium ions, mineral carbon content by titration by using dichromate potassium and nitrate Ferro ammonium sulfate (Bremmer and Mulvaney, 1992). Based upon the profile description and laboratory analysis, that group of soils that had similar properties and located in a same physiographic unit were considered as a series of soils and were taxonomied to form a soil family as per to keys to soil taxonomy 2006.

In the present study almost totally 8 soil series were categorized and climatic, topography and soil properties were prepared and ranked based upon Sys *et al*. (1991) tables and proposed tables of the Iranian soil and water research institute (Givi, 1997) and the Manual of land classification for irrigation (Mahler, 1979) (Table 2). Climate data and those related to different stages of plant growth were taken from Khuzestan soil and water research institute and physiological requirements of each plant were extracted from tables prepared specifically for Iran (Givi, 1997). In evaluating of the qualitative land suitability, land properties were compared with the corresponding plant requirements. In this stage, in order to classify the lands the simple limitation and parametric methods (i.e., Story and Square root methods) were used. Simple limitation method compares the plant requirements with its corresponding qualitative land and climatic characteristics and the most limiting characteristics defines land suitability class while in parametric method land and climate characteristics are defined using different ratings. The measurement of theses characteristics can be done using the followings:

Storie method:

$$I = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{F}{100}$$

where, I is the specified index and A, B, C… are different ratings given for each property.

Square root method:

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

where, Rmin is the minimum rank.

By determining the specific land index and using the guidelines given by Sys *et al*. (1991), the qualitative land suitability classes (Table 3) and the limiting factors of the plant growth in different soil series for each plant were determined.

RESULTS AND DISCUSSION

Eight soil series and fifteen series phases were derived from the semi-detailed soil study of the area. The soil series are shown in Fig. 1 as the basis for any land evaluation practice. The soils of the area are of Inceptisols and Entisols orders. Also, the soil moisture regimes are Aquic and Ustic while the soil temperature regime is Hyperthermic (KWPA, 2006).

The ultimate evaluation of the qualitative land suitability for different typical land uses using simple limitation and parametric methods are given in Table 4-6 and land suitability maps in Fig. 2-5. The results of the physical evaluation showed a close correlation between the simple limitation method and parametric method

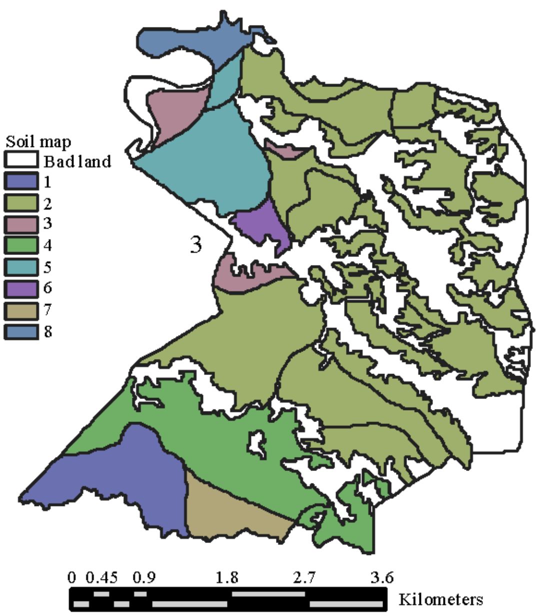

Fig. 1: Soil map of the study area

(Square root method); however, due to the interaction of many-sided impacts of the land properties, using Storie method in determining of the land index will lead to underestimation of the land classes obtained compared to what gained through simple limitation and square root methods. Hence yet, in some of the soil series there are minor differences in land class evaluation by these methods for some plants which are mainly due to the different estimation of the climatic, soil and topographic characteristics of the region. Each is estimated individually and differently in the Simple limitation method.

In parametric method, however, a land index which contains the three of the above properties is usually evaluated. For example, due to climatic limitations, lime presence, drainage limitation and soil slope, a land series 2 for maize belongs to class S_2 in Simple limitation method while in parametric method (Square root method) it goes to class S_3. Part of the differences in results can be explained by the results of multiplication of the land suitability ratings by each other used in calculating of the land index in parametric method. In this method, due to the multiplication of different land suitability ratings by each other and converting of the calculated climatic index to a climatic rating, a lower class has been obtained compared to that developed by limitation method. This can be clearly observed in land series of 1, 2, 3, 4 and 5 for maize.

Table 4: Results of the qualitative suitability evaluation of different land series for crops under study using simple limitation method

	Suitability classes			
Land units	Wheat	Maize	Barley	Alfalfa
1	S_2s	S_2sc	S_2s	S_2s
2	S_2tsw	S_2tswc	S_2ts	S_2tsw
3	S_3snw	N_1snwc	S_3snw	S_3snw
4	S_2s	S_2sc	S_2s	S_2s
5	S_3sw	cS_3sw	S_2sw	S_2snw
6	S_1	S_2sc	S_1	S_1
7	S_2s	S_2sc	S_2s	S_2s
8	S_1	S_2sc	S_1	S_1

Designates c, n, s, t and w represent the climatic limitations, salinity and alkalinity, physical properties of soil, topography and drainage

Table 5: Results of the qualitative suitability evaluation of different land series for crops under study using parametric method (square root)

	Alfalfa		Barley		Maize		Wheat	
Land units	Land index	Suitability classes	Land index	Suitability classes	Land index	Suitability classes	Land index	Suitability classes
1	54.53	S_2s	44.40	S_3tc	55.71	S_2s	58.60	S_2s
2	51.39	S_2tsw	36.07	S_3tswc	55.94	S_2tsw	45.57	S_3tsw
3	12.10	N_1snw	10.56	N_2snwc	18.51	N_1snw	13.09	N_1snw
4	51.81	S_2s	43.33	S_3sc	53.01	S_2s	61.95	S_2s
5	27.14	N_1sw	22.95	N_1swc	50.68	S_2sw	25.39	S_3snw
6	79.21	S_1	52.12	S_2sc	80.15	S_1	77.65	S_1
7	50.05	S_2s	51.13	S_2sc	51.03	S_2s	60.01	S_2s
8	76.57	S_1	50.34	S_2sc	79.14	S_1	75.31	S_1

Table 6: Results of the qualitative suitability evaluation of different land series for crops under study using parametric method (storie)

	Alfalfa		Barley		Maize		Wheat	
Land units	Land index	Suitability classes	Land index	Suitability classes	Land index	Suitability classes	Land index	Suitability classes
1	46.54	S_3s	26.00	S_3tc	48.57	S_3s	53.27	S_2s
2	29.85	S_3tsw	16.65	N_1tswc	47.53	S_3tsw	31.26	S_3tsw
3	5.86	N_2snw	3.76	N_2snwc	13.71	N_1snw	6.79	N_2snw
4	38.94	S_3s	21.82	N_1sc	40.76	S_3s	55.19	S_2s
5	18.42	N_2sw	11.10	N_2swc	37.57	S_3sw	15.97	N_1snw
6	53.07	S_2s	29.56	S_3sc	55.20	S_2s	56.19	S_2s
7	36.79	S_3s	25.81	S_3sc	38.18	S_3s	52.35	S_2s
8	50.83	S_2s	28.90	S_3sc	53.94	S_2s	52.65	S_2s

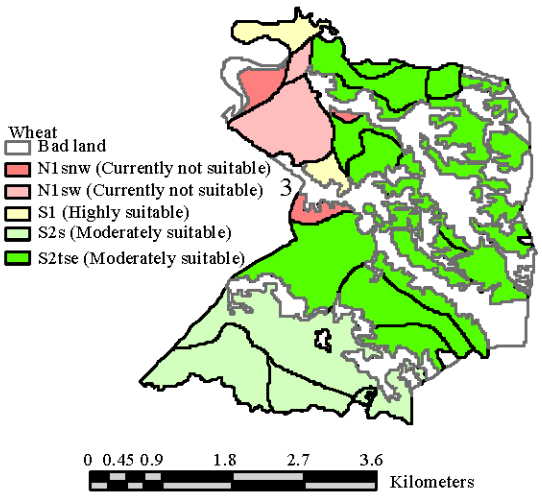

Fig. 2: Land suitability map for wheat

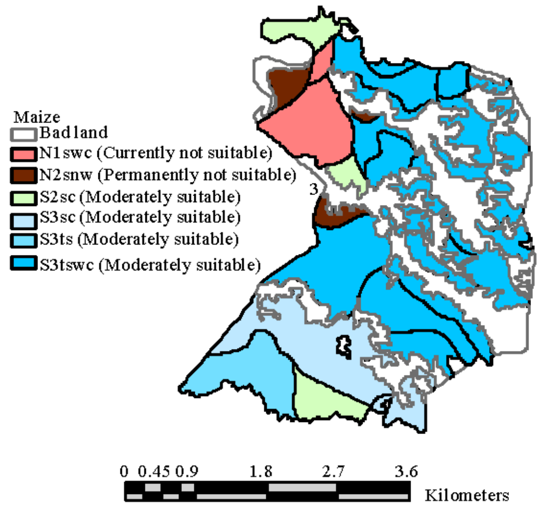

Fig. 4: Land suitability map for maize

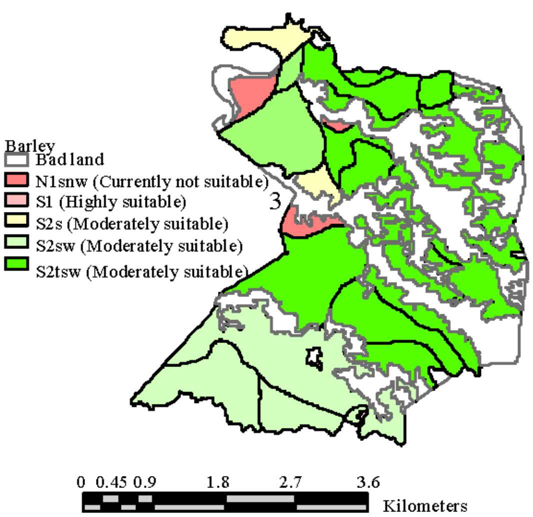

Fig. 3: Land suitability map for barley

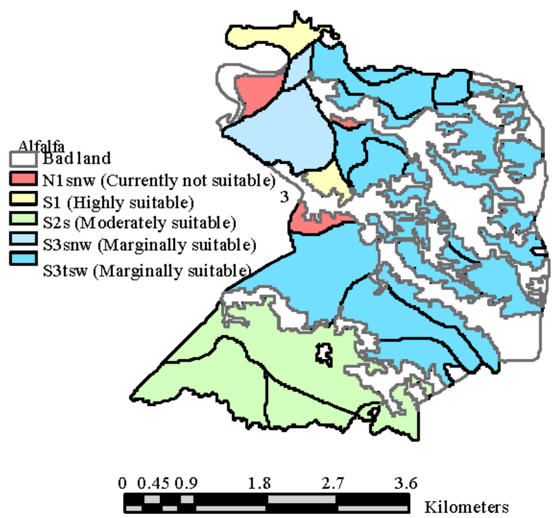

Fig. 5: Land suitability map for alfalfa

Regarding the accuracy and several advantages of the parametric method (Square root method) the results obtained by this method in the present study will be reviewed briefly.

As the results of the Fig. 3-6 show, the land series 6 and 8 with an area of 432 ha (2.73%) shows the best land suitability for wheat, barley and alfalfa productions. Land series 7 with an area of 388 ha (2.45%) shows moderate suitability for all the crops under study and series 1 and 4 with an area of 2624 ha (16.57%) show an average suitability for wheat, barley and alfalfa. Land series 2 also with an area of 6201 ha (39.17%) shows an

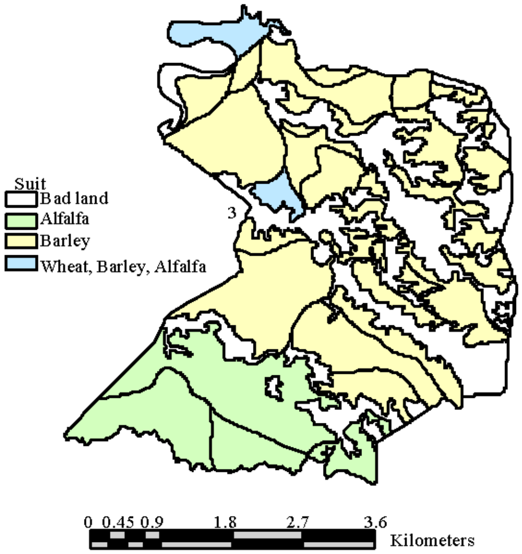

Fig. 6: The most suitable map for principal crops

average suitability for growing wheat and barley. Land series 5 with an area of 975 ha (6.16%) shows moderate suitability for barley and series 6 and 8 with an area of 432 ha (2.73%) shows an average suitability for maize. Land series 2 and 5 with an area of 7176 ha (45.33%) shows a low suitability for alfalfa and series 1, 2 and 4 with an area of 8825 ha (55.74%) Exhibited a low suitability for maize. Land series 5 with an area of 975 ha (6.16%) demonstrated physically unsuitable for wheat and maize productions and finally series 3 with an area of 406 ha (2.57%) was determined physically unsuitable for all the crops under study.

The comparison of the land indexes for wheat, barley, alfalfa and maize, Table 5 and 6 indicated that in land series 6 and 8 growing wheat, barley and alfalfa was the most suitable than maize. In land series coded 1, 4 and 7 growing alfalfa was the most suitable compared with wheat, barley and maize. and finally, In land series coded 2, 3 and 5 growing barley was the most suitable compared with other productions. Figure 6 shows the most suitable map for principal crops in the Gargar Region, by notation to land index (Li). As seen from this map, the largest part of this plain was suitable for barley and some part of this area was suitable for alfalfa, also, there was not founded area that was suitable for maize.

Generally, the most important limiting factors in wheat and barley productions in the region under study included physical properties of the soil especially lime content and partly soil texture and drainage. Briza *et al.* (2001) also suggested that the most limiting factors of the land suitability in the Province of Ben Slimane, Morocco, in wheat and barley productions included physical characteristics such as soil texture, soil depth and drainage.

The major limiting factors in maize production are low relative humidity and high n/N ratio during the plant growth, lime content among the soil physical properties, drainage and soil salinity. Limiting factors in producing alfalfa also include lime content among the soil physical properties, salinity and drainage. Osie (1993) introduced salinity and drainage as the most limiting factors of alfalfa and maize productions in their land suitability evaluations of southeastern lands of Nigeria.

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REFERENCES

Al-Areba, A., A.S.A. Salami, A. Ouafae, B. Rigobert, D. Laura and G. Gebremeskel *et al.*, 2007. Land evaluation in Essaouira province Morocco. Proceedings of 27th Professional Course on Geomatics and Natural Resources Evaluation, Nov. 6, 2006-Jun. 22, 2007, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, pp: 1-213.

Bremmer, J.M. and C.S. Mulvaney, 1982. Nitrogen-Total. In: Methods of Soil Analysis, Page, A.L. (Ed.). Part II. 2nd Edn. Agron. Monogr. 9. ASA and SSSA, Madison, WI., pp: 595-624.

Dunshan, C., D.B. Claudia, D.S. Sara, D. Hui, D.L.L. Maddalena, L. Weidong and M.A. Hailong *et al.*, 2006. Land evaluation in danling county, sichuan province, China. Proceedings of 26th Course Professional Master Geomatics and Natural Resources Evaluation, Nov. 7, 2005-Jun. 23, 2006, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, Italy, pp: 1-153.

FAO, 1976. A framework for land evaluation. Fao Soil Bulletin No. 32. Rome, pp: 72., www.fao.org/docrep/x5310e/x5310e00.htm.

FAO, 1983. Guidelines: Land evaluation for rainfed agriculture. FAO Soils Bull. No 52, FAO, Rome. http://www.fao.org/ag/AGL/agll/landuse/faopubs.stm.

FAO, 1984. Guidelines: Land evaluation for forestry. FAO Soils Bull. Rome. http://www.fao.org/ag/AGL/agll/landuse/faopubs.stm.

FAO, 1985. Guidelines: Land evaluation for irrigated agriculture. FAO Soils Bull. FAO, Rome. http://www.fao.org/docrep/x5648e/x5648e00.htm.

Francesco, A., B. Abu El-Ish, D. Pierre, D. Vladan, I. Mirjana, K. Rosa and Babacar *et al*., 2003. Land evaluation in the province of Thies, Senegal. Proceedings of 23rd Course Professional Master Geomatics and Natural Resources Evaluation, Nov. 8, 2002-Jun. 20, 2003, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, Italy, pp: 1-148.

Givi, J., 1997. Qualitative Evaluation of Land Suitability for Field and Fruit Crops. 1st Edn., Iranian Soil and Water Research Institute, Tehran, Iran.

KWPA, 2005. Meteorology report of gargar plain. Ahwaz, Iran (In Persian). http// www.kwpa.com.

KWPA, 2006. Semi-detailed soil study report of grgar plain. Ahwaz, Iran (In Persian). http//www.kwpa.com.

Ljusa, M. and I. Pajovic, 2002. Land evaluation in the province of larache Morocco. Proceedings of 22nd Course Professional Master Geomatics and Natural Resources Evaluation.

Mahler, P.J., 1979. Manual of Land Classification for Irrigation. 3rd Edn., Soil and Water Research Institute, Iran, pp: 103.

Njiki, A.G.A., B. Antonio, C.V.M. Fernanda, C. Sara, F. Wenqiang and F. Edoardo *et al*., 2005. Land evaluation in the shouyang county, shanxi province, China. Proceedings of 25th Course Professional Master Geomatics and Natural Resources Evaluation, Nov. 8, 2004-Jun. 23, 2005, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, Italy, pp: 1-141.

Osie, B.A., 1993. Evaluation of some soil in south eastern Nigeria for arable crop production. Soil Sci. Plant Anl., 24: 757-773.

Sokol, B., B. Federico, F. Marco, M. Imene, M. Rosa, M. Cheikh and P. Paolo *et al*., 2004. Land evaluation in the oud rmel catchment, Tunisia. Proceedings of 24th Course Professional Master Geomatics and Natural Resources Evaluation, Nov. 10, 2003-Jun. 23, 2004, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, Italy, pp: 1-149.

Sys, C., E. Van Ranst and J. Debaveye, 1991. Land evaluation, Part l, principles in land evaluation and crop production calculations. International Training Centre for Post-graduate Soil Scientists, University Ghent, www.plr.ugent.be/publicatie.html.

Yasmina, A., A. Moulay, A.M. Najmia, B. Enrico, B. Yasmina, C. Paolo Omar and D. Aldo *et al*., 2001. Land evaluation in the province of ben slimane, Morocco. Proceedings of 21st Course Professional Master Remote Sensing and Natural Resource Evaluation, Nov. 10, 2000-Jun. 22, 2001, Ministry of Foreign Affairs, Istituto Agronomico Per L'oltremare, Italy, pp: 1-148.