Qualitative land suitability evaluation for the growth of onion, potato, maize, and alfalfa on soils of the Khalat pushan research station

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Abstract: An area suitability assessment for crop production requires a considerable effort, which can provide necessary information for optimum land use. Agricultural land use has benefited significantly from the use of suitability systems in recent years. These systems have jointly showed their capabilities in the evaluation and assessment of suitable sites for a variety of crops.

In the present study and research work land suitability evaluation (qualitative classification) has been determined for onion, potato, maize and alfalfa in Khalat pushan research station of Tabriz University in East Azerbaijan by using of Simple Limitation method (SLM), Limitation Method regarding Number and Intensity (LMNI) and parametric (PM) such as square root and storie methods. Climate, soil and landscape qualities and their characteristics which most influence crop suitability have been combined by the adopted methodology. In this study economic factors have been excluded and moderate management has been assumed. The use of different methods showed that the most important limitation factors are climate, lime, pH, OM, texture and gravel alone or in combinations. Evaluation indicates that SLM and LMNI show similar suitability classes, which confirms the previous findings for several crops by other researchers. However, in many cases the use of parametric methods, especially the square root method revealed to be more realistic in showing the distinguished suitability classes in many cases. Therefore, based on the obtained results (especially by the square root method), the cultivation of alfalfa, potato and onion can be recommended, except for soil profile 2, which is not suitable (N2) for onion.

Key words: climate, gravel, landscape, lime, soil, pH

Introduction

Land and soil are the ultimate sources of wealth and the foundation on which civilization is constructed. A main problem is inappropriate land use, which leads to inefficient exploitation of natural resources, destruction of land resources, poverty and other social problems and even to the destruction of civilization (Rossiter, 1994). The climate of Iran is one of great extremes because of the geographic location and varied topography. Most of the country is arid to semiarid with an average annual precipitation of about 250 mm, whereas it ranges on the northern flanks of the Alburz mountains from 750 to 2000 mm. Therefore, in arid and semiarid areas of the country with an extent of 32.5 million ha the soils have a low production potential due to the restricted rainfall (Zeynaddini & Banaei, 2001).

Suitable land change after degradation by salinity or alkalinity requires suitable land use. A part of the problem can be solved by land evaluation leading to rational land use planning FAO (1976) and appropriate and sustainable use of natural and human resources and also optimizing the use of a land piece for a specified use (Sys et al., 1991a). Special land productivity depends very much on climate, soil, topography and water availability, which are the most important categories of environmental information required for judging land suitability and microorganisms activity (Aliasgharzad et al., 2006). In fact, land suitability evaluation is an examination process of the degree of land suitability for a specific utilization type (Sys, et al., 1991b) and/or description method or estimation of potential land productivity (Rossiter, 1994). In this manner all requirements can be provided at the present time and also a suggestion about the future population needs can be made, which is one of the basic principles of precision agriculture (Seyed Jalali, 2001). Onion, potato, maize and alfalfa crops are important and commercially produced in the majority parts of East and West Azerbaijan province. Also in several parts of Iran land suitability evaluation for some of these crops has been done by Movahhedi Naeni (1993), Ghasemi Dehkordi (1994), Sarvari & Mahmoudi (2001), Shahbazi & Jafarzadeh (2004), Jafarzadeh & Atabakazar (2004), Jafarzadeh et al. (2004, 2005a,b) and Shabi (2005). Therefore, this

Table 1. Analytical characterization of the soil profiles in the study area.

Profile	Horizon	Depth (cm)	C* (%)	Si* (%)	S* (%)	Text Class	pH H_2O	OM (%)	CaCO3 (%)	ECe (dS/m)	CEC (Cmol+/kg)	Gravel (%)
1	A	0–10	8	18	74	LS**	6.8	0.04	5.8	0.05	13	21
	AC	10–26	8	17	75	LS	7.4	–	8.2	0.052	13	22
	C_1	26–33	7	19	74	LS	7.3	–	8.6	0.042	13	24
	C_2	33–55	5	19	76	LS	7.3	–	8.3	0.042	10	24
	C_3	55–81	4	15	81	LS	7.2	–	8.1	0.046	8	22
2	Ap	0–10	12	5	83	LS	8.2	0.01	26.6	0.028	16	21
	AC	10–26	3	19	78	LS	7.5	–	28.0	0.049	10	22
	C_1	26–33	3	3	94	S**	8.0	–	28.0	0.045	10	24
	C_2	33–55	3	6	91	S	8.3	–	18.0	0.043	9	24
	C_3	55–81	4	7	89	LS	8.3	–	10.5	0.098	10	22
3	A	0–10	3	6	91	S	7.4	0.04	5.7	0.042	10	17
	AC	10–42	2	9	89	S	6.4	0.04	5.3	0.022	7	12
	C_1	42–80	1	8	91	S	7.3	–	5.1	0.177	7	13
	C_2	80–98	2	14	85	LS	7.8	–	6.5	0.015	8	15
	C_3	>98	3	12	85	LS	7.7	–	4.5	0.020	8	16
4	A	0–10	4	25	71	SL	7.6	0.13	5.8	0.071	14	18
	AC	10–39	10	31	59	SL**	8.1	–	5.9	0.067	16	23
	C_1	39–58	8	15	77	LS	7.6	–	5.8	0.069	11	20
	C_2	58–71	4	7	89	S	7.2	–	5.4	0.058	11	8
	C_3	71–107	5	15	80	LS	7.5	–	5.3	0.110	11	5
5	A	0–9	17	42	41	L**	7.5	0.01	0.0	0.191	19	8
	B	9–32	6	29	65	SL	6.9	–	–	0.066	16	9
	C_1	32–62	1	24	75	LS	7.7	–	–	0.054	11	8
	C_2	>62	7	11	82	LS	8.1	–	–	0.044	11	10
6	Ap	0–9	5	10	85	LS	7.0	0.01	5.9	0.071	11	10
	AC	9–35	5	6	89	S	7.1	–	6.1	0.42	11	11
	C_1	35–56	5	15	80	LS	7.1	–	5.6	0.14	10	8
	C_2	56–81	6	25	69	SL	7.2	–	7.2	0.17	15	36
	C_3	>81	10	23	67	SL	7.0	–	7.5	0.17	13	33
7	Ap	0–10	10	36	54	SL	8.1	0.19	12	0.085	17	9
	B_1	10–20	9	35	56	SL	8.1	–	12.5	0.124	17	11
	B_2	20–48	9	29	62	SL	6.9	–	11.9	0.212	16	8
	BC	48–68	14	26	60	SL	7.4	–	9.9	0.182	14	10
	C	68–90	7	29	64	SL	7.9	–	10.7	0.34	12	17
8	Ap	0–7	3	1	96	S	6.7	0.3	8.7	0.038	9	11
	C_1	7–49	3	7	90	S	7.0	–	11.0	0.032	9	9
	C_2	49–66	3	9	88	S	8.0	–	11.7	0.056	8	12
	C_3	66–89	3	5	92	S	7.3	–	12.0	0.062	8	14
	C_4	89–101	3	13	84	SL	7.4	–	12.7	0.045	9	27
9	Ap	0–7	9	28	63	SL	6.9	1.3	8.4	0.066	20	16
	B_1	7–23	8	33	59	SL	8.2	–	9.4	0.057	18	4
	B_2	23–54	8	23	69	SL	7.1	–	6.8	0.093	12	4
	C_1	54–93	3	7	90	S	7.3	–	6.8	0.045	11	13
	C_2	>93	3	9	88	S	7.3	–	4.0	0.028	9	10
10	Ap	0–14	19	12	69	SL	7.8	0.27	7.8	0.053	14	16
	B_1	14–33	9	35	56	SL	6.9	–	7.0	0.051	15	17
	B_2	33–58	17	15	68	SL	7.2	–	7.6	0.052	–	26
	B_3	58–110	26	32	42	L	7.3	–	10.4	0.051	21	26

* C (clay), Si (silt), S (sand), ** LS (loamy sand), S (sand), SL (silt loam) and L (loam), estimated by the hydrometer method

study not only confirms some obtained results about the methods described by previous researchers, but also presents a land suitability based upon SLM & LMNI methods and evaluates the capabilities of the study area for the above mentioned crops. The methodology adopted combines most aspects of climate, site and soil characteristics that influence crop suitability of the study area.

Table 2. Climatic characteristics of the meteorological station of Khalat pushan research station for 22 years (JAFARZADEH et al., 2005a).

Characteristics	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean max t (℃)	1.6	3.1	8.1	15.0	20.5	26.7	30.6	31.5	27.8	20.1	12.0	4.9
Mean min t (℃)	–7.8	–7.9	–3.5	2.4	6.2	10.7	15.0	15.3	10.3	4.9	–0.4	–4.5
Absol max t (℃)	8.9	10.2	16.3	23.5	28.0	33.2	35.7	35.9	32.0	25.6	16.9	10.8
Absol min t (℃)	–15.8	–16.0	–10.7	–3.3	1.5	6.5	11.0	10.8	4.9	–0.9	–8.2	–14.1
Mean month t (℃)	–3.1	–2.4	2.3	8.7	13.3	18.7	22.8	23.4	19.1	12.5	5.8	0.2
Rainfall (mm)	20.4	20.2	26.0	42.7	43.6	13.8	8.6	2.4	2.1	17.2	29.3	20.9
Relative humidity (%)	75.7	69.7	64.0	58.2	54.3	46.2	45.1	43.8	46.5	54.5	67.1	72.3
Sunshine (hours)	5.5	5.5	6.7	7.7	9.0	11.6	11.9	11.2	9.4	6.5	5.2	5.2
Calculated ETp (mm)	0.00	0.0	15.5	81.0	124.0	241.5	282.1	248.0	114.0	68.2	15.0	0.0

Table 3. Land suitability classes for 10 representative soil profiles of the study area for potato and alfalfa based on different methods.

Soil Profile	Potato				Alfafa			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	$S3_{S*}$	$S3_S$	S3	S2	$S3_S$	$S3_S$	S3	S3
2	$S3_S$	S3	N2	S3	$S3_S$	$S3_S$	N1	S3
3	$N1_S$	$N1_S$	S3	S3	$S3_S$	$S3_S$	S3	S3
4	$S2_S$	$S2_S$	S3	S2	$S2_{CS}$	$S2_{CS***}$	S3	S2
5	$S2_S$	$S2_S$	S2	S2	$S2_{CS}$	$S2_{CS}$	S2	S2
6	$S3_S$	$S3_S$	S3	S3	$S2_{CS}$	$S2_{CS}$	S3	S2
7	S3f**	S3f	S3	S3	$S2_{CS}$	$S2_{CS}$	S3	S3
8	$N1_S$	$N1_S$	N1	S3	S3S	S3S	S3	S3
9	$S2_S$	$S2_S$	S3	S2	$S2_{CS}$	$S2_{CS}$	S2	S2
10	$S2_S$	$S2_S$	S3	S2	$S2_{CS}$	$S2_{CS}$	S3	S2

S* = soil limitation, f** = fertility limitation, CS*** = climate and soil limitations

Material and methods

According to JAFARZADEH (1996), the area with ten distinguished soil profiles and an extent of 26 ha, lies between 38°5′ North longitudes and 46°17′ East latitudes. The altitude of the region is 1362 m a.s.l. In order to have more confident soil data, particularly to control the soil boundaries and up-dating the soil determination, the soil reports have been studied and 10 soil profiles in physiographic units alluvial plain were selected for more detailed soil survey. Profile description of pedons was made using standard terminology (USDA, 2003a) and also after preparation and analyzing of samples (Tab. 1), soils were classified by USDA classification system (USDA, 2003b) in Entisols and Inceptisols orders. The most important climate characteristics necessary for suitability determination (temperature, rainfall, relative humidity, etc.) were collected from Khalat pushan metrological station (Tab. 2) with an average total rainfall of about 247 mm and a mean temperature of 10.1℃.

Based on obtained information about topography, soil, climate, and suitability evaluation methods (SYS et al., 1991b), 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.

Results and discussion

Suitability is largely a matter of producing yield with relatively low inputs (VINK, 1960) and there are two stages in finding land that is suited to a specific crop. Firstly, the requirements for the crop need to be known, or alternatively which soil and site attributes adversely influence the crop. The second stage is to identify and to delineate land with the desirable attributes but without the undesirable ones. In the present study reported specified requirements for onion, potato, maize and alfalfa by SYS et al. (1993a) were used.

There is an optimal climatic condition for irrigated potato and onion which makes that the region received a high suitable class (S1) for these crops. The absolute minimum temperature during the growing cycle of irrigated maize causes an unsuitable condition for this crop (N2) which can not be corrected. The mean temperatures during the growing cycle of alfalfa result into moderately suitable (S2) classes. Therefore, the most important limiting factors in the area studied are climate, texture and structure, gravel, lime, OM, and pH. Their effects can appear alone or in combinations.

Soil attributes data such as pH, lime, OM, and texture & structure had influence on the land suitability for potatoes and resulted: 1) into mainly moderately to non suitable (N1) land classes by using the limitations and storie methods and 2) into moderately to marginally suitable classes by using the parametric square method (Tab. 3). Also in the majority parts of the study area, texture & structure, and gravel for alfalfa (Tab. 3), pH, OM, lime, texture & structure and gravel for onion, and

Table 4. Land suitability classes for 10 representative soil profiles of the study area for onion and maize based on different methods.

Soil Profile	Onion				Maize			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	$S3_{S*}$	$S3_S$	S3	S2	N2cl***	N2cl	N2	N2
2	$N2_S$	$N2_S$	N2	N2	N2cl	N2cl	N2	N2
3	$S3_S$	$S3_S$	S3	S3	N2cl	N2cl	N2	N2
4	$S2f_S$	S2f**	S3	S2	N2cl	N2cl	N2	N2
5	$S2_S$	$S2_S$	S2	S2	N2cl	N2cl	N2	N2
6	$S2_S$	$S2_S$	S3	S2	N2cl	N2cl	N2	N2
7	N1f	N1f	N1	S3	N2cl	N2cl	N2	N2
8	$S3_S$	$S3_S$	S3	S3	N2cl	N2cl	N2	N2
9	$S2_S$	$S2_S$	S3	S2	N2cl	N2cl	N2	N2
10	$S2_S$	$S2_S$	S3	S3	N2cl	N2cl	N2	N2

S* – soil limitation, f** – fertility limitation, cl*** – climate limitations

climate for maize are the main limiting factors (Tab. 4). Simple limitation method, limitation method regarding number and intensity and parametric methods (Storie and Square root) were employed and land suitability classes were determined. The simple limitation method results are similar to those of the limitation method regarding number and intensity. The accuracy of obtained results by the square root method is high and more realistic when compared with the limitation methods results. Therefore according to the results of square root method cultivation of alfalfa, potato and onion can be recommended except for soil profile 2, which is not suitability for onion (N2).

References

Aliasgharzad, N., Neyshabouri, M.R. & Salimi, G. 2006. Effects of arbuscular mycorrhizal fungi and *Bradyrhizobium japonicum* on drought stress of soybean. Biologia, Bratislava **61(Supl. 19):** S324–S328.

FAO 1976. A frame work for land evaluation. Soil Bulletin, 32. FAO, Rome, 72pp.

Ghasemi Dehkordi, V.R. 1994. Soil study an land suitability evaluation of Barkhar region of Isfahan. MSc. Thesis, Faculty of Agriculture, Soil Science Department, Tehran University.

Jafarzadeh, A.A. 1996. Detailed survey of the 26 hectares of the land and soils of Khalat pushan research station. Journal of the Faculty of Humanities and Social Science, No. 4, pp. 14–35.

Jafarzadeh, A.A. & Atabakazar, M.R. 2004. Land suitability evaluation of Shakaryazi region for wheat, barley, alfalfa, sugar beet, potato and sunflower. In: Int. Conference of CIGR, Collection of extended abstracts Vol. 2, p. IV–71. Beijing, China.

Jafarzadeh, A.A., Khoshazaman, T., Neyshabouri, M.R. & Shahbazi, F. 2005a. Qualitative evaluation of land suitability in Karkaj Research Station of Tabriz University for wheat, potato, maize, tomato, bean and alfalfa, pp. 95–102. In: Int. Conference of ICEM, Hyderabad, India.

Jafarzadeh, A.A., Momtaz, H.R. & Neyshabouri, M.R. 2005b. Qualitative land suitability evaluation in Yakhfarvazan region of Ahar for wheat, barley, safflower, bean, soybean and potato, pp. 342–348. In: Int. Conference of ICEM, Hyderabad, India.

Movahhedi Naeni, S.A.R. 1993. Land suitability evaluation of Gorghan area for main agricultural crops. MSc. Thesis, Faculty of Agriculture, Soil Science Department, Tarbiat Modarres University.

Rossiter, D.G. 1994. Lecture notes: Land evaluation. Cornell University, College of Agriculture and Life Sciences, Department of Soil, Crop and Atmospheric Sciences.

Sarvari, S.A. & Mahmoudi, Sh. 2001. Qualitative land suitability evaluation for irrigated sugar beet in Ghazvin region. Iranian Journal of Soil and Water. Special issue on soil survey and land evaluation, pp. 66–75.

Seyed Jalali, S.A. 2001. Comparison of land suitability classification methods for irrigated winter wheat. Iranian Journal of Soil and Water. Special issue on soil survey and land evaluation, pp. 56–65.

Shahabi, M. 2005. Qualitative evaluation of land suitability in Azarbaijan University region of East Azarbaijan for onion, potato, maize, tomato and chickpea. MSc. Thesis, Faculty of Agriculture, Soil Science Department, Tabriz University. Tabriz, Iran.

Shahbazi, F. & Jafarzadeh, A.A. 2004. Qualitative evaluation of land suitability in Khusheh-Mehr region of Bonab for wheat, barley, alfalfa, onion, sugar beet and maize. Agricultural Science, Scientific Journal of Faculty of Agriculture, University of Tabriz. **14:** 67–85.

Sys, C., Vanranst, E. & Debaveye, J. 1991a. Land evaluation part 1: Principles in land evaluation and crop production calculation. General Administration for development cooperation. Agric. Publ. No. 7. Brussels, Belgium, 174 pp.

Sys, C., Vanranst, E. & Debaveye, J. 1991b. Land evaluation part 11: Methods in land evaluation. General Administration for development cooperation. Agric. Publ. No. 7. Brussels, Belgium, 247 pp.

Sys, C., Vanranst, E. & Debaveye, J. 1993. Land evaluation part 111: Crop Requirements. International Training Center for Post Graduate Soil Scientists. Ghent University. Ghent, Belgium, 199 pp.

USDA 2003a. Soil Survey Manual. University press of pacific. Honolulu, Hawaii.

USDA 2003b. Keys to Soil Taxonomy. Soil Survey Staff, USDA, 9th Edition.

Vink, A.P.A. 1960. Quantitative aspects of land classification. In: Trans. 7th Int. Cong. Soil Science. Vol. 4, pp. 371–378.

Zeynaddini, A. & Banaei, M.H. 2001. Qualitative and quantitative land suitability classification for major crops in the Negar area, Kerman Province. Iranian Journal of Soil and Water. Special issue on soil survey and land evaluation, pp. 47–55.