International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.iaurasht.ac.ir
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)

Land Suitability Classification of East Azerbaijan Research Station for Tomato, Potato, Onion and Bean

Parisa Alamdari* * and Setareh Amanifar

Received: 16 February 2015,
Accepted: 26 July 2015

Abstract

In this study, qualitative land suitability evaluation was made for research station of East Azarbaijan, for tomato, potato, onion and bean. The study was done using Simple Limitation Method (SLM), Limitation Method regarding Number and Intensity (LMNI) and Parametric Methods (PM) such as the square root and the Storie methods. The results from different methods indicated that the most important limiting factors are Organic Matter (OM), salinity and sodicity and calcium carbonates, either alone or in combination. Evaluation indicated that the (SLM) and (LMNI) mainly show similar suitability classes, but Parametric methods especially square root method which it's results revealed to be more realistic show different suitability classes in many cases. According to the square root method, the area can be recommended as marginally suitable for cultivation of tomato and potato and expected to yield about 40-65% of optimal production.

Keywords:
SLM, LMNI, PM, Storie, Square root methods

Assistant Professors of Soil Science, University of Zanjan, Iran.
** Corresponding author's email: esfand1970@yahoo.com*

INTRODUCTION

With respect to increasing world population and scarce of arable lands, for food security, land evaluation accuracy should be considered. In this regard, land suitability evaluation can play key role in getting the best decides by developers and agriculturists in order to match the land optimum use, because it has long been found that land suitability is a part of a "rational" cropping system (FAO, 1976). Land evaluation assesses the performance of land based on a more or less systematic analysis of the physical land conditions. Land evaluation is a tool or a technique to compare the various use potentials and benefits that can be obtained from the land. The land evaluation in its simplest form selects the best lands for specific purpose. Main objective of land evaluation is achieving optimum usage from each land and soil with assessment physical, social and economic phases. In Iran 32 million ha of agricultural soils are suitable for crop cultivation; either rain fed or irrigated so to indicate suitability of these soils for particular use under particular climate, soil studies are carried out (Sys and Verheye,1974). Onion, potato and been are important crops, that mainly produced in major parts of Iran and also in the East and West Azerbaijan provinces, where their production depends on soil and climate. In different parts of Iran, evaluation of land suitability was done for some of crops by Jafarzadeh *et al*. (2005), Jafarzadeh *et al.* (2008), Kamkar *et al*. (2014), Safari *et al*. (2013), in order to find an optimum use for each land unit. Therefore this study not only confirm some obtained results for previous researchers about the different methods but also presents a land suitability based on SLM, LMNI and PM methods and evaluates the capabilities of the study area for the above named crops.

MATERIALS AND METHODS

This research station with about 200 ha located between 47°18' and 47°30' East latitudes and between 35°11' and 35°19 North longitudes. The altitude of the region is about 1230 m above sea level. The climate characteristics necessary for land suitability estimation (temperature, rainfall and relative humidity) were collected from the Ahar meteorological station was shown in Table 1, where the average annual total rainfall is about 302.8 mm, with the mean and maximum annual temperatures being 1.8°C and 19.5°C, respectively.

In order to obtain reliable soil data, the available soil survey reports were inspected and, based on this; seven representative soil profiles were chosen investigation within different land units with different average slope steepness. Soil profile descriptions, samplings and analyses were made using standard terminology and procedures (Soil Survey Staff, 1993). The soils were classified according to USDA classification system (Soil Survey Staff, 2014). As shown in Table 2, the soils were classified as an Aridisols order, Sodic Haplocambids and Typic Haplocambids suborders. According to the map of soil temperature and moisture regimes of Iran (Banaei, 1998), the soil temperature and moisture regimes of the area were identified as mesic and aridic, respectively. In the process of qualitative land suitability evaluation, it is the 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 (ACEC)), sum of exchangeable base cations, pH in H_2O, organic matter) and the salinity and alkalinity that play an important role. The land qualities such as the moisture and oxygen availability and the foothold for root development depend to a large extent on the soil texture. The content of coarse fragments, influence the capacity of soil to retain nutrients and water and tillage conditions. Investigations have indicated that most crops produce excellent yields with an effective root zone depth of 90 to 100 cm. Therefore, for annual crops, the dense root system is usually assumed to occur within the upper 100 cm, while most tree crops have a dense to moderate root system up to 150 cm depth. The textural classes to be used for land suitability evaluation were recalculated using depth weighting factors up to the depth 1 m for annual crops and up to 1.5 m or up to an impermeable layer for perennial crops. When the content of gypsum in the root zone is higher than 25% and the

Table1: Climatic characteristics of the meteorological station of Tabriz

Characteristics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean max t(°C)	2.6	3	8.8	16.3	20	25.5	17.7	27.1	24.6	17.8	11.5	5.5
Mean min t(°C)	-5.5	-5	-0.8	2.3	8	11.8	15.2	14.9	10.8	6.3	1.6	-2.3
Absol max t(°C)	15.6	17.4	21	26.5	30.2	34.2	36.4	36.4	35	29	22.5	17
Mean month t(°C)	-1.5	-0.6	4	10.3	14.5	18.7	21.5	21	17.7	12	6.6	1.6
Rainfall (mm)	18.44	19.2	38.9	42.7	14.4	29.4	5.3	9.1	9	33	31.1	22.2
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
Calculated ETp(mm)	13.35	17.8	27.9	47.8	65.5	85.9	95.7	89.8	69.1	42.8	25.3	17.1

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 paralithic 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.

The crop requirements with respect to climate, landscape and soil were summarized in separate tables according to Sys *et al*. (1993). With use of these tables, the qualitative land suitability evaluation was done for onion (*Allium cepa* L.), potato (*Solanum tuberosum* L.), tomato (*Solanum lycopersicum* esculentum L.) and bean (*Phaseolus vulgaris* L.) by comparing the actual soil characteristics and qualities with the crop requirements. The Simple Limitation Method (SLM), the Limitation Method regarding Number and Intensity (LMNI) and two Parametric Methods (PM), namely, the square-root and the Storie methods (Sys *et al*., 1991a, b) were used to lands classification.

Simple Limitation Method (SLM): The simple limitation method implies that the crop requirement tables are made for each land utilization type. For each characteristic, the tables define the class-level criteria. The methodology suggests that, in the first place, an evaluation of the climatic characteristics is made, with an aim to determine a climate class level to be used in the following evaluation. The climate class level is determined by the lowest class level among those found for particular climatic characteristics. Then, similarly, the land class is determined by the lowest class level among those found for particular soil characteristics.

Limitation method regarding number and intensity of limitations (LMNI): This method defines land classes according to number and intensity of limitations. The crop requirement tables are requested which define limitation levels for each characteristic. The methodology evaluates, in the first place, the climatic characteristics, regrouped according to radiation, temperature, rainfall and humidity. For each climatic characteristic group, the most severe limitation determines the suitability of climatic class, which is subsequently used as the corresponding limitation level for the total land evaluation. The evaluation is carried out by comparing the actual land characteristics with the limitation levels defined by the crop requirement tables. This method is more difficult than SLM, but the results accuracy is more honest, 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): The parametric land evaluation consists in numerical rating of different limitation levels of land characteristics according to a numerical scale between the maximum (normalized as 100%) and the minimum value. Lastly, the climatic index, as well

Table 2: Selected soil characterization and classification of profiles

Profile	Horizon	Depth (cm)	C (%)	Si (%)	S (%)	Text. class	Gravel (%)	ECe	pH	OC (%)	$CaCO_3$ (%)	CEC Cmol/ Kg
Loamy, mixed, active, mesic, Sodic Haplocambids												
1	A	0-35	31	31	38	SiCL	0	20	8.8	0.27	24.8	15.84
	B_{w1}	35-80	25	42	33	L	0.11	4.4	10	0.2	25	13.15
	B_{w2}	80-120	23	34	43	L	0.15	1.4	9.9	0.26	24.9	12.42
	C	>120	24	35	41	L	0.13	2.9	9.9	0.23	24	12.46
Coarse Loamy, mixed, active, mesic, Sodic Haplocambids												
2	A	0-9	33	29	38	CL	0	3.9	7.6	0.2	24	16.7
	B_{w1}	9-22	31	32	37	CL	3.16	0.05	7.1	0.2	24.8	16
	B_{w2}	22-64	18	2	80	LS	0.75	11	7.4	0.13	25.5	9.9
	C_1	64-120	34	27	39	CL	60	0.9	7.5	0.27	25.8	17.5
	C_2	>120	32	25	43	CL	60	0.5	7	0.26	23.9	16.6
Loamy, mixed, active, mesic, Sodic Haplocambids												
3	A	0-30	28.3	24.4	47.3	SCL	3.33	6.6	7	0.35	24.8	14.8
	B_{w1}	30-60	21.5	26.1	52.4	SCL	0.9	6.7	7.8	0.22	24.9	11.1
	B_{w2}	60-105	25.5	40.3	34.2	L	0	3.9	7.1	0.19	24.8	13.1
	C	>105	5.1	52.2	42.7	SiL	0.8	1.9	7.3	0.2	25	2.3
Loamy, mixed, active, mesic, Sodic Haplocambids												
4	A	0-35	35	29	43	CL	0.6	14.5	7.4	0.26	24.9	18
	B_{w1}	35-75	22.7	34.1	43.2	L	0.14	4.9	7.1	0.21	24.8	11.7
	B_{w2}	75-120	30.5	40.5	29	CL	0.16	4.5	7.5	0.22	24	15.6
	C	>120	17.9	29.9	52.2	L	0.15	3.4	8	0.24	25	9.4
Loamy, mixed, active, mesic, Typic Haplocalcids												
5	A	0-28	22.6	33	4.44	L	0.02	6.2	7.2	0.25	23	11.7
	Bk	28-55	32	27	41	CL	0.05	5.72	7.4	0.23	23.9	16.7
	C_1	55-120	2.8	54.4	43.8	SL	0.15	5.4	7.8	0.24	21	1.8
	C_2	>120	4	55	41	SL	0.2	5.6	7	0.25	22	2
Fine, mixed, superactive, mesic, Sodic Haplocambids												
6	A	0-25	3.36	33.7	41	SL	0.11	7.9	7.7	0.2	23	18.5
	C1	25-55	9.33	27.8	39.3	SL	0	3	7.2	0.23	23.8	16.9
	C2	55-120	43.1	15.9	41	C	0	0.6	7.5	0.25	20	23
	C3	>120	45	16	39	C	0	0.3	7.4	0.2	22	22.9
Coarse Loamy, mixed, active, mesic, Sodic Haplocambids												
7	A	0-25	13	34	53	SL	2.9	8.4	8.1	0.23	224.9	7
	Bw	25-50	9.6	31.2	59.2	SL	0.1	5.5	8	0.21	24.5	4.6
	C	50-80	4.2	40	55.8	SL	33	5.7	9	0.16	24	3.2
	2AB	80-120	17.1	30.5	52.4	SL	0.2	5.5	10	0.24	23.3	9.3
	3C	>120	14	28	58	SL	0.28	5.2	9.7	0.2	24.4	7.5

Table 3: Qualitative land suitability classes of study area for tomato, potato, onion and bean

Profile	Tomato				Potato			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	N_2fn	N_2fn	N_2	N_2	N_2fn	N_2fn	N_2	N_2
2	S_3sf	S_3sf	N_2	N_1	S_3f	S_3f	N_2	S3
3	S_3cf	S_3cf	N_1	S_3	S_3fn	S_3fn	N_1	S3
4	N_2n	N_2n	N_2	N_2	N_2n	N_2n	N_2	N_2
5	S_3s	S_3s	S_3	S_3	S_3n	S_3n	S3	S3
6	S_3s	S_3s	S_3	S_3	S_2sn	S_2sn	S3	S_2
7	S_3sn	S_3Sn	N_1	S_3	S_3fn	S_3fn	N_1	S3

Profile	Onion				Bean			
	SLM	LMNI	Storie	Square root	SLM	LMNI	Storie	Square root
1	N_2fn	N_2fn	N_2	N_2	N_2fn	N_2n	N_2	N_2
2	S_3s	S_3s	N_2	N_2	N_2n	N_2n	N_2	N_2
3	S_3sn	S_3sn	N_2	N_2	N_2n	N_2n	N_2	N_2
4	N_2sn	N_2sn	N_2	N_2	N_2n	N_2n	N_2	N_2
5	N_2sn	N_2sn	N_2	N_1	N_2n	N_2n	N_2	N_1
6	N_2sn	N_2sn	N_2	N_1	N_2n	N_2n	N_2	N_1
7	N_2sn	N_2sn	N_2	N_2	N_2n	N_2n	N_2	N_2

SLM, Simple Limitation Method, LMNI, Limitation Method regarding Number and Intensity, f, fertility, n, salinity and alkalinity limitations, s, soil limitation.

as the land index, is calculated from these individual ratings. In our case, the indices were calculated following two alternative procedures:

1) The Storie method (Storie, 1978):

I=A×B/100×C/100× ...

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

2) Square Root Method (Khiddir, 1986):

I= A×B/100×C/100× ..., in which R min is the minimum rank.

RESULTS AND DISCUSSION

The results of soil profile analyzing have shown in Table 2, and the results for land suitability of the study area for selected crops have shown in Table 3. In this study after analyzing soil samples, the requirements for tomato, potato, onion and bean summarized by Sys *et al*. (1993) were used, then the Simple Limitation Method (SLM), Limitation Method regarding Number and Intensity (LMNI) and the Parametric Methods (Storie and Square Root methods) were employed. The classes of land suitability were determined S_1 or highly suitable with production of 80-100% of optimum, S_2 or moderately suitable with production of 60-80% of optimum, S_3 or marginally suitable or 40-60% of optimum and N or non-suitable (N_1&N_2). Economic factors were excluded and moderate level of management was assumed. According to Table 3, most important limiting factors in studied area are organic matter, pH and soil salinity which their effect can appear alone or together. Soil attribute dada such as OM, $CaCO_3$ and salinity for tomato and potato, $CaCO_3$ and salinity for onion and salinity for bean caused marginally suitable to non-suitable. In simple limitation method and limitation method regarding number and intensity 69% of area are marginally suitable (S_3) for tomato and 21.2% of area is S_2, 47.8% are S_3 for potato, but for onion and bean 100% of area are actually unsuitable and non-potentially suitable (N_2). In parametric method (Storie) 35.3% of area is S_3, 19.4% is N1 and 45.3% is N_2 for tomato and potato and 100% is N_2 for onion and bean. In parametric method (Square root) 54.7% is S_3, 14.3% is N_1 and 31% is N_2 for tomato, 21.2% is S_2, 47.8% is S_3 and 31% is N_2 for potato, 35.3% is N_1 and 67.4% is N_2 for onion and bean. The results obtained by the parametric square root method are probably more realistic, as suggested by comparison with other reports (Jafarzadeh *et al*., 2005; Jafarzadeh *et al*., 2008; Sarvari and Mahmoudi, 2001) in which different methods were applied in different parts of country. The parametric square root method suggests that the study are possesses optimal climatic conditions for irrigated potato, onion and bean (S_1), while the climatic conditions during the growing cycle make the region only moderately suitable (S_2) for irrigated tomato.

CONCLUSION

In general, the area is highly suitable (S_1) from the climatic point of view for potato, onion, bean, moderately suitable (S_2) for tomato. However the soil fertility characteristics (f), the salinity and alkalinity conditions (n) and in some cases, the soil physical characteristics (s) make the lands marginally suitable (S_3) or even non-suitable (N). Based on obtained results especially results from square root method, the cultivation of tomato and potato can be recommended, but the majority of region is non-suitable for onion and bean. Limitations are posed mainly by the high salinity and low organic matter and high calcium carbonates.

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How to cite this article:

Alamdari, P., & Amanifar, S. (2016). Land suitability classification of East Azerbaijan research station for tomato, potato, onion and bean. *International Journal of Agricultural Management and Development,* 6(1), 117-122.

URL: http://ijamad.iaurasht.ac.ir/article_521201_77b89f762979b91b433e2d9f6953afd1.pdf