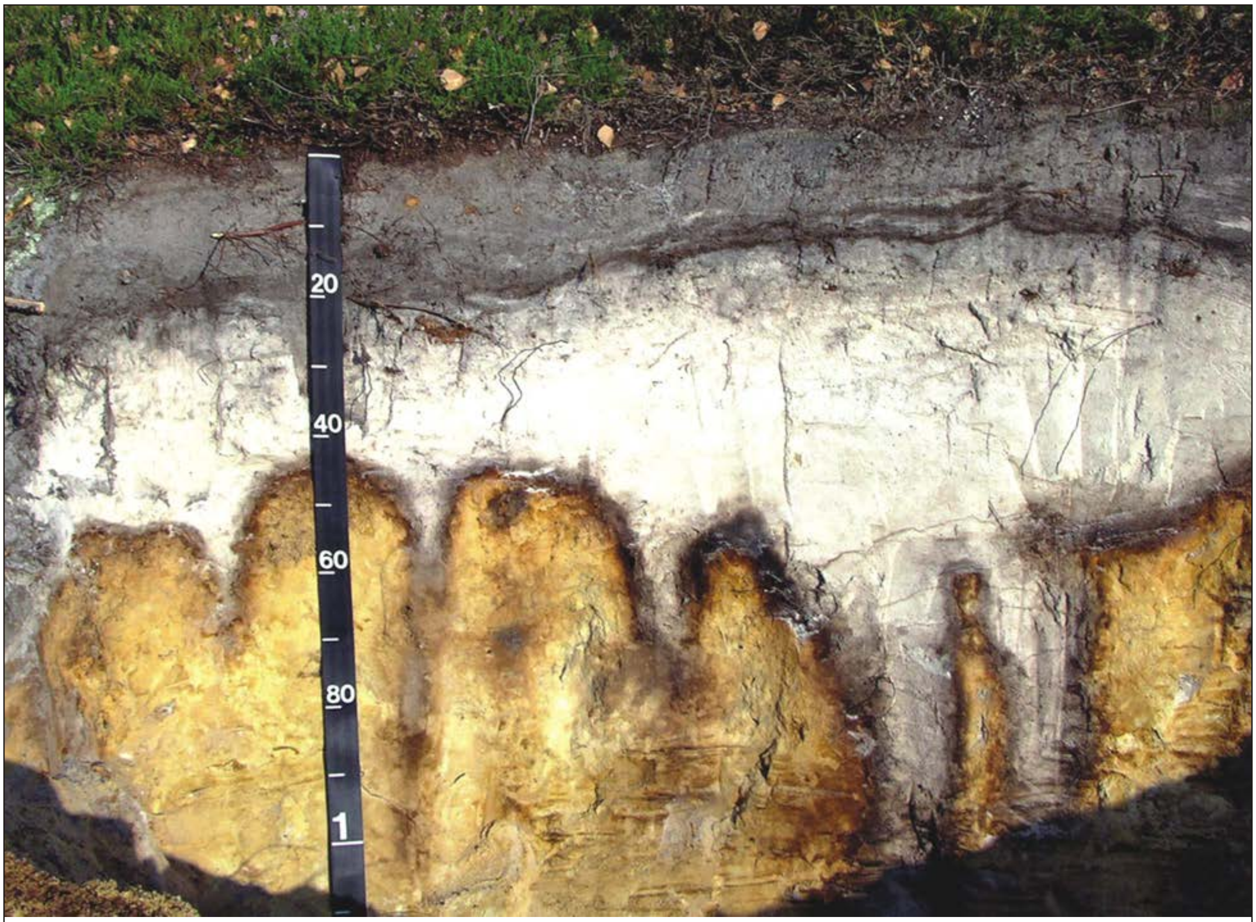

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Evaluation of Qualitative, Quantitative and Economical Land Suitability for Major Crops in Dezful Region

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ABSTRACT

The aim of this study is the qualitative, quantitative and economic land suitability evaluation of wheat, barley, maize and rapeseed crops in Dezful region. The steps of this study include field study, laboratory examination and land evaluation methods. In quantitative evaluation, climatic characteristics, topography and soil characteristic of each plant compared with crop requirements and quantitative suitability classes determine by simple limitation and parametric methods. In qualitative evaluation, rate of yield in a unit of area and in economic evaluation, rate of gross margin in a unit of area, calculated results of quantitative evaluation as show in study area and crops cultivation because of climatic limitations were relatively stable. In addition of climatic limitation, soil salinity and drainage limitations were presence in part of land for growth of the crops. The results of quantitative evaluation show that the suitability class of land units, as compared as qualitative suitability classes, was sane or upper that can be caused as improved managements in farms. Results of economic evaluation shows that the most of land units for two utilization types of barley and rapeseed was S1 class and for two utilization types of wheat and maize, was S2 and S3 classes. Barley cultivation is more beneficial as compared with other crops.

Key words: Land suitability evaluation, qualitative, quantitative, economic, potential yield, marginal yield

INTRODUCTION

The soil is considered crop and livestock production and resource center of the main economic activities of various, therefore, its characteristics, classification, assessment and compliance capabilities and inherent talents that can cause unity of economic and environmental perspectives governing it. Because of this strategy which is the theme of sustainable development or development without destruction, the profitability of capital and national economic prosperity is guaranteed and are observed environmental thresholds and capacities (Martin and Uehara, 1984). To achieve these goals, many complicated steps, careful evaluation, multilateral resources and talent earth are required in every place and time suitablity for field operation is selected (Afify, 2009). In the past, several methods have been used to assess land which partly continues. Of including can be pointed out land suitability classification by Department of Agriculture United States of America method (Soil Survey Laboratory Staff, 1996) and the Iranian method to land classification (Givi, 1997). This type of land classification was made for general use such as irrigation, dry farming grassland development and forestry and to assess for specific crop plants and horticultural not applicable (Brinkman, 1978). For this reason, for the first time in 1976, FAO defined the types of efficiency and devised classification of land suitability for specific uses. This evaluation system, considered of effective factors in the production and according to the requirements of each product, climate and land characteristics compared with the product and finally the land suitability for the production of that product, has identified and classified (FAO, 1976, 1985). Thus, the lands are assigned according to their characteristics for most suitable and profitable land use. Today, the land suitability evaluation in most European countries and the developing countries is the main focus in the evaluation methods, the reason is that this method will consider all the factors required for the optimal use. Maji (1992) studied in Hawaii, California, Brazil, New Zealand and Malaysia. In these studies, soil maps prepared by the US classification Soil Taxonomy (Soil Survey Staff, 1975; USDA-SCS, 1999) was used (Maji, 1992). Johnson *et al.* (1994) studied ALES computer model based on the FAO framework for quantitative and economic land suitability (Johnson *et al.*, 1994). Zinaldini (1992) described qualitative and quantitative assessment of land suitability for major crops in the Negar region Bardsir, province Kerman and stated that the results of the qualitative study show that Gypsum is the most limiting characteristic for the production of wheat, corn, potatoes and sugar beet (Zinaldini, 1992). Mehnatkash (2008) described classes qualitative, quantitative and economic land suitability for major crops of Shahrkord included wheat, alfalfa, potatoes and sugar beet the irrigated and concluded that the cultivation of potatoes in all units studied are more profitable than wheat and alfalfa (Mehnatkash, 2008). Jalalian *et al.* (2008) during studies in Mehran plain, Ilam province evaluated the qualitative, quantitative and economic land suitability for wheat, corn and sesame expressed quality evaluation. Results showed that most units are classified moderately suitable land for products and limitations of the physical properties of the soil. Qualitative and quantitative comparison of classes of wheat and maize showed that quantitative classes are a grade equal to or higher than the quality of classes which gives products from a high level of management. While, quantitative classes of sesame are lower than qualitative classes due to poor management in the cultivation of this product. The economic suitability of the results showed that profitable crop has been wheat and crop rotation of wheat and sesame in cultivated units is more profitable than rotation with wheat and corn (Jalalian *et al.*, 2008). The objectives of this study were land suitability evaluation (qualitative, quantitative and economical classification) for major crops in Dezful region as well as suitability maps within the framework of GIS.

MATERIALS AND METHODS

Geographical location of the study area and specification: Study area of 12239.7 ha, is located at 20 km South of Dezful in Khuzestan province between 32°, 8' to 32°, 16' North latitude and 48°, 14' to and 48°, 30' longitude eastern (Fig. 1). Height of 82 m above sea level in the northern part and 64 m in the southern region slope of 0-2%. Average rainfall in the study area is 341.8 mm and the annual average temperature is about 32°C. Regional climate based on emberger index is hot and semi-arid and has a tropical climate with mild winters, short spring and hot and long summer.

Soil studies and land units descriptions: To conduct this study the soil studies of the desired range were performed at first. After selecting the control profiles for each unit of study, soil horizons were separated based on features such as color, texture, structure, boundaries genetic horizons, solute concentration, particle stability, moisture conditions and the form of accumulation of lime.

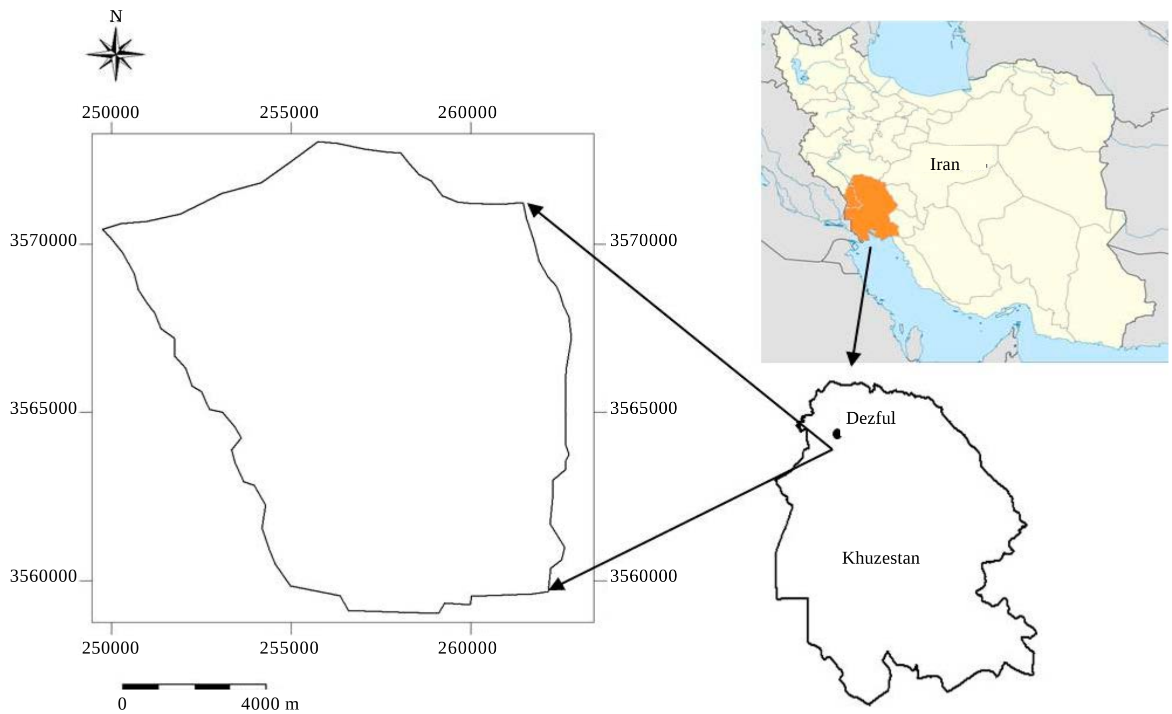

Fig. 1: Geographical location of the study area

And then each of the horizons of the profile soil samples were prepared and sent to the laboratory. Soil classification comprehensive of the keys to soil taxonomy, 2010. The physico-chemical analysis, soil samples taken, open-air and in the shade dried and after the beating, were passed through a 2 mm sieve. Physical and chemical testing was performed according to the soil and water research institute of standards on soil samples as follows: Soil texture by hydrometer method (Klute, 1986), soil acidity, the electrical conductivity of the saturation extract, measuring lime to residue normal hydrochloric acid titration method with a normal base. Organic carbon, wet oxidation method, calcium and magnesium in soil extracts with EDTA method (Aliehyaei, 1993).

Productivity types: Productivity type included irrigated wheat, barley, maize and rapeseed. Climate, soil and topography requirements of the products were collected from available resources and information related to the products of the growth cycle of Dezful agricultural research center reports as well as the advice of the farmers.

Evaluation of qualitative, quantitative and economical land: In this study, qualitative land suitability studies were conducted using both simple limitation and parametric method. Also, during the initial survey, other information required in relation to climatic conditions and agricultural products were collected such as planting and harvesting dates growth stages etc. (Messing *et al.*, 2003; Brinkman, 1978). Simple limitation method compares land use requirements of the property or land quality. The most undesirable characteristic or quality of land class is recognized as the final class of land. The parametric method of a grading scale 0-100 can be attributed to the limitation levels (Embrechts *et al.*, 1988). And a mathematical relationship is obtained as the final lands index to combine degrees of different properties to parametric method Storie (1976) and the square root equation (Khiddir, 1986).

The Storie method (Storie, 1976):

$$I = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \ldots \quad (1)$$

where, I is land index and A, B, C is degrees of different properties.

Square root method (Khiddir, 1986):

$$I = R_{min} \sqrt{\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \ldots} \quad (2)$$

where, I is land index, R_{min} is minimum rating between different properties and A, B, C is other characteristics ratings apart from the character with the minimum degree.

After determining land index, land suitability classes are determined according to Table 1.

Since, the quantity and economic evaluation stage having information is necessary for different units of land in connection with the production rates, costs and income resulting, for this purpose, the preparation of the questionnaire were collected from farmers (Soltani, 1998; Rossiter, 1995). Quantitative and economic land suitability studies, various data management, the actual production rate and economic data in different units of land earn with the preparation of the questionnaire and consulting with farmers. The quantitative assessment is based on the total annual income, total variable costs and critical production rate as determined by the Eq. 1:

$$\text{Critical production} = \frac{\text{Sum of variable costs}}{\text{Price of a unit of production}} \quad (3)$$

The economic suitability classes are determined based on gross profit. Maximum gross profit determined for each type of efficiency (Rossiter, 1995) based on the value of the maximum and instructions are provided and the economic suitability classes are determined in Table 2.

Table 1: Land index values for land suitability classes (Sys *et al.*, 1991a)

Suitability class	Land index
Very suitable (S1)	Lands having indexes >75
Moderate suitable (S2)	Lands having indexes 50-75
Marginal suitable (S3)	Lands having indexes 25-50
Inappropriate in the current situation (N1)	Lands having indexes 12.5-25
Permanent inappropriate (N2)	Lands having indexes < 12.5

Table 2: Economic evaluation classes based on the gross profit rate (FAO, 1983)

Economic evaluation class	Gross profit rate
S1	Lands having >75 maximum gross profit
S2	Lands having 50-75 maximum gross profit
S3	Lands having 0-50 maximum gross profit
N	Lands having <0 maximum gross profit

In order to do quantitative evaluation need to calculate the production potential of each product in the area using the FAO (1983, 1991), the final Eq. 4 was calculated (Sys *et al.*, 1991b, 1993):

$$Y = \frac{0.36\ \text{bgm} \times \text{KLAI} \times \text{Hi}}{(1/L) + 0.25\text{Ct}} \quad (4)$$

In this equation, Y product (kg ha^{-1}), bgm is maximum gross biomass production (kg CH_2O/ha year), KLAI is correction factor LAI, Hi is Harvesting index, L is duration of the growing season (days), Ct is respiration rate. Production predicted is obtained by multiplying production potential of the product in the soil index. In this phase of the study, it is aimed to estimate the amount of the cost and land income and calculating the profits of the culture a product of predetermined. To check the correctness of the assessment, regression relationship was established between observed field production and predicted production. In case of significant relationship, the linear regression equation was established for quantitative evaluation studies and quantitative evaluation of class was determined by Sys *et al.* (1991b).

RESULTS AND DISCUSSION

Soil studies conducted in the area indicate that four soil series in the study area are divided based on features such as percent slope, drainage conditions, flood situation, salinity and alkalinity taking into five separate series. Figure 2 shows the geographical distribution of various units. Studied soils classification of USDA and WRB methods (USDA-NRCS, 2010) is shown in Table 3 and some properties of control profiles are summarized in Table 4.

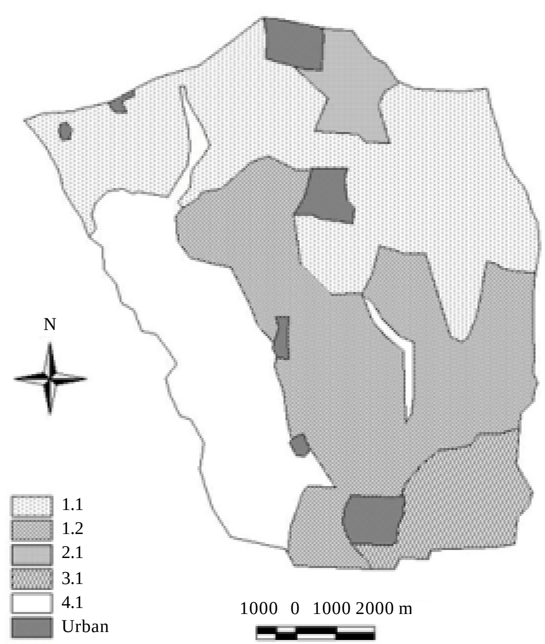

Fig. 2: Mapping soil series in the lands of the study area

Table 3: Classification of soils of the study area within USDA and WRB methods

	Soil taxonomy, 2010			
Phase series	WRB	Order	Sub group	Soil family
1.1	Eutric calcisols	Inceptisols	Typic calciustepts	Fine loamy, mixed, haperthermic
1.2	Eutric calcisols	Inceptisols	Typic calciustepts	Fine loamy, mixed, haperthermic
2.1	Eutric cambisols	Inceptisols	Typic haplustepts	Fine loamy, calcareous, haperthermic
3.1	Calcaric cambisols	Inceptisols	Calcic haplustepts	Fine loamy, mixed, haperthermic
4.1	Eutric regosols	Entisols	Typic ustorthents	Fine loamy, calcareous, haperthermic

Land quality evaluation: At this point, comparing land properties (climatic characteristics and properties of the soil and terrain view) requires of the intended use. Using three methods of simple constraints, story and square root, suitability of the land units for the cultivation of wheat, barley, canola and corn have been studied and are presented in Table 5. The results of these studies indicate that the main limitation of this land for wheat production constraints to soil fertility (organic carbon) and is climate. So that, the suitability of the land for wheat in land units is 1-1, 2-1, 1-2 and 1-3 in class S2 (relatively good). Other limitation can named limit the drainage, land unit (1-4) the unit's suitability for wheat planting in low or critical suitability classes (S3). The main limitations of the land for planting barley is climate limitations that suitability is placed of more land units in the relatively suitable class (S2) to low suitable (S3). The suitability of the land to the barley, land units 1-1, 2-1, 1-2 and 1-3 in the class S2 is relatively suitable. Drainage land, include limitation that are placed suitability, land unit (1-4) for sowing barley in low or critical suitability class (S3). Climatic limitations are for corn planting in all units and also limits the percentage of lime, organic carbon and drainage, including the limitation that the suitability of most land classes is critical suitability (S3) to inappropriate (N). The suitability of land is for planting corn on land units 1-1, 2-1, 1-2 and 1-3 in relatively suitable class (S2). Drainage limitation caused that land unit class is inappropriate (N2) for planting corn. Suitability of land units for the cultivation of canola is in the relatively suitable class (S2). Limits available include soil acidity, lime and organic carbon. Soil texture and structure are other limiting factors in land unit 1-4. Other limitations can be named drained in land units (1-4 and 1-3) that are suitability inappropriate classes (N) these units for planting canola. Land suitability map, parametric method for planting wheat, barley, corn and canola are shown in Fig. 3a-d.

The symptoms of s, n, t and f, respectively represent the limits of physical properties, alkalinity and salinity, topography and PH.

Quantitative evaluation of land suitability: Quantitative evaluation of land required to determine the yield potential, expected yield, critical yield and observed yield. Observed yield, the actual production, is collected from farms under favorable conditions. While, the predicted yield is multiplied of the yield potential of soil index, is reflect the limitations of climate, soil, topography and drainage in order to optimize the yield of wheat, barley, maize and canola. Due to the use of climatic parameters in calculating the yield potential to prevent interactions between climatic characteristics, soil temperature is not included in the index calculation. Yield potential, based on the FAO method using climatic and agronomic parameters, was calculated for various products. Respectively for wheat, barley, maize and canola after applying the seed moisture content is 13/9, 72/6, 21/11 and 39/3 t ha^{-1}. Mehnatkash (2008) earned wheat yield potential of 26/11 t ha^{-1} in the Sharkord.

Table 4: Results of some morphological, physical and chemical control profiles of the different units of land

Horizon	Depth (cm)	Soil color (wet)	Soil structure	Sand (%)	Silt (%)	Clay (%)	Texture	Saturation	Gravel (%)	pH	Ece (ds m^{-1})	Organic carbon (%)	Lime (%)
Control profiles series 1.1													
A	0-20	10YR4/4	3mgr	16	52	32	Silty clay loam	35.5	10-15	7.8	2.1	0.8	7.7
Bk1	20-50	10YR4/3	2msbk	32	33	35	Clay loam	37.7	15-20	7.9	2.8	0.6	18.5
Bk2	50-80	10YR5/3	2msbk	27	37	36	Clay loam	34.5	20-25	7.6	3.4	0.3	22.9
C1	80-150	10YR5/4	m	58	26	16	Sandy loam	27.8	15-20	7.9	4.5	0.2	13.7
Control profiles series 1.2													
A	20-0	10YR4/4	3mgr	34	33	33	Clay loam	43.5	10-15	7.7	1.7	0.9	4.2
Bk	65-20	10YR5/3	3msbk	56	20	24	Sandy clay loam	37.7	20-25	7.8	3.8	0.5	18.7
C1	95-65	10YR5/4	m	61	22	17	Sandy loam	24.5	15-20	7.5	3.9	0.2	14.1
C2	160-95	10YR5/3	m	67	15	18	Sandy loam	26.8	25-30	7.9	6.1	0.2	11.8
Control profiles series 2.1													
A	25-0	10YR4/3	3mgr	29	42	29	Clay loam	38.3	15-20	7.8	2.3	1.1	3.1
Bw1	63-25	10YR5/4	3msbk	18	50	32	Silty clay loam	34.1	15-20	7.8	2.1	0.7	7.4
Bw2	78-63	10YR5/3	3msbk	29	49	22	Loam	31.2	20-25	7.5	2.9	0.4	12.7
C1	110-78	10YR5/4	m	55	29	16	Sandy loam	22.5	20-25	8.1	2.8	0.4	8.9
C2	150-110	10YR6/3	m	59	23	18	Sandy loam	20.8	20-25	7.9	3.1	0.2	9.3
Control profiles series 3.1													
A	0-20	10YR4/4	3mgr	24	38	38	Clay loam	5/32.0	15-20	8/7.0	1/3.0	7/0.0	3/12.0
Bw1	20-55	10YR5/4	3fsbk	34	37	29	Clay loam	4/34.0	10-15	9/7.0	8/3.0	4/0.0	5/15.0
Bw2	55-93	10YR5/3	3msbk	54	24	22	Sandy clay loam	9/29.0	20-25	6/7.0	4/5.0	4/0.0	9/17.0
C1	93-150	10YR6/4	m	67	14	19	Sandy loam	8/19.0	25-30	9/7.0	7/6.0	1/0.0	1/18.0
Control profiles series 4.1													
A	0-15	10YR5/4	3mgr	39	38	23	Loam	31.9	20-25	7.8	4.7	0.6	8.1
C1	15-64	10YR5/3	m	60	9	31	Sandy clay loam	36.1	20-25	8.1	6.8	0.3	12.5
C2	64-80	10YR5/4	m	31	35	34	Clay loam	39.7	35-40	8.3	11.2	0.2	21.2
C3	80-150	10YR6/4	m	65	18	17	Sandy loam	23.2	40-45	8.1	18.6	20.2	19.7

Table 5: Final results of qualitative assessment for the parametric study

	Irrigated canola				Irrigated corn				Irrigated barley				Irrigated wheat			
Land Unit	Qualitative class	Land index	Climate class	Climate index	Qualitative class	Land index	Climate class	Climate index	Qualitative class	Land index	Climate class	Climate index	Qualitative class	Land index	Climate class	Climate index
1-1	S2 c	65.63	S2	52.32	S2 c	65.10	S2	50.33	S2 c	83.85	S2	65.40	S2 c	82.55	S2	58.80
1-2	S2 c	71.42	S2	52.32	S2 c	77.44	S2	50.33	S2 c	83.27	S2	65.40	S2 c	82.72	S2	58.80
2-1	S2 c	75.07	S2	52.32	S2 c	80.40	S2	50.33	S2 c	85.04	S2	65.40	S2 c	84.78	S2	58.80
3-1	N2 c	24.58	S2	52.32	S2 c	67.17	S2	50.33	S2 c	81.27	S2	65.40	S2 c	79.43	S2	58.80
4-1	N1 cn	32.34	S2	52.32	N2 cn	23.83	S2	50.33	S3 cw	57.40	S2	65.40	S3 cf	41.73	S2	58.80

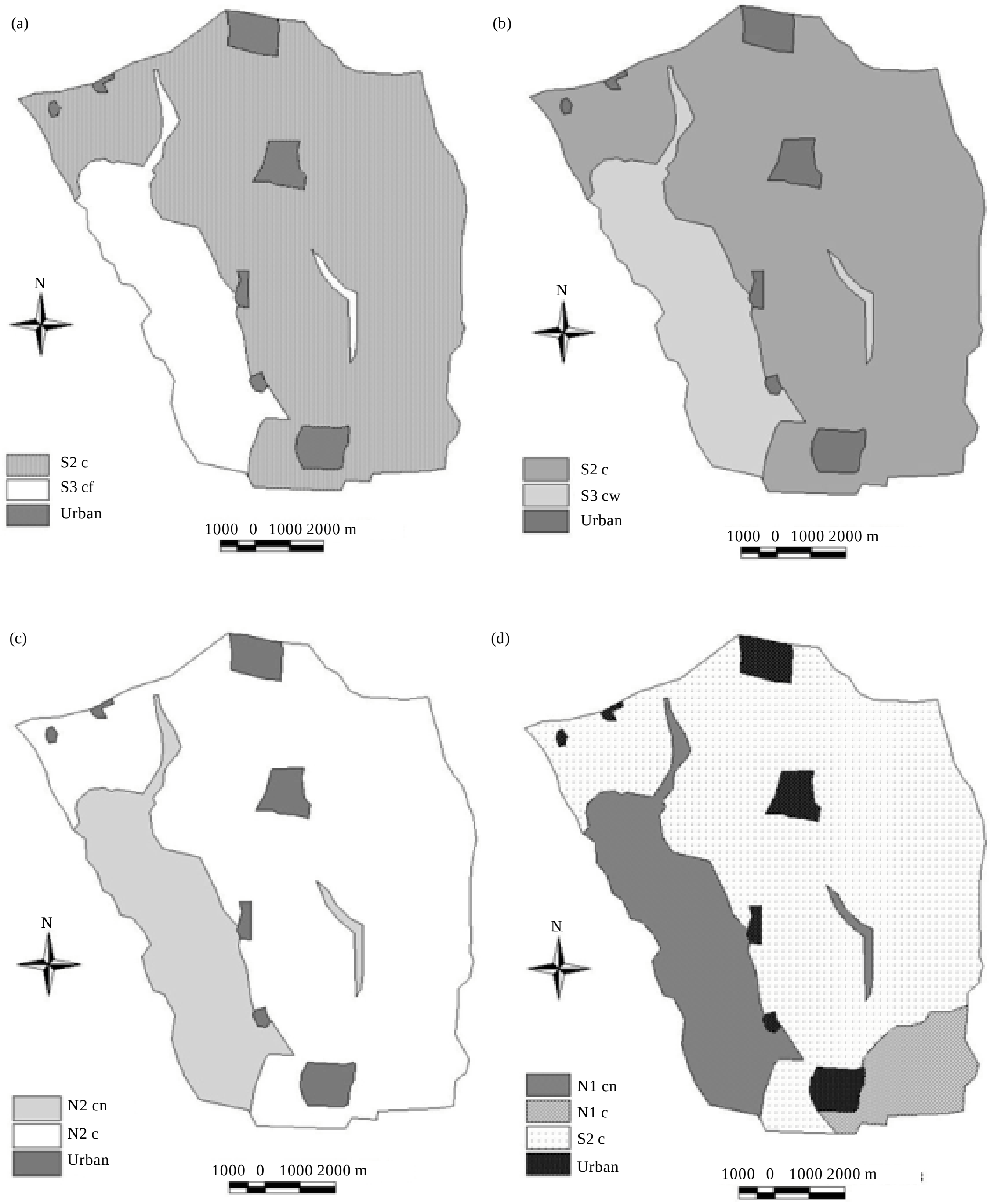

Fig. 3(a-d): Qualitative land suitability map for (a) Wheat, (b) Barely, (c) Corn and (d) Canola

Bazgir (1998) estimated yield potential for dry wheat and barley, respectively, 64/7 and 48/7 t ha^{-1} in Kermanshah area. Rostaminia (2008) estimated yield potential for irrigated wheat

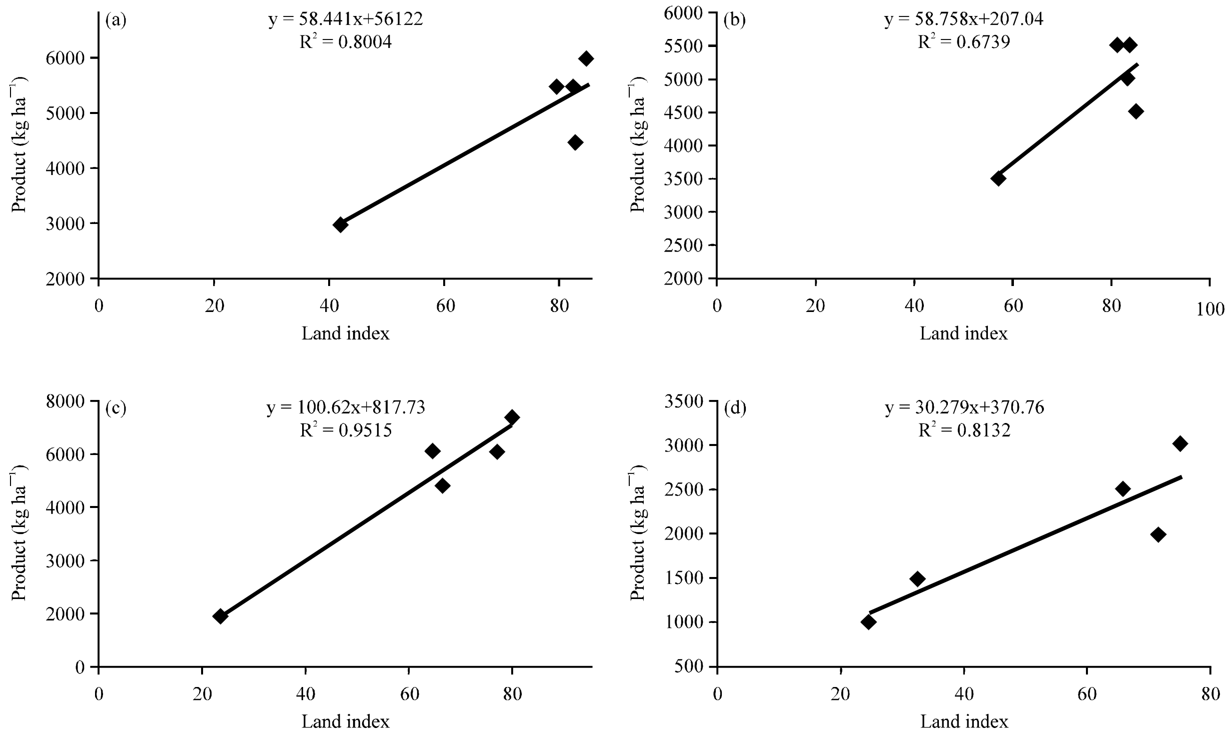

Fig. 4(a-d): Relationship between land index and crop production for (a) Wheat, (b) Barely, (c) Corn and (d) Canola

Table 6: Quantitative classes of land suitability based on land index and production rates for different products

	Product (kg ha^{-1})				Land index			
Product	N	S3	S2	S1	N	S3	S2	S1
Wheat	>3519	3519-5474	5474-6849	<6849	>50.65	50.65-84.13	84.13-100	<100
Barley	>2217.6	2217.6-3449.6	4538.8-5043	<5043	>34.19	34.19-5515	55.15-82.24	<82.24
Corn	>2917.8	2917.8-4538.8	4538.8-8412.75	<8412.75	>37.13	37.13-53.24	53.24-91.74	<91.74
Canola	>1441.8	1441.8- 2242.8	2242.8-2542.5	<2542.5	>35.37	35.37-61.83	61.83-71.72	<71.72

and maize in the region Mehran 21/9 and 42/7 t ha^{-1}, respectively. Givi (1998) estimated yield potential for wheat, barley and rice as 6/9, 5/7 and 4/13 t ha^{-1}, respectively, in Falavarjan. Regression relationship was established between the land index and the yield observed in wheat, barley, corn and canola. The results of these regressions are shown in Fig. 4a-d. Significant regression relationship is between land index and production. With the increase of the land index which represents the quality of land, yield increase is based on range quantitative land suitability classes. Sys guidelines based on land index and the production values, are presented in Table 6, based on relationship created between production and land index. According to the land index values calculated for each product per land unit, has been estimated as production rates and quantitative land class (Table 7).

Quantitative studies show that the majority of land unit, wheat class are S3, N. Barley is most suitable plants in the land units 1-1, 2-1 and 1-2 in area 8417 ha, both corn and canola are most

Table 7: Results of quantitative assessment for various products

	Irrigated canola			Irrigated corn			Irrigated barley			Irrigated wheat		
Land unit	Land class	Land Index	Estimated production	Land class	Land Index	Estimated production	Land class	Land Index	Estimated production	Land class	Land Index	Estimated production
1-Jan	S2	65.63	2.35	S2	65.10	5.73	S1	83.85	5.13	S3	82.55	5.38
2-Jan	S2	71.42	2.53	S2	77.44	6.97	S1	83.27	5.10	S3	82.72	5.39
1-Feb	S1	75.07	2.64	S2	80.40	7.27	S1	85.04	5.20	S3	84.78	5.51
1-Mar	N	24.58	1.11	S2	67.17	5.94	S2	81.28	4.98	S3	79.43	5.20
1-Apr	N	32.34	1.35	N	23.83	1.58	S2	57.40	3.58	N	41.73	3.00

Table 8: Maximum gross profit per hectare and extent of economic land suitability classes for different products (10000 Rials ~ 1 Dollar)

Gross profit (R ha^{-1})					
N	S3	S2	S1	Maximum gross profit	Product
<0	10532500-0	15798750-10532500	<15798750	21065000	Wheat
<0	7141200-0	10711800-7141200	<10711800	14282400	Barley
<0	7800300-0	11700450-7800300	<11700450	15600600	Corn
<0	2016700-0	3025050-2016700	<3025050	4033400	Canola

Table 9: Economic suitability classes amounts to gross profits and for different products (gross profit by Rials (h))

	Canola		Corn		Barley		Wheat	
Land unit	Land class	Gross profit	Land class	Gross profit	Land class	Gross profit	Land class	Gross profit
1-Jan	S1	3250610	S3	6724575	S1	11758573	S3	8115914
2-Jan	S1	4004249	S2	10077586	S1	11606576	S3	8169233
1-Feb	S1	4479913	S2	10881221	S1	12065136	S3	8830680
1-Mar	N	2094407	S3	7287562	S1	11093712	S3	7113307
1-Apr	N	1083728	N	4488610	S3	4915489	N	5005500

suitable plants in units 1-1 and 2-1 in area of 7998 ha, both barley and maize are the best plants in 1-3 unit area of 841 ha. Barley, maize and canola are known as the most appropriate plants in land unit 1-2 area of 3904 ha.

Economic land suitability evaluation: For each product, due to the amount of estimation per land unit and monetary value per unit of production and subtracting the variable costs to produce per unit area, gross profit calculated rials in hectare. And range economic suitability of land classes for different crops is presented in Table 8. In the next step, by comparing the profitability of each land unit for each product, economic land suitability classes results were calculated for various products are presented in Table 9. And also, maps the results are shown in Fig. 5a-d.

Between products as evaluated in the study area, canola and barley cultivation in units 1-1, 1-2 and 2-1 in economy class are very good, due to the good properties of the soils in this unit and production high. The result of study indicates that quantitative and economic evaluation studies are difficult and time-consuming and sometimes is not available because of lack of local data, however, it should be noted that the most important factor is for farmers in the use of land, the maximum profit. Therefore, finally consider the physical suitability area, decisions should be based on product profitability.

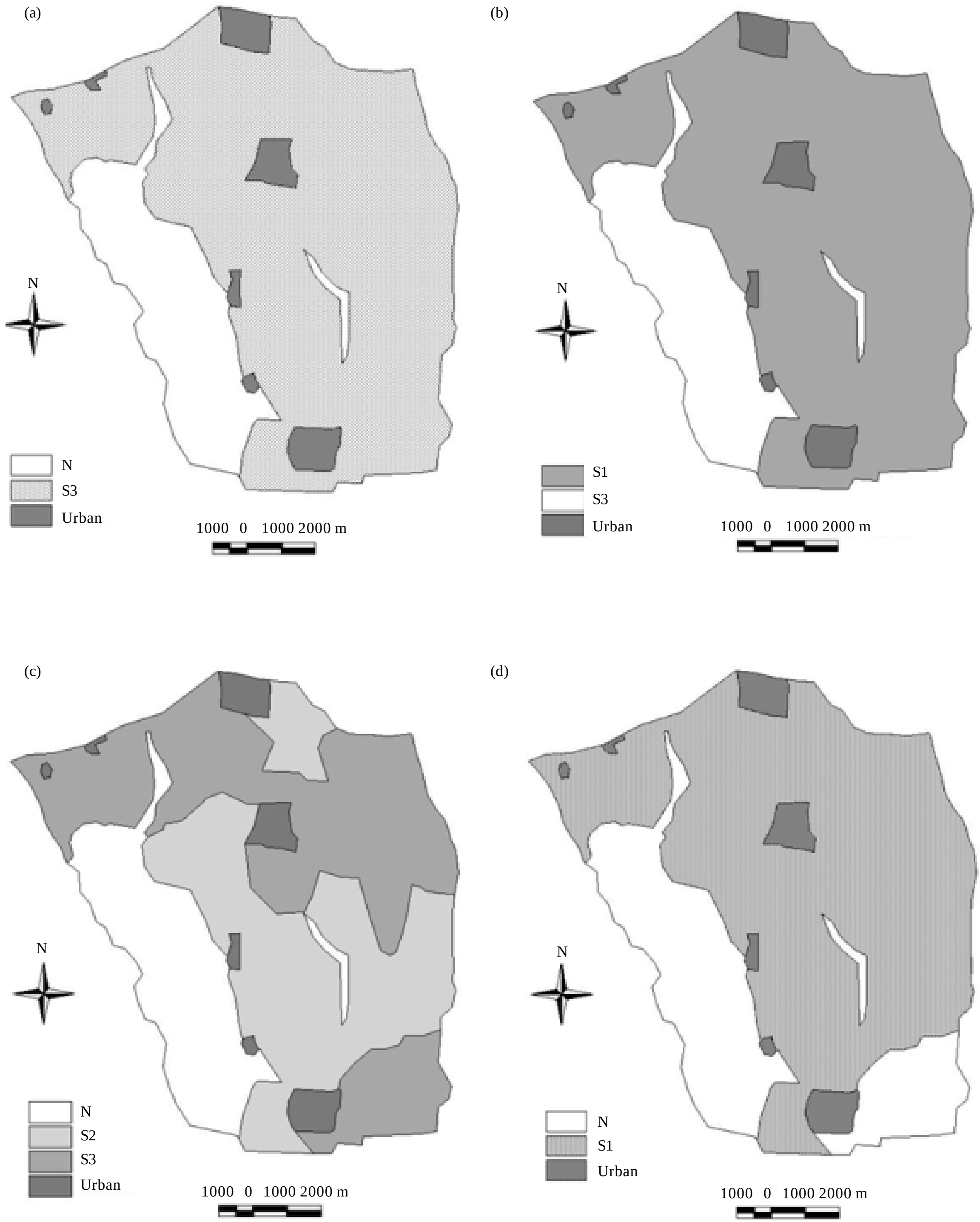

Fig. 5(a-d): Economic land suitability map for planting of (a) Wheat, (b) Barely, (c) Corn and (d) Canola

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