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# Land Suitability Evaluation in Damghan Plain for Barley, using Compare and Conformity Methods (Northeast-Iran)

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**Abstract:** In this study, land suitability evaluation based on FAO guidelines on the land evaluation system has been determined for barley irrigated area of about 3400 ha in the south of plains Damghan. In order to have more reliable soil data, particularity to control the old soil map of the area, a new soil survey was carried out in the area. South soils of Damghan plain were classified based on semi detailed studies of three physiogrphy units, four map units and two order Aridisols and Entisols. Climatic Data were used from Damghan meteorological synoptic stations for climate evaluation for barley. With respect to climate and soil severe limitations in the study area, the results of map units as the assessment methods include the storie, square root and the number of simple constraints were the same as $N_2$ with permanent unsuitable.

**Key words:** Land evaluation, barley, plain Damghan, square root method, simple limitation method

## INTRODUCTION

Detailed soil spatial information is required for many environmental modeling and land management application (Burrough, 1996). As current soil surveys were not designed to provide such detailed soil information (Zhu, 1999), the quality of soil maps which are increasingly used for land evaluation, land suitability analysis, land use planning and Geographic Information System (GIS) application and accuracy of procedures used for crop recommendations would be questionable The most serious limitations of the current soil survey include uncertainty regarding the presence of inclusions, lack of mechanism to quantify spatial variability (Rogwski and Wolf, 1994) and the assignment of properties derived from typical pedons to the entire map unit, regardless of the inherent spatial and temporal variability of field soils (Beckett and Webster, 1971; Bouma *et al*., 1982; Breeuwsma *et al*., 1986). Barley is one of the major crops in Damghan Plain. Its production is an important source of income for many farmers. FAO guidelines on the land evaluation system (FAO, 1976, 1985) were widely used for the land suitability. This system was based on matching between land qualities/characteristics and crop requirements. Physical land evaluation methods (Sys *et al*., 1991) are crucial for evaluating potentials and constraints of land for intended land use. Physical resources, such as soil, climate, hydrology and topography are evaluated. Different technical procedures were used for physical land evaluation ranging from simple methods based on expert knowledge to more complex methods based on simulation models. Salehi *et al*. (2003) expressed that although criteria for purity of mapping units have been improved; however, traditional soil mapping approaches are not able to reasonably show the variability of pedons and top soil properties even in a detailed soil map named at series level. 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' choice of 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.

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## MATERIALS AND METHODS

**Study area and project date:** The present study was conducted on Damghan Plain, Semnan Province in Northeast of Iran during 2009-2010 approximately 54" 20′ E" 54' 28' E", 36" 5' 36" 3' N and covers an area of 3400 ha. Base map is selected from Topographic map with 1:50,000 scale. It falls in drought-prone region of Semnan, Iran. The Damghan is located in desert margins and low rainfall, plant of crops has encountered with some difficulties.The serious problems of this area is water shortage. Most of the study area's soils are new alluvial sediments in period of the Fourth of Geology. Parent material in the northern and western of plain are sediments mixed with sand and gravel.

**Material:** Basically, various forms of originally collected and derived data were used in the study. The crucial data sources are (a) topographic maps, (b) soil maps, (c) hydrological maps, (d) infrastructure accessibility maps, (e) fertility soil map, (f) ecological requirements of the Damghan Plain obtained through research results from literature review, expert opinions, local farmers and (g) other published and unpublished information, such as agricultural statistics, soil and population reports, and horticultural crops reports.

**Methodology:** The methodology used for the physical land suitability analysis is a multi-criteria evaluation based on FAO land evaluation framework (FAO,1976, 1985). The methodology consists in matching soil/land qualities against barley needs and assigning a suitability rating to each land characteristic. In order to develop a set of themes for evaluation and ultimately to produce a suitability map for Damghan Plain, the crop requirement in terms of land qualities was reviewed (Sys *et al*., 1991; FAO, 1985). In this research used the following land evaluation methods including storie „ square root, the simple limits, the number and severity of limits: FAO assessment methods can be done in three stages:

To determine the properties of lands:

The following properties are used for the determination of the characteristics of the land.

- **Determine climation properties (Fig. 1):** Climate data and those related to different stages of plant growth (Table 2) were taken from Damghan soil and water research institute and physiological requirements of barley were extracted from tables prepared specifically for Iran
- **Determine land properties:** it is 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 organic mater (OM%) and soil acidity (pH) were considered in terms of soil fertility
- **Match the land requirements(for barley) with land properties:** When the land requirements (physiologic needs for barley) with land characteristics match, are used FAO methods to be determine the of quality classes of lands suitability and factors limiting growth. Equations used to determine the lands index in various ways

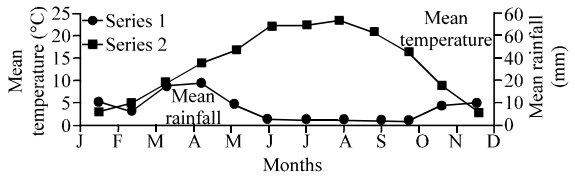


Fig. 1: Ragional unbrothermic figure

Storie method (Storie, 1976) is used for calculating the land index (I) following equation:

$$I = A * B/100 * C/100 * \ldots \ldots$$

where, I is land index and A, B, C.... are rating of different factors effective on land index.

Table 1: Determine classes of land suitability for FAO methods

| Orderc | Class | Description |
|---|---|---|
| Suitable (S) | S1 | (highly suitable) Land having not ins ignificant limitations |
| | S2 | (moderately suitable) Land having minor limitations |
| | S3 | (marginally suitable) Land having moderate limitationse. |
| Not suitable (N) | N1 | (permanently unsuitable)Land that have so severe limitationst hat are very difficult to be over come |
| | N2 | (permanently unsuitable) Land that have so severe limitations that are very difficult to be over come |

Table 2: Barley growth cycle in study region

| Plant | Planting to stability | Vegetative stage | Flowering stage | Ripening stage | Harvest growing | Cycle |
|---|---|---|---|---|---|---|
| Barley | 12 Oct-11Nov | 11 Nov-30 Mar | 30 Mar-30 Apr | 30 Apr-31May | 31 May | 231 |

The square root method is used to calculate t of land index ( I ) the equation below:

$$I = R\min * \sqrt{A/100 * B/100 * C/100 * \ldots\ldots\ldots\ldots}$$

where, R is one of the factors with Minimum of Rating, A, B, C.... are rating of different factors effective on land index, D-Determine and Comparsion classes of land suitability for barley based on fitness indicators obtained from the Storie and the square root methods with Table 1.

## RESULTS AND DISCUSSION

With regarding to results obtained from climation properties and climatic data (Fig.1) and climatic suitability evaluation that was given by Sys *et al*. 1991, the climatic characteristics of region are not suitable (N2) for barley plantation (Table 4). The results showed that the soils on the basis of soil taxonomy system were classified as Entisols and Aridisols (Table 3). The results according to description of soil profiles and physical and chemical analyses of soil samples showed the level of gravel, Exchangeable Sodium (ESP) and salinity in land units 1.1, 1.2 and Exchangeable Sodium Percentage (ESP) and salinity in land units 2.1, 3.1 were the most limitating factors for barley plantation in this region (Table 5).

Therefore, these parameters will improve the yield of barley. Table 6 illustrates the comparison of qualitative land suitability methods results for barley plant. all of evaluation methods were N2. Also, Fig. 2 shows the qualitative land units map of the region obtained from different methods.

Table 3: Soil classifiation of study region

| | | Taxonomy USDA soil | | |
|---|---|---|---|---|
| Physiography | Land Unit | Family | Subgroup | Order |
| Old Plateau | 1.1 | Coarse | Loamy, Mixed, Thermic | Typic Torriorthents Entisols |
| | 1.2 | Coarse | Loamy, Mixed, Thermic | Typic Torriorthents Entisols |
| Alluvium plain | 2.1 | Fine | Loamy, Mixed,Thermic | Typic Torriorthents Entisols |
| Low land | 3.1 | Fine | Loamy, Mixed,Thermic | Typic Aquisalids Aridisols |

Table 4: Factor rating of Climatic for Barley in Damghan plain

| Climatic properties | Data | Simple limits | Number and severity of limits | Parametric rating |
|---|---|---|---|---|
| Rainfll of growing cycle for (mm) | 95.41 | N2 | 4 | 12.5 |
| Monthly rainfall vegetative Stage (mm) | 58.53 | S1 | 0 | 97.5 |
| Monthly rainfall for flowering stage | 22 | S1 | 1 | 94.33 |
| Monthly rainfall for ripening stage | 9.34 | S3 | 3 | 50.00 |
| Mean temp of vegetative stage | 6.60 | S1 | 1 | 92.00 |
| Mean temp of for flowering stage | 16.82 | S1 | 0 | 98.24 |
| Mean temp of for ripening stage | 19.80 | S1 | 0 | 97.4 |
| Mean daily min temp coldest month | -1.075 | S1 | 0 | 97.5 |
| Mean daily max temp coldest month | 7.85 | | | 05.3 |
| Climatic Index | Stori | | | 5.3 |
| | Square root | | | 8.2 |
| Climatic class | | N2 | N | N |

Table 5: Quantities of land Index properties and factor rating in land unit for barley

| Land unit | Microrelif | R | Dranage | R | Texture-structure | R | %Gravel | R | Depth(cm) |
|---|---|---|---|---|---|---|---|---|---|
| 1.1 | 5-15 | 90 | >3 | 97.5 | SL | 72.5 | >56 | 12.5 | <120 |
| 1.2 | 30-60 | 50 | >3 | 97.5 | SL | 72.5 | >56 | 12.5 | >80 |
| 2.1 | 5-15 | 90 | >3 | 97.5 | CL | 97.5 | 0-30 | 95.0 | >90 |
| 3.1 | 5-15 | 90 | 1-2 | 72.5 | CL | 95 | 0-30 | 95.0 | >90 |

| R | %$CaCO_3$ | R | %$CaSO_4$ | R | Ph | R | Ec | R | ESP | R |
|---|---|---|---|---|---|---|---|---|---|---|
| 90.00 | 29.65 | 88.5 | 6.35 | 78.25 | 7.88 | 93 | 60.35 | 12.5 | 44.0 | 42.0 |
| 85.00 | 88.75 | 88.75 | 6.35 | 80.95 | 7.88 | 93 | 60.5 | 12.5 | 44.0 | 42.0 |
| 97.5 | 34.65 | 83.5 | 11.00 | 58.0 | 8.1 | 86 | 74.5 | 12.5 | 41.48 | 47.0 |
| 97.5 | 30.94 | 87.71 | 9.11 | 64.5 | 7.88 | 95 | 109.88 | 12.5 | 49.3 | 12.5 |

R:Rating

Table 6: Comparsion methods of land evaluation and Land Index-climatic index in land unit for barley

| Land unit | LI | CI | The simple limits | LI | CI | Number and severity of limits | Storie | Square root |
|---|---|---|---|---|---|---|---|---|
| 1.1 | 1.98 | 8.5 | N2 | 5.0 | 13.2 | N2 | N2 | N2 |
| 1.2 | 2.0 | 8.5 | N2 | 5.0 | 13.2 | N2 | N2 | N2 |
| 2.1 | 2.4 | 8.5 | N2 | 5.45 | 13.2 | N2 | N2 | N2 |
| 3.1 | 0.8 | 8.5 | N2 | 3.2 | 13.2 | N2 | N2 | N2 |

LI: Land index, CI: Climatic index

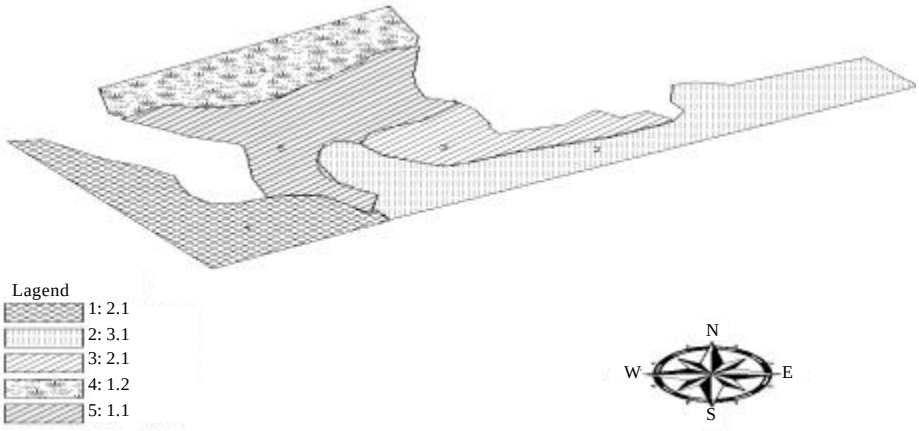


Fig. 2: Map of land unit in Damghan plain for Barely

The ultimate evaluation of the qualitative land suitability for barley using simple limitation and number and severity of limits and square root and parametric methods are given in Table 6. The results of the physical evaluation showed a close correlation between all of the methods (the results were N2). Jafarzadeh and Abbasi (2006) indicated that Simple Limitation method and Number and Severity of Limits show similar suitability classes, However, in many studies, the use of the square root method display the more realistic results in suitability classes.. The results of the physical evaluation showed a close correlation between two method limited and parametric. Behzad *et al.* (2009) showed that from the methods used i.e., simple limitation and Storie and Square root methods, the latter (Square root methods) produced more realistic results for barley, wheat and alfalfa on the existing conditions of the region. Limiting factors in different crop yield in the region along with climatic variables included soil physical properties, especially carbonate contents, soil salinity and drainage. Yasmina *et al.* (2001) showed that by the use of the parametric methods, 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. Al-Areba *et al.* (2007) showed the evaluation class suitable to permanently not suitable for Barley and wheat in Essaouira Province, Morocco.This was due to the different conditions that the crops require for their developments in the local area in question.Generally, the most important limiting factors in barley production in the Damghan plain included climate(deficit rainfall during the growing season) and physical properties of the soil, especially gravel, Exchangeable Sodium Percentage (ESP) and salinity in land unit 1.1, 1.2 and Exchangeable Sodium Percentage (ESP)and salinity in land unit 2.1, 3.1. Albaji *et al.* (2009) showed that the indexes obtained for alfalfa,Wheat and barley were higher on comparison to that developed for maize. Shahbzi and Jafarzadeh (2004) suggested that the parametric method based on square root is more realistic than others.

## CONCLUSION

The results showed that the methods used which include simple limitation, number and severity of limits and parametric methods (Storie and square root methods), on the region had close correlation .The results of this study showed that climatic characteristics of the region were unsuitable for barley plantation on the all methods. All parts of the study area were classified as non-suitable for barley because of physical and chemical soil parameters on the all methods. Furthermore, the most limiting chemical factors considered in this area were soil salinity and alkalinity. The unsuitable land units in the study area based on quantitative evaluation and according to actual yield of the region were land unit 1.1, 1.2 ,2.1 ,3.1 4.1, respectively. These results are confirmed by the calculated land index for each land unit. The qualitative land suitability evaluation assists decision makers in ensuring that lands are used according to their capacities to satisfy human needs for present and future generations, thus, sustaining ecological and economic productivity of natural resources. On the other hand, the soil maps for agricultural suitability designed in this research can be helpful in carrying out the management processes.

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