Land Suitability Evaluation for Irrigation in Dejen District, Ethiopia

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Abstract- The objective of this study was to evaluate the suitability of the soil properties of the area for irrigation purpose. Soil properties of the study area such as texture, depth, electrical conductivity, drainage, calcium carbonate content and slope were collected from eight sampling sites in the form of semi-detailed surveying level. Qualitative evaluation was carried out by means of parametric method. The results showed that the major portion of the cultivated area (308.1ha) is deemed as being marginally suitable (S3) land due to moderate slope, and medium soil depth. 33ha of the area was found to be currently non-suitable (N1) mainly due to moderate slope, gravelly soil texture and medium soil depth. In the study area, 120.2ha was also found as permanently non-suitable (N2) because of the high slope, gravelly soil texture and shallow soil depth. For almost the total study area elements such as salinity, drainage and CaCO3 were not considered as limiting factors.

Index Terms- Soil properties, irrigation, qualitative evaluation, parametric method

I. INTRODUCTION

In agricultural context, finding optimal locations for crops can increase economic benefits, as well as reduce negative environmental consequences (Ashraf et al., 2010). Proper recognition of land abilities and allocation of them to the best and most profitable and stable revenue operation system has special importance for preventing of ecosystem structure destruction. With the increase of demand for land, land evaluation has become more important as people strive to make better use of the limited land resources. Land evaluation is the process of assessment land performance for specified purposes (Rossiter, 1996).

Proper evaluation of land resources in irrigation command area is prerequisite for better utilization of land resources which help to optimize and sustain the productivity of these land resources. Availability of irrigation leads to land use change as well as intensive cropping system. Improper use of irrigation water has resulted in environmental degradation of natural resources that leads to decline in the productivity of land resources and deterioration of land quality for its future use (Suresh et al., 2002).

Irrigation has been a basic need for sedentary societies settled in arid or semiarid lands. However, in recent times the modernization or the enlargement of irrigation schemes has been called into question by nonagricultural water users in many developed countries where irrigation schemes were intended to alleviate situations of poverty (Hargreaves and Mekley, 1998).

Sys et al. (1991) suggested a parametric evaluation system for irrigation methods which was primarily based upon physical and chemical soil properties. In their proposed system, the factors affecting soil suitability for irrigation purposes can be subdivided into four groups: physical properties determining the soil-water relationship in the soil such as permeability and available water content; chemical properties interfering with the salinity/alkalinity status such as soluble salts and exchangeable Na; drainage properties and environmental factors such as slope. Hired et al. (1996) and Bond (2002) improved the classification methods for evaluating suitability in effluent irrigation and land suitability for irrigation.

Seleshi (2005) described that Ethiopia has immense potential in expanding irrigated agriculture. Despite its irrigation potential which is estimated to be about 3.7 million hectare, only about 190,000 hectare (5.3%) of the potential is currently under irrigation, which plays insignificant role in the country's agricultural production. Thus, to bring food security at national as well as household level, improvement and expansion of irrigated agriculture must be restored.

In Ethiopia, limited number of reports and investigations were made to assess the irrigation potential based on the physical land and water resources (Sleshi, 2005). Small scale studies conducted on soils of the country seem to be inadequate in providing basic soil information that can help to make decision on proper utilization of resources. Therefore, the objective of this study was to determine the suitability of the study area for irrigation purpose using the parametric evaluation system. It is believed that, such information will be used as a reference for the future development of irrigation method in similar site conditions contributing to their success. It will also ensure feasibility of irrigation establishment as land suitability study for irrigation is a key factor.

II. MATERIALS AND METHODS

Study site

The study was conducted at Bicheat Watershed of Dejen district, Amhara National Regional State which lies between 10^0 21' N and 38^0 05' E; elevation range from 1721m to 2530m. Geographically, it has a very flat (0-2%) and very steep (>60%)

slopes. The mean annual rainfall of the area is 1157mm. The mean annual temperature is 16.9^{0}C. *Eucalyptus* and *Juniperus* species are the dominant tree species in the study area. The dominant soil types of the area includes: Vertisol, Nitisols and Lepthosols.

Soil sampling and chemical analyses

Profile descriptions were made at eight sampling sites. Following to Denis [5] coarse fragments were separated from the fine earth fraction and the content of coarse fragment was determined by weighing the residue left on a 2mm sieve in the laboratory according to Cf (weight %) = (Soil fraction >2mm/ Weight of the total dry soil)*100. The effective soil depth, drainage, and the slope were measured directly at the field. EC was determined using (1:2.5 ratio of soil: water) suspension using EC meter. Texture of the soil was determined by the hydrometer method [6].

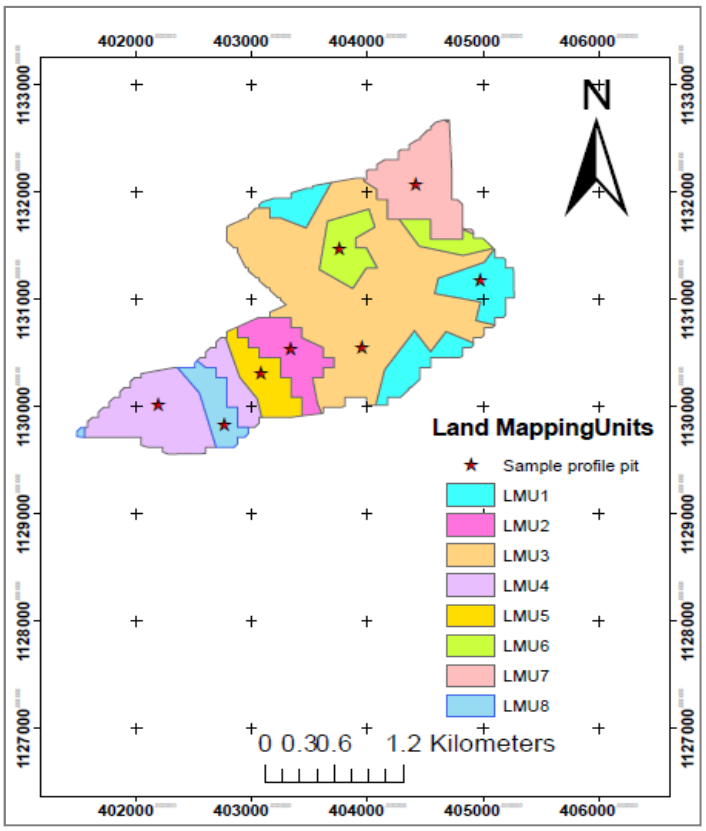

Figure 1. Location of sampling sites (land mapping unit).

Land evaluation procedure

To evaluate the land suitability for irrigation the parametric evaluation system of Sys et al. (1991) was applied, using soil and land characteristics. These characteristics concern environmental factors, drainage properties, soil physical and chemical properties. They are rated and used to calculate the capability index for irrigation (Ci) according to the formula:
Ci = A*B/100*C/100*D/100*E/100*F/100

Where: Ci: capability index for irrigation, A: rating of soil texture, B: rating of soil depth C: rating of $CaCO_3$ status, D: salinity/alkalinity rating, E: drainage rating, and F: slope rating.

According to the results of measured land index in parametric method suggested by Sys et al. (1991) lands having indexes >80 are in S1 (very suitable); 60-80 are in S2 (moderate suitable); 40-60 are in S3 (marginal suitable); 30-45 are in N1 (currently not suitable); and <30 are in N2 (permanently not suitable).

III. RESULTS AND DISCUSSION

The ultimate evaluation of the qualitative land suitability for irrigation using parametric methods is presented in Tables 1 and 2. As shown in Tables 1 and 2, there was not found highly suitable lands (S1) in the study area. The analysis of the suitability for irrigation indicates that the major portion of the cultivated area (308.1ha) is deemed as being marginally suitable land due to moderate slope, and medium soil depth. The currently non-suitable area which is only 33ha was due to moderate slope, gravelly soil texture and medium soil depth. In the study area, 120.2ha was also found as permanently non-suitable because of the high slope, gravelly soil texture and shallow soil depth. For almost the total study area elements such as salinity, drainage and $CaCO_3$ were not considered as limiting factors. These results are incongruent to Ali et al. (2009) who investigated soil quality for different irrigation systems in Lali Plain, Iran. They found that factors such as drainage, salinity and CaCO3 never influenced the suitability of their study area.

Briza et al. (2004) applied a parametric system Sys et al. (1991) to evaluate land suitability for both surface and drip irrigation in Ben Slimane Province, Morocco. They reported that there was no highly suitable (S1) area for irrigation. And most of the areas were classified as marginally suitable (S3) for irrigation purposes. The most limiting factors were physical parameters such as slope, soil texture and soil depth.

Table 1. Capability index value and suitability classes the eight land unit.

Land unit	Area (ha)	Capability index	Suitability classes
1	59	67.2	S2
2	33	39.5	N1
3	219.7	58.14	S3
4	74.2	12.97	N2
5	25.5	28.26	N2
6	34.9	48.05	S3
7	53.5	48.05	S3
8	20.5	12.97	N2

Table 2. Area coverage and ratio of the eight land units

Suitability classes	Area (ha)	Ratio (%)	Land unit
S1	-	-	-

S2	59	11.3	1
S3	308.1	59.2	3, 6, 7
N1	33	6.3	2
N2	120.2	23.2	4, 5, 8
Total	520.3	100	

IV. CONCLUSION

To evaluate the land suitability for irrigation the parametric evaluation system was applied using soil and land characteristics. These characteristics concern environmental factors, drainage properties, soil physical and chemical properties. In the study area, 120.2ha and 33ha were found as permanently non-suitable and currently non-suitable respectively. Generally, the most important limiting factors in the area under study included land slope and physical properties of the soil, especially soil texture and soil depth.

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