

Suitability / Un-Suitability of Soil under Command Area of Irrigation Gomal Zam Dam Multipurpose Project

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-----Abstract-----

The main objective of this soil survey study is to locate as far as possible the future irrigation on the best soils of the project area and identify the areas which are unsuitable for irrigation due to salinity/sodicity.

The land classes suitable for irrigation were worked out by considering the data regarding texture, salinity, lime and soil series, soil depth, slope and drainage. It was revealed that very some study area (8.23% samples) had highly suitable (class-I) soils. The largest parts of the study area (61.17% samples) were classified as moderately suitable (class-II) lands but marginally suitable (class-III) land units also occupied a fairly large area (25.88% samples). Some areas (4.7% samples) were classified as unsuitable (class-IV, V, VI) mainly due to physical soil limitations like rough broken and stony lands, stony lands and badlands. The chemical factors like salinity and CaCO₃ were almost not limiting factors.

Maps illustrating different classes of various parameters like salinity/ sodicity, texture, lime, soil series and classes of land suitability for irrigation were also prepared. In saline soils, ridge sowing and growing of salt tolerant crops are suggested. Moreover frequent heavy irrigations will also flush down the soluble salts below root zone provided the soils have better permeability. Presence of fine clayey stratification or hard pan and bedrock at shallow level may pose problem of perched water table development. The growers should be educated about the judicious use of water and cultivation of low delta crops in those areas.

Keywords – Clay, Loams, Gomal Zam Dam Multipurpose Project, Silt, Sand

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I. INTRODUCTION

Gomal Zam Dam is a mega project having two main purposes as given below:

- To generate Hydropower of about 17.40 MW
- To irrigate land under command area of 163,100 acres

The problem arises to check the land under a culturable command area (CCA), is either fit for cultivation or not and how much area is feasible / unfeasible in terms of percentage.

During meeting with Water and Power Development Authority (Ministry of Water & Power), Government of Pakistan, it was informed that no previous study was conducted to resolve the problem.

1.1. Objectives of Study:

- The main objective of this study / thesis is to locate as far as possible the future irrigation on the best soils of the project area and identify the areas which are unsuitable for irrigation due to salinity/sodicity, Lime status and drainage.
- To examine the physical properties of the soil i.e. soil texture and soil depth.
- To evaluate the soil drainage properties of the study area.
- To evaluate the slope gradient of the land for surface irrigation.
- To find out the area suitable for surface irrigation purpose and unsuitable respectively.
- To calculate the area suitable / unsuitable in terms of percentage under a culturable command area (CCA) of main canal.
- To develop physical land suitability map for irrigation of the study area.

1.2. Scope of study:

Irrigation is the most common means of ensuring sustainable agriculture and coping with periods of inadequate rainfall and drought. Pakistan is an agriculture country and about 70 % of the people of the country is engaged in agriculture; irrigation is most common and easy way for agriculture.

Irrigation, applying water to assure sufficient soil moisture is available for good plant growth, because it is used to enhance the rainfall that occurs during the growing season. Irrigation is used on full season agronomic crops to provide a reliable yield every year. It is also used on crops where water stress affects the quality of the yield. Hence irrigation is very needed for the country.

Land classification for irrigation is the systematic examination, description, appraisal and grouping of land on the basis of physical and chemical characteristics affecting its suitability for sustained production under irrigation agriculture. The purpose of this study / research is to determine the extent and degree of suitability of land for irrigation.

II. Methodology

2.1. Sample Collection

A total of eighty five (85) soil samples from different locations (Mozas) were collected covering the area of Gomal Zam Multipurpose Project (irrigation component) in the month of November-December, 2011. Soil samples were taken from upper 0-30 cm depth. Soil samples were analyzed for physio-chemical characteristics i.e. salinity/sodicity, lime status and texture to determine the suitability of land for irrigation.

2.1.2 Soil Samples:

Sample Collection is the first step in soil testing. Collecting samples from roadways or near roadways, pathways and areas (where manures have been piled), were avoided.

Care should be taken for the following points while sampling.

1. Used Polythene bags for soil samples.
2. Removed stones and big gravels.
3. Labeled the samples in duplicate with water proof ink.
4. Noted sample number, location and date of sampling.
5. The soil sample was about one kg.

2.1.3 Preparation of Sample:

Drying:

The soil sample was spread out on a tray of metal, stones were removed and large soil aggregates were broken-up. Obvious pieces of under composed organic matter were also discarded. The sample was labeled and left for air drying. It was mixed during drying to expose fresh surfaces. The samples were protected from direct sun and wind.

Sieving:

After drying, the samples were passed through a 2 mm sieve. The process was continued until the material retained on the sieve contains no soil aggregates. The material larger than 2mm are discarded.

The soil texture was determined by hydrometer method (Gee and Bauder, 1986). The pH, electrical conductivity of soil extract (ECe), calcium plus magnesium, sodium & lime were determined following standard methods (Mclean, (1982), Richards, (1954), Nelson and Sommers, 1992), respectively

2.2. Indexing of Soils

The criteria used for classifying soils into different classes on the basis of given specifications are as under:

Table-2.2. Classification of different Parameters

S.#.	Measurement	Optimum	Marginal	Adequate
1.	Slope	< 2%	2-8%	>8%
2.	Drainage	S,LS,SL	L,SiL,CL,SCL,SiCL	C,SiC,SC
3.	Lime (%)	Slightly Calcareous	Moderately Calcareous	Strongly Calcareous
		< 2.0	2.0 – 14.0	> 14.0
4.	Textural Class	Coarse	Medium	Moderately Fine
		S, LS, SL,	L, SiL, Si	CL, SCL, SiCL
5.	Salinity	Normal	Saline	
		< 4 dS/m(EC)	> 4 dS/m(EC)	
6.	Sodicity	Non-Sodic	Sodic	
		< 12 SAR	> 12 SAR	

2.3. Classification regarding Land Suitability for Irrigation

Land suitability for irrigation was worked out according to Sys, et al. (1991). Different land characteristics that influence the soil suitability for irrigation are related to the capability index for irrigation (Ci)

The Ci was calculated according to the formula:

$$Ci = A * B/100 * C/100 * D/100 * E/100 * F/100 \quad [\text{Eq. 2.1}]$$

Where Ci = Capability Index for irrigation

A = Rating of soil texture

B = Rating of soil depth

C = Rating of CaCO₃ status

D = Salinity/ Alkalinity rating

E = Drainage rating

F = Slope rating



Fig.2.1. USDA Soil Textural Triangle

III. Results & Discussions

3.1 General Characteristics of the Soils

The soils of the area could be classified into three broad groups (i) sandy, (ii) loamy and silty and (iii) clayey. In terms of the hydraulic characteristics i.e., water intake rate, available water retention, and water transmission, these groups are quite variable.

- i. The first group (sandy soils) is quite good in respect of water intake rate but its available water retention capacity is low. It is also good in conserving stored moisture because of its low capillarity hindering evaporation losses. These soils are mostly in the upper reaches of the Piedmont plain close to the mountains or occupy torrent levels in the centre of the plain. Their surface is generally undulating.
- ii. Loamy and silty soils, occurring in the central part of the Piedmont plain, have high available water-holding capacity and retain moisture once surface soil mulch is created by cultivation. Also, these soils have physical characteristics favorable for deep and extensive crop root development.
- iii. Clayey soils, including silty clays, clays and silty clay loams, form a major part of the project land. They have unfavorable hydraulic characteristics and also pose difficulties in their tillage and hinder plant root development. Furthermore, their surface cracking increases the moisture loss through evaporation.

Salinity is a problem in the virgin soils but not in cultivated land. However, it is heartening to mention that the soils do not have a Sodicy problem and the salinity disappears gradually with cultivation under irrigation.

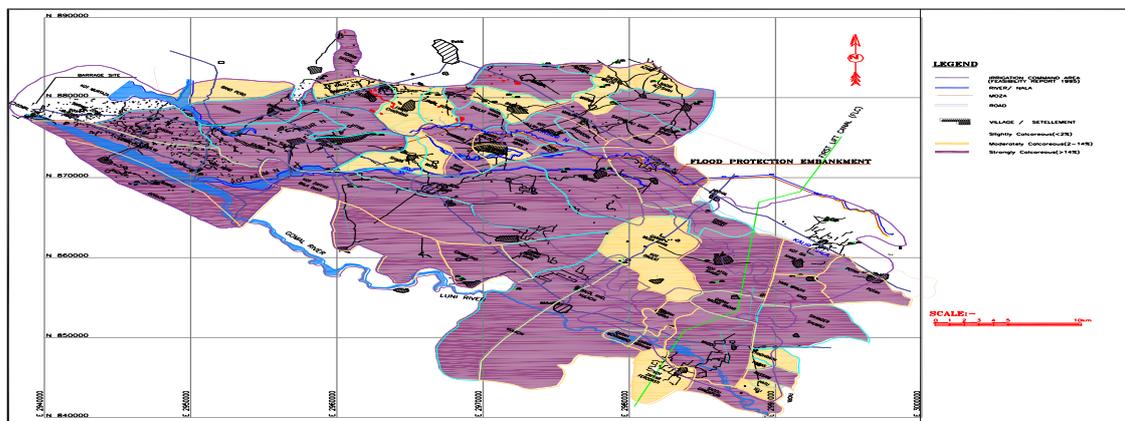
3.2. Chemical Characteristics of Soils of Study Area

Chemical Characteristics of soils of study area are analysed as per general criteria of Sys et al.1991. From the results, it is clear that all soils are alkaline in reaction with pH ranging from 7.7 to 8.6. The electrical conductivity of the soil extract (ECe) varied from 0.75-8.00 dS/m indicating salinity encroachment (ECe > 4 dS/m) in seventeen (17) locations out of 85 locations. However, sample # 1, 4, 9 and 15 had > 6 dS/m EC. Five locations have only sodicity problem while other five are saline sodic. Probably the salts were accumulated due to prolonged dry periods, which may be reclaimed with irrigation of good quality water and cultivation of crops. In saline soils, ridge sowing and growing of salt tolerant crops are suggested. More over frequent heavy irrigations will also flush down the soluble salts below root zone provided the soils have better permeability. Presence of hard pan or bedrock at shallow level may pose problem of perched water table development. In that case, the farmer should be educated about the judicious use of water and cultivation of low delta crops.

Salinity levels may improve under irrigation provided internal drainage of the soil is favorable. The soils with E_{Ce} levels greater than 6 dS/m in the surface 0.5 m generally require improvement prior to irrigation development. Irrigation of such soils may also result in unfavorable relocation and accumulation of salts in lower lying areas. The degree of salinity and /or Sodicty may vary widely within short distances and there may be no clear indication of the area occupied by each salinity/sodicty level. Unless a very detailed mapping and sampling program is carried out, it is impossible to estimate the acreage occupied by each salinity level. It is also very difficult to accurately predict the amount and extent of salinity that may develop after irrigation water is applied, but some general estimates can be made. Salinity and sodicty levels may improve under irrigation provided that internal drainage of the soil profiles is favorable. Our observations suggest that the soils which were saline prior to CRBC have become productive due to washing out of salts with canal irrigation. Likewise Graveland, 1970 revealed that soluble salts concentration may change rapidly throughout the growing season when water application and evaporation are at their maximum.

Fig. 2 depicts the Salinity/ Sodicty classes of the study area

Fig-2.Map depicting the status of lime content in the study area



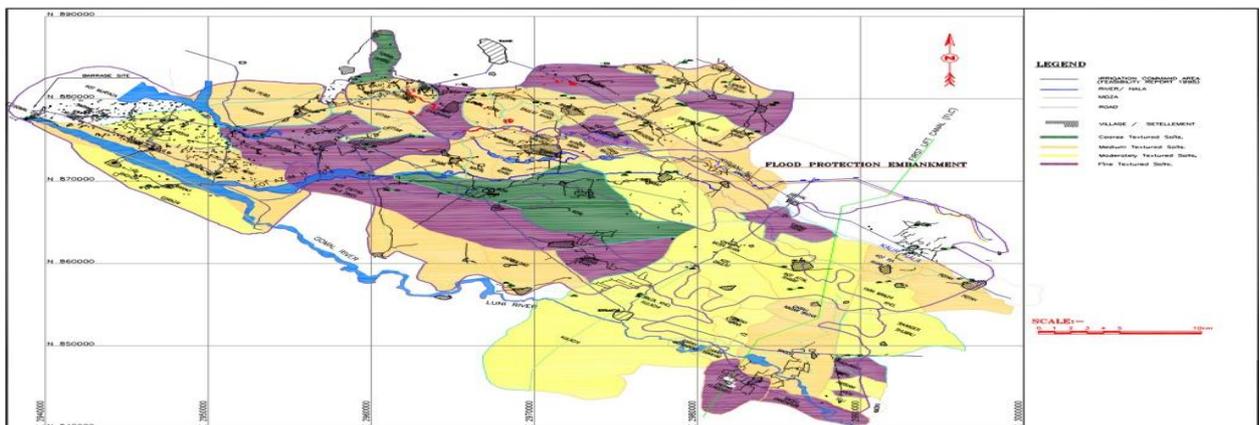
3.2 Texture of Soils of Study Area

Texture is an important factor to consider when rating soil as to its suitability for irrigation. Available moisture holding capacity is seen to be higher in fine than in coarse-textured soils. Infiltration rate and hydraulic conductivities are observed to be slower in fine than in coarse textured soils. Medium textured soils developed in uniform deposits are the most desirable for irrigation. The degree to which soil texture deviate from this optimum determines their suitability for sustained irrigated agriculture. Coarse texture soils are limited by low available moisture holding capacity. Fine textures soils are less suitable due to slow infiltration and low hydraulic conductivity.

The soils had variable texture. It varied from coarse textured soils to fine textured soils. There were three coarse textured soils (SL), 43 medium textured soils (L, SiL, Si), 22 moderately fine textured soils (CL, SCL, SiCL), and 17 fine textured soils (SC, SiC, C).

Fig. 3 shows different textural classes of soils of study area

Fig-3.Map illustrating different textural classes of soil in the study area



3.3. Soil Depth of Study Area

The depth of soil profiles was categorized into four classes viz < 50, 50-80, 80-100 and >100 cm. Almost 60% soils (51 locations) had profile deep >100 cm and were classified as very deep soils while the profile depth of 20% soils (17 locations) varied from 80-100 cm and were considered as deep soils. The depth of 15.3% soils (13 locations) ranged from 50-80 cm and were classified as moderately deep soils whereas 4.7% soils (4 locations) had <50 cm depth and fell in the category of shallow soils.

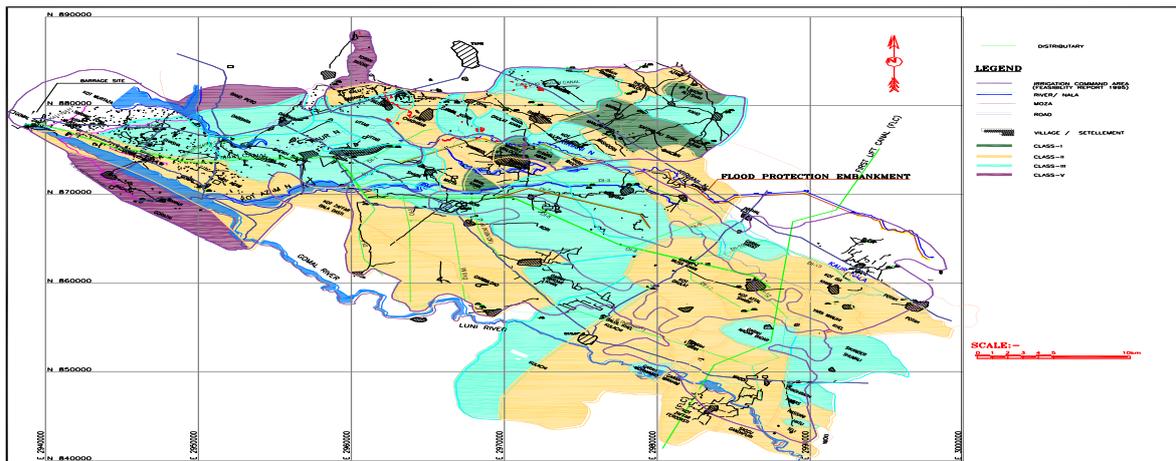
3.4. Soil Drainage of Study Area

The Soil Drainage was categorized into five classes viz 100%, 80-90%, 70-80% and 60-65%. Almost 72.94 % soils (62 locations) had Soil Drainage 80-90% and were classified as moderately Drainage, 3.53% soils (03 locations) was 100 % and were considered as Well Drained Soils. The Drainage of 18.82% soils (16 locations) ranged from 70-80% and were classified as imperfectly drained soils whereas 4.70% soils (4 locations) had 60-65% and fell in the category of Poorly Drained soils. Water Table depth below G.L of Study area is worked out in Geo-Technical report, (2010), by Water and Power Development Authority (WAPDA), Project Director Office, Gomal Zam Dam, Multipurpose Project, CRBC Colony D.I.Khan.

3.5. Soil Slope of Study Area

The soil slope was categorized into Seven classes viz 0-1% , 1-3% , 3-5% , 5-8% , 8-16% , 16-30% and > 30%. Almost 100% soils (85 locations) had slope in between 0-1% and were classified as optimum slope. Slope of Study area is worked out on the basis of available data of elevation/distance of command area obtained from Geo-Technical Report, (2010), of Water and Power Development Authority (WAPDA), Project Director Office, Gomal Zam Dam, Multipurpose Project, CRBC Colony, D.I.Khan.

Fig-5. Map illustrating the different suitability classes for irrigation in the study area



Conclusion

Land suitability classification was estimated by adopting the procedure described by Sys, et al. (1991). Considering the data regarding texture, salinity, lime and soil series description containing the soil profile depth, drainage, slope and horizon description, the following conclusions are drawn:

- 8.23 % Area- highly suitable or excellent (class-I)
- 61.17% Area- suitable or good (class-II)
- 25.88% Area- slightly suitable or fair (class-III)
- 4.70 % Area- classified as unsuitable (class-IV)

Mainly due to physical soil limitations like rough broken and stony lands, stony lands and badlands. Map showing different suitability / capability classes is presented in Figure-5.

Four locations (Turan tatur, Gara Baloach, Ghurazai and sarangnowal) have been identified as non-irrigable due to the reasons described above. The area under moza Turan tatur measuring 6478 acres is non irrigable, out of which 1423 acres fall with in the specified project boundary. Likewise area of moza Ghurazai measuring 4567 acres is non irrigable but is outside the project boundary. Areas along banks of nullah Kaur and Kiryani are also non irrigable due to rough, broken and stony lands. The area of this unsuitable land is $(2 \times 60 \text{ km} \times 10 \times 2) = 240 \text{ ha}$ or 593 Acre.

1.3. Recommendations

- i. It is recommended that chemical factors like salinity and CaCO_3 are almost not a limiting factor throughout the whole study area. In saline soils, ridge sowing and growing of salt tolerant crops are suggested. Moreover frequent heavy irrigations will also flush down the soluble salts below root zone provided the soils have better permeability.
- ii. The presence of fine clayey layers or hard pan and bedrock at shallow depth was identified at three locations which may pose problem of perched water table development or induced water logging. These areas are Hawasi, Hussni and Chadrer. In those areas, the growers should be educated about the judicious use of irrigation water and growing of low delta crops.
- iii. It is recommended that environment should be considered in irrigation development. The expansion and intensification of agriculture made possible by irrigation has the potential for causing: increased erosion; pollution of surface water and groundwater from agricultural biocides. The potential negative environmental impacts of irrigation include water logging and salinization of soils, increased incidence of water-borne and water-related diseases.
- iv. Land-use policy must take account of land suitability in relation to the expected future needs and the possibility of meeting demands. The critical importance of land for specified uses should be known either physical or economic suitability. This means not only whether it is important that this specific area of land should be used in particular way but also whether a particular area is physically suitable.
- v. Agricultural land use system of the country should meet the demands of food supply for increasing population. Therefore, irrigation should be considered as an important investment for improving rural income through increased agricultural production in the country.

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