The Federal Democratic Republic of Ethiopia Regional State of Tigray Bureau of Water Resource

Lot Three Scheme on Diversion Irrigation Project
/Misra Teli site/ Wereda Enderta, Tabia Mahbere Genet
Soil Resource Survey Final Report

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List of Abbreviations

BD	Bulk Density
BSP	Base Saturation Percentage
Ca	Calcium
$CaCO_3$	Calcium Carbonate
CEC	Cation Exchange Capacity
EC	Electrical Conductivity
ECe	Electrical conductivity of saturated paste
ESP	Exchangeable Sodium Percentage
FAO	Food and Agriculture Organization of the United Nation
Fe	Iron
GIRDIC	Generation Integrated Rural Development Consultants
GIS	Geographical Information System
GPS	Geographical Positioning System
GTP	Growth and Transformation Plan
Ha	Hectare
HCl	Hydrochloric Acid
K	Potassium
Km	kilometer
M	meter
m.a.s. l	meter above sea level
Meq	mill-equivalent
Mg	Magnesium
N	Nitrogen
Na	Sodium
OC	Organic Carbon
OM	Organic Matter
P	phosphorus
PH	Soil Reaction (a measure of acidity or basicity)

Ppm	parts per million
RSG	Reference Soil Group
TWWSDSE	Tigray Water Works Study, Design and Supervision Enterprise
TOR	Term of Reference
UTM	Universal Transverse Mercator
USDA	United States Department of Agriculture
UNDP	United Nation Development Program

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Executive summary

The Water Works Design and Supervision Enterprise in association with Continental Consultants have conducted soil survey of Irrigation project at the scale of 1:1,000 for the Misrar-Teli Irrigation Project command area in the River Basin in South Eastern Zone of Tigray Regional State. This study is, therefore continuation of the previous study which covers the gross 100ha. As per the agreement signed, for farther study from which 50 ha was found for feasibility study, mainly focusing on sustainable irrigation production as part of achieving the 5-year Growth and Transformation Plan (GTP) to support sustainable production.

The overall objective of the soil survey work is to appraise the suitability of the Misrar-Teli Irrigation command areas for the production of Irrigation system. The command area of the Misrar-Teli Irrigation Project is located in Misrar-Teli river basin in Enderta wereda of South East zone, Tigray National Regional State. Its western and eastern boundaries are geographically. The site is located at the South of the Mekelle town at a distance of 24 km. Geographical location of the command site is located from 39^0 24′ 20″ up to 39^0 24′ 40″ Easting and 13^0 34′ 5″ up to 13^0 35′ 0″ Northing. The elevation of the irrigation site ranges between 1770 and1682 m.a.s.l. The project area can be accessed in 3 km from Romanat town in south west direction. Mahber-Genet tabia is classified Kola (lowland) into climatic zones.

Based on the slope classification the commanded area is classified in to 9 types. The soil survey was done at one observation density per twelve hectares of land, hence 50 was auger observation and 7 full profile descriptions from which samples were made for laboratory analysis. For the verification of soil types and mapping units of the command area, soil Auger and road cut were described in the field and samples were taken from each horizon for major physical and chemical analysis.

In general, the soil profile descriptions results of this survey confirmed that the soils and land mapping units are correctly delineated. Four major soil types at Reference Soil Group level namely, 67.31% Cambisols, 22.27% Leptosols and 10.42% Vertisols were

identified. The main limiting factors in the command areas are topography, wetness, soil physical characteristics and soil fertility characteristics. Apart from this detailed study, there is also a potential area for further development of irrigation in the future, but this needs further study before any implementation takes place.

1. Introduction

The general aim of soil surveys is to provide information about the soil of areas of land. The information can be about particular soil attributes such as the presence or absence of calcium carbonate or of specified horizons. It can consist of measured values of individual soil properties such as depth to rock, organic carbon content or salinity, obtained in the field or in the laboratory, or it can be expressed in terms of classes of soil characterized by specified sets of properties. As stated by Beckett and Burrough (1971), a soil survey of an area may be expected to answer any or all of the following questions:

1. (a) What classes of soil are present?
   (b) In what proportions do they occur?
   (c) What proportions are occupied by soil with particular attributes or particular ranges of one or more properties?
2. (a) What is the soil class at any site of interest?
   (b) What are the properties of the soil at any site of interest?
3. (a) Where can soil of a particular class be found?
   (b) Where can soil with particular attribute, or particular ranges of one or more properties, be found?

Questions of the first type can be answered most efficiently by identifying the soil (that is allocating it to a class) or determining the properties of interest at a sufficient number of points within the area, using a statistically sound sampling procedure. However, most soil surveys also aim to answer questions of the second and third types by the production of a soil map showing how and where the soil varies.

The commonest kind of soil map, exemplified by soil mapping unit, shows the distribution of kinds or classes of soil. It partitions the area into parcels of land within each of which the soil is less variable than in the area as a whole. One or more similar parcels constitute a map unit, each of which is identified by a particular color or symbol and represented in the map legend as consisting predominantly of a single kind of soil or of a few kinds that are listed or described. In making these conventional soil maps, the classification is pre-determined, the soil is identified as sampling points, and the mapped boundaries are delineated by the surveyor using some combination of direct field inspection and indirect evidence of soil changes afforded by changes in landform, geology, vegetation or appearance on air photographs.

Soil survey data can also be displayed as point-symbol maps. In the former, soil characteristics are shown by symbols placed at points corresponding to those at which observations or measurements were actually made. Users can interpolate between symbols on the map if they wish, but interpolation is not part of the mapping procedure. The symbols can simply show the presence or absence of single attribute; alternatively, by using a suitable hatching or color scale, they can show soil classes or several levels or states of a variable such as texture or depth to mottling; or they can combine two or more soil or site characters in so called Boolean maps, as illustrated in figures and tables. In the maps, the distribution of a continuous variable, such as thickness of soil or topsoil PH, is shown by lines of equal value. They are constructed by interpolation from sample data, either manually or by the use of computer assisted techniques based on mathematical models.

The analysis and description of soil survey are the main input for sustainable agriculture, especially for crop and irrigation development in the selected site and in overall the country. Know a day the issues are to interlink between land, water and manpower. Soil is the vital habitat that regulates our environment and responds to the pressures imposed upon it, ignored by the majority of us, soil carries out a number of key tasks that are essential to our well-being. Soil is the medium that enables us to grow our food, natural fiber and forest and supports wildlife habitats. Generally, soil is a natural filter and regular of water flow. As per the agreement the Diversion irrigation scheme is an initial and fruitful approach in the interconnection water and land for in secured area and in hill and long distance irrigation application. The study focuses to analysis physical and chemical features of the project. Further, identification of strength and weakness for soil forming factors are done in the prefeasibility study and the final analyses are expected after laboratory result. Then the following activities are done up to this report time.

Accordingly, assessment was undertaken in order to investigate their technical and social suitability. Different alternatives have been evaluated within the proposed scheme in order to have chances of prioritizing schemes with relatively minor social impacts and with minimum conflict of interest. In this regard one alternative is taken in the Enderta; Mahbere-Genet Tabia within the Misrar-Teli River, the consultant has been identified 52.5-hectare command size.

1.1 Back ground of the study area

The climate of the study is characterized with low annual precipitation and high temperature contributes in aggravating land degradation. The majority of the land is alluvial plain and the annual precipitation is low (609mm) which makes crop cultivation suitable. However, the major environmental problem facing the land is moisture stress, which negatively affects soil water holding capacity. The study area consist the topography meter above sea level is found in this area. Like other parts of the study, the climate of the area is characterized as arid and semi-arid with low and erratic rainfall.

The purpose of the soil survey is to provide detailed information on land and soils of the command area of the project as basis for confirming/rejecting the irrigation potential (all or part of the area), crop selections, irrigation designs, agricultural input requirements such as fertilizer applications etc. the study also focuses on identifying the various topographic forms, soil types, present land use assessment as a basis for assessment of land and crop suitability for irrigation. The objective of soil survey is to map the physical potential for irrigated agricultural development in the area under both surfaces and/or over-head irrigation systems. This information is required for the formulation of the feasibility land use plan of project area.

1.2 Statement of the study

- The study area project involves different disciplines and experts, as such the availability of necessary materials and updated information might be not organized at the right time. On the other hand the sample analysis might be late because of the laboratory facilitation depends on the laboratory technicians. Lack of study documents in relation to soil and lack of up to date thematic and spatial information.
- Access of road to some of the Kebelle was very challenging
- Lack of GIS layers for the study area: Study area boundary was initially known by size and by the zone name.
- Obtaining high resolution satellite images of good quality was a challenge. Hence, selection of appropriate Land sat image for soil classification was a challenge

1.3 Objectives

- To identify the environment feature of the irrigable land
- To Map the land in to soil mapping unit
- To dig profile whole for detail study of physical and chemical properties
- To made legend construction using the following
  - ✓ Order----------Geo –Structure
  - ✓ Sub-order-------Morphogenetic
  - ✓ Group-----------Environment
  - ✓ Sub-group------ Landscape
  - ✓ Family----------Relief/molding
  - ✓ Sub-family-----Lithology/facies land form
- To logging the profile using standard format

1.4 Method of assessment

- Review Relative document
- Over view field observation using GPS tools by supporting Google,
- Transect walking field assessment for verification the command area
- Preparation of Standard Soil Description format using FAO Guideline
- Following check lists for the study area.
- Discussing with Tabia development agents and farmers of the specific site.
- Assessing the existing land use land cover

1.5 Materials Used

All available materials are used to survey soil physical and chemical property:

- Standard Soil feature description format
- 10% Hcl
- Soil Munsell color chart
- The Harmonized World Soil Database(HWSD) viewer
- Food and Agriculture Organization of the Unites Nations (FAO) Guide line 2006

1.6 Significant of the study

Misrar-Teli Irrigation project is one of the other irrigation project planned under the growth and transformation plan, when fully completed will have the capacity to insure food security. The project covers 52.5 hectares of land with supporting irrigation technology on Misrar-Teli River and other water resources. To produce the intended amount of production, there was a need to study the current potential of the land for the proposed crop and identify the limitations from the land so as to recommend corrective measures/ strategies for its maximal use.

1.7 Scope of the study

The soil survey was carried out using internationally accepted standard methods and procedures. Hence, the scope of the survey is to undertake different field investigational and observations; in situ and laboratory tests; and consultation of different available secondary information in order to meet the stipulated overall objectives of the study. Therefore, the scope of the study planned to attain the main objectives are:-

- Review of previous studies and identification of their gaps and short comings;
- Investigate, identify, analyze and describe distribution of different soils and mapping units;
- Survey to an average density of one observation per twelve ha
- Prepare soil maps at scales of1:1,000
- Carry out auger observation as the rooting depth of most crops and profile pit at a depth of 2m,except obstructed by lithic contact at shallower depth
- Conduct standard Soil physical and chemical properties analyses
- Collect Undisturbed core samples for determination of moisture release characteristics at representative pits for which core samples taken from each pits

2. LITERTURE REVIEW

2.1 Soil survey

The main objective of soil survey is to determine the pattern of soil cover, characterize it and present it in understandable and interpretable form to integrated land use plan. Zink (1988/89) developed an approach to systematically integrate geomorphology and pedology using geomorphology as a tool so that to improve and speed up the soil survey. He named this as Geopedological approach. This depends on the truth of two hypotheses: boundaries drown by landscape analysis separate most of the variation in the soils, and sample areas are representative; their soil pattern can be reliably extrapolated to unvisited map units. Moreover, the approach has advantages in legend construction and structuring. On the other hand ,since all the delineations are not actually visited, the sampling is biased towards 'typical' landscape positions, so only crude estimates of internal variability's are shown" (Rossiter,2000b).

2.2 Soil morphology and profile description

Soil morphology deals with the form and arrangement of soil features. Micro morphology is using micro morphological techniques (e.g. thin sections) and measurements in the laboratory. Field morphology is the study of soil morphological features in the field by thorough observation, description and interpretation.

Observations may be refined with the aid of a hand lens. Simple tests are also used in the field to record salient chemical properties (e.g., pH, presence of carbonates). In addition, field observations and measurements may be refined through a range of laboratory analytical procedures that include more sophisticated evaluation of chemical, biological and physical attributes. However, the quality of field description and sampling ultimately defines the utility of any subsequent laboratory analyses. A keen eye that can discern specific features and their relationship to adjoining features coupled with well-calibrated fingers that can distinguish among relative differences in physical properties of soil material are essential and can only be acquired and maintained through practice.

Field morphology starts with an in situ examination of a soil profile. Field descriptions are organized by subdividing a vertical exposure of the soil (soil profile) into reasonably distinct layers or horizons that differ appreciably from the horizons immediately above and below in one or more of the soil features listed below. The delineation of horizons is necessarily a somewhat subjective process because changes in soil attributes are often gradational rather than abrupt. Thus, obvious boundaries between horizons are not always apparent and their assignment may require integrated assessment of changes in several attributes before a sensible and defensible delineation can be made. Knowledge of similar soils and a well-defined rationale for the purpose of the description helps considerably in development of systematic criteria for defining and delineating horizons.

The following information is collected for assembling standard profile descriptions: Depth intervals of horizons or layers (measured from the top of the mineral horizon), Horizon boundary characteristics, Color, Texture, Structure, Consistence, Roots, effervescence, Special features such as coatings, nodules, and cementations

Differences between horizons generally reflect the type and intensity of processes that have caused changes in the soil. Ideally, we should always be striving in our descriptions to maintain a link between process and morphology. In many soils, these differences are expressed by horizons that lie approximately parallel to the land surface, which in turn reflects vertical partitioning in the type and intensity of the various processes that influence soil development. However, there are many exceptions to this preferred horizontal organization.

2.3 General Perspective of Soil Classification

People have a natural tendency, urge, and need to sort and classify the natural objects of their environment. Folk, or local, classifications (for example, those made by indigenous peoples) are based on recognition of natural breaks in readily perceivable characteristics. These classification systems tend to classify all natural objects in a local geographic area and make class distinctions according to technology locally available at a basic level of generalization roughly comparable to the level of the genus (Berlin 1978; Rosch 1978). Soils are no exception. Folk classification and names of soils have carried over into present-day classifications (Simonson 1985).

Soils are present throughout the world, and many classification systems exist. Many soil classification systems that include only portions of the world are well constructed, but are limited in the worldwide transfer of information among soil scientists and others that seek information regarding soil properties.

The classification system used in a scientific discipline reflects the state of the art and knowledge in the field. Kubiena (1948) claims, "Show me your [classification] system and I will tell you how far you have come in the perceptions of your research problems." The renowned physicist Ampére is reported to have said, "Perfect scientific classification is first possible when one knows everything concerning the classified natural objects" (Kubiena 1948).

2.4 Soil Type

There are several ways of classifying a soil, from the simple to the complex. A soil type may be as simple as 'a sandy soil' or 'a clayey soil' and this is often the perception of many land users, such as farmers or civil engineers, who see it as material they have to deal with to achieve an end result, such as the growing of a crop of wheat, or the building a road etc. Simple classifications tend to be of local and restricted relevance only. At the other end of the spectrum is the soil scientist who needs to understand how soils have formed, which types occur where, and for what the different types of soil can be used. The soil scientist seeks a much broader understanding, with the aim of underpinning the use and preservation of this important natural resource, and this has manifested itself in a number of detailed soil classification systems worldwide.

There have also been several major attempts at a world classification of soils, each of which have differed in the emphasis they have given to different soil properties. Such classification systems enable soil types to be classified and identified within a national and international framework. The two most widely used international classifications are those of Soil Taxonomy (developed by the US Soil Conservation Service) and based on soil properties that can be objectively measured and observed and the FAO/UNESCO legend/classification which is along broadly similar lines but not as precisely defined. It is regrettable that to date it has not been possible to produce an international classification that has been adopted worldwide but soil science is a young science with an important future and a unified classification system should eventually be developed.

3. Methods and Materials

3.1 Methods

3.1.1 Description of the study Area

Tigray is the northern most region of Ethiopia, extending from 12°15′ to 14°50′N latitude and from 36°27′ to 39°59′E longitude. It covers an area of around 54,572.6 km^2, most of which are highlands between 1,500 m and 3900 m.a.s.l (Solomon. et al 2006, and Mintesnot et.al. 2006). Misirar Teli Diversion irrigation is located in the South Eastern zone of Tigray, Enderta wereda Tabia Mahbere Genet. The site is located at the South of the Mekelle town at a distance of 24 km. Geographical location of the command site is located in 13°34′25″ to 13°35′0″N latitude and from 39°24′20″ to 39°24′40″E longitude. The altitude suited from 1770 to 1862 m.a.s.l. Though, the actual area of the command have been determined by measured average lean flow of the river during feasibility study current, potential of the command area at different classified are about 52.34ha.

Diversion irrigation is located in the South Eastern zone of Tigray, Enderta wereda, Tabia Misrar-Teli. The site is located at the South West of the Romanat town at a distance of 7 km. Geographical location of the command site Misrar-Teli is located in the altitude ranges from 1870-1862 m.a.s.l .

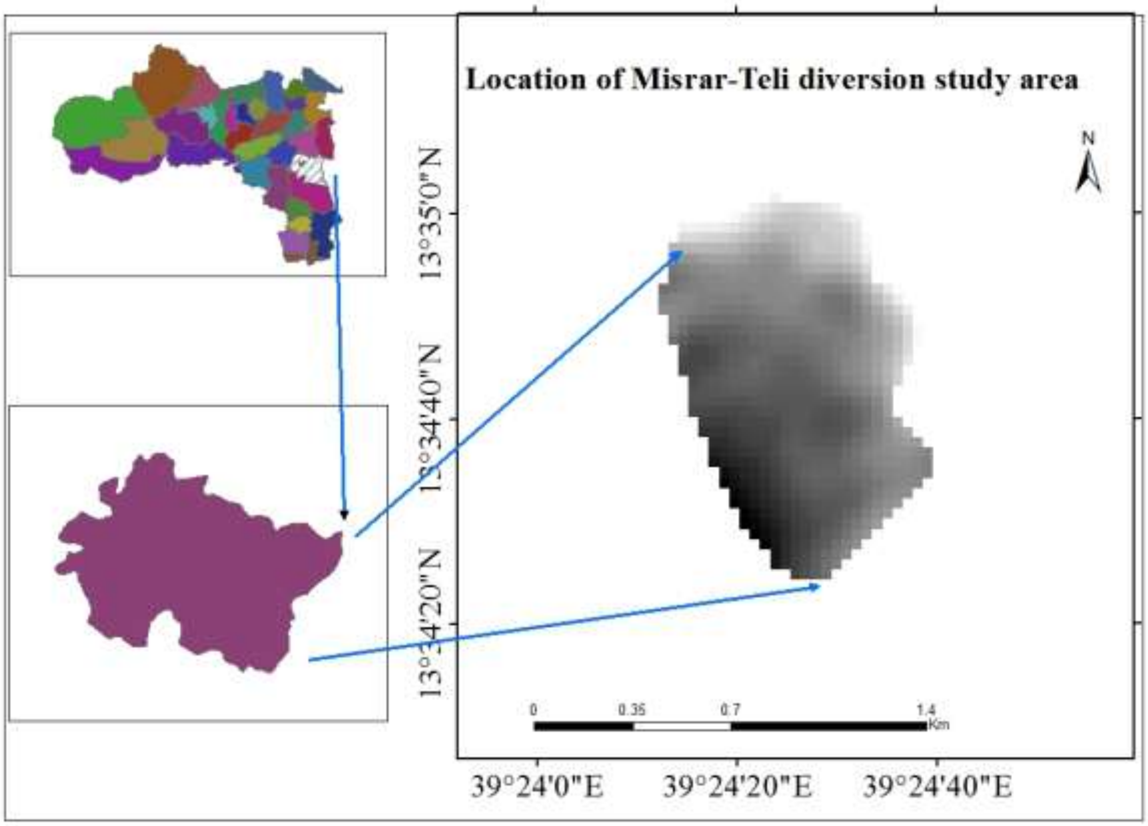

Figure 1: Location map of Misrar-Teli diversion study area

3.1.2 Soil and water Relation

Infiltration is the physical process involving the movement of water through the soil surface, essentially the boundary between the atmosphere and the ground. The ability of water to enter the soil is related to its porosity (the amount of space within the soil) and permeability (the ability of liquids to flow through the soil). In turn, these factors are governed by the texture and structure of the soils, the initial soil moisture content, soil composition and the swelling of clay mineral that can cause cracks in the soil to close water that has infiltrated the soil can later be released through evapotranspiration or subsurface flow percolation is the movement of water through the soil by gravity and capillary forces. Water that is in contact with air in the soil is called vadose water; this saturated zone is called ground water. Ground water can move in both vertical and horizontal directions. The boundary that separates the vadose and the saturation zones is called the water table. A spring is a feature in the landscape where the water table reaches the surface. Ground water discharges from the soil form the base flow of streams and rivers. This is especially important for maintaining a minimum level of water in channels during dry periods.

3.1.3 Geology of the study

The geology of the study area falls in to the following litho logical units in the northern part of Mekelle town according to their age are bedded limestone, limestone-marl-shale intercalations, dolerite and unconsolidated sediments.

3.1.4 Climate

Tigray belongs to the African dry lands, which is often called the Sudano-Sahelian region (Warren and Khogali1992, as quoted in Fitsum et al., 1999). The climate of Tigray may be described as a sub-tropical continental type with extended dry period of nine to ten months and a maximum effective rainy season of 50 to 60 days (Hunting, 1975).

There is no metrological station in the command area and also the surrounding vicinities have very limited metrological station. Only specific station directly represents the command area however, it has inadequate data and doesn't represent the entire command area. There is no other station that could directly represent the command area while at some extent the rainfall of the catchment can be represented by rain gauge station. Therefore, climatic data from other nearby stations were utilized to judge the local condition. The command areas mean rainfall and monthly rainfall series is estimated from year's records of representative stations.

The rainfall data of the site is collected from Mekelle Airport (AAAP) and this data shows that the mean annual rainfall of 38 years between (1980-2017G.C) is 542. 7mm.Out of the total amount of 542.7 mm rainfall 77 %(418 mm) of the rain is received only in two months of the year (July and August). June and September contribute 12% (64.6 mm) and the remaining eight months receive 11% (60.1mm) of the annual rainfall.

Moreover the distribution of rainfall is not uniform throughout the season. The rainfall pattern shows that supplementary irrigation is required during the months of June, September and October in the wet season while the dry season crops (Dec. - May) crops should only be raised with full irrigation. The average mean annual temperature varies from 28.1^{0}c to 15.1 ^{0}c. The monthly maximum temperature reaches highest in June (30.9^{0}c) while the minimum temperature drops to its lowest in January (12.6 ^{0}c). Therefore, the temperature is suitable for growing variety of crops including cereals, vegetables, cash crops and fruit crops.

Table 1 Mean metrological data

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	unit	Total
Rain mean	2.49	7.29	22.51	36.93	32.57	33.20	192.23	226.88	31.37	6.07	5.69	0.74	mm	542.7
Max.Tem.0c	26.9	28.1	29.0	29.6	30.5	30.9	27.2	26.4	28.1	27.2	26.7	26.3	oc	28.1
Min.temp.0c	12.6	13.6	14.8	15.8	17.2	17.0	16.5	16.5	15.5	14.7	13.7	12.7	oc	15.1
P.eff.	-8.5	-5.6	3.5	12.2	9.5	9.9	128.8	156.5	8.8	-6.4	-6.6	-9.6	mm	292.6
P.eff.Mod.	0.0	0.0	3.5	12.2	9.5	9.9	128.8	156.5	8.8	0.0	0.0	0.0	mm	329.2

Data taken from Mekelle airport (AAAP) metrological station (NMA) while the temperature data is interpolated to Misrar-teli.

3.1.5 Vegetation

The general terrain condition of the catchment, the reservoir area and dam site is characterized by high topographical variability. The drainage system of the area is dominated by steep and undulating terrains which includes part of the Gerbe_Tsiliwe Mountain. The selected diversion site corridor is on a relatively narrow gorge with steep slopes, especially along the top part of the abutments. The reservoir area includes both river channels and areas with low slope gradient (even flat plains) which are currently used as farmlands, grazing and settlement areas. Generally, the command site around the river has poor vegetation cover. The undulating slope is scatter vegetated, while the flat plains are farmlands, grazing areas and partly settlement. The areas within river terraces are moderately vegetated with trees (Figure 2).

Figure 2: Typical vegetation features of the project area

It is important to mention that since the trees in the reservoir area would be inundated with water after the construction of the dam it is worth to plan harvesting these resources in time.

The High and lowlands of Tigray and their surrounding escarpments account for the largest natural vegetation cover of the Tigray Region. However, since recently it is appreciably degraded due to the growing intensity of human pressure. A wide spread deforestation is taking place in the area due to expansion of smallholder peasant cultivation, large scale commercial farming and settlements. It is evident that the rate of deforestation in the western lowlands is very high due to resettlement of large number of people from the degraded and highly populated highland areas, influx of people from the adjacent highlands for cultivation, and expansion of commercial farms. In addition to the expansion of cultivation and establishment of new settlement areas, there is a rapid growth of the existing towns and villages. In the area human habitation is rapidly increasing through establishment of new settlement areas and expansion of the existing villages and towns. The rate of deforestation is most serious in the areas occupied for cultivation and near the settlement centers due to over-exploitation of the vegetation for construction and fuel wood.

The natural vegetation types of the project area correspond mainly to altitude, topography, soil type and climate. The vegetation in most part of the project area has been significantly modified by human activities mainly cultivation, grazing and settlements. The vegetation in the proposed diversion and irrigation areas is predominantly wood land, which is characterized by trees with fairly large deciduous leaves mixed or interspersed with small leaved trees.

3.1.6 Land use land cover

According to the data obtained from the Environmental Protection and Land Use and Administration Authority of Tigray (EPLUAA), the main land use and land cover of the Tigray Region include cultivated lands, grazing/grass lands, and natural vegetation areas (wood-, bush- and shrub- lands). In most places the areas of natural vegetation and grasslands are intensively used for grazing and browsing by livestock. Comparing these data with the current data obtained from the DA offices, the proportion of cultivated land has shown significant increase mainly due to rapid population growth in the area.

The hilly, rocky areas or areas with very shallow soils that are not suitable for cultivation are covered by open to dense woodland vegetation. However, most of these areas are highly disturbed due to intensive livestock grazing, exploitation trees, and deforestation for obtaining construction and fuel wood materials and expansion of settlement areas.

3.1.7 Review of previous studies

For identification of the data gaps of the past studies and requirement for further study, the information sources which were closely reviewed and consulted in this study includes as primary and secondary data.

3.1.8 Data collection and description

A short outline of the methodology adopted for the detailed soil survey carried out is described below. The soil survey activities are divided into the following 3 stages, Vis: per-fieldwork, field work and post fieldwork.

3.1.8.1 Per-fieldwork

Filed soil survey guidelines, and field data collection formats for soil profile description, soil auger description, infiltration and hydraulic conductivity *in-situ* tests have been prepared and field soil survey crew on soil survey methodology and data collection has been made at desk work stage.

A preliminary delineation of approximate land unit boundaries was undertaken based on pedo-geomorphic ground as a guide to location of auger hole transects and profile pits. The base maps used were the 1:50,000 topo maps, with 20m contours from ortho-photo maps prepared from SPOT imagery (1993) obtained from MOWR GIS center.

For the proposed field survey techniques, for profile pits and grid auger hole observations transects have been laid out in the command area. To ensure that a minimum density of 1 per 12ha was achieved on all land units delineated as potentially suitable land. The field soil survey was carried out with transects 100m apart, with routine auger hole observations every 100m along these transects.

3.1.8.2 Field work

During the fieldwork stage, a rigid grid soil survey technique was used with an observation density of 1 per 12ha. The observation density varied from 1 per 12ha for the potential and less potential areas. About 50 observations were made, of which 4 are profile pits, and all are described. Soil samples were collected from each soil profile horizon for full laboratory analysis. In situ infiltration tests and core samplings have been carried out at some 4 representative profile sites.

Image interpretation is not an end by itself, thus some sites of the command area were visited to verify the accuracy of land resources (e.g. climate, soil and vegetation surveys) of various land mapping units of the command area (Misrar-Teli project area). four representative soil samples (1.5*1.5* 2 m deep), 50 observations using augers, Gully side, River side and road cut were described and soil samples were taken for laboratory analysis, with the intention of cross checking the representative soil samples taken by soil experts.

The physical profile description of this study corresponds with the pits described, indicating the soil map produced is accurate from the physical point of view. Physico-chemical properties of the representative soil samples are being analyzed. Samples were taken and analyzed as the following in table 2 and EMGT shows as E=Enderta, M=Mahbere,G= Genet ,T=Test

Table 2 : Test pit point data

No	Sampled profile pits	Number of sample
1	EMGT1	1
2	EMGT2	1
3	EMGT3	1
4	EMGT4	2
5	EMGT5	2
6	EMGT6	2
7	EMGT7	2
Total		**11**

3.1.8.3 Post fieldwork

After completion of field data collection, a systematic re-interpretation of field data and laboratory data (whichever is available) entry and analysis are made. For the geo-referenced data that are included in the GIS environment, acquisition was made.

A total of 11 soil samples were collected from 7 profiles from representative horizons for full analysis from 7 Test pit 11 undisturbed and 11 disturbed samples were analyzed.

All the data collected during previous study and the present filed-survey and laboratory results have been entered into a data based in Microsoft Access and MS Excel for storage data processing by linking in GIS.

For the recording of site and profile data collected in the field, the data entry forms were prepared by the project and have been designed in accordance with the data entry screens of the soil database. The soil databases are then linked to geographic information system, which contains the map information in a digital form.

The final detailed soil maps at the scale of 1:1,000 were derived from the data collected during the field survey, combined with systematic desk study and which is compared to the base maps, prepared. The base maps were overlaid on the geo-corrected to a required, final map production at scale of 1:1,000. Finally, these base maps transformed to the soil map (soil unit). The mapping was then digitized and produced at scale of 1:1,000.

3.1.9 Soil sample analysis

Soil samples were collected from the four main land use types described above. Sample plots had dimensions of grid system with an "X" design and samples taken from the four corners and center of each sample plot and pooled. Approximately 1/2 kilogram of composite sample from each soil depth was taken and put into plastic bags, air-dried at room temperature, crushed, homogenized, and passed through a 2mm sieve before laboratory analysis.

3.1.10 Method of soil laboratory analyses for main physical and chemical properties

- Particle size distribution was determined by hydrometer method following pretreatment with H_2O_2 to remove organic matter, and dispersion aided by sodium hexa meta phosphate.
- Bulk density was determined on oven-dry weight basis using undisturbed core samples.
- Moisture volume at field capacity (1/3 atm) and at permanent wilting point (15 atm) by pressure plate extraction
- Water content at field capacity and permanent wilting point (0.33 and 1.5 MPa, respectively) were determined by pressure plate extractor.
- Gypsum content: Total Nitrogen (%) by the Kjeldah method (Black et al.,1965
- Electrical conductivity was determined at a soil/water ratio of 1:2.5.it is measured in desi simens per meter(ds/m)
- Soil pH was measured in H2O and 1M KCL at a soil/solution ratio of 1:2.5.It is unit less
- Organic carbon was determined by the wet combustion procedure of modified Walkley Black method, (Jackson, 1967).it is measured in percentage.
- Exchangeable Ca^{++}, Mg^{++}, K^{+} and Na+ were extracted by leaching with 1 M NH4OAc(Ammonium Acetate) at pH 7, and the cations in the leachate were measured by atomic absorption spectrophotometer (AAS) for Ca^{++}, Mg^{++}, and by flame photometer for K^{+} and Na+ .It is measured in centi mol charge per kilogram of soil (cmol(+)/kg
- The cation exchange capacity (CEC) was determined by saturation with NH4OAc (Ammonium Acetate) at pH 7 (Jackson, 1970) and subsequent replacement of NH4 by NaCl extraction. It Is measured in centi mol charge per kilogram of soil (cmol (+)/kg.
- The available phosphorus content of the soils was determined by 0.5 M sodium bicarbonate extraction solution (pH 8.5) method of Olsen. It is measured in ppm or milligram per kilogram of soil

- The free Caco3 content of the soils was determined by acid neutralization method. It is measured in percentage.

3.2 Materials used

Topographic maps published at 1:50,000 scales, digital elevation models (30mx30m resolutions), published and unpublished digital maps (administrative, infrastructural, institutional, hydrological, climate and resource maps and data from different alternative sources) were used to prepare different types of base maps through computer aided mapping software and semi-automated map preparation and overly operation techniques.

FAO guidelines for soil description (FAO, 2006) were among the central materials guiding the identification, description and characterization of Soil Mapping Unit. Added supplies used during the survey were: global positioning system (GPS); digital camera; laptop computer and different software's; profile and auger description sheets. Besides, munsell color identification charts, core sampler and Clinometers were the major materials for soil survey. Satellite image, Land sat spot image, Google earth and Geological map, Shovels, spade, pick-axe and geological hammer, Measuring tapes, Diluted 10% HCL, Wash bottle with tap water, field umbrella ,Plastic Sample bags/polytine tube, Laminated description checklists, Auger-hole, soil profile description and soil sample labeling formats, Guideline for soil classification (FAO, 2006),Different camping materials were used.

Using DEM 30 data of the project area, Hand held GPS in the field observation assessments. Hand held Compass, Digital Camera, Satellite data and software analysis Information and discussion with the members of the locality. Climatic data from the National Methodological Service Agency and land use & soil data that compiled by FAO, Using guidelines & manuals related to the study.

4. RESULT AND DISCUSION

4.1 Geopedologic of the study

Mapping of soil was conducted using the so-called geopedologic approach. This approach was developed by Zinck (1988/89) to systematically integrate geomorphology and pedology using geomorphology as a tool to improve and speed up the soil survey. This depends on the truth of two hypotheses: boundaries drawn by landscape analysis separate most of the variation in the soils, and sample areas are representative via their soil pattern can be reliably extrapolated to unvisited map units. In the case of Misrar-Teli project, most of the map units were visited and sampled

T**he volcanic plain** has three different relief or molding types: the low, mid and high volcanic plain. It is underlain by layers of different episodes of volcanic materials erupted from Longo not and Olkaria complex, the most recent 200 years ago (Thompson and Dodson, 1963). This unit, for example around Longo not branch, shows hummocky surfaces that are sandier than the lacustrine plain. They are most probably transported and shaped by wind, sand dunes. It also includes areas of 'black' (obsidian-rich) sands

4.2 Descriptions of soil mapping unit and legend construction

The study area was classified based on landscape, relief type facies ,land form with code mapping unit .The legend construction referees Geopedological approach. In detail expressed. The study area is characterized by plains which surround an interior basin with river plains and Alluvial plain. The distribution of the soils is largely determined by the physiographic and parent material as shown in appendix 6.

4.3 Soil sampling and profile description

The study area has their characteristics as such, indicates the general description by each profile at each soil mapping units as showing in figure.

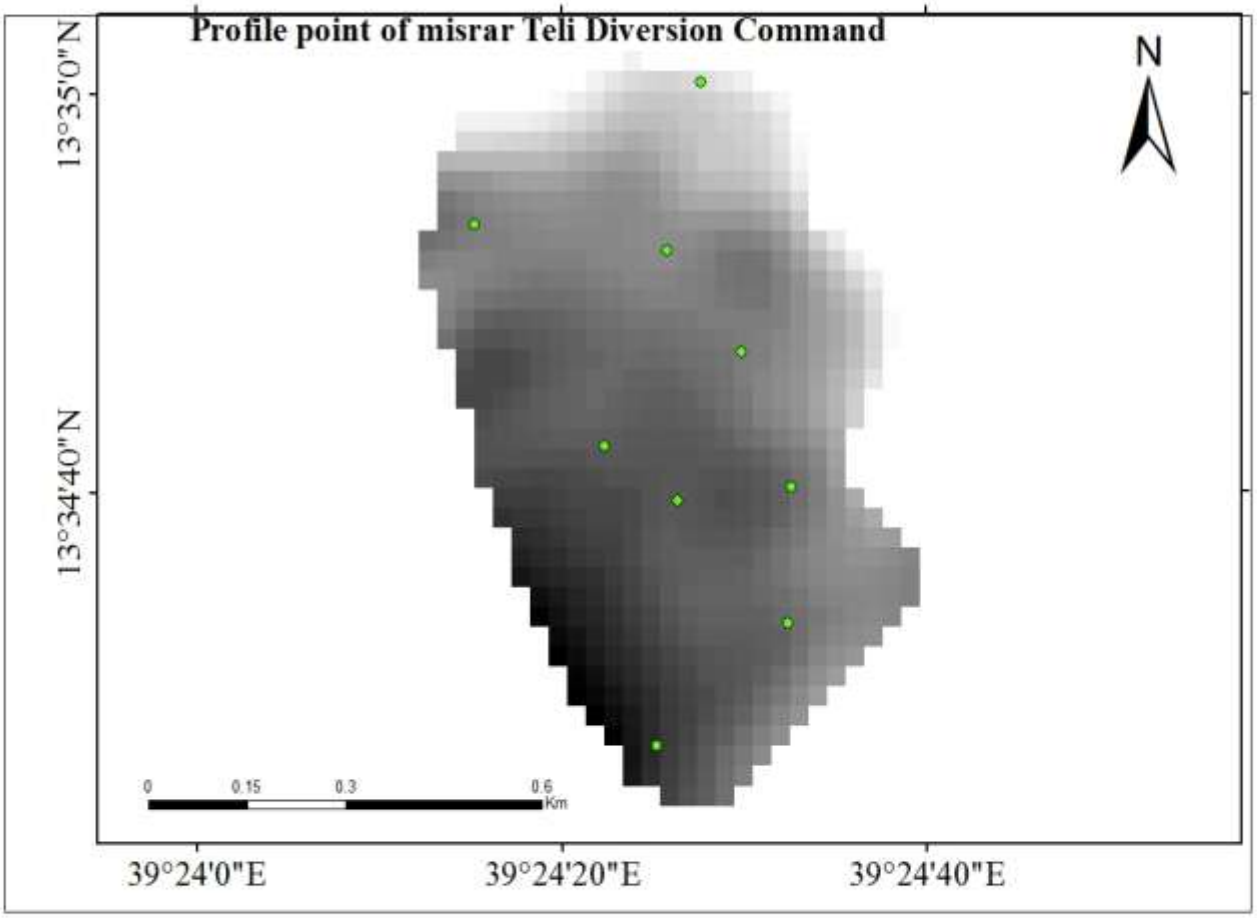

Figure 3:-Location map of profile sample

4.4 Soil auger description

Soil auger is commonly used to obtain disturbed soil samples at or near the surface and for boring to depths where soil samples may be obtained with a separate soil sampler. The bits of the soil auger are open to allow entry of small soil clumps and relatively small rocks and particles. The assessment soil survey using auger about 50 observations at the potential of the study area were identified. This type of surveying was helping us to collect data for delineation of map in the fast and qualitative approach.

4.5 Soil moisture regime

There is no source of soil moisture data in the study area or at nearby location which has similar agro climatic condition to adopt it to the local condition of the command area. Because of this constraint the soil moisture regime of the project command area was estimated from available water balance and metrological climatic data and length of growing period. Therefore, soils of the well-drained and moderately well drained have Ustic soil moisture regime. The soil moisture control section in areas of the Ustic moisture regime is dry in some or all parts for 90 or more cumulative days in the normal years. It is moist, however, in some part either for more than 180 cumulative days per year or for 90 or more consecutive days (SSS, 2003).

4.6 Soil temperature regime

Soil moisture measured at a depth of 50 cm below the soil surface. However, there is no data available on soil temperature within the study area. The soil temperature is therefore, estimated by adding 10c to the mean monthly and annual air temperature (soil taxonomy 1975).The soils of the command area have thermic soil temperature regime. Because the mean annual air temperature of the command area is estimated about 20.870C, thus the soil temperature at depth of 50 cm is estimated about 21.870C (20.87 0C plus 1 will give 21.870C). The mean annual temperature of thermic soil temperature regime ranges from 150C to 220C.

4.7 Physical and Chemical Characteristics

4.7.1 Physical Characteristics

The physical characteristics of the soil were mainly summarized as the following parameters:-

4.7.1.1 Soil Texture

Soil physical properties such as ease of cultivation, nutrient and moisture holding capacity, aeration, and drainage to some extent suitability for cultivation are much influenced by soil texture. The general description shows, sandy soils provide good aeration and drainage and are generally loose and friable and their cultivation is therefore easy. Soils with high clay content, having internal surface areas, have high absorptive capacity and retain nutrients and moisture well. Clayey soils generally have fine pores, are poorly drained and aerated and tillage operations are relatively difficult.

Silty soils are intermediate between sandy and clays soils and are suitable for most crops and according Laboratory and field survey the study indicates sandy loam texture.

4.7.1.2 Soil Structure

The aggregation of soil particles in a definite pattern is known as soil structure. The type of structure is determined by size, shape and builds up of soil aggregates. For more, granular structure having rounded porous particles is considered to be the best for crop growth and usually have satisfactory porosity, moisture retention capacity, and aeration and drainage characteristics and are said to have a good tilth. Soil with structure of single grain, Blocky and platy have permeability of rapid, moderate and slow respectively. The same is true for granular, prismatic and massive structure. Therefore, in this study the structure is analysis as Granular.

4.7.1.3 Field Capacity

The Field capacity ranges of this study is between 20.5 (Moderate) and 48.1 (high).

4.7.1.4 Permanent Wilting Points

The Permanent wilting point ranges of this study is between 9.99 (Low) and 29.99 (High).

4.7.1.5 Bulk Density

The bulk density ranges of this study is between 1.95 (optimum) and 3.29 (optimum) and the average result shows 2.19(suitable).

4.7.1.6 Available Water Capacity (AWC)

One of physical characteristic of project area Vertisols that critically limit crop production and agricultural practices is narrow moisture range. The available water capacity measurement carried out for some selected representative profile pits revealed that average of 52.22% with minimum values of 41.22% and maximum of 68.77%. This value indicates that there could be error incurred during measurement or sampling otherwise the average result for clay soil should be 20% by volume (Landon et al., 1991). It is advisable to use 20% soil moisture content for the Vertisols for different purpose of the project. Generally the moisture range of the soil is optimum for agricultural practice and limited mechanization hence, proper scheduling is require to safely executing farming operation.

4.7.1.7 Infiltration rates

The measured infiltration rate of the command area Vertisols range from marginally suitable (0.3cm/h) to suitable (3.2 cm/h), which is very high as compared with the expected range for clay soil. The normal rate of clay soils range from 0.01 to 0.8cm/hr(Landon,et al,1991).Therefore, generally the result of the infiltration rate measurement is not dependable to draw conclusive recommendation; however, it gives indication regarding the infiltration rate of the soils. Accordingly, the average of mean infiltration rate of some selected sites of the black cracking vertisols is 0.5 cm/hr. Therefore, literature values should be used for different purposes of the study.

Table 3: Accumulation infiltration rate of study area

S.No	Sampled profile pits	Cumulative (cm/hr.
1	EMGT1	12.5
2	EMGT2	12.5
3	EMGT3	6.5
4	EMGT4	3.5
5	EMGT5	0.5
6	EMGT6	3.5
7	EMGT7	6.5

EMGT shows as E=Enderta,M=Mahbere,G= Genet ,T=Test

The slow permeability can limit subsurface drainage; however, the slope at which the project command area Verticals exists provides a room for external drainage. Hence, the limitation of subsurface drainage can be resolved through use of surface drainage systems. The average bulk density of the soils is 2.13g/cm3 which are suitable and this bulk density value indicates that the soils have suitable bulk density as compared to optimum range for clayey soils. However, the bulk density of the soils doesn't have deleterious effects of reduced air-filled pore space, however, the increase in soil density impose stresses on a plant root system such as root mechanical impeding, decrease air-field porosity, decrease permeability which in turn make field crops susceptible to the adverse effect of water logging (Landon, et, al.,1991). Therefore, the soils can be categorized as good potential for irrigated crop with proper scheduled mechanization and designing of appropriate surface drainage system.

4.7.2 Chemical Characteristics

The chemical characteristics of the soil were mainly summarized as the following parameters:-

4.7.2.1 Organic Matter (OM, %)

Organic Matter was estimated indirectly from the organic carbon determination (OM %= 1.724*% of OC).It improves water holding capacity, nutrient release, and soil structure. The OM % for this study ranges between 1.1(Very low) and 1.9(very low) for this study. Generally the organic content of the soil in average is 1.74% which is very low.

4.7.2.2 Electrical conductivity (Soil EC)

The EC range of this study is between 0.005(salt free) and 1.58ds/m (salt free), I average 0.64 (salt free) which indicates the soils are non-saline; generally the study area is salt free.

4.7.2.3 Total Nitrogen (N %)

Total Nitrogen is a vitally important plant nutrient and is the most frequently deficient of all nutrient. The N% content ranges between < 0.07(medium) and 0.16(very low) in this study the average is 0.09 which is very low and this indicates Low nitrogen content.

4.7.2.4 Available phosphorus (Av.P,ppm)

Available P ranges between 3.19(low, Fertilizer response most likely) and 49.3 (high, Fertilizer response unlikely) in average which is 9.95(Medium, Fertilizer response probable) for this study. The range indicates Fertilizer response most likely and Fertilizer response unlikely respectively.

4.7.2.5 Exchangeable bases Ca, Na, Mg, and K (meq/100g of soil)

- Ca cation ranges between 5.6 (Medium) and 21(very high) in average 14 which is high,
- Na cation ranges between 10.7(Very high) and 494.1 (Very high) in average which is 76.26 (very high),
- K cation ranges between 29.3(very high) and 116.3 (very high) in average 76.26 which is very high, and
- Mg cation ranges between 3(high) and 7.8 (high) in average) which is 5.18 (high and in this study the result is based on laboratory result and FAO.

4.7.2.6 Cation Exchange Capacity (CEC meq/100g soil)

CEC is the capacity of the soil to retain cations in exchangeable form to plants. It serves for the overall assessment of potential fertility of the soil. The CEC for this study ranges between 8.8 (Moderate to poor response to fertilizer) and 37.8(As above only small amounts of time and K fertilizer needed), which is very high. CEC average is 26.19meq/100gm of soil, which is very high and it is normal good agricultural soil.

4.7.2.7 Calcium carbonate Percentage

The calcium carbonate ranges between 0.75(low) to 8.25(high) for this study. The carbonates are low to medium calcareous.

4.7.2.8 Soil reaction (PH)

Soils are often described being acid or alkaline or having a certain PH value. The PH scale is from 0 to 14 indicates the degree of acidity based on the concentration of hydrogen ions in a solution. Soils typically fall between PH_4 to PH_{11}, with a neutral soil having a PH of 7, alkaline soils will have a PH greater than 7 while acid soils; will have a PH below 7. The PH is usually measured by mixing a sample of soil with deionized water, KCL or $CaCl_2$-. The ranges are classified as: 0=Battery acid, 1= Gastric acid, 2= Lemon juice, 3= Orange juice , 4=Acid rain , 5= Black coffee, 6= Urine ,7= Distilled water, 8= Sea water, 9= Baking soda,10=Salt lakes, 11= Ammonia, 12= Soapy water,13=Bleack,14= Drain Cleaner. Those are grouped as Shown in table 6

The optimum pH range for crop is 6.0-7.5 but crop being as versatile as it is can tolerate a pH range of 4.5-8.5 (Blume, 1985; Tarimo and Takamura, 1998; Cornland et al., 2001). Soil acidity should, therefore, be monitored and regulated as low pH may affect microbial activity within the soil, hence affecting nutrient cycling (Cornland et al., 2001). The optimum soil pH is about 6.5 but crop can tolerate considerable degree of soil acidity and alkalinity. Hence, it is found growing in soils with pH in the range of 5 to 8.5. Liming is required if pH is less than 5.0, or gypsum application if pH is more than 9.5. The pH of Misrar-Teli study ranges between 7.18(slightly alkaline) and 8.18(strongly alkaline).

4.8 Description of Major soil units and Soil Mapping Units

Misrar-Teli diversion irrigation project command area is divided in to 5 soil mapping units. The soil mapping units are presented in land form, namely flat plain, almost flat plain, gently undulating plain and miscellaneous land units. The miscellaneous Soil Mapping Unit includes dissected plain, river terraces and hill/hillsides.

As per FAO Soil Classification System (2006), three major soil groups are identified in the command area. These soil types are Cambisols, Leptosols and Vertisols. The total area delineated for soil survey is 50 ha. These soils have narrow and shallow cracking, sandy loam texture and light brown color. These features are widely observed in the project area.

The cultivated lands in the command area are occupied by the sandy soils that are agriculturally suitable in terms of soil depth, fertility and topography. However, they are easy to work on due to poor internal drainage or water somewhat excessively drained.

4.9 Major Soils and Soil Mapping Units of the study Area

The five major group soils are found in the study area according to FAO –ISRIC-IUSS (WRB, 2006 and updated 2007) classification system. The major soil type identified Reference Soil Group is further subdivided using prefixes and suffix qualifiers.

Here, the study area is analyzed using land form of thread riser complex, Bottom side complex, River channel point bars undifferentiated, Point bars, Decantation basin, Levee, unconsolidated, Distal proximal, Proximal, Distal ,hogback and slope facet undifferentiated. The study area is also classified using land scape of alluvial plain, Piedmont, Hill land, and mountain. The litho logy of the study area are expressed as Alluvial, colluvial/alluvial and Igneous. The relief type are identified as alluvial, High and low terrace, Low and high hills, Flood plain, Swale, colluvial fan ,vale dyke for all explanations shown in table 5 and 6.The coverage area of each Major soil is shown in summary in table 7 and Figure 3.

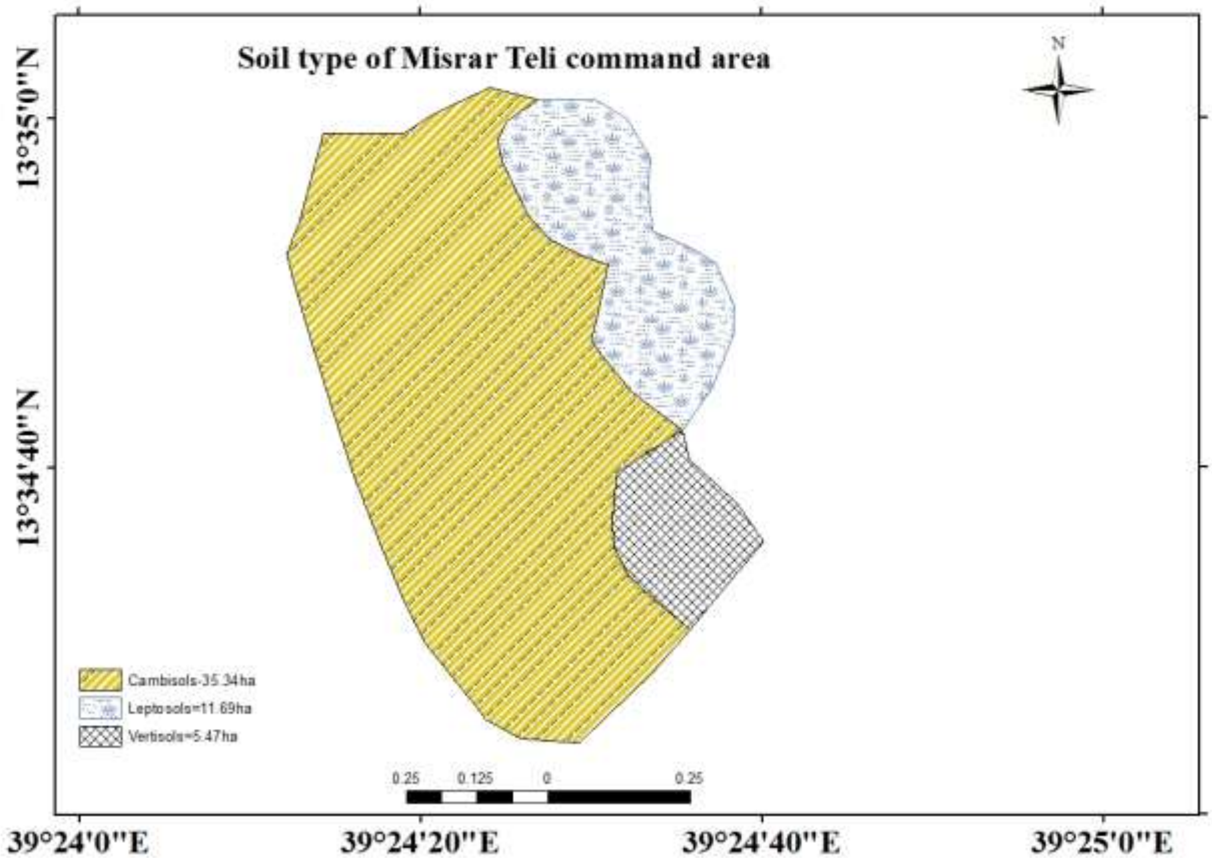

Figure 4 : Soil type of the command area

The above figure 3 shows the command area classification of soil type based of soil mapping unit and the following in table 7 are indicated the coverage in hectare.

Table 4: Major soil coverage of the study area

S.No	Soil type	Hectare	%
EMGT 1	Cambiols	35.34	67.31
EMGT 2	Leptosols	11.69	22.27
EMGT 3	Vertisols	5.47	10.42
Total		52.5	100

EMGT shows as E=Enderta,M=Mahbere,G= Genet ,T=Test

4.10 Sampling technique and preparation

This study was carried out during 2014 during the months of November and January. In order to evaluate the different land use types with their soil genesis classification and their physico- chemical properties at field and laboratory experiments.

The method of sample selection was applied using Geopedological approaches sampling technique and we had eighty profile at different Soil Mapping Unit. During the field survey soil profile description sheet was prepared for describing all the physical features of the profile such as the soil color, consistency, field textural class, distinctness, topography, Mottling…etc. were observed and analyzed in the field. In detail is shown in Appendix.

Almost the area is exposed high erosion, Deforested area, Scatter cover of bush and shrub land due to free grazing. The land use and land cover topography is undulating with Annual field cropping.

4.11 Major Soil

From field assessment majority of the command area are Cambisols, Leptosols, and Vertisols and soil texture is sandy loam which is deposited by water erosion and weathered rock transformation from upper part of the area. The color of the soil is in dry brown yellow (10YR6/8) and in wet brown (10YR4/3). Based on physical and field assessment of topsoil texture, topography, leveling requirement, rock out crop areas and slope majority of the schemes command area can be used for irrigation purpose with key limitation and inadequacy on effective soil depth, soil fertility, sheet erosion, estimation slope range 15 to 25%, stoniness, and texture of the soil.

Soil management practices that improve soil fertility like addition of manure and artificial fertilizer, drainage systems with soil and water conservation measures are also highly recommendable for the areas to improve the existing productivity and sustainability of the land

4.11.1 Cambisols

Cambisols are moderately developed soils characterized by slight or moderate weathering of the parent material and by absence of appreciable quantities of illuviated clay, organic matter, aluminum or iron compounds. The soils are *in situ* weathered from basalt and/or colluvial deposit brought from the immediate upper slope. Few to abundant medium to course gravels and stones commonly cover the surface. The size and abundance of surface coarse fragments sometimes are in the extent to affect mechanization. It has been used for both rain fed crop production and livestock grazing), few cases for settlement purposes and has open woodland coverage. Termite mound and animal tracts are the common features of these soils. Cambisols occur with association of Fluvisols.

The Cambisols were further subdivided in to Leptic,Fluvic and Vertic based on the base saturation percentage and depth. In this report they are symbolized as in the bracket: Cambisols (calcaric and Skeletic).

4.11.2 Leptosols

These are shallow soils, limited in depth by continuous hard rock or a continuous cemented layer within 20 cm of the surface or highly calcareous materials. These soils are second largest soil group in the project area. Farmers are used it for cultivation due to shortage of arable land. The soils are typically *in situ* derived from ingenious rock origin mainly from basalt. In this geological formation, the rock out crops and very thin soil surface covers large area to map as Leptosols of no and/or thin soil cover (lithic Leptosols). Unlike most Leptosols, the shallow depth Leptosols of the study area mainly that are formed on flat and gently undulating plain are due to the nature of the parent material than removal soil through erosion (effect of topography/slope on soil development). Surface of the soils, where there are no and/or less rock outcrop are covered by abundant to dominant gravel, stone and boulders. Leptosols occur with asssociation of continuous hard rock with in 25cm from soil surface and with Regosols.

The Leptosols were further subdivided in to Cambic, Lithic,Haplic,Vertic Leptic and Vertic Lithic based on the base saturation percentage and depth. In this report they are symbolized as in the bracket: Leptosols (calcaric ,Clayic,Skeletic).

4.11.3 Vertisols

Vertisols are largest soil group in the project area. These soils are one of the widely occurring that occupies plain and river terraces of the command area. Vertisols of the command area are used for both cultivation and grazing and are formed from alluvial/colluvial materials transported from upper catchments and/or *in situ* derived from basalt. The clay mineralogy of these soils is dominated by poorly drained. Vertisols occur with association of vertic horizon and Fluvisols. The Vertisols were further subdivided in to Endoleptic based on the base saturation percentage and depth. In this report they are symbolized as in the bracket: Vertisols (calcaric).

4.12 The soil in profile

In most cases, a hole into the soil and observed at the vertical section revealed. We have notice a number of different layers, roughly parallel to the surface. These layers are referred to as 'horizons' and are the result of a range of geological, chemical and biological processes that have acted upon the parent material over the lifetime of the soil. Relatively young soils, such as those on river sediments, sand dunes, or volcanic ash, may have indistinct or even no horizon formation. As age increases, horizons are generally more easily observed (there are exceptions such as in deeply weathered tropical or permafrost-affected soils).

Most soils usually exhibit three or four horizons (there can be more or less).Organic matter and presence of carbonates. More detailed chemical characteristics can be measured in the laboratory. Some soils show a gradual change from one horizon to another while other soils may possess horizons that have markedly different characteristics to each other.

The identification and quantitative description of horizons are an important aspect of studying soils. Most soils conform to a similar general pattern of horizons and in soil science. Major horizons are usually denoted by a capital letter as a means of shorthand and easy communication (typically followed by several alphanumerical characters to denote a characteristic feature).

4.13 Constraint and opportunity of soils in the study area

4.13.1 Opportunity of Soils

Soil is a fundamental element of the environment which supports a host of communities of living organisms, and is a main medium for agricultural production and other essential biochemical processes. Thus, soil is an indispensable resource that human, animals and plants exclusively dependent on for their existence.

The EC of the soils of the command area is also very low, which is in the order of 50 to80 µS/cm. Therefore, there will be no salinity hazard upon irrigation. However, the low salinity water may result in water infiltration problems, regardless of the low sodium to calcium ratio. Water-logging is among the adverse soil modification problems in irrigation schemes. It is a condition in the soil where free drainage is restricted so that excess water in the root zone area exists.

The soils of the command area are predominantly heavy clay textured soils, which are imperfectly drained due to the expanding characteristics of the soils. These soils are classified as Vertisols, and are the most extensive soils within the command area. Because of its physical properties such as low permeability and low infiltration rate, efficient irrigation and proper drainage are highly required to minimize the risk of water-logging problem. Since the entire canal system would be lined, there is enough natural drainage and good surface slope, there is very little likelihood of water logging in general.

The irrigable land is not continuously flat; instead it is mostly rugged, undulating and dissected by many watercourses including several streams and rivers. Hence, the irrigable area is generally well drained. The alluvial sediments along the banks of rivers and streams got high porosity to drain the sub-surface water to the watercourses very easily. Therefore, there is very little likelihood of groundwater rise and the risk of secondary soil salinity problem is likely to be minimal. However, a perched water table could develop particularly in the areas of heavy clay soils if surplus irrigation water is applied.

Efficient water application and sufficient drainage system especially for the flat areas will minimize groundwater level rise. In addition, groundwater level monitoring at selected intervals along the central and northern fringe of the command area will be required in order to check any potential problem. The potential for salinity and sodality is low as the quality of both the soils and irrigation water is below the threshold values to cause adverse effects. Alkaline or sodic soils are defined as soils having an exchangeable sodium percentage (ESP) >15 and saline soils having an EC >4 mS/cm; the ESP of soils of the command area is in the range of 0.35 to 1.09, which is very much below 15, and their EC values range between 0.05 to 0.2 mS/cm.

4.13.2 Constraint of soils

Agricultural activities including irrigation schemes usually bring significant adverse effects on soils through destruction of its structure and enhancement of soil erosion. Related to the activities to be involved in construction of the proposed dam, conveyance canals, irrigation infrastructures, access roads and land preparation of the irrigable area are likely to remove the vegetation cover and destruct the topsoil and expose it to runoff water erosion. These activities will increase the risk of soil erosion and physical impacts on soil structure. Upon removal of the protective cover and destruction of its structure, the soils are prone to water erosion. The degree of soil erosion depends on several factors like inherent characteristics of the soils, slope and intensity of rainfall. A significant proportion of the project area has fragile soils like Leptosols, sloping topography (slope over 2%) and high rainfall (mean annual rainfall of about 609.5mm). These situations may aggravate the rate of soil erosion. The erosion from the disturbed areas could be significant and result in increased sediment loading of the receipt streams, rivers and irrigation structures. During project operation, soil erosion is likely to occur due to irrigation water flowing in furrows and irrigation fields in sloping areas. This may result in the degradation of the land, while the associated sediment also causes siltation and pollution in downstream. Siltation increases the cost of clearing and maintaining irrigation structures and roadside ditches. Besides soil loss through erosion or impairment due to compaction and damaging of soil structure, soils can be impacted as a result of disposal of waste materials from excavation works. In addition, soils can be affected due to soil pollution resulting from disposal of wastes from contractor's camps and used oils and lubricants and spills of oils and fuel from engines of vehicles and diesel operating machinery as well as accidental spillage. Therefore, appropriate avoidance and mitigation measures should be implemented in order to prevent or minimize soil erosion and other adverse impacts on soils.

4.13.3 Soils: Strength, Weaknesses, Opportunities' and Threats of the study

Cambisols

Strengths: Cambisols are among the better agricultural soils in the study as they are less depleted of nutrients than other tropical soils and have a sufficiently high nutrient-holding capacity to retain fertilizers.

Weaknesses: Strongly weathered Cambisols contain limited amounts of nutrients.

Opportunities: Depending on their depth, their water-holding capacity can be high.

Threats: In hilly or mountainous areas, where cambisols are most frequent, care should be taken to prevent erosion when the surface is bare. In such conditions, these soils are best be kept under forest or perennial crops such as tea or.

Vertisols

Strengths: Vertisols can be productive provided the right measures are taken.

Weaknesses: As most Vertisols occur in level areas water movement in the soil is limited and during wet periods water can stagnate on the surface. Heavy to work when wet. Swelling and shrinkage may destroy the foundation of structures (e.g. roads, irrigation canals).

Opportunities: Raised beds made out of the surface layer, which is often crumbly, are good seed beds as the water drains quickly into the adjacent furrows.

Threats: can be susceptible to droughts

Leptosols

Strengths: They provided a solid foundation for construction.

Weaknesses: Leptosols are unsuitable for growing crops. They have a limited rooting depth, a low water-holding capacity and their nutrient supply is confined to what is available in the shallow top layer.

Opportunities: Farmers use Leptosol areas only for grazing of their cattle.

Threats: Erosion

5 CONCLUSION AND RECOMMENDATIONS

A range of crops are suitable to be grown in the area. These include Sesame, Sorghum, Maize, Onion, Pepper, Tomato, Cabbage and perennial crops can also be grown provided feeder road accessibility and market outlet is improved for the area. The study of this rough assessment on crops and soil resource in study showed that, the command area can be used for irrigation purposes with serious limitations on effective soil depth, soil fertility, sheet erosion, slope, stoniness, and texture of the soil.

Soil management practices that improve soil fertility like addition of manure and artificial fertilizer, soil and water conservation measures are recommendable. Though fertility analysis is not done for the site from field observation the soil is very poor in fertility and hence, application of adequate dose of P and N containing fertilizer is important. The deficiency of micro nutrient could be expected thus application of the nutrients has a paramount importance in the field while the crops are actually growing and shows symptoms on the crops. Trials and demonstration need to be carried out on the use of improved seeds, fertilizer dose, timely application of pesticides and disease control methods. For new crop variety adaptability trial of the recommended crops should also be carried out to select the most promising ones.

5.1 Conclusion

Misrar Teli plain studied irrigation feasibility and detail design project has been identified, delineated and proposed as one of the potential area for irrigated agricultural development. Accordingly this study reviewed those reports to obtain data and information gaps so that the current survey is planned in a way to fill the gaps. Hence, in this study additional data are collected through intensive soil survey. The soil survey was carried out over a gross area of 80 ha at feasibility level and mapped at 1:1,000 scales. Satellite image and different map interpretation were made to ease and facilitate the field soil survey. Almost full of the opened and described profile pits are sampled. For verification of soil types and mapping units of the command area, 4 soil profiles, 50 auger observation, gully and river side description and road cut are described in the field and samples are taken from each horizon for full physical and chemical analysis. The soil profile descriptions results of survey confirmed that the soils mapping units are correctly delineated although there could some mapping units may have an association of soils which are not indicated in the survey. Five major soil types at Reference Soil Group level namely Cambisols, Leptosols and Vertisols are identified. Based on the available data the land evaluation was done for irrigation using various methods of land evaluation methods (see, the independent report of land suitability evaluation and classification).

5.2 Recommendations

First, some recommendations on soil management in the study area, based on this study and field observations:

- Soil tillage was found to destroy important soil physical properties such as soil structure. Therefore, either the property of the soil has to be improved by applying organic matter or should be done using appropriate tillage implements or one has to adjust the frequency of tillage.
- Protection of the catchment surrounding the irrigable land through delineation of a buffer zone around the perimeter of the reservoir, and prohibition or minimization of human activities in order to effectively reduce erosion and sedimentation. This should also be considered as a compensation for the loss of habitats from the submergence area and command area.
- Establishment of an efficient water application/management system that delivers only necessary quantities of water to irrigation fields in order to prevent adverse soil modification like water-logging, and creation of mosquito and snail breeding sites.
- Use of environmentally friendly chemicals and biological control measures against pests and diseases.
- Establishing a monitoring program for checking the critical parameters like water quality, relevant soil characteristics, groundwater level, water-logging, and disease vector breeding places

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Appendix

Appendix 1: Profile description and soil classification

Wereda: Enderta ,Tabia: Mahbere_Genet,

Scheme name: Misrar_Teli, Scheme Type: Diversion

Reference Profile: EMGT3

Coordinate: X= 544065 Y=1501056 Z=1804

Description each Horizons classes and depth

0-20cm (Ap):

Soil color is 7.5YR6/4(light brown) (Dry), 7.5YR4/3(brown) (wet), Coarse Angular (structure), loose (Dry), loose (moist), very slight Sticky, very slight Plastic (wet), few, fine(Roots), strong Calcareous Soil texture sandy , preliminary soil type Leptosols

Wereda: Enderta ,Tabia: Mahbere_Genet,
Scheme name: Misrar_Teli, Scheme Type: Diversion
Reference Profile: EMGT4

Coordinate: X= 544169 Y=1501285 Z=1810

Description each Horizons classes and depth

0-20cm (Ap):

Soil color is 7.5YR4/2(brown) (Dry), 7.5YR3/2(dark brown) (wet), Coarse Angular (structure), Hard (Dry), firm (moist), slight Sticky, slight Plastic (wet), few, fine(Roots), strong Calcareous Soil texture clay loam ,

20-140cm (B):

Soil color is 7.5YR3/1(Very dark gray) (Dry), 7.5YR2.5/1(black) (wet), blocky Angular (structure),Very Hard (Dry), Very firm (moist), Sticky, Plastic (wet), .few, fine(Roots), strong Calcareous, Soil texture clay loam ,preliminary soil type Vertisols

Wereda: Enderta ,Tabia: Mahbere_Genet,

Scheme name: Misrar_Teli, Scheme Type: Diversion

Reference Profile: EMGT5

Coordinate: X= 544102 Y=1501701 Z=1822

Description each Horizons classes and depth

0-20cm (Ap):

Soil color is 10YR6/8(brownish yellow) (Dry), 10YR4/3(brown) (wet), Angular (structure), Hard (Dry), firm (moist), slight Sticky, slight Plastic (wet), few, fine(Roots), none Calcareous Soil texture sandy loam ,

20-170cm (A):

Soil color is 10YR4/6dark yellowish brown) (Dry), 10YR3/4(dark yellowish brown) (wet), Angular (structure), Hard (Dry), firm (moist), Sticky, Plastic (wet), .few, fine(Roots), none Calcareous, Soil texture sandy loam, preliminary soil type Cambisols

Appendix 2: Soil chemical properties

No.	Sample ID	Analyzed Parameters										
		PH	OM	MC	OC	CEC	AV.P	TN	Exchangeable			
									Ca	Mg	K	Na
22	EMGT1.1	8.32	1.16	2.145	0.673	35.94	6.149	0.056	6.4	5.8	51.3	10.7
23	EMGT2.1	7.2	1.37	2.041	0.796	32.92	8.082	0.071	17	6.6	29.3	65.2
24	EMGT3.1	8.19	3.36	2.145	1.95	23.31	7.252	0.16	6.6	5.8	33.5	10.4
25	EMGT4.1	7.57	2.13	2.501	1.233	27.18	8.446	0.167	17.2	7.8	110.2	130
26	EMGT4.2	7.93	2.21	1.958	1.282	18.7	6.138	0.116	11	5.6	61.3	133.4
27	EMGT5.1	8.18	1.1	2.556	0.64	8.82	6.256	0.049	9.8	3	89.4	120.1
28	EMGT5.2	7.38	1.11	2.103	0.641	9.945	5.207	0.055	6.8	3.4	116.3	158.3
29	EMGT6.1	8.01	1.61	5.664	0.933	37.89	5.495	0.071	6.6	3.4	63.4	247.1
30	EMGT6.2	7.18	1.7	5.197	0.987	37.39	3.198	0.07	46	6.8	90.6	494.1
31	EMGT7.1	7.36	1.97	2.48	1.145	26.05	49.35	0.101	5.6	3	114.1	169.7
32	EMGT7.2	7.73	1.39	2.145	0.807	30.03	3.882	0.077	21	5.8	101.5	132.2
	Average	7.73	1.74	2.812	1.008	26.2	9.951	0.09	14	5.181818	78.26364	151.9273

Source: Laboratory result

Appendix 3: soil Physical properties

No.	Sample ID	Analyzed Parameters				
		BD	% sand	% silt	% clay	class
1	EMGT1.1	2.208	64	20	16	Sandy Loam
2	EMGT2.1	2.007	46	36	18	Loam
3	EMGT3.1	3.297	60	20	20	Sandy Loam
4	EMGT4.1	1.999	66	18	16	Sandy Loam
5	EMGT4.2	1.943	56	20	24	Sandy clay loam
6	EMGT5.1	2.503	38	30	32	Clay loam
7	EMGT5.2	1.877	68	20	12	Sandy Loam
8	EMGT6.1	2.058	28	42	30	Clay loam
9	EMGT6.2	2.148	26	44	30	Clay loam
10	EMGT7.1	2.084	72	14	14	Sandy Loam
11	EMGT7.2	1.959	46	36	18	Loam
	Average					

Source: Laboratory result

Appendix 4: Rating and recommended criteria for soil data interpretations

1. Drainage class: combination of internal and external drainage

Class code	Class rating	Description of the class
E	Excessively drained	Water is removed from the soil very rapidly. The soils are commonly very coarse textured or rocky. Shallow or on steep slopes
S	Somewhat excessively drained	Water is removed from the soil rapidly. The Soils are commonly sandy and very pervious.
W	Well drained	Water is removed from the soil readily but not rapidly. The soils commonly retain optional amounts of moisture, but wetness does not inhibit the growth of roots for significant periods
M	Moderately well drained	Water is removed from the soil somewhat slowly during some periods of the year. The soils are wet for short periods within the rooting depth. They commonly have an almost impervious layer, or periodically receive heavy rainfall.
I	Imperfectly drained	Water is removed slowly so that the soils are wet at shallow depth for significant periods. The soils commonly have an almost impervious layer, a high water table, and additions of water by seepage, or very frequent rainfall
P	Poorly drained	Water is removed so slowly that the soil is commonly wet at a shallow depth for considerable periods. The soils commonly have a shallow water table, which is usually the result of an almost impervious layer, seepage or very frequent rainfall
V	Very poorly drained	Water is removed to slowly that the soils are wet at a shallow depth for long periods. The soils have a very shallow water table and are commonly in level or depressed sites or have very rainfall falling almost every day.

2. Effective soil Depth:- The depth of soil penetrable by roots without considering groundwater table and toxic substances

Depth Categories	Depth (cm)	Depth Categories	Depth (cm)
Very deep	>150	Shallow	30 – 50
Deep	100 –150	Very shallow	< 30
Moderately deep	50 – 100		

Source: Landon et al., (1991) and GIRDIC soil survey manual

3. Erosion Status: observed /Accelerated Erosion by water

Type	Sheet, Rill, Gully
Grades	None, slight, Moderate and severe(not quantified

4. Surface stoniness: percentage surface cover by stones and rock outcrops

Per cent	Description	Per cent	Description	Per cent	Description
0%	None	15 – 40 %	many	5 – 15%	common
0 –2 %	very few	40 – 80%	abundant		
2 –5 %	Few	>80%	dominant		

Source: Landon et al., (1991) and GIRDIC soil survey manual

5. Infiltration

Basic Infiltration Rate Cm/hr.	Suitability for surface Irrigation	Basic Infiltration Rate Cm/hr.	Suitability for surface Irrigation
<0.1	Unsuitable (too slow)	3.5-6.5	Suitable
0.1-0.3	Marginally suitable (too slow),	6.5-12.5	Marginally suitable (too rapid); small basins needed
0.3-0.7	Suitable;	12.5-25	Suitable only under special conditions, very small basins needed
0.7-3.5	Optimum	>25	Unsuitable (too rapid) surface irrigation methods only

Source: Landon et al., (1991) and GIRDIC soil survey manual

6. Texture/structure

Texture/structure	Description	Texture/structure	Description
Cm	Massive clay	SiL	Silty loam
SiCm	Massive silty clay	SC	Sandy clay
C+60, v	Fine clay, Vertisol Structure	L	Loam
C+60, s	Fine clay, blocky structure	SCL	Sandy clay loam
C-60, v	Clay Vertisol Structure	SL	Sandy loam
C-60, s	Clay, blocky structure	Lfs	Loamy fine sand
SiCs	Silty clay, blocky structure	LS	Loamy sand
Co	Clay, Oxisols structure	LcS	Loamy coarse sand
SiCL	Silty clay loam	fS	Fine sand
CL	Clay loam	S	Sand
Si	Silty	cS	Coarse sand

Source: Landon et al., (1991) and GIRDIC soil survey manual

7. Hydraulic Conductivity: permeability is a general term for the same ability to transmit water (FAO, 1990)

KC(m/day)	Hydraulic conductivity Class	KC(m/day)	Hydraulic conductivity Class
<0.2	Very slow	1.4-1.9	Moderately rapid
0.2-0.5	Slow	1.9-3	Rapid
0.5-1.4	Moderately slow	>3	Very rapid

8. Available Water Holding Capacity

AWC(mm/m)	Rating for irrigation suitability
<120	Low
120-180	Medium
>180	High

9. Soil reaction

CEC(me/100g soil)	Rating	General interpretation
>8.5	Very high	Ca & Mg unavailable may have high Na, possible B toxicity, otherwise as below
7-8.5	High	Decreasing availability of P & B, above 7.0, Increasing liability of deficiency of Co, Cu, Fe, Mn, Zn
5.5-7	Medium	Preferred range for most crops
<5.5	Low	Acid soils, possible Al toxicity and excess Co, Cu, Fe, Mn, Zn. Deficiency in Ca, K

10. CEC

CEC(me/100g soil)	Rating	General interpretation
>40	Very high	Normal good agricultural soil
25-40	High	As above only small amounts of lime and K fertilizer needed
12-25	Medium	Satisfactory for agriculture given fertilizer
5-15	Low	Moderate to poor response to fertilizer
<5	Very low	Few nutrient reserves. Marginal for sustainable and rain fed agriculture unsuitable for irrigation

Source: Landon et al., (1991) and GIRDIC soil survey manual

11. Percent Base Saturation (BS %)

BS %	Rating or levels
<20	Low
20-60	Medium
>60	High

12. Organic Carbon (%)

OC %	Rating	OC %	Rating	OC %	Rating
>20	Very high	4-10	Medium	<2	Very low
10-20	High	2-4	Low		

Source: Landon et al., (1991) and GIRDIC soil survey manual

13. Total Nitrogen

N%	Rating	Source: Landon et al., (1991) and GIRDIC soil survey manual	
>1.0	Very high	0.1	Very low
0.5-1.0	High	<0.2	Low
0.2-0.5	Medium	0.2-0.5	Medium
0.1-0.2	Low	>0.5	High

14. Available Phosphorus

Available P(ppm)	rating	Comments
>15	High	Fertilizer response unlikely
5-15	Medium	Fertilizer response probable
<5	Low	Fertilizer response most likely

Source: Landon et al., (1991) and GIRDIC soil survey manual

15. Carbonate %

%	Rating or Description	%	Rating or Description
<1	Low	<15	Low to medium calcareous
1-4	Medium	15-40	Calcareous
4-10	High	>40	Extremely calcareous
>10	Very high		

Source: Landon et al., (1991) and GIRDIC soil survey manual (meq/100gm)

16. Carbon/Nitrogen ratio for OM added to the soil

C:N	rating	C:N	rating
Very low	<10	High	25-70
Low	10-15	Very High	70-100
Medium	15-25	Extremely high	>100

17. Exchangeable cations (meq/100g of soil)

Cations	Very low	Low	Medium	High	Very high
Ca	<2	2-5	5-10	10-20	>20
Mg	<0.5	0.5-1.5	1.5-3	3-8	>8
K	<0.1	0.1-0.3	0.3-0.6	0.6-1.2	>1.2
Na	<0.1	0.1-0.3	0.3-0.7	0.7-2	>2

Source: Landon et al., (1991) and GIRDIC soil survey manual

18. Electrical Conductivity (ms/cm)

Ms/cm	degree	Ms/cm	degree	Ms/cm	degree
0-2	Salt free	8-15	Moderately saline	>40	Very high
4-8	Slightly saline	>15	Strongly saline		

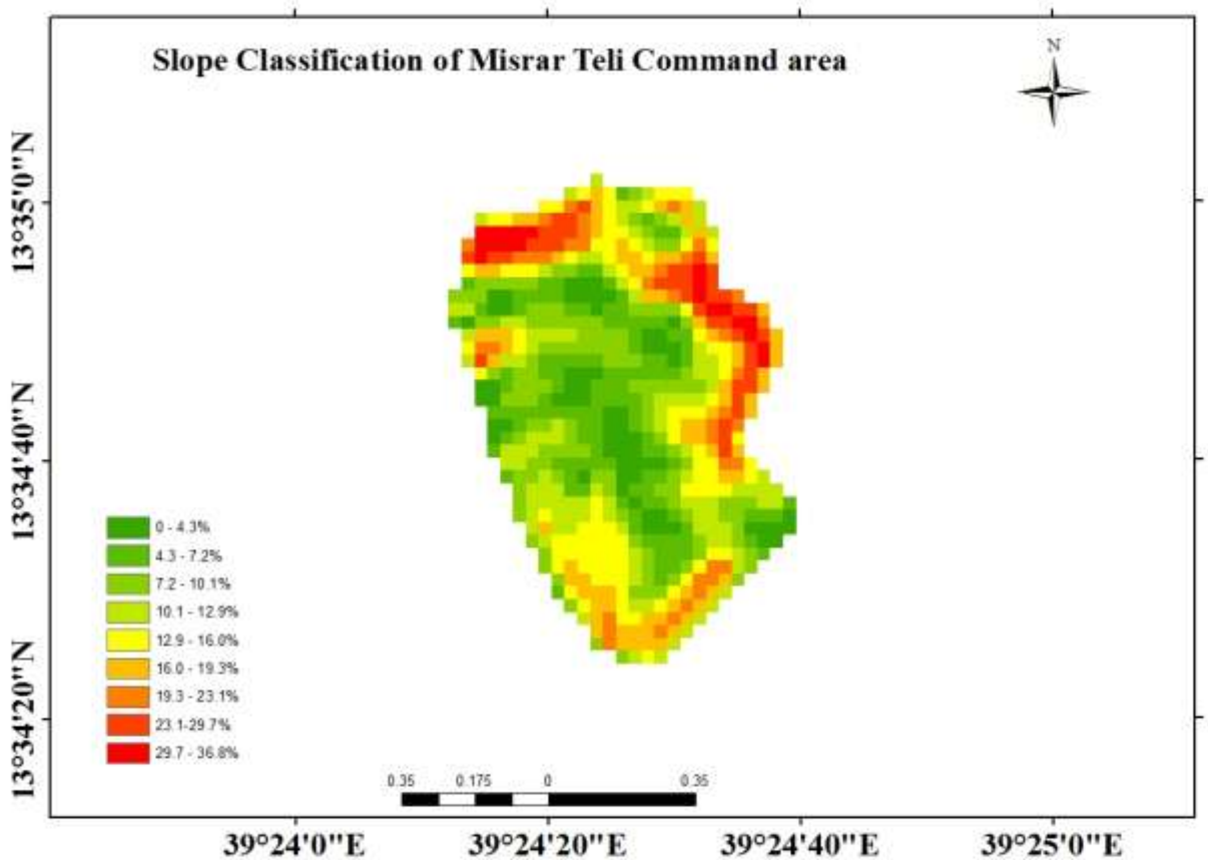
Source: Landon et al., (1991) and GIRDIC soil survey manual

19. PH

PH Value	Rating	PH Value	Rating
<4.5	Extremely acidic	6.6-7.3	Neutral
4.5-5.0	Very strongly acidic	7.4-8.0	Slightly alkaline
5.1-5.5	Strongly acidic	8.1-9.0	Strongly alkaline
5.6-6.0	Moderately acidic	>9.0	Very strongly alkaline
6.1-6.5	Slightly acidic		

Source: Landon et al., (1991) and GIRDIC soil survey manual

Appendix 5: Slope classification of the study area



Appendix: Map Legend and Field analysis

Code map	Area_ha	Land scape	Relief Type	Facies	Landform
Pl211	13.70	Alluvial Plain	Low terrace	Alluvial	Levee
Pl114	13.05	Alluvial Plain	Low terrace	Alluvial	Thread riser complex
Pl113	11.05	Alluvial Plain	High terrace	Alluvial	Thread riser complex
Pl112	8.15	Alluvial Plain	High terrace	Alluvial	Decantation basin
Pl111	4.05	Alluvial Plain	High terrace	Alluvial	Levee