AG; DP/ETH/82/012
Field Document No 2

ASSISTANCE TO SETTLEMENT

ETHIOPIA

LAND USE PLANNING AND SOIL AND WATER CONSERVATION DEVELOPMENT PLANNING OF TEDELE HAROLE

PROVISIONAL MILITARY GOVERNMENT
OF SOCIALIST ETHIOPIA
RELIEF AND REHABILITATION COMMISSION

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

ADDIS ABABA 1986

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ASSISTANCE TO SETTLEMENT
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Land Use Planning and Soil and Water Conservation Development Planning Of The Tedele/Harole

by

S.K. Choi

The Provisional Military Government
Of
Socialist Ethiopia
Relief and Rehabilitation Commission

United Nations Development Programme
Food and Agriculture Organization of
The United Nations

Addis Ababa July 1986

This technical report is one of a series of reports prepared during the course of the FAO/UNDP project (ETH/82/012) preparing the Assistance to Settlement Project Phase IV. The conclusions and recommendation given in the report are these considered appropriate at the time of its preparation. However, they may be modified in the light of further knowledge gained at subsequent stages of the project.

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ABSTRACT

This report describes the result of detailed survey of Land Use Planning and Soil and Water Conservation of Tedele/Harole Settlement Project (16,000 ha in Western Shewa administrative region). The Land Resources map, Present Land Use/Cover, Slope and Erosion classes map and Land suitability classification map at one scale of 1:50,000 and Soil and Water Conservation Development Plan at a scale of 1:20,000 (consisting of 6 map sheets and 1 legend sheet) accompaies the report.

The natural resources data and development plan information presented here is based on data collected during field work and the analysis of soil samples and reference of the Technical report 1.2.3.10. Assistance to Land Use Planning Project (ETH/78/003). Aerial Photointerpretation played an important role in locating land resources boundaries and basic studies.

ACKNOWLEDGEMENTS

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MAP (in seperate volume)

I. INTRODUCTION

1.1 General

This document with its relevant maps is one of a series of documents prepared during the course of the FAO/UNDP Assistance to Settlement Project ETH/82/012 while preparing land use planning and soil and water conservation development planning and implementation for three large-scale settement namely:Tedele/Harola, Harawa and Asosa of the Relief and Rehabilitation Commission (RRC) of Ethiopia.

This document has been presented with the aim of transforming and promoting the selected settlement into sustainable self-reliant through the development of Land Suitability Classification and Soil and Water Conservation plan based on the FAO methodology for land use planning and soil and water conservation.

With respect to the planning exercise the fundamental requirement and an essential component has been the compilation of a comprehensive land resources of each selected settlement site. (Please, refer the location map of Tedele/Harole settlement site which is presented in figure 1 of this document).

1.2 Methods and Results

The methodology for the study of land use planning to prepare and explain the land suitability classification was based on the (FAO 1976) "Framework for Land Evaluation", (FAO 1983) "Land Evaluation in Rainfed Agriculture and (FAO 1986) "Guidelines for Land Use Planning" of third draft The soil and water conservation plan for the settlement is based on (FAO-1977) "Soil Conservation and Management in Developing Countries" and (FAO-1979) "Watershed Development with special reference to soil and Water Conservation.

Analysis of land resources as a basis for land evaluation was based on combination of a series of thematic maps into a

development of a land resources map at a scale of 1:50 000 with basic information on Agroclimatology, Geomorphology and soils.

As has been pointed out earlier, the land resources map is the focus of the land resources inventory. This is because it provides the necessary assemblage and integration of resources data to carryout a land suitability evaluation.

A well formulated soil and Water Conservation Development Plan at a scale of 1:20,000 which determines the methodology and technique to be used to understand the physical and social conditions. This is important for the formation of needs and priorities of the settlers and to indicate the most suited development options for the settlements.

2. BACKGROUND DATA

2.1 General Description

2.1.1 Location

The Tedele-Harole Settlement Project is located in Chebona Gurage Awraja Showa Administrative region between latitiudes $8^{O}15'N$ and $8^{O}30'$ and longitudes $37^{O}30'E$ and $37^{O}45'E$ see location map, Figure 1.

The settlement area is 200 km from Addis Ababa on the Addis-Jimma road which then turns to the right extending 17 km north-west of the main road. The total settlement area is 16,000 ha and the elevation varies from 1500 to 1700 m.a.s.l.

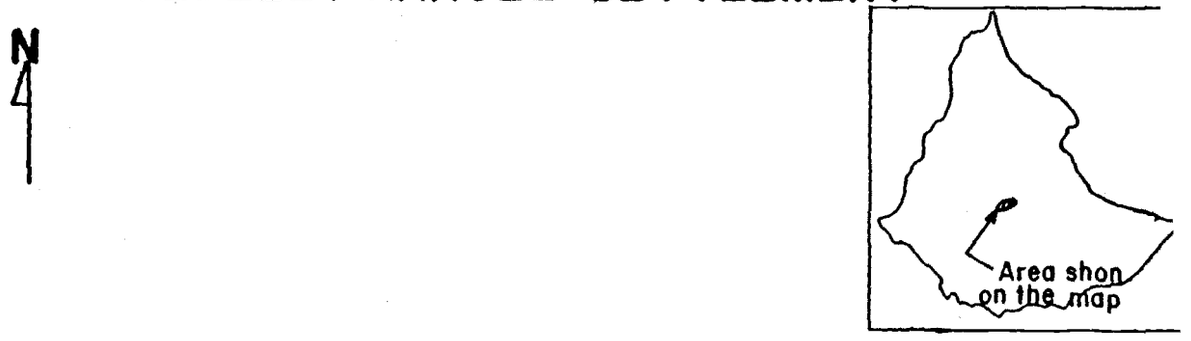
2.1.2 Physiography

The Tedele/Harole forms part of an extensive highland plateau which are separated by perrenial and seasonal rivers and the seasonal ones being mostly negligible nature in providing water during the dry season.

Slopes are dominatly south-westerly direction with slightly less than 1% but with gentle slopes on the river valles varying from 2-6% and

figure I

TEDELE / HAROLE SETTLEMENT



LEGEND

All weather road .....

Town ..... o

Settlement .....

River .....

Scale 1:1000000

increasing to steeper slopes towards the actual valleys.

The plateau and the scarps area consists of major surface drainage of the Kulit and Darge perrennial rivers channelled by seasonal meandering streams form the Gibe river main drainage system.

The two perrennial rivers are providing multipurpose benefits (water supply and irrigation) for settlement units 1,2,4,5,7 and units 2 and 5 respectively. However, with proper feasibility and design studies the rivers have good potential for irrigation and water supply than foreseen. Thus, irrigation in the settlement could be of great significance to the production of main crops in addition to Horticultural farms being undertaken by traditional irrigation; although the traditional practice is subjected to whims of nature such as flood hazards.

No ground water surveys have been undertaken in the settlement. It is recommended that surveys should be carried out for the area which comprises short term ground water surveys to assess the need for ground water development and site selection for well drillings and well development. The preliminary evaluation of current dug wells used by units 3,6,9 and 10 indicates ground water table to be very shallow to moderately deep.

Inventory of the underlying geological strata shows shallow colluvium over tertiary tuffs, welded tuffs and associate basalts and convix hills to moderately inclined side slopes which have tertiary trachytes, rhyolites and associated basalts and tuffs.

According to Soil Surveys conducted in the settlement, the dominant soils have been classified as the soils with heavy clay soil 'Pellic Vertisols' which are very compact and their permeability is low. The soils are generally of swellings nature and becomes heavy when wet which due to high plasticity and low permability may also show deep cracks during the dry season due to high plasticity and low. The pellic vertisols of the valleys are subjected to low permeability and slow internal drainage problem.

2.1.3 Climate

The main climatic factor affecting agricultural and livestock production in the Tedele/Harole settlement is rainfall and its variation. According to the climate data (Refer table 1.) the climate is favourable for rainfed agriculture, as it is characterized by a length of growing period (LGP) of 211 to 240 days. Since the area is flat to moderately slope, other climatic elements hardly vary throughout the settlement except low sunshine intensities during the rainy season. The area has two rainfall regimes.

Rainfall is concentrated in the period mid June to late September but amounts vary; the maximum mean annual rainfall being 1200m.m. while during the months of February to May the rainfall reliability drops to 1000 m.m. to 1200 m.m. per annum.

The mean monthly maximum temperature ranges from 26.7^{0}C in the months of February to June and 23^{0}C in January. Themean monthly mean temperature ranges from 10.3^{0}C in September to 12.5^{0}C in April. Agroclimatic data over the area based on a meterological station at Welkite 30 km southeast from the settlement site is shown in Table 1.

2.1.4 Vegetation and Land Use

As indicated by some topics considered in this document, most of the land in the area of survey which is either suitable or moderately to marginally suitable for cropping is determined by climatic types. This can be illustrated by the ranging variety of agro-ecological aspects. For example, in the Woinadega (15^{0}C-20^{0}C) rainfed arable mixed farming such as Maize, Sorghum and Teff are major staple crops where as oil seeds and leguminuous crops come as alternate crops. On the highland plateau the natural vegetation consists of open woodland with scattered accacia and tall grass savanna.

The convix hills and moderately inclined sideslopes on the periphery have thicker vegetation consisting mainly of accacia thickets and tall grasses

Table 1 Climatic Data

Station: Weliso	Administrative region: Shewa	Rainfall pattern region: B. 3.03	Altitude asl m: 1 960	No. of years for precipitation: 10	No. of years for other data: 14

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
Mean max. temp. °C		25.6	26.7	26.7	26.6	26.9	24.0	21.6	21.5	23.2	24.5	24.2	25.6	24.8
Mean min. temp. °C		11.4	11.7	12.1	12.5	11.5	11.2	11.5	10.9	10.3	10.4	10.4	10.3	11.2
Mean temperature °C		18.5	19.2	19.4	19.6	19.2	17.6	16.6	16.2	16.8	17.5	17.3	18.0	18.0
Vapour pressure mb	E	10.0	9.6	10.1	11.9	12.7	14.3	15.9	15.5	14.5	10.6	8.5	10.1	12.0
Rel. humidity %	E	47	43	45	52	57	71	84	84	76	53	43	49	59
Wind speed 2 m m/s	E	1.3	1.4	1.4	1.3	1.4	0.9	0.8	0.8	1.0	1.6	1.5	1.5	1.2
Sunshine %	E	74	67	63	54	56	40	22	27	41	65	78	79	55
Total rad. cal/(cm^2 x day)	E	468	479	494	468	467	400	335	359	411	481	492	472	444
Precipitation mm		5	39	63	79	99	256	277	239	109	20	16	6	1 208
PET mm		107	108	125	114	117	80	62	66	79	115	106	109	1 188
Dates				15 BM(S)		18 BH(S)				22 EH	4 EM 9 EHS	3 EMS		

LGP_1 3/4 - 3/11 normal	Days	Mean max. temp. °C	Mean min. temp. °C	Mean temp. °C	Total$_2$ rad. cal/(cm^2 x day)	P	PET	P/PET
BEG-END	214	24.0	11.2	17.6	417	1 074	632	1.70
BEG-BHS/BH(S)	45	26.9	12.2	19.5	470	121	175	0.69
BHS/BH(S)-EHS/EH(S)	144	23.0	11.0	17.0	388	941	364	2.59
EHS/EH(S)-END	25	24.6	10.4	17.5	489	12	94	0.13
LGP_2 15/3 - 3/11 normal with prolonged prehumid moist period								
BEG-END	233	24.2	11.2	17.7	423	1 115	707	1.58
BEG-BHS/BH(S)	64	26.8	12.2	19.5	476	162	250	0.65
BHS/BH(S)-EHS/EH(S)	144	23.0	11.0	17.0	388	941	364	2.59
EHS/EH(S)-END	25	24.6	10.4	17.5	489	12	94	0.13

and broad-leaved trees.

2.2. Development in the Area

Evaluation of the area for their suitability to enhance rain-fed arable mixed farming on a mechanized agriculture indicates land quality which consists predominatly of a flat plain with slops of 0-8%.

The settlement site is linked with a 30 km all weather road to Wolkite where most of the basic social and administrative services are botained.

In the mean time, however, developments in the settlement possess two parts i.e. Tedele units 4,5,6,7 and Harole units 1,2,3,9,10 comprising 3 development units in whole Tedele/Harole development project area.

However, the area has some limitations in it's development endeavor such as tuberculosis and diarrhoea whereby a strategy to amelinate the situation should be outlined to advance the desired objectives.

The 3 development units accommodate 3,870 heads of families.

2.2.1 Origion of settlers

The settlement was established in 1978. Most of the settlers came from drought effected areas of Kambata and Hadya Awraja and Addis Ababa who were urban unemployed. Few of the settlers came from Gamugofa administrative region, who were meking their living by producing charcoal and few are from drought affected areas of Wollo and Tigrai.

For the distribution of settlers within the units reference has been made in table 2.

Table 2 Distribution of settlers and land in the Tedele/Harole

Unit	No of families heads	Crop land		Non crop land	Total
1	496	487	1,299	931	2,230
2	576	400	936	230	1,166
3	312	395	979	528	1,507
4	497	400	1,384	1,912	3,296
5	460	547	1,002	472	1,474
6	491	221	1,152	335	1,487
7	349	324	952	633	1,585
9	321	331	1,673	482	2,155
10	368	460	851	220	1,081
Total	3,870	3,565*	10,238**	5,743	15,381

* 1986 1st cultivated area

** Total cropland

On the basis of earlier proposals by the Relief and Rehabilitation Commission (RRC), the settlement model has been defined as having 500 family heads per settlement unit of 1250 hectares of land. Although, their use has been recommended to ensure that the proposed plan will form a basis on which the settlers can work to their benefit, in practice this was not so, far Tedele/Harole project due to the following reasons:

The settlement area is located along the perennial rivers, Kulit, Darge and Woldega and the seasonal river Ottona, which are all the tributeries of Gibe River.

At present the demand of domestic water supply of the settlers is met from the perennial rivers.transporting by tractors and dug wells. Unit 1,2,4,5, get drinking water from Kullit river travelling 1 km 2 km 7 km and 9km respectively. Unit 7 gets from Darga river travelling 2 km and unit 3, 6, 9,and 10 get from dug Wells.

2.3 Land Survey

Th survey intensity in the area was in accordance with specific investigations and objectives. As a result, an area of some 19,000 ha was surveyed at semi-detailed level and classified into nine landscape units by taking considerations expressed on differences in land-form, soils, hydrographic pattern, slope, relief and vegetation density. Each unit is evaluated for its current and potential land use suitability and the results of the survey was shown on an aerial photo mosaic and tooographic maps at a scale of 1:50,000.

3. LAND-USE STUDY

3.1 Methods of study

3.1.1 Aerialphoto Interpretation

The essence of Land-Use Study for the Tedele/Harole settlement area is to make sure that the development activities being carried and should be carried in the future meet the needs of the settlers and to help them tackle the main problems and development bottle-necks and to lead them make best use of the development plans in their future development endevour.

As a result aerial photo interpretation for the area was one of the basic requirements and invaluable method used to guide land-use study in the settlement.

Thus, investigations show that, the photography was flown in 24 November 1973 at approximately 1:50, 000 scale. The API was done with Top Con mirror stereoscope with 3 x dinocular eyepiece. After scanning the general area and examining stereo pairs, an API legend was prepared with supporting data from the field survey. This legend was reworked into soils oriented legend.

The API lengend is shown in Appendix 1 and is thought to be self-explanatory.

The principal points of the APS were marked on the existing Mosaic. Transparent drafting paper was placed over the Mosaic and the principal points were transferred and identified by number. The flight lines were drawn by joining the points in the flight line.

The APS with their delineations were placed under the transparency with flight lines in perfect coincidence and the lines and symbols transferred.

Some Mosaics were more distorted than others and adjustments had to be made during the transfer. Where distortion was too great, the information was transferred to the alternate APS not previously marked so that only information in the center of Ap was shown, thus reducing the adjustments in positioning. The

scale of the map was calculated from identifiable point on the 1:50,000 scale and an average figure was shown.

3.1.2 Area Measurement

Another approach undertaken during the course of land-use study was area measurement of landscape units. Individual mapping units were measured by planimeter and adjusted for the appropriate scale.

Area below 15 ha are given to the nearest 5 or 10 depending on size. The sum of the individual mapping units was checked against the whole units area sinuous riverine forest was taken as the difference between the sum of all other areas and the overall area within the unit boundary and hence includes errors. According to table 2 nearly 18,000 ha was measured (19,000 ha).

3.2. Soil Survey and Soil Sampling

Inorder to identify and make a comparison of promising kinds of land-use items applicable to the settlement, soil survey field work was carried in 1985. The approach of the soil survey is described as follows:-

During the field work observation was made in which approximately 21 auger descriptions were made (generally to a depth of 180 cm). The augerings were made with a screw type auger. Both land and soil characteristics were recorded on a standard form for auger descriptions.

Observations include recording of physiography soil surface conditions and soil profile characteristics which were obtained by means of augerings taken from small natural exposures.

The methodology for describing soil profile and augerings was adapted from the "Guideline for soil profile description (FAO-1977) and from the Munsell Soil Colour Charts (1975). All sampling sites were plotted on AP's which were used as base map in the field work.

3.3. Laboratory Methods

3.3.1 General Description

On the basis of twenty one representative soil samples which were chemically and physically analysed by the soil laboratory of the Land Use Planning and Regulatory Department of the Ministry of Agriculture, analytical data were presented in Appendix 3.

3.3.2 Methods of Soil Analysis

The soil samples were transported from the soil survey area to the soil laboratory in polythene bags with proper identification tags.

Samples Preparation: The soil samples were air-dried at room temperature by spreading on paper sheets. On drying they were ground in metal mortar and pestle and sieved through a 2 mm sieve.

Texture: The particle-size distribution was determined by modified Bouyoucos Method. 50 g soil was soakd with 100 ml distilled water for one hour. 60 ml of 9% H_2O_2 were added and the contents heated on a hot plate for one hour to destroy the organic matter. Then 2 g of 1 N-hexametaphosphate (calgon) was added and the suspension was transferred to dispersion cup and stirred for five minutes. The suspension was then transferred to the hydrometer jars and volume made to one litre mark. The hydrometer readings were taken at 40 seconds and 2 hours intervals to calculate the silt + clay and clay percentage respectively. Sand percentage was calculated by subtracting silt + clay percentage from 100.

PH: 20 g soil was treated with 20 ml of water or salt solution (KCl or $CaCl_2$ for half a day with occasional stirring and the pH was read using standard glass and calomel electrodes.

Organic Carbon: (Walkley and Black Method) To soil (passing through 0.5 mm sieve containing 10-25 mg of organic carbon was added 10 ml of N Potassium dichromate and 20 ml of conc. sulphuric acid. After half an hour 200 ml of distilled water 10 ml of orthophosphoric acid and 0.5 ml of barium diphenylaminsulphonate as indicator were added and titrated with 0.5 N ferrous ammonium sulphate. The percentage of organic matter was calculated from the amount of potassium dichromate used to reduce the organic matter.

Total Nitrogen: To 1 g soil (passing through 0.15 mm sieve) was added 1 g of catalyst mixture (containing potassium sulphate, copper sulphate and selenium powder in the ratio of 10:4:1) and 6 ml of conc. sulphuric acid in a kjeldahl flask. The contents were digested till clear and cooled. Then transferred to another kjeldahl flask washing with little portions of distilled water (about 60 ml), 20 ml of 40% NaOH added and NH_3 distilled in 10 ml of 0.2 N H_2SO_4. The excess acid was back titrated with 0.1 N NaOH with methyl red as an indicator. Percentage of total nitrogen was calculated from the acid used.

Available Phosphorus To 10 g soil (passing through 1 mm sieve) is added 1 teaspoonful of activated carbon (Darco G60) and 50 ml of Morgan's extracting solution (10% solution of Na-acetate in 3% acetic acid). The contents were shaken for 30 minutes and filtered. P was determined in 2 ml of the extract by adding six drops of formaldehyde solution, 1 ml of sodium cobaltinitrite and 2 ml of isopropyl alcohol. The turbidity of the samples was compared with the standards.

Exchangeable cations: 5 g of soil (passing through 1 mm sieve) was leached with 150 ml of neutral (pH 7) N NH_4-acetate and made to 250 ml with distilled water. Ca + Mg were determined in 10 ml of the leachate by acidifiying with 0.1N HCl, boiling for a few minutes, complexing Mg with Mg-complexonate, adding 2 ml of 2% aquous solution of KCN and 3 ml of NH_4OH-NH_4Cl buffer. The contents were titrated with 0.02 N disodium salt of EDTA after adding a pinch of Erichrome Black T.

For determination of Ca, a separate 10 ml portion of leachate was titrated with 0.02 N disodium salt of EDTA using a pinch of HHSNN (Paton and Readers reagent) until the color turns from wine red to blue. Exchangeable Mg was obtained by subtracting exchangeable Ca from exchangeable Ca + Mg.

Exchangeable K and Na were determined by flame photometer using air butane flame.

Cation Exchange Capacity: The soil previously leached with NH_4-acetate was successively washed with 10 ml portions of 95% ethanol using a total of 80 to 100 ml of ethanol. Absorbed NH_4 was then replaced with Na by extracting the soil with 40 ml of 10% NaCl. NH_4 was determined in the extract by adding 5ml of 40% NaOH and distilling NH_3 in 10 ml of 0.2 N sulphuric acid and titrating the excess acid by 0.1 N NaOH.

Exchangeable Aluminium: 10 g soil was extracted with 100 ml N KCl by shaking for two hours. 5 ml of KCl extract was diluted to 25 ml with water, 2ml of 1% thioglycolic acid and 10 ml of aluminium reagents (containing NH_4-aurine tricarboxalate, gum accacia, NH_4OAC and HCl) were added. The contents were heated over boiling water bath for 16 minutes and then cooled.

On cooling the volume was made to 50 ml with water, mixed and absorbance measur at 520 millimicrons.

Exchange acidity: Exchange acidity was determined by the potassium chloridetri-ethanalamine buffer method. 10 g oil and 25 ml of 0.5 N KCl -0.2 N TEA buffer were shaken for half an hour and filtered through a gooch crucible containing a moist whatman no. 42 filter paper. Additional 25 ml of buffer solution were used to transfer the soil to the crucible. The soil was then leached with small portions of 100 ml of replacement solution (0.5 N KCl solutic containing 10 ml of buffer solution). The combined leachates in the flask were titrated with 0.1 N HCl using 10 drops of bromo-cresol green and 2 drops of methyl red with the progressive color change from blueish green through violet to pink. The end point was checked against a bland containing 50 ml of buffer solution and 100 ml of replacement solution. Exchange acidity was calculated by the difference between the titration value for blank solution and the leachate.

$CaCO_3$percentage: 5 g of soil was treated with 50 ml of 0.5 N HCl by gently boiling for 5 minutes. After cooling the contents were filtered and washed with water to wash all the acid out. The amount of unused acid was determined by adding two drops of phenolphatalein and back titrating with 0.25 N NaOH. The percentage of $CaCO_3$ was calculated from the acid used.

Exchangeable Ca + Mg in calcareous soils: In case of calcareous soils exchangeable Ca + Mg was extracted using 10 g of soil and 40 ml of CKCl-TEA buffer (containing 1 N KCl and 0.2 N TEA, PH 8.2) stirring occasionally for one hour. 10 ml of the filtrate were used for Ca +Mg determination by EDTA method (as described under exchangeable Ca + Mg in N NH_4-acetate extract

3.4 Soil classification and Landscape Units

3.4.1 Level of detail of soil characterization

It was decided to describe the soil units in terms of the following characteristics:

- Soil depth
- Soil drainage
- Soil colour
- Soil texture
- Degree of accelerated soil erosion by water
- Slope range
- Soil phase

For a description of the classes employed for the description of each characteristic the referred to landscape units. Soil classification follow FAO Soil Map of the World.

3.4.2 Landscape units and landform genesis

A hierarchical classification system is applied in the description of the geomorphology of the landscape units. At the broadest level, 12 subdivisions, related to the general physiographic character of the landforms, occur as follows:

1. Wetland
2. Seasonal wetland and seasonally waterlogged land
3. Plains and undulating sideslopes
4. Plains and low plateaux with hills, moderately dissected sideslopes and dissected plains
5. Hills with plains
6. Low to moderate relief hills
7. Moderate to high relief hills, severely dissected sideslopes and plateaux
8. High to mountainous relief hills
9. High plateaux
10. Moderately dissected plateaux, plateaux with hills and rolling to hilly plateaux
11. Rubble land and rock outcrop
12. Sand and salt deposits

4. Selection of crops for Land Evaluation

The overall approach used for identifying the requirements of crops was by taking considerations in terms of ranges of suitability based on a standard devise for recording crop requirements through assessment of land qualities and characteristics determined in the field survey at a semi-detailed scale.

From the guideline obtained from the survey the major kinds of land-use which involves crop production are rain-fed agriculture (annual perrennial and mixed) irrigated agriculture, livestock and forestry.

4.1 Selection of crops

The fundamental requirements for selecting the list of seven crops as land utilization types (LUT) was drawn up which included other perrennial crops excluding forestery species.

In terms of boosting crop production in Tedele/Harole settlement, this would mean identifying the crops and the legend that best suits essentially to grow them. This would enable the settlers to make most efficient use of the land to produce more crop production and for utilization of other forms of land use in the future.

A part from planning other forms of land use, crop production should also be designed to lead to fulfill the basic needs of the community which should be planned possessing local and national level development endeavours with a capital reserve to up-grade the living standards of the settlers.

From the above approach, activities of paramount importance would be reinforcement of health and education and promotion of basic needs required by the settlement site.

A further consideration in determining up a list of crops to be treated was the identification of priorities which would have more potentials for crop production within the settlement development.

Based on the crop requirements, the most fundamental list of crops of Tedele/Harole settlement project are as follows: Maize, Teff, Sorghum, Chickpeas, Pepper, Haricot bean, Noug.

4.2 Cropping Systems

A farming system practice such as the seed complex involves various range of crops. The cropping system practice by settlers within this type of farming system indicates differsnce from one locality to another. For example, the Tedele/Harole settlement project practiced a cropping system which consists of some cereals, pulses and vegetables. For instance, Maize, Teff, Sorghum, Chickpeas, Pepper, Haricot bean and Noug with other minor crops and vegetables (See Figure 2.)

The mixture of main food crops and minor crops are cultivated and recommended to meet the needs of the local community. The farming calender is designed to show that crops are grown and mature in adequate conditions for seed ripening to fill a food gap to satisfy the needs of the settlement.

4.2.1 Crop Establishment

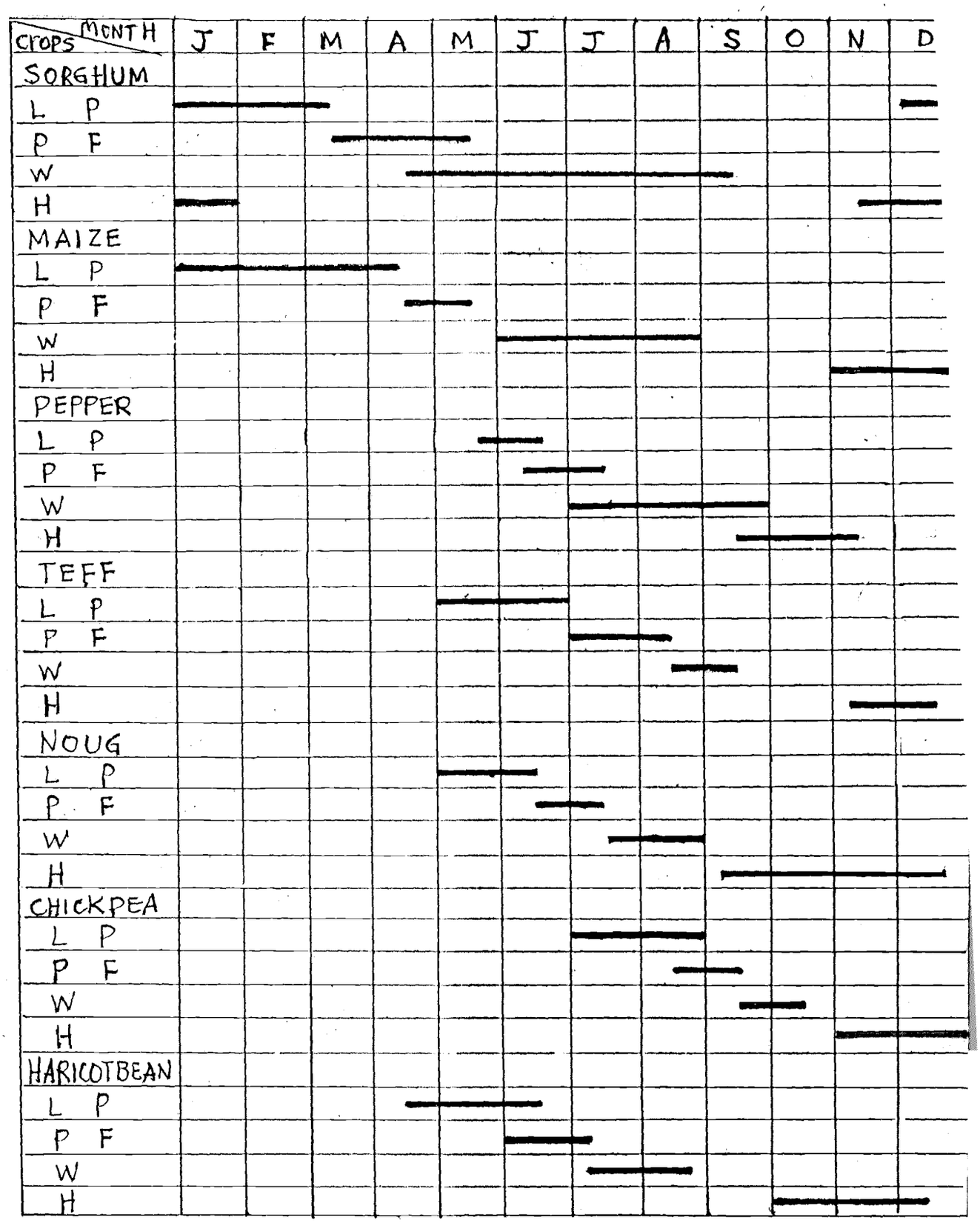
The main climatic factor affecting crop production in the settlement is rainfall and it's variation. The average rainfall superior to 50 mm from March to October (8 months). These months represent 94%, having a monthly rainfall (1180 mm) the wet season (June, July and August) represent 58% of the yearly total, while the period May-September having a monthly rainfall superior to 100 mm/month represents 73% of the yearly rainfall. Consequently, the settlement has a growing period of at least 6 months (May-October), depending on the storage of soil moisture available after the rains stop.

The months March and May have enough rain for land preparation possibility.

After May, the weather becomes probably too wet for land preparation indicating minimization of problems such as destruction of soil structure, formation of plough sole, and insufficient carrying capacity of the soil.

In terms of crop growth and rainfall reliability, the overall climate situation was not favourable for crop production. First, plowing starts around mid of March and extends to late May. Except for the Maize and Sorghum, plowing starts mid of November until late of March, planting starts mid of February

Figure 2. CALENDAR OF OPERATION
TEDELE / HAROLE SETTLEMENT PROJECT



LP - Land preperation PF - planting fertilizing
W - Weeding H - Hervesting

to mid of April. Other crops start mid of May to July. Weeding and cultivating seems to be accomplished in the months of June to July. Most crops are harvested from late August to late Janauary. (For detailed information on cropping calendar refer to Figure 2.)

4.3 Agro-Forestry in Relation to Crop Production

Although survey of supply and demand pattern is inevitable to clearly map out forestry development trend in the area, at present, one of the pressing needs is to find out sufficient source of construction materials and fuel-wood for the settlers.

As a complementary to land conservation and ameliorate the rapid rate of soil erosion, establishment of forest on eroded areas is necessary. Erosion danger exists also on cultivated gentle slopes which requires the introduction and promotion of perrennial tree crops or Agro-Forestry.

Environmental conditions related to the semiarid areas of settlement sites are more marginal for crop production than the humid areas. Although these areas are taken as potential grounds for the development of settlements and state farms assessment and complementary investigations show that they have the most fragile eco-systems. In prehumid area, cultivation and clearance of forests causes quick soil loss and fertility and on steep slopes sheet and gulley erosion becomes apparent.

These adverse effects are not always immediately apparent as the yields in the first few years after cleared cultivation could be dramatically high. But erosion danger under pre-humid conditions start to exist gradually as the original fertility of the soil in leached away which requires the introduction of increasing inorganic fertilizers to maintain even moderate crop yields. Tedele/Harole settlement site has already established and launched an extensive reforestration programme for its area but it is possible that the range of species could be extended to include trees which could provided fodder and food.

Observing the plains and undulating slopes where much of this settlement development is taking place shows that they are often devoid of trees or gradually being affected by land clearance for cultivation and search for

building materials and fuel wood. Thus, the advantages of these indigenous species such as Acacia Tortilis is really appreciated except perhaps by the indigenous pastoralities. Therefore, the establishment of trees should be multipurpose to provide practical services of wind break fuel wood and construction.

Responsible practice should also be given to indigenous multi-purpose species such as Acacia, Albida and Tamarindus Indica which are draught tolerance species. Observance of land conservation, wind breaks, forage for animals and food for settlers as well as fuel wood supply and enhancing handicrafts could be made through the introduction of multi-purpose such as Pigeon Pea.

The establishment of tree crops in association with the traditional food crops should be given more attention in planning and extension activities for settlement development.

Consideration should also be given to indigenous multi purpose tree species such as Acacia Albida, Mangifera indiea, Moringa oleifera, Piliostigma thonniggii and Tamarindus indica which not only provide wooden products but possibly serve various purposes such as oil conservation and improvement, fodder production and food.

Establishment of a system of wind break, land conservation, forage production and food for settlers as wood supply to inhance handicrafts could be made through the introduction of exotic multi-purpose tree species such as Acacia decurrens, Leuceana leucocephala,Azandrachta indica, Eucalyptus camoldulensia, Pigeon pea

Inventory of the pre-humid areas indicates that, they are suitable for rain-fed crop production although they are under increasing susceptible condition to environmental degradation. These areas also require establishment of tree species to provide variety of foods of perrennial horticultural crops and construction wood and fuel.

In existing areas where depletion of tree species had been occurred, careful selection should fit to introduce fast growing trees that could ameliorate immediate problems by giving due consideration to agro-forestry as well.

In Tedele/Harole, reaforestation was started in 1981 till 1985. The plan of operation was to raise and plant 4.2 million seedlings.

The tree species to be raised in the settlement was as follows:

Cupressus Luistancia
Eucalyptus Canaldulensia
Eucalyptus Globulus
Seucena Leucocephala
Acacia Decurrens
Eucalyptus Saligna

5. Crop Environmental Requirements

5.1 General Description

Crop environmental requirement condition is related to the physical conditions of the settlement covering a wide range of climatic, soil and other issues. Climatic data for possible crop environmental requirement includes maximum and minimum temperatures intensity and frequency of rains and relative humidity for rain-fed agriculture.

Based on the above factors and other associated patterns qualitative and quantitative approaches had been carried to draw up identifying the land qualities to be considered for evaluating rain-fed agriculture and the land characteristics needed to describe these qualities. The definitions of a land quality and a land characteristic are as follows:-

A land quality is an attribute of land which acts in a distinct manner in it's influence on the suitability of the land for a specific kind of use.

A land characteristic is an attribute of land that can be measured or estimated. The above definitions involve the following basic statements:

First: (land quality) are fewer in number (than land characteristics), secondly, they direct attention to the effect upon land use, and thirdly they take an accountof interactions between environmental factors.

In accordance with specific investigation for each crop, the requirement are given in two ways. The basic requirements as employed in the land evaluatio are given as tables in standard form at appendix 2 for 17 land qualities and the land characteristics by which they are measured or estimated.

Approaches considered of crop environmental requirements are as follows:

Abbreviation used for the suitability ranges are:

- Soil texture follows

S	Sand
ls	Loamy sand
sl	Sandy loam
l	Loam
sil	Silt loam
cl	Clay loam
sicl	Silty clay loam
sic	Silty clay
sc	Sandy Clay
c (rd)	Clay (Red)
c (bl)	Clay (Black)

- Slope Classes

0-2%	Flat or almost flat
2-8%	Gentle sloping
8-16%	Sloping
16-30	Moderately steep
30-50	Steep
50+	Very steep

Drainage classes follow FAO methodology as described above except for lands subject to seasonal flooding which are given two classess:- One for the period during the rainy season and the other for the rest of the year. This was deliberately done to accomodate requirements of the land evaluation:-

VP	-	Very poor
I	-	Imperfect
W	-	Well
E	-	Excessive
P	-	Poor
MW	-	Moderately well
S	-	Somewhat excessive

Rock outcrop descriptions follow FAO methodology:-

Stonliness classess are:-

None	< 1%
Fairly stony	1-3%
Stony	3-10%
Very stony	10-50%
Exceeding stony	50-90%
Rubble land	> 90%

Effective soil depth are (in cm)

< 25	Very shallow
25-50	Shallow
50-100	Moderately deep
100-150	Deep
> 150	Very deep

PH Soil Reaction

< 4.5	Strongly acid
4.5-5.5	Medium acid
5.5-6.5	Slightly acid
6.5-7.5	Neutral
7.5-8.0	Slightly alkaline
8.0-8.5	Medium alkaline
> 8.5	High alkaline

Electrical Conductivity MM has/cm at 25°C.

< 4 mm has/cm	Non saline
4-8	Slightly saline
8-15	Medium saline
> 15	Highly saline

Organic matter classes are (in%)

< 1	Low
1-3	Medium
3-10	High
>10	Very high

Castion exchange capacity classes are: (me/100g)

< 16	Low
16-35	Medium
35-70	High
> 70	Very high

Available phosphorous (Olsen) classes are (in PPM)

< 5	Very low
5-10	Low
10-15	Medium
15-25	High
> 25	Very high

Erosion (ALL Lands)

Symbol	Description Term	
1	None to slight erosion	Less than 25% of original top soil removed
2	Moderate erosion	From 25 to 75% of original top soil removed, occasional gullies may be present.
3	Severe erosion	From 75% of original top soil to 25% subsoil removed, occasional deep gullies or frequent shallow gullies may be present.
4	Very severe erosion	All of original topsoil and 25% to 75% of subsoil removed.
GL1	Slightly & Moderately Gully land	An intercate network of very frequent moderatly Gullies are presents. The soil has been eroded to the extent that all or practically all of the original surface soil, or A horizon, has been removed. (This GL1 will be practiced only planting trees and grass).
GL2	Deep Gully land	An intericate network of very frequent deep gullies are present. Soil profiles have been destroyed except in small areas between gullies. (This GL2 will be practiced planting trees, and structures).
EMP	Exposed parent material and/or rock	Areas consisting of exposed parent material and/or rock resulting from the complete, removel of all of the original topsoil and subsoil by natural processes where attributed to man induced processes, it will be differentiated by placing the symbol in parenthesis.

The classes used for the description of soil drainage soil texture refer to the standard soil description classes in FAO "Guidelines for Soil Profile Description".

5.2. Modifications to Crop Requirements for High Levels of Inputs

Possible consideration was elaborated initially to identify the requirements for each crop at each of three input levels. i.e. low, medium and high. As forseen for the different levels of input certain environmental deficiencies have to be overcomed or ameliorated at higher levels of inputs. e.g. discontinuation of drainage impedance by introducing drainage works, improvement of erosion hazard through soil conservation works etc.

Besides, phased introduction of the high level mechanization may call for more stringent environmental requirements.

At high inputs level as in settlements the following adjustments in the values of the land characteristics are made:-

Soil drainage (land equality drainage). For imperfect improve the suitability by one class i.e. N1 (Currently not suitable) becomes S3 (Marginally suitable) and S3 becomes S2 (moderately suitable) and S2 becomes S1 (highly suitable).

Stones and rock out crop (land quality management land preparation and mechanization potential).

Change the suitable ranges of most crops as follows:-

S1	None to fairly stony	(0-1% of the area)
S2	Fairly stony	(1-3% of the area)
S3	Stony	(3-10% of the area)
N1	Very stony	(15-50% of the area)
N2	Exceeding stony and Rubble	(Over 50% of the area)

This adjustmentis made on the basis that stones and rock outcrops impede land preparation and mechanization activities.

Slope angle (land quality-degradation hazard)

S1	Slopes of	0-8%
S2	"	" 8-16%
S3	"	" 16-30%
N1	"	" 30-50%
N2	"	" 50%+

The adjustment is made on the basis that at high inputs levels slope of 8-16% are moderately suitable for cultivation if provision is made to maintain the area through soil conservation works.

The environmental requirement for crop combination for Tedele/Harole Settlement Project is shown in tables of Appendix 2.

6. LAND RESOURCES MAP

6.1 General Description

The land evaluation methodology used in the preparation of the land-use plan is in accordance with theFAO framework evaluation (FAO-1976) and the FAO Agro-Ecological Zones (AEZ) project (FAO-1978). The development and proceeding to obtain the land resources basis for land evaluation a series of thematic maps were combined into a land resources map at 1:50,000 scale which has integrated information on Agro-climatology, Geomorphology and Soils.

They are the main indicaters for potential agricultural production. The land resources map involves the framework of the land resources inventory by consisting the necessary assemblage and integration of resources data to carry out a land suitability evaluation.

Thus, the main components of the land resources map are the thematic maps of thermal zones, lengths of growing periods geomorphology and soils.

Mapping of thermal zones (Tz) and lengths of growing periods (LGP) is

based on the methodology of the FAO Agro-Ecological Zone Project and ETH/82/010 Project. The fundamental data for Geomorphology and soils result from geomorphological interpretation of aerial photo and available surveys.

Field traverses and agro-climatic information eminated from landscape units roughly small groups of land systems.

6.2. Land Resources Units

The Matrix tables shown below was developed as part of a comprehensive Land Resources Map legend for the map units derived from the integration of information contained in the thematic maps described above.

However, a brief description with illustrative examples are presented to the user to help him understand the nature of LRU'S described on the map and the means by which thermatic data on thermal zones, length of growing periods and geomorphology and soils have been integrated to delinate them.

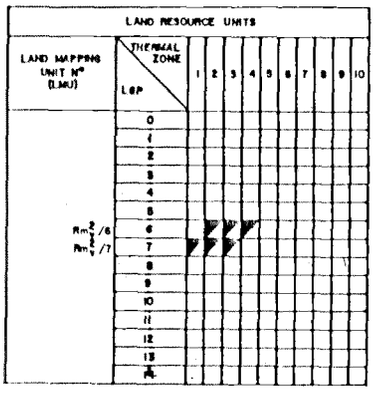
Legend for the mapunits derived from the integration of information contained in the thematic maps referred to above. A brief description and illustrated example follow, however, to assist the user in understanding the nature of LRU'S shown on the map and the means by which thematic data on thermal zones, lengths of growing periods, and geomorphology and soils have been integrated to delineate them. See appendix 4.

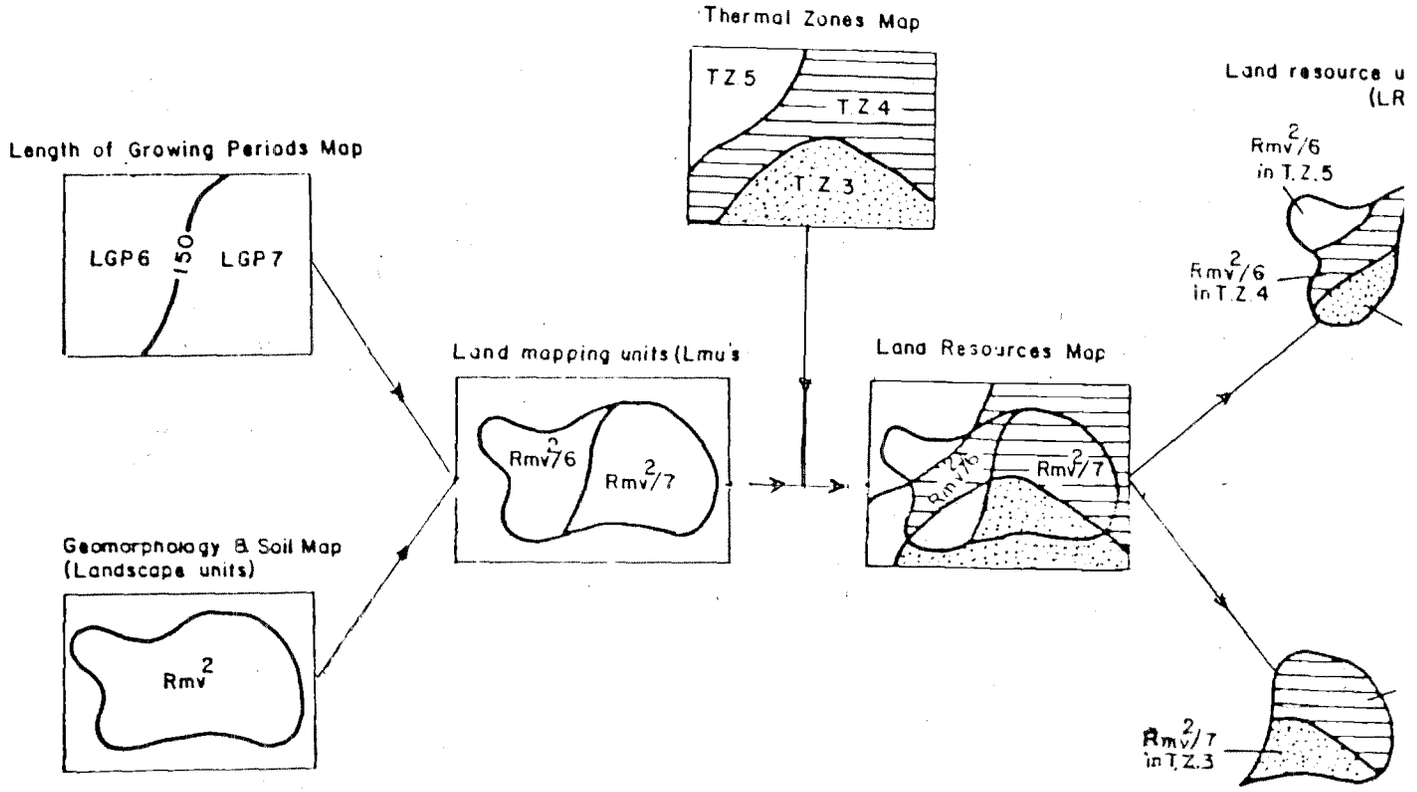
6.2.1 Land mapping units

The combination of landscape units from the Geomorphology and soils map and the various zones from the lengths of growing periods map. The symbols are comprised of two parts, for example $Rm^{2}_{V}/7$. The first part of the symbol, Rm^{2}_{V}, represents the landscape component, the second part, /7, represents the growing period zone. Both aspects are explained in more detail below.
See Land Resources Map 2.

Figure 3

Method of integrating thematic data and lad resources units





6.3 Explanation of Thematic map inputs

6.3.1 Thermal zones

Thermal zones are defined by mean daily temperature (in ^{O}C) during the growing season. The following relation between temperature and altitude was determined from data from155 meteorological stations,throughout country.

$T^{O}C = 30.20 - 0.0059 \times$ Altitude, $R^2 = 0.90$ Gradient = $0.59^{O}C$/100m rise.

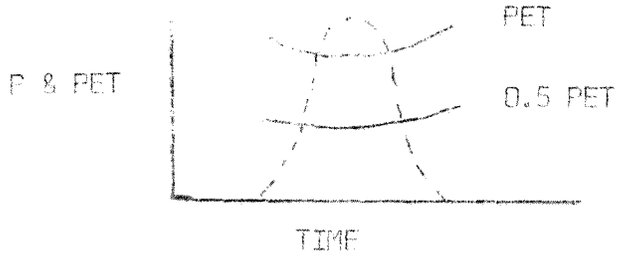
Thermal zone	Corresponding altitude in meters
10 < 7.5	> 3800
9 7.5 - 10.0	3400 - 3800
8 10.1 -12.5	3000 - 3400
7 12.6 - 15.0	2600 - 3000
6 15.1 - 17.5	2200 - 2600
5 17.5 - 20.0	1700 - 2200
4 20.1 - 22.5	1300 - 1700
3 22.6 - 25.0	900 - 1300
2 25.1 - 27.5	500 - 900
1 >27.5	< 500

6.3.2 Lengths of growing periods

The LGP's are closely related to altitude (temperature) and the mean annual rainfall, the latter in all its three attributes of amount, distribution, and pattern, two main types of LGP's were identified, normal and intermediate.

Normal 240

A normal growing period is defined as the period (in day) during a year when precipitation exceeds half the potential evapotranspiration (PET), plus a period required to evapotranspire an assumed 100 mm of water from excess percipitation (or less if not available) stored in the soil. Normal LGP's are common in humid areas of the country. The Tedele/Harole settlement project site of LGP's is 211 to 240 days.



For convenience of tabulation, LGP zones are assigned numerical codes as follows:

LGP zone (in days)	LGP zone code
0	0
1 - 45	1
46 - 60	2
61 - 75	3
76 - 90	4
91 - 120	5
121 - 150	6
151 - 180	7
181 - 210	8
211 - 240	9
241 - 270	10
271 - 300	11
301 - 330	12
331 - 364	13
365	14

6.4 Explanation of Landscape Units Legend

Landscape units, defined as mapping units which are reasonably homogenous with respect to geomorphology, soils and vegetation , have been delineated on this map. Manual interpretation of aireal photo 1:50, 000 scale existing survey, field surveys, agroclimatic information, and geologic and topographic maps have been used in the delineation and description of these landscape units. The symbols on the map represent on hierarchial classification

of landscape units. An explanation, with examples, of the operation of the classification follows:

(1) Six subdivisions, represented by the capital letters, reflect the genesis and form, i.e. the geomorphic types.

Alluvial	A	Volcanic	V
Deolian	D	Structural	S
Evaporite	E	Residual	R

(2) Subclasses of these geomorphic types are indicated by the first lower case letters. 'm in Rm^{2}_{g} refers to the subclass of the residual geomorphic type that is 'moderate to high relief hills'. 'b' in Ab' refers to the subclass of the alluvial geomorphic type that is 'basins and depressions with seasonal drainage deficiencies'. The full range of subclasses, or geomorphic units, is given below in the summary legend.

(3) Structural and residual landforms require a third character, the subscript lower case letter, which identifies the main parent material origin of the landform. Alluvial, aeolian, evaporite and volcanic landforms do not have this third character. The subscript letters are as follows:

Volcanic (basalts, tuffs, etc)	v
Felsic precambrian basement (gneisses, granites, etc)	g
Metamorphic precambrian basement (slates, schists, phyllites, etc)	m
Evaporite (predominantly gypsum)	e
Sandstone	s
Calcareous (predominantly limestone)	c

Such symbols are normally used alone but may be used together, for examp

$^{sh}c/g$, where parent materials are mixed and not easily separated at this scale of mapping.

(4) Geomorphic units are further subdivided on the basis of soil association which occur within them into final landscape units of the type described above. This final subdivision is represented by superscript numbers. The superscript number is absent where each occurrence of the geomorphic unit has the same soil association.

There are listed below in the legend, organized according to the general physiographic character of the landforms, for example, wetland, low to moderate relief hills and high plateaux in Tedele/Harole settlement site. See Land Resources Map 2.

6.4.1 Summary Legend

High to mountainous relief hills

Volcanic Landforms

Vh^1 — Degraded extinct central volcanoes, caldera remnants and associated forms of high to mountainous relief.

High plateaux

Volcanic Landforms

Vp^1 — Undulating high plateaux formed predominantly on pyroclastic deposits

Moderately dissected plateaux, plateaux with hills and rolling to Hilly plateaux

Volcanic Landforms

vj^1 — Moderately dissected sideslopes of extinct central volcanoes and other relic volcanic forms, often with small volcanic vent and cone remnants.

Moderate to High Relief Hills and Severely Dissected Sideslopes and Plateaux

Volcanic Landform

vx^1	Steep severely dissected sideslopes of extinct central volcanoes and other relic volcanic forms. Often with small volcanic vent and cone remnants.

(For detailed information on Landscape unit refer to Appendix 4)

6.5. Significant land facets

The specific features upon which the detailed descriptions of landscape units are based on the legend of the map are land facets.

Characteristics used to describe significant land facet

- Landscape Unit No
- Geomorphology
- Total area (Km^2)
- Significant land facet
- Area (%)
- Geology
- Slope range
- Dominant vegetation and/or land use
- Soil
  - FAO Classification
  - Colour (moist)
  - Texture
  - Drainage classes

Rock outcrop
Surface stones
Effective depth
pH
OM (Organic matter) %
CEC (Cation exchange capacity)
Available P
SMU No(Soil Management Unit)

The Description of landscape unit is presented in the appendix 4.

7. Land suitability classification map

7.1 Land suitability Evaluation

The results of the land suitability classifcation conducted in Tedele/Harole Settlement Project are presented in two main ways.

- Land suitability maps
- Land suitability classification tables

For the 6 crops considered within the rainfed agriculture, One (1) group combination 1:50 000 scale of land suitability maps have been prepared for the Tedele/Harole Settlement Project.

Similar land suitability maps for the forestry land utilization types and the livestock land utilization types have also been compiled at 1:50,000 scale. The second major result of the suitability classification is contained in appendix 2. Land suitability classification units in table 3.

Here, details of suitability limitations for S2 (moderately) S3 (marginally suitable), N1 (currently not suitable) and N2 (permanently not suitable) are indicated for all matchings involving these two classifications. No limitations are assumed present for these areas indicated as S1 and are thus not tabulated.

7.2 Land suitability classes

Suitability classes indicate degrees of suitability, within the order suitable (S). It is usual to recognize three classes, 'highly', 'moderately', and 'marginally' suitable. The following names and definitions may be

appropriate in a qualitative classification.

Class S1 Highly suitable

Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.

Class S2 Moderately suitable

Land having limitations which in aggregate are moderately serve for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained form the use although still attractive, will be appreciably inferior to that expected on class S1 land.

Class S3 Marginally suitable

Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.

Class N1 Currently not suitable

Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost, the limitations are so severe as to preclude successful sustained use of the land in the given manner.

Class N2 Permanently Not suitable

Land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner.

According to the land suitability evaluation detailed above 10,238 hectares of land in the area, comprising land suitability units 1, 2 and 7 have been recommended for cooperative farms and homestead production of crops adopted to the area, i.e. wheat, sorghum, maize and minor pulses, haricot beans

and sunflower. On the other hand 5,743 hectares, which combines all the other land suitability units are available 1,484 hectares for livestock grazing land and afforestation 1,519 hectares.

7.3 Land suitability subclass

Land suitability subclass reflect kinds of limitations, e.g. moisture deficiency, erosion hazard. Subclasses are indicated by lower-case letters with mnemonic significance, e.g. S2m S3m.

There are no subclasses in class S1

Examples of symbols are given below.

W	drainage deficiency
e	erosion hazard
p	management limitation
x	toxicity limitation
r	rooting condition deficiency

7.4 Land suitability units

The land in Tedele/Harole Settlement Project site has been evaluated for rainfed agriculture and classified into 10 suitability units.

Their distribution is indicated in map 3 land suitability classification map.

Table 3 Limitations and Recommended use of Land Suitability Classification in Tedele/Harole

Landscape Unit Symbol	Significant Land facet	Limitation	Recommended Use and Treatment	Land suitability classes
1	Undulating plateau 0-6% slopes.	Vertisols soil difficult to manage in wet season.	Cultivation of maize, teff, sorghum pepper. Haricotbeans and Noug. Fields to be on the contour cropping, grass strips every 30-50 m and grass water way along the depressions.	S1
7	Convex hills 8-16% slopes	Moderate erosion difficult to manage in wet season	Same as S1, but field to be on the contour crooping below 10% slope. More grass tips every 20-30 m and 10-16% of slope land with soil conservation (bench terrace and reducing slope percent down to 10%).	S2e
2	Marshy depression on 0-2 % slopes	Water logging and seasonal swamp	Grazing during dry season or horticulture for after draining. Soil needed drainage ditches every 50 m interval along the depression. After drain cultivation of cereals and pulses.	S2w
3	Small volcanic vent and cone remnant 8-16% slopes	Severe erosion	Some as S2, but narrow grass strips for better soil and moisture conservation best suitable to pasture improvement. After soil conservation (bench terrace) cultivation of cereals and pulses.	S3e
32 5 81	Small volcanic vent 6-30%, Cone remanant 30-50% and Inclined side slopes 16-30% on slopes	Severely eroded steep slopes moderate to shallow soil depth with stony phase	Afforestration and building materials and fuelwood plantation, grazing during the wet-season.	N1e

Land scape unit symbol	Significant Land facet	Limitation	Recommended use and treatment	Land suitability classes
4	Intermantance valleys on 0-5% slopes	Swampy, very irregular or sandy	Afforestration and building materials (micro basins) and grazing during the dry season.	N2w
82	Steep cut and/on severe eroded ravines30-50% + slopes	Very severe eroded Very steep slope with stony phase	Erosion controlled by hillside terrace and/or soil and stone bunds for afforestration in selected area.	N2e
6	Steep cut and/on severe eroded ravines, rocky 50%+slopes	Very severely eroded and gully land/or rocky	Afforestration in selected area. If large area keep in wieldlife conservation.	N2a

8. Development plan

The development plan incorporation at improvements most suited to the subwatershed and offering optimum benefit to the settlement, any activities that will improve or at least sustain production, on that is of benefit to the settlement, may be termed a development option. The options considered are those that will lead to improving or atleast sustaining agriculture, forestry or livestock production. Marketing and storing produce, together with water development (springs, farm ponds, dams and diversion weirs) are also considered. Farm management is considered as an essential continous input components such as reforestration or strip cropping established as a development input must be continued under a good farm management programme.

8.1 The development plan map

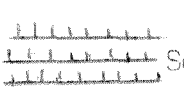
The development plan map and the table of inputs are the most important parts of the development plan. Plan to locate on the ground where the various soil and water conservation measures are to be built. Furthermore, the map is essential at the planner for determining the extent of the areas and volume of inputs required. Any development work that has been previously implemented should be transferred to the development map using the symbols as given in Table 4. It is important that the new plans are complementary to the existing work and that there is no duplication.

The additional development work, including maintenance or improvement of existing structures should be added to the plan. These areas are scheduled for soil or stone bunding, hillside terraces, micro basins, etc. The location of farm points, spring development, water storage dam, diversion weir, check dam are shown on the development plan map, using symbols as given in table 4. Thus the complete development map of the physical work is prepared development map, to a scale of 1:20,000, seen in Map 4.

Table 4 Legend for Development Plan Map

Legend	Detailed
Cu	Arable land (cultivated)
Gr	Grazing land
Fs	Forest/Shrubland
Wl	Wood land
Ro	Rockout crop/boulders
Fp	Forest planation
Rp	Range pasture
Nu	Nursary site
2w	Water logging
	Settlement site
	Road (with gravel all weather)
	Farm Road path
	Path
	Seasonal } --Rivers and water courses
	Permanent }
	Old dam
	Old Bridge
	School / Church

Development work and Improvmenet

	Soil and stone faced bunds
	Micro basins for afforestation

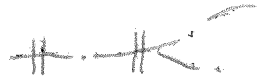
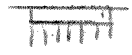
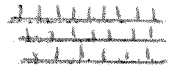
Legend	Detailed
	Check dam (Gully control)
	Channel Improvement
	Drainage water way and hill side drains
	New Bridge
	Pasture and range development
	Gully control
	Unit boundary
3	Unit Number
	Farm road
	Diversion weir
	Hill site terrace
	New dam

TABLE 5 Development Plan Work Components

Work Components	Unit LUN	1	2	3	4	5	6	7	9	10	Total
Present Land Use											
Cultivated land	1	1060	805	871	963	618	982	1354	1209	705	7567
Water logging	2	-	-	-	205	-	20	8	321	156	710
Grass land	31	228	-	-	-	-	-	-	-	-	228
Wood land	32	166	-	-	-	-	-	-	-	-	166
River valley	4	259	133	168	292	260	264	365	250	160	2151
Forest/shrub land	5	-	-	-	-	17	-	22	-	-	39
Steep cut or severly eroded	6	-	-	56	1034	-	-	-	-	-	1090
Mixed cultivated land	7	239	131	108	216	384	150	590	143	-	1961
Forest land/A	81	-	2	-	-	85	-	120	-	-	207
Eroded land	82	148	-	198	426	-	-	56	-	-	828
Range pasture	RP	-	-	26	-	-	-	-	156	-	182
Tree plantation	TP	-	-	-	-	-	-	-	23	-	23
Nursery	N	-	7	-	-	-	-	-	-	-	7
Settlement	H	130	88	80	160	110	71	70	53	60	822
Total	ha	2230	1166	1507	3296	1474	1487	1585	2155	1081	1598
Development plan											
Proposed cultivated Land		1299	934	969	1179	1002	1113	924	1315	675	941
Drainage improvement		-	-	-	205	-	20	8	321	156	710
Afforestration		296	76	84	146	232	132	324	148	80	1519
Natural grazing land		129	86	84	146	130	132	183	125	80	1074
Pasture improvement		228		26	-	-	-	-	156	-	410
Soil and stone bunds		148	-	198	426	-	-	56	-	-	828
Wield life conservation		-	-	56	1034	-	-	-	-	-	1090
Settlement		130	90	90	160	110	90	90	90	90	940
Total	ha	2260	1166	1507	3296	1474	1487	1585	2155	1081	1598
Check dam	site	9	5	7	19	19	-	19	7	9	94
Dams weir	site	1	1	-	-	1	3	-	-	1	7
Water way Hill site drains	km	-	4	9	11	2	3	5	10	2	47
Farm road improve	km	8	8	3	4	5	10	3	4	4	43
Food path	km	-	-	1	20	-	-	-	10	-	31
Channel improve	km	-	3	2	-	2	38	1	2	4	51

Proposed land use plan

Proposed land use	Present land use and landscape unit No
Cultivated land	1. Cultivated land (0-8%) 7. Mixed cultivated land with grassland (8-16%)
Drainage improvement (Micro basins)	3_2 Woodland (16-30%) 5 Forest shrub land (16-50%) 8_1 Forest land with accasia (16-30%) 4 River valleys, half of total area (0-50%) N Existing nursery TP Existing tree plantation
Natural grazing land	4 Intermantance valleys, half of total area (0-50%)
Pasture improvment	3_1 Grassland (8-16%) RP Existing range pasture
Wieldlife conservation	6 Steep cut or severely eroded revrines (50%)
Soil and stone bunds	8_2 Eroded land (30-50%+)
Settlement (homestead)	At present less than 90 ha of homestead, increased up to 90 ha. Unit 2, 3, 6, 7, 9, 10. area deduct from cultivated land.
Drainage improvement	2. Water logging and seasonal swamp (0-2%)

8.2 Engineering Measures for Soil and Water Conservation

Any measure that involves the physical movement of soil or stones, or requires construction, termed as an engineering measure. Usually, such measures are not complete in themselves and require the addition of a vegetative cover before becoming fully effective and permanent.

8.2.1 Soil and Stone Bunds

The construction of soil and stone bunds is an effective method retarding rainfall runoff and thereby reduce soil erosoion from arable and forest area. Well-maintained bunds will eventually develop in level bench terraces.

The bunds are constructed along the contour at intervals of 10 to 20 m apart andfrom 0.5 to 1.0 m in height. The distance apart and height will be dependent on the degree of slope and rainfall intensity.

8.2.2 Hillsite Terrace

Hillsite terrace may be considered as a closely spaced developed stone bunds. They are constructed on slope 30% and cover, where there is adequate soil depth and an abundence of stone. The width of these terrace should not be greater than 1½ to 2 m. while their height will vary from 0.5 to 10 m.

8.2.3. Gully Control

Units 4, 5, 6, 7 and 10 majority of the gullies, are of a modest size and can be easily protected by vegetative measures. In unit 2,3, and 9 the gullies are deep and extensive. In these areas, the revegetation must be supported by the construction of structures. Gullies are formed by a concentration of rainfall runoff flowing down a hillside. Frequently road culverts orworm foot paths and cattle tracks are the initial cause of a gully. Graded bunds hillside drains constructed without proper outlets may be another cause. Once established, a deep gully is exceedingly difficult to repair. Seldomist possible to do more stabilize its condition, thus preventing further growth. The gully control is stopping the overland flow to enter the gully. This must be done by diversion drains. Steep slope must be reduced to slopes less

than 1:1 ratio in order to facilitate the revegetation. The spoil will be put on the bottom of the gully, and strips of grass roads are placed across the gully at a distance 10-20m depending on the gully bottom slope. The grass roads (with roots) are to be found in the near vicinity of most gullies. Dimensions of the sods are 10x15 cms width of the grass strip in 20-30 cm. If grass strips across the gully are not sufficient, check dams must be constructed. They can be made of stones or wood (brush). Care must be taken with the application of these constructions, as they locally increase water velocities and thus the errosive force of the water. There are two many example of check dams which caused excessive errosion.

8.2.4 Grass Water Way

Interception ditches at the bottom of each row of plots will generally have a slight gradient towards grassed water ways. The uppermost interception ditch must be large enough to accept the considerable runoff from the ridge. The grassed water ways will convey the runoff down hill and terminate in natural depressions. If possible, they should be sited in a wide natural depression or gully shaped, so as to spread out the flow as widely as possible to reduce the velocity.

Excavated waterways will be needed where natural channels are absent. Where stone channel, debouches from the plots areas into the farm land, it should flare out into a grassed waterway.

In most cases, the internal roads or tracks which allow access to the row paths and to the farm land will be on the catchment divide. Since they run radiolly downslope, they will develop into gullies. Therefore, where these roads cross the interception ditches, they should be slightly humped i.e. the hump of the road is an extension of the ridge of the ditch, and runoff will be stopped by the hump and diverted into the ditch channel.

8.2.5 Check dams

Check dams are made to slow down excessive water velocity and to promote sedimentation. After introducing check dams the runoff to diminish the power of runoff so that it has less effect on vegetation. Although check dams are used to slow down the water speed and erosion, they locally increase them. Specially, the side slopes just above the checkdam and the bottom and sideslopes just downwards must be well protected.

A common error made is to hinder the runoff too much. The discharge capacity of the check dams must be as big as possible to diminish the risks of collapsing and meandering. Depending on risks, availability of money and materials, a lot of different types of checkdams exist.

For permanent use, checkdams will be of timber, masonny, rainforced concrete. Those checkdams can be made of stones, brush woods, burlap bags and

grass sods. All checkdams must be trenched at less 0.5 m in the reshaped gully banks and 0.25m into the gully bottom. Unless the gully is very deep (3m) checkdams must continued to the upper limit of the gully banks.

8.3. Vegetative and Agronomic measures for Soil and Water Conservation.

A good vegetative cover is a very effective method of controlling soil erosion. Unfortunately this cover, so valuable for the protection of the soil is constantly removed by man's activities. However, with some discipline, there are methods by which the cover can be maintained and at the same time provide a greater yield than of left to undisciplined exploitation. Ideally, vegetative measures for the control of soil erosion should, if practical, always take procedure over engineering measures. The fact that engineering work involves physical movement of the soil is, in itself creating an erosion hazard if it is not carefully carried out.

All agriculture activities must be aimed to diminish the amount of runoff, specially if gully formation took place. The first possibilities to minimize runoff are to plough in the proper direction and to adopt crops (for crop rotations) to the natural environment. If the amount of runoff is not decreased sufficiently by this measures, strip cropping and the construction of terraces must be considered. Special care must be taken around the gullies, must be given a good protection against erosion and runoff could be minimized by farmi the crops closely.

8.3.1 Tree planting

The long run objective of tree planting in the Tedele/Harole Settlement is to provide energy, construction materials, farming tools, fodder for the community and to prevent a further deterioration of the area.

Tree can be planted on steep slopes not suited for cultivation, for stablization of an area and to minimize erosion rates. The choice of exotic tree species will be after careful consideration of their adaptability for growth and their fitness for the purpose of plantation.

Tree planting is being carried out in the village, common service areas, along farm roads and gully dissected lands. In general, the area is without

forest cover which is needed to support the needs of the settlers for fuel wood, for fodder, construction poles etc. In previous years, thousand of trees were planted. However, due to natural circumstances such as the condition of the soil and the prevalence of drought and absence of cultivation practices after planting the aurvival rate has been below 50% (weeding, pest and disease control).

Proposed species for tree planting

A) Species for wood lot establishment

1. Acacia decurrens
2. Acacia aligna
3. Casuarina eqsistifolia
4. Cupressus luistanica
5. Eucalptus camaldulensis
6. Eucalyptus Saligna
7. Leuceana leucacephala

B) Species for the establishment of a system of wind break

1. Acacia decurrens
2. Albezia lebbek
3. Casuarina equistifolia
4. Cupressus luistanica
5. Melia azondrachta
6. Grevillea robusta

C) Species for soil conservation and improvement, bee flora, forage and fodder.

1. Acacia soligna
2. Cordia africana
3. Spathodes nilotica
4. Leuceana leucocephola
5. Sesbania aculata

8.3.2 On pasture and Grazing Land

Pasture and grazing lands comprise a small area in Tedele/Harole. These lands carry a large number of livestock, so large that overgrazing has taken near the surrounded settlement areas. This results in a fall in the quality and quantity of fodder, so fewer animals can be supported. The soil as left without a vegetation cover, thus prone to erosion by water and wind. Loss of topsoils through erosion reduce the fertility of the soil, and thus the likelihood of re-establishing a good quality pasture goes down. The land is with 8-36% slope with no worse than slightly eroded or irregular topography. The implication is that, it can be cropped from time to time in a long ley system to exploit the fertility build up without incurring excessive erosion penalties.

The unit 9 has about 156 ha of pasture land and fenced. The pasture management will probably require a system of rotational grazing and forage conservation. Access to pasture poss the problem of straying into field of growing crop. Desirable shade and browse trees should be planting in the pasture areas. Natural grazing that can be recommended will come from two classes of land. One is dissected slopes 16-36% slope land will provide the upland grazing in the wet season. Grazing must be done carefully, the more areas will need to be managed with care and needed strict grazing control. The depressional areas during the dry season. Don't graze the gully when the soil is wet or in the dry season, so that the vegetation is not damaged. During the wet season, cattle must not be allowed in the gully and sheeps and goats are preferred. Mowed grasses must be removed out of the gully, so that it does not hamper the runoff. It can be used as hay or mulch material. These areas could also be used for water storage in the future as suggested in water storage dams.

8.3.3 On cultivated land and Homestead plots

Apart from the physical structures for soil conservation, a number of agronomic measures can be used in combatting erosion on cultivated land and homestead plots. The methods directly increasing surface storage capacity would be tillage septems like contour cultivation, chiseling and ridging. Contour cultivation aims at intercepting the flow of water and spreading it across

the slope. Thus increasing the time for infiltration chiseling loosens the soil without turning it around, and while the infiltration is improved, the soil is left less susceptible to erosion than if it had been ploughed. Ridging, as done for sweet potatoes, shape the soil into micro basins which retain the water and leave it a longer time to infiltrate. Indirect methods of increasing infiltration rates are by the use of farmyard manure, green manure and crop residues, as well as by some types of minimum or zero tillage. The higher content of organic matter in the soil increases the infiltration by creating more stable aggregates less susceptible to splash erosion and by encouraging a higher porosity through higher biological activity. Ordinary agricultural methods for increasing productivity, i.e. supporting a higher plant population, like rotation systems and the use of fertilizer and manure, lead to increased vegetation cover and therefore can be said to have beneficial effects for soil conservation.

Slowing down the speed of the water on certain parts of the slope are strips cropping, narrow grass strips, residue or mulch lines and hedges. In a strip cropping system, contoured belts of crops inviting high erosion risk one alternated with belts of crops with low erosion risk. Narrow grass strips, much line or hedges used for building up a terrace. The strip slows down the speed of the water and the soil settles in the bund. Therefore a terrace slowly develops. The process can be enhanced by the farmer ploughing up soil to the bund from both sides when cultivating.

It is important that the plots be equal in size according to the settlement model and allocated by the producers cooperative. Since the plots are intended to be cultivated intensively for supplement food and obtain cash for the family, vegetable garden, fruit trees, raising poultry, etc. Unfavourable soil should be identified by a soil survey in advance and not used for plots on, extra area should be allowed.

Unless the topography is very even, plot dimensions will not be uniform, generally narrower at the upper end. Plot dimensions should aim to be 40-50 long 20-25m wide, but there is no hard and fast rule and the length is dependent on the distance required between interception ditches which protect the upper

end of each plot from runoff from the plot above. These ditches will run on the contour or a slight gradient and will generally not be parallel to each other. Therefore, the plot lengths will vary and plot widths will also vary in accordance. Paths along each row of plots run below the ridge of the interception ditch.

The advantage of more frequent ditches is that they receive small volumes of runoff and hence can be of smaller gradient and allow opportunity for runoff to infiltrate in the ditch itself. In this case, trees planted on the ridge would benefit from the improved moisture regime.

8.4 Water Development and Control Measures

Although some components of water development are not directly related to soil conservation, this aspect of subwater shed management and development is considered particularly important. The development of a farm pond or spring reduces the movement of livestock for watering, this will immediately result in less erosion.

The more movement of livestock destroys vegetation, and their worn tracks are frequent cause of gully erosion. A good source of clean water is essential for the health of the settlers. Furthermore, if the source can be made available close to homesteads, much time will be saved for more productive work than collecting water.

Both rivers Kulit and Dargaa are perennial and have good potential for irrigation and water supply for human and livestock use. Units 1. 2. 4. 5 and 7 get water for drinking from these two rivers and Units 2 and 5 irrigate their horticultural farms from the Kulit River. It is proposed that the nurseries that will be established for the settlement will get water by pumping or division weires from these rivers. Ground water table seems to be very shallow, Units 3. 6. 9 and 10 get water for drinking from dug wells using hand pumps.

8.4.1 Farm Ponds, Dams and Wells

In Tedele/Harole there are seasonal and perennial rivers and have good potential for farm ponds and dams and wells. The consturction of those facilities

should be considered as part of the development programme. Idealy, the ponds and dams should be located in natural depressions where the soil is impervious, or an impervious layer can be spread on the bottom. Seepage losses will therefore be small, and if the ponds and dams are relatively deep to their surface area, evaporation loss will be reduced.

- Pollution of the ponds by livestock is a serious problem. Fencing to keep the animal out of the pond, be made to pipe the water from the pond to nearby water trough.
- The siltation of ponds and dams. Generally, ponds and dams are constructed across natural water courses. Care has to be taken the spillaway is of adequate size to accommodate the runoff from the catchment area. The capacity of the reservoir (dam up to 8 m in height, dependent on the size of the dam) should be consistent with the volume of runoff. A disproportionately large catchment will require a large spillway, and the heavier silt load will more quickly reduce the capacity of the reservoirs.

Where the water table is less than 2 or 3m deep, the consturction of wells may provide a good water supply for domestic and livestock needs.

8.4.2. Diversion Weirs

Diversion weirs are structures, usually concrete, built across either permanent or seasonal rivers to divert river flow into a channel. No water storage of the river flow is intended, although sometimes the structure raises the water in the river to facilitate its diversion into a channel. Weirs may be constructed to divert flow for irrigation purposes and to fill pools and sometimes dams in adjacent catchments. Unit 2 has a good potential sites for diversion weir from perennial river Kulit, get water for irrigation of nursery and horticultural.

8.4.3 Swamp Drainage Water logging

Experience with the drainage problems is rather limited as the majority of the unit management, which are more than average rainfall. Most problems are

related to maize, that changed its colour (becoming yellow) during the months June and July. This changing of colour can be the symptom of an unbalanced nutrient uptake due to the excess water in/on the soil. Other problems were that going in the field was very difficult or impossible for man (July-mid August) and for tractors July August,mid September). Unit 9. 10. 4 has been waterlogging for 30 days on the fields. The introduction of a surface drainage system will solve partly the above mentioned problems. The presence of furrows related to row drilling, facilitates the overland flow and weeding, which favorate both crop performance.

Accessibility of the fields for men can be improved by drainage, but the use of wheel tractors in these clays during the rainy season will always be troublesome. The use of wheel tractors is even to dissuade, as destruction of soil structure is nearly inevitable in these conditions.

8.5 Other measures

The principal soil and water conservation measures that might be required in an subwatershed development programme have been outlined in the three subsections above. These are the measures that will lead to improving or at least sustaining yields. However, in order to obtain the maximum benefits from the soil and water conservation inputs and satisfy the integrated approach to settlement development, other measures are required. Listed below are some of the measures not directly related to soil and water conservation but all closely connected with agriculture output, and these should be considered in the formulation of the development plan.

However, in other circumstances other development options may be appropriate, such as sericulture (silk production), apiary (bee keeping), and aquaculture (fish farming). Marketing, Food storage and Energy conservation.

8.5.1 Access Roads and Tracks

Remote and inaccessible areas are difficult to develop. Ease of access to and from the farmland is an essential requirement when the settlers are to be reached by the extension service or by education and health schemes. As road

construction is a frequent cause of landslide and gully erosion, particular care should be taken over their alignment.

The improvement of tracks should not be overlooked. In some areas these are vital for the movement of people and pack animals. As in the case of roads, tracks are a common cause of gully erosion. Any accumulation of runoff along the track should be channelled away at frequent intervals. Critical lengths and possibly these on relatively steep grades may have to rock-paved in order to prevent erosion.

Appendix I

Photo-Interpretation and Soil Survey Mapping Legend

SOIL DEPTH (ALL LANDS)

Symbol	Range (Cms.)	Descriptive Term
5	less than 25	Very shallow
4	from 25 - 50	Shallow
3	from 50 - 100	Moderate
2	from 100 - 150	Deep
1	more than 150	Very deep

TEXTURE (ALL LANDS)

Symbol	Descriptive Term for Texture Group	Included Texture Classes
	Fine (light)	Clay (c) Sandy clay loam (scl) Salty clay loam (sicl) Clay loan (cl)
	Medium	Silt loam (sil) loam (l) Very fine sandy laom (vfsl)
	Course (light)	Fine sand loam (fsl) Sandy laom (sl) Loamy fine sandy (lfs)
	Very coarse (very light)	Loamy sand (ls) sand (s) Course sand (cos)

COARSE FRAMEMENTS: (DIT LAND)

a) Gravel, cobble, and other coarse framements will be mapped when they occur in sufficient amounts to influence land use. They will be shown as textural modifiers of the present top soil as follows:

Mapping Symbol	Descriptive Term	Size Range (diameter)
g	Gravelly	up to 3"
c	Cobbly	3" to 10"
s	Stone	10" to moveable
r	Rock	unmoveable

b) Quantity of course fragments will be mapped in accordance with the amounts shown in the following table:

Mapping Symbol	% gravel by volume	% cabble volume	% stone by volume	% rock by volume
g c	30 - 50	30 - 50		
Vg Vc	50 - 90	50 - 90		
S1			30 - 50	
S2			50 - 70	
S3			70 - 90	
R				10 - 50
700				50 - 100

c) Areas containing more than 90% of coarse fragments and more than 50% Rocky will be place into an appropriate miscellaneous land type.

COARSE FRAGMENTS : (ALL LAND)

a) Coarse fragments for soil classed as to series will be denoted as follows:

SIZE OF FRAGMENTS			
3" - 10" in diameter		More than 10" in diameter to moveable	
Class	% by Volume	Class	% surface area Occupied by rock
S1	30 - 50		
S2	50 - 70	R	10 - 50
S3	70 - 90	700	50 - 100

b) Areas having surface rock outcropping and/or accumulations of loose, detached rock fragments (greater than 10 inches in diameter) in excess of 50% will be classed as Colluvial Rock land. (See Miscellaneous Land Types, T.M. SS-5)

c) The "S" and "R" symbols, when mapped, will follow the depth class symbol.

PERMEABILITY (ALL LANDS)

Sumbol	Permeability Class	Probable Texture	Probable Structure	Spproximate Per Rate Cm
2	Slow	fine (heavy)	pr, abk, pl	0.13 to 0.5
3	moderately slow	fine medium	pr, abk	0.5 to 2.0
4	moderate	medium	pr, s	2.0 to 6.3
5	moderately rapid	coarse	sbk, gr, cr	6.3 to 12.5
6	rapid	very coarse	cr, sg	12.5 to 25.0

Parent Material

This item should include information on the origin of the parent material and, where possible, on the nature of the parent rock(s).

Type & Underlying Material will always be shown regardless of depth of soil material (All Lands).

Symbol	Description
v	Volcanic (basalts, tuffs, etc)
g	Felsic Precambrain basement (gneisses granites, etc.)
m	Metomorphic Preceambrain basement (slates, sehists, phyllites, etc.)
e	Evaporite (predominantly gypsum)
s	Sandstone
c	Calcareous (Predominantly limestone)

Slope (ALL LANDS) Both class and degree of slope will be mapped.

Example:

Degree..... $\frac{\text{Scil}}{\text{12 Cl - Erosion}}$

Class Symbol	Degree in % slope	Descriptive Term
A	0 - 2	Flat or almost flat
B	2 - 8	Gently slopping
C	8 - 16	Slopping
D	16 - 30	Moderately Steep
E	30 - 50	Steep
F	50 +	Very Steep

Erosion (All Lands)

Symbol	Description Term	
1	None to slight erosion	Less than 25% of original top soil removed
2	Moderate erosion	From 25 to 75% of original top soil removed; occasional gullies may be present.
3	Severe erosion	From 75% of original top soil to 25% subsoil removed; occasional deep gullies or frequent shallow gullies may be present.
4	Very severe erosion	All of original topsoil and 25% to 75% of subsoil removed.
GL1	Slightly & moderately Gully land	An intercate network of very frequent moderately gullies are present. The soil has been eroded to the extent that all or practically all of the original surface soil, or A horizon, has been removed. (This GL1 will be practiced only planting trees & grass).
GL2	Deep Gully land	An intericate network of very frequent deep gullies are present. Soil profiles have been destroyed except in small areas between gullies. (This GL2 will be practiced planting trees, and structures).
EMP	Exposed parent material and/or	Areas consisting of exposed parent material and/or rock resulting from the complete, removal of all of the original topsoil and subsoil by natural processes where attributed to man-induced processes, it will be differentiated by placing the symbol in arenthesis.

Presence of Salt or Alkali

Exact classification of saline, alkali and saline-alkali soil conditions must be based on laboratory data, but the following simple classes, as defined in the Soil Survey Manual, can usually be distinguished in the field and can be included with advantage in a field soil description:

Class 0	Soils free of excess salt or alkali. Practically no crops are inhibited by, or show evidence of injury from excess salts or alkali.
Class 1	Soils slightly affected by salt or alkali. The growth of sensitive crops is inhibited but that of salt-tolerant crops may not be.
Class 2	Soils moderately affected by salt or alkali. Crop growth is inhibited and no crop does well.
Class 3	Soils strongly affected by salt or alkali. Only a few kinds of plants survive.

Where conductivity measurements are available, the following classes of salinity, as defined in the Soil Survey Manual, can be recognized.

Approximate Limits of Salinity Classes

Class	Conductivity of Saturation extract in millionhos per cm^2
Class 0 : Free	0 - 4
Class 1 : Slightly affected	4 - 8
Class 2 : Moderately affected	0 - 15
Class 3 : Strongly affected	above 15

Drainage

The following definitions for soil drainage classes for use in soil profile description are derived directly from the Soil Survey Manual:-

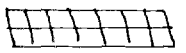
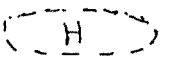
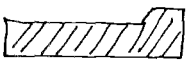
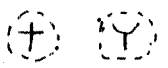
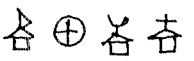
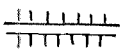
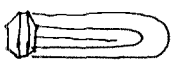
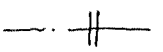
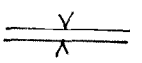
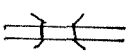
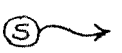
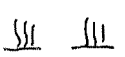
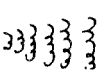
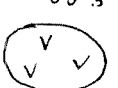
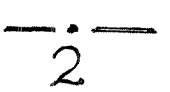
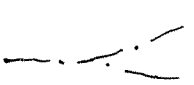
Class 0 Very Poorly Drained - water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded.

Class 1 Poorly Drained - water is removed so slowly that the soil remains wet for a large part of the time. The water table is commonly at or near the surface during a considerable part of the year. Poorly drained conditions are due to a high water table, to a slowly permeable layer within the profile, to seepage, or to some combination of these conditions.

Class 2 Imperfectly Drained - water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Imperfectly drained soils commonly have a slowly pereable layer within the profile, a high water table, additions through seepage, or a combination of these conditions.

Class 3 Moderately Well Drained - water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant part of the time. Moderately well drained soils commonly have a slowly permeable layer within or immediately hebeath the solum, a relalively high water table, additions of water through seepage, or some combination of these conditions.

Special Features

Symbol	Description
	Tukul Settlement
	Village
	Town, Public Buildings
	Cemetry: Christian, Moslem
	School, Hospital, Mosque, Church
	Levee
	Dam, Reservoir
	Check Dam, Gully plug
	All weather raods
	Farm Roads
	Culvert
	Bridge
	Perennial streams
	Lake or pond
	Spring
	Wells or water tanks
	Swemp or march
	Lava flow
	Outcrop Rock
	Cliff
	Escarpment
	Sand dunes
	Unit boundary
2	Unit Number
2	Landscape Unit Number
Ⓢ A-1-5	Location of major soil samples Reference Numbers
	Seasonal streams

Land Use

Symbol	Description
F	Forest
T	Thicket
Ba	Bamboo
P	Plantation
R	Riverine forest
EW	Eucalyptus, Woodland
S	Scrub
Sc	Scattered Trees
L	Cultivated Land without Conservation
Lc	Cultivated Land with Conservation
B	Bareland
G	Grassland
EPM	Exposed Parent Material
GL1	Moderate Gully Erosion
GL2	Severe Gully Erosion
A	Strongly Affected Salts andAlkali
—— .. ——	Ridge
→ → →	Grass water way
- - - - - -	Food path
N	Nursery

ENVIORNMENTAL REQUIREMENT FOR CROP CHILLI PEPPER

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME	Altitude	m	1000 – 2000	1000 – 800	800 – 700	700 – 600	< 600
					2000 – 2200	2200 – 2300	2300 – 2400	> 2400
		Mean Temperature (Thermal Zone)	°C	18 – 24	15 – 17	12 – 14	8 – 11	< 8
					25 – 28	29 – 31	32 – 35	> 35
2	GROWING PERIOD	Length of Growing Period	day	150 – 240	150 – 140	140 – 130	130 – 120	< 120
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	100 – 150	50 – 150	25 – 50	10 – 25	< 10
		Growth cycle	day	220 – 240	~~200 – 220~~	~~180 – 200~~	170 – 180	< 170
4	DRAINAGE	Soil Drainage	class	W	MW	I – P	P – SW	VP – E
					SW	SW		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	18 – 24	15 – 17	12 – 14	8 – 11	< 8
					25 – 28	29 – 31	32 – 35	> 35
		Length of Growing Period	day	150 – 240	150 – 140	140 – 130	130 – 120	< 120
		Soil Texture	class	LS – CL	SiCl	SC	SiC – C(b1)	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 – 8	8 – 16	16 – 30	30 – 35	> 35
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	LS – CL	SiCl	SC	SiC – C(b1)	S
		Soil Reaction	pH	6.5 – 7.0	6.5 – 6.0	6.0 – 5.0	5.0 – 4.5	< 4.5
					7.0 – 7.5	7.5 – 8.0	8.0 – 8.5	> 8.5
		Organic Matter	%	3 – 6	3 – 2 6.0 – 7.5	2 – 1 7.5 – 9.0	1 9.0 – 10.0	> 10
7	ROOTING CONDITION AND WORKABILITY	~~Effective Soil Depth~~	cm	100 – 150	50 – 100	25 – 50	10 – 25	< 10
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				HIGHLY S_1 SUITABLE	MODERATELY S_2 SUITABLE	MARGINALLY S_3 SUITABLE	CURRENTLY N_1 N.S	PERMANENTLY N_2 N.S
8	TOXICITIES	Salinity	mmhos/cm	0 – 4	4 – 8	8 – 12	12 – 15	>15
		Alkalinity	ESP	0 – 6	6 – 10	10 – 13	13 – 15	>15
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0 – 8	8 – 16	16 – 30	30 – 35	>35
		Staniness	Class	None	fairly stony	stony	very stony	exceeding stoney
		Soil Texture	Class	LS – CL	SiCl	SC	SiC – C(61)	S

No	LAND QUALITY	LAND CHARACTERISTIC	CI	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GEAMINATION AND ESTABLISHMENT	Seed-bed Preparation	VH – Very high energy required H – High " M – Medium " L – Low " VL – Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I – Intolerant M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost sensitivity	S – Sensitive M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
		Hail Sensitivity	S – Sensitive M – Medium	Sorghum Maize	S S	chickpea pepper	T M

ENVIORNMENTAL REQUIREMENT FOR CROP CHILLI PEPPER

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat Teff Haricot beans	M T M	Noug Seasame Sunflower	T T S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum Maize Wheat Pepper Teff	M L H VL L	Chickpea Noug Seasame	L L L
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Moderately T – Tolerant	Sorghum Maize Wheat Teff Haricot beans	M S M M S	Chickpea Pepper Noug Seasame Sunflower	S M S M S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum Maize Wheat Teff Haricot beans	L M L Not Know Not Know	Chickpea Pepper Noug Seasame Sunflower	L Not Know " " "
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low work input required M – Medium " H – High "	Sorghum Maize Wheat Teff Haricot beans	H M H H M	Chickpea Pepper Noug Seasame Sunflower	M L H H H
17	WORKABILITY	Mechanized farming (general)	L – Low M – Medium H – High	Sorghum Maize Wheat Teff Haricot beans	H H H M H	Chickpea pepper Noug Seasame [illegible]	H L L L L

ENVIORNMENTAL REQUIREMENT FOR CROP HARICOT BEANS

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME	Altitude	m	1400 – 1800	1400 – 1200	1200 – 1100	1100 – 1000	<1000
					1800 – 1900	1900 – 2000	2000 – 2100	>2100
		Mean Temperature (Thermal Zone)	°C	21 – 25	15 – 20	10 – 14	7 – 9	<7
					26 – 28	29 – 31	31 – 35	>35
2	GROWING PERIOD	Length of Growing period	day	100 – 120	90 – 100 120 – 130	80 – 90 >130	70 – 80	<70
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	50 – 100	25 – 50	10 – 25	<10	–
		Growth cycle	day	100 – 120	90 – 100	80 – 90	<10	–
					120 – 130	>130		
4	DRAINAGE	Soil Drainage	class	MW – W	I	I	? – ?	=
					SE	P		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	20 – 22.5	20 – 19	19 – 18	18 – 17.5	<17.5
					22.5 – 23	23 – 24	24 – 25	>25
		Length of Growing period	day	100 – 120	90 – 100 120 – 130	80 – 90 >130	70 – 80	>70
		Soil Texture	class	SL – CL	LS	C (rd)	C (bl)	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 – 8	8 – 16	16 – 30	30 – 35	>35
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	SL – CL	LS	C (rd)	C (bl)	S
		Soil Reaction	pH	5.5 – 6.7	5.5 – 5.3	5.3 – 5.0	5.0 – 4.7	<4.7
					6.7 – 7.0	7.0 – 7.3	7.3 – 7.6	>7.6
		Organic Matter	%	>3	3 – 2	2 – 1	1 – 0	–
	ROOTING CONDITION AND	Effective Soil Depth	cm	50 – 100	25 – 50	10 – 25	<10	–
								exceeding stony

ENVIRONMENTAL REQUIREMENT FOR CROP HARICOTBEANS

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				HIGHLY S1 SUITABLE	MODERTLY S2 SUITABLE	MARGINALLY S3 SUITABLE	CURRENTLY N1 N.S	PERMANENTLY N2 N.S
8	TOXICITIES	Salinity	mmhos/cm	0 – 1	1 – 1.5	1.5 – 2	2	>2
		Alkalinity	ESP	0 – 5	5 – 8	8 – 10	10 – 12	>12
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0 – 8	8 – 16	16 – 30	30 – 35	> 35
		Staniness	Class	None	fairly stony	stony	very stony	exceeding stony
		Soil Texture	class	SL – CL	" LS "	C (rd")	"C (bl)	S

No	LAND QUALITY	LAND CHARACTERISTIC	CI	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GERMINATION AND ESTABLISHMENT	Seed-bed Preparation	VH – Very high energy required H – High " M – Medium " L – Low " VL – Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I – Intolerant M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost Sensitivity	S – Sensitive M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
			S – Sensitive	Sorghum	S	Chickpea	T

ENVIORNMENTAL REQUIREMENT FOR CROP HARICOT BEANS

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat Teff Haricotbeans	M T M	Noug Seasame Sunflower	T T S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum Maize Wheat Pepper Teff	M L H VL L	Chickpea Noug Seasame	L L L
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Moderately T – Tolerant	Sorghum Maize Wheat Teff Haricotbeans	M S M M S	Chickpea Pepper Noug Seasame Sunflower	S M S M S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum Maize Wheat Teff Haricotbeans	L M L Not Know Not Know	Chickpea Pepper Noug Seasame Sunflower	L Not Know " " "
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low work input required M – Medium " H – High "	Sorghum Maize Wheat Teff Haricotbeans	H M H H M	Chickpea Pepper Noug Seasame Sunflower	M L H H H
17	WORKABILITY	Mechanized faming (general)	L – Low M – Medium H – High	Sorghum Maize Wheat Teff Haricotbeans	H H H M H	Chickpea pepper Noug Seasame Sunflower	H L L L L

ENVIORNMENTAL REQUIREMENT FOR CROP SCQ = T - M

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME	Altitude	m	1500 - 2200	1500 — 1400	1400 — 1300	1300 — 1200	< 1200
					2200 - 2270	2270 — 2350	2350 — 2400	> 2400
		Mean Temperature (Thermal Zone)	°C	18 — 23	14 — 17	37 30	31 35	< 15
					24 — 26			> 35
2	GROWING PERIOD	Length of Growing Period	day	180 — 240	170 — 180	160 — 170	150 — 160	< 150
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	> 150	150 — 100	100 — 50	50 - 25	< 25
		Growth cycle	day	200 — 250	180 — 200	160 — 180	140 — 160	< 140
					250 — 270	> 270		
4	DRAINAGE	Soil Drainage	class	MW — W	I — P	P — VP	VP — E	SE — E
					W — SW	SW — C		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	18 — 23	14 — 17	37 - 30	31 - 35	< 15
					24 — 26			> 35
		Length of Growing Period	day	180 — 240	180 — 170	170 — 160	160 — 150	< 150
		Soil Texture	class	L — SC	LS — SL	Sic — C (61)	C (rd)	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 — 8	8 — 16	16 — 30	30 — 50	> 50
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	L — SC	LS — SL	Sil — C (61)	C (rd)	S
		Soil Reaction	pH	6.5 — 7.0	6.5 — 6.0	6.0 — 5.0	5.0 — 4.5	< 4.5
					7.0 — 7.5	7.5 — 8.0	8.0 — 8.5	> 8.5
		Organic Matter	%	3 - 6	3 — 2 / 6.0 — 7.5	2 — 1 / 7.5 — 9.0	9.0 — 10.0	> 10.0
7	ROOTING CONDITION AND WORKABILITY	Effective Soil Depth	cm	> 150	150 — 100	100 — 50	50 — 25	< 25
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Soil Texture	class	L — SC	LS — SL	Sic — C (61)	C (rd)	S

ENVIORNMENTAL REQUIREMENT FOR CROP SORGHUM

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				HIGHLY S1 SUITABLE	MODERTLY S2 SUITABLE	MARGINALLY S3 SUITABLE	CURRENTLY N1 N.S	PERMANENTLY N2 N.S
8	TOXICITIES	Salinity	mmhos/cm	0-4	4-8	8-12	12-15	>15
		Alkalinity	ESP	0-6	6-10	10-13	13-15	>15
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0-8	8-16	16-30	30-50	>50
		Stoniness	Class	None	fairly stony	stony	very stony	Exceeding stony
		Soil Texture	Class	L-SC	LS-SL	SiC-C(bl)	C(rd)	S

No	LAND QUALITY	LAND CHARACTERISTIC	CL	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GERMINATION AND ESTABLISHMENT	Seed-bed Preparation	VH - Very high energy required H - High " M - Medium " L - Low " VL - Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I - Intolerant M - Medium T - Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost Sensitivity	S - Sensitive M - Medium T - Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
						Chickpea	T

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat	M	Noug	T
				Teff	T	Seasame	T
				Haricotbeans	M	Sunflower	S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum	M	Chickpea	L
				Maize	L	Noug	L
				Wheat	H	Seasame	L
				Pepper	VL		
				Teff	L		
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Moderately T – Tolerant	Sorghum	M	Chickpea	S
				Maize	S	Pepper	M
				Wheat	M	Noug	S
				Teff	M	Seasame	M
				Haricotbeans	S	Sunflower	S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum	L	Chickpea	L
				Maize	M	Pepper	Not Know
				Wheat	L	Noug	"
				Teff	Not Know	Seasame	"
				Haricotbeans	Not Know	Sunflower	"
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low work input required M – Medium " H – High "	Sorghum	H	Chickpea	M
				Maize	M	Pepper	L
				Wheat	H	Noug	H
				Teff	H	Seasame	H
				Haricotbeans	M	Sunflower	H
17	WORKABILITY	Mechanized faming (general)	L – Low M – Medium H – High	Sorghum	H	Chickpea	H
				Maize	H	pepper	L
				Wheat	H	Noug	L
				Teff	M	Seasame	L
				Haricotbeans	H	Sunflower	L

ENVIORNMENTAL REQUIREMENT FOR CROP MAIZE

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME.	Altitude	m	1300 – 2200	1300 –1200	1200 – 1100	1100 – 1000	< 1000
					2200–2270	2270 –2350	2350 – 2400	> 2400
		Mean Temperature (Thermal Zone)	°C	18 – 23	14 – 17	~~27 30~~	~~31 36~~	< 14
					24 – 26			> 35
2	GROWING PERIOD	Length of Growing Period	day	210 – 150	150 – 140	140 – 130	130 – 120	< 120
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	> 150	150 – 100	100 – 50	50 – 25	< 25
		Growth cycle	day	160 – 170	150 – 160	140 – 150	130 – 140	< 130
					170 – 180	> 180		
4	DRAINAGE	Soil Drainage	class	I – W	I – P	P – VP	~~VP – E~~	~~VP – E~~
					W – SW	SW – E		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	18 – 23	14 – 17	~~27 – 30~~	~~31 – 36~~	< 14
					24 – 26			> 35
		Length of Growing Period	day	210 – 150	150 – 140	140 – 130	130 – 120	< 120
		Soil Texture	class	L – SC	LS – SL	SiC – C (rd)	C (bl)	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 – 8	8 – 16	16 – 30	30 – 50	> 50
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	L – SC	LS – SL	SiC – C(rd)	C(bl)	S
		Soil Reaction	pH	6.5 – 7.0	6.5 – 6.0	6.0 – 5.0	5.0 – 4.5	< 4.5
					7.0 – 7.5	7.5 – 8.0	8.0 – 8.5	> 8.5
		Organic Matter	%	3 – 6	3 – 2 / 6.0 – 7.5	2 – 1 / 7.5 – 9.0	9.0 – 10.0	> 10.0
7	ROOTING CONDITION AND WORKABILITY	Effective Soil Depth	cm	> 150	150 – 100	100 – 50	50 – 25	< 25
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony

ENVIORNMENTAL REQUIREMENT FOR CROP MAIZE

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				HIGHLY S_1 SUITABLE	MODERTLY S_2 SUITABLE	MARGINALLY S_3 SUITABLE	CURRENTLY N_1 N.S	PERMANENTLY N_2 N.S
8	TOXICITIES	Salinity	mmhos/cm	0 – 4	4 – 8	8 – 12	12 – 15	>15
		Alkalinity	ESP	0 – 6	6 – 10	10 – 13	13 – 15	>15
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0 – 8	8 – 16	16 – 30	30 – 50	>50
		Staniness	Class	none	fairly stony	stony	very stony	exceeding stony
		Soil Texture	class	L – SC	LS – SL	Sic – C(rd)	C (bl)	S

No	LAND QUALITY	LAND CHARACTERISTIC	CI	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GEAMINATION AND ESTABLISHMENT	Seed-bed preparation	VH – Very high energy required H – High " M – Medium " L – Low " VL – Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I – Intolerant M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost sensitivity	S – Sensitive M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
		Hail Sensitivity	S – Sensitive M – Medium	Sorghum Maize	S S	Chickpea pepper	T M

ENVIORNMENTAL REQUIREMENT FOR CROP MAIZE

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat	M	Noug	T
				Teff	T	Seasame	T
				Haricot beans	M	Sunflower	S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum	M	Chickpea	L
				Maize	L	Noug	L
				Wheat	H	Seasame	L
				Pepper	VL		
				Teff	L		
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Moderately T – Tolerant	Sorghum	M	Chickpea	S
				Maize	S	Pepper	M
				Wheat	M	Noug	S
				Teff	M	Seasame	M
				Haricot beans	S	Sunflower	S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum	L	Chickpea	L
				Maize	M	Pepper	Not Know
				Wheat	L	Noug	"
				Teff	Not Know	Seasame	"
				Haricot beans	Not Know	Sunflower	"
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low work input required M – Medium " H – High "	Sorghum	H	Chickpea	M
				Maize	M	Pepper	L
				Wheat	H	Noug	H
				Teff	H	Seasame	H
				Haricot beans	M	Sunflower	H
17	WORKABILITY	Mechanized faming (general)	L – Low M – Medium H – High	Sorghum	H	Chickpea	H
				Maize	H	pepper	L
				Wheat	H	Noug	L
				Teff	M	Seasame	L

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME	Altitude	m	1700 – 2300	1700 – 1500	1500 – 1300	1300 – 1000	< 1000
					2300 – 2500	2500 – 2600	2600 – 2800	> 2800
		Mean Temperature (Thermal Zone)	°C	15 – 20	14 – 12	~~25 – 28~~	~~29 – 35~~	< 10
					21 – 24			> 35
2	GROWING PERIOD	Length of Growing Period	day	90 – 120	90 – 70	70 – 60	60 – 45	< 45
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	> 50	50 – 25	25 – 10	15 – 10	< 10
		Growth cycle	day	100 – 120	100 – 90	90 – 80	80 – 70	< 70
					120 – 130	> 130		
4	DRAINAGE	Soil Drainage	class	I – W	I – P	P – VP	VP	~~SE – E~~
					W – SW	SW – E		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	15 – 20	12 – 14	~~25 – 28~~	~~29 – 35~~	< 10
					21 – 24			> 35
		Length of Growing Period	day	90 – 120	90 – 70	70 – 60	60 – 45	< 45
		Soil Texture	class	Sil – C(bl)	L – SL	CL – C(bl)	SL	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 – 8	8 – 16	16 – 30	30 – 50	> 50
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	Sil – C(bl)	L – SL	CL – C(bl)	SL	S
		Soil Reaction	pH	6.5 – 7.0	6.5 – 6.0	6.0 – 5.0	5.0 – 4.5	< 4.5
					7.0 – 7.5	7.5 – 8.0	8.0 – 8.5	> 8.5
		Organic Matter	%	3 – 6	6.0 – 7.5	2 – 1 / 7.5 – 9.0	< 1 / 9.0 – 10.0	> 10.0
7	ROOTING CONDITION AND WORKABILITY	Effective Soil Depth	cm	> 50	50 – 25	25 – 15	15 – 10	< 10
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Soil Texture	class	Sil – C(bl)	L – SL	CL – C(bl)	SL	S

ENVIORNMENTAL REQUIREMENT FOR CROP TEFF

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S_1 HIGHLY SUITABLE	S_2 MODERTLY SUITABLE	S_3 MARGINALLY SUITABLE	N_1 CURRENTLY N.S	N_2 PERMANENTLY N.S
8	TOXICITIES	Salinity	mmhos/cm	0 – 4	4 – 8	8 – 12	12 – 15	>15
		Alkalinity	ESP	0 – 6	6 – 10	10 – 13	13 – 15	>15
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0 – 8	8 – 16	16 – 30	30 – 50	>50
		Staniness	Class	none	fairly Stony	stony	very stony	exceeding stony
		Soil Texture	class	Si – CL (bl)	L – SCL	CL (bl) – C (bl)	SL	S

No	LAND QUALITY	LAND CHARACTERISTIC	Cl	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GEAMINATION AND ESTABLISHMENT	Seed-bed preparation	VH – Very high energy required H – High " M – Medium " L – Low " VL – Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I – Intolerant M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost sensitivity	S – Sensitive M – Medium T – Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
			S – Sensitive				

ENVIORNMENTAL REQUIREMENT FOR CROP TEFF

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat Teff Haricotbeans	M T M	Noug Seasame Sunflower	T T S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum Maize Wheat Pepper Teff	M L H VL L	Chickpea Noug Seasame	L L L
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Moderately T – Tolerant	Sorghum Maize Wheat Teff Haricotbeans	M S M M S	Chickpea Pepper Noug Seasame Sunflower	S M S M S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum Maize Wheat Teff Haricotbeans	L M L Not Know Not Know	Chickpea Pepper Noug Seasame Sunflower	L Not Know " " "
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low work input required M – Medium " H – High "	Sorghum Maize Wheat Teff Haricotbeans	H M H H M	Chickpea Pepper Noug Seasame Sunflower	M L H H H
17	WORKABILITY	Mechanized farming (general)	L – Low M – Medium H – High	Sorghum Maize Wheat Teff Haricotbeans	H H H M H	Chickpea pepper Noug Seasame	H L L L

ENVIORNMENTAL REQUIREMENT FOR CROP _____

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				S1 HIGHLY SUITABLE	S2 MODERTLY SUITABLE	S3 MARGINALLY SUITABLE	N1 CURRENTLY Not.S	N2 PERMANENTLY Not.S
1	TEMPERATURE REGIME	Altitude	m	1000 -1200	~~1200-1300~~	~~1300-1400~~	~~1400-1600~~	~~>1600~~
		Mean Temperature (Thermal Zone)	°C	18 -23	15 - 17	10 -14	7- 9	<7
					24 -28	29 - 31	32 -34	>32
2	GROWING PERIOD	Length of Growing period	day	120 -150	110 - 120	100 -110	90-100	<90
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	50 -100	25-50	10 - 25	-	<10
		Growth cycle	day	120 - 150	~~115 - 125~~	~~105 - 110~~	90-100	<90
4	DRAINAGE	Soil Drainage	class	MW - W	I	I	VP I	E
					SE	P		
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	21 -27	21 -23	18 - 20	15-17	<15
					28 - 30	31 - 32	33- 35	>35
		Length of Growing period	day	120 - 150	110 - 120	100 - 110	90-100	<90
		Soil Texture	class	SL - CL	LS	Sicl - Sic	C(rd) - C(bl)	S
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Slope angle	%	0 - 8	8 -16	16 - 30	30 - 35	>35
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	SL - CL	LS	Sicl - Sic	C(rd) - C (bl)	S
		Soil Reaction	pH	5.5 - 6.7	5.5 -5.3	5.3 -5.0	5.0 - 4.7	<4.7
					6.7 - 7.0	7.0 - 7.3	7.3 - 7.6	>7.6
		Organic Matter	%	>3	3 - 2	2 - 1	1 - 0	-
7	ROOTING CONDITION AND WORKABILITY	Effective Soil Depth	cm	50 -100	25-50	10 -25	-	<10
		Stoniness	class	none	fairly stony	stony	very stony	exceeding stony
		Soil Texture	class	SL - CL	LS	Sicl - Sic	C(rd) - C(bl)	S

ENVIORNMENTAL REQUIREMENT FOR CROP NOUG

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	UNIT	RANGES OF SUITABILITY				
				HIGHLY S1 SUITABLE	MODERATELY S2 SUITABLE	MARGINALLY S3 SUITABLE	CURRENTLY N1 N.S	PERMANENTLY N2 N.S
8	TOXICITIES	Salinity	mmhos/cm	0-6	6-8	8-9	9-10	>10
		Alkalinity	ESP	0-6	8-10	10-12	12-15	>15
9	MAGEMENT LAND PREPARATION AND MECHANIZATION POTENTIAL	Slope Angle	%	0-8	8-16	16-30	30-35	>35
		Stoniness	Class	None	fairly stony	stony	very stony	exceeding stony
		Soil Texture	Class	SL-CL	LS	SiCl-SiC	C(vd)-C(Cl)	S

No	LAND QUALITY	LAND CHARACTERISTIC	CL	CROP	RATING	CROP	RATING
10	CONDITION AFFECTING GEAMINATION AND ESTABLISHMENT	Seed-bed Preparation	VH - Very high energy required H - High " M - Medium " L - Low " VL - Very low "	Sorghum Maize Wheat Teff Haricotbean	H M H VH M	Chickpea Pepper Noug Sunflower Seasame	M L H H VH
11	FLOOD HAZARD	Attack by Surface water	I - Intolerant M - Medium T - Tolerant	Sorghum Maize Wheat Teff Haricotbean	M M I I M	chickpea Pepper Noug Seasame Sunflower	M T I I M
12	CLIMATE HAZARD	Frost Sensitivity	S - Sensitive M - Medium T - Tolerant	Sorghum Maize Wheat Teff Haricotbean	S S S T S	Chickpea Pepper Noug Seasame	S S S S
			S - Sensitive	Sorghum	S	Chickpea	T

ENVIORNMENTAL REQUIREMENT FOR CROP NOUG

APPENDIX 2

No	LAND QUALITY	LAND CHARACTERISTIC	CLASSES	CROP	RATING	CROP	RATING
12	CLIMATE HAZARD	Hail Sensitivity	T – Tolerant	Wheat	M	Noug	T
				Teff	T	Seasame	T
				Haricotbeans	M	Sunflower	S
13	SALINITY	Tolerance to Salinity	VH – Very high tolerance to Salinity H – High M – Medium L – Low VL – Very Low	Sorghum	M	Chickpea	L
				Maize	L	Noug	L
				Wheat	H	Seasame	L
				Pepper	VL		
				Teff	L		
14	SODICITY	Saturation of the exchange complex with Na ions	S – Sensitive M – Modevately T – Tolerant	Sorghum	M	Chickpea	S
				Maize	S	Pepper	M
				Wheat	M	Noug	S
				Teff	M	Seasame	M
				Haricotbeans	S	Sunflower	S
15	TOXICITY	Ca Co 3	L – Low Tolerance M – Medium Tolerance H – High Tolerance	Sorghum	L	Chickpea	L
				Maize	M	Pepper	Not Know
				Wheat	L	Noug	"
				Teff	Not Know	Seasame	"
				Haricotbeans	Not Know	Sunflower	"
16	WORKABILITY NON MECHANIZI	Non Machanized farming (tillage)	L – Low workinput required M – Medium " H – High "	Sorghum	H	Chickpea	M
				Maize	M	Pepper	L
				Wheat	H	Noug	H
				Teff	H	Seasame	H
				Haricotbeans	M	Sunflower	H
17	WORKABILITY	Mechanized faming (general)	L – Low M – Medium H – High	Sorghum	H	Chickpea	H
				Maize	H	pepper	L
				Wheat	H	Noug	L
				Teff	M	Seasame	L
				Haricotbeans	H	Sunflower	L

APPENDIX 3

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedele / Harole Field Number : Unit 1 – 10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 in			CaCO3 %	Free Fe_2O_3 %
			>2	2-0.2	0.2-0.05	0.05-0.002	<0.002		H_2O	KCl	NaF		
1638	T-1-1	0-40						C	6.10				
1639	T-3-1	10-20						CL	6.10				
1640	T-10-1	0-25						L	6.30				
1641	T-4-1	0-30						SCL	6.40				
1642	T-6-1	15-35						CL	6.70				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100gm soil										Base Saturat. %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
1638	T-1-1	0-40	0.814	1.728	47	8							
1639	T-3-1	10-20	0.922	1.408	44	8							
1640	T-10-1	0-25	0.814	1.120	29	5							
1641	T-4-1	0-30	0.868	1.600	51	1							
1642	T-6-1	15-35	0.811	1.356	47	5							

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
1638	T-1-1	0-40		0.126		1.311	6.4	300					
1639	T-3-1	10-20		0.070		0.794	2.4	270					
1640	T-10-1	0-25		0.084		1.346	3.2	480					
1641	T-4-1	0-30		0.140		1.518	4.0	200					
1642	T-6-1	15-35		0.126		1.139	9.6	150					

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedele / Harolo Field Number : Unit 1-10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 in			CaCO3 %	Free Fe_2O_3 %
			>2	2-0.2	0.2-0.05	0.05-0.002	<0.002		H_2O	KCl	NaF		
691	T-1-2	0-30			18.7	19.7	61.6	C	5.85				
692	T-1-2	85-95			20.7	21.7	57.6	C	5.65				
693	T-2-1	0-25			20.7	21.7	57.6	C	6.25				
694	T-2-1	100-110			22.7	17.7	59.6	C	7.10				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100gm soil										Base Saturat. %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
3691	T-1-2	0-30	0.926	1.837	46	6.5						44.2	
3692	T-1-2	85-95	0.354	1.789	43.5	8.0						39.0	
3693	T-2-1	0-25	0.245	1.933	50.5	7.0						22.8	
3694	T-2-1	100-110	0.814	1.773	60.5	7.0						48.4	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
3691	T-1-2	0-30		0.028		2.312							
3692	T-1-2	85-95		0.04		3.105							
3693	T-2-1	0-25		0.098		3.450							
3694	T-2-1	100-110		0.042		1.897							

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedele / Horole Field Number : Unit 1–10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 In			CaCO3 %	Free Fe_2O %
			>2	2–0.2	0.2–0.05	0.05–0.002	<0.002		H_2O	KCl	NaF		
3695	T-4-2	0-25			18.7	17.7	63.6	C	6.50				
3696	T-4-2	80-95			16.7	21.7	61.6	C	5.80				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100gm soil										Base Satura %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
3695	T-4-2	0-25	1.771	1.901	46.5	8.5						35.2	
3696	T-4-2	80-95	0.409	1.837	40.0	9.0						31.4	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
3695	T-4-2	0-25		0.036		2.07							
3696	T-4-2	80-95		0.054		2.834							

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedele / Harole Field Number : Unit 1-10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 in			CaCO3 %	Free Fe_2O_3 %
			>2	2-0.2	0.2-0.05	0.05-0.002	<0.002		H_2O	KCl	NaF		
3697	T-5-1	0-28			16.7	19.7	63.6	C	6.55				
3698	T-5-1	85-95			18.7	15.7	65.6	C	7.20				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil										Base Saturat. %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
3697	T-5-1	0-28	0.354	1.581	56.0	14.0						47.6	
3698	T-5-1	85-95	1.199	1.645	61.0	10.5						42.2	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
3697	T-5-1	0-28		0.07		2.381							
3698	T-5-1	85-95		0.014		2.243							

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedele / Hanole Field Number : Unit 1–10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 In			CaCO3 %	Free Fe_2O_3 %
			>2	2–0.2	0.2–0.05	0.05–0.002	<0.002		H_2O	KCl	NaF		
3699	T-7-1	0-30			24.7	14.7	57.6	C	6.40				
3700	T-7-1	85-100			20.7	15.7	63.6	C	6.90				
3701	T-7-2	0-30			24.7	14.7	57.6	C	6.80				
3702	T-7-2	90-110			20.7	15.7	63.6	C	7.10				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil										Base Saturat. %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
3699	T-7-1	0-30	0.327	1.614	46.5	6						28.8	
3700	T-7-1	85-100	1.308	1.438	54.0	4.5						37.8	
3701	T-7-2	0-30	0.327	1.645	57.0	7.0						38.2	
3702	T-7-2	90-110	1.308	1.677	65.0	4.50						43.0	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
3699	T-7-1	0-30		0.075		—							
3700	T-7-1	85-100		0.042		1.725							
3701	T-7-2	0-30		0.042		2.277							
3702	T-7-2	90-110		0.014		2.174							

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Tedel / Harde Field Number : Unit 1–10

Location / Coordinates : SHEWA

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 In			CaCO3 %	Free Fe_2O_3 %
			>2	2–0.2	0.2–0.05	0.05–0.002	<0.002		H_2O	KCl	NaF		
3703	T-9-1	0-28			22.7	17.7	59.6	C	5.75				
3704	T-9-1	80-90			18.7	17.7	63.6	C	5.50				
3705	T-9-2	0-35			18.7	13.7	57.6	C	6.60				
3706	T-9-2	75-95			20.7	21.7	57.6	C	7.25				

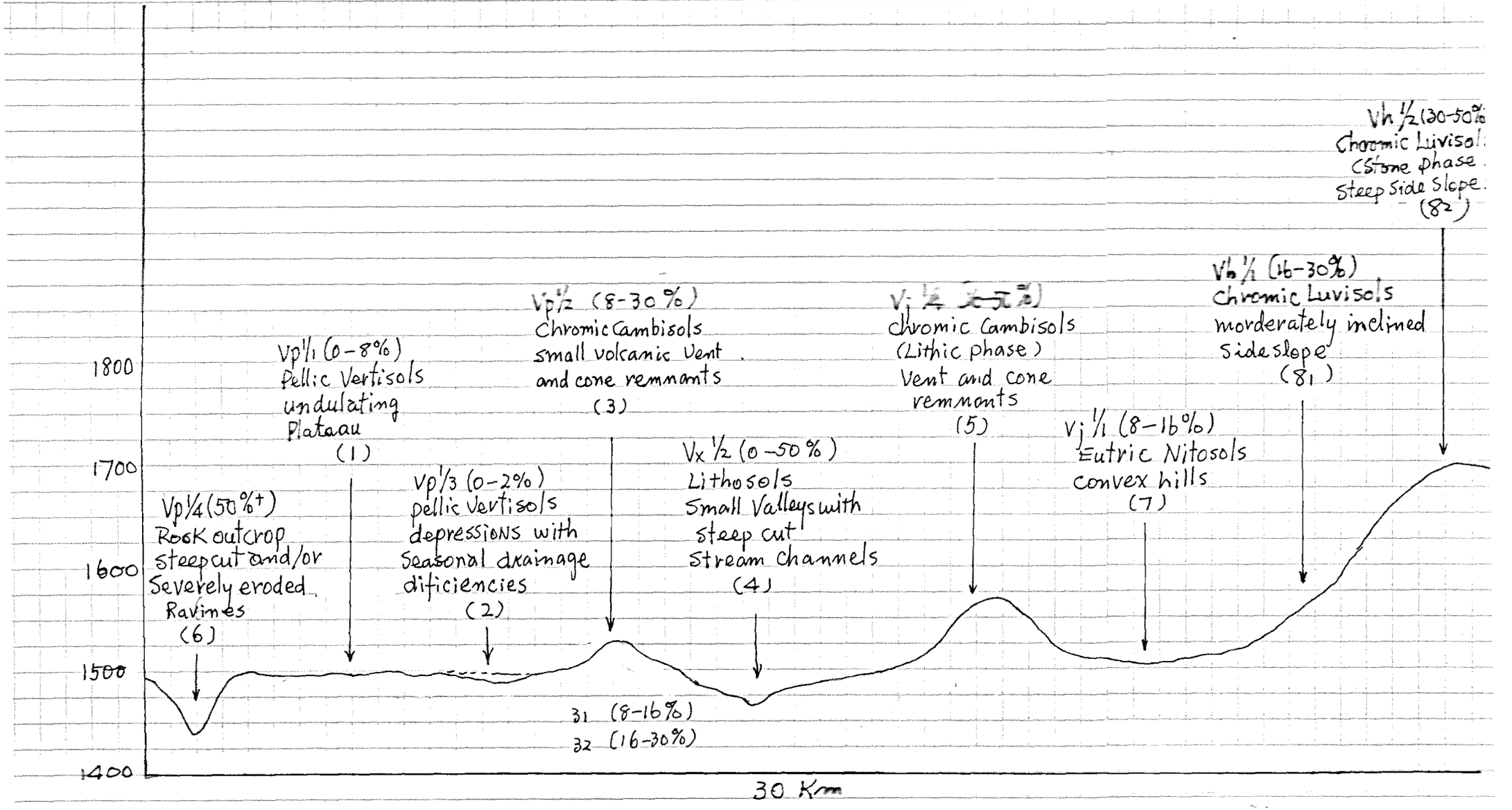
Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil										Base Saturat. %
			Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	
3703	T-9-1	0-28	0.218	1.358	51.5	8.5						27.8	
3704	T-9-1	80-90	0.790	1.390	48.0	5.0						44.8	
3705	T-9-2	0-35	1.335	1.725	50.5	8.0						20.4	
3706	T-9-2	75-95	0.926	1.917	66.5	6.0						43.6	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot. N %	C/N	O. M %	Avail. P_2O_5 ppm	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
3703	T-9-1	0-28		0.14		3.795							
3704	T-9-1	80-90		0.112		3.519							
3705	T-9-2	0-35		0.156		2.243							
3706	T-9-2	75-95		0.084		1.484							

Date _____ Chief of Lab. _____

APPENDIX 4

TEDELE/HAROLE LANDSCAPE UNITS



Landscape Unit No. Vp 1/1

Geomorphology : Undulating high plateaux formed predominantly pyroc. deposite

Remarks : Ash layers are frequently found in the soil profile

Total Area : (km²)

Significant Land Facet : underlating plateaux

Soil Management Unit No. : 6 Area (%) (km²)

Geology : tertiary tuffs, welded tuffs and associate basalts

Slope Range (%) : 0 - 8

Soils:

FAO classification	:	pellic vestisols
Colour (moist)	:	very dark gray to black
Texture	:	clay to clay loam
Drainage	:	imperfectly
Rock outcrop	:	none
Surface stones	:	fairly stony
Effective depth (cm)	:	>150
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail. P (PPM)	:	<5

Dominant Vegetation and/or Land use : Intensive rainfed peasant cultivation of cereals and pulses.

Remarks (Significant Land Facet)

Localized rock outcrop and rubble land occour over 5% of this face where very flat much of this facet is susceptible to seasonal wate logging.

Tedele - 2

Landscape Unit No. Vp 1/3

Geomorphology : See above

Remarks : See above

Total Area : (km²)

Significant Land Facet : depressions with seasonal drainage deficiencies

Soil Management Unit No. : 6 Area (%) (km²)

Geology : shallow colluvium over tertiary tuffs, welded tuffs and associated basalts

Slope Range (%) : 0 - 2

Soils:

FAO classification	: pellic vertisols
Colour (moist)	: very dark gray to black
Texture	: clay to clay loam
Drainage class	: poorly / imperfectly
Rock outcrop	: none
Surface stones	: fairly stony
Effective depth (cm)	: >150
pH	: 5.5 - 6.7
OM (%)	: 3 - 10
CEC (me/100g)	: 35 - 70
Avail. P (PPM)	: <5

Dominant Vegetation and/or Land use : Peasant cultivation of cereals and pulses as water recedes.

Landscape No. Vp 1/2

Geomorphology : See above

Remarks : See above

Total Area : (km^2)

Significant Land Facet : small volcanic vent and cone remnants

Soil Management Unit No. : 65 Area (%) (km^2)

Geology : tertiary basalts, trachytes and rhyolite:

Slope Range (%) : 16 - 30

Soils:

FAO classification	:	chromic cambisols (lithic phase)
Colour (moist)	:	dark brown to dark reddish brown
Texture	:	clay loam to sandy clay loam
Drainage class	:	well
Rock outcrop	:	rocky
Surface stones	:	very stony
Effective depth (cm)	:	25 - 50
pH	:	5.5 - 6.7
CEC (me/100g)	:	16 - 35
Avail. P (PPM)	:	< 5

Dominant Vegetation and/or Land use : Shrubbed grassland with peasant live stock grazing and browsing.

Remarks (Significant Land Facet)

Eutric nitosols and chronic Iuvisols occur as slopes decrease toward 16% lithosols occur.

Tedele - 4

Landscape Unit No. Vx 1/2 — Steep severely dissected sideslopes of extinct central volcanoes and other relic volcanic forms often with small vent and cone ruminants.

Geomorphology :

Total Area : (km^2)

Remarks (Landscape Unit): Vitric and mollic andosols of lighter texture occur; ash layers are frequently found in the soil profile

Significant Land Facet : vallyes with steep out stream channels

Soil Management Unit No. : 1

Area (%) : (km^2)

Geology : tertiary trachytes, rhyolites and associated basalts and tuffs

Slope Range (%) : $30 - 50^{+}$

Soils:

FAO classification	:	lithosols
Colour	:	none
Texture	:	"
Drainage class	:	"
Rock outcrop	:	"
Effective depth (cm)	:	"
pH	:	"
OM	:	"
CEC (me/100g)	:	"
Avail. P (PPM)	:	"

Dominant Vegetation and/or Land Use: Scattered scrub and grass vegetation with peasant livestock grazing and browsing.

Remarks (Significant Land Facet)

Eutric combisols (lithic phase) occur.

Landscape Unit No. V_j 1/4

Geomorphology : See above

Total Area (km^2)

Remarks (Landscape Unit) : See above

Significant Land Facet : vent and cone remants

Soil Management Unit No. : 65
Area (%) : (km^2)
Geology : tertiary trachytes, basalts, tuffs and associated rhyolites
Slope Range (%) : 16 - 50
Soil:
FAO classification : chromic cambisols (lithic phase)
Colour (moist) : reddish brown to dark reddish brown
Texture : clay to sandy clay loam
Drainage class : well
Rock outcrop : rocky
Surface stones : very stony
Effective depth (cm) : 25 - 50
pH : 5.5 - 6.7
OM (%) : 3 - 10
CEC (me/100g) : 16 - 35
Avail. P (PPM) : <5

Dominant Vegetation and/or Land use : Shrubbed grassland with peasant livestock grazing and browsing.

Remarks (Significant Land Facet)
Lithosols occur.

Landscape Unit No. Vp 1/4

Geomorphology : See above

Remarks (Landscape Unit) : See above

Total Area : (km^2)

Significant Land Facet : steep cut and/or severely eroded ravines

Soil Management Unit No. : 1 Area (%) (km^2)

Geology : tertiary tuffs, welded tuffs, basalts, trachytes and rhyolites

Slope Range (%) : 50

Soils:

FAO classification	:	none
Colour (moist)	:	"
Texture	:	"
Drainage	:	"
Rock outcrop	:	"
Surface stones	:	"
Effective depth (cm)	:	"
pH	:	"
OM (%)	:	"
CEC (me/100g)	:	"
Avail. P (PPM)	:	"

Dominant Vegetation and/or Land use : Rock surface.

Remarks (Significant Land Facet)

Lithosols occur.

Landscape Unit No. Vj 1/1

Geomorphology : Moderately disscted sideslopes of extinct central volcanoes and other relic volcanic forms, often with small cone and vent remnants central highlands.

Total Area : (km^2)

Remarks (Landscape Unit) : Mollic andosols of lighter texture occur near Mountain Batu; ash layers are frequen ly found in the soil profile.

Significant Land Facet : convex hills

Soil Management Unit No. : 56 Area (%) (km^2)

Geology : tertiary trachytes, basalts, tuffs and associated rhyolites

Slope Range (%) : 8 - 16

Soils:

FAO classification	:	entric nitosols
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	clay to clay loam
Drainage class	:	well
Rock outcrop	:	none
Surface stones	:	stony
Effective depth (cm)	:	>150
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail P. (PPM)	:	<5

Dominant Vegetation and/or Land use : Moderate to intensive rainfed peasant cultivation of cereals and pulses, at Indibir peasant cultivation of ensets and peasant livestock grazing of grass-land.

Remarks (Significant Land Facet)

Stony phases occur.

Landscape Unit No. Vh 1/1

Geomorphology: Degraded extinct central volcanoes, calders remants and associated forms of high to mountanous relief-central highlands and the Awash.

Total Area : (km^2)

Remarks (Landscape Unit) : Some occurences of this unit have substantial crater floors with andsols and/or vertisols, as at Ambo, chromic cambisols (lithic phase) predominate in some occurrences of this unit.

Significant Land Facet: moderately inclined sideslopes

Soil Manageemnt Unit No. : 66

Area (%) : (km^2)

Geology : tertiary and quaternary basalts, trechytes and rhyolites

Slope Range (%) : 16 - 30

Soils:

FAO classification	:	chromic lurisols
Colour	:	reddish brown to dark reddish brown
Texture	:	clay to clay loam
Drainage class	:	well
Rock outcrop	:	fairly rocky
Surface stones	:	fairly stony
Effective depth (cm)	:	50 - 100
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail. P (PPM)	:	< 5

Dominant Vegetation and/or Land use: Moderate rainfed peasant cultivations of cereals and pulses.

Remarks (Significant Land Facet) : Eutric nitesols occur.

Landscape Unit No. Vh 1/2

Geomorphology : Degarded extinct central volcanoes, caldera remants and associated forms of high to mountanous Relief-Western highland.

Total Area : (Km^2)

Remarks : (Landscape Unit)

Significant Land Facet: steep sideslope

Soil Management Unit No. : 42 Area (%) (km^2)

Geology : tertiary basalts, trachytes and rhyolites

Slope Range (%) : $30 - 50^+$

Soils:

FAO classification	: chronic lurisols (stony phase)
Colour (moist)	: reddish brown to dark reddish brown
Texture	: clay to sandy clay loam
Drainage class	: well
Rock outcrop	: rocky
Effective depth (cm)	: 50 - 100
pH	: 5.5 - 6.7
OM	: 3 - 10
CEC (me/100g)	: 16 - 35
Avail. P. (PPM)	: <5

Dominant Vegetation and/or Land use: Disturbed high forest with some moderate rainfed peasant cultivation of cereals and pulses.

Remarks (Significant Land Facet): Some occurrences of this facet are severely eroded and eutric regosols (lithic phase) occur; eutric and/or chronic cambisols occur at very high altitudes and on steepest slopes.