AG: DP/ETH/82/012
Field Document No 1

ASSISTANCE TO SETTLEMENT

ETHIOPIA

LAND USE PLANNING AND SOIL AND WATER CONSERVATION DEVELOPMENT PLANNING OF HAREWA

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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Field Document 1

ASSISTANCE TO SETTLEMENT

E T H I O P I A

Land Use Planning and Soil and Water Conservation Development Planning Of the Harawa

by
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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/02/012) preparing the Assistance to Settlement Project Phase IV. The conclusions and recommendation give in the report are these considered appropriate at the time of its preparation.

FAO. Assistance to Settlement Project, Ethiopia Land Use Planning and Soil and Water Conservation Development Plans for Harawa. by S.K. Choi. Addis Ababa, 1986. 94 p., 5 tables, 3 figures, supplement including 4 map sheets. AG;DP ETH/82/012, Field Document 1.

ABSTRACT

This report describes the result of detailed survey of Land Use Planning and Soil and Water Conservation of Harawa Settlement Project (20,000 ha in Northern Bale 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) accompanies the report.

The natural resource 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 resource boundaries and basic studies.

ACKNOWLEDGEMENTS

The writer of this Field Document are greatly inhabited for the assistance received from both National and International member of the Project.

They are also greatful for the comments made by members of related project in Ethiopia, and in particular Land Use Planning Project (ETH/82/010). Soil and Water Conservation Project (ETH/81/003), and National Soil Service (ETH/82/011), and Ato Asrat Yigletu N.P.C. of Project and former N.P.C. Ato Tesfaye Desta, Ato Semen W/Berhan, Ato Tessema Chekun Ato Yibrah Hagos, Ato Tedla Desta and their technical staff in Department and Land Reclamation and Utilization Relief and Rehabilitation of Commission.

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(IN SEPARATE VOLUME)

1. 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 pre paring Land Use Planning and Soil and Water Conservation Development Planning and Implementation for three large-scale settlement. Namely; Tedele/Harolo, 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 excercise 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 Harawa settlement site which is presented in figure 1 of this document).

1.2 Methods and Results

In preparing this document on the development plan of Harawa large scale settlement, the methodology for the study of land-use planning and land suitability classification is based on the FAO "Framework for Land Evaluation (FAO 1976) and the Land Evaluation in Rainfed Agriculture (FAO 1983). In addition, the study attained a much broader framework by following the "Soil Conservation and Management in developing countries (FAO 1977) and watershed development with special reference to soil and water conservation (FAO 1979). The land resources basis for land evaluation is treated by consisting a series of thematic maps into Land Resources Map at a scale of 1:50 000 which provides information in an integrated approach on Agro-Climatology, Geomorphology and soils.

Thus, the land resources map played an important role in the land resources inventory ranging from providing the necessary data assemblege to integration of data resources for carrying out a land suitability evaluation.

The soil and water conservation development plan prepared at a map scale of 1:20 000 is dealt with especially from the physical and social point of view by recognising the needs and priorities of the settlers and underlining the most suited development options for the settlements.

2. Background Data

2.1 General description

2.1.1 Location

The project area, Harawa covers 20,000 ha with a population of 18,857 persons.

The settlement area is located in the northern part of CINIR town some 17 kms apart and about 600 kms south-east of Addis Ababa in Wabe Awraja, Bale Administrative Region.

2.1.2 PHYSIOGRAPHY

The general landscape of the area consists of an undulating sideslopes and piedmont zones which have been strongly influenced by colluvial processes but there are distinct residual characteristics and high mountainous relief hills whose altitudes increase from 1600 to 2000 meters above sea level.

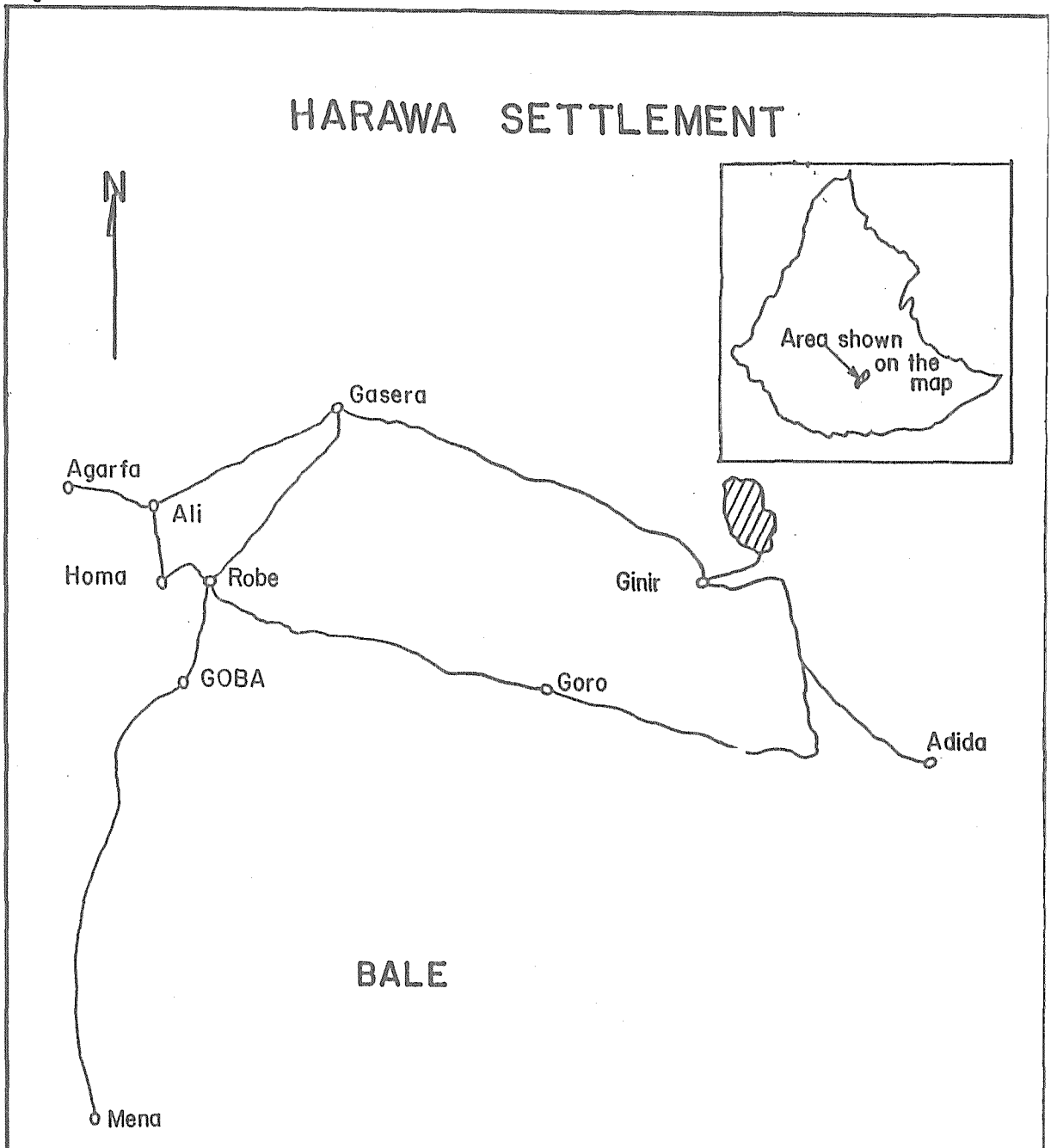
The plateau of the area is dissected by numerous rivers which are broad and dry valleys flowing through the area.

It is a paramount importance to consider the prevailing situation of water resources development in the project area, i.e. surface water is very limited and the disappointing results of development efforts in underground water were below satisfactory level. Few wells along Elbuso River bed have been drilled.

The underlying geological strata consists of tertiory basalts and tuffs; the soil parent material is shallow colluvium underlain by tertiory basalts and tuffs.

The soils of the project area are dominantly classified as Pellic Vertisols on the undulating sideslopes, piedmont plains and lava plateaux.

figure I


HARAWA SETTLEMENT
N
Area shown on the map
Gasera
Agarfa
Ali
Homa
Robe
Ginir
GOBA
Goro
Adida
BALE
Mena
LEGEND
All weather road.....
Town..... o
Settlement.....
Scale 1 : 1000000

The plateau terraces, gentle sideslopes and moderate sideslopes consist of entric mitosols where as steep sideslops and very steep sideslope areas are covered by chronic luvisols at shallower depth.

2.1.3. Climate

The main climatic factor affecting rain-fed agriculture in Harawa is Rainfall and its variation. Other climatic elements hardly vary throughout the area except in the high mountians. According to the climatic data (Refer table 1.) the climate is favourable for rainfed agriculture, as it is characterized by a length of growing period (LGP) of 61 to 150 days. The average annual rainfall is moderate (600-1044 mm). per annum but is not very erratic. The rainfall distribution is basically bi-modal, the main rains are from March to June and the small rains from October to November

The lowest mean monthly temperature varies between $7^{O}C$ in January to $15^{O}C$ in July while the highest mean monthly temperature vary between $28^{O}C$ in February and September to $26^{O}C$ in March.

2.1.4 Vegetation and Land-Use

Cropping patterns in Harawa and Melka Oda are related to differences in altitude, i.e. differences in temperature and rainfall. Generally, most of the land in the area of survey which is suitable or only moderate to marginally suitable for cropping is under cultivation. At intermediate altitude (woina dega) there is a wider variety of crops including wheat, teff, sorghum, maize as main crops and sun-flowsr as secondary crop.

The vegetation on the plateau consists of open woodland savannah with scattered acacia and broad-leaved trees. The steeper areas on the periphery have thicker vegetation consisting mainly of acacia thickets.

Table 1 Climatic Data

Station: Goba	Administrative region: Bale	Rainfall pattern region: C. 1.10	Altitude asl m: 2 710	No. of years for precipitation: 19	No. of years for other data: 18

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR
Mean max. temp. °C	20.1	20.7	20.9	19.8	20.3	20.5	20.0	19.6	19.0	17.7	18.0	19.3	19.7
Mean min. temp. °C	4.1	5.1	6.3	7.8	7.9	7.3	7.3	7.1	7.5	7.2	5.0	3.7	6.4
Mean temperature °C	12.1	12.9	13.8	13.8	14.1	13.9	13.7	13.4	13.3	12.5	11.5	11.5	13.0
Vapour pressure mb	9.0	9.1	10.1	11.8	11.9	11.3	12.1	12.1	11.9	11.6	10.3	9.1	10.9
Rel. humidity %	64	61	64	75	74	71	77	79	78	80	76	67	72
Wind speed 2 m m/s E	1.1	1.3	1.7	1.1	1.0	1.1	0.9	1.0	0.9	0.7	0.8	1.0	1.1
Sunshine %	67	62	57	45	47	49	42	41	37	27	50	66	49
Total rad. cal/(cm^2 x day)	455	468	474	432	429	427	404	409	396	348	406	441	424
Precipitation mm	22	41	63	131	113	63	96	118	122	107	66	16	958
PET mm	77	83	100	77	80	78	72	73	68	59	63	71	901
Dates		15 BM	27 BH(S)			5 EH 27 BH					17 EH	4 EM 15 EHS	

LGP_1 10/2 - 10/2 yearu round normal	Days	Mean max. temp. °C	Mean min. temp. °C	Mean temp. °C	Total rad. cal/(cm^2 x day)	P	PET	P/PET
BEG-END	365	19.7	6.4	13.0	424	958	901	1.06
BEG-BHS/BH(S)	45	20.9	5.8	13.4	473	85	150	0.57
BHS/BH(S)-EHS/EH(S)	263	19.4	6.9	13.2	409	834	614	1.36
EHS/EH(S)-END	57	20.0	4.1	12.0	454	38	137	0.28
LGP_2								
BEG-END								
BEG-BHS/BH(S)								
BHS/BH(S)-EHS/EH(S)								
EHS/EH(S)-END								

2.2 Development in the Area

The physical landscape of the area indicates that there is predominance of a flat plain with a slope of between 0-12% in which the present situation has led to carryout large-scale mechanized agricultural settlement.

Accessibility is relatively good to tap basic social and administrative services from the nearest town (17 kms) at Ginir which is also the Awraja capital.

The present number of settlement units in the project area includes two units of Melka Oda and eight units of Harawa following the RRC unit standard settlement pattern which are planned clusters of settlement sites of approximately 500 families each with their own social services and farming blocks.

The present health conditions and implications remains far from satisfactory especially tuberculosis and diarrhaea affects many people in most settlement sites. Malaria is not endemic in the area.

The total heads of families for the ten units is 4,754 The distribution by No. of settlers and land in Harawa settlement project is presented in Table 2.

TABLE 2

Distribution of Settlers and Land
HARAWA SETTLEMENT PROJECT

Unit	No. of families Head	Cropland		No. of Cropland	Total Ha
1	500	451	1110	1003	2113
2	500	483	888	1126	2014
3	492	438	767	1869	2636
4	490	382	595	1571	2166
5	496	436	963	1116	2079
6	491	353	1136	613	1749
7	498	392	856	678	1534
8	483	381	631	550	1181
9	393	306	802	1019	2127
10	411	260	325	1684	2009
Total	4754	3882 *	8073 **	11229	19608

* 1986 1st cultivated land

** Total cropland

The way in which the Harawa Settlement scheme is implemented has been made to differ from the RRC Settlement model which is governed by the size of settlement holding of 1250 hectares per unit of 500 family heads. The limitedland suitable for cultivation has led to changes in sizes of the planned holding but still to maintain the same number of settlers which reminds us to make full utilization of available suitable land for crop production and the marginal land desirable to be managed for forestry and grazing. The arable land head of population is 1 ha. and the arable land per family is 4 ha.

2.3 Land Survey

During the field survey an area of some 20 000 ha was surveyed at semi-detailed level by dividing into nine landscape units based on differences in land form, soils, hydrographic pattern, slope, relief and vegetation density. Such survey was shown on maps at scale of 1:50 000 based on an aerial photo mosaic and topographic maps at a scale of 1:50 000. In the survey each unit is evaluated for its current and potential landuse suitability.

3. Land-Use Study

3.1 Methods of Study

3.1.1 Aerial photo interpretation

The method of aerial photo interpretation was used as follows:

The photography was flown in January 1972 at approximately 1: 50 000 scale. The API was done with Topcon Mirror Stereoscope with 3 x binocular eyepiece . After scanning the general area and examining stereopairs, an API legend was prepared using data from the field study stage of the survey. The legend was reworked into soils oriented legend. See appendix 1.

The principal points of the aerial photography were marked on the existing mosaic. To identify the same points transparent drafting paper was placed over the mosaic and the principal points were transferred. The flight lines were drawn by joining the points in the flight line. The aerial photos 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 Aerial Photos not previously marked, so that only information in the centre of aerial photo was used, 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 taken.

3.1.2 Area measurement

Planimeter was used for measuring individual mapping units by adjusting for the appropriate scale. When measuring large areas, the methodology used was to treat area below 15 ha. to the nearest ha and larger areas are rounded of to the nearest mapping units was checked against the whole unit area by considering sinuous riverine forest 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 19,608 ha was measured by planimeter. This is roughly 98% of the total area surveyed (20,000 ha).

3.2. Soil Survey and Soil Sampling

Soil survey has been conducted in the study area during 1985. The study was carried out through 40 auger descriptions taken to a depth of 120 cm. The augerings were made with a screw type auger. Land and soil characteristics were recorded on a standard form for auger description which included recordings of physiography, soil surface conditions and soil profile characteristics observed from small natural exposures.

The soil profile and augering description depended on the "Guideline for profile description (FAO-1977) and the Munsell Soil colour charts (1975). All sampling sites surveyed were plotted on APs which were used for base map in the field work.

3.3 Laboratory Methods

3.3.1 General Description

40 representative soil samples were chemically and physically analysed by the soil laboratory of the LLPRD, MOA. Analytical data are presented in the report in Appendix 3.

3.3.2 Methods of Soil Analysis

The soil samples were transported from the soil survey area to the 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 soaked 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 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 2hours 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 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 indicator. Percentage of total nitrogen was calculated from the acid used.

- Available phosphorous: 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 filltered. P was determined in 2ml of the extract by adding six dorms 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 + Ng 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 burns from wine red to blue. Exchangeable Mg was obtained by subtracting exchangeable Ca from exchangeab 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. Adsorbed 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 5 ml 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, 2 ml 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 measured at 520 millimicrons.

- Exchange acidity: Exchange acidity was determined by the potassium chloridetriethanalamine buffer method. 10 g of soil 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 25ml 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 solution 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 blank 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 KCl-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 Land scape units

3.41 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
- Slop 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 unit and landform genesis

A hierarchial classification system is applied in the description of the geomorphology of the landscape units. At the broadest level, 12 sudivisions 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 methodology for the study and identification of the requirements of crops was established based on ranges of suitability. The methodology is explained in detail in a standard proforma which has based itself on land qualities and characteristics derived from the survey at a semi-detailed scale.

The main types of land use in the project area are apprec-ably classified as rainfed agriculture (which involves annual, perrenial crops and mixed farming) irrigated agriculture, livestock production and forestry.

4.1 Selection of crops

A list of 5 of the main crops of the area together with other perennial crops except forestry species were selected for consideration as land utilization types (LUT). Identifying the LUT in terms of crop performance and requirements would have the desirable effects to identify the crops and the legend that best suits to grow them in the area. This would support settlers to make an important contrast between the introduced innovation which would enable them to produce more and previous forms of land use. Besides crop production should not be only realized to produce food production just sufficient to feed the population. In spite of the fact that the production design should gear to produce crop surpluses to meet the basic needs of the community, locality and national level with a capital reserve to upgrade the living standards of all its members, especially the most basic social services like health, education and other vital needs are required by the Settlement community.

Another factor for treating the following crops is the considerable production of these crops within the project area. Due to the above stated reasons the following list of crops were considered:-

Wheat	Maize
Sunflower	Teff
Sorghum	[illegible]

4.2. Cropping Systems

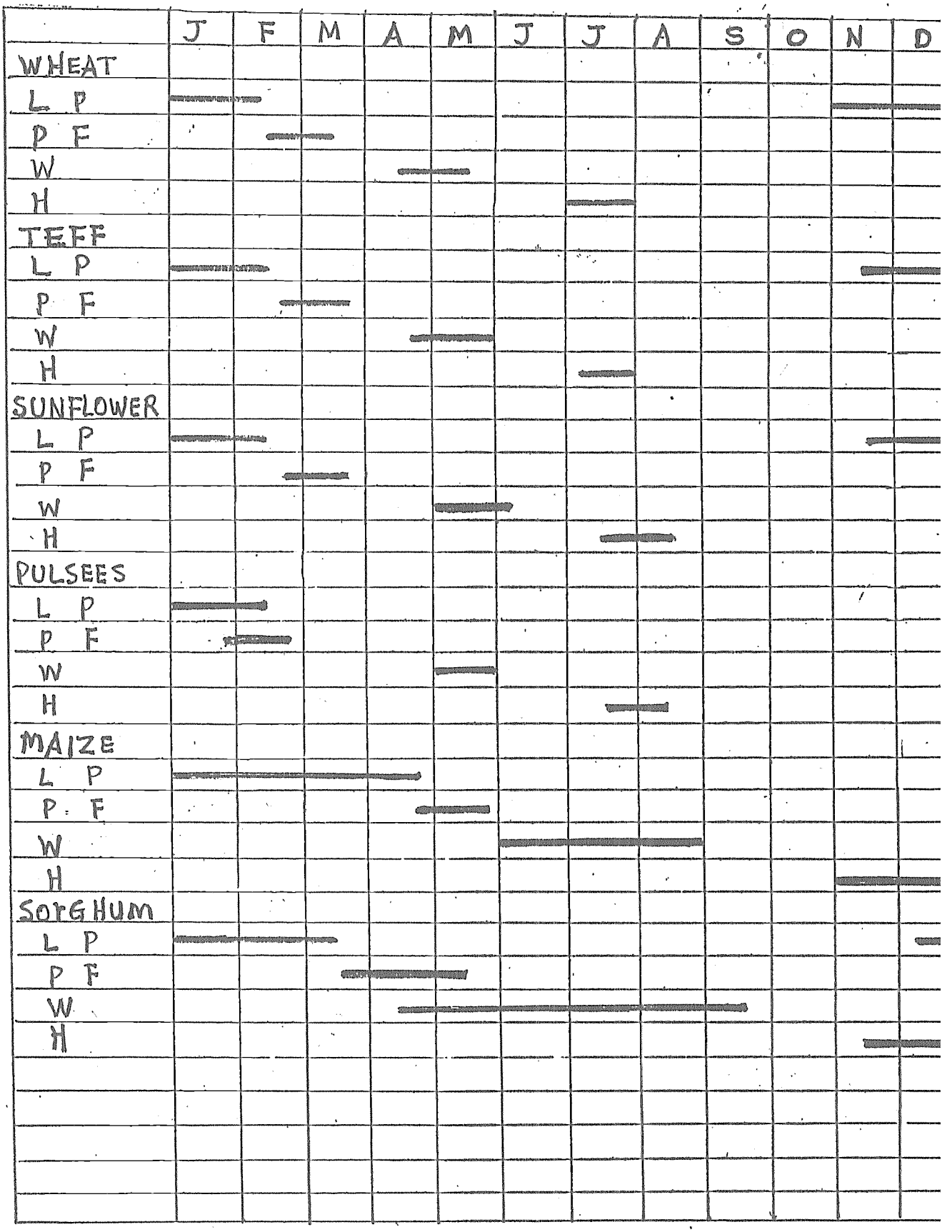
There is appreciable contrast between the cropping system used within the seed complex farming system in one area and others. Main crops in Harawa cropping system is based on wheat , sunflower, sorghum, maize and teff with other minor crops. Some crops are sometimes mixtured to satisfy the needs of the local community and the cropping calendar is designed to provide ample time for work, whereby crops are planted at appropriate period to give them enough time to mature and fill a food gap.

4.2.1 Crop Establishment

As it was indicated earlier, under the current farming system, the settlement was largely based on wheat production. The cultivation of wheat during the main rainy season starts with the first plowing in mid-November extending untill late January. Second ploughing begins in mid-January to mid-February. This is followed by secondary harrowing from late January to late February.

Seeding times for wheat is practiced between late February and late March whereas weeding is carried out in the months of April and May. The harvesting period for wheat is from late June to early August. The number of plowing decreases to one time plowing and two times harrowing on areas previously cultivated. (For detailed information on cropping calendar refer to Figure 2.

Figure. 2. CALENDAR OF OPERATION
HARAWA SETTLEMENT PROJECT



L P - Land preperation W - Weeding
P F planting fertilizing H - Harvesting

4.3 Agro-Forestry in Relation to Crop Production

The present inadequate fuelwood supply in the settlement has led to a serious shortage of wood for fuel and construction purposes.

The semi-arid areas of settlement sites are more marginal for crop production than the humid areas. These are also the areas most likely to be taken up for the development of settlements and state farms, but they also have the most fragile ecosystems. In prehumid areas, once the forests are removed the soils quickly loose their fertility, the climate becomes more harsh, on steep slopes in particular, the soil can erode easily.

These adverse effects are not always immediately apparent as the yields in the first few years after the natural vegetation has been cleared and can be dramatically high. But under prehumid conditions, the original fertility of the soils is leached away and increasing amounts of inorganic fertilizers have to be added to maintain even moderate crop yields.

This landuse cover the settlement nearly 85 percent of the land area mainly on cultivate areas . However all the woodland and grazing areas are under extreme pressure from both human and livestock demands for fuel and fodder and in many areas unproductive.

Reforestation in the settlement sites with mainly eucalyptus species and cupressus luistancia on reverian area has been carried out, but it is possible that the range of species could be extended to include suitable multy purpose tree species which could provide fodder and food for animal and human consumption. Suitable species could also include indigenous multipurpose species such as accacia, albida and tamarindus indica which are drought tolerant.

In addition, the introduction of multi-purpose crops like pigeon pea could serve to protect soil erosion, used for forage, feed for animals and

and human consumption, stand as windbreaks and provide fuelwood as well as its branches can be used for basket making. To overcome future problems of soil erosion and shortage of fuelwood supply, there is a need to give greater attention to associate such useful crops with traditional food crops in the planning and extension activities of settlement development.

The present inadequate supply of fuelwood is obtained from the plains and undulating slopes of the settlement where it is diminishing and being degraded at accelerated rate as a result of land clearing, exploitation of existing trees for building materials and fuelwood.

Thus, reafforestation and existing woodlots should be given serious consideration to avoid future disasters in fuelwood crises and soil erosion.

The humid areas are the most suitable for rainfed crop production, They are still susceptable to environmental degradation.

In areas where serious depletion of tree species occurred, careful selection of suitable species which could grow fast such as eucalyptus saligna, globules spp could solve the major problems.

As benefits from forest development are only attained in the longterm, due consideration should also be given to the local indigeneous tree species that grow in these areas by avoiding damage during establishment.

The type of tree species raised and planted in Harawa Settlement project are as follows:

Acia Albida
Acacia Melanoxylon
Casvarina Equisetifolia
Cordia Africana
Croton Macrostachus
Eucalyptus Gamphecephala

Eucalyptus Seligna
Eucaly ptus Globules
Leucana Leucocephala
Grevillea Rubusta

Emphasis for tree plantation was given from 1983 to 1985. The afforestation programme had raised and planted a total of 1.5 million seedlings on 940 ha.

5. CROP ENVIRONMENTAL REQUIREMENTS

5.1 General description

The total area within the study area has been shown by identifying or indicating the land qualities to be considered for evaluation, rainfed agriculture and land characteristics needed to describe these land qualities:-

The definitions of a land quality and land characteristics are:-

- A land quality is an attribute of land which acts in a distinct manner in its 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. First, land qualities are fewer in number (than land characteristics) , secondly, they direct attention to the effect upon land use and thirdly, they take account of interactions between environmental factors.

For each crop considered the requirements are indicated in two ways: The basic requirements as employed in the land evaluation, are shown on the tables in standard form at Appendix 2. The land qualities, the land characteristics by which they are measured 17 for estimated.

Abbreviations used for t he suitability ranges are:-

- Soil texture follows:

S	Sand
L	Loam
LS	Loamy sand
SCL	Sand clay loam
SL	Sandy loam
Sil	Silt loam
CL	Clay loam
Sicl	Silty clay loam
SC	Sandy clay
Sic	Silty clay
C (rd)	Clay (red)
C (bl)	Clay (black)

- Slope classes:

0-2%	Flat or almost flat
2-8	Gentle slope
8-16	Slope
16-30	Moderately steep
30-50	Steep
50^{+}	Very steep

- Drainage classes follow FAO, as above, but for this exception: For land subject to seasonal flooding two classes are given, one for the period during the rainy season and one for the rest of the year. This was done to accommodate requirements of the land evaluation.

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

- Rock outcrop descriptions follow FAO as above stoniness classes are:

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

- 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>	Highly alkaline

- Electrical conductivity mm hos/cm at $25^{o}C$

< 4 mm hos/Cm	Non -saline
4-8	Slightly saline
8-15	Medium saline
15 >	Highly saline

The classes used for the description of soil drainage, soil texture refer to the standard soil description classes as in FAO "Guideline for soil profile description"

- Organic matter classes are (in%)

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

- Cation 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 35% 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 oringinal top soil to 25% subsoil removed; occasional deep gullies may be present.
4	Very severe erosion	All of original topsoil and 25% to 75% of subsoil removed.

Symbol	Description Term	
GL1	Slightly & Moderately Gully land	An intercate network of very frequent moderately Gullies 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, removal of all of the original topsoil and subsoil by natural processes, it will be differentiated by placing the symbol in parenthesis.

5.2 Modifications to Crop Requirements for High Level of Input

Consideration was initially given to identifying separately the requirements of each crop at each of the three input levels, i.e. low, medium and high e.g. drainage impedence by drainage works, erosion hazard by soil conservation works. On the other hand, one feature of the high level mechanization may call for more stringent environmental requirements.

At high input levels like in settlements the following adjustments in the values of the land characteristics are made:-

Soil drainage (land quality; drainage). For imperfect drainage improve the suitability by one class, i .e. N (Not Suitable) becomes S3 (Marginally Suitable) and S3 becomes S2 (Moderately Suitable) and S2 becomes S1 (Highly Suitable).

Stones and Rock outcrops (land quality; management, land preparation and mechanization potential).

Change the suitable ranges of most crops are 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	(10-50% of the area)
N2	exceeding stony and nubble	(over 50% of the area)

This adjustment is 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 input levels, slope of 8-16% are moderately suitable to be cultivated on settlements provided that very careful attention is given to the construction and maintenance of soil conservation works.

The Harawa Settlement Project Environmental Requirement for crop combination is given in the tables of Appendix 2.

6. LAND RESOURCES MAP

6.1 General Description

The description of the main components of the Land Resources map given below are basically thematic maps of thermal zones, lengths of growing periods, geomorphology and soils. Mapping of thermal zones (TZ) and length of growing periods (LGP) is based on the FAO Methodology Agro-Ecological Zone Project, and ETH/82/010 Project.

Geomorphology and Soils data result from geomorphology interpretation of aerial photo, from available survey and field traverse and agroclimatic information.

6.2 Land Resources Units

The Matrix tables shown below was developed as part of the comprehensive Land Resources map lengend for the map units derived from the integration of information contained in the thematic maps referred to above.

A brief description and illustrated example could assist the user in understanding the nature of Land Resources Units shown on the map and the means by which thematic data of thermal zones, lengths of growing periods, 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.V^2/7. The first part of the symbol, RM.V^2, represents the landscape component, the second para /7, represent the growing period zone. Both aspects are explained in more detail as follows:- See Land Resources Maps 2.

6.3 Explanation of Thematic Map Units

6.3.1 Thermal Zones

Thermal zones are defined by mean daily temperature (in ^{O}C) during the growing season.

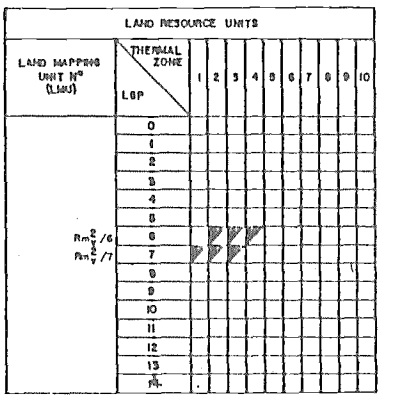
The following relation between temperature and altitude was determined from the data collected in 155meteorological stations throughout the country.

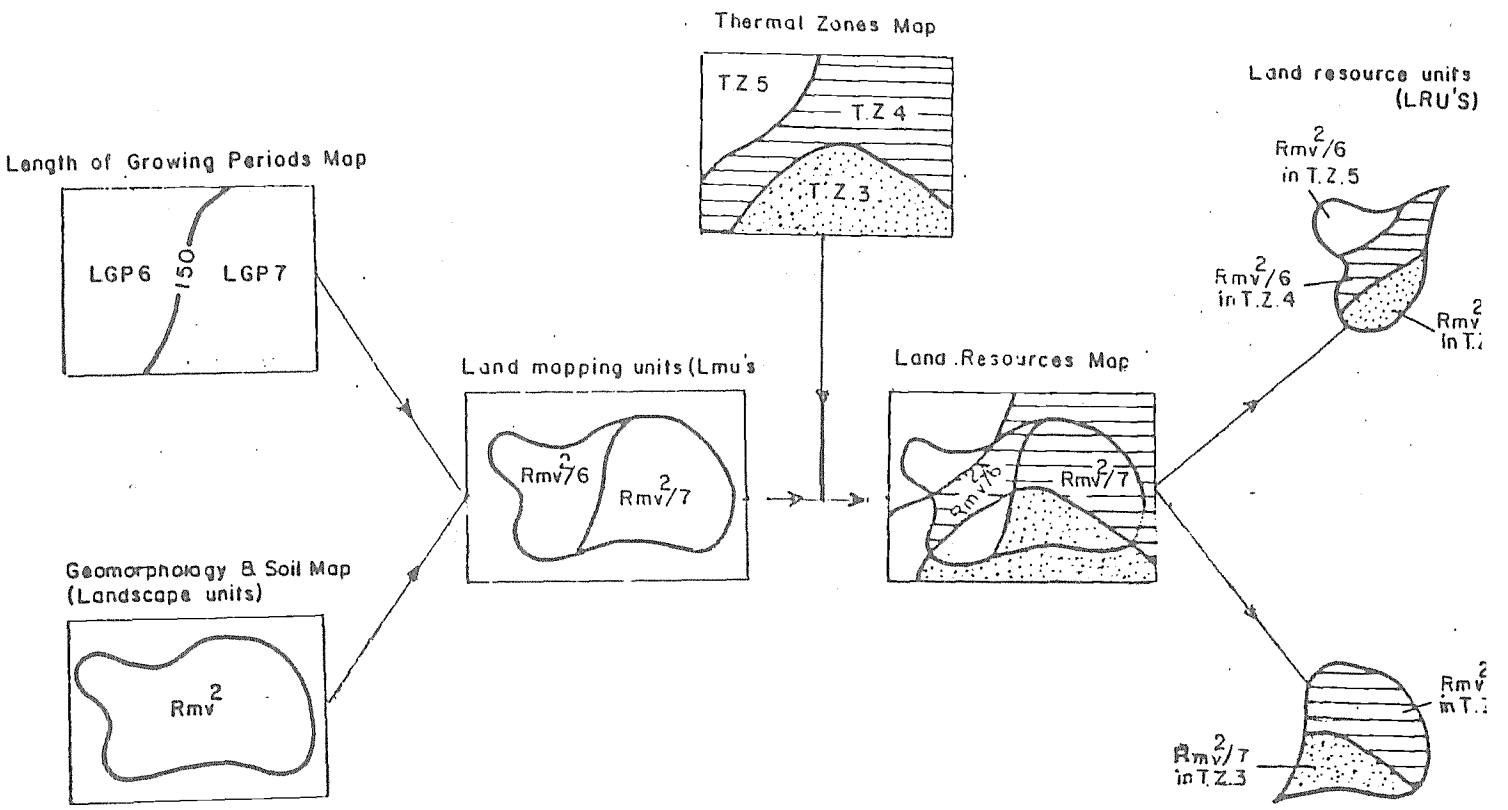
$$T\ ^{O}C = 30.20 - 00.0059 \times \text{Altitude},\ R^2 = 0.90$$

Gradient=0.59^{O}C/100m use

Figure 3

Method of integrating thematic data and lad resources units





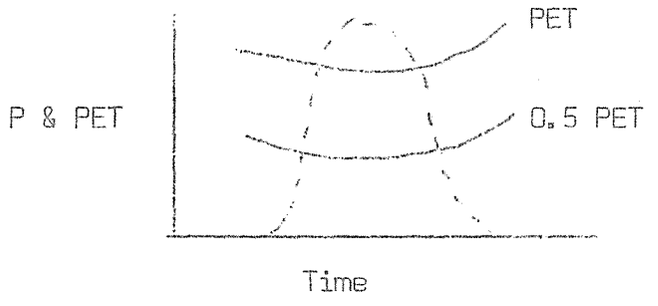
Thermal Zone		Corresponding Altitude in Meters
10	7.5	3800
9	7.5 - 10.0	3400 - 3800
8	10.1 - 12.5	3000 - 3400
7	12.6 - 15.0	2600 - 3000
6	15.1 - 17.5	2200 - 2600
5	17.5 - 20.0	1700 - 2200
4	20.6 - 22.5	1300 - 1700
3	22.6 - 25.0	900 - 1300
2	25.1 - 27.5	500 - 900
1	27.5	500

6.3.2 Length of Growing Periods

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

NORMAL ——— 150 ———

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 evapotraspire an assumed 100 mm of water from excess precipitation (or less if not available) stored in the soil. Normal LGP's is 150 days.



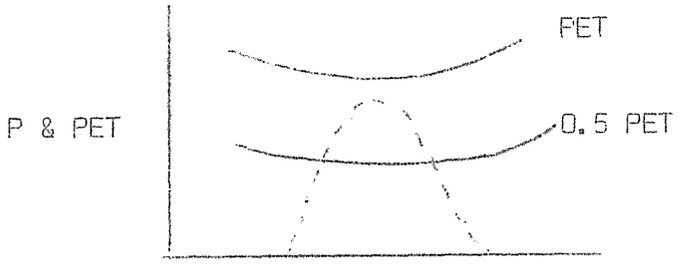
Intermediate - - - - - - - - - 45/90 - - - - - - - - -

An intermediate growing period implies that throughout the year the average monthly precipitation does not exceed the full rate of the average potential evapotranspiration.

The beginning and end of such an intermediate growing period are defined as the points where the precipitation, Curve Crosses the 0.5 PET Curve.

Intermediate growing periods are common in semi-arid areas and their codes are indicated on this map enclosed in parenthesis e.g. $RMV^2/(3)$.

The Harawa Settlement Project Site of LGP's is 150 days and also overlapping 45/90 days of intermediate zones.

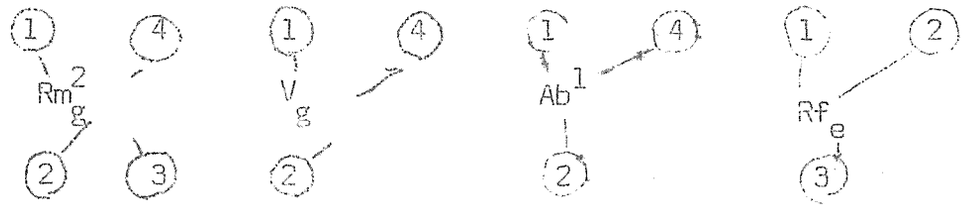


For convenience of Tabulation LGP zones are assigned numerical codes as follows:-

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 reasonable homogenous with respect to geomorphology, soils and vegetation, have been delineated on this map. Manual interpretation of aerial 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: See map 2.



(1) Six subdivisions, represented by the capital Letters reflect the genesis on the landforms, 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 unit, 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 precambrain basement (saltes, schists, phyllites, etc.)	m
Evaporite (predominantly gypsum)	e
Sandstone	s
Calcareous (predominantly gypsum)	c

Such symbols are normally used alone but may be used together, for example, ^{sh}cg, 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.

They 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 Harawa settlement site. See map 2.

6.4.1 Summary Legend

- High to mountainous relief hills

  Residual landform

  Rh (Rmg^2) High to mountainous relief hills

- Moderately dissected plateaux, plateaux with hills and rolling to hilly plateaux

  Volcanic landform

  Vg High volcanic piedmonts and lava plateaux

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 facets

Landscape Unit No.
Geomorphology
Total Area (Km^2)
Significant land facets
Area (%)
Geology
Slope range
Dominant ve getation and/or land use
Remarks (by land facet)
(by landscape unit)

Soils FAO classi fication
Colour (Moist)
Texture
Drainage Class
Rock outcrop
Surface stones
Effective depth
ph
OM (organic matters) (%)

CEC (Cation Exchange Capacity)
Available p
SMU No. (Soil Management Unit)
Erosion

The description of landscape unit is presented in Appendix 4.

7. LAND SUITABILITY CLASSIFICATION MAP

7.1 Land Suitability Evaluation

The results of the land suitability classification conducted in settlement project are presented in two main ways:

- Land suitability maps
- Land suitability classification tables

For the 5 crops considered within the rainfed agriculture, one group combination 1:50,000 scale of land suitability maps have been prepared for the Harawa settlement project.

Similar land suitability maps for the forestry LUT's and a livestock LUT's 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 Tables. Here, details of suitability limitations for S2 (moderately) S3 (marginally). Suitability and N (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 classess indicate degrees of suitability, within the order (S). It is usual to recognize three classes, 'highly", moderately and marginally suitable. The following names and definitions may be appropriate in a qualitative classi fication:

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 severe 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 from 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 limitation 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, 12075 hectares of land in the area, comprising land suitability units I and II, have been recommended for cooperative farms and homestead production of crops adopted to the area, i.e. wheat, sorghum, maize, teff.

On the other hand, 6,533 hectares, which combines all the other land suitability units, are available 3809 hectares for livestock grazing lan d and afforestation 777 hectares.

7.3 Land Suitability Subclasses

Land suitability subclasses reflect kinds of limitations, e.g. moisture deficiency, erosion hazard. Subclasses are indicated by lower-case letters with minemonic significance, e.g. S2m S3me.
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 Harawa Settlement Project site has been evaluated for rainfed agriculture and classified into 7 suitability units. Their distribution is indicated in Map 3 of land suitability classification map. See table 3.

Table 3 Limitations and Recommended use of Land Suitability Classification in Harawa

Landscape Unit Symbol	Significant Land Facet	Limitation	Recommended Use and Treatment	Land Suitability Classes
1	Plains and undulating gentle sideslopes interfluences on 2-8% slopes	Low phosphorous soil difficult to manage.	Cultivation of wheat, teff sorghum, maize pulses and sunflower, Fields to be on the contour, grass strips every 50 m and grass water way along the depressions and limited applications of DPA fertilizer especially on wheat.	S1
2	Marshy depression on 0-2% slopes	Low phosphorous water logs during wet season	Grazing during dry season or horticulture after draining. Soils needed drainage water on ditches every 50 m interval along the depressions after drain cultivation of cereals and pulses.	S2w
6	Moderate sideslopes on 8-16% slopes	Low phosphorous moderate erosion	Same as S1 but narrow grass strips better soil and moisture conservation, best suitable to pasture development after soil conservation cultivation of cereals and pulses.	S3e

Landscape Unit Symbol	Significant Land Facet	Limitation	Recommended Use and Treatment	Land Suitability Classes
7	Intermantance valleys on 0-8% slopes	Swampy, very irregular on sandy	Afforestration and building materials and grazing during the dry season. Micro basins for afforestration.	N1w
3.4	Very steep sideslope to escarpments on 30-50 and 50+% slopes	Very severe erosion and gully land. Very steep and/or rocky.	Afforestration in selected areas, if large areas keep in wildlife conservation.	N2e
5	Steep sideslopes on 16-30% slopes	Moderate to severe erosion moderately deep soil	Grazing land, range pasture, fuel wood plantations and fruit trees. When land preapre by Bench terrace can cultivated few selected crops.	N1e
8	Plateau terrace and gentle sideslope	Low pheopharous slight erosion	Same as S1 but slight erossion. Field to be more need soil conservation measures grass strips every 50 m and limited application of DPA Firtilizer especially on wheat.	S2e

8. DEVELOPMENT PLAN

The development plan incorporating at improvements most suited to the subwatershed and offering optimum benefit to the settlements.

Any activity that will improve or at least sustain production, or that is of benefit to the settlement, may be termed a development option. The options considered are those that will lead to improving or at least 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 good farm management programme.

8.1 The Development Plan Map

The development plan may 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 to the planner for determining the extent of the areas and the volume of inputs required.

Any development work that has been previously implemented should be transferred to the developme nt map using the symbols as given in Table 4.

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, microbasins, etc. The location of farm ponds, spring development, waterstorage dam, diversion wier, check dam are shown on the development 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 ' - Legend for Development Plan Map

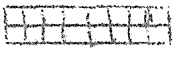
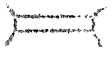
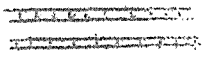
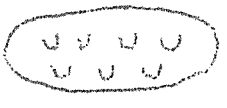
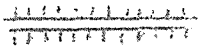
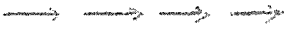
Legend	Detailed
CU	Arable land (cultivated)
GL	Grazing land
FS	Forest shrubland
WL	Wasteland
RO	Rock outcrop/boulders
FP	Forest Planatation
RP	Range pasture
NU	Nursary site
2w	Water logging
	Settlement site
	Road (with gravel all weather)
	Farm Road
	Path
	Seasonal Permanent } Rivers and water courses
	Existing dam
	Bridge
	School
	Church
Development workand Improvement	
	Soil and stone faced bunds
	Micro basins for · micro basins for afforestation
	Check dam (gully control)
	Channel improvement
	Drainage water way and hillside drains

Table 3. Cont'd

Legend	Detailed
	New Bridge
	New Church
	New School
	Pasture range development
	Unit boundary
	Unit number
	Road repair
	Diversion Dam

Table 5 Development Plan Work Component Harawa

Work Component	Unit LUN	1	2	3	4	5	6	7	8	9	10	Total
Present Land Use												
Cultivated land	1	1110	888	767	595	963	1136	856	631	802	325	8,073
Water logging	2	50	69	15	-	-	-	-	-	-	-	194
Escarpment or severly eroded	3	-	-	-	-	160	10	-	-	13	-	183
Forest/shrub land	4	-	7	-	306	616	259	-	-	-	300	1,488
Woodland/Accacia	5	197	61	500	344	-	37	101	-	578	87	1,905
Grass land	6	210	116	40	-	-	167	367	344	-	-	1,244
River Valley	7	29	50	116	100	88	50	104	87	673	200	1,497
Mixed cultivated land	8	401	723	1073	689	151	-	-	-	-	1034	4,071
Tree plantation	TP	10	-	-	-	-	6	-	-	7	-	23
Nursery	N	-	-	-	7	-	-	-	-	-	-	7
Settlement	H	106	100	125	125	101	84	106	119	54	63	983
Total	ha	2113	2014	2636	2166	2079	1749	1534	1181	2127	2009	19,608
Development Plan												
Proposed Cultivated land		1511	1611	1840	1284	1114	1130	856	631	766	1323	12,075
Drainage Improvement		50	69	15	-	-	-	-	-	-	-	134
Afforestration		24	25	58	57	44	131	52	43	343	100	777
Pasture Development		407	177	540	344	-	204	468	344	578	87	3,149
Natural grazingland		15	25	58	50	44	25	52	44	337	100	750
Hillside terrace Soil and stone bunds		-	7	-	306	616	259	-	-	13	300	1,501
Wield life conservation		-	-	-	-	160	10	-	-	-	-	170
Settlement		106	100	125	125	101	90	106	119	90	90	1,052
Total	ha	2113	2014	2636	2166	2079	1749	1534	1181	2127	2009	19,608
Check dams	Site	6	6	10	6	11	6	2	4	11	12	74
Dam, weirs	Site	1	-	-	-	1	1	1	1	-	1	6
Water way hill side drains	Km	4	4.5	1.5	0	1.5	3	3	3	5	2	27.5
Farm road improve	Km	-	-	-	1	2.3	-	-	-	3	-	6.3
Bridge	Site	1	1	-	-	-	1	-	-	1	-	4

Proposed Land Use Plan

Proposed Land Use	Present Land Use and Land scape Unit No
Cultivated land	1. Cultivated land (0-8%) 8. Mixed cultivated land with grass (2-8%)
Drainage Improvement	2. Water logging and seasonal swamp (0-2%)
Afforestration (Micro basins)	7 River valleys half of total area (0-8%) TP Reee plantation N Nursery
Bench terrace or pasture improvement	6. Grassland (8-16%) 5. Woodland with acacia (16-30%)
Natural grazing land	7. River valleys half of total area (0.8%)
Hillside terrace soil and stone bunds	4. Forest shrubland (30-50%)
Wild life conservation	3. Escarpment severely eorded (50%)
Settlement	At presently less than 90 ha of homestead, increased up to 90 ha unit 6 and 10.

8.2 Engineering Measures for Soil Conservation

Any measure that involves the physical movement of soil or stones, or requires construction, call termed an engineering measure. Usually such measures are not complete in themselves and require the addition of a negative 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 of retarding rainfall runoff and thereby reduce soil erosion from arable and forest areas. 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 and from 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 closely spaced developed stone bunds. They are constructed on slope 30% and over, where there is adequate soil depth and an abundance of stone. The width of these terrace should not be greater than 1.5 to 2.0m. while their height will vary from 0.5 to 1.0m.

8.2.3 Micro Basins

Micro basins, or eyebrow terraces as they are sometimes called, are small basins (depression) cut into the hillside to enhance the growth of seedlings.

They are generally constructed on any slopes and are less costly to build the hillside terraces. Each seedling has an individual basin. These basins are circular or semi-circular and 0.5 to 1.0 m in diameter. Their spacing apart will depend on the species to be planted.

Micro basins will retain only a small portion of runoff during intense rainfall. If this runoff is likely to build up into a large volume,

as would occur on long slopes, hillside drains should be constructed at intervals to intercept this surface runoff.

8.2.4 Gully Control

Outside of units one and two areas, gully erosion are serious problem. Gullies are formed by or concentration of rainfall runoff flowing down a hillside. Frequently road culverts or worn footpaths 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. Seldom it is possible to do more than stabilize its condition, thus preventing further growth.

8.2.5 Grass water way

Interception ditches at the bottom of each row of plots will generally have a slight gradient towards grassed waterways. The uppermost interception ditch must be large enough to accept the considerable runoff from the ridge. The grassed waterways will convey the runoff downhill 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 is available a narrow stone channel, debouches from the plots areas into the farmland, it should flare out into a grassed waterway.

In most cases, the interval roads or tracks which allow access to the row paths and to the farmland will be on the catchment divide. Since they run radially 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.

8.3 Vegetative and agronomic measures for soil 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 if left to undisciplines 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.

8.3.1 Tree Plantations

Trees can be planted to protect the soil and to provide fuel wood, ploes, fodder, or fruit. They can be established on steep slopes not suited for cultivation or for stabilization of an area, minimizing erosion rates without excluding production. The kinds of trees to be chosen depend on the agro-ecological conditions, the soil and the priorities of the settlers in the settlement. Tree planting has been carried out in the villages, 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,thousands 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 65%.

Species to be raised as follows:

- Wood lots species to be raised
  Acacia melanoxylon
  Casuarian equistifolia
  Cupressus liustania
  Eucalyptus camaldulens

Eucalyptus globules
Eucalypts saligna
Melia azandrachta (Melka Oda Settlement site)

- -Wind Break species to be raised
  Acacia melanoxylon
  Casuarina equistifolia
  Cupressus luistanica
  Gravillea robusta
  Melia azandrachta)
  Parkinsonia aquilata) - (Melka Oda Settlement site)
  Schinus molle)

- -Other species to be raised for Beeflora
  Cordia africana
  Delonix regia
  Eucalyptus camaldulesis
  Eucalyptus saligna
  Spathodea nilotica

- Agro forestry
  Acacia albida
  Leuceana leucacephala
  Moringa olifera
  Cajanus cajana (Pige on pea)

8.3.2 On pasture and Grazing Land

Pasture and grazing lands comprise a large area in Harawa. These lands carry a large number of livestock, so large that over-grazing has taken near the surrounded settlement areas. This results in a fall in the quality and quantity of fodder, so few animals can be supported.

The soil is left without a cover, thus prone to erosion by water and wind. Loss of topsoil through erosion reduce the fertility of the soil, and thus the likelihood of reestablishing ; a good quality pasture goes down.

The land is with 8-16% slope with no worse than slightly eroded or irregular topography. The implication is that the land can be cleared and cultivated for reseeding pasture and that it can be cropped from time to time in a long ley system to exploit the fertility buildup without incurring excessive erosion penalities.

The pasture management will probably require a system of rotational grazing and forage conservation. Access to pasture poses the problem of straying into field of growing crops. Desirable shade and browse trees should be planting in the pasture areas.

Natural grazing can be recommended will come from two classes of land. One is dissected slopes 16-36% slopeland will provide the upland grazing in the wet season. The more areas will need to be managed with care and needed strict grazing control. The depressional areas along the stream should provide the source of the grazing during the dry season. These areas could also be used for water storage in the future as suggested in water storage dams.

8.3.3 On arable land

For case of mechanization, trees have been cleared from arable lands, which will lead to serious soil erosion problem. This underlines the need for developing agroforestry land use system (introduction of multy purpose trees for conservation, fuel, fodder and food etc.)

An agroforestrys system would provide a further alternative, especially for arable lands supply of N through nitrogen fixing trees may decrease purchase price of urea, increasing forage for livestock and fuel wood. Establishment of a system of wind break will protect crops from desicating winds.

8.3.4 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 systems 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 eriosion 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 suceptible 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 vegetative cover and therefore can be said to have beneficial effects for soil conservation.

Showing down the speed of the water on certain parts of the slope are strip cropping, narrow grass strips residue or much lines and hedges. In a strip cropping system, contoured belts of crops inviting high erosion risk are alternated with belts of crops with low erosion risk. Narrow grass strips, much lines or hedges used for building up a terrace. The strip shows 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 or, extra area should be allowed.

Unless the topography is very even, plot dimersions will not be uniform, generally narrower at the upper end. Plot dimensions should aim to be 40-50m 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 and 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 paralleld 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 ditch is that they receive smaller 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 subwatershed 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 mere 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.

8.4.1 Farm Ponds, Dams and Wells

In Harawa there are no permanent rivers or springs, the construction of farm ponds should be considered as part of the development programme. Ideally, the ponds should be located in natural depressions where the soil is impervious, or an impervious layer can be spread on the bottom. See page losses will therefore be small, and if the ponds are relatively deep to their surface area, evaporation loss will be reduced.

- Pollution of the ponds by livestock is a serious problem. The fencing to keep the animal out of the pond, be made to pipe the water from the water from the pond to a nearby water through.

- The siltation of ponds. Generally, dams are constructed across natural water courses. Care has to be taken the spillway is of adequate size to accommodate the runoff from the catchment area. The capacity of the reservoir (dam up to 8m 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 reservoir.

- Where the water table is less than 2 or 3m deep, the construction 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.

8.4.3 Swamp Drainage

Frequently, there are areas in subwatershed with poor drainage. Where such areas are in deep depressions, it is usually not practical to drain them, and the depth and area of the swamp will fluctuate with the amount of rainfall. However, often swamps occur in shallow depressions or even on gently slopping land such as Units 1,2,3. In these areas, consideration should be given to drainage. If the water table can be lowered by the construction of a network of drainage channels, greatly improved grazing can be obtained, and possibly arable cultivation may become practical.

8.5. Other Measures

The principal soil and water conservation measures that might be required in a 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), apiculture (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 landslides 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 those on relatively steep grades may have to be rock paved in order to prvent 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
F	Fine (light)	Clay (C) Sandy clay loam (Scl) Silty clay loam (Sicl) Clay loam (CL)
M	Medium	Silt loam (Sil) loam (l) Very fine sandy loam (vfsl)
L	Course (light)	Fine sandy loam (FSL) Sandy loam (SL) Loamy fine sand (Lfs)
C	Very coarse (very light)	Loamy sand (LS) sand (S) Course sand (CoS)

COARSE FRAGEMENTS: ALL LAND)

a) Gravel, cobble, and other coarse fragements 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	% cobble 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.

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

PERMEABILITY (ALL LANDS)

Sumbol	Permeability Class	Probable Texture	Probable Structure	Approximate Per Rate Cm
2	Slow	fine (heavy)	pr, abk, pl	0.13 to 0.5
3	moderately slow	fine or medium	pr, abk pl	0.5 to 2.0
4	moderate	medium	pr, sbk	2.0 to 6.3
5	moderately rapid	coarse	sbk, gr, cr	6.3 to 12.5
6	rapid	very course	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	Caleareous (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 n 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:-

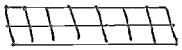
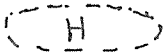
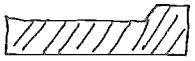
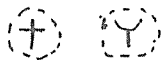
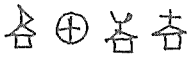
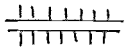
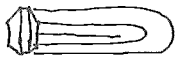
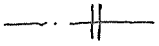
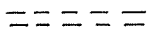
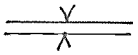
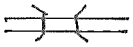
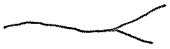
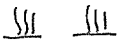
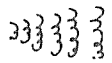
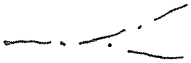
Class 0 Very Poorly Drained - water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded.

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 WHEAT

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	2000 – 2600	1800 – 2000	1650 – 1800	1500 – 1650	< 1500
					2600 – 2730	2730 – 2860	2860 – 3000	> 3000
		Mean Temperature (Thermal Zone)	°C	17 – 20	12 – 16	8 – 11	6 – 7	< 6
					21 – 22	23 – 25	26 – 35	> 35
2	GROWING PERIOD	Length of Growing period	day	> 121	120 – 110	110 – 100	100 – 90	< 90
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	100 – 150	100 – 50	50 – 25	25 – 10	< 10
		Growth cycle	day	140 – 110	110 – 100	100 – 90	80 – 90	< 80
					150 – 140	> 150		
4	DRAINAGE	Soil Drainage	class	MW – W	W – I	I – P	P	IP
					MW – SE	W – SE	SE	E
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	17 – 20	16 – 12	11 – 8	7 – 6	< 6
					21 – 22	23 – 25	26 – 35	> 35
		Length of Growing period	day	> 121	120 – 100	110 – 100	100 – 90	< 90
		Soil Texture	class	L – C (rd)	SL	C (bl)	LS	S
		Stoniness	class	None	fairly stony	stony	very stony	exciding stony
		Slope angle	%	0 – 8	8 – 16	16 – 30	30 – 50	50+
6	NUTRIENT STATUS AND RETENTION	Soil Texture	class	L – C (rd)	SL	C (bl)	LS	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 – 8	2 – 1 8 – 10	< 1 > 10	-
7	ROOTING CONDITION AND WORKABILITY	Effective Soil Depth	cm	100 – 150	100 – 50	50 – 25	25 – 10	< 10
		Stoniness	class	none	fairly stony	stony	very stony	exciding stony
		Soil Texture	class	L – C (rd)	SL	C (bl)	LS	S

ENVIORNMENTAL REQUIREMENT FOR CROP WHEAT

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	6 – 16	16 – 30	30 – 50	>50
		Staniness	Class	hone	fairly stony	stony	very stony	exceeding stony
		Soil Texture	Class	L – C(vd)	SL	C(bl)	LS	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 WHEAT

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 workinput 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	Machanized 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 SORGHUM

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	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	1 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 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
		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	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 SORGHUM

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 TEFF

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	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	3 – 2 / 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				
				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	Si – CL (bl)	L – Sc1	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
		Hail Sensitivity	S – Sensitive M – Medium	Sorghum Maize	S S	Chickpea pepper	T M

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 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 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~~	~~SE – 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	1 / 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(rd)	C (bl)	S

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 N.S	N2 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
		stoniness	Class	none	faily 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
				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 SUNFLOWER

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	1200 – 2000	1200 – 1100	1100 – 1050	1050 – 1000	< 1000
					2000 – 2200	2200 – 2500	2500 – 2800	> 2800
		Mean Temperature (Thermal Zone)	°C	22 – 24	19 – 21	15 – 18	10 – 14	< 10
					25 – 30	31 – 35	36 – 38	> 38
2	GROWING PERIOD	Length of Growing period	day	90 – 150	90 – 85	85 – 80	80 – 75	< 75
3	MOISTURE AVAILABILITY	Effective Soil Depth	cm	100 – 150	50 – 100	25 – 50	10 – 25	< 10
		Growth cycle	day	110 – 140	100 – 110	90 – 100	80 – 90	< 80
					140 – 160	> 160		
4	DRAINAGE	Soil Drainage	class	MW – W	I	P	P	VP
					SE	SE	E	E
5	DEGRADATION HAZARD	Mean Temperature (Thermal Zone)	°C	22 – 24	19 – 21	15 – 18	10 – 14	< 10
					25 – 30	31 – 35	36 – 38	> 38
		Length of Growing period	day	90 – 150	90 – 85	85 – 80	80 – 75	< 75
		Soil Texture	class	LS – SCL	Sil	Sic	C (rd)	C (bl)
		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 – SCL	Sil	Sic	C (rd)	C (bl)
		Soil Reaction	pH	6.5 – 7.0	6.5 – 6.0	6.0 – 5.5	5.5 – 5.0	< 5.0
					7.0 – 7.5	7.5 – 8.0	8.0 – 8.5	> 8.5
		Organic Matter	%	> 3	2 – 3	1 – 2	0 – 1	
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
		Soil Texture	class	LS – SCL	Sil	Sic	C (rd) – C (bl)	S

ENVIORNMENTAL REQUIREMENT FOR CROP SUNFLOWER

APPENDIX 2

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 – 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	LS – SCL	Sil	SiC	C(vd) – 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 SUNFLOWER

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 – 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 farming (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

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT.
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Addis Ababa

APPENDIX.3

Study Area / Project : Harawa Field Number : Unit I-B

Location / Coordinates : Bale

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm) >2	2-0.2	0.2-0.05	0.05-0.002	<0.002	Texture Class	pH, 1:1 In H_2O	KCl	NaF	$CaCO_3$ %	Free Fe_2O_3 %
1749	H-1-1	10-30						SL	7.30				
1750	H-1-1	120-140						C	7.25				
1751	H-1-2	30-50						C	7.40				
1752	H-1-3	10-30						L	8.20				
1753	H-1-3	110-125						CL	6.60				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	Base Saturat. %
1749	H-1-1	10-30	0.109	1.984	53	5							
1750	H-1-1	120-140	0.326	1.536	65	3							
1751	H-1-2	30-50	0.291	2.016	45	7							
1752	H-1-3	10-30	0.054	2.4	26	2							
1753	H-1-3	110-125	0.109	1.504	27	9							

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 %	
1749	H-1-1	10-30	3.105	0.196		3.105	5.0						
1750	H-1-1	120-140	1.898	0.126		1.898	4.8						
1751	H-1-2	30-50	0.897	0.084		0.897	4.8						
1752	H-1-3	10-30	2.691	0.21		2.691	4.8						
1753	H-1-3	110-125	0.863	0.112		0.863	2.4						

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

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Study Area / Project : Harawa Field Number : Unit 1-8

Location / Coordinates : Bale

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		
1754	H-2-1	0-20						scL	6.40				
1755	H-2-1	75-90						C	6.50				
1756	H-3-1	0-30						L	6.05				
1757	H-4-1	20-40						cL	6.40				
1758	H-4-1	97-110						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.	
1754	H-2-1	0-20	0.054	2.464	29	3							
1755	H-2-1	75-90	0.054	1.536	28	4							
1756	H-3-1	0-30	0.027	2.624	29	5							
1757	H-4-1	20-40	0.054	3.648	40	2							
1758	H-4-1	97-110	0.109	1.600	43	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 %	
1754	H-2-1	0-20		0.224		2.45	5.8						
1755	H-2-1	75-90		0.168		1.932	4.8						
1756	H-3-1	0-30		0.182		2.76	5.8						
1757	H-4-1	20-40		0.238		1.898	11.2						
1758	H-4-1	97-110		0.042		1.38	5.8						

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT.
MINISTRY OF AGRICULTURE
Addis Ababa

Study Area / Project : Hajawa Field Number : Unit 1-8

Location / Coordinates : BALE

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm) >2	2-0.2	0.2-0.05	0.05-0.002	<0.002	Texture Class	pH, 1:1 In H_2O	KCl	NaF	$CaCO_3$ %	Free Fe_2O_3 %
1759	H-5-1	0-25						L	6.25				
1760	H-5-1	60-76						C	6.50				
1761	H-6-1	0-30						SCL	6.05				
1762	H-6-1	65-80						C	6.30				
1763	H-7-1	10-30						L	6.35				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	Base Saturat. %
1759	H-5-1	0-25	-	1.728	27	1							
1760	H-5-1	60-76	0.163	1.536	26	2							
1761	H-6-1	0-30	0.027	1.76	29	3							
1762	H-6-1	65-80	0.109	1.216	30	4							
1763	H-7-1	10-30	0.271	1.92	25	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 %	
1759	H-5-1	0-25		0.168		4.14	8.0						
1760	H-5-1	60-76		0.126		1.553	4.8						
1761	H-6-1	0-30		0.182		2.243	8.0						
1762	H-6-1	65-80		0.112		1.380	2.4						
1763	H-7-1	10-30		0.154		2.070	0.8						

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

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Study Area / Project : HARAWA Field Number : Unit 1-8

Location / Coordinates : BALE

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		
1764	H-7-1	80-95						CL	6.90				
1765	H-8-1	0-20						SCL	6.30				
1766	H-8-1	30-60						C	6.40				
1767	M-1	0-30						C	8.15				
1768	M-1	70-90						C	8.60				

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. Def.	
1764	H-7-1	80-95	0.380	1.216	30	7							
1765	H-8-1	0-20	0.163	1.632	25	1							
1766	H-8-1	30-60	0.271	1.504	26	5							
1767	M-1	0-30	1.194	0.992	91	10							
1768	M-1	70-90	8.572	0.288	82	13							

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 %	
1764	H-7-1	80-95		0.048		1.380	3.2						
1765	H-8-1	0-20		0.280		2.484	6.4						
1766	H-8-1	30-60		0.042		1.829	4.8						
1767	M-1	0-30		0.168		1.725	6.4						
1768	M-1	70-90		0.084		1.553	3.2						

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

LAND USE PLANNING AND REGULATORY DEPARTMENT
MINISTRY OF AGRICULTURE
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Study Area / Project : Harawa — Field Number : Unit 9
Location / Coordinates : Bale

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm)					Texture Class	pH, 1:1 in			CaCO3 %	Free Fe2O3 %
			>2	2–0.2	0.2–0.05	0.05–0.002	<0.002		H_2O	KCl	NaF		
350/86	H9-1-A				38.0	32.0	30.0	CL	7.55				
351/86	H9-1-B				38.0	30.0	32.0	CL	7.45				
352/86	H9-2-A				42.0	28.0	30.0	CL	6.40				
353/86	H9-2-B				28.0	18.0	54.0	C	6.85				

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. Met.	
350/86	H9-1-A		0.271	0.736	54	9						47.4	
351/86	H9-1-B		0.488	0.544	57	6						50.0	
352/86	H9-2-A		0.163	0.640	53	6						41.6	
353/86	H9-2-B		1.573	0.608	61	14						27.4	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm kg/ha	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
				0.182		4.00	1.6						
				0.154		3.240	0.8						
				0.196		6.000	0.8						
				0.168		2.970	1.2						

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SOIL CHEMICAL AND PHYSICAL ANALYSIS

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Study Area / Project : Harawa Field Number : Unit 9

Location / Coordinates : Bale

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm) >2	2-0.2	0.2-0.05	0.05-0.002	<0.002	Texture Class	pH, 1:1 in H_2O	in KCl	in NaF	$CaCO_3$ %	Free Fe_2O_3 %
354/86	H9-3-A				30.0	24.0	46.0	C	6.55				
355/86	H9-3-B				34.0	20.0	46.0	C	6.05				
356/86	H9-4-A				36.0	26.0	38.0	CL	5.90				
257/86	H9-4-B				34.0	20.0	46.0	C	6.60				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100gm soil Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	Base Saturat. %
354/86	H9-3-A		0.108	1.792	36	8.0						38.2	
355/86	H9-3-B		0.163	1.728	47	6.0						33.6	
356/86	H9-4-A		0.108	2.624	31	9.0						39.4	
357/86	H9-4-B		0.759	2.144	44	10						44.6	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 Kg/ha	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
				0.056		3.93	0.4						
				0.112		2.588	0.8						
				0.196		4.350	trace						
				0.07		1.860	0.4						

Date _____ Chief of Lab. _____

SOIL CHEMICAL AND PHYSICAL ANALYSIS

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Study Area / Project : Harawa Field Number : Unit 9

Location / Coordinates : Bale

Lab. No.	Field No.	Depth, cm.	Texture, % (Ø = mm) >2	2-0.2	0.2-0.05	0.05-0.002	<0.002	Texture Class	pH, 1:1 H_2O	pH, 1:1 KCl	pH, 1:1 $CaCl_2$	CaCO3 %	Free Fe_2O_3 %
358/86	H9-5-A				32.0	22.0	46.0	C	6.35				
359/86	H9-5-B				36.0	26.0	38.0	CL	6.65				
360/86	H9-6-A				38.0	32.0	30.0	CL	6.75				
361/86	H9-6-B				28.0	34.0	38.0	CL	6.80				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100gm soil Na	K	Ca	Mg	Al+H	Al	H	S....	C.E.C. Sum	C.E.C. Ext.	Base Saturation %
358/86	H9-5-A		0.108	1.824	64	1						55.0	
359/86	H9-5-B		0.163	1.120	68	2						61.25	
360/86	H9-6-A		0.108	1.472	62	1						55.20	
361/86	H9-6-B		0.108	1.248	60	6						32.6	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 Kg/hr	Avail. K ppm	Satur. %	Field Capacity %	P.W.P %	Available H_2O %	
358/86	H9-5-A			0.266		6.560	1.6						
359/86	H9-5-B			0.21		0.173	1.6						
360/86	H9-6-A			0.098		3.071	1.6						
361/86	H9-6-B			0.112		1.415	1.6						

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SOIL CHEMICAL AND PHYSICAL ANALYSIS

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Location / Coordinates : Bale

Lab. No.	Field No.	Depth, cm.	Texture, % (ø = mm) >2	2-0.2	0.2-0.05	0.05-0.002	<0.002	Texture class	pH, 1:1 in H_2O	KCl	NaF	$CaCO_3$ %	Free Fe_2O_3 %
362/86	H9-7-A				50.0	24.0	26.0	SCL	6.75				
363/86	H9-7-B				42.0	24.0	34.0	CL	6.90				
364/86	H9-8-A				54.0	28.0	18.0	L	7.20				
365/86	H9-8-B				38.0	20.0	42.0	C	7.50				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalents / 100 gm soil Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Det.	Base Saturat. %
362/86	H9-7-A		0.108	0.728	69	3						47.2	
363/86	H9-7-B		0.814	0.608	72	13						47.8	
364/86	H9-8-A		0.108	1.216	60	1						52.8	
365/86	H9-8-B		0.868	0.800	86	13						48.0	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 Kg/Ha	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
362/86	H9-7-A			0.224		2.480	4.8						
363/86	H9-7-B			0.098		3.278	0.8						
364/86	H9-8-A			0.098		2.415	2.0						
365/86	H9-8-B			0.098		3.347	trace						

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Study Area / Project : Harawa Field Number : Unit 9
Location / Coordinates : Bale

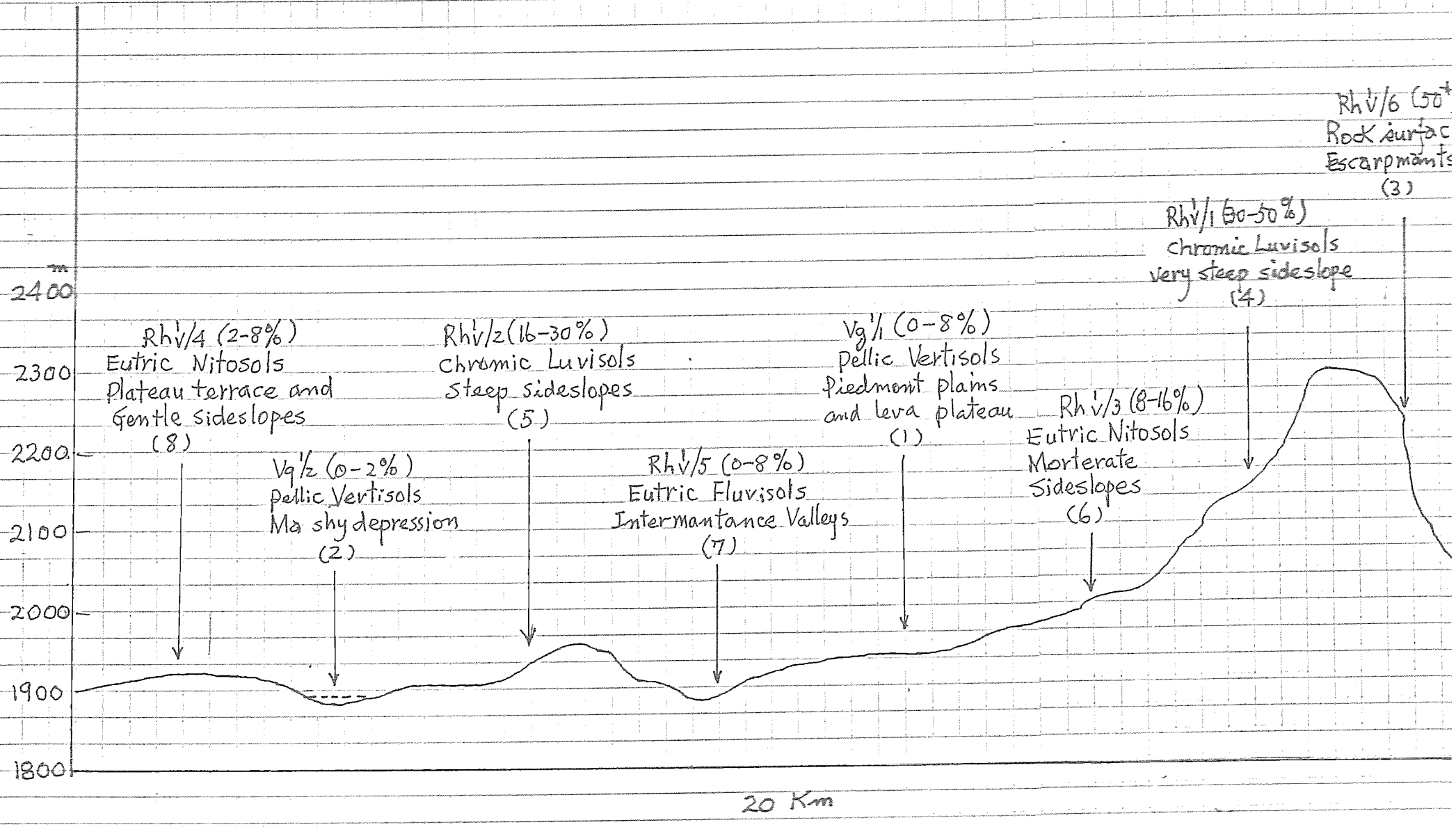
Lab. No.	Field No.	Depth, cm.	Texture, % (ø = mm) >2	2–0.2	0.2–0.05	0.05–0.002	<0.002	Texture Class	pH, 1:1 in H_2O	pH, 1:1 in KCl	pH, 1:1 in NaF	$CaCO_3$ %	Free Fe_2O_3 %
366/86	H9-9-A				38.0	38.0	24.0	L	7.75				
367/86	H9-9-B				36.0	16.0	48.0	C	7.90				
368/86	H9-10-A				34.0	26.0	40.0	C	7.00				
369/86	H9-10-B				36.0	28.0	36.0	CL	7.30				

Lab. No.	Field No.	Depth, cm.	Exchangeables, milliequivalent / 100 gm soil Na	K	Ca	Mg	Al+H	Al	H	Sum	C.E.C. Sum	C.E.C. Ext.	Base Saturat %
366/86	H9-9-A		0.108	1.152	55	34						52.00	
367/86	H9-9-B		0.488	0.928	81	7						48.0	
368/86	H9-10-A		0.108	1.280	64	27						35.0	
369/86	H9-10-B		0.108	0.928	79	34						52.8	

Lab. No.	Field No.	Depth, cm.	Org.C %	Tot.N %	C/N	O.M %	Avail. P_2O_5 ppm kg/hr	Avail. K ppm	Satur. %	Field capacity %	P.W.P %	Available H_2O %	
366/86	H9-9-A			0.126		3.036	2.4						
367/86	H9-9-B			0.140		4.000	0.4						
368/86	H9-10-A			0.028		2.312	2.8						
369/86	H9-10-B			0.098		4.209	2.8						

Date _____ Chief of Lab. _____

HARRAWA LANDSCAPE UNITS



Landscape Unit No. Vg 1/1

Geomorphology : High volcanic piedmonts and lave plateaux central highland.

Total Area : 9km²)

Remarks (Landscape Unit) : Some occurences of this unit are severely eroded and vertic combisols of depths approaching 50cm are frequent, as in North Eastern Shewa and Southern Wello; ash layers are frequently found in the soil profile.

Significant Land Facet : piedmont plains and lava plateaux

Soil Management Unit No. : 6

Area (%) : (km²)

Geology : tertiary basalts and tuffs

Slope Range (%) : 0 - 8

Soils:

FAO classification	: pellic vertisols.
Colour (moist)	: very dark gray to black
Texture	: clay and clay loam
Drainage class	: imperfectly
Rock outcrop	: none
Surface stones	: none
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)

Stony phases occur; where very flat this facet is susceptible to seasonal waterlogging.

Landscape Unit No. Vg 1/2

Geomorphology : See above

Total Area : (km²)

Remarks (Landscape Unit) : See above

Significant Land Facet : marshy depressions

Soil Management Unit No. : 6

Area (%) : (km²)

Geology : shallow colluvium over tertiary basalts and tuffs.

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	:	none
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 : Seasonal marsh with seasonal peasant livestock grazing of grassland and peasant cultivation of cereals and pulses as water recedes.

Remarks (Significant Land Facet)

Landscape Unit No. $\frac{1}{Rh\ v/6}$

Geomorphology : See above

Total Area : See above

Remark (Landscape Unit)

Significant Land Facet : escarpments

Soil Management Unit No. : 1

Area (%) : (km^2)

Geology : tertiary basalts and tuffs

Slope Range (%) : 50^+

Soils:

FAO classification	:	not applicable
Colour (moist)	:	not applicable
Texture	:	" "
Drainage class	:	" "
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)

Landscape Unit No. $Rh\ \frac{1}{v}/1$

Geomorphology : High to mountainous relief hills central highlands

Total Area : (km^2)

Remarks (Landscape Unit) : Chromic cambisols predonimate in some occurence of this unit

Signigicant Land Facet : very steep sideslopes

Soil Management Unit No. : 42

Area (%) : (km^2)

Geology : tertiary basalts and tuffs

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

Soils:

FAO classification	:	chromic luvisols (stony phase)
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	clay to sandy clay loam
Drainage class	:	well
Rock outcrop	:	rocky
Surface stony	:	very 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 : Dense mixed scrub forest

Remarks (Significant Land Facet) :

Lithic phase occur; chromic cambisols (lithic phase) occur.

Landscape Unit No. $Rh\ v/2^{1}$

Geomorphology : See above

Total Area (km^2) : See above

Remarks (Landscape Unit)

Significant Land Facet : steep sideslopes

Soil Management Unit No. : 112
Area (%) : (km^2)
Geology : tertiary basalts and tuffs
Slope Range (%) : 16 - 30
Soils:

FAO classification	:	chromic luvisols
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	clay to clay loam
Drainage class	:	well
Rock outcrop	:	fairly rocky
Surface stories	:	stony
Effective depth (cm)	:	100 - 150
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail. P (PPM)	:	<5

Dominant Vegetation and/or Land use : Dense mixed scrub forest.

Remarks (Significant Land Facet)

Eutric nitosols occur.

Landscape Unit No. $Rh\ \frac{1}{v}/3$

Geomorphology : High to mountainous relief hills central highland

Total Area : (km^2)

Remarks (Landscape Unit) : Chromic cambisols predominate in some occurance of this unit.

Significant Land Facet : Moderate sideslopes

Soil Management Unit No. : 36
Area (%) : (km^2)
Geology : tertiary basalts and tuffs
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	:	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 : Dense mixed scrub forest.

Remarks (Significant Land Facet)

Landscape Unit No. $Rh^{1}_{v/5}$

Geomorphology : See above

Total Area : (km^2)

Remarks (Landscape Unit)

Significant Land Facet : intermontane valleys

Soil Management Unit No. : 13

Area (%) : (km^2)

Geology : shallow colluvium over tertiary basalts and tuffs

Slope Range (%) : 0 - 8

Soils:

FAO Classification	:	entric fluvisols
Colour (moist)	:	dark brown to dark reddish brown
Texture	:	clay to sandy clay loam
Drainage class	:	morderately well
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 : Dense mixed high forest

Remarks (Significant Land Facet)

Chromic vertisols occur in wider less inclined valleys.

Landscape Unit No. Rh $\frac{1}{v}$/4

Geomorphology : See above

Total Area : (km²)

Remarks (Landscape Unit)

Significant Land Facet : plateau terraces and gentle sideslopes

Soil Management Unit No. : 9
Area (%) : (km²)
Geology : tertiary basalts and tuffs
Slope Range (%) : 2 - 8
Soils:

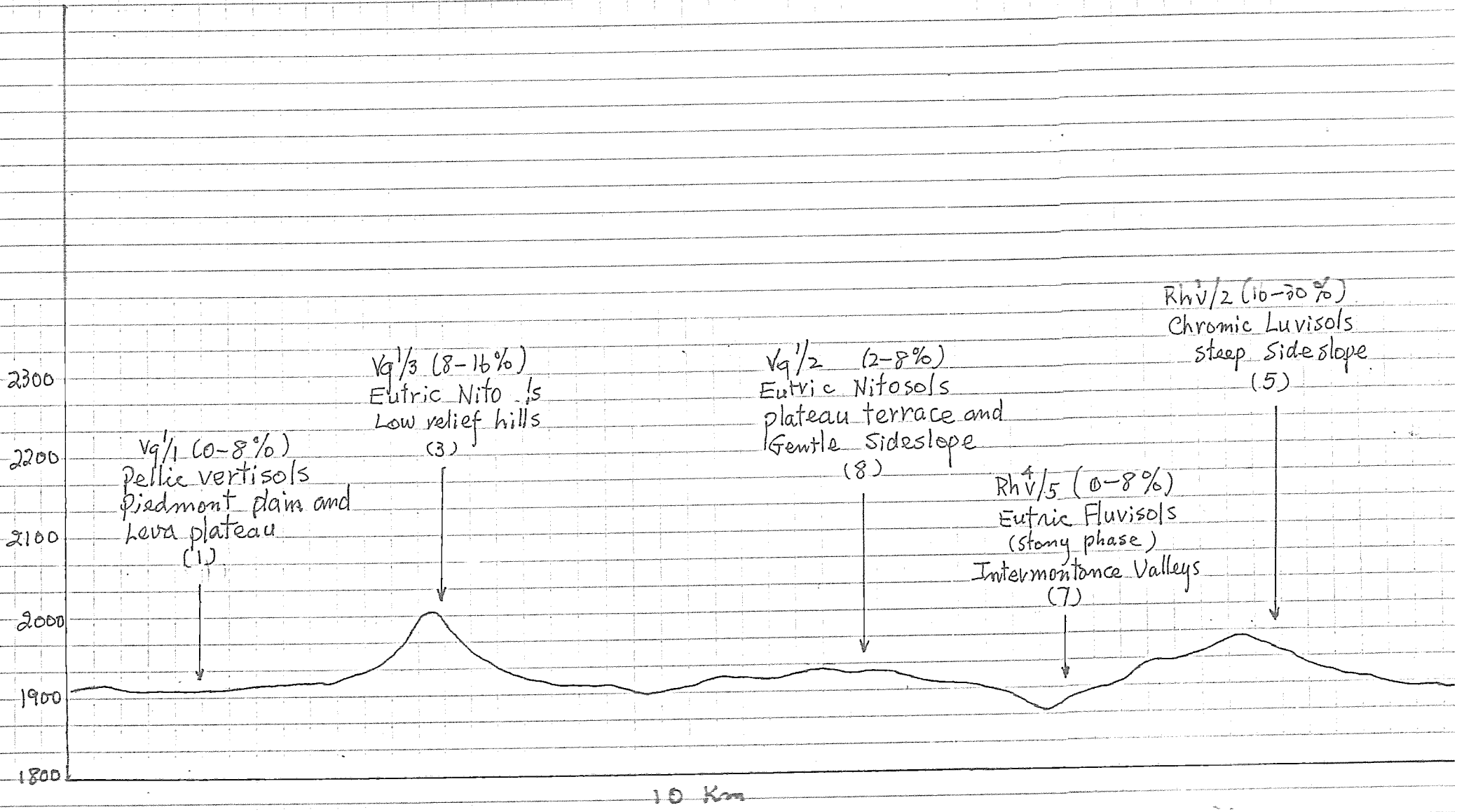
FAO classification	:	entric nitosols
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	clay to clay loam
Drainage class	:	well
Rock outcrop	:	fairly rocky
Surface stones	:	fairly stone
Effective depth (cm)	:	>150
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail. P (PPM)	:	<5

Dominant Vegetation and/or Land use : Dense mixed scrubforest.

Remarks (Significant Land Facet)

Chromic vertisols occur.

HARRAWA UNIT 9 LANDSCAPE UNITS



Landscape Unit No. Vg 1/1

Geomorphology : High volcanic piedmonts and lava planeaux central highlands

Total Area : (km^2)

Remarks (Landscape Unit): Some occurrences of this unit are severely eroded and vertic cambisols of depths approaching 50 cm one frequent, ash layers are frequently found in the soil profile.

Significant Land Facet: Piedmont plains and lava plateaux

Soil Management Unit No.: 6

Area (%) : (km^2)

Geology : Tertiary basalts and tuffs

Slope range (%) : 0 - 8

Soils:

FAO classification	:	Pellic vertisols
Colour	:	Very dark grey to black
Texture	:	Clay to caly loam
Drainage class	:	Imperfectly
Rock outcrop	:	None
Surface stones	:	None
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) : Stony phases occur; where very flat this facet is susceptible to seasonal waterlogging.

Landscape Unit No: Vg 1/3

Geomorphology : See above
Total area : (km^2) See above
Remarks (Landscape Unit) : See above

Significant Land Facet : Low relief hills
Soil Management Unit No. : 56
Area (%) : (km^2)
Geology : Tertiary basalts and tuffs
Slope Range (%) : 8 - 16
Soils :

FAO classification	: Eutic nitosols
Colour	: Reddish brown to dark redddish brown
Texture	: Clay to clay loam
Drainage	: 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: Opengrassland with peasant livestock grazing.

Remarks (Significant Land Facet): Chronic levisols occur, particularly in eroded areas; in northeastern Shewa and southern Welo eutric cambisols occur; stony phases occur.

Landscape Unit No. $Rh\ \frac{1}{v/2}$

Geomorphology : See above

Total Area (km^2) : See above

Remarks (Landscape Unit)

Significant Land Facet : steep sideslopes

Soil Management Unit No. : 112

Area (%) : (km^2)

Geology : tertiary basalts and tuffs

Slope Range (%) : 16 - 30

Soils:

FAO classification	: chromic luvisols
Colour (moist)	: reddish brown to dark reddish brown
Texture	: clay to clay loam
Drainage class	: well
Rock outcrop	: fairly rocky
Surface stories	: stony
Effective depth (cm)	: 100 - 150
pH	: 5.5 - 6.7
OM (%)	: 3 - 10
CEC (me/100g)	: 35 - 70
Avail. P (PPM)	: <5

Dominant Vegetation and/or Land use : Dense mixed scrub forest.

Remarks (Significant Land Facet)

Eutric nitosols occur.

Landscape Unit No. Rh $\overset{4}{v}$/5

Geomorphology : See above

Total Area : (km²)

Remarks (Landscape Unit)

Significant Land Facet : intermontane valleys

Soil Management Unit No. : 13

Area (%) : (km²)

Geology : shallow colluvium over tertiary basalts and tuffs

Slope Range (%) : 0 - 8

Soils:

FAO Classification	: Eutric fluvisols
Colour (moist)	: dark brown to dark reddish brown
Texture	: clay to sandy clay loam
Drainage class	: morderately well
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 : Dense mixed forest

Remarks (Significant Land Facet)

Chromic vertisols occur in wider less inclined valleys.

Landscape Unit No. Rh $\frac{1}{v}$/4

Geomorphology : See above

Total Area : (km²)

Remarks (Landscape Unit)

Significant Land Facet : plateau terraces and gentle sideslopes

Soil Management Unit No. : 9
Area (%) : (km²)
Geology : tertiary basalts and tuffs
Slope Range (%) : 2 - 8
Soils:

FAO classification	:	entric nitosols
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	clay to clay loam
Drainage class	:	well
Rock outcrop	:	fairly rocky
Surface stones	:	fairly stone
Effective depth (cm)	:	>150
pH	:	5.5 - 6.7
OM (%)	:	3 - 10
CEC (me/100g)	:	35 - 70
Avail. P (PPM)	:	<5

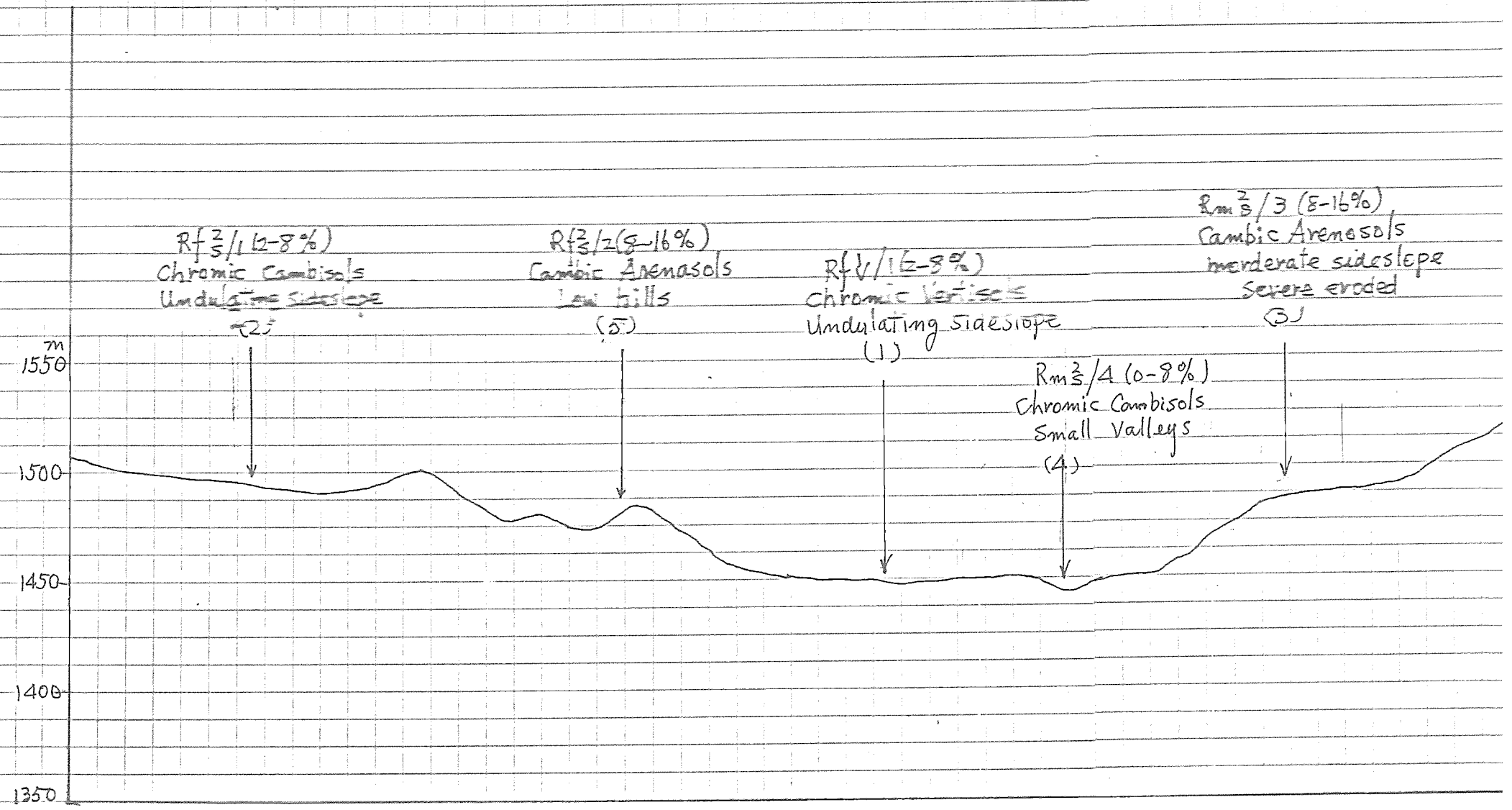
Dominant Vegetation and/or Land use : Dense mixed scrub forest.

Remarks (Significant Land Facet)

Chromic vertisols occur.

100

HARRAWA UNIT #10 LANDSCAPE UNITS



Landscape Unit No. Rf $\frac{1}{v/1}$

Geomorphology : Undulating sideslopes and piedmont zones strongly influenced by colluvial processes but retaining distinct residual characteristices - Western Gonder, Gojjam, Welega and Sidamo.

Total Area (km^2)

Remarks (Landscape Unit)

Significant Land Facet : undulating sideslopes

Soil Management Unit No. : 6

Area (%) : km^2

Geology : shallow colluvium over tertiary basalts and tuffs

Slope Range (%) : 2 - 8

Soils:

FAO classification	:	chromic vertisols
Colour (moist)	:	very dark grayish brown to very dark brc
Texture	:	clay to clay loam
Drainage class	:	imperfectly
Rock outcrop	:	none
Surface stones	:	none
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 : Bushed and shrubbed grassland with scattered peasant cultivation of maize and limited peasant livestock grazing and browing; peasant cultivation of perennial crops.

Remarks (Significant Land Facet)

Vertisols grade to eutric nitosols as slopes increase toward 8%

Melka Oda - 2

Landscape Unit No. Rf^{2} s/1

Geomorphology : Undulating sideslopes and piedmont zones strongly influenced by colluvial processes but retaining distinct residual characteristices - Bale and Tigray

Total Area (km^2)

Remarks (Landscape Unit)

Significant Land Facet : undulating sideslopes

Soil Management Unit No. : 32

Area (%) : (km^2)

Geology : shallow colluvium over mesozoic sandstones

Slope Range : 2 - 8

Soils:

FAO classification	:	chromic cambisols
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	loam to sandy clay loam
Drainage class	:	well
Rock outcrop	:	none
Surface stones	:	fairly stony
Effective Depth (cm)	:	100 - 150
pH	:	7.3 - 8.0
OM (%)	:	1 - 3
CEC (me/100g)	:	< 16
Avail. P (PPM)	:	10 - 15

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

Remarks (Significant Land Facet)

Cambic arenosols occur; gleyic cambisols occur.

Landscape Unit No. Rm ^{2}s/3

Geomorphology : Moderate to high relief hills - Northern Bole

Total Area (km^2)

Remarks (Landscape Unit)

Significant Land Facet : moderate sideslopes, severe eroded

Soil Management Unit No. : 138
Area (%) : (km^2)
Geology : mesozoic sandstones
Slope Range (%) : 8 - 16
Soils:

FAO classification	:	cambic arenosols (lithic phase)
Colour (moist)	:	red to dark reddish brown
Texture	:	sandy clay loam to sand
Drainage class	:	sonewhat excessively
Rock outcrop	:	very rocky
Surface stones	:	very stony
Effective depth (cm)	:	25 - 50
pH	:	7.3 - 8.0
OM (%)	:	1 - 3
CEC (me/100g)	:	<16
Avail. P (PPM)	:	5 - 10

Dominant Vegetation and/or Land use : Dense woodland with nomadic livestock grazing and browsing.

Remarks (Significant Land Facet)

Melka Oda - 4

Landscape Unit No. Rm^{2} s/4

Geomorphology : See above

Total Area (km^2)

Remarks (Landscape Unit)

Significant Land Facet : small valleys

Soil Management Unit No. : 98

Area (%) : (km^2)

Geology : shallow colluvium over mesozoic sandstones

Slope Range (%) : 0 - 8

Soils:

FAO classification	:	chromic cambisols
Colour (moist)	:	yellowish red to dark reddish brown
Texture	:	clay loam to sandy loam
Drainage	:	well
Rock outcrop	:	none
Surface stones	:	stony
Effective depth (cm)	:	>150
pH	:	7.3 - 8.0
OM (%)	:	1 - 3
CEC (me/100g)	:	16 - 35
Avail. P. (PPM)	:	10 - 15

Dominant Vegetation and/or Land use : Dense woodland with nomadic livestock grazing and browing.

Remarks (Significant Land Facet)

Landscape Unit No. Rf $\frac{2}{s}$/2

Geomorphology : See above

Total Area (km^2)

Remarks (Landscape Unit)

Significant Land Facet : low hills

Soil Management Unit No. : 138
Area (%) : (km^2)
Geology : Mesozoic sandstones
Slope Range (%) : 8 - 16
Soils:

FAO classification	:	cambic arenosols (lithic phase)
Colour (moist)	:	reddish brown to dark reddish brown
Texture	:	sandy clay loam to sand
Drainage class	:	somewhat excessively
Rock outcrop	:	rocky
Surface stones	:	very stony
Effective depth (cm)	:	25 - 50
pH	:	7.3 - 8.0
OM (%)	:	1 - 3
CEC (me/100g)	:	$<$ 16
Avail. P (PPM)	:	5 - 10

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

Remarks (Significant Land Facet)