AG: DP/ETH/82/010
Field Document 6

ASSISTANCE TO LAND USE PLANNING

ETHIOPIA

PROVISIONAL SOIL ASSOCIATION MAP OF ETHIOPIA (1:2,000,000)

THE PROVISIONAL MILITARY GOVERNMENT OF
SOCIALIST ETHIOPIA
MINISTRY OF AGRICULTURE
LAND USE PLANNING AND REGULATORY DEPARTMENT

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

Addis Abeba, 1984

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PROVISIONAL SOIL ASSOCIATION MAP OF ETHIOPIA (1:2 000 000)

Report prepared for
the Government of Ethiopia

by

the Food and Agricultural Organization of the
United Nations acting as excecuting agency for
the United Nations Development Programme

based on the work of
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UNITED NATIONS DEVELOPMENT PROGRAMME
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ADDIS ABABA, 1984

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CHAPTER 1

INTRODUCTION

The Soil Associations map of Ethiopia (1984) at 1: 2000 000 scale is an attempt to further update the FAO/Unesco Soil map of the world (1974) at 1: 5 000 000 scale.

The present 1: 2 000 000 Soil Associations map is based on the Geomorphology and Soils map, at 1: 1 000 000 scals, prepared by the FAO/UNDP - Eth/78/003, Assistance to Land Use Planning Project in 1983. It incorporates some new information obtained since the finalizing of the Geomorphology and soils map.

It is envisaged that updating will be a continuous process, as more detailed soil surveys are carried out and checking continues in the future.

The map and legend follow the format of the FAO/Unesco Soil map of the world. The soils terminology applied is the FAO/Unesco legend.

A further subdivison of the soil units is not attempted, as the amount of reliable information concerning Ethiopia soils is still limited.

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CHAPTER 2

MAP UNITS

2.1. GENERAL

The legend of the Soil Associations map of Ethiopia comprises about 160 different map units, which consist of individual soil units or of associations of soil units.

When a map units is not homogeneous, it is composed of a dominant soil and of associated soils, the latter covering at least 20 percent of the map unit area, important soils which cover less than 20 percent of the are added as inclusions. The textural class of the dominant soils and the slope class are given for each association. Phases are used where hard rock or indurated layers occur at shallow depth or in order to indicate stoniness, salinity, alkalinity or flooding hazard.

The different elements of the legend are defined below.

2.2 SOILS

The number of soil units described in the legend of the Soil Association map of Ethiopia is 43.

The basic principles which underlie the separation of these soils units and their definitions are discussed below.

2.2.1 Introduction

In this chapter the elements underlying the FAO classification and the soil units themselves are discussed. The latter are described mainly from agricultural point of view. For exact definitions refer to the FAO/Unesco legend for the Soil Map of the world (1974).

Only those diagnostic horizons and diagnostic properties are described which are likely to occur in Ethiopia. The soil units discussed are those identified in Ethiopia and three soil types, Ferralsols, Rankers and Planosols- not identified on the Soil Associations Map but possibly occuring in Ethiopia.

2.2.2 Diagnostic Horizons

Diagnostic horizons are used to identify soil units. They have quantitatively defined properties and are the same as those adopted in Soil Taxonomy. The main characteristics are given only.

Histic H Horizon

The histic H horizon has 28 percent or more organic matter if the mineral part has more than 60 percent clay, and 14 percent or more organic matter if the mineral part is sand (intermediate proportions for soils with intermediate clay content) and is thicker than 20 cm. A histic H horizon is formed under waterlogged conditions, often to be found in soils of depressions that are wet the whole year round.

Mollic A horizon

A thick dark horizon with a high base saturation (greater than 50 percent), and a strong soil structure. It is more than 25 cm thick in normal soils, and the organic matter content is greater than 1 percent. It is diagnostic for Chernozems, Phaeozems, etc.

The organic matter is thoroughlymixed with mineral materials. Mollic A horizons almost do not occur in the tropical lowlands.

Umbric A horizon

A horizon similar to the mollic A horizon, except for base saturation, which is less than 50 percent. It is diagnostic for non-calcareous soils, for example in Andosols where some have a mollic A horizon (Mollic Andosols) and others an umbric A horizon (Humic Andosols).

Ochric A Horizon

The most common surface horizon without the characteristics of a histic a mollic A, or an umbric A horizon.

An ochric horizon is diagnostic of Arenosols and Regosols. It is also characteristic for Xerosols and Yermosols. Soil formation of these soils is extremely slow, because they are usually dry and have only sparse vegetation. Therefore the ochric A horizon in these soils is weakly (Xerosols) or very weakly (Yermosols) developed.

Very weak means less than .5 percent organic matter in sandy soils and less than 1 percent in clay soils. A weak ochric A horizon has more organic matter but still less than 1 percent.

Argillic B Horizon

An important subsurface horizon, because it is diagnostic of various major soil units. It is a horizon in which clay particles have accumulated from the upper soil layer. Mostly fine clay particles have been translocated and settled in the B horizon in a very thin layer on the surface of structural elements. A considerable amount of clay has to be translocated before a real argillic B horizon is formed. This often takes a long time and consequently an argillic B horizon is diagnostic of well developed older soils. Depending on the soil parent material and the environmental conditions somewhat different argillic B horizons can be observed in the field. It is often difficult to detect the various characteristics, particularly clay skins.

The main properties are as follows:

- the increase in clay content occurs within a vertical distance of 30 cm
- in sandy soils it contains at least 3 percent more clay than the upper h horizon
- in clayey soils it contains at least 8 percent more clay than the upper horizon
- intermediate proportions for soils with intermediate clay contents
- in sandy soils it is more than 15 cm and in clay soils more than 7.5 cm thick
- there are clay skins on ped surfaces and in pores

In the tropics argillic B horizons often occur in older soils that are alternately moist and dry. Such conditions are typical for a climate with wet and dry seasons.

In tropical regions Nitosols, Acrisols and Luvisols are the soils for which an argillic horizon is diagnostic. A really distinct argillic B horizon occurs in Acrisols and Luvisols. The difference between the two is base saturation, which is (at least in a part of the B horizon) less than 50 percent in Acrisols and more than 50 percent in Luvisols.

Natric B. Horizon

This has all the properties of an argillic B horizon and in addition an exchangeable sodium percentage (ESP) of more than 15 percent. It is a characteristic horizon for Solonetz. The natric B horizon is rather dense and has a clear prismatic or columnar structure.

Cambic B horizon

An altered subsurface horizon with the following main properties:

- soil texture is very fine sand, loamy very fine sand or finer
- the soil has structure
- there is more than 3 percent weatherable mineral material and the CEC of clay fraction is over 16 me/100 g
- soil material has been altered; for instance clay content is higher than in the C horizon, or the colour is redder than that of the C horizon, or part of the carbonates present in the parent material is removed and accumulated in the underlying horizon, and finally there may be evidence of reduction.

Oxic B horizon

A subsurface horizon of the tropical regions. The main properties are as follows:

- it is at least 30 cm thick, usually considerably thicker
- it has only traces of weatherable minerals
- the texture is sandy loam or finer
- CEC of the clay fraction is less than 16 me/100 g clay, indicating clay of the kaolinite group and/or oxides of iron and aluminium

The horizon has almost uniform properties. The oxic B horizon has good physical properties, it is porous and very permeable and roots can penetrate easily. However chemically the oxic B is poor, not only because there are no weatherable minerals but also because the CEC is low. Moreover many oxic horizons may have a high percentage of absorbed aluminium that can be toxic for plants. The oxic horizon is diagnostic of Ferralsols.

Calcic horizon

A horizon of accumulation of calcium carbonate. It mostly occurs in B or C horizons, the thickness is more than 15 cm and lime content is 15 percent or more. It is a typical horizon in soils of arid or semi-arid regions, in which only a small amount of rainwater penetrates.

Gypsic horizon

Similar to a calcic horizon, but with accumulation of gypsum (calcium sulphate) instead of lime. The thickness should be more than 15 cm and it should have more than 5 percent more gypsum than in the underlying C horizon. A gypsum horizon often occurs in soils also having a calcic horizon. As gypsum is somewhat more soluble than calcium carbonate, the gypsic horizon is found at greater depth than the calcic horizon.

2.2.3 Diagnostic Soil Properties

Besides the diagnostic horizons, there are also some soil properties used to separate major soils. The most important ones are mentioned below.

Aridic moisture regime

Indicating very dry soils of arid regions (Xerosols and Yermosols). Soils with an aridic moisture regime are dry, except for at most 90 consecutive days.

Gilgai microrelief

In association with Vertisols, consisting of small shallow microbasins and microknolls in nearly level areas.

High salinity

The electric conductivity is more than 15 mmhos/cm within 125 cm for sandy soils and 75 cm for clay soils. Intermediate depths for soils with intermediate clay contents.

Hydromorphic properties

They are related to an alternately low and high groundwater, causing alternate oxidation and reduction. The lower part of the soil is continously reduced, and is gray or bluish-gray. In the zone of fluctuating groundwater, reddish and orange mottles caused by segregated iron compounds occur in a matrix of reduced soil.

Hydromorphic properties characterize Gleysols and gleyic groups in various other major soils.

Sulphidic material

Material characterized by a very low pH (less than 3.5). Sulphidic material is characteristic of Thionic Fluvisols. They are typical for non-calcareous sediments in brackish or marine water.

2.2.4 Soil Units

A. ACRISOLS

These soils have a distinct argillic B horizon and a low base saturation (less than 50 percent). Acrisols occur in high rainfall areas.

Normal Acrisols are Orthic Acrisols, those with an umbric horizon are Humic Acrisols.

Chemically these soils are poor, the content of weatherable minerals is rather low, pH is less than 5.5 and available P contents are very low. Physically these soils have few limitations. Rooting depth might be restricted by the argillic horizon or by rock a shallow depth. The moisture storage capacity is good. Only when the topsoil is very sandy, tillage operations can create problems like compaction and erosion.

The Acrisols have a rather limited agricultural value as they mainly occur on slping terrain.

B. CAMBISOLS

Cambisols have a cambic B horizon or an deep umbric A horizon.

Those with only an umbric A horizon are called Humic Cambisols. These are similar to the Phaeozems, only they have an umbric A horizon. Cambisols with a base saturation of less than 50 percent are Dystric Cambisols; Chromic Cambisols have a strong brown or red colour and Eutric Cambisols have a base saturation of 50 percent or more. Cambisols showing vertic properties are Vertic Cambisols.

Most Cambisols have limited agricultural value, as they occur dominantly on slopes, are often shallow or have many stones or rock outcrop. Where Cambisols are deep and not stony, they are good for agriculture, but available P contents can be low.

C. CHERNOZEMS

[illegible] are soils with a deep almost black mollic A horizon and a calcic horizon at shallow depth. Those are Calcic Chernozems.

Chernozems are good for agriculture. The mollic A horizon can absorb much water, the CEC is high (35-70 me/100 g soil) and it contains much organic matter. Natural fertility is good, and physically these soils are very suitable for agriculture. Available P is low to moderate.

E. RENDZINAS

These soils have only a mollic A horizon over calcareous rock material.

Their agricultural value is limited becuase generally the rooting depth is small and there are many stones and rock outcrops.

G. GLEYSOLS

These are the poorly drained soils, often in low-lying areas and in depressions, that are influenced by high groundwater and therefore show hydromorphic properties.

Gleysols have a reducing condition in the part of the soil that is continously saturated with water.

Gleysols with a mollic or an umbric A horizon are respectively called Mollic Gleysols and Humic Gleysols and those with base saturation of less than 50 percent or more than 50 percent are respectively called Dystric Gleysols and Eutric Gleysols.

Soil fertility of Gleysols depends on the type of parent material and on the depth of groundwater, that sets a limit to the rooting system. Gleysols may be improved by drainage.

H. PHAEOZEMS

These soils occur mainly in the tropical highlands, where soil depth is often limited by hard rock at shallow depth.

Those without an argillic B and without calcium carbonate are Haplic Phaeozems. Luvic Phaeozems have an argillic B horizon.

Phaeozems have limited agricultural value when they are shallow and stony. When they are deeper they have similar properties as the Chernozems and are very suitable for agriculture. As most of the Luvic Phaeozems in the Rift Valley have sodic pahses, their agricultural value is limited.

I. LITHOSOLS

These soils are mineral soils less than 10 cm thick, developed over hard rock.

These soils have no agricultural value.

J. FLUVISOLS

Fluvisols are young soils developed in recent alluvial deposits of river plains, deltas, former lakes and coastal areas. Sediments consist of materials eroded from uplands and mountains. The mineralogical composition of the soil materials is related to the type of rocks, their weathering products and alterations during soil formation before transport.

Soil conditions are highly variable. In arid regions, many soils are saline.

Fluvisols with calcareous material are called Calcaric Fluvisols, those in non-calcareous material Eutric Fluvisols, except when the base saturation is below 50 percent, which are called Dystric Fluvisols. In coastal areas, Thionic Fluvisols occur in the zone of brackish water, when lime content of the soil material is low and there is organic matter. If such a soil is drained, the soil pH decreases on oxidation to 3 or 2 and hardly any plant can grow, as aluminium becomes soluble and is highly toxic.

Thionic Fluvisols are very poor soils. The other Fluvisols are generally good agricultural soils and often intensively used, although land use has to be adopted to floods, inundations or high groundwater.

L. LUVISOLS

These soils have an argillic B horizon and a high base saturation (50 percent or more).

The normal ones are Orthic Luvisols, those with vertic properties are Vertic Luvisols. Luvisols with a strong brown or red B horizon are Chromic Luvisols.

Most Luvisols are good for agriculture:base saturation is good and they have weatherable minerals. In soils with a heavy textured B horizon or with vertic properties, permeability may be low and a good root distribution can be hindered. Available P contents are low to moderate.

N. NITOSOLS

Nitosols are clayey red soils with an argillic B horizon. They occur on undulating to rolling land.

Dystric Nitosols have a base saturation of less than 50 percent, Eutric Nitosols have a pH of 5.5 or greater.

Histosols have a very limited agricultural value. Reclamation of Histosols can give problems, because with drainage the organic materials will mineralize and the surface soil will subside.

Q. Arenosols

These are coarse-textured sandy soils. The subsoil may have the characteristics of an argillic, cambic or oxic horizon, but does not classify as such becuase the soil texture is too coarse.

Arenosols with thin layers of clay accumulation are Luvic Arenosols, Arenosols with characteristics of Ferralsols are Ferralic Arenosols, and those with a cambic-like but too light-textured horizon are Cambic Arenosols

Arenosols have a low water retention, are very permeable, have a low natural fertility and a low CEC. Rooting depth is often restricted by limited soil depth. They are poor for agriculture.

R. REGOSOLS

Regosols are soils without profile development. They occur in areas with little precipitation and on slopes subject to severe erosion. They consist mostly of loose soil material.

Those with a lime accumulation are Calcaric Regosols. Eutric Regosols have a base saturation of 50 percent or more.

They have limited agricultural value, especially where woil depth is limited. Water retention in Regosols is low.

S. Solonetz

Solonetz are characterized by a natric B horizon. As a consequence of the high percentage of Na on the complex, soil structure deteriorates.

Molic Solonetz have a mollic A horizon Orthic Solonetz have an ochric A horiozn, those with hydromorphic properties within 50 cm of the soil surface are Gleyic Solonetz.

For agriculture Solonetz have poor physical conditions because of the natric B horizon and the deteriorated soil structure.

T. ANDOSOLS

Andosols occur in volcanic regions. They are formed in volcanic ash material. The ash material being very light, their bulk density is less than .85 g/cm^3.

Recent volcanic soils that have more than 60 percent vitric volcanic ash are called Vitric Andosols, they occur in rather arid zones. Andosols with a mollic A horizon are Mollic Andosols; those with an umbric A horizon are Humic Andosols; they occur in cool and humid regions, at altitudes.

Most Andosols are good for agriculture. They can absorb much water, the CEC is high (35-70 me/100 g soil) and the organic matter content is often high. Natural fertility is high. Most Andosols are very porous.

Rooting depth is often restricted by limited soil depth. Some Andosols, especially in the Rift Valley and the Afar Triangle, have a high sodium content.

V. VERTISOLS

These are heavy clay soils in flat areas that have a pronounced dry season during which they shrink and have large deep cracks in a polygonal pattern. During the wet season the clay swells and causes pressure in the subsoil.

Pellic Vertisolsare dark, usually occupying areas which are waterlogged during the rainy season; Chromic Vertisols are brownish and better drained.

Vertisols have fairly good, but limited agricultural potentialities, because the land is rather difficult to prepare. Dry soils are hard and wet soils are sticky. There is only a short period when moisture condition of the surface layer is favourable to prepare land. Another difficulty is that drainability of the subsoil is very low, because of the swelling clay. Very often the soils are flooded or have stagnant water during the wet season.

The organic matter content in Vertisols is often not more than 1 percent. The soil has a high water retention, but a relatively small amount of water is available for plant growith. Rooting might be restricted because of the swelling and shirinking properties of the soil.

X. XEROSOLS

Xerosols are soils in arid and semi-arid regions, with a weakly developed A horizon.

Those with an argillic B horizon, mostly at shallow depth, are Luvic Xerosols. These are soils in a transitional zone to Luvisols. Those without a calcic horizon are Haplic Xerosols, those with a calcic horizon are Calcic Xerosols. The calcic horizon may harden, forming a petrocalcic horizon.

The agricultural value of Xerosols is low, except when they can be irrigated and when physical properties are good for irrigated crops.

Y. YERMOSOLS

The moisture regime of these soils is also aridic and they have a very weakly developed ochric A horizon. They consist of highly gypsiferous parent material.

Those with a gypsic horizon are called Gypsic Yermosols. The gypsic horizon may harden, forming a petrogypsic horizon.

Gypsic Yermosols are not suitable for agriculture in irrigation projects.

Z. SOLONCHAKS

Solonchaks are highly saline soils containing soluble salts that influence plant growth. They are poor soils because most plants cannot grow at all.

Most Solonchaks are Orthic Solonchaks. If they have hydromorphic properties caused by shallow groundwater within the first 50 cm, they are called Gleyic Solonchaks.

In saline soils that have a moderate to rapid permeability to a depth of at least 3m, and that can be drained, the harmful soluble salts can be washed out, and carried away in drainwater. When this is completed, soils may have agricultural potential, although it is necessary to take care that salts cannot acumulate in the rooting zone again.

Not identified on the Soil Associations Map:

F. FERRALSOLS

Ferralsols are soils with an oxic B horizon. These soils can occur in the high rainfall areas and on old stable surfaces.

The soil profile is uniform. It is well drained, has a good permeability and a stable structure. As there is little or no weatherable mineral, natural fertility is very low.

Physically these soils are very good, but chemically these soils are very poor, because of a low CEC, a deficiency of bases like Ca, Mg and K, a strong P fixation and a high exchangeable Al percentage.

U. RANKERS

Rankers are soils with only an umbric A horizon of less than 25 cm over hard non-calcareous rock. They can occur at high altitudes at high rainfall areas.

They have hardly any agricultural value because rooting depth is limited and there are many stones and rock outcrops.

W. PLANOSOLS

Planosols are soils with a coarse textured topsoil overlying a slowly permeable subsurface horizon, they are formed in flat areas or in shallow depresseions. In the wet season there is water stagnation in the topsoil.

TABLE List of soil types occuring in Ethiopia and their extent.

Soil Type	Area (Km^2)	%	Soil Type	Area (Km^2)	%
Ao	53 019.5	4.3	Xh	20 090.5	1.6
Ah	2 707	0.2	Yk	28 549	2.3
Bc	5 182.5	0.4	Xl	10 771.5	0.9
Bd	14 917	1.2	Yy	34 950	2.8
Be	64 546.5	5.2	Zg	895	0.07
Bh	7 503.5	0.6	Zo	58 362.5	4.7
Bk	22 192.5	1.8			
By	30 096	2.4			
Ck	814	0.07			
E	16 348	1.3			
Gd	4 382.5	0.4			
Ge	447	0.03			
Gm	444	0.03			
Hh	23 584	1.9			
Hl	8 967	0.7			
I	210 585	17.0			
Jc	44 896	3.6			
Je	57 565.5	4.7			
Lc	41 888.5	3.4			
Lo	18 224.5	1.5			
Lv	9 650.5	0.8			
Ne	59 273.5	4.8			
Nd	90 816	7.4			
Od	554.5	0.04			
Oe	4 165	0.3			
Qc	9 024	0.7			
Rc	36 068.5	2.9			
Re	99 527.5	8.0			
Sm	495	0.04			
Tm	3 440	0.3			
Tv	8 263	0.7			
Vc	52 011	4.2			
Vp	71 574	5.8			
Th	1 853	0.15			

2.3 TEXTURAL CLASSES

Textural classes reflect the relative propertions of clay (fraction less then 2 microns), silt (2-50 microns) and sand (50-2 000 microns) in the soil. The texture of a soil horizon is one of its most permanent characteristics. It is also a very important characteristic since, in combination with other properties, it is directly related to soil structure, consistence, porosity and cation exchange capacity.

Three textural classes are recognized (indicated by the figures 1,2 and 3 on the map), as shown in the textural triangle.

1. Coarse textured: sands, loamy sands and sandy loams with less than 18 percent clay, and more than 65 percent sand.
2. Medium textured: sandy loams, loams, sandy clay loams, silt loams, silt, silty clay loams and clay loams with less than 35 percent clay and less than 65 percent sand; the sand fraction may be as high as 82 percent if a minimum of 18 percent clay is present.
3. Fine textured: clays, silty clays, sandy clays, clay loams and silty clay loams with more than 35 percent clay.

The textural class is given for the dominant soil of each soil association. It refers to the te xture of the upper 30 cm of the soil, which are important for tillage and water retention. Marked changes in texture within the soil resulting from profile development are indicated in the definitions of the soil units (for example, the presence of argillic horizons).

Textural classes are limited to three, because of the scale of the map and because parts of the country lack of sufficient data. For detailed agricultural management purposes however soil texture should be defined more precisely.

2.4 SLOPE CLASSES

Slope is an integral part of the land surface. It influences drainage, run-off, erosion exposure and accessibility. The slope classes refered to here indicate the slope which dominates the area of a soil association. Seven slope classes are distinguished:

aa. level: slopes ranging between 0 and 2 percent;

a. level to gently undulating: dominant slopes ranging between 0 and 8 percent;

ab. gently undulating to hilly: dominant slopes ranging between 2 and 30 percent;

b. rolling to hilly: dominant slopes ranging between 8 and 30 percent;

b*. gently undulating to steeply dissected/mountainous, slopes varying from 2 to over 30 percent;

bc. rolling to steeply dissected/mountainous: dominant slopes ranging from 8 to over 30 percent;

c. steeply dissected to mountainous: dominant slopes over 30 percent.

2.5 PHASES

Phases are subdivisions of soil units based on characteristics which are significant to the use or management of the land, but are not diagnostic for the separation of soil units themselves. The phases recognized on the Soil Associations Map of Ethiopia are: stony, lithic, petrocalcic, petrogypsic, saline, sodic and flooding.

stony phase

The stony phase marks areas where the presence of gravel, stones, boulders or rock outcrops in the surface layers or at the surface makes the use of mechanized agricultural equipment impracticable.

lithic phase

The lithic phase is used when continuous coherent and hard rock occurs within 50 cm of the surface. Generally these soil units are stony as well, but the stony phase is not indicated.

For Lithosols the lithic phase is not shown, since the presence of hard rock is already implied in the soil definition..

petrocalcic phase

The petrocalcic phase marks soils in which the upper part of a petrocalcic horizon occurs within 100 cm of the surface.

A petrocalcic horizon is a continuous cemented or indurated calcic horizon, cemented by calcium carbonates and in places by calcium and some magnesium carbonates. Accessory silica may be present.

The petrocalcic horizon is continuously cemented to the extent that dry fragments do not slake in water and roots cannot enter. It is massive or platy, extremely hard when dry so that it cannot be penetrated by spade or auger, and very firm to extremely firm when moist. Noncapillary pores are filled; hydraulic conductivity is moderately slow to very slow. It is usually thicker than 10 cm. A laminar capping is commonly present but not required. If present, the carbonates constitute half or more of the weight of the laminar horizon.

petrogypsic phase

The petrogypsic phase marks soils in which the upper part of a petrogypsic horizon occurs within 100 cm of the surface. A petrogypsic horizon is a gypsic horizon that is so cemented with gypsum that dry fragments do not slake in water and roots cannot enter. The gypsum content in the petrogypsic horizon is commonly far greater than the minimum requirements for the gypsic horizon.

Generally these soil units are saline as well, but the saline phase is not indicated.

saline phase

The saline phase marks soils which, in some horizons within 100 cm of the surface, show electric conductivity values of the saturation extract higher than 4 mmhos/cm at 25°C. The saline phase is not shown for Solonchaks because their definition implies a high salt content.

Salinity in a soil may show seasonal variations or may fluctuate as a result of irrigation practices.

sodic phase

The sodic phase marks soils which have more than 6 percent saturation with exchangeable sodium in some horizons within 100 cm of the surface. The sodic phase is not show nfor the Solonetz because the definition implies a high exchangeable sodium saturation in the natric B horizon.

flooding phase

The flooding phase is used when units are subjected to severe flooding during the rainy season. The land cannot be used for agriculture during this time, without flood prevention measures.

CHAPTER 3

CARTOGRAPHIC REPRESENTATION.

3.1 SYMBOLS

The soil associations have been noted on the map by the symbol of the dominant soil unit, followed by a figure which refers to the descriptive legend in which the full composition of the association is given.

Example: Be4 — Eutric Cambisols and Orthic Luvisols with Lithosols and Vertic Cambisols

Je1 — Eutric Fluvisols and Eutric Histosols

Associations in which Lithosols are dominant are marked by the Lithosol symbol I combined with one or two associated soil units.

Example: I-Re — Lithosole and Eutric Regosols

I-Hh/Re — Lithosols, Haplic Phaeozems and Eutric Regosols

Where there are no associated soils, the symbol I alone is used.

If information on the texture of the surface layer is available, the textural class figure follows the association symbol, separated from it by a dash.

Example: Be4-2 — Eutric Cambisols, medium textured, and Orthic Luvisols with Lithosols and Vertic Cambisols

Where two groups of textures occur that cannot be separated on the map, two figures are used.

Example: Je1-1/2 — Eutric Fluvisols, coarse and medium textured, and Eutric Histosols

The slope classes are indicated by one or two small letters, immediately following the textural notation.

Example: Be4-2ab — Eutric Cambisols, medium textured, and Orthic Luvisols with Lithosols and Vertic Cambisols, gently undulating to hilly.

If information on the texture is not available, then the small letter indicating the slope class will immediately follow the association symbol.

Example: I-Hh/Re-bc   Lithosols, Haplic Phaeozems and Eutric Regosols, rolling to steeply dissected/mountainous.

3.2 COLOURS

Each of the soil units used for the soil Associations map of Ethiopia has been assigned a specific colour. The map units have been coloured according to the dominant soil unit . Map units having the same dominant soil unit but which differ in their associated soils are separated on the map by different symbols.

Associations dominated by Lithosols are shown by a striped pattern. using the colours of both the Lithosols and the associated soils. If no associated soils are recognized, because they occupy less than 20 percent of the map unit area, the colour of the Lithosol unit is applied uniformly with a hatched overprint.

3.3 OVERPRINTED PATTERNS

Phases which indicate land characteristics not reflected by the soil units or by the composition of the soil associations are shown on the map by overprinted patterns. The phases listed in the legend are: stony, lithic, petrocalcic, petrogypsic, saline, stony and flooding. Phases are normally shown only when they apply to the whole area covered by a map unit.

Areas of dunes, salt flats and lava flows are also shown by overprinted symbols.

CHAPTER 4

LEGEND

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA (KM^2)
Ao1	Nd	Vp	29 880
Ao2	Bd,Nd	I	55 550
Ao3	Nd	Bd,Gd	2 620
Bc1	Qc	Be	4 190
Bc2	Qc	Be,I	4 040
Bd1	Ao,Nd	I	8 460
Be1	Bv,Lc	I,Je	280
Be2	Bv,I	Je	7 310
Be3	Bv,Lo		710
Be4	Lo	Bv,I	9 890
Be5	I	Bv,Je,Lo	18 860
Be6	I	Bv,Je	7 050
Be7	I	Lc,Re	8 890
Be8	I	E,Vc	4 330
Be9	Bv	E	1 190
Be10	I	Bv,Vc	7 280
Be12		Bv,Je	660
Be13	I,Lc	Lv,Re	9 200
Bh1	Ah,I	Nd,Th	7 640
Bh2	Th	Od	710
Bh3	I,Nd	Ah	7 860

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
Bk1	Bv		14 850
Bk2	Vc	Be,I	13 610
Bk3	Bv		840
Bk4	I		870
Bv1		Je,Vc	4 350
Bv2	Bk		6 540
Bv3	Be,I	Lc,Vp	6 180
Bv5	Be,Vc	I	1 550
Bv6	Be,Ge	Tv	220
Ck1	Gm	Vp	1 480
E2	I	Hh	380
E3	I	Bk,Jc	19 640
E4	Hh,I	Jc	11 030
Hh1	Vp	E	1 200
Hh2	E	Vp	1 880
Hh3	Hl,I	Je	32 600
Hh4	Bv	Ge,Tv	900
Hhs		Bv,Je,Tm	1 480
Hh6	I,Re	Hl	4 280
Hl1	Lc	Be,I	410
Hl2	Hh	Sm	1 720
Hl3	Be,Hh	I,Sm	240

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
I		Jc	13 950
I-Be	Be	Bv,Tv	16 030
I-Bh	Bh		1 440
I-Hh/Rc	Hh,Rc	Vc	2 340
I-Hh/Re	Hh,Re	Tm,Vc	11 780
I-Rc	Rc	Jc,Re,Zo	47 500
I-Re	Re	Be,Lc,Qc	15 100
I-Re	Re	Je,Zo	20 160
I-Re/Xh	Re,Xh		26 140
I-Th	Th		2 920
I-Tv	Tv		10 450
I-Xh	Xh		2 340
I-Yy/Rc	Rc,Yy	Jc,Zo	4 870
I-Zo/Re	Re,Zo		24 680
Jc1	Vc		4 460
Jc2	Xk ,Zo		7 020
Jc3	I	Je,Re	5 340
Je1	Oe		3 490
Je2		Vp	11 190
Je3	Jc	Vc	2 380
Je4	Jc	Re,Zo	16 660
Je5	Jc	Re,Xh	7 390
Je6	Jc	Xh	1 280
Je7	Bv,Vc	Be	15 880
Je8	I,Jc	Re,Zo	4 000
Je9		Oe	560
Je10	Vc	Oe	1 540
Je11	Tm	Be,Vp	400
Je12	Jc,Vc	Oe	1 360
Je13	Jc,Oe	Sm,Zo	2 130

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
Lc1	Ne	I,Vp	8 300
Lc2	I,Ne	Hh,Vp	6 900
Lc3	I,Ne	H1,Tm	5 580
Lc4	Bc,I	Tm,Vp	760
Lc5	I	Ne,Tm	800
Lc6	Ne	Vc	4 880
Lc7		Ne,Vc	840
Lc8	Ne,Vc	Bc,I	2 580
Lc9	Be,I	Lv	6 220
Lc10		Be,I	4 260
Lc11	Be,Re	I	20 170
Lo1	Ne	Vp	1 940
Lo2	Ne	Be,Vp	13 880
Lo3	Be,I	Je,Ne	4 340
Lo4	Be,I	Lv	2 110
Lo5	Vc	Bv,Lv	1 510
Lo6	Be	Lv,Vc	2 270
Lo7	Lv,Vc	Be,Ne	2 890
Lv1	Lo	Be,Vc	4 130
Lv2	Lc,Ne	Vc	800
Nd1		Gd	25 410
Nd2	Vp	Jd	4 230
Nd3	Vp		9 530
Nd4	Ao	Vp	15 850
Nd5		Ao,Vp	15 700
Nd6		Ao	14 040
Nd7	Vp	Ao,I	1 550

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
Ne1	Vp	Lc	13 740
Ne2	Lc	Vp	7 770
Ne3	Lo	Vp	260
Ne5	Vp		19 290
Ne6	Lc,Vc		13 080
Od1		Jd,Vp	560
Oe1		Jc,Je	1 260
Oe2		Je,Vc	220
Qc1	I	Be,Q1	10 720
Qc2	Be,I	Q1	1 160
Rc1		I	1 290
Re1			11 590
Re2	Je	I	6 880
Re3		I,Je	730
Re4		I	42 960
Re5	I,X1	Je,Xc	1 730
Re6	I		2 250
Re7	Tv	I,Zo	1 080
Re8	Be,I	Lc	4 040
Tm1	Be	Ne,Vp	1 420
Tm2	Be,I	Ge,Je	1 780
Tv1		Je,Tm,Zo	4 200
Tv2	Re,Tm	I	2 360

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
Vc1		Bv	13 200
Vc2	Jc		8 450
Vc3	Ne		14 670
Vc4	Lc	Lv	640
Vc5	Vp	Ge,Je	1 350
Vc6	Je,Lv		7 590
Vp1	Oe	Gd	2 060
Vp2		Je	10 260
Vp3		Nd	6 330
Vp4	Je,Nd		1 980
Vp5		I,Ne	7 760
Vp6	Ne	I,Lv	24 260
Vp7	Bc	I	720
Vp8	I,Ne		2 160
Vp9		Lo,Lv	600
Vp10	Vc		5 090
Xh2	Je	I,Re	2 600
Xh3	Re	I	5 010
Xk2	Re	I,Je	1 380
Xk3	Xh	I,Je	6 720
Xk4	I,Rc	Jc	5 100
Xk5	Rc,Xh		29 840
Xk6	Rc,Xh	I	5 920

SOIL ASSOCIATION

DOMINANT SOIL	ASSOCIATED SOILS	INCLUSIONS	AREA(KM^2)
X11			9 200
X12	Re	I	2 210
Yy1	Rc,Zo		32 850
Yy2	Rc	I,Zo	17 040
Yy3	Rc,Zo	I,Je	13 520
Zg1	Zo	Jc,Oe	1 110
Zo1		Jc	24 920
Zo2	Je,Oe	Jc,Re	1 300
Zo3	Jc	Rc,Yy	3 380
Zo4	Jc	I,Rc	21 160
Zo5	Je,Zg	Tv	140
Zo6	Je	Zg	2 080