



REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE - NATIONAL AGRICULTURAL LABORATORIES

KENYA SOIL SURVEY

**EXPLORATORY SOIL MAP AND AGRO-CLIMATIC ZONE MAP OF KENYA, 1980
SCALE 1:1,000,000**

by

W.G. Sombroek, H.M.H. Braun and B.J.A. van der Pouw

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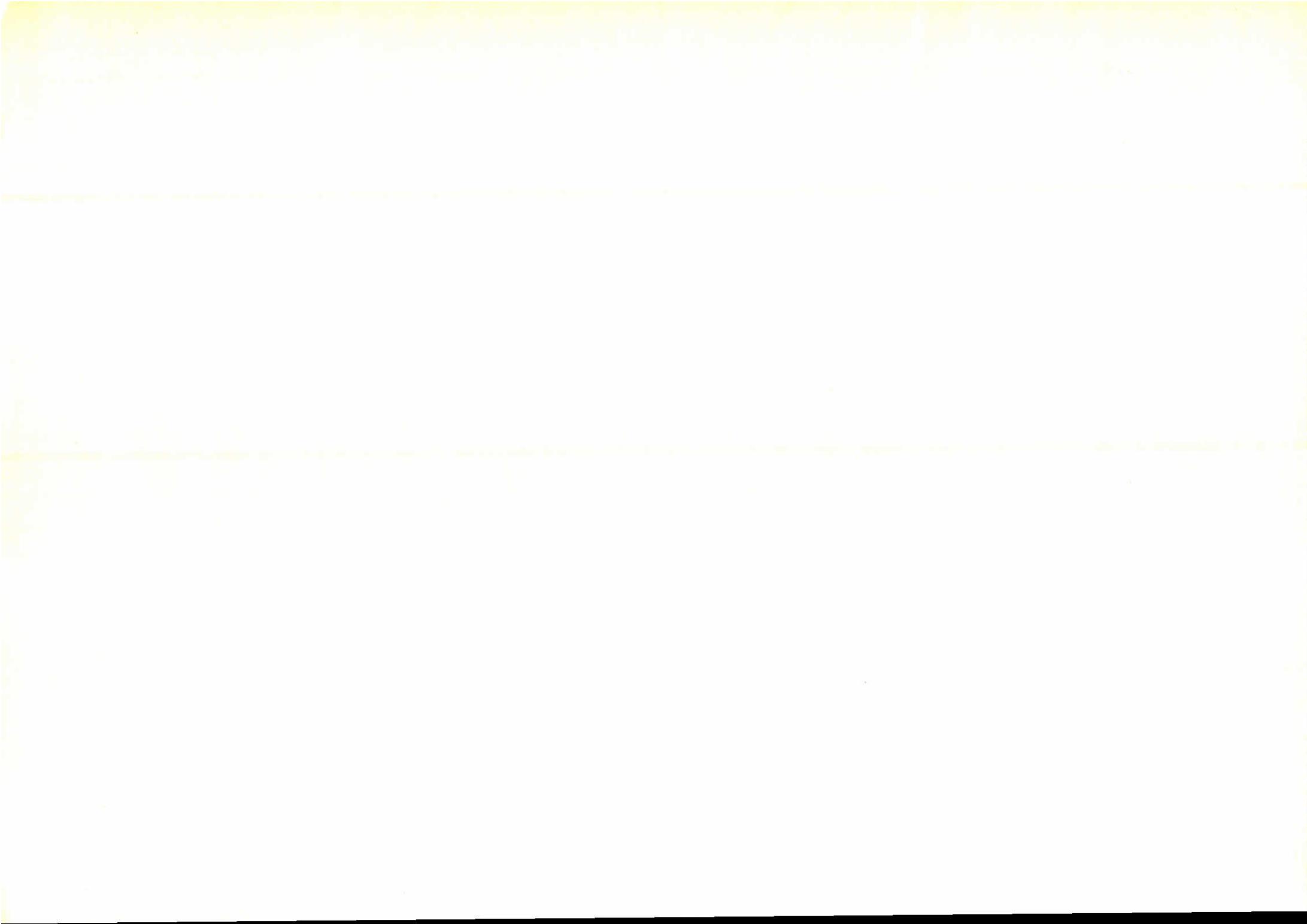
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Colophon

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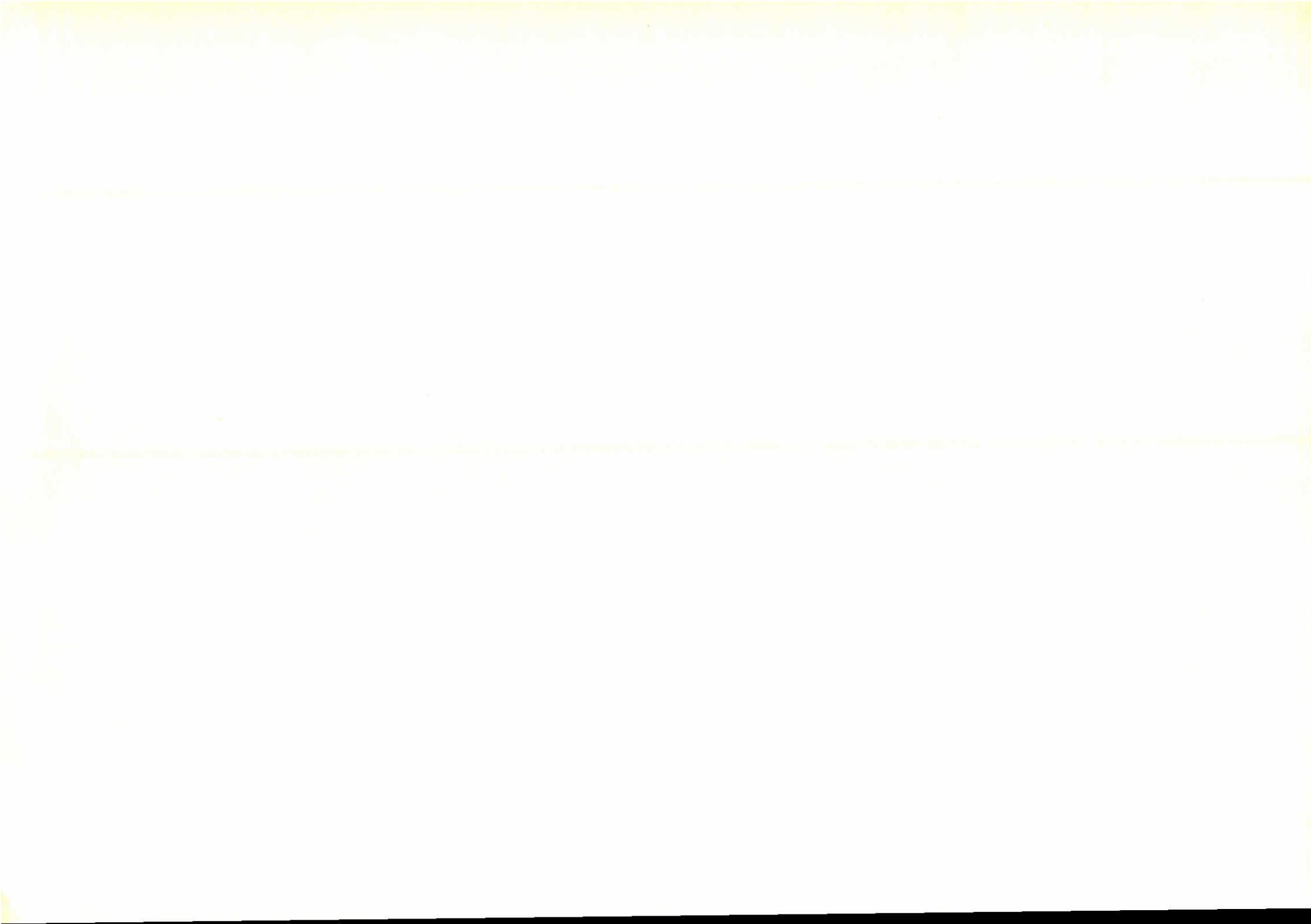
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FOREWORD

The present report of the Exploratory Soil Map and Agro-Climatic Zone Map of Kenya is the first of the Kenya Soil Survey exploratory survey reports to be printed. The report serves as an explanatory note to the soil and agro-climatic zone maps of Kenya at scale 1:1,000,000.

A programme of updating the existing general soil map of Kenya at scale 1:3,000,000 (Scott's map of 1959) was initiated by the Kenya Soil Survey in 1972, after strengthening with manpower and funds from the Netherlands Directorate for Development Co-operation through the "Kenya Soil Survey Project" of the then Soil Survey Unit of the National Agricultural Laboratories in Nairobi. This programme aims at enlarging the scale of both the soil map and the agro-climatic zone map from 1:3,000,000 to 1:1,000,000 or larger as more and more data are being collected.

The exploratory soil map and the accompanying agro-climatic zone map form the logical basis for the selection by planners, particularly at the national level, of areas to be developed for one or another specific type of land use. Once such areas and their development options are identified, then these parts of the selected areas may be covered by more detailed soil surveys. At the present scale (1:1,000,000) the exploratory soil map and the accompanying agro-climatic zone map can be used as a first basis for the programming of soil conservation and soil management in general. It can also be taken as a starting point for the assessment of the percentage of land suitable for crops, for areas that may have possibilities for arable cropping development, the broad evaluation of suitability of a certain area for irrigation development, etc.

This report gives an ample description of how the soil map and the agro-climatic zone map have been compiled, the source of the information which has been used to compile these maps and also explains the various codes appearing on the maps.

It is shown in the maps that Kenya has an intricate pattern of soils and of climatic zones. However, it should be noted that some of the information contained in these maps is liable to be improved as more data are being gathered.

The preparation of the maps and reports is a co-operative effort of the staff of the Kenya Soil Survey and the Netherlands Soil Survey Institute (STIBOKA). It should be mentioned that the Soil Survey Institute of the Netherlands has undertaken all the final cartographic and lithographic work and has supervised the printing of the maps and reports. The co-operation that has existed between the Kenya Soil Survey and STIBOKA is greatly appreciated and acknowledged. Special thanks are due to the Director of the Institute, Ir. R.P.H.P. van der Schans and the members of the Cartography Section. Special acknowledgement is also due to the Government of the United States of America which, through its Defence Mapping Agency supplied us with all the film positives and negatives of the "Operational Navigation Chart" which has been used for the compilation of the base map.

Acknowledgement is also due to the Soil Chemistry Section of NAL for analysing the soils and the Meteorological Department of the Ministry of Transport and Communications for supplying the climatic data.

Nairobi, January, 1982

F.N. Muchena

HEAD, KENYA SOIL SURVEY



1. THE EXPLORATORY SOIL MAP OF KENYA

1.1 Introduction

This exploratory soil map of Kenya at a scale of 1:1,000,000, dated 1980, is the fourth attempt to present the soils of the country in a comprehensive manner. It incorporates all the information available at the end of 1979.

The first provisional soil map of the country was included in Milne's provisional 1:2,000,000 soil map of East Africa (Milne et al., 1935a and b and 1936). The second map at scale 1:3,000,000, was prepared by Gethin-Jones and Scott (1959) for the first edition of the National Atlas of Kenya (Survey of Kenya, 1959), which was reprinted in 1962 (2nd edn.) and 1970 (3d edn.).

Scott used essentially the same information for the 1:4,000,000 soil map of East Africa as that in Morgan's book on the peoples and natural resources of the region (Scott, 1969).

In all these maps, the soils were presented largely following the "catena" concept developed by Milne (1935). This concept was used either in its narrow sense (first class catena: a regular sequence of soil types down a slope, derived from the same parent material) or in its wider sense (second class catena: a regular sequence, but derived from different parent materials). The soils terminology applied was basically the early U.S.A. soil classification (Baldwin, Kellogg and Thorp, 1938), which often had a descriptive East African Terminology included.

The catena concept was taken a step further, into a "land system" approach, with the preparation of a "Land System Atlas for the western part of Kenya", scale 1:500,000 (Scott, Webster and Lawrence, 1971). In this publication the soils terminology applied was the one developed by the Commission for Technical Co-operation in Africa (CCTA) for the continent as a whole (D'Hoore, 1964).

The present 1:1,000,000 exploratory soil map incorporates new information on soils, geology, topography, vegetation and land use obtained since the publication of the general soil map prepared by Gethin-Jones and Scott (1959). As part of the process of updating the latter map, special exploratory field trips were also made. It is envisaged that the present exploratory soil map will itself undergo this process of updating. The updating should become a continuous exercise, as more and more information is being gathered on Kenya's soils. Therefore it is hoped that a new edition of the exploratory soil map will be prepared in a decade's time.

1.2 Map compilation

The exploratory soil map was compiled from two different basic sources of information:

- (a) published information or information that was in preparation at the end of 1979 (existing information);
- (b) exploratory fieldwork during the period 1973-1977.

Existing information

At the end of 1979 much new information on Kenya's soils had been published or was in preparation. The maps and reports published by the Kenya Soil Survey were a major source of information. The maps and reports actually used in the compilation of the exploratory soil map are indicated in appendix 4, while a separate list of these maps and reports is given in ch. 1.7.2. All KSS publications appear in the KSS publications list (1981), which is revised annually. Maps and reports published by other agencies were another major source of information. Those actually used are also shown in appendix 4 and listed separately in ch. 1.7.2.

Note that if an area had been covered by a reconnaissance soil survey, only that reconnaissance

soil survey is indicated in appendix 4, although other surveys may have been carried out in the same area.

An inventory of all soil surveys carried out in Kenya, both by KSS and other agencies, is given in another KSS publication (Siderius, 1979). The code numbers of the soil surveys presented in appendix 4, correspond with the code numbers used in the latter publication and in the KSS publications list.

Other sources of soil information and sources from which soil conditions can be surmised were extensively used. These sources are given in ch. 1.7.3.

Exploratory fieldwork

In 1972, in its proposed programme of work, the Kenya Soil Survey clearly stated the need to update the existing 1:3,000,000 general soil map of Kenya.

From the same programme of work it was evident that in the near future large parts of Kenya could not be mapped systematically by reconnaissance soil surveys. Therefore, from 1973 to 1977, a programme of exploratory field trips was organised to collect basic soils information in those areas. During these field trips, scattered soil descriptions were made throughout the country. The actual sites, all indicated on the information base map (appendix 4), were chosen after consulting existing topographic, geologic and vegetation maps, aerial photographs and satellite imagery (ERTS-LANDSAT), to ensure a high degree of representativeness of the sites.

The same documents were used for the final delineation of the mapping units. For the characterisation of a mapping unit, the field descriptions and laboratory data of the exploratory trips were compared and compiled.* In some cases the existing soil data cards of the former EAAFRO** Soils Section at Muguga were used.

1.3 Legend composition

The soils pattern in Kenya is very intricate because of striking differences in altitude, landforms (their shape, stability, age) geology and climate (including past climates). In general, the present map attempts to reveal the complex relation between landforms and geology and soils using the methodology developed by the Kenya Soil Survey from 1972 onwards ("physiographic soil survey"). In this methodology, recently elaborated by Sombroek and van de Weg (1980), the legends of the major survey areas reflect landforms at the highest level and there is a subdivision according to important differences in geology at the second level, which is followed by the descriptions of individual soil mapping units.

The guidelines for this approach appear in the "Manual for soil survey and land evaluation in Kenya" (Kenya Soil Survey Staff, in prep.). The principles are outlined below.

Landforms

The landforms are the first entry in the legend. They are described pragmatically rather than strictly geomorphologically and are intended to give the map user an immediate insight into the physiography of the country, and its altitude and slope patterns.

In the legend, the major landforms, together with their soil mapping units are arranged approximately

* Note: The forms with the original field and laboratory data can be consulted at the KSS Data Storage.

**) Note: East African Agricultural and Forestry Research Organisation, now Kenya Agricultural Research Institute (K.A.R.I.), Muguga, P.O. Box 30148 Nairobi, Kenya.

in sequence from high to low: Mountains and Major Scarps (M) - Hills and Minor Scarps (H) - Plateaus and High-Level Structural Plains (L) - Volcanic Footridges (R) - Foothslopes (F) - Piedmont Plains (Y) - Uplands (U) - Plains (P) - Floodplains (A) - Bottomlands (B). The codes used for the landforms also form the first component of each mapping unit code in the legend. A complete key to landforms and codes is given in table 1.

Table 1. Key to landforms (sequence as in legend)

code	landform	legend page
M	Mountains and major scarps	17
H	Hills and minor scarps	18
Hs	Step-faulted scarps of the Rift Valley	19
L	Plateaus and high-level structural plains	19
Ls	Step-faulted floor of the Rift Valley	20
Lc	Coastal plateaus	21
Lu	Plateau/upper-level upland transitions	21
R	Volcanic footridges	21
F	Foothslopes	22
FY	Foothslopes and piedmont plains undifferentiated	23
Y	Piedmont Plains	23
U	Uplands	24
Uu	Upper-level uplands	24
Uh	Upper middle-level uplands	24
Um	Lower middle-level uplands	25
Ul	Lower-level uplands	26
Ux	Uplands, undifferentiated levels	27
Uc	Coastal uplands	28
Up	Upland/high-level plain transitional lands	29
P	Plains	29
Pn	Non-dissected erosional plains	29
Pd	Dissected erosional plains	31
Ps	Sedimentary plains	31
Psh	Higher-level sedimentary plain ("red sand" plain)	31
Psm	Middle-level sedimentary plains ("enclosed" plains and sealing loam plain)	31
Psl	Lower-level sedimentary plain ("grey clay" plain)	32
Psx	Sedimentary plains of undifferentiated levels	32
Pv	Volcanic plains	33
Pc	Coastal plains	33
Pch	Higher-level coastal plain	34
Pcl	Lower-level coastal plain	34
Pcr	Reef coastal plain	34
Pl	Lacustrine plains	34
Pt	Sedimentary plains of upper river terraces	35
Pf	Sedimentary plains of large alluvial fans	35
Pf1	Older fans	35
Pf2	Younger fans	35
A	Floodplains	36
B	Bottomlands	37

Miscellaneous land types

D	Dunes or dune land
La	Lava flows
S	Swamps
T	Mangrove swamps
V	Minor valleys
W	Badlands
Z	Coastal or lake-side beach ridges

legend page
37
38
38
38
38
38
38

Geology

The geology (parent rock) forms the second entry in the legend. The geological subdivisions are again pragmatic, mainly according to the resistance to weathering of the rock and the richness of the parent material, always observing the correlation with soil formation. In the legend the geological entries are arranged in a certain sequence within each landform. The major sequence is igneous rocks - metamorphic rocks - sedimentary rocks. If different igneous rocks are distinguished, their entries are arranged approximately from basic (e.g. basalt) to acid rocks (e.g. granite). A similar sequence is maintained for the metamorphic rocks, while the sedimentary ones are arranged from fine-textured (e.g. shales) to coarse-textured (e.g. sandstones). All geological subdivisions are characterised by the codes (usually one, sometimes two capital letters) given in table 2. The standard code of each soil mapping unit comprises the relevant code for its geology, preceded by the landform code.

Soil mapping units

The third entry in the legend is the description of the main soil or soils of the individual soil mapping units. At the exploratory level of mapping a soil mapping unit rarely comprises a single soil: usually it consists of one main soil with minor associates. In this case the legend describes the main soil only, while the minor associates, together approximately less than 30% of the unit, are considered as *inclusions*. Frequently, however, a soil mapping unit comprises several soils of considerable extent. When the various soils of such a soil mapping unit occur in a recognizable geographical pattern in defined proportions they constitute a *soil association*: if such a pattern is absent, they form a *soil complex*.

In a way, the "catena concept", developed by Milne (1935, 1936), has been maintained in the present map. However, in many cases the enlarged scale of mapping enabled the main elements of the major catenas to be presented separately. In other cases, the soils are presented as soil associations or soil complexes.

Each mapping unit is described in a *descriptive terminology* as used by the Kenya Soil Survey (KSS staff, in prep.). The descriptive terminology is intended to allow non-soil specialists, such as agronomists, planners, extension officers etc., an insight into features without confusing them with modern soil taxonomy jargon.

For the purpose of national and international soil correlation each mapping unit or component of a mapping unit is classified on the basis of the legend of the 1:5,000,000 "Soil Map of the World" (FAO-Unesco, 1974)*. A code reflecting the soil classification (see table 3) is the third component of the standard soil mapping unit code.

It is emphasized that the legend gives two sets of codes. The standard codes explained above are given in the second column of the legend. As in many cases these standard codes proved too long to be set inside the areas delineated on the exploratory soil map, simplified codes had to be used. The simplified codes actually used on the map are given in the first column of the legend.

*) Note: Hereafter referred to as (FAO-Unesco op. cit.).

Table 2. Key to geological subdivisions (codes in alphabetical order)

code	geology
A	(alluvial) sediments from various sources *)
B	basic and ultra-basic igneous rocks (basalts, etc.)
B+	as in B, but with volcanic ash admixture
BP	as in B, but with influence of volcanic ash predominant
D	mudstones, claystones
E	aeolian sediments (cover sands)
F	gneisses rich in ferromagnesian minerals, hornblende gneisses
G	granites, granodiorites
G+	as in G, but with volcanic ash admixture
GF	biotite-hornblende granites
GF+	as in GF, but with volcanic ash admixture
GP	as in G, but with influence of volcanic ash predominant
GR	complex of G and R
I	intermediate igneous rocks (syenites, etc.)
I+	as in I, but with volcanic ash admixture
J	lagoonal deposits
K	siltstones
KT	complex of K and T
L	limestones, calcitic mudstones
N	biotite gneisses
N+	as in N, but with volcanic ash admixture
O	Plio-Pleistocene bay sediments
P	pyroclastic rocks
Q	quartzites
R	quartz-feldspar gneisses
S	sandstones, grits, arkoses
T	shales
U	undifferentiated Basement System rocks (predominantly gneisses)
U+	as in U, but with volcanic ash admixture
UP	as in U, but with influence of volcanic ash predominant
V	undifferentiated or various igneous (volcanic) rocks
W	marls
X	undifferentiated or various rocks
X+	as in X, but with volcanic ash admixture
Y	acid igneous rocks (rhyolite, aplite)
Y+	as in Y, but with volcanic ash admixture

*) Note: If the source of alluvial sediments and bottomland infills is known (e.g. basalts), then the code for this rock is used, otherwise the code A applies.

1.4 Soil classification

1.4.1 Introduction

The Kenya Soil Survey has used the FAO-Unesco legend for the Soil Map of the World for the purpose of classifying and correlating soils. The FAO-Unesco legend was designed to accommodate world soils in order to overcome gaps in national classification systems and to provide an internationally accepted basis for soil correlation. Although it is not a taxonomic soil classification system in the strict sense of the word, it can be considered as a mono-categorical soil classification system (FAO-Unesco op. cit., p. 10), underlain by internationally accepted principles of soil information, which are reflected in the nomenclature. The identification of soils is based on the presence of diagnostic horizons and diagnostic properties, which are defined by measurable morphological, physical and chemical criteria related to soil characteristics that are the result of soil formation. Therefore the defined soils need not be regarded solely as units in a soil map legend, but may also form a basis for soil classification. Note that most of the diagnostic concepts in the FAO-Unesco system have been derived from "Soil Taxonomy" (Soil Survey Staff, 1975). One of the reasons for selecting the FAO-Unesco system as a framework for soil classification in Kenya was the belief that it provides a more easily understandable framework of classification than the official systems. The application of the FAO-Unesco system over the past years has confirmed this and has increased confidence in the system.

In various meetings of FAO's Eastern African Sub-Committee for Soil Correlation and Land Evaluation (Nairobi, 1974; Addis Ababa, 1976; Lusaka, 1978; Arusha, 1980) the FAO-Unesco system has been used alongside other systems; a factor that has also greatly contributed to its acceptance as a means for soil classification in Eastern Africa.

The FAO-Unesco system has been used in different types of soil survey, but most intensively in the various reconnaissance soil surveys (see ch. 1.7.2 and appendix 4) and in the exploratory soil map. Its intensive use in these surveys has revealed the need for greater detail in the existing framework of classification. It has also led to some adaptations of the first and the second level terminology as well as to the application of a third level terminology. These adaptations and additions to the FAO-Unesco classification systems are known as "Kenya concepts" and have been described by Siderius and van der Pouw (1980). A summary of the adaptations and additions used for the exploratory soil map is given in the following sections. A comprehensive list of all soil classification units occurring in the exploratory soil map legend (ch. 1.6.3) is given in table 3, together with the components that make up the standard soil mapping unit codes.

1.4.2 Diagnostic horizons and diagnostic properties

All diagnostic horizons have been used as defined in the FAO-Unesco legend. With regard to the diagnostic properties, note that the definition of *ferric* properties was narrowed down, while the use of *vertic* properties was widened (see below).

ferric properties*

The original concept of ferric properties, only to be used in connection with Luvisols and Acrisols, is the presence of *one or more* of the following (FAO-Unesco op. cit., p. 28):

1. many coarse mottles with hues redder than 7.5 YR or chromas more than 5, or both;
2. discrete nodules, up to 2 cm in diameter, the exteriors of the nodules being enriched and weakly cemented or indurated with iron and having redder hues or stronger chromas than the interior;
3. a cation exchange capacity (from NH₄Cl) of less than 24 me/100g clay in at least a subhorizon of the argillic B horizon.

*) Note: = Kenya concept (see ch. 1.4.4)

Item (3) of this definition is identical to the definition of *ferralic* properties (FAO-Unesco op. cit., p. 28), a term which is only used for Cambisols and Arenosols. To avoid a situation in which the same characteristic of a low CEC from NH₄Cl appears under two different names in the soil units (e.g. ferralic Cambisols vs. ferric Luvisols), the term ferric properties is only used to cover the first two items of the above definition. The use of the terms ferric and ferralic at unit level has not been widened, but they may be used in a wider context at subunit level (see ch. 1.4.5, prefix ferralo).

vertic properties

The definition of vertic properties (FAO-Unesco op. cit., p. 31) has not been changed, but its use at unit level has been widened. A new unit, viz. vertic Gleysols (see ch. 1.4.4) has been introduced.

Table 3. Key to soil classification units (FAO-Unesco, 1974)

a	Acrisols	ec	cambic Rendzinas
ac	chromic* Acrisols	eo	orthic Rendzinas
ag	gleiyic Acrisols		
ah	humic Acrisols	f	Ferralsols
ai	ferralo-chromic* Acrisols	fa	acric Ferralsols
ai	ferralo-ferric Acrisols	fh	humic Ferralsols
ai	ferralo-orthic Acrisols	fn	nito-humic Ferralsols
ao	orthic Acrisols	fn	nito-rhodic Ferralsols
ap	plinthic Acrisols	fo	orthic Ferralsols
at	ando-humic Acrisols	fr	rhodic Ferralsols
		fx	xanthic Ferralsols
b	Cambisols	g	Gleysols
bc	chromic Cambisols	gc	calcaric Gleysols
bd	dystric Cambisols	gd	dystric Gleysols
be	eutric Cambisols	gh	humic Gleysols
bf	ferralic Cambisols	gm	mollic Gleysols
bg	gleiyic Cambisols	gv	vertic* Gleysols
bh	humic Cambisols		
bk	calcic Cambisols	h	Phaeozems
bn	nito-chromic Cambisols	hg	gleiyic Phaeozems
bt	ando-chromic Cambisols	hh	haplic Phaeozems
bt	ando-eutric Cambisols	hn	nito-luvic Phaeozems
bv	vertic Cambisols	ho	ortho-luvic Phaeozems
c	Chernozems	hr	chromo-luvic Phaeozems
ch	haplic Chernozems	ht	ando-haplic Phaeozems
ck	calcic Chernozems	hv	verto-luvic Phaeozems
e	Rendzinas	i	Lithosols

j	Fluvisols	r	Regosols
jc	calcaric Fluvisols	rc	calcaric Regosols
je	eutric Fluvisols	rd	dystric Regosols
jt	thionic Fluvisols	re	eutric Regosols
		rt	ando-calcaric Regosols
k	Kastanozem		
kh	haplic Kastanozem	s	Solonetz
l	Luvisols	sg	gleiyic Solonetz
la	albic Luvisols	sl	luvo-orthic Solonetz
lc	chromic Luvisols	sm	mollic Solonetz
lf	ferric Luvisols	so	orthic Solonetz
lg	gleiyic Luvisols	t	Andosols
li	ferralo-chromic Luvisols	th	humic Andosols
li	ferralo-ferric Luvisols	tm	mollic Andosols
li	ferralo-orthic Luvisols	tv	vitric Andosols
lk	calcic Luvisols	u	Rankers
ln	nito-chromic Luvisols		
ln	nito-ferric Luvisols	v	Vertisols
lo	orthic Luvisols	vc	chromic Vertisols
lv	vertic Luvisols	vp	pellic Vertisols
m	Greyzems	w	Planosols
mo	orthic Greyzems	wd	dystric Planosols
mv	verto-orthic Greyzems	we	eutric Planosols
		wh	humic Planosols
n	Nitisols	ws	solodic Planosols
nd	dystric Nitisols	wv	verto-eutric Planosols
ne	eutric Nitisols		
nh	humic Nitisols	x	Xerosols/Yermosols (see ch. 1.4.3)
nm	mollic* Nitisols	xh	haplic Xerosols/Yermosols
nt	ando-humic Nitisols	xk	calcic Xerosols/Yermosols
nv	verto-eutric Nitisols	xy	gypsic Xerosols/Yermosols
nv	verto-mollic* Nitisols		
o	Histosols	z	Solonchaks
od	dystric Histosols	zg	gleiyic Solonchaks
q	Arenosols	zo	orthic Solonchaks
qa	albic Arenosols	zt	takyric Solonchaks
qc	cambic Arenosols		
qf	ferralic Arenosols		
qk	calcaro-cambic Arenosols	Miscellaneous	
ql	luvic Arenosols		
		ir	ironstone soils (see ch. 1.4.3)

1.4.3 First-level terminology (great group level)

At the first level of the FAO-Unesco legend, 26 soil units are defined, e.g. Vertisols, Fluvisols, etc. Of these, no less than 23 units occur in Kenya (see table 3). For two of these units (the Lithosols and Nitisosols) a slightly modified "Kenya concept" was introduced.

Lithosols

By definition (FAO-Unesco op. cit., p. 34) Lithosols are soils limited in depth by continuous hard rock within 10 cm of the surface. This depth limitation was found to be inadequate for Kenyan conditions and was re-set at 25 cm.

Nitosols

Nitosols, formerly called Reddish-Brown Lateritic soils "show a movement of clay within the profile but have diffuse horizon boundaries and a deeply stretched clay bulge, and generally show a low clay activity. Because of their favourable physical properties and their often higher fertility, especially when derived from basic rock, these soils are separated from the Ferralsols" (FAO-Unesco op. cit., p. 14). They are called Nitisosols because of their characteristic shiny ped faces (Latin "nitidus" = shiny, bright, lustrous). Unfortunately these aspects are not adequately defined in the criteria for Nitisosols in the key to the soil units (FAO-Unesco op. cit., p. 51), which has resulted in the term being used to cover a range of soils without shiny ped faces and soils with a deep, coarse-textured A horizon over a fine-textured B horizon.

In Kenya, Nitisosols *sensu stricto* are very extensive. In view of their extent and their importance for agricultural production a more strict definition was applied. To distinguish these more narrowly defined soils from the Nitisosols as used by FAO-Unesco, they are called *Nitisols*. Nitisols are defined as having the following characteristics:

1. an argillic B horizon with a high clay content (more than 40%) and a moderate to low silt percentage (silt/clay ratio less than 0.35); the requirement of sufficient clay increase within a vertical distance of 30 cm may be waived if all of the following characteristics are present;
2. a gentle clay bulge extending beyond 150 cm depth and only a gradual increase in clay% from A to B horizon (clay% ratio B/A horizon usually between 1.0 and 1.2);
3. many shiny ped faces, especially in the deeper B horizon (more than 10% of the surface area), which cannot or can only partly be ascribed to illuviation argillans;
4. moderately to strongly developed, very fine to medium, angular blocky structure (polyhedral)
5. very friable to friable when moist
6. high aggregate stability (practically no water dispersable clay in horizons with low organic matter content)
7. clay activity (excluding organic matter content) of less than 24 me/100g.

The typical Nitisols are well drained, dark red or dark reddish brown, extremely deep (often 3-6 m), friable, fine clayey (60-70% clay) soils. They appear to have a relatively high specific surface and the dry fine earth usually shows a degree of magnetism.

Detailed information on the Kenya Nitisols is given by Nyandat (1976), Siderius (1976) and Sombroek and Siderius (1975).

Ironstone soils

The term Ironstone soils was coined to embrace all soils with a massive ironstone layer (petroferric horizon) starting within 50 cm of the surface. It is a pragmatic grouping to cover a variety of soil units that all have in common the presence of massive ironstone at shallow depth, although the soils themselves may be genetically different (Cambisols, Arenosols, Phaeozems, etc.).

Xerosols, Yermosols

The FAO-Unesco legend avoids using soil climate (soil moisture and/or temperature regimes) as a criterion for soil classification, except in the case of the Xerosols and Yermosols. One of the criteria for their identification is an arid moisture regime. At present it is very difficult to apply this criterion in Kenya, because hardly any soil moisture data from direct measurements are available for the drier parts of the country. Reliable methods of estimating the soil moisture regime from atmospheric climatic conditions have not been worked out for arid and semi-arid areas having year-round high temperatures and a bimodal rainfall pattern as is the case in most parts of Kenya.

In theory, the difference between Xerosols and Yermosols is that Xerosols have a weak ochric A and Yermosols have a very weak ochric A.

This criterion is not practicable in Kenya, given the scarcity of data on organic matter content in the topsoils. Moreover this criterion may not be realistic in view of the many processes that particularly affect the topsoil (e.g. erosion and sedimentation). Other features, such as a certain degree of decalcification (for the Xerosols) and the occurrence of appreciable amounts of arid-region clay minerals such as palygorskite throughout the profile (for the Yermosols) may prove to be better distinguishing features. There is evidence that palygorskite occurs in many of the soils in the arid areas around Lake Turkana and the Chalbi desert in the northwest and in Mandera district in the extreme northeast. Ongoing research on clay mineralogy at the National Agricultural Laboratories (Nairobi) and the International Soil Museum (Wageningen) may elucidate this.

It is certainly useful and important to set apart the Xerosols and Yermosols, which are essentially soils with little profile development characterized by a re-arrangement of salts of varying solubility (free lime throughout the profile, presence of salinity, calcic-petrocalcic and/or gypsic-petrogypsic horizons). However, in the FAO-Unesco legend the Xerosols and Yermosols not only key out before the Cambisols, but also before Luvisols, Acrisols and Nitisosols - all soils with an argillic B horizon - including those that are intergrades to the ferralic Arenosols and the Ferralsols. All these soils normally develop and occur extensively in humid to subhumid areas. However, in many parts of Kenya - and possibly of tropical Africa - these soils developed on old and stable land surfaces during humid periods of the Pleistocene, although nowadays they cover extensive areas of arid and semi-arid lands (Sombroek et al., 1976). Soil moisture is in short supply both in the relatively young, true Xerosols and Yermosols as well as in the old, decalcified Luvisols, Acrisols and Nitisosols, but chemically the latter soils are much poorer than the former. This is evident in strong differences in the grass, shrub and tree cover.

In view of the above it was arbitrarily decided to exclude soils with a decalcified argillic B horizon and/or ferralic properties from the Xerosols/Yermosols and to restrict the application of the Xerosols/Yermosols denomination to the extensive arid areas in the northeast and northwest of the country, north of the crystalline Basement fringe. Furthermore it was decided not to differentiate between Xerosols and Yermosols and therefore they each receive the letter x in the legend (see also table 3).

1.4.4 Second-level terminology (unit level)

At this level the main soil units, i.e. the first level "great groups", are further subdivided into units according to a number of properties that are directly relevant to soil behaviour and plant growth. All units occurring in the exploratory soil map legend are given in table 3. It was found necessary to define some new subgroups to fill gaps encountered at the exploratory and reconnaissance soil survey level, and to adjust the meaning of certain terms in order to make them more relevant to soil conditions in Kenya.

cambic and orthic Rendzinas

The FAO-Unesco legend (1974) only distinguishes Rendzinas as such. However, during the preparations for the soil map of Europe at scale 1:1,000,000 it was proposed to subdivide the Rendzinas into *cambic* and *orthic* Rendzinas (FAO, 1970). These two units and their definitions were adopted for the exploratory soil map and therefore should not be considered as "Kenya concepts". Cambic Rendzinas are those Rendzinas that have less than 5% calcium carbonate in the surface horizons, while orthic Rendzinas comprise all other Rendzinas.

vertic* Gleysols

Vertic* Gleysols are a "Kenya concept". They comprise those Gleysols that have vertic properties as defined in the FAO-Unesco legend (p. 31). In the key to the soil units they would key out directly after the plinthic Gleysols.

mollic* Nitisols

Mollic* Nitisols are Nitisols (as defined in chapter 1.4.3.) having a mollic epipedon. In the key to the soil units they would key out before the humic Nitisols.

According to the present FAO-Unesco legend all newly defined mollic* Nitisols should be classified as luvic Phaeozems. However, in view of the very characteristic set of properties of Nitisols *sensu stricto* (Nitisols in Kenya concept), it was arbitrarily decided that all the soils having the Nitisol characteristics outlined in ch. 1.4.3 should be retained in that unit, irrespective of the presence of a mollic A horizon. Soils that have all the characteristics of mollic* Nitisols, except the depth requirement, are classified as chromo-luvic Phaeozems (see ch. 1.4.5).

Chromic* Acrisols, chromic Luvisols and chromic Cambisols

Chromic* Acrisols are also a "Kenya concept". In the FAO-Unesco legend the colour notation "chromic" is associated with soils of high base saturation only (chromic Cambisols and chromic Luvisols). For the Kenyan situation it was felt important to distinguish a group of soils of low base saturation on the basis of their red colour, i.e. chromic* Acrisols.

The FAO-Unesco definition of the chromic units for the Luvisols and Cambisols is unsuitable for Kenyan conditions. Therefore the chromic units of these soils and of the Acrisols have been defined as having a red B horizon, i.e. if the soil has a hue of 5YR and a chroma of more than 4, or a hue redder than 5YR.

1.4.5 Third-level terminology (subunit level)

The FAO-Unesco legend does not have a third-level terminology. However, in 1970 the FAO made recommendations for the subdivision of existing soil units into subunits in order to reflect a greater amount of detail in the 1:1,000,000 Soil Map of Europe (FAO, 1970). The same need was felt during the various reconnaissance soil surveys carried out by the Kenya Soil Survey and also during the exploratory soil mapping. FAO's recommendations were followed as much as possible and, where necessary, new subunits were introduced.

A subunit is formed by adding a prefix, e.g. *chromo* to an existing soil unit, e.g. *luvic Phaeozems*. The new subunit of *chromo-luvic Phaeozems* is then defined as luvic Phaeozems with red colours. All subunits distinguished in the legend of the exploratory soil map are included in table 3. FAO (1970) recommends a three-letter code for subunits, e.g. Hlc for chromo-luvic Phaeozems. For reasons of brevity only two letters are used in table 3; these are also used in the standard soil mapping unit codes of the exploratory soil map legend.

The prefixes used to distinguish subunits are briefly outlined below.

ando (FAO, 1970)

Andic subunits are distinguished for humic Acrisols, chromic and eutric Cambisols, haplic and luvic Phaeozems, humic Nitisols and calcareous Regosols. The prefix ando indicates a low bulk density and the presence of volcanic ash.

calcaro (FAO, 1970)

A calcareous subunit is distinguished for the cambic Arenosols. The prefix calcaro denotes the presence of a calcic horizon or a soil that is calcareous at least between 20 and 50 cm from the surface.

chromo (FAO, 1970)

A chromic subunit is distinguished for the luvic Phaeozems. The prefix chromo indicates the presence of red colours in the B horizon.

ferralo (new)

Ferralic subunits are distinguished for the chromic, ferric and orthic Acrisols and Luvisols (see also ch. 1.4.2 on the definition of ferric and ferralic properties). The prefix ferralo not only indicates the presence of ferralic properties but also other properties that make these soils intergrades between Luvisols or Acrisols on the one hand and Ferralsols on the other hand. Although these soils do have an argillic B horizon, it lacks obvious signs such as an appreciable amount of clay cutans. Moreover the textural differentiation is gradual rather than clear, with the clay increase often masked by the presence of iron compounds that cause incomplete dispersion of the soil material during textural analysis.

In addition to a weakly developed B horizon these soils have some characteristics that are reminiscent of Ferralsols. Usually they have a low percentage of weatherable minerals (about 4%), a silt/clay ratio that is slightly above 0.2 and a CEC-clay below 24 me/100g. Furthermore they have gradual horizon transitions, subangular blocky rather than angular blocky peds and a friable to firm consistency.

More detailed information on these intergrades between Luvisols/Acrisols and Ferralsols can be found in the various reconnaissance soil survey reports (R1 to R7) of the Kenya Soil Survey (see list of survey reports under References), while a summary is given by Siderius and van der Pouw (1980). These intergrades and the Ferralsols have also been the subject of contributions to international soil classification workshops (Sombroek and Muchena, 1979; Muchena and Sombroek, 1981a and b).

luvo (new)

A luvic subunit is distinguished for the orthic Solonetz. A luvo-orthic Solonetz can be defined as an orthic Solonetz that has, above the natic B horizon, a layer at least 15 cm thick that is of coarser texture by at least 1 class, and that does not show an albic E horizon with hydromorphic properties. (Many of the solodised Solonetz of older classification systems are involved).

nito (new)

Nitic subunits are used for chromic Cambisols, humic and rhodic Ferralsols, luvic Phaeozems and chromic and ferric Luvisols. The prefix nito indicates intergrading characteristics towards the Nitisols, especially as regards the physical/chemical properties of the soil material (polyhedral structure with shiny ped surfaces in some parts; high aggregate stability; magnetism; rather low clay activity but relatively high specific surface, etc.).

ortho (new)

An orthic subunit is only distinguished for the luvic Phaeozems. The prefix ortho is used to separate the common, brown luvic Phaeozems from the red ones, the chromo-luvic Phaeozems.

*) Note: "Kenya concepts" are indicated by *.

vertic (FAO, 1970)

Vertic subunits are distinguished for luvis Phaeozems, orthic Greyzems, eutric and mollic* Nitisols and eutric Planosols. The prefix vertic indicates the presence of vertic properties as defined in the FAO-Unesco legend (p. 31).

1.5 Soil phases

Phases are subdivisions of soil units based on characteristics that have significance for the use of the management of the land but are not diagnostic for the separation of the soil units themselves (FAO-Unesco op. cit., p. 5).

The soil phases recognised on the exploratory soil map of Kenya can be grouped into phases indicating a *mechanical* hindrance or limitation (rocky, bouldery, boulder-mantle, stony, stony-mantle, gravel-mantle), phases indicating an effective *soil depth* limitation (lithic, paralithic, petrocalcic, pisocalcic, petroferric, pisoferic) and phases indicating a *physico-chemical* limitation (saline, sodic and saline-sodic). Some of these phases are already defined in the FAO-Unesco legend (FAO-Unesco op. cit.), while others are new introductions. The soil phases, each with a particular symbol, are briefly outlined below. If a soil phase applies to more than 50% of a soil mapping unit, the relevant soil phase code appears in parenthesis below the standard soil mapping unit code. (see also ch. 1.6.1).

r rocky phase (new)

The rocky phase marks areas where the presence of rock outcrops makes the use of mechanized agricultural equipment impracticable.

b bouldery phase (new)

The bouldery phase marks areas where the presence of boulders in the surface layers makes the use of mechanized agricultural equipment impracticable.

bm boulder-mantle phase (new)

The boulder-mantle phase marks areas where an excessive amount of boulders at the surface makes any arable use impossible and renders extensive range very difficult.

s stony phase (new)

As for the bouldery phase, but with stones.

sm stone-mantle phase (new)

As for the boulder-mantle phase, but with stones.

gm gravel-mantle phase

As for the boulder-mantle phase, but with gravel.

p lithic (FAO-Unesco op. cit., p. 6) and paralithic (new) phases

The lithic phase is used when continuous coherent and hard rock occurs within 50 cm of the surface. The term paralithic phase is used for softer rock.

k, K petrocalcic phase (FAO-Unesco op. cit., p. 6)

The petrocalcic phase is used for areas in which the upper part of a petrocalcic horizon occurs within 100 cm of the surface. The code k is used when the upper part of the petrocalcic horizon occurs between 50 and 100 cm depth, while the code K is applied if the petrocalcic horizon starts within 50 cm of the surface.

k, K pisocalcic phase (new)

The pisocalcic phase marks soils that show a layer, at least 25 cm thick and starting within 100 cm of the surface, of 40 per cent or more, by volume, of loose fragments of secondary calcium carbonate, usually concretions.

The symbols k and K are applied as described for the petrocalcic phase.

m petroferric phase (FAO-Unesco op. cit., p. 6)

The petroferric phase marks soils in which the upper part of the petroferric horizon occurs within 100 cm of the surface. In areas where the petroferric horizon usually starts within 50 cm of the surface, the soils are termed IRONSTONE soils; this is shown by the code ir in the standard soil mapping unit code (see also ch. 1.4.3).

m pisoferic phase (new)

The pisoferic phase marks soils which show a layer consisting of 40% or more, by volume of oxidic concretions or of hardened plinthite, or ironstone with a thickness of at least 25 cm, the upper part of which occurs within 100 cm of the surface.

a saline phase (FAO-Unesco op. cit., p. 7)

The saline phase is used for soils that show electric conductivity values of the saturation extract higher than 4 mmhos/cm at 25°C in some horizons within 100 cm of the surface.

o sodic phase (FAO-Unesco op. cit., p. 7)

The sodic phase marks soils that have more than 6% exchangeable sodium in some horizons within 100 cm of the surface.

ao saline-sodic phase

The saline-sodic phase is used for soils that combine the saline and sodic phases as defined above.

1.6 Legend

1.6.1 Descriptive terminology

The descriptive terminology applied is described in Kenya Soil Survey's "Manual for soil survey and land evaluation" (in prep.) and is largely based on FAO's "Guidelines for soil profile description" (1977) and the "Soil survey manual" (Soil Survey Staff, 1962). Each soil mapping unit description refers mainly to the characteristics of the subsoil, usually the B horizon, to a depth of 100 cm (less if impenetrable material such as bedrock or a petroferric horizon, occurs at a shallower depth). A rather strict scheme is followed in all descriptions. The following information is given in the sequence indicated:

- drainage condition
- effective soil depth
- colour (moist conditions)
- mottling (if present only described as "mottled")
- consistence (moist conditions)
- calcareousness if present
- salinity, sodicity if present
- rockiness if present
- stoniness if present
- cracking if present

- texture
- additional information on special topsoil or subsoil features, landform, geology, inclusions of other soils, etc.
- soil classification according to the FAO-Unesco legend (op. cit.), including soil phases.

Most of these aspects are described using the standard terminology referred to above. The effective soil depth, additional information and soil classification are elaborated upon below.

effective soil depth

The effective soil depth is described using the following key:

0 - 50 cm	shallow
50 - 80 cm	moderately deep
80 - 120 cm	deep
120 - 180 cm	very deep
more than 180 cm	extremely deep

additional information

The additional information often given at the end of soil mapping unit descriptions basically concerns the following subjects:

- Special topsoil and subsoil characteristics. The phrasing of these characteristics often includes a reference to thickness or depth, as follows:

phrase	thickness/depth
..... "with a topsoil of"	topsoil is less than 30 cm thick
..... "with a thick topsoil of"	topsoil is 30-60 cm thick
..... "with a very thick topsoil of"	topsoil is more than 60 cm thick
..... "with a deeper subsoil"	subsoil below 50 cm depth
- Inclusions of soils that differ from the main body in one or more characteristics.
- Position in landscape (especially for soil associations) and/or geology.

Examples for a, b and c:

- "with a thick humic topsoil"; "humic topsoil" refers to a mollic epipedon and "acid humic topsoil" to an umbric epipedon.
- "with a topsoil of" (texture); used when the topsoil texture differs by two or more classes from the subsoil texture
- "abruptly underlying a topsoil of" (consistence, texture); used for Planosols
- "with a calcareous deeper subsoil"
- "over petroplinthite"
- "over petrocalcic material"
- "in places saline and sodic"
- "with inclusions of recent lava flows"
- "on interfluves"
- "on valley sides"
- "lower level of Chalbi"
- "upper level of Kano Plains"

soil classification and soil phases

Each soil mapping unit description is followed by the soil classification and, if applicable, the soil phases in parenthesis. The following situations may occur:

- A soil mapping unit is classified as one classification unit only, e.g. soil mapping unit M1 (standard code MPr) which is classified as "ando-calcaric Regosols, partly lithic phase". In this case the code rt for ando-calcaric Regosols forms part of the standard code (see also table 3). The use of soil phase codes below the standard soil mapping unit codes is explained in section h.
- A soil mapping unit consists of one major classification unit and one or more minor units. This is indicated as follows (example from unit M6, standard code MVbn): "nito-chromic Cambisols; with haplic Phaeozems lithic phase, Lithosols, eutric Regosols and Rock Outcrops". In this case only the code bn for the major classification unit of nito-chromic Cambisols is added to the standard code.
- A soil mapping unit consists of two major classification units. Example from soil mapping unit L4 (standard code LBfn + bc): "nito-rhodic Ferralsols and chromic Cambisols, lithic and/or bouldery phase". In this case the codes of both major classification units are added to the standard code, as indicated above.
- A soil mapping unit comprises two major classification units and one or more minor ones. Example from soil mapping unit R4 (standard code RBne + bn): "eutric Nitisols and nito-chromic Cambisols; with chromo-luvic Phaeozems". In this case the codes for the two major units, i.e. the eutric Nitisols (ne) and the nito-chromic Cambisols (bn) are also added to the standard code as shown above.
- A soil mapping unit is classified as an intergrade between two soil units. Example from unit Pd6 (standard code PdXbc/lo): "chromic Cambisols to orthic Luvisols". The codes for the two classification units (bc and lo) are incorporated in the standard code in the way shown above. If the intergrade is between two soil units of the same great group, e.g. acric to rhodic Ferralsols, the codes of the two units (fa and fr) are shortened to fa/r (see standard code LcSfa/r for soil mapping unit Lc2).
- A soil mapping unit consists of an undifferentiated great group, with or without minor soil classification units. Example from unit A4 (standard code AVz): "undifferentiated Solonchaks; with Fluvisols, saline-sodic phase". In this case only the single code of the major great group, z for Solonchaks, is added to the standard code as shown above.
- A soil mapping unit is so complex that it consists of more than two major classification units or no soil classification at all is given. In these cases the code C for complex is added to the standard soil mapping unit code e.g. unit F9 with standard code FVC. It should be noted, however, that most soil complexes (and soil associations for that matter), consist of well defined individual classification units whose codes have been incorporated in the standard codes of the mapping unit concerned, following the guidelines given above.
- If a soil mapping unit comprises two or more soil phases, only the symbol for the most limiting soil phase is indicated below the standard soil mapping unit code.

1.6.2 How to read map and legend

In the preceding sections the legend composition, soil classification, soil phase and descriptive terminology used for the soil mapping unit descriptions are described in detail. To facilitate the reading of the map and its legend a brief summary is given here.

All areas delineated on the exploratory soil map (appendix 1) are identified by a particular code such

as L24, R13, Um19, Ps15 etc. All areas with the same code (e.g. L24) together form a soil mapping unit identified by its particular soil mapping unit code and a particular colour. The initial capital letter of the soil mapping unit code stands for the landform (e.g. L for Plateaus and High-Level Structural Plains; see table 1). One or more soil mapping units may occur within a landform: these are then numbered consecutively e.g. L1, L2, etc. These codes, together with their particular colour, can be found in the first column of the legend. The codes are not alphabetically ordered, but grouped according to the natural sequence of the landscape, approximately from high (M for Mountains and Major Scarps) to low (B for Bottomlands). This sequence of landscapes is also shown in table 1. Table 1 also indicates on which page of the legend a landform can be found. To facilitate the location of individual soil mapping unit codes (e.g. L24) in the legend, the top outer corner of each legend page shows a summary of the codes appearing on that page.

The second column of the legend gives, for each soil mapping unit, a second, more elaborate code which is called the *standard* soil mapping unit code. For example, soil mapping unit code L24 is followed by the standard code L Ifr/(m), which is a shorthand notation for landform (L; see table 1), geology or parent material (I; see table 2), soil classification (fr; see table 3) and soil phase (m; see ch. 1.5).

The standard soil mapping unit code is followed by a systematic description (column 3 of the legend) of the soil mapping unit in terms of drainage condition, soil depth, colour, consistence, texture, etc. For an account of this descriptive terminology, the reader is referred to the preceding section. Each soil mapping unit description is followed, in parenthesis, by the soil classification, e.g. rhodic Ferralsols for unit L24, and, if applicable, the soil phase, e.g. petroferric phase for unit L24 (see also ch. 1.4).

	1.6.3	The legend
M		MOUNTAINS AND MAJOR SCARPS (slopes predominantly over 30%)
MP		Soils developed on ashes and other pyroclastic rocks of Recent volcanoes
M1	MPrt	somewhat excessively drained, shallow to moderately deep, brown to dark brown, firm and slightly smearable, strongly calcareous, stony to gravelly clay loam; in many places saline and/or sodic and with inclusions of lava fields (ando-calcaric REGOSOLS, partly lithic phase)
MV		Soils developed on olivine basalts and ashes of major older volcanoes
M2	MVth	well drained, very deep, dark reddish brown to dark brown, very friable and smearable, clay loam to clay, with a thick, acid humic topsoil; in places shallow to moderately deep and rocky (humic ANDOSOLS, partly lithic phase)
M3	MVne	well drained, very deep, dusky red to dark reddish brown, friable clay (eutric NITISOLS)
M4	MVtm	well drained, moderately deep, dark reddish brown, very friable and smearable clay loam, with a humic topsoil (mollic ANDOSOLS)
M5	MVbh (r)	well drained, shallow to moderately deep, dark reddish brown, friable, humic, rocky and stony, clay loam (humic CAMBISOLS, rocky and partly lithic phase)
M6	MVbn	well drained, shallow to moderately deep, dark reddish brown to dark brown, friable, rocky and bouldery, clay loam to clay; in places with a humic topsoil (nito-chromic CAMBISOLS; with haplic PHAEZOZEMS, lithic phase, LITHOSOLS, eutric REGOSOLS and Rock Outcrops)
M7	MVbc (p)	well drained, shallow, dark reddish brown, friable, rocky and stony clay loam, with inclusions of lava vents (chromic CAMBISOLS, lithic and rocky phase)
M8	MVre (p)	well drained, shallow, dark brown, firm, rocky and stony, clay loam (eutric REGOSOLS, lithic phase; with Rock Outcrops)
M9	MVod (p)	imperfectly drained, shallow to moderately deep, dark greyish brown, very friable, acid humic to peaty, loam to clay loam, with rock outcrops and ice in the highest parts (dystric HISTOSOLS, lithic phase; with LITHOSOLS, Rock Outcrops and Ice)
MF		Soils developed on Basement System rocks rich in ferromagnesian minerals
M10	MFbc	complex of well drained soils, ranging from shallow, rocky and stony to deep, non-rocky and non-stony, dark red to dark brown, friable to firm, sandy loam to sandy clay (chromic CAMBISOLS, partly lithic phase; with eutric REGOSOLS and Rock Outcrops)

	MU	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)		HY+	Soils developed on acid igneous rocks (rhyolites, aplites), with volcanic ash admixture
M11	MUbe (p)	somewhat excessively drained, shallow to moderately deep, reddish brown, friable, rocky and stony, sandy clay loam (eutric CAMBISOLS, partly lithic phase; with LITHOSOLS, eutric REGOSOLS and Rock Outcrops)	H8	HY+ u	somewhat excessively drained, shallow, dark reddish brown, friable, gravelly clay; in places with a humic topsoil, partly acid (RANKERS; with ando-haplic PHAEZOZEMS, lithic phase and LITHOSOLS)
M12	MUbh	well drained, moderately deep, reddish brown to brown, friable, stony sandy clay loam, with an acid humic topsoil (humic CAMBISOLS; with dystric REGOSOLS and Rock Outcrops)		HV	Soils developed on undifferentiated Tertiary volcanic rocks (olivine basalts, rhyolites, andesites)
H		HILLS AND MINOR SCARPS (slopes predominantly over 16%)	H9	HVi	well drained, shallow, dark reddish brown, friable, very calcareous, bouldery or stony, loam to clay loam; in many places saline (LITHOSOLS; with calcic XEROSOLS, lithic, bouldery and saline phase and Rock Outcrops)
HB		Soils developed on basic igneous rocks (serpentinites, basalts, nepheline phonolites, older basic tuffs included)	H10	HVre	complex of well drained to moderately well drained, shallow to moderately deep, dark brown, firm, stony, clay loam to clay; in places with a humic topsoil (eutric REGOSOLS, partly lithic phase; with verto-luvic PHAEZOZEMS, partly lithic phase)
H1	HBbh	somewhat excessively drained, shallow to moderately deep, dark reddish brown, friable, gravelly clay, with an acid humic topsoil (humic CAMBISOLS, partly paralithic phase)		HG	Soils developed on granites
H2	HBbc (p)	well drained, shallow, dark reddish brown, friable, rocky and stony, clay loam (chromic CAMBISOLS, lithic phase; with Rock Outcrops)	H11	HGrd (p)	complex of somewhat excessively drained, shallow, stony and rocky soils of varying colour, consistence and texture (dystric REGOSOLS, lithic phase; with ferralic CAMBISOLS, lithic phase and Rock Outcrops)
H3	HBi	well drained, shallow to moderately deep, very dark brown, firm, stony and rocky, clay loam (LITHOSOLS; with verto-luvic PHAEZOZEMS, lithic phase and Rock Outcrops)		HU	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
HP		Soils developed on ashes and other pyroclastic rocks of Recent volcanoes	H12	HUbf	somewhat excessively drained, moderately deep, red, very friable, sandy clay loam to sandy clay; in places rocky (ferralic CAMBISOLS; with rhodic or orthic FERRALSOLS and Rock Outcrops)
H4	HPbt (p)	somewhat excessively drained, shallow, dark brown to brown, friable and slightly smeary, rocky and stony, clay loam (ando-eutric CAMBISOLS, lithic and stony phase; with Rock Outcrops)	H13	HUre (p)	somewhat excessively drained, shallow, reddish brown, friable, rocky or stony, sandy clay loam (eutric REGOSOLS, lithic phase; with Rock Outcrops and calcic CAMBISOLS)
H5	HPtm	well drained, moderately deep to deep, black, very friable and smeary, very gravelly loam, with a humic topsoil (mollic ANDOSOLS)	H14	HUbh (p)	somewhat excessively drained to well drained, shallow to moderately deep, dark reddish brown to brown, friable, rocky and stony, sandy clay to clay; in many places with an acid humic topsoil (humic CAMBISOLS, partly lithic phase; with LITHOSOLS/REGOSOLS, chromic LUVISOLS, partly lithic phase and Rock Outcrops)
H6	HPtm+bt	complex of: - well drained, deep to very deep, dark brown to greyish brown, friable and smeary clay loam, with a thick humic topsoil (mollic ANDOSOLS) - soils of unit H4	H15	HUrd (p)	complex of excessively drained to well drained, shallow, dark red to brown, friable, sandy clay loam to clay; in many places rocky, bouldery and stony and in places with an acid humic topsoil (dystric REGOSOLS, lithic phase; with LITHOSOLS, humic CAMBISOLS, lithic phase and Rock Outcrops)
HI		Soils developed on intermediate igneous rocks (syenites, trachytes, etc.)			
H7	HIhv (b)	well drained, to moderately well drained, shallow to moderately deep, dark reddish brown to dark brown, firm, bouldery or stony clay, with a humic topsoil (verto-luvic PHAEZOZEMS, bouldery and partly lithic phase)			

	HQ	Soils developed on quartzites	L	PLATEAUS AND HIGH-LEVEL STRUCTURAL PLAINS (flat to gently undulating; slopes in general less than 8%)
H16	HQu	somewhat excessively drained, shallow, dark brown, very friable, rocky, sandy loam to clay loam; in many places with an acid humic topsoil (RANKERS; with LITHOSOLS and Rock Outcrops)	LB	Soils developed on Tertiary basic igneous rocks (olivine basalts, nepheline phonolites; older, basic tuffs included)
	HX	Soils developed on various parent materials (mixed igneous and metamorphic rocks)	L1	well drained, very deep, dark red, very friable clay (nito-rhodic FERRALSOLS)
H17	HXbc (p)	well drained, shallow, reddish brown, friable, rocky and stony, sandy clay to clay (chromic CAMBISOLS, lithic phase; with eutric REGOSOLS, lithic phase, LITHOSOLS and Rock Outcrops)	L2	well drained, very deep, dark reddish brown to dark brown, friable to firm, clay; in places with a humic topsoil (vertic-eutric NITISOLS; with mollic* NITISOLS)
	HL	Soils developed on Precambrian to Jurassic limestones and calcitic mudstones	L3	well drained, moderately deep to deep, dark brown, firm clay, with a thick humic topsoil (ortho-luvic PHAEOZEMS)
H18	HLi	somewhat excessively drained, shallow, greyish brown, friable, strongly calcareous, stony clay; on hills and plateau remnants of sedimentary limestones and calcitic mudstones (LITHOSOLS)	L4	complex of well drained, shallow to very deep, dark red, friable clay; in many places rocky and bouldery (nito-rhodic FERRALSOLS and chromic CAMBISOLS, lithic and/or bouldery phase)
H19	HLeo (p)	somewhat excessively drained, shallow, dark grey, firm, moderately calcareous, stony clay; on crystalline limestones (orthic RENDZINAS, lithic phase)	L5	well drained, shallow to moderately deep, reddish brown, firm clay loam, with a humic topsoil (chromo-luvic PHAEOZEMS, partly lithic phase)
H20	HLeC	well drained, shallow to moderately deep, dark brown to yellowish brown, firm, moderately calcareous clay; on Kambe sedimentary limestone (cambic RENDZINAS, partly lithic phase)	L6	well drained, shallow to moderately deep, dark reddish brown, firm, strongly calcareous clay loam, with a stony to bouldery surface; partly saline and/or sodic (calcareous XEROSOLS, boulder-mantle and partly lithic and saline-sodic phase)
	HK	Soils developed on Jurassic-Cretaceous fine sandstones, siltstones and sandy limestones	L7	well drained, shallow, brown, firm, gravelly clay, with a stony to bouldery surface (chromic CAMBISOLS, lithic and boulder-mantle phase)
H21	HKi	somewhat excessively drained, shallow, dark brown, friable, rocky and stony, clay loam; on hills and plateau remnants (LITHOSOLS)	L8	well drained to moderately well drained, deep, very dark greyish brown, firm cracking clay, with a thick humic topsoil (vertic-luvic PHAEOZEMS)
	HS	Soils developed on Jurassic sandstones, grits and conglomerates	L9	moderately well drained, very deep, dark greyish brown, firm clay (vertic-luvic PHAEOZEMS; with eutric PLANOSOLS)
H22	HSre (p)	well drained, shallow, brown, friable, rocky and stony, sandy clay loam; on hills and plateau remnants (eutric REGOSOLS, lithic phase)	L10	imperfectly drained, very deep, very dark greyish brown to black, very firm, cracking clay, with a topsoil of friable, humic clay loam (vertic-orthic GREYZEMS)
	Hs	STEP-FAULTED SCARPS OF THE RIFT VALLEY (slopes variable)	L11	imperfectly drained, very deep, dark grey to black, firm to very firm, bouldery and stony, cracking clay; in places with a calcareous, slightly saline deeper subsoil (pellic VERTISOLS, stony phase and partly saline phase)
	HsV	Soils developed on undifferentiated Tertiary volcanic rocks (olivine basalts, rhyolites, andesites)	L12	imperfectly drained, deep, black to dark grey, very firm, cracking clay (pellic VERTISOLS and vertic-luvic PHAEOZEMS)
Hs1	HsVi	well drained, shallow, dark reddish brown, friable, strongly calcareous, rocky or stony, clay loam; in many places saline (LITHOSOLS; with Rock Outcrops and XEROSOLS, lithic, bouldery and saline phase)	L13	imperfectly drained, deep, very dark greyish brown, very firm, cracking clay (chromic VERTISOLS)

L14	LBwe	imperfectly drained, deep, dark greyish brown, firm clay (hardpan), abruptly underlying a topsoil of sandy clay loam (eutric PLANOSOLS)	LGF+	Soils developed on biotite-hornblende granites, with volcanic ash admixture
L15	LBvp+eo	imperfectly drained, moderately deep to deep, very dark grey to black, firm to very firm, slightly calcareous, cracking clay; in many places with a gravelly, calcareous deeper subsoil (pellic VERTISOLS and orthic RENDZINAS)	LGF+ mo	imperfectly drained, very deep, very dark greyish brown to black, very firm sandy clay, with a topsoil of friable, humic, sandy clay loam to clay loam (orthic GREYZEMS)
L16	LBvp (ao)	imperfectly drained to poorly drained, deep to very deep, dark grey to black, very firm, calcareous, saline and sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)	LR	Soil developed on quartz-feldspar gneisses
L17	LBir+v	complex of: - moderately well drained, shallow, yellowish red to dark yellowish brown, friable, gravelly clay over petroplinthite or rock (50-70%), (IRONSTONE SOILS*; with LITHOSOLS) - poorly drained, deep to very deep, dark brown to very dark greyish brown, mottled, firm to very firm, cracking clay; in places moderately deep to very deep over petroplinthite (undifferentiated VERTISOLS and vertic* GLEYSOLES)	Lrvp+we	association of: - imperfectly drained, moderately deep, dark greyish brown to black, very firm, gravelly, cracking clay; in places saline; on gentle slopes (pellic VERTISOLS, partly saline phase) - imperfectly drained, moderately deep, dark greyish brown to black, very firm, gravelly clay, abruptly underlying a topsoil of gravelly sandy clay loam; on terrain tops (eutric PLANOSOLS)
LP		Soils developed on ashes and other pyroclastic rocks of Recent volcanoes	LQ	Soils developed on quartzites
L18	LPtm	This unit has been deleted.	LQf	well drained, deep to very deep, reddish brown, friable clay, with an acid humic topsoil (humic FERRALSOLS)
L19	LPht	well drained, deep to very deep, very dark greyish brown, friable and smearable, loam to clay loam, with a thick humic topsoil (mollic ANDOSOLS)	LL	Soils developed on Jurassic limestones ("Muguda surface", structural plain)
L20	LPws	well drained, moderately deep to very deep, dark brown, friable and slightly smearable, clay loam to clay (ando-luvic PHAEOZEMS)	LLik (K)	well drained, shallow to moderately deep, dark reddish brown, firm, moderately calcareous clay, over petrocalcic material; on oolithic limestones (calcareous LUVISOLS, petrocalcic phase)
L21	LPht+hv	imperfectly drained, deep very dark greyish brown, mottled, firm clay, abruptly underlying a thick topsoil of friable silty clay loam (solodic PLANOSOLS)	LLbk (p)	well drained, shallow, red, friable, moderately calcareous sandy loam; on dolomitic limestones (calcareous CAMBISOLS, lithic phase)
L22	LI	complex of: - well drained, deep to very deep, very dark greyish brown to dark brown, friable and slightly smearable, clay loam (ando-luvic PHAEOZEMS) - imperfectly drained, deep, very dark greyish brown to black, firm, moderately calcareous, cracking clay (verto-luvic PHAEOZEMS)	LLi (b)	well drained, shallow, dark reddish brown, firm, moderately calcareous, bouldery clay loam; on non-oolithic limestones and calcitic mudstones (LITHOSOLS, bouldery phase)
L23	LIIfn	Soils developed on intermediate igneous rocks (syenites, trachytes, phonolites, etc.)	LD	Soils developed on Tertiary claystones (Banissa beds, "intermediate" peneplain)
L24	LIfr (m)	well drained, very deep, dark reddish brown to dark red, friable clay (nitro-rhodic FERRALSOLS)	LDfr (m)	well drained, deep, dark red, friable clay, over petroplinthite (rhodic FERRALSOLS, petroferric phase)
LI		STEP-FAULTED FLOOR OF THE RIFT VALLEY (flat to gently undulating, with minor scarpes)	Ls	
Ls1	LsBbt (b)	Soils developed on Tertiary basic igneous rocks (olivine basalts, nepheline phonolites; older basic tuffs included)	LsB	
Ls2	LsBxk (b)	well drained, moderately deep, dark reddish brown to reddish brown, friable to firm and slightly smearable, bouldery and stony, clay loam to clay; in places calcareous (ando-chromic CAMBISOLS, bouldery phase; with calcic XEROSOLS)		
Ls		as in Ls1, but mainly calcic XEROSOLS		

Lc	COASTAL PLATEAUS	R5	RBIn	well drained, moderately deep to very deep, dark reddish brown, friable to firm, clay (nito-ferric LUVISOLS; with humic NITISOLS)
LcL	Soils developed on Jurassic limestones (Kambe limestone)	R6	RBhr	well drained, moderately deep to deep, dark reddish brown, friable to firm, clay, with a humic topsoil (chromo-luvic PHAEZOZEMS)
Lc1	LcLne well drained, deep, dark reddish brown, friable, fine sandy clay (eutric NITISOLS)	R7	RBhv	well drained, moderately deep, dark reddish brown, firm, cracking clay, with a humic topsoil (vertic-luvic PHAEZOZEMS)
LcS	Soils developed on Pliocene sandstones (Magarini sands)	R8	RBbn+be (b)	complex of well drained, shallow to very deep, dusky red to dark brown, friable, rocky, bouldery, stony or gravelly, silty clay loam to clay (nito-chromic CAMBISOLS and eutric CAMBISOLS, lithic and bouldery phase)
Lc2	LcSfa/r well drained, extremely deep, red to dusky red, very friable, sandy clay loam to clay (acric to rhodic FERRALSOLS)	R9	RBnh+bh	association of: - well drained, extremely deep, dark reddish brown, friable clay, with an acid humic topsoil; on interfluves (humic NITISOLS)
LcE	Soils developed on cover sands (mainly derived from Magarini sands)			- well drained, shallow to moderately deep, dark reddish brown to dark brown, friable, clay loam to clay, with an acid humic topsoil; on valley sides (humic CAMBISOLS, partly lithic phase)
Lc3	LcEqf excessively drained, very deep, yellowish red to pale yellow, loose, loamy sand to sandy loam (ferralsic ARENOSOLS; with albic ARENOSOLS)			as in RB, but with volcanic ash admixture
Lu	PLATEAU/UPPER-LEVEL UPLAND TRANSITIONS (undulating)			association of: - well drained, extremely deep, dark reddish brown, friable and slightly smearable clay, with an acid humic topsoil; on interfluves (ando-humic NITISOLS)
LuP	Soils developed on ashes and other pyroclastic rocks of Recent volcanoes	RB+		- well drained, shallow to moderately deep, dark brown, friable, clay loam to clay, with an acid humic topsoil; on valley sides (humic CAMBISOLS, partly lithic phase)
Lu1	LuPth well drained, deep to very deep, dark brown, friable and smearable, sandy clay to clay, with an acid humic topsoil (humic ANDOSOLS)	R10	RB+nt+bh	Soils developed on ashes and other pyroclastic rocks of Recent volcanoes
Lu2	LuPtm well drained, deep to very deep, very dark greyish brown, friable and smearable, clay loam, with a thick humic topsoil (mollic ANDOSOLS)			well drained, very deep, dark reddish brown, friable to firm, clay, with a humic topsoil (chromo-luvic PHAEZOZEMS; over buried NITISOLS)
R	VOLCANIC FOOTRIDGES (dissected lower slopes of major older volcanoes and mountains; undulating to hilly)	RP		well drained, moderately deep to deep, dark yellowish brown, friable and smearable, sandy clay loam to clay loam, with a humic topsoil (mollic ANDOSOLS)
RB	Soils developed on Tertiary basic igneous rocks (olivine basalts, nepheline phonolites; older basic tuffs included)	R11	RPhr	association of: - well drained, very deep, dark reddish brown, very friable and smearable, sandy clay loam to clay, with a thick humic topsoil; on interfluves (mollic ANDOSOLS)
R1	RBnt well drained, extremely deep, dark reddish brown to dark brown, friable and slightly smearable clay, with an acid humic topsoil (ando-humic NITISOLS; with humic ANDOSOLS)	R12	RPtm	- well drained, shallow to moderately deep, dark brown to dark reddish brown, very friable and slightly smearable, clay loam to clay; on valley sides (ando-eutric CAMBISOLS, partly lithic phase)
R2	RBnh well drained, extremely deep, dusky red to dark reddish brown, friable clay, with an acid humic topsoil (humic NITISOLS)	R13	RPtm+bt	
R3	RBne well drained, extremely deep, dusky red to dark reddish brown, friable clay; with inclusions of well drained, moderately deep, dark red to dark reddish brown, friable clay over rock, pisoferric or petroferric material (eutric NITISOLS; with nito-chromic CAMBISOLS and chromic* ACRISOLS, partly pisoferric or petroferric phase)			
R4	RBne+bn well drained, deep to extremely deep, dark reddish brown to dark brown, friable to firm, clay; in places gravelly (eutric NITISOLS and nito-chromic CAMBISOLS; with chromo-luvic PHAEZOZEMS)			

	RV	Soils developed on olivine basalts and pyroclastic rocks		FVC	complex of well drained to moderately well drained, deep, reddish brown to very dark greyish brown, firm, sandy clay loam to clay; in many places with a humic topsoil and/or cracking and/or moderately calcareous (undifferentiated LUVISOLS, luvic PHAEZOZEMS and chromic VERTISOLS)
R14	RVi+xk (b)	well drained, shallow to moderately deep, dark brown, firm, strongly calcareous, stony clay loam, with a rocky and bouldery surface; in many places saline and sodic; with inclusions of recent lava flows (LITHOSOLS and calcic XEROSOLS, bouldery phase and partly saline-sodic phase)			
	F	FOOTSLOPES (gently sloping to sloping; slopes 2-8%)		FL	Soils developed on colluvium from crystalline limestones
	FB	Soils developed on colluvium from basic igneous rocks (serpentinites, basalts, etc.)	F10	FLic (o)	well drained, very deep, dark reddish brown, firm, slightly calcareous clay, with a slightly to moderately sodic deeper subsoil (chromic LUVISOLS, sodic phase)
F1	FBne	well drained, very deep, dark reddish brown, friable clay (eutric NITISOLS)	F11	FLiv (o)	well drained, very deep, dark brown, firm, moderately to strongly calcareous, slightly to moderately sodic, cracking clay (vertic LUVISOLS, sodic phase)
F2	FBfn	well drained, deep to very deep, dusky red to dark reddish brown, friable clay; in places with a humic topsoil (nito-rhodic FERRALSOLS; with verto-mollie* NITISOLS)		FU	Soils developed on colluvium from undifferentiated Basement System rocks (predominantly gneisses)
F3	FBbk	well drained, deep to very deep, dark reddish brown, firm, moderately calcareous clay (calcic CAMBISOLS)	F12	FUfr	well drained, very deep, dark red, loose, loamy coarse sand to friable sandy clay loam (rhodic FERRALSOLS; with ferralic ARENOSOLS and ferralo-chromic LUVISOLS)
	FP	Soils developed on colluvium from ashes and other pyroclastic rocks of Recent volcanoes	F13	FUlc	well drained, very deep, yellowish red to dark reddish brown, loose, loamy coarse sand to friable sandy clay loam (chromic LUVISOLS; with rhodic FERRALSOLS and luvic/ferralic ARENOSOLS)
F4	FPh	well drained to moderately well drained, very deep, dark brown, friable and slightly smearable clay, with a humic topsoil (ando-luvic PHAEZOZEMS)	F14	FUxh	well drained, very deep, brown, slightly to moderately calcareous, loose loamy coarse sand to friable sandy clay loam (haplic XEROSOLS; with calcaric ARENOSOLS)
F5	FPxh (sm)	well drained, moderately deep, dark reddish brown, firm, strongly calcareous clay loam, with a gravel to stone surface, in many places saline and/or sodic (haplic XEROSOLS, stone-mantle phase and partly saline-sodic phase)	F15	FUa	complex of somewhat excessively drained to well drained, deep to very deep, dark red to brown, loose sandy loam to friable to firm, clay (undifferentiated ACRISOLS; with ARENOSOLS)
	FY +	Soils developed on colluvium from acid igneous rocks (rhyolites), with volcanic ash admixture	F16	FUqf	complex of well drained, deep to very deep, dark reddish brown to dark yellowish brown soils of varying consistency and texture; in places gravelly and stratified (ferralic ARENOSOLS; with ferralo-chromic/orthic LUVISOLS)
F6	FY + hg	moderately well drained to imperfectly drained, deep, dark reddish brown, mottled, friable clay loam, with a humic topsoil and a deeper subsoil of compact clay (gleycic PHAEZOZEMS)		FQ	Soils developed on colluvium from quartzites
	FV	Soils developed on colluvium from various volcanic rocks (mainly basalts)	F17	FQah	well drained, deep to very deep, reddish brown to yellowish red, friable, sandy loam to clay, with an acid humic topsoil (humic ACRISOLS; with luvic ARENOSOLS)
F7	FVat	well drained, deep to very deep, reddish brown, friable clay, with an acid humic topsoil (ando-humic ACRISOLS)		FX	Soils developed on colluvium from various rocks
F8	FVxk (bm)	imperfectly drained, moderately deep, dark reddish brown to dark greyish brown, friable to firm, strongly calcareous, moderately saline and strongly sodic, stony clay loam; in many places with a boulder surface (calcic XEROSOLS, boulder-mantle and saline-sodic phase)	F18	FXlc	well drained, moderately deep to very deep, dark red to reddish brown, friable to firm, sandy clay to clay (chromic LUVISOLS; with rhodic FERRALSOLS)

	FS	Soils developed on colluvium from sandstones, grits and conglomerates (Taru grits and Mazeras sandstone)		Y5	YVzo (sm)	moderately well drained, very deep, dark brown to greyish brown, firm, strongly calcareous, moderately to strongly saline and sodic, fine sandy loam to clay loam, with a stone surface (orthic SOLONCHAKS, stone-mantle phase)
F19	FSql	excessively drained, very deep, reddish yellow, loose, sand to loamy sand (luvic ARENOSOLS; with ferralic and albic ARENOSOLS)		YL		Soils developed on alluvium from crystalline limestones
	FY	FOOTSLOPES AND PIEDMONT PLAINS UNDIFFERENTIATED (nearly flat to sloping; slopes 0-8%)		Y6	YLi+lv	association of: - well drained, deep to very deep, dark reddish brown, friable to firm, sandy clay to clay; on convex to straight slopes (ferralo-ferric LUvisols) - moderately well drained, very deep, dark reddish brown to dark brown, firm, moderately calcareous clay; with a saline and sodic deeper subsoil; on concave slopes (vertic LUvisols, saline-sodic phase)
	FYU	Soils developed on colluvium and alluvium from undifferentiated Basement System rocks (predominantly gneisses)		YU		Soils developed on alluvium from undifferentiated Basement System rocks (predominantly gneisses)
FY1	FYUlc+lv	well drained, moderately deep to deep, red to dark reddish brown, firm, sandy clay loam to clay (chromic and vertic LUvisols)		Y7	YUli	well drained, very deep, dark red, friable, sandy clay to clay (ferralo-chromic LUvisols)
	FYL	Soils developed on colluvium and alluvium from crystalline limestones		Y8	YUlo	well drained, very deep, dark reddish brown to dark brown, loose sandy loam to friable to firm, sandy clay (orthic LUvisols; with luvinic ARENOSOLS)
FY2	FYLlc+kh	well drained, deep to very deep, dark brown, friable to firm, clay loam to sandy clay; in places calcareous (chromic LUvisols and haplic KASTANOZEMS)		Y9	YUbk (o)	well drained, deep, dark brown, friable, moderately calcareous clay loam, with a sodic deeper subsoil (calcic CAMBISOLS, sodic phase)
	FYK	Soils developed on colluvium and alluvium from fine sandstones, siltstones and sandy limestones		Y10	YUxh (o)	moderately well drained, very deep, dark yellowish brown to strong brown, slightly to moderately calcareous, slightly sodic, loose loamy sand to friable sandy clay loam (haplic XEROSOLS, sodic phase; with calcaro-cambic ARENOSOLS)
FY3	FYKbk	well drained, very deep, dark red, friable, moderately calcareous, very fine sandy clay loam (calcic CAMBISOLS)		Y11	YUvv	imperfectly drained, very deep, very dark grey to black, very firm, cracking, clay, with a calcareous deeper subsoil; in places gravelly (verto-eutric PLANOSOLS)
	Y	PIEDMONT PLAINS (nearly flat to gently sloping; slopes 0-5%)		Y12	YUwe	poorly drained, very deep, dark greyish brown to very dark grey, mottled, firm, to very firm, clay, abruptly underlying a topsoil of friable, sandy clay loam; in places with a sodic deeper subsoil (eutric PLANOSOLS; with solodic PLANOSOLS)
	YP	Soils developed on alluvium from ashes and other pyroclastic rocks of Recent volcanoes		Y13	YUC	complex of moderately well drained to poorly drained, very deep, dark brown to dark grey, firm to very firm, sandy clay to clay; in places stratified, sodic and/or cracking (PLANOSOLS, GLEYSOLES, SOLONETZ, VERTISOLS and FLUVISOLS)
Y1	YPtm+fch (r)	complex of well drained, shallow to deep, greyish brown to black, very friable and smearable, rocky or bouldery, gravelly, sandy clay loam to clay (mollic ANDOSOLS, rocky phase and haplic CHERNOZEMS, stony and partly lithic phase)				
	YY	Soils developed on alluvium from various Tertiary/Quaternary volcanic rocks (mainly basalts)				
Y2	YVlv	well drained, deep to very deep, dark brown, firm clay; in places cracking and/or calcareous and sodic (vertic LUvisols; with calcic LUvisols, sodic phase and chromic VERTISOLS, sodic phase)				
	Y3	YVbe	well drained, deep to very deep, dark brown, very friable, clay loam to gravelly clay loam (eutric CAMBISOLS)			
	Y4	YVbk (ao)	well drained, moderately deep to very deep, dark brown, very friable, moderately calcareous, gravelly clay loam, with a slightly saline and sodic deeper subsoil; in places over petrocalcic material (calcic CAMBISOLS, saline-sodic phase)			

Uu-Uh

	U	UPLANDS		UhY +	Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture
	Uu	UPPER-LEVEL UPLANDS (usually rolling to hilly; altitudes 6500-11,000 feet; about 4,000 feet above local base level)		Uh6	well drained, very deep, dark red to dark reddish brown, friable, sandy clay to clay (nito-rhodic FERRALSOLS)
	UuI⁺	Soils developed on intermediate igneous rocks (syenites, trachytes, andesites), with volcanic ash admixture		UhY +fn	Soils developed on granites
Uu1	Uu I⁺nm+hr	well drained, deep to extremely deep, reddish brown, friable clay, with a thick humic topsoil (mollic* NITISOLS and chromo-luvic PHAEZOZEMS)		UhG	well drained, very deep, dark red to yellowish red, friable to firm, sandy clay to clay, with an acid humic topsoil (humic ACRISOLS) as in Uh7, but rocky (humic ACRISOLS, rocky phase)
	UuY +	Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture		Uh7	well drained, deep, yellowish red to brown, friable clay loam, with an acid humic topsoil (humic CAMBISOLS; with humic ACRISOLS)
Uu2	UuY +ht	well drained, deep to very deep, dark reddish brown, friable and slightly smeary, silty clay loam, with a thick humic topsoil (ando-luvic PHAEZOZEMS)		Uh8	Soils developed on hornblende gneisses
	UuU	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)		Uh9	well drained, extremely deep, dark reddish brown, friable clay, with a thick acid humic topsoil (humic NITISOLS)
Uu3	UuUu+bh	complex of: - well drained, shallow, black to very dark brown, acid humic, very friable loam; in places rocky (RANKERS) - well drained, moderately deep, dark brown, friable clay loam, with a very thick acid humic topsoil (humic CAMBISOLS)		UhF	Soils developed on biotite gneisses
	Uh	UPPER MIDDLE-LEVEL UPLANDS (usually undulating to rolling; altitudes 5000-8000 feet; about 2500 feet above local base level)		Uh10	well drained, extremely deep, dark reddish brown, friable clay, with a thick acid humic topsoil (humic NITISOLS)
	UhB	Soils developed on Tertiary or older basic igneous rocks (basalts, nepheline phonolites, etc.; basic tuffs included)		UhN	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
Uh1	UhBnh	well drained, extremely deep, dark reddish brown to dark red, friable clay, with an acid humic topsoil (humic NITISOLS)		Uh11	well drained, moderately deep to deep, dark reddish brown to dark brown, friable, sandy clay loam to clay, with a thick acid humic topsoil; in places shallow and rocky (humic ACRISOLS and humic CAMBISOLS, partly lithic phase; with Rock Outcrops)
Uh2	UhBnm	well drained, extremely deep, dark reddish brown, friable clay, with a humic topsoil (mollic* NITISOLS)		Uh12	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
Uh3	UhBne	well drained, extremely deep, dark reddish brown, friable clay (eutric NITISOLS)		UhU	well drained, deep, red to yellowish red, friable sandy clay (ferralo-chromic* ACRISOLS)
Uh4	UhBbn	well drained, shallow to moderately deep, dark reddish brown, to dark red, friable clay (nito-chromic CAMBISOLS; with chromic CAMBISOLS, lithic phase)		Uh13	well drained, deep, red, firm sandy clay, with a topsoil of sandy loam (chromic LUVISOLS)
Uh3 + Uh4	UhBne+bn	complex of soils of units Uh3 and Uh4		Uh14	well drained, moderately deep to very deep, dark red to reddish yellow, friable to firm, rocky, sandy clay loam to clay (chromic* ACRISOLS, rocky phase; with CAMBISOLS and FERRALSOLS)
	Uh I⁺	Soils developed on intermediate igneous rocks (syenites, andesites, etc.), with volcanic ash admixture		UhQ	Soils developed on quartzites
Uh5	Uh I⁺nm	well drained, extremely deep, reddish brown, friable clay, with a thick humic topsoil (mollic* NITISOLS)		Uh16	well drained, very deep, dark reddish brown, friable to firm, sandy clay to clay, with a humic topsoil (chromo-luvic PHAEZOZEMS)
				Uh17	well drained, very deep, reddish brown to brown, friable, sandy clay loam to clay, with a very thick acid humic topsoil (humic CAMBISOLS)
				UhX	Soils developed on various rocks
				Uh18	well drained, very deep, dusky red to yellowish red, friable to firm, clay loam to clay; in places with an acid humic topsoil (ferralo-chromic*/orthic ACRISOLS)

	UhX ⁺	as in UhX, but with volcanic ash admixture			
Uh19	UhX ⁺ ht	moderately well drained, moderately deep, reddish brown to red, firm clay loam, with a humic topsoil (ando-luvic PHAEOZEMS)	Um12	UmGag	imperfectly drained, moderately-deep, brown to dark yellowish brown, mottled, friable, gravelly sandy clay loam; in places rocky and shallow (gleiyic ACRISOLS, partly paralithic and rocky phase)
Um		LOWER MIDDLE-LEVEL UPLANDS (usually undulating; altitudes 3500-6500 feet; about 1500 feet above local base level)	UmGF		Soils developed on biotite/hornblende granites
Umb		Soils developed on basic igneous rocks (basalts, etc.)	Um13	UmGFfn	well drained, very deep, reddish brown to red, friable clay, with a thick acid humic topsoil (nito-humic FERRALSOLS)
Um1	UmBnd	well drained, extremely deep, dark reddish brown, friable clay (dystric NITISOLS)	Um14	UmG Fah/c	well drained, moderately deep to deep, yellowish red to red, friable to firm, clay, partly with an acid humic topsoil; in places shallow and rocky (humic to chromic* ACRISOLS; with LITHOSOLS and Rock Outcrops)
Um2	UmBne	well drained, very deep, red to dark red, friable to firm, clay; in places moderately deep over petroplinthite (eutric NITISOLS; with rhodic FERRALSOLS, partly petroferric phase)	UmF		Soils developed on Basement System rocks rich in ferromagnesian minerals
Um3	UmBnm	well drained, deep to extremely deep, dark red, friable clay, with a thick humic topsoil (mollic* NITISOLS; with nito-luvic PHAEOZEMS)	Um15	UmFn	well drained, very deep, dark red, friable to firm, clay (nito-rhodic FERRALSOLS)
UmP		Soils developed on ashes and other pyroclastic rocks of Recent volcanoes	UmN		Soils developed on biotite gneisses
Um4	UmPtM	well drained, deep to very deep, dark reddish brown, friable and smeary, silty clay to clay, with a humic topsoil (mollic ANDOSOLS)	Um16	UmNfr	well drained, deep, red, friable clay (rhodic FERRALSOLS; with ferralo-chromic* ACRISOLS)
UmI		Soils developed on intermediate igneous rocks (andesites, etc.)	Um17	UmNai	well drained, moderately deep to deep, dark reddish brown to brown, friable to firm, sandy clay loam to clay; in places with an acid humic topsoil (ferralo-orthic ACRISOLS; with dystric and humic CAMBISOLS and humic ACRISOLS)
Um5	UmInh	well drained, extremely deep, dusky red to dark reddish brown, friable clay, with an acid humic topsoil (humic NITISOLS)	Um18	UmNlo	well drained, moderately deep to deep, brown to dark yellowish brown, firm sandy clay loam (orthic LUvisols)
Um6	UmIfn	well drained, very deep, dusky red to dark red, friable clay (nito-rhodic FERRALSOLS)	UmU		Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
Um7	UmIbf	well drained, shallow to moderately deep, reddish brown to yellowish red, friable, gravelly sandy clay loam to clay loam, over soft rock (ferralic CAMBISOLS, partly paralithic phase)	Um19	UmUai	well drained, moderately deep to very deep, dark reddish brown to dark yellowish brown, friable to firm, sandy clay to clay; in many places with a topsoil of loamy sand to sandy loam (ferralo-chromic*/orthic/ferric ACRISOLS; with LUvisols and FERRALSOLS)
UmY		Soils developed on acid igneous rocks (rhyolites, etc.)	Um20	UmUfr+fo	well drained, moderately deep to deep, dark red to yellowish red, friable, sandy clay loam to clay (rhodic and orthic FERRALSOLS; with ferralo-chromic*/orthic/ferric ACRISOLS)
Um8	UmYhr	well drained, deep to extremely deep, reddish brown, friable clay, with a humic topsoil (chromo-luvic PHAEOZEMS; with mollic* NITISOLS)	Um21	UmUlc+lri	well drained, moderately deep to deep, dark red to yellowish red, friable to firm, sandy clay to clay, often with a topsoil of loamy sand (chromic LUvisols and ferralo-chromic/orthic/ferric LUvisols)
Um9	UmYhr+lo	well drained, moderately deep to deep, reddish brown to brown, friable, gravelly clay loam to clay; in many places with a humic topsoil (chromo-luvic PHAEOZEMS and orthic LUvisols)	Um22	UmUlo	well drained, shallow to moderately deep, strong brown to brown, firm, gravelly to stony, sandy clay to clay loam, over soft rock (orthic LUvisols, partly paralithic phase)
UmG		Soils developed on granites			
Um10	UmGai	well drained, deep to very deep, brown to dark brown, friable, sandy clay to clay (ferralo-orthic ACRISOLS)			
Um11	UmGah	well drained, deep, dark red, friable clay, with an acid humic topsoil (humic ACRISOLS)			

Um–UI

Um23	UmUbe (p)	well drained, shallow, dark brown to dark yellowish brown, friable, gravelly sandy clay loam to sandy clay, over soft rock (eutric CAMBISOLS, paralithic phase)	UI5	UI Iir+be	well drained, shallow, dark reddish brown to brown, friable to firm, sandy clay loam to gravelly clay, partly over petroplinthite (50-75%) (IRONSTONE SOILS* and eutric CAMBISOLS, lithic or petroferric phase; with orthic LUvisols)
Um24	UmUlc+lhi	complex of well drained, shallow to deep, red to dark red, friable to firm, sandy clay loam to sandy clay; in places rocky (chromic and ferralo-chromic LUvisols; with chromic CAMBISOLS, lithic phase and Rock Outcrops)	UI6	UI Iir+nd	association of: - well drained to moderately well drained, shallow, friable sandy clay loam, over petroplinthite (about 50%); on interfluves (IRONSTONE SOILS*) - well drained, very deep, dark reddish brown to strong brown, friable clay; on valley sides (dystric NITISOLS; with orthic FERRALSOLS)
Um25	UmUlc+bdi	complex of well drained, shallow to deep, reddish brown to brown, friable to firm, sandy clay loam to clay (chromic LUvisols and dystric CAMBISOLS, lithic phase)	UIY		Soils developed on acid igneous rocks (rhyolites, etc.)
UmU+		as in UmU, but with volcanic ash admixture	UI7	UIYfo (m)	well drained, moderately deep to deep, yellowish red to strong brown, friable clay, over petroplinthite or rock; in places shallow over petroplinthite (orthic FERRALSOLS, partly petroferric phase; with IRONSTONE SOILS*)
Um26	UmU+hr	well drained, moderately deep to deep, reddish brown to red, firm, stony sandy clay to clay loam, with a humic topsoil (chromo-luvic PHAEZOZEMS)	UI8	UIYhg+hh	well drained to moderately well drained, moderately deep to deep, reddish brown to dark grey, friable clay, with a humic topsoil (gleiyic and haplic PHAEZOZEMS)
UmQ		Soils developed on quartzites	UI9	UIYir	well to moderately well drained, shallow, dark reddish brown, friable, stony to gravelly clay over petroplinthite; in places moderately deep to deep (20%) (IRONSTONE SOILS*; with ferralo-chromic* ACRISOLS)
Um27	UmQfq	complex of somewhat excessively drained to well drained, shallow to very deep, dark reddish brown to yellowish brown, loose loamy sand to friable sandy clay loam; in places rocky and stony (ferralic ARENOSOLS; with orthic FERRALSOLS, ACRISOLS, etc.; partly lithic and stony phase)	UI10	UIYhr+I (m)	complex of predominantly well drained, moderately deep to deep, reddish brown to brown, friable, gravelly clay loam to clay, often with a humic topsoil; in many places shallow over petroplinthite (chromo-luvic PHAEZOZEMS and orthic and chromic LUvisols, partly petroferric phase; with IRONSTONE SOILS*)
UmX		Soils developed on various rocks (Kavirondian sediments, often mudstones)	UIG		Soils developed on granites
Um28	UmXfr/o	well drained, deep to very deep, dark reddish brown to strong brown, friable clay (rhodic to orthic FERRALSOLS)	UI11	UIGfo+ir	complex of: - well drained, moderately deep to very deep, reddish brown to yellowish brown, friable clay, over petroplinthite (orthic FERRALSOLS, partly petroferric phase; with orthic ACRISOLS) - moderately well drained, shallow, brown to dark brown friable sandy clay loam, over petroplinthite (about 30%) (IRONSTONE SOILS*)
Um29	UmXah/g	imperfectly drained, moderately deep to deep, very dark greyish brown, firm, sandy clay loam to sandy clay; in places mottled and/or with a humic topsoil (humic to gleyic ACRISOLS)	UI12	UIGah+ir	complex of: - well drained, deep, reddish brown, friable, sandy clay loam, with an acid humic topsoil (humic ACRISOLS) - moderately well drained, shallow, dark reddish brown, friable sandy loam, over petroplinthite (about 20%) (IRONSTONE SOILS*)
UI		LOWER-LEVEL UPLANDS (usually gently undulating; altitudes 2500-6000 feet; about 500 feet above local base level)			
UIB		Soils developed on basic igneous rocks (basalts, etc.)			
UI1	UIBne	well drained, extremely deep, dark red, friable clay (eutric NITISOLS)			
UI2	UIBhr	well drained, moderately deep, red, firm clay, with a humic topsoil; with inclusions of imperfectly drained, deep, dark grey, mottled, very firm clay (chromo-luvic PHAEZOZEMS; with gleyic LUvisols)			
UI3	UIBhv	moderately well drained, shallow to moderately deep, dark brown, firm clay (vertic-luvic PHAEZOZEMS, partly lithic phase)			
UII		Soils developed on intermediate igneous rocks (andesites, etc.)			
UI4	UI Ilc (m)	well drained, moderately deep to deep, dark reddish brown, friable clay; in many places over petroplinthite (chromic LUvisols, partly petroferric phase; with IRONSTONE SOILS*)			

UIGR	Soils developed on granites and quartz-feldspar gneisses				
UI13	UIGRfo	well drained, deep, strong brown to reddish yellow, very friable, sandy clay loam to sandy clay (orthic FERRALSOLS; with ferralic CAMBISOLS)	UI21	UIXhh+ir (m)	moderately well drained, moderately deep, dark brown to dark greyish brown, friable gravelly clay, over petroplinthite, with a humic topsoil; in many places shallow over petroplinthite (10-40%) (haplic PHAEZOZEMS, petroferric phase and IRONSTONE SOILS*)
UIF		Soils developed on Basement System rocks rich in ferromagnesian minerals		Ux	UPLANDS, UNDIFFERENTIATED LEVELS (undulating to rolling; altitudes and base level variable)
UI14	UIFc	well drained, moderately deep to deep, dark reddish brown to dark red, friable to firm, sandy clay to clay; in many places with stonelines (chromic LUVISOLS)		UxB	Soils developed on basic igneous rocks (basalts, etc.)
UIN		Soils developed on biotite gneisses	Ux1	UxBbk (b)	well drained, shallow to moderately deep, dark greyish brown, friable to firm, calcareous, very rocky and bouldery clay (calcareous CAMBISOLS, lithic and bouldery phase)
UI15	UINfr	well drained, very deep, dark red to dark reddish brown, very friable, sandy clay loam to clay (rhodic FERRALSOLS)	Ux2	UxBlc+hv (s)	association of: - well drained, deep to very deep, dusky red to dark reddish brown, friable, stony, clay loam to clay; on upper slopes (chromic LUVISOLS, stony phase) - imperfectly drained, deep to very deep, dark brown to very dark greyish brown, firm, calcareous, saline and sodic, stony, cracking clay; on lower slopes (vert-louvic PHAEZOZEMS, stony and saline-sodic phase)
UI16	UINfr+ir	association of: - well drained, moderately deep to very deep, red, very friable, sandy clay to clay, over petroplinthite; on valley sides (rhodic FERRALSOLS, partly petroferric phase) - well drained, dark reddish brown, friable sandy clay loam over petroplinthite (about 50%); on interfluves (IRONSTONE SOILS*)		UxP	Soils developed on basic igneous rocks (basalts, etc.), but with influence of volcanic ash predominant
UIU		Soils developed on undifferentiated Basement System rocks (predominantly gneisses)	Ux3	UxBPln	well drained, deep to very deep, dark reddish brown to dark red, firm clay; with inclusions of imperfectly drained, moderately deep, dark greyish brown clay (nitro-ferric/chromic LUVISOLS; with gleiyic LUVISOLS)
UI17	UIUfr	well drained, very deep, red to dark red, very friable to friable, clay (rhodic FERRALSOLS)		UxP	Soils developed on pyroclastic rocks
UI18	UIUlc+ft	association of: - well drained, moderately deep to deep, dark red to dark reddish brown, friable to firm, sandy clay to clay; on slopes (chromic LUVISOLS) - well drained, very deep, light brown to strong brown, very friable clay; on flat interfluves (orthic and xanthic FERRALSOLS)	Ux4	UxPtm	well drained, very deep, dark reddish brown to dark brown, very friable and smeary, silty clay loam, with a humic topsoil (mollic ANDOSOLS)
UI19	UIUao (m)	complex of well drained to imperfectly drained, shallow to moderately deep, dark red to dark yellowish brown, firm, non-rocky to rocky, non-stony to stony, sandy loam to clay, partly over pisoferric material (orthic ACRISOLS, pisoferric phase; with chromic LUVISOLS and eutric CAMBISOLS, lithic phase)		UxV	Soils developed on undifferentiated volcanic rocks (mainly basalts)
UIX		Soils developed on various rocks (Kavirondian sediments, often mudstones)	Ux5	UxVht	well drained, very deep, dark reddish brown to very dark greyish brown, friable and slightly smeary clay, with a humic topsoil (ando-louvic PHAEZOZEMS)
UI20	UIXH+ir (m)	well drained, moderately deep to very deep, dark red to strong brown, friable clay; in many places shallow over petroplinthite (10-40%) (orthic to rhodic FERRALSOLS, partly petroferric phase and IRONSTONE SOILS*)	Ux6	UxVlc (s)	well drained, shallow to moderately deep, dark reddish brown, firm, rocky and stony clay (chromic LUVISOLS, stony and partly lithic phase)
			Ux7	UxVrc (sm)	well drained, shallow, dark brown, friable, strongly calcareous, strongly saline and moderately sodic, stony loam; with a stone surface (dissected older piedmont plain) (calcaric REGOSOLS, stone-mantle and saline-sodic phase)

Ux–Uc

Ux8	UxVnet+bc (b)	association of: - well drained to imperfectly drained, moderately deep to very deep, dusky red to very dark greyish brown, friable to firm, clay loam to clay; in many places stony and bouldery and/or cracking; with severe gully erosion and many rock outcrops; in major upland area (eutric NITISOLS; with chromic CAMBISOLS, bouldery phase, VERTISOLS and Rock Outcrops) - somewhat excessively drained, shallow, dark reddish brown, friable to firm, gravelly and bouldery clay loam; on volcanic cones (chromic CAMBISOLS, lithic and bouldery phase)	Uc4	UcKlo	well drained, deep, dark brown to yellowish brown, firm, very fine sandy clay loam to clay, with a topsoil of loamy very fine sand to very fine sandy loam; in places with an abrupt transition to a sodic deeper subsoil (orthic LUvisols; with solodic PLANOSOLS)
Ux9	UxVhr+vc	complex of: - well drained, shallow to moderately deep, reddish brown, friable, stony and gravelly clay loam, with a humic topsoil (chromo-luvic PHAEZOZEMS, partly lithic phase) - imperfectly drained, moderately deep, very dark greyish brown to black, very firm, cracking clay (chromic VERTISOLS)	Uc5	UcKbe (p)	well drained, shallow, dark brown to dark yellowish brown, friable to firm, fairly stony, fairly rocky, fine sandy clay loam to clay (eutric CAMBISOLS, lithic phase; with orthic LUvisols)
UxU		Soils developed on undifferentiated Basement System rocks (predominantly gneisses)	Uc6	UcKao	well drained to imperfectly drained, deep, yellowish red to dark brown, friable, fine sandy clay loam to fine sandy clay, with a topsoil of loamy fine sand to fine sandy loam (orthic ACRISOLS)
Ux10	UxUrc (gm)	well drained, shallow brown, friable, strongly calcareous, moderately to strongly sodic and saline, gravelly sandy clay loam; with a gravel surface (calcaric REGOSOLS, gravel-mantle and saline-sodic phase; with gleyic SOLONETZ)	Uc7	UcKws	imperfectly drained, deep to very deep, yellowish brown, mottled, firm, slightly sodic, fine sandy clay loam to clay, abruptly underlying 20-100 cm of fine sand to fine sandy loam (solodic PLANOSOLS)
Uc		COASTAL UPLANDS (undulating to rolling; altitude 1000 feet or less)	UcS		Soils developed on coarse sandstones and grits (Mazeras sandstone and Shimba grits)
Uc I		Soils developed on intermediate igneous rocks rich in ferromagnesian minerals (intrusives)	Uc8	UcSfr+fo	well drained, very deep, red to dark red and strong brown, friable, sandy clay loam to sandy clay, with a topsoil of loamy sand to sandy loam (rhodic and orthic FERRALSOLS)
Uc1	Uc Ine	well drained, extremely deep, dark red to yellowish red, friable clay (eutric NITISOLS)	Uc9	UcSai+q	complex of: - well drained to imperfectly drained, very deep, dark red to dark greyish brown, friable to firm, sandy clay to clay, with a topsoil of loamy sand to sandy loam (ferralo-chromic*/orthic ACRISOLS; with gleyic LUvisols) - excessively drained to imperfectly drained, very deep, red to light yellowish brown, loose, sand to loamy sand (ferralic to luvic ARENOSOLS)
UcT		Soils developed on shales	UcO		Soils developed on Plio-Pleistocene bay sediments (Marafa beds)
Uc2	UcTbe+hv	association of: - well drained to imperfectly drained, shallow to moderately deep, yellowish brown to very dark grey, firm to very firm clay; on dissected parts (eutric CAMBISOLS, partly lithic phase) - imperfectly drained, deep, dark grey to olive grey, very firm clay, with a humic topsoil and a sodic deeper subsoil; on interfluves (vertic PHAEZOZEMS, sodic phase; with vertic CAMBISOLS, sodic phase)	Uc10	UcOsm	imperfectly drained to poorly drained, moderately deep to deep, dark yellowish brown to light olive brown, firm to very firm, moderately calcareous, sandy clay to clay, with a humic topsoil; predominantly moderately sodic and in places saline (mollic SOLONETZ; with orthic RENDZINAS and verto-luvic PHAEZOZEMS)
UcK		Soils developed on fine sandstones and siltstones (Mariakani sandstone and Upper Maji-ya-Chumvi beds)	UcX		Soils developed on undifferentiated sedimentary rocks (Mazeras and Mariakani sandstones and Marafa beds)
Uc3	UcKqa/l	well drained, deep to very deep, pinkish grey to brown, very friable, fine sand to loamy fine sand (albic to luvic ARENOSOLS)	Uc11	UcXI	complex of well drained to moderately well drained, moderately deep, reddish brown, friable to very firm, sandy loam to clay loam; partly with a humic topsoil and/or a sodic subsoil (undifferentiated LUvisols; with verto-luvic PHAEZOZEMS)

Up	UPLAND/HIGH-LEVEL PLAIN TRANSITIONAL LANDS (gently undulating; altitude 5000-7000 ft)		
UpB	Soils developed on basic igneous rocks (basalts, etc.)		
Up1	complex of moderately well drained to imperfectly drained, moderately deep to very deep, very dark grey to dark greyish brown, firm to very firm, clay loam to clay; in places cracking (verto-eutric PLANOSOLS and chromic VERTISOLS)	Up7	UpN ⁺ we imperfectly drained, deep, dark greyish brown to dark grey, very firm, sandy clay to clay, abruptly underlying a topsoil of friable loam (eutric PLANOSOLS)
UpB ⁺	as in UpB, but with volcanic ash admixture	UpU	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
Up2	association of: - imperfectly drained, deep, very dark greyish brown to very dark grey, very firm clay, abruptly underlying a topsoil of friable silty clay loam; on straight to convex slopes (eutric PLANOSOLS) - imperfectly drained, deep, very dark greyish brown to very dark grey, very firm, cracking clay; in places sodic; on flat interfluves (chromic VERTISOLS)	Up8	association of: - well drained, deep to very deep, dark reddish brown, friable to firm, sandy clay loam to sandy clay, with a calcareous deeper subsoil; on upper, convex slopes (chromic LUvisols) - imperfectly drained, deep to very deep, dark grey to black, firm to very firm, clay, abruptly underlying a topsoil of friable sandy clay loam; on lower, straight slopes (eutric PLANOSOLS)
UpY ⁺	Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture	P	PLAINS
Up3	association of: - poorly drained, deep, very dark grey, very firm, cracking clay, in many places abruptly underlying a topsoil of friable loam; on flat parts (eutric PLANOSOLS; with chromic VERTISOLS) - well drained, moderately deep, dark reddish brown, firm clay loam, with a humic topsoil, on slopes (chromo-luvic PHAEOZEMS)	Pn	NON-DISSECTED EROSIONAL PLAINS
UpF	Soils developed on gneisses rich in ferromagnesian minerals	PnB	Soils developed on basic igneous rocks (basalts, etc.)
Up4	complex of well drained to imperfectly drained, shallow to very deep, dark red to black, friable to firm, cracking clay; in places sodic (pellic VERTISOLS; with verto-eutric NITISOLS, verto-eutric PLANOSOLS and orthic SOLONETZ, partly lithic phase)	Pn1	well drained, very deep, dark reddish brown to dusky red, friable clay; in places bouldery (nito-rhodic FERRALSOLS)
UpN	Soils developed on biotite gneisses	Pn2	well drained, shallow, very dark reddish brown, friable, slightly calcareous, stony and bouldery, clay loam to clay (chromic CAMBISOLS, lithic and bouldery phase)
Up5	association of: - imperfectly drained, moderately deep to deep, dark brown to dark grey, firm, sandy clay to clay; on convex to straight slopes (verto-eutric PLANOSOLS) - imperfectly drained, very deep, very dark greyish brown to black, firm to very firm, cracking clay, with a calcareous and sodic deeper subsoil; on concave slopes (pellic VERTISOLS, sodic phase)	Pn3	imperfectly drained, deep, very dark greyish brown to dark grey or black, very firm, moderately calcareous, moderately to strongly sodic, cracking clay (pellic to chromic VERTISOLS, sodic phase)
UpN ⁺	as in UpN, but with volcanic ash admixture	Pn4	as in PnB, but with volcanic ash admixture
Up6	imperfectly drained, deep, very dark greyish brown to black, firm clay, with a sodic deeper subsoil (verto-luvic PHAEOZEMS, sodic phase)	Pn5	imperfectly drained, deep, very dark greyish brown to black, very firm, cracking clay, with a calcareous deeper subsoil; in places saline and sodic (pellic VERTISOLS, partly saline-sodic phase)
(o)		Pn6	imperfectly drained, deep, dark brown to dark grey, firm, sandy clay to clay (verto-eutric PLANOSOLS)
		Pn7	Soils developed on granites, with volcanic ash admixture
		PnGP	imperfectly drained, deep, dark greyish brown, mottled, very firm, gravelly clay loam to clay, abruptly underlying a thick topsoil of friable loam (eutric PLANOSOLS)
		PnGPws	Soils developed on granites, but with influence of volcanic ash predominant
			imperfectly drained, moderately deep, very dark greyish brown, very firm, slightly sodic, gravelly clay, abruptly underlying a topsoil of friable loam (solodic PLANOSOLS)

	PnF	Soils developed on Basement System rocks rich in ferromagnesian minerals		PnUP	Soils developed on undifferentiated Basement System rocks, but with influence of volcanic ash predominant
Pn8	PnFr	well drained, deep to very deep, dusky red to dark red, friable sandy clay (rhodic FERRALSOLS)	Pn20	PnUPlv (ao)	moderately well drained, very deep, dark reddish brown to dark brown, firm, strongly calcareous, slightly saline and moderately sodic, cracking clay (vertic LUVISOLS, saline-sodic phase)
Pn9	PnFlc+ho	well drained, moderately deep, dark reddish brown, firm, slightly calcareous, sandy clay loam (chromic LUVISOLS and ortho-luvic PHAEOZEMS)	Pn21	PnUPhv (ao)	imperfectly drained, very deep, very dark greyish brown, brown, very firm, moderately calcareous, slightly saline and moderately sodic, cracking clay (verto-luvic PHAEOZEMS, saline-sodic phase)
Pn10	PnN+wv (o)	Soils developed on biotite gneisses, with volcanic ash admixture imperfectly drained, deep, brown to dark grey, firm clay, with a calcareous and sodic deeper subsoil (verto-eutric PLANOSOLS, sodic phase)	PnX		Soils developed on various rocks (Kavirondian sediments, often mudstones)
Pn11	PnN+mv	imperfectly drained, deep, very dark grey to very dark greyish brown, very firm clay, with a topsoil of friable clay loam (verto-orthic GREYZEMS)	Pn22	PnXsl	imperfectly drained, very deep, very dark brown to black, firm, moderately sodic clay (luvo-orthic SOLONETZ)
PnU		Soils developed on undifferentiated Basement System rocks (predominantly gneisses)	Pn23	PnXwe+ws	imperfectly drained to poorly drained, deep, dark grey, firm clay, abruptly underlying a topsoil of friable silt loam; in many places with a sodic deeper subsoil (eutric and solodic PLANOSOLS)
Pn12	PnUfr+fo	well drained, deep to very deep, dark red to strong brown, friable, sandy clay to clay (rhodic and orthic FERRALSOLS)	Pn24	PnXwe+ir	complex of: - poorly drained, deep, dark grey, mottled, firm clay, abruptly underlying a topsoil of friable silt loam (eutric PLANOSOLS) - moderately well drained to imperfectly drained, shallow to moderately deep, dark brown to dark greyish brown, friable gravelly clay loam, over petroplinthite; in many places with a humic topsoil (IRONSTONE SOILS*; with haplic PHAEOZEMS, petroferric phase)
Pn13	PnUlft+lc	well drained, moderately deep to deep, dark red to strong brown, friable to firm, sandy clay loam to clay (ferric and chromic LUVISOLS)		PnL	Soils developed on crystalline or Plio-Pleistocene sedimentary limestones and gypsiferous rocks (Wajir-El Wak beds)
Pn14	PnUlo (ao)	moderately well drained to imperfectly drained, moderately deep, dark brown to dark reddish brown, very firm, moderately calcareous, slightly saline, slightly to moderately sodic, clay loam to sandy clay, with a topsoil of strongly sealing, sandy loam to sandy clay loam (orthic LUVISOLS, saline-sodic phase)	Pn25	PnLbc	well drained, moderately deep, dark reddish brown, friable clay (chromic CAMBISOLS)
Pn15	PnUvp (o)	imperfectly drained, deep, black to very dark grey, very firm, slightly to moderately sodic, cracking clay (pellic VERTISOLS, sodic phase)	Pn26	PnLlk (K)	imperfectly drained, shallow to moderately deep, strong brown to pale brown, firm, strongly calcareous, sandy loam to loam, over petrocalcic material; in many places stony (calcareous LUVISOLS, petrocalcic phase)
PnU+		as in PnU, but with volcanic ash admixture	Pn27	PnLi	imperfectly drained, shallow, pale brown, firm, moderately calcareous, stony loam, over petrocalcic or petrogypsic material (LITHOSOLS; with calcic CAMBISOLS, petrocalcic phase)
Pn16	PnU+lft+ln	well drained, moderately deep to very deep, dusky red to dark brown, friable to firm, sandy clay loam to clay (ferric and nito-chromic LUVISOLS)		PnT	Soils developed on Permian-Triassic shales (Lower Maji-ya-Chumvi beds and Taru carbonaceous shales)
Pn17	PnU+lv+vc	well drained to imperfectly drained, deep to very deep, dark reddish brown to very dark greyish brown, friable to firm, slightly calcareous clay; in many places cracking (vertic LUVISOLS and chromic VERTISOLS)	Pn28	PnTvp (ao)	imperfectly drained, very deep, very dark grey to black, very firm, strongly calcareous; moderately saline and sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)
Pn18	PnU+hv (ao)	moderately well drained, deep, yellowish red, firm, slightly calcareous, slightly saline, moderately sodic, cracking clay, with a thick humic topsoil (verto-luvic PHAEOZEMS, saline-sodic phase)			
Pn19	PnU+sl (a)	imperfectly drained, moderately deep, dark brown, extremely firm, moderately calcareous, slightly saline, moderately sodic, clay loam to sandy clay, with a topsoil of strongly sealing sandy loam (luvo-orthic SOLONETZ, saline phase)			

Pn29	PnThv (o)	imperfectly drained, moderately deep to deep, dark greyish brown, very firm, cracking, fine sandy clay to clay; with a strongly calcareous and moderately sodic deeper subsoil (verticluvic PHAEZOZEMS, sodic phase)	PdU	Soils developed on undifferentiated Basement System rocks (predominantly gneisses)
PnKT		Soils developed on Triassic siltstones and shales (Lower Maji-ya-Chumvi beds)	Pd3	well drained, shallow, dark red to yellowish red, friable to firm, stony loamy sand to clay (chromic CAMBISOLS, paralithic and stony phase; with ferralic ARENOSOLS, lithic phase)
Pn30	PnKTbe (p)	well drained, shallow, dark reddish brown to very dark brown, firm, fine sandy clay loam to clay; slightly dissected plain (eutric CAMBISOLS, lithic phase; with LITHOSOLS)	Pd4	complex of well drained, shallow to moderately deep, dark red to yellowish brown, non to moderately calcareous, friable to firm, stony sandy clay loam, over petrocalcic material or quartz gravel (calcic CAMBISOLS, lithic or petrocalcic phase; with chromic LUvisols)
PnK		Soils developed on Triassic fine sandstones and siltstones (Mariakani sandstone)	PdW	Soils developed on Jurassic marly limestones, gypsumiferous shales and sandy limestones (Shangalla and Asaharbito beds of Mandera)
Pn31	PnKlo (o)	well drained, very deep, brown, friable to firm, sandy clay loam to clay, with a sodic deeper subsoil; in places with a very thick topsoil of loamy sand to sandy loam; slightly dissected plain (orthic LUvisols, sodic phase)	Pd5	well drained, deep, pale brown to yellowish brown, firm, strongly calcareous and gypsumiferous, stony loam (gypsic XEROSOLS, stony phase)
PnS		Soils developed on Carboniferous-Permian gritty sandstones (Taru grits)	PdX	Soils developed on undifferentiated sedimentary rocks
Pn32	PnSlc	well drained, deep, red, firm, sandy clay loam to clay (chromic LUvisols)	Pd6	complex of well drained, shallow, dark reddish brown to strong brown, non to moderately calcareous, firm, stony and gravelly loam to sandy clay loam, partly over petrocalcic material (chromic CAMBISOLS to orthic LUvisols, lithic or paralithic phase; with calcic CAMBISOLS, petrocalcic phase)
Pn33	PnSlo	well drained, deep, strong brown to dark brown, firm, sandy clay loam to clay, with a topsoil of loamy sand to sandy loam (orthic LUvisols; with orthic ACRISOLS)	Ps	SEDIMENTARY PLAINS (mainly from sheetwash)
Pn34	PnSql	well drained, deep, yellowish red to reddish brown, friable, loamy coarse sand to sandy clay loam (luvic ARENOSOLS; with orthic LUvisols)	Psh	HIGHER-LEVEL SEDIMENTARY PLAIN ("RED SAND" PLAIN)
Pn35	PnSi (gm)	well drained, shallow, dark brown, friable gravelly sandy clay loam, with a gravel surface (LITHOSOLS, gravel-mantle phase)	PshU	Soils developed on sheetwash and aeolian deposits from undifferentiated Basement System rocks (predominantly gneisses)
Pd		DISSECTED EROSIONAL PLAINS	Ps1	well drained, very deep, dark red to dusky red, loose loamy sand to very friable sandy loam (ferralic ARENOSOLS)
PdV		Soils developed on various volcanic rocks	Ps2	well drained, deep to very deep, dark red to dusky red, friable, sandy loam to sandy clay loam (ferralo-chromic LUvisols; with ferralic ARENOSOLS)
Pd1	PdVhr (p)	well drained, shallow, dark reddish brown to dark brown, friable to firm, sandy clay loam to clay loam; in places rocky (chromo-luvic PHAEZOZEMS, lithic phase; with Rock Outcrops)	Ps3	as in Ps2, but predominantly more acid (ferralo-chromic* ACRISOLS; with ferralic ARENOSOLS and ferric LUvisols)
PdN		Soils developed on biotite gneisses	Ps3 + Ps15	complex of soils of units Ps3 and Ps15
Pd2	PdNhv (p)	well drained to moderately well drained, shallow, dark brown to black, very firm, gravelly and stony clay (verticluvic PHAEZOZEMS, lithic and stony phase)	PshK	Soils developed on sheetwash and aeolian deposits from fine sandstones, siltstones and sandy limestones
			Ps4	well drained, deep, red, friable, loamy fine sand to fine sandy loam (cambic ARENOSOLS)

Ps5	PshKwst+sl	imperfectly drained, very deep, red to reddish brown, firm, slightly calcareous, moderately saline and moderately sodic sandy clay, abruptly underlying a topsoil of loamy sand (solodic PLANOSOLS and luvo-orthic SOLONETZ, saline phase)		PsmS	Soils developed on sheetwash deposits from gritty sandstones
	PshS	Soils developed on sheetwash deposits mainly from gritty sandstones		Ps14	PsmSlk (k) "SEALING LOAM" PLAIN
Ps6	PshSlo	well drained, very deep, dark brown to reddish brown, friable, sandy clay loam to sandy clay (orthic LUVISOLS)		PsmO	Soils developed on Plio-Pleistocene bay sediments (Marafa beds)
	Psm	MIDDLE-LEVEL SEDIMENTARY PLAINS "ENCLOSED" PLAIN		Ps15	imperfectly drained, moderately deep, brown, extremely firm, moderately calcareous, moderately sodic clay loam, with a topsoil of sealing sandy loam (luvo-orthic SOLONETZ)
	PsmF	Soils developed on sheetwash deposits from Basement System rocks rich in ferromagnesian minerals		Ps16	imperfectly drained to poorly drained, deep, greyish brown, extremely firm, slightly calcareous, moderately saline, moderately sodic, cracking clay, with a very thin topsoil ¹⁾ of sandy clay loam (gleiyic SOLONETZ, saline phase)
Ps7	PsmFlc	well drained, very deep, dark reddish brown to dark red, friable to firm, sandy clay; in places moderately calcareous; on sheetwash and lacustrine sediments (chromic LUVISOLS; with calcic LUVISOLS)		Ps17	poorly drained, deep, dark grey, firm, moderately calcareous, slightly sodic clay, with a soft surface (calcaric GLEYSOILS, sodic phase)
Ps8	PsmFlf	well drained, deep to very deep, red to dark red, friable firm, sandy clay to clay, over pisocalcic material; on sheetwash and fluvialite sediments (ferric LUVISOLS)		Ps18	poorly drained, deep, black to very dark grey, firm to very firm, calcareous, sodic, cracking clay (pellic VERTISOLS, sodic phase)
	PsmU	Soils developed on sheetwash deposits mainly from undifferentiated Basement System rocks (predominantly gneisses)		Ps19	complex of: - imperfectly drained, moderately deep, brown, extremely firm, moderately calcareous, moderately sodic clay loam, with a topsoil of sealing sandy loam (luvo-orthic SOLONETZ) - imperfectly drained to poorly drained, deep, greyish brown, extremely firm, slightly calcareous, moderately saline, moderately sodic, cracking clay (gleiyic SOLONETZ, saline phase)
Ps9	PsmUxh (ao)	well drained, very deep, brown to dark reddish brown, friable, slightly calcareous, sandy loam to clay loam, with a saline and sodic deeper subsoil (haplic XEROSOLS, saline-sodic phase)			Soils developed on sheetwash deposits from Plio-Pleistocene bay sediments (Marafa beds)
Ps10	PsmUsl (a)	imperfectly drained, very deep, dark reddish brown to reddish brown, very firm, moderately calcareous, slightly saline and very strongly sodic, sandy clay loam to clay with a topsoil of loamy sand to sandy loam (luvo-orthic SOLONETZ, saline phase)		Ps20	imperfectly drained, deep, brown, extremely firm, slightly calcareous, slightly sodic clay loam, abruptly underlying a thick topsoil of sealing sandy loam (solodic PLANOSOLS)
	PsmX	Soils developed on sheetwash deposits mainly from undifferentiated Basement System rocks, with admixture of sediments from olivine basalts and possibly old lacustrine deposits		Psi	LOWER-LEVEL SEDIMENTARY PLAIN ("GREY CLAY" PLAIN)
Ps11	PsmXso (a)	imperfectly drained to poorly drained, deep, brown, extremely firm, moderately calcareous, slightly saline and excessively sodic, sandy clay loam to clay (orthic SOLONETZ, saline phase)		PsiV	Soils developed on sediments mainly from various volcanic rocks
Ps12	PsmXzo	poorly drained, deep, dark reddish brown, firm, moderately calcareous, moderately saline clay, with a crusted and puffed surface (orthic SOLONCHAKS)		Ps1Vso	moderately well drained to imperfectly drained, very deep, dark brown, firm, strongly calcareous, non to slightly saline and strongly sodic, sandy clay (orthic SOLONETZ)
Ps13		This unit has been deleted			
Ps11 + D1	PsmXso+Dqk	complex of soils of units Ps11 and D1			

¹⁾ generally less than 5 cm.

PsIO	Soils developed on remodelled Plio-Pleistocene bay sediments (Marafa beds)	Pv	VOLCANIC PLAINS
Ps22	PsiOxh	PvB	Soils developed on alluvium from early Pleistocene volcanic rocks (mainly olivine basalts)
	moderately well drained, very deep, greyish brown to reddish brown, firm, slightly calcareous, clay loam to clay, non to slightly saline and/or sodic till about 100 cm (haplic XEROSOLS, partly saline and/or sodic phase)	Pv1	well drained, extremely deep, dusky red to dark reddish brown, friable clay (eutric NITISOLS)
Ps23	PsiOsl (a)	Pv2	well drained, very deep, dark red, friable, stony and bouldery clay (chromic LUvisols, bouldery phase)
	imperfectly drained, deep, brown, very firm, moderately calcareous, moderately saline, moderately sodic clay loam, with a thin topsoil of strongly sealing sandy clay loam (luvo-orthic SOLONETZ, saline phase)	Pv3	well drained, deep, dark red, friable, strongly calcareous, moderately sodic clay loam, with a stone surface (calcareic XEROSOLS, stone-mantle and sodic phase)
Ps24	PsiOso (a)	Pv4	imperfectly drained, deep, dark reddish brown to dark greyish brown, firm, strongly calcareous, moderately saline, strongly sodic clay (orthic SOLONCHAKS, sodic phase)
Ps25	PsiOvp (ao)	Pv5	poorly drained, deep, dark grey to black, very firm, slightly calcareous, moderately saline, moderately sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)
	Soils developed on sediments from various sources	PvP	Soils developed on ashes and other pyroclastic rocks of Recent volcanoes
Ps26	PsiAqc	Pv6	excessively drained to well drained, very deep, dark greyish brown to olive grey, stratified, calcareous, loose fine sand to very friable fine sandy loam or silt (ando-calcaric REGOSOLS)
Ps27	PsiAxk (ao)	Pv7	somewhat excessively drained, very deep, strong brown to dark yellowish brown, very friable and smeary, slightly sodic, gravelly sandy clay loam, with a humic topsoil (mollic ANDOSOLS, sodic phase)
Psx	SEDIMENTARY PLAINS OF UNDIFFERENTIATED LEVELS	Pv8	well drained, deep to very deep, dark reddish brown to dark brown, friable, slightly gravelly loam to clay loam, with a humic topsoil (mollic ANDOSOLS)
PsxE	Soils developed on cover sands	Pv9	well drained, moderately deep to deep, brown to dark brown, very friable, loam to sandy clay loam (vitric ANDOSOLS)
Ps28	PsxElk (o)	Pv10	imperfectly drained, very deep, yellowish brown to olive grey, friable, slightly saline, slightly sodic, sandy loam to silt loam, with a brittle and strongly sodic deeper subsoil (gleytic SOLONETZ, saline and fragipan phase)
Ps28+D1	PsxElk+Dqk	Pv11	imperfectly drained, moderately deep to deep, very dark greyish brown to dark yellowish brown, firm to very firm, slightly sodic, silty clay loam to clay, abruptly underlying a thick topsoil of friable, silt loam to clay loam (solodic PLANOSOLS)
	Soils developed on sediments from marl deposits (Asaharbito beds)	Pv12	poorly drained, deep, black, very firm clay, abruptly underlying a topsoil of friable loam; with a calcareous deeper subsoil (eutric PLANOSOLS)
Ps29	PsxWxy (a)		

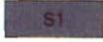
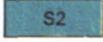
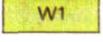
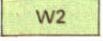
Pc	COASTAL PLAINS	Pcr	REEF COASTAL PLAIN
Pch	HIGHER-LEVEL COASTAL PLAIN	PcrL	Soils developed on raised-coral-reef limestone, with admixture of lagoonal deposits
PchJ	Soils developed on lagoonal deposits (Kilindini sands)	Pc8	well drained, deep, dark red to reddish brown, friable, sandy clay loam to sandy clay, with a topsoil of loamy sand (rhodic FERRALSOLS)
Pc1	PchJqa+qf excessively drained to well drained, very deep, reddish yellow to white, loose, sand to loamy sand (albic and ferralic ARENOSOLS; with orthic FERRALSOLS)	PcrLfr	
Pc2	PchJws imperfectly drained, very deep, brown, very firm, sandy loam to sandy clay loam, abruptly underlying a thick topsoil of friable loamy sand and with a slightly to moderately sodic deeper subsoil; with inclusions of many small bottomlands of unit B15 (solodic PLANOSOLS)	Pc9	well drained, shallow, dark brown to dark reddish brown, friable, rocky, sandy clay loam to sandy clay (LITHOSOLS; with ferralic CAMBISOLS, lithic phase)
Pc3	PchJsl+lv (a) imperfectly drained, deep to very deep, very dark greyish brown to olive brown, mottled, firm to very firm, sandy clay to clay; moderately calcareous and moderately saline and sodic throughout or in deeper subsoil (luvo-orthic SOLONETZ, saline phase and vertic LUVISOLS, saline-sodic phase)	Pc10	imperfectly drained, deep, greyish brown, mottled, firm, slightly calcareous, non to slightly saline, slightly sodic sandy clay loam, abruptly underlying a thick topsoil of friable loamy sand (solodic PLANOSOLS)
Pcl	LOWER-LEVEL COASTAL PLAIN	PI	LACUSTRINE PLAINS
PclJ	Soils developed on lagoonal deposits (Kilindini sands)	PIV	Soils developed on sediments from pyroclastic rocks and olivine basalts
Pc4	PclJlg/a (o) moderately well drained, very deep, yellowish brown to greyish brown, mottled, very firm, sandy loam to sandy clay loam, with a very thick (60-100 cm) topsoil of light brownish grey to yellow, friable loamy sand; with inclusions of many small bottomlands of unit B16 (gleytic to albic LUVISOLS, sodic phase; with ferralo-chromic LUVISOLS, dystric or solodic PLANOSOLS and cambic ARENOSOLS)	PI1	imperfectly drained, deep, dark brown, friable to firm, moderately calcareous, strongly saline, gravelly clay loam, with a fine gravel surface; upper level of Chalbi (undifferentiated SOLONCHAKS, gravel-mantle phase)
Pc5	PclJsg (a) imperfectly drained to poorly drained, very deep, grey to brown, mottled, very firm clay; slightly calcareous and strongly saline and sodic throughout or in deeper subsoil (gleytic SOLONETZ, saline phase; with gleytic or verto-luvic PHAEZEMS, saline-sodic phase)	PI2	Soils developed on sediments from limestone
Pc6	PclJC complex of very deep soils of varying drainage condition, colour, consistence, texture and salinity (albic ARENOSOLS, orthic FERRALSOLS, gleytic LUVISOLS, solodic PLANOSOLS, pellic VERTISOLS)	PI3	imperfectly drained, shallow, greyish brown, friable, excessively calcareous, fine sandy clay loam, over petrocalcic material; middle level of Chalbi (LITHOSOLS; with calcic XEROSOLS, petrocalcic phase)
PclJ	Soils developed on aeolian deposits (reworked lagoonal deposits)	PI4	Soils developed on sediments from various sources
Pc7	PclJfo well drained, very deep, yellowish red, very friable, fine sandy loam to fine sandy clay loam (orthic FERRALSOLS)	PI5	poorly drained, very deep, dark greyish brown, friable to firm, moderately calcareous, moderately saline, strongly sodic, loam to clay loam, in places gypsiciferous; with common low sand dunes; lower level of Chalbi (undifferentiated SOLONCHAKS, sodic phase)
		PIAzt	poorly drained, deep, dark brown, very firm, excessively saline, cracking clay; lower level of Chalbi (takyric SOLONCHAKS)
		PIAz0	very poorly drained, deep, greyish brown, firm, excessively saline clay, with a crusted and puffed, saline surface; lower level of Chalbi (orthic SOLONCHAKS)
		PIX	Soils developed on sediments from volcanic ashes and other sources

PI6	PIXvc (o)	imperfectly drained to poorly drained, very deep, dark grey to dark greyish brown, very firm, slightly calcareous, non to slightly saline, moderately sodic, cracking clay; upper level of Lambwe valley chromic VERTISOLS, sodic phase)	Pt1	PtUlk (k)	well drained, deep, dark reddish brown to reddish brown, friable, sandy clay loam to sandy clay, over pisocalcic material (calcid LUVISOLS, pisocalcic phase; with chromic LUVISOLS, and pellic to chromic VERTISOLS, saline-sodic phase)
PI7	PIXs (a)	imperfectly drained to poorly drained, very deep, dark greyish brown to dark brown, firm to very firm, slightly to moderately calcareous, slightly to moderately saline, moderately to strongly sodic, silt loam to clay; in many places, with a humic topsoil; Subrecent lake edges of the Central Rift Valley (undifferentiated SOLONETZ, saline phase)	Pt2	PtUbe	well drained to moderately well drained, deep, dark brown, friable to firm, slightly calcareous, clay loam to clay (eutric CAMBISOLS)
PI8	PIXzg (o)	poorly drained, very deep, black to very dark olive grey, mottled, very firm, strongly calcareous, strongly saline, strongly sodic clay; lower level of Amboseli (gleiyic SOLONCHAKS, sodic phase)	Pt3	PtLqk	Soils developed on sediments mainly from limestones and marls well drained, very deep, dark red, friable, strongly calcareous, loamy sand to sandy loam; in places clayey (calcaro-cambic ARENOSOLS; with calcic XEROSOLS)
PI9	PIXsm (a)	very poorly drained, very deep, very dark grey, very firm, slightly to moderately calcareous, gypseriferous, slightly saline, strongly sodic clay, with a humic topsoil; lower level of Lambwe valley (mollic SOLONETZ, saline phase)	PtO		Soils developed on sediments mainly from Plio-Pleistocene bay deposits moderately well drained to imperfectly drained, very deep, dark reddish brown to dark brown, firm, moderately calcareous, moderately saline, moderately to strongly sodic, cracking clay (orthic SOLONETZ, saline phase)
PI10	PIXzo+so (k)	complex of moderately well drained to imperfectly drained, shallow to deep, strongly calcareous, strongly saline and strongly sodic soils of varying colour, consistence and texture; over pisocalcic or petrocalcic material; higher level of Amboseli (orthic SOLONCHAKS and orthic SOLONETZ, petrocalcic phase)	Pt4	PtOso (a)	
PIP		Soils developed on sediments mainly from volcanic ashes	Pf		SEDIMENTARY PLAINS OF LARGE ALLUVIAL FANS
PI11	PIPh+bg	complex of: - well drained, moderately deep to deep, dark brown, friable and slightly smearable, fine gravelly, sandy clay loam to sandy clay, with a humic topsoil (ando-haplic PHAEZOEMS) - imperfectly drained, moderately deep to deep, strong brown, mottled, firm and brittle, sandy clay to clay (Gamblian lake of the Central Rift Valley), (gleiyic CAMBISOLS, fragipan phase)	Pf1		OLDER FANS
PID		Soils developed on sediments from lacustrine mudstones	Pf1U		Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)
PI12	PIDvp (o)	poorly drained, very deep, very dark grey to black, very firm, slightly sodic, cracking clay, with a calcareous deeper subsoil; lower level of Kano plains (pellic VERTISOLS, sodic phase)	Pf1U1		well drained, very deep, dark red to dark brown, firm, sandy clay loam to clay (undifferentiated LUVISOLS)
PI13	PIDvc (o)	poorly drained, shallow to deep, very dark brown to very dark grey, firm to very firm, slightly sodic, cracking clay; upper level of Kano plains (chromic VERTISOLS, sodic and partly lithic phase)	Pf2	Pf1Oxk (ao)	Soils developed on sediments mainly derived from bay deposits well drained, very deep, reddish brown, friable to firm, slightly to moderately calcareous, sandy clay to clay, with a saline and sodic deeper subsoil; basin lands (calcic XEROSOLS, saline-sodic phase)
Pt		SEDIMENTARY PLAINS OF UPPER RIVER TERRACES	Pf3	Pf1Osl (a)	complex of well drained to imperfectly drained, very deep, reddish brown to grey, firm clay soils of varying calcareousness, salinity and sodicity, in many places with a strongly sealing topsoil; with inclusions of well drained, very deep, brown, loose loamy sand; levee complex (luvo-orthic SOLONETZ, saline phase; with solodic PLANOSOLS, saline phase, chromic VERTISOLS, saline-sodic phase and cambic ARENOSOLS)
PtU		Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)	Pf2		YOUNGER FANS
			Pf4	Pf2Oso (a)	Soils developed on sediments mainly derived from bay deposits moderately well drained, very deep, dark reddish brown to dark brown, firm, moderately calcareous, moderately to strongly saline, strongly sodic, sandy clay to clay; levee complex (orthic SOLONETZ, saline phase; with orthic SOLONCHAKS, sodic phase)

Pf5	Pf2Ovc (ao)	imperfectly drained, very deep, dark reddish brown to dark greyish brown, firm, moderately calcareous, moderately to strongly saline, strongly sodic, cracking clay; basin lands (chromic VERTISOLS, saline-sodic phase)	AO	Soils developed on sediments mainly from bay deposits (older floodplains)
A	FLOODPLAINS		A7	imperfectly drained, very deep, dark grey, very firm, slightly calcareous, cracking clay, with a slightly to moderately saline and sodic deeper subsoil (vertic* GLEYSOLES, saline-sodic phase)
AB	Soils developed on sediments from basic igneous rocks (basalts, etc.)		AA	Soils developed on sediments from various sources (recent floodplains)
A1	ABjc (ao)	imperfectly drained, very deep, dark brown to dark reddish brown, firm, moderately to strongly calcareous, stratified clay loam to clay, with varying salinity and sodicity in the deeper subsoil (calcaric FLUVISOLS, saline-sodic phase)	A8	well drained to imperfectly drained, very deep, dark brown to yellowish brown, stratified, micaceous, strongly calcareous, predominantly loamy soils (calcaric FLUVISOLS)
AP	Soils developed on sediments mainly from volcanic ashes		A9	as in AAjc, but slightly to moderately saline (calcaric FLUVISOLS, saline phase)
A2	APje	well drained to moderately well drained, very deep, dark greyish brown to yellowish brown, friable, stratified, silty clay loam to clay; in places slightly to moderately saline and slightly to moderately sodic (eutric FLUVISOLS, partly saline-sodic phase)	A10	moderately well drained, shallow to moderately deep, dark brown, friable, strongly calcareous, sandy clay to clay loam, over petrocalcic material (calcareous CAMBISOLS, petrocalcic phase)
AV	Soils developed on sediments from various volcanic and pyroclastic rocks		A11	imperfectly drained, very deep, dark brown, firm, strongly calcareous, moderately saline, strongly sodic clay, with a topsoil of sandy clay loam (calcareous LUVISOLS, saline-sodic phase)
A3	AVjc (o)	well drained, very deep, very dark greyish brown to dark yellowish brown, friable, stratified, micaceous, moderately to strongly calcareous, non to slightly saline, moderately sodic, loam to clay (calcaric FLUVISOLS, sodic phase)	A12	imperfectly drained to poorly drained, very deep, dark reddish brown to dark greyish brown, firm to very firm, cracking clay; in many places mottled and with a calcareous, saline and sodic deeper subsoil (chromic VERTISOLS, saline-sodic phase)
A4	AVz	poorly drained, very deep, greyish brown to light olive brown, friable, strongly calcareous, strongly saline, slightly to moderately sodic, silt loam to clay (undifferentiated SOLONCHAKS; with FLUVISOLS, saline-sodic phase)	A13	poorly drained, very deep, very dark grey, very firm, moderately calcareous, slightly saline, slightly to moderately sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)
AU	Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)		A14	poorly drained, deep, dark greyish brown, mottled, firm clay, with an acid humic topsoil (humic GLEYSOLES)
A5	AUje	well drained to imperfectly drained, very deep, brown to dark brown, friable, micaceous, slightly calcareous, sandy loam to clay loam; in places with a saline-sodic deeper subsoil (eutric FLUVISOLS)	A15	poorly drained, deep, very dark grey, mottled, firm clay, with a humic topsoil and a sulfidic deeper subsoil (mollic GLEYSOLES)
AL	Soils developed on sediments mainly from limestones and marls		A16	very poorly drained, deep, dark grey, soft (unripe), strongly saline, strongly sulfidic, clay (thionic FLUVISOLS, saline phase)
A6	ALjc+tg	association of: - well drained, very deep, dark reddish brown to dark brown, stratified, micaceous, strongly calcareous soils; on Recent deposits (calcaric FLUVISOLS) - imperfectly drained to poorly drained, very deep, brown, mottled, firm, strongly calcareous, strongly saline, strongly sodic, sandy clay loam to silty clay; on Subrecent deposits (gleycic SOLONCHAKS, sodic phase)	A17	association of: - well drained, very deep, dark reddish brown to dark brown, friable to firm, calcareous, sandy clay loam, with a saline and sodic deeper subsoil; on higher parts (calcareous LUVISOLS, saline-sodic phase) - imperfectly drained, very deep, very dark grey, firm, moderately calcareous, moderately saline, moderately to strongly sodic, cracking clay; on lower parts (pellic VERTISOLS, saline-sodic phase)
			A18	complex of well drained to imperfectly drained, very deep, dark greyish brown to dark reddish brown, stratified soils of varying consistence and texture (eutric FLUVISOLS)

	AAjc+vc (ao)	complex of soils of units A8 and A12		BUwd	complex of imperfectly drained to poorly drained, very deep, very dark grey to brown, mottled, friable to firm, sandy clay to clay, often abruptly underlying a topsoil of friable, sandy clay loam; in places saline and sodic (dystric PLANOSOLS; with pellic VERTISOLS, vertic* and humic GLEYSOLES and plinthic ACRISOLS)
BOTTOMLANDS					
	BP	Soils developed on infill from volcanic ashes		BUgd	complex of imperfectly drained to very poorly drained, very deep, very dark grey to dark greyish brown, mottled, firm clay; in places peaty or with an acid humic topsoil (dystric GLEYSOLES; with eutric PLANOSOLS and some dystric HISTOSOLS)
	BPh	imperfectly drained to poorly drained, moderately deep, dark greyish brown, mottled, very firm clay loam, abruptly underlying a topsoil of acid humic friable loam (humic PLANOSOLS)			
	BI	Soils developed on infill from intermediate igneous rocks (phonolites)		BL	Soils developed on infill from limestones
	BIm	poorly drained, moderately deep, dark grey to grey, mottled, firm clay, with a humic topsoil; in many places over petroplinthite (mollic GLEYSOLES, partly petroferric phase)		BLzt	imperfectly drained to poorly drained, deep, very firm, greyish brown to dark reddish brown, strongly calcareous, strongly saline, cracking clay loam (takyric SOLONCHAKS)
	BV	Soils developed in infill from undifferentiated volcanic rocks		BLch	poorly drained, deep, very dark grey to very dark brown, firm, moderately calcareous, clay loam to clay, with a humic topsoil (haplic CHERNOZEMS)
	BVv (ao)	imperfectly drained, very deep, dark brown to dark grey, firm, slightly to moderately saline, moderately sodic, cracking clay; in many places calcareous (chromic and pellic VERTISOLS, saline-sodic phase)		BS	Soils developed on infill from gritty sandstones (Taru grits)
	BVvtz	imperfectly drained, deep, dark brown to olive grey, firm to very firm, clay soils of varying calcareousness, salinity and sodicity; in many places cracking (VERTISOLS and SOLONCHAKS, undifferentiated)		BSsl (a)	imperfectly drained to poorly drained, very deep, dark brown to dark grey, firm to very firm, sodic clay, with a calcareous and saline deeper subsoil (luvo-orthic SOLONETZ, saline phase)
	BVwe	poorly drained, deep, grey to light olive brown, mottled, firm clay, abruptly underlying a thick topsoil of silt loam (eutric PLANOSOLS)		BJ	Soils developed on infill from lagoonal deposits (Kilindini sands)
	BVck (o)	poorly drained, deep, very dark greyish brown, firm, moderately to strongly calcareous, slightly sodic clay, with a humic topsoil (calcic CHERNOZEMS, sodic phase)		BJhg	imperfectly drained to poorly drained, very deep, light brownish grey to brown, mottled, firm to very firm, clay; in places sodic and cracking; higher-level depressions (gleytic PHAEZOZEMS; with verto-luvic PHAEZOZEMS and pellic VERTISOLS, sodic phase)
	BU	Soils developed on infill mainly from undifferentiated Basement System rocks (predominantly gneisses)		BJwh	poorly drained, very deep, greyish brown, mottled, very firm clay, abruptly underlying a topsoil of friable, humic sandy clay loam; lower-level depressions (humic PLANOSOLS)
	BUvc (ao)	imperfectly drained, very deep, dark grey to dark brown, very firm, slightly to moderately calcareous, moderately sodic clay, with a saline deeper subsoil (chromic VERTISOLS, saline-sodic phase)		D	MISCELLANEOUS LAND TYPES
	BUso	imperfectly drained to poorly drained, very deep, brown to dark brown, very firm, slightly calcareous, strongly sodic clay (orthic SOLONETZ)		Dqk	DUNES
	BUvp	poorly drained, very deep, dark greyish brown to black, very firm, slightly calcareous, cracking clay; in many places with a saline and sodic deeper subsoil (pellic VERTISOLS, partly saline-sodic phase; with eutric or vertic* GLEYSOLES)		Dqc	excessively drained, very deep, brown to pale brown, loose, moderately calcareous, loamy sand to sandy loam (calcareo-cambic ARENOSOLS)
				Dbk (a)	excessively drained, very deep, brown to pale brown, loose, sand to loamy sand (cambic ARENOSOLS)
				Dqk+P1Az	well drained, very deep, dark brown, friable or brittle, strongly calcareous, moderately saline sandy clay loam, with fragipans at various depths (calcic CAMBISOLS, saline and fragipan phase)
					complex of soils of units D1 and P13

La-S-T-V-W-Z

	La	LAVA FLOWS		Z	COASTAL OR LAKE-SIDE BEACH RIDGES
 La		excessively drained, exceedingly bouldery to stony, extremely rocky land (Boulders and Rock Outcrops)		Z1	Soils developed on older coastal beach ridges
	S	SWAMPS		Z1fr	well drained, very deep, red, very friable, sandy clay loam (rhodic FERRALSOLS)
 S1 (o)		poorly drained to very poorly drained, very deep, dark greyish brown to dark olive grey, firm to very firm, strongly calcareous, strongly saline, strongly sodic clay; in many places with fragipans at various depths (gleiyic SOLONCHAKS, sodic phase and partly fragipan phase)		Z2	Soils developed on younger coastal beach ridges often covering coral rock
 S2	Sgh	very poorly drained, very deep, very dark grey to black, firm, cracking clay, with an acid humic topsoil; seasonal swamps (humic GLEYSOLES)		Z2ai (o)	moderately well drained, very deep, dark brown to reddish brown, firm to very firm, often moderately sodic, sandy clay loam, underlying a thick topsoil of friable loamy sand; in places shallow over coral rock (ferralo-chromic*/orthic ACRISOLS, sodic phase; with solodic PLANOSOLS)
 S3	Sgh+od	very poorly drained, very deep, dark grey to black, firm clay, with an acid humic topsoil; in many places peaty; permanent swamps (humic GLEYSOLES and dystric HISTOSOLS)		Z3	Soils developed on lake-side beach ridges
	T	MANGROVE SWAMPS		Z3z	imperfectly drained, very deep, dark brown to greyish brown, friable, sandy loam to sandy clay of varying salinity and sodicity; with inclusions of loose sand to loamy sand (undifferentiated SOLONCHAKS; with undifferentiated ARENOSOLS)
 Tjt+zg		very poorly drained, very deep, olive to greenish grey, soft (unripe), excessively saline, moderately to strongly sodic, loam to clay; in many places with sulfidic material (thionic FLUVISOLS, saline phase and gleiyic SOLONCHAKS)			
	V	MINOR VALLEYS			
 V1	VC1	complex of well drained to poorly drained, deep, dark reddish brown to black, firm, silty clay to clay; in places calcareous and/or cracking			
 V2	VC2	complex of well drained to imperfectly drained, shallow to moderately deep, dark reddish brown to very dark greyish brown, firm, slightly to moderately calcareous, rocky stony, or gravelly clay			
	W	BADLANDS			
	WO	Badlands developed on Plio-Pleistocene bay sediments (Marafa beds)			
 W1	WOs	excessively drained, brown, very firm, strongly sodic, gravelly clay loam to sandy clay of varying depth; strongly eroding and strongly sealed (undifferentiated SOLONETZ)			
	WX	Badlands developed on various older lacustrine and volcanic rocks			
 W2	WXs	excessively drained, reddish brown, firm, strongly calcareous, slightly to moderately saline, strongly sodic, silt loam to clay loam of varying depth; strongly eroding and in many places with a gravel or stone surface (undifferentiated SOLONETZ; with calcic XEROSOLS, LITHOSOLS, etc.; stone-mantle phase)			

1.7 References and other relevant publications

1.7.1 References

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1.7.2 Maps and reports included in appendix 4 (information base)

A. Maps and reports published by Kenya Soil Survey

(a) Reconnaissance soil surveys

Code	Reference	Map scale
R1	R.F. van de Weg and J.P. Mbuvi (eds.), 1976, Soils of the <i>Kindaruma</i> area (quarter degree sheet 136)	1:100,000
R2	H.F. Gelens, H.C. Kinyanjui and R.F. van de Weg (ed.), 1976, Soils of the <i>Kapenguria</i> area (quarter degree sheet 75)	1:100,000
R3	D.O. Michieka, B.J.A. van der Pouw and J.J. Vleeshouwer, 1978, Soils of the <i>Kwale-Mombasa-Lunga lunga</i> area (quarter degree sheets 200, 201, 202)	1:100,000
R4	W.G. Wielemaker and W.H. Boxem, 1982, Soils of the <i>Kisii</i> area (quarter degree sheet 130)	1:100,000
R5	F.N. Muchena and C.R.K. Njoroge, in prep., Soils of the <i>Makueni</i> area (quarter degree sheet 163)	1:100,000
R6	L. Touber, 1982, Soils and vegetation of the <i>Amboseli-Kibwezi</i> area (quarter degree sheets 173, 174, 181, 182)	1:250,000
R7	W. van Wijngaarden, 1982 Soils and vegetation of the <i>Tsavo</i> area (quarter degree sheets 175, 176, 183, 184 (Mtito Andei sheet) and 190, 191, 196, 197 (Voi sheet))	1:250,000
R8	D.O. Michieka and J.R. Rachilo, in prep., Soils of the <i>Busia</i> area (quarter degree sheet 101)	1:100,000
R9a	F.N. Muchena and B.J.A. van der Pouw (eds.), 1981, Soils of the proposed <i>Bura East Irrigation Settlement Scheme</i>	1:100,000

(b)	Semi-detailed soil surveys		
S1*	J. Thorp et al., 1960, Soil survey of the <i>Songhor</i> area. Govt. Printer, Nairobi	1: 50,000	
S2*	F.T. Miller et al., 1961, Soil survey of the <i>East Konyango</i> area. Govt. Printer, Nairobi.	1: 50,000	
S4	J.M. Kibe, O.O. Oswago and K.L. Sogomo, 1981, Semi-detailed soil survey of a part of <i>Muhoroni</i> area	1: 50,000	
(c)	Detailed soil surveys		
D2	F.N. Muchena and G. Ngari, 1975, Soils of the proposed <i>Wamumu</i> Extension of Mwea Irrigation Settlement Scheme	1: 10,000	
D3	E.N.K. Mugai, H. Bonarius and P.N. Njoroge, 1976, Detailed soil survey of the proposed extension of <i>Kimala</i> Irrigation Scheme (Taita-Taveta District)	1: 5,000	
D4	H. Bonarius and E.N.K. Mugai, 1977, Detailed soil survey of the <i>Jara-Jara</i> Irrigation Scheme (Mbalambala)	1: 2,500	
D5	E.N.K. Mugai and H. Bonarius, 1977, Detailed soil Survey of the <i>Kainuk I</i> Irrigation Scheme (Turkwel river)	1: 5,000	
D6	P.J.K. Kanake and E.N.K. Mugai, 1977, Detailed soil survey of the <i>Mnazini</i> Irrigation Scheme (Lower Tana area)	1: 2,500	
D7	W. Siderius and R.M. Muriuki, 1977, Detailed soil survey of the Seeds Testing Station, <i>Lanet</i> (Nakuru)	1: 5,000	
D8	P.J.K. Kanake and E.N.K. Mugai, 1977, Detailed soil survey of the <i>Wema</i> and <i>Hewani</i> Irrigation Schemes (Lower Tana)	1: 5,000	
D9	E.N.K. Mugai, 1977, Detailed soil survey of the <i>Malka Daka</i> Irrigation Scheme (Ewaso Nyiro)	1: 5,000	
D10	O.O. Oswago, 1979, Detailed soil survey of <i>Kibirigwi</i> Irrigation Scheme	1: 10,000	
D12	E.N.K. Mugai and B.J.A. van der Pouw, 1978, Detailed soil survey of an experimental site for the <i>Bura</i> Irrigation Settlement Project	1: 5,000	
D14	H.C.K. Kinyanjui, 1980, Detailed soil survey of <i>Tatton Farm</i> , Egerton College (Njoro)	1: 12,500	
D15	W.N. Wamicha, D.N. Mungai and M.M. Gatahi, 1980, Detailed soil survey of the Beef Research Station <i>Lanet</i> (Nakuru)	1: 5,000	
D17	P.J.K. Kanake, 1981, Detailed soil survey of the <i>Oda</i> Irrigation Scheme	1: 5,000	
D18	P.J.K. Kanake, 1981, Detailed soil survey of the <i>Ngao</i> Irrigation Scheme	1: 5,000	
(d)	Site evaluations		
P2	R.F. van de Weg, 1972, Report of a site evaluation trip to <i>Lake Kenyatta</i> Cotton Scheme (Lamu District)		
P3	H.M.H. Braun and S.M. Wokabi, 1973, Irrigation suitability of the <i>Olkeramatian</i> experimental area	1: 50,000	
P4	H.F. Gelens and G. Ngari, 1973, Report of a site evaluation of the proposed location of <i>Alupe</i> sub-station	1: 12,500	
P5	N.N. Nyandat, 1973, A reconnaissance survey of arable land in the area <i>East of Meru</i> town	1: 50,000	
P6	H.M.H. Braun and N.N. Nyandat, 1972, Report of a visit to the experiment area of the <i>Ishiarra</i> Irrigation Scheme		
P7	W.G. Sombroek, J.J. Vleeshouwer and S.M. Wokabi, 1973, Report of a site evaluation of Irrigation suitability of the soils and waters of the <i>Merti</i> area (Isiolo District)	1: 50,000	
P8	H.F. Gelens and G. Ngari, 1973, Report of a site evaluation for a proposed irrigation project at <i>Kunati</i> (Meru District)		1: 55,000
P10	W.G. Sombroek, H.M.H. Braun and J.M. Kibe, 1973, A preliminary evaluation of the irrigation suitability of the soils in the <i>Mandera-Ramu</i> area (North Eastern Province)		1: 55,000
P11	H.M.H. Braun and H.W. Okwaro, 1974, Drainage problems of soils in the <i>Bomet</i> area		1:100,000
P12	J.J. Vleeshouwer and J.P. Mbuvu, 1974, A preliminary evaluation of the irrigation suitability of the soils and the waters of <i>Katilo</i> irrigation Scheme With a photo-interpretation map of the middle <i>Turkwel</i> valley		1: 20,000 1:100,000
P14	W.G. Sombroek, J.P. Mbuvu, J.M. Kibe and H.W. Okwaro, 1974, A preliminary evaluation of the irrigation suitability of the lands in the <i>middle-lower Tana Valley</i>		1:100,000
P15	W.G. Sombroek, J.P. Mbuvu and H.W. Okwaro, 1973, A preliminary evaluation of the irrigation suitability of the lands in the <i>pre-delta Tana floodplain</i>		1: 50,000
P17	J.J. Vleeshouwer and D.O. Michieka, 1975, Irrigation suitability of the soils and waters of the floodplain of the <i>Kerio</i> river NE of <i>Lokori</i> (Turkana District)		1: 40,000
P18	J.P. Mbuvu, 1975, A preliminary evaluation on the suitability of the area of <i>Busia</i> District for sugarcane development		1:100,000
P19	J.P. Mbuvu and R.F. van de Weg, 1974, A preliminary evaluation of the soils around <i>Nyangoma Mission</i> (Bondo Division)		1: 50,000
P20	H. Bonarius and P.N. Njoroge, 1974, A preliminary evaluation of the irrigation suitability of lands in the <i>Kanjoo</i> area (Meru District)		1: 25,000
P21	W.G. Sombroek, J.P. Mbuvu and R.A. Leyder, 1975, Preliminary evaluation of soil conditions on the East bank of the lower Tana (<i>Bura East area</i>) for large scale irrigation development (with addendum by B.J.A. van der Pouw)		1:150,000
P23	S.M. Wokabi, W.G. Sombroek and J.P. Mbuvu, 1975, Evaluation of <i>Tana delta</i> soils for large scale irrigation development		1:100,000
P24	W. Siderius, 1978, Soils resources of the <i>Upper Kerio Valley</i> - a preliminary investigation		1:100,000
P25	J.P. Mbuvu and R.F. van de Weg, 1975, Some preliminary notes on the soils of <i>Katumani</i> , <i>Kampi ya Mawe</i> , <i>Embu</i> and <i>Murinduko</i> Agricultural Research Stations		1: 10,000 1: 3,750 1: 3,000
P26	W. Siderius and E.B. Njeru, 1976, Soil conditions in the <i>Muthangene Location</i> (Meru District)		1: 25,000
P27	F.N. Muchena, 1976, Soil resources of <i>Maseno</i> Division (Kisumu District); a preliminary investigation		1:100,000
P28	W. Siderius and E.B. Njeru, 1976, Soils of <i>Trans-Nzoia</i> District		1:100,000
P29	J.P. Mbuvu and E.B. Njeru, 1977, Soil resources of the <i>Mau Narok</i> area (Narok District); a preliminary assessment		1:100,000
P30	R.F. van de Weg and W.G. Sombroek, 1976, Soil conditions of the <i>Marafa-Magarini</i> area (Kilifi District); a preliminary assessment		1:100,000
P31	B.J.A. van der Pouw, J.M. Kibe and C.R.K. Njoroge, 1977, Soil conditions of the <i>Mitunguu-Materi</i> area (Meru District)		1: 50,000
P32	R.F. van de Weg, R. Muriuki and E. Kinyanjui, 1976, Soil conditions at three proposed sites for the <i>Kenya Inspection Service for Seeds</i> , <i>Lanet</i> (Nakuru)		1: 12,500
P33	W. Siderius, 1977, Soil conditions in the <i>Kimalewa</i> area (Bungoma District)		1: 25,000
P34	J.R. Rachilo, 1978, Soil conditions of the <i>Kinangop Plateau</i>		1:100,000

*) Note: carried out by NAL/USAID personnel prior to the existence of the Kenya Soil Survey as such

P35	F.N. Muchena and C.R.K. Njoroge, 1977, The soil resources of <i>Kiteta</i> Location (Machakos District); a preliminary investigation	1: 50,000	Dg	J. Makin and V. D'Costa, 1967, The soils of Mwea extension Karaba. Govt. Report	1: 12,500
P36	D.O. Michieka, 1977, Soils of the Valley bottoms of the <i>Kabete Veterinary Labs.</i> , Nairobi; a preliminary assessment for irrigation suitability	1: 10,000	Di	N.N. Nyandat, 1968, The soils of the <i>Wamumu</i> cotton scheme (Kirinyaga district). Govt. Report	1: 6,250
P37	D.O. Michieka and W. Siderius, 1978, The soil and land suitability for irrigation of three sites in the Upper Tana catchment area (<i>Kunati</i> , <i>Ishiara</i> and <i>Rupingazi</i> - Eastern Province)	1: 50,000 1: 10,000 1: 40,000	DI	N.N. Nyandat, 1969, The development of arable settlement scheme on soils bordering Lake Mkunguya and Mapenya (Lamu District) and stretching to the east. Govt. Report	1: 12,500
P38	B.J.A. van der Pouw (ed.), 1978, Soil conditions of the <i>Kinna-Rapsu</i> area (Isiolo/Meru Districts)	1: 50,000	Do	N.N. Nyandat and O.O. Oswago, 1970, The soils of Turbo afforestation scheme. Govt. Report	1: 12,500
B. Maps and reports by other agencies			Dq	O.O. Oswago, 1970, Soils of Kaputir Agricultural Development Scheme, Turkana District. Govt. Report	1: 5,000
(a) Reconnaissance soil surveys	R.M. Scott et al, 1963, Soils of the <i>Nairobi/Thika/Yatta/Machakos</i> area. Govt. Printer, Nairobi	1:100,000	Dr	D.O. Michieka and O.O. Oswago, 1970, Soils of Mwea Tebere Cotton Research Station. Govt. Report	1: 2,500
	L. Touber, 1978, Soil map of Athi-Kapiti plains. Ministry of Tourism and Wildlife, FAO/KEN/71/526	1:250,000	Ds	O.O. Oswago, 1971, Soils of Tigoni Potato Research Station. Govt. Report	1: 2,500
Rc	USAID, 1978, Kenya marginal/semi-arid lands pre-investment inventory. Vol. 10, part I, <i>Machakos-Kitui-Embu</i> area, Min. of Agric., Nairobi	1:250,000	Du	D.O. Michieka, 1971, Soils of the <i>Wamumu</i> extension - Mwea. Govt. Report	1: 10,000
Rd	Do., part II, <i>Baringo-Kerio valley</i> area	1:250,000	Dw	O.O. Oswago, 1972, Soils of Gituamba Experimental Farm. Govt. Report	1: 5,000
(b) Semi-detailed soil surveys	F.W. Collier, 1962, The soils of the Ewaso Ng'iro catchment area in relation to potential irrigation development. Appendix to: Min. of Works, 1963, An investigation into the water resources of the Ewaso Ng'iro basin, Kenya. Hydr. Branch Rep. No. 4 and 5	1: 50,000	Dy	Technisucr - IRAT, 1976, N'zoia sugar project, morpho-pedological survey (nucleus estate). Govt. Report	1: 12,000
Sa	J. Makin and N.N. Nyandat, 1965, A reconnaissance investigation of the agricultural potential of the Lambwe valley. Govt. Report	1: 50,000	Dad	A.P. Oosterom, 1975, A detailed soil survey of the irrigation trial plot in Kirindo valley, South Nyanza. Prel. Rep. No. 10, Agric. Univ., Wageningen	1: 1,000
Sb	J. Makin and V. D'Costa, 1966, The soils of the country around Mumias. Govt. Report	1: 12,500	Dae	H.v.d. Ham and D. Noordam, 1976, A detailed soil survey of the Mbita area. Prel. Report No. 11, Agric. Univ., Wageningen	1: 12,500
Sg	G.A. Woodruff, 1967, Reconnaissance soil map of Sotik area	1: 30,000	Daf	A.P. Oosterom, 1976, A detailed soil survey of Sena and Ukula, Mfangano Island. Prel. Report No. 12, Agric. Univ., Wageningen	1: 12,500
Sh	FAO, 1968, Survey of the Irrigation potential of the Lower Tana River Basin, Kenya. Vol. I, general; Vols. III and IIIA, Soils and Vegetation. FAO, Rome	1: 50,000	Dag	T. Duijkers - v.d. Linden and N. Duijkers, 1976, Detailed soil survey of the Ntimaru - Angata Baragoy area. Prel. Report No. 26, Agric. Univ., Wageningen	1: 12,500
Si	V. D'Costa and S.H. Ominde, 1973, Soil and land use survey of the Kano plain, Nyanza Province. Occ. Memoir No. 2, Dept. of Geogr., Univ. of Nairobi	1: 50,000	Dah	E. O'Herne, 1978, Detailed soil survey of the Homa Hills Agricultural Training Centre. Prel. Rep. No. 28, Agric. Univ., Wageningen	1: 2,500
Sk	Norconsult A.S. and Hunting Technical Services Ltd., 1978, Turkwel Gorge Multipurpose Project, soils investigation. Min. of Water Dev., Nairobi	1: 20,000	Dai	L. Bouwman, 1979, Detailed soil survey of Loyapat area, Turkana District, MSc. thesis, Agric. Univ., Wageningen	1: 2,000
Sl	G.P. McGowan and Associates Pty. Ltd., 1978, Magarini Land Settlement Project. Annex 5, Land inventory and capability. Min. of Lands & Settlement and Min. of Water Dev., Nairobi	1: 28,571			
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(c) Detailed soil surveys	J. Makin and N.N. Nyandat, 1964, A detailed soil investigation of Kamleza North, Taveta. Govt. Report	1: 2,500			
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 60 South Horr area, 1963
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- 74 Loperot area, 1966
82 Nothern Turkana, 1969
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85 Loiya-Lorugumu area, 1970
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2. THE AGRO-CLIMATIC ZONE MAP OF KENYA

2.1 Introduction

The purpose of an agro-climatic zone map is to provide a tool for assessing which areas are climatically suitable for various land use alternatives, with particular emphasis on the suitability for crops or crop varieties.

The major aspects of climate that affect plant growth are the balance between rainfall and evaporation, and temperature. With regard to rainfall, the length and intensity of the rainy and dry seasons and their variation from year to year are of particular importance.

In Kenya, because the average annual rainfall ranges from 250 to 2500 mm, the average potential evaporation ranges from less than 1200 mm to 2500 mm, the average annual temperature ranges from less than 10° to 30° and there are many different rainfall distribution types, any attempt to produce a simple agro-climatic classification into 10 or 20 zones is beset with problems. But for effective nationwide planning such a simple zoning system is nevertheless essential. It is hoped that the agroclimatic zoning system presented here fulfills this requirement.

The Kenya Soil Survey zonation methodology outlined below is a follow-up to the system introduced by Pratt, Greenway and Gwynne (1966) which has also been published in the Kenya Atlas (S.o.K, 1970). With some modifications and additions this KSS methodology has been in use since 1973.

The agro-climatic zone map (appendix 2) has been published at a scale of 1:1,000,000 to be used in conjunction with the exploratory soil map (appendix 1) which has been published at the same scale.

2.2 Terminology

Different terms have been used by various authors to designate essentially the same kind of zone. The term "ecological zone" (Pratt, Greenway and Gwynne, 1966) seems the most widely used, but eco-climatic (Pratt and Gwynne, 1977), agro-climatic (this report) and agro-ecological (FAO, 1978; Jätzold and Schmidt, in prep.) are also used. The rationale for the use of the term "ecological" is that site conditions other than climate, particularly soil moisture storage, have been incorporated in the map.

Because our map (appendix 2) is purely climatic and is to be used in conjunction with the soil map (appendix 1), we prefer the term "agro-climatic" to the term "ecological" which we used at the Kenya Soil Survey prior to the preparation of the 1:1 million map. Though the climatic classification has mainly been done with agricultural interpretation in mind, the map can also be used for climatic assessments of forestry, wildlife, tourism, or any other land use. For this reason "bio-climatic" might be a more apt term to describe the map.

2.3 Historical Review

The relation between climate, vegetation and agricultural potential in Kenya has long been recognized (Edwards, 1940, 1956). The essence of the first maps of ecological zones was that the natural vegetation was interpreted in terms of site potential for agriculture. The map of ecological zones at a scale of 1:3 million compiled by Pratt, Greenway and Gwynne (1966) was basically a derived vegetation map, though climatic indices were also given for each zone. The major purpose of that map was to indicate the potential use of the land for domestic livestock. With some modifications the same map was reproduced as a map of ecological potential in the third edition of the National Atlas of Kenya (S.o.K, 1970) for more general purposes of agricultural planning. The legend of the map is headed "climatic zones" and in an accompanying table the term

"eco-climatic zone" appears. In a later publication, the same map at a scale of 1:5 million appears under the title "Ecology of Kenya", with "eco-climatic zones" in the accompanying legend and "climatic zones", "ecological zones" and "eco-climatic zones" in other tables (map 1 and tables 6-8 in Pratt and Gwynne, 1977).

Though the method of calculating the moisture index is not given in any of the above publications, which all refer to Thornthwaite (1948), it should be noted that Thornthwaite changed his method of calculation and his classification a few years after his original publication (Thornthwaite and Hare, 1955; Thornthwaite and Mather, 1955; Thornthwaite's associates, 1962). It has been shown (Braun, 1977d) that in many cases the boundaries of the ecological maps discussed above do not correspond with the moisture indices given in the legend. These maps, particularly the one in the National Atlas, have been widely used for all kinds of planning purposes.

Woodhead (1970a) used the average index of available water, based on the monthly balance between average rainfall and evaporation, as a guide to site potential. His map at a scale of 1:3 million is accurate but has not been used very much. Woodhead's index is difficult to calculate and it has been argued it is no better than our simpler r/Eo ratio (Braun 1977d).

A major disadvantage of the National Atlas and the Woodhead maps is that they are at a scale of 1:3,000,000 which is really too small for regional or even for national planning purposes.

Since 1973 the Kenya Soil Survey has used the ratio of average annual rainfall to evaporation when delimiting the ecological/agro-climatic zones for the 1:100,000 reconnaissance soil surveys (e.g. van de Weg and Mbuvu, 1975; Gelens et al, 1976). The same methodology, with some modifications, has been used to delimit the moisture availability zones of the 1:1 million agro-climatic zone map. The same method had been already considered by Moreau in 1938.

A disadvantage of the methodology is that the annual ratio takes no account of the seasonal distribution of rainfall and its variations. These aspects have been studied for the reconnaissance survey areas and shown in tables, maps and separate publications (van de Weg and Mbuvu, op. cit, Gelens et al, op. cit., Michieka et al. 1978; Braun 1977a, 1977b, 1977c).

Jätzold (1977) mapped moisture and temperature zones at a scale of 1:1 million for parts of Kenya, Uganda and Tanzania. The moisture zones, which he based on the number of humid months, consist of 10 major types each divided into 4 sub types; the temperature zones have 5 major types and each is divided into 2 sub types. The system and its use have been further described by Jätzold (1979).

The FAO Agro-ecological zones project (FAO, 1978) calculates the length of the rainy and growing seasons on the basis of average monthly rainfall and potential evapotranspiration (PET), assuming 100 mm soil moisture storage. The rainy and growing season are assumed to start when the rainfall exceeds 0.5 PET. The date is determined from the intersection of the rainfall and 0.5 PET graphs. The end of the rainy season is the date when the 0.5 PET line drops below the rainfall line. The period between the start and end of the rainy season during which the rainfall exceeds PET is called humid. The amount of excess rainfall during this humid period which enters and is stored in the soil determines how long the growing season will extend beyond the end of the rainy season, but the maximum soil moisture storage is assumed to be 100 mm. The maps have been published at a scale of 1:40 million, which is of little use to agricultural planning in Kenya. More recently, the same methodology has been applied to climatic data from individual years, using periods of three days (FAO, in prep.) and periods of five days (Jätzold and Schmidt, in prep.) instead of monthly data. The resulting maps are at scales 1:1 million or larger. As is further explained in section 2.7 these studies and their maps will provide important additional information for the assessment of potential agricultural production.

2.4 Methodology

The agro-climatic zoning system has two components:

- A) the moisture availability zones
- B) the temperature zones

The moisture availability zones are based on the ratio of the measured average annual rainfall and the calculated average annual evaporation. These zones are indicated by the Roman numerals I to VII (see table A of appendix 2).

The temperature zones are based on the calculated average annual temperature, which is the mean of the average maximum and minimum temperatures. These zones are indicated by Arabic numerals 1 to 9 (see table B of appendix 2).

Each unit of the agro-climatic zone map (appendix 2) has a code consisting of a combination of a Roman and Arabic numeral VII2, V4 etc.)

In sections 2.5 and 2.6 further details on the methodology are given separately for the moisture availability and temperature zones.

2.5 Moisture availability zones

2.5.1 Data base

Most of the rainfall data were obtained from the published records in the serial publication "Summary of rainfall in Kenya for the year" (EAMD 1974a and earlier) for the years 1937, 1939, 1944-1946, 1948, 1950-1952, 1954, 1956-1961, 1963-1972. All these record books are available at the Kenya Soil Survey. The issue concerning the year 1972 was published in 1974; the 1973 issue was published in 1981, after our agro-climatic map had been completed.

A list was compiled showing, for each rainfall station, the issue of the published records in which its last rainfall averages appear and the period on which these averages were based. Thus, for example station 90.36000 last appeared in the 1972 issue with an average over a 45 year period station 90.36004 last appeared in the 1964 issue with an average over a 43 year period station 90.36005 last appeared in the 1954 issue with an average over a 12 year period station 90.36006 last appeared in the 1939 issue with an average over a 18 year period station 90.36006 last appeared in the 1939 issue with an average over a 18 year period station 90.36009 last appeared in the 1937 issue with an average over a 16 year period There were approximately 1500 stations whose data in the record books covered two or more years.

For the Tsavo area, rainfall data were available from some 20 stations, whose records dated from 1972. Since these records only covered a few years, the long-term average rainfall was estimated by comparing them with records from nearby stations that have a long period of recording. The locations of the rainfall stations used for the compilation of the moisture availability map are given in appendix 4.

The average annual potential evaporation (Eo) was calculated for all areas except a 100 km wide strip along the coast, using Woodhead's (1968) altitude equation. For the latter area a modified equation that takes account of the nearness of the sea was developed (Braun, in prep.). The basic equations relating Eo to the altitude in feet or metres are:

$$\begin{aligned} Eo \text{ (in mm)} &= 2422 - 0.109 h \text{ (feet)} \\ &= 2422 - 0.358 h \text{ (metres)} \end{aligned}$$

For areas within 100 km of the Indian Ocean, the following equations relating Eo to altitude in feet or metres and distance in kilometres from the coast were used:

$$\begin{aligned} Eo \text{ (in mm)} &= 2175 - 0.109 h \text{ (feet)} + 2.47 d \text{ (km)} \\ &= 2175 - 0.358 h \text{ (metres)} + 2.47 d \text{ (km)} \end{aligned}$$

Example: Kwale, 400 m altitude, 18 km from coast; Eo = 2175 - 143 + 44 = 2076 mm

2.5.2 Boundary criteria

For the reconnaissance soil survey of the Kindaruma (van de Weg and Mbuvi, 1975) and the Kapenguria areas (Gelens et al, 1976) the agro-climatic boundaries were mainly chosen on the basis of vegetation differences in accordance with the approach adopted by Pratt, Greenway and Gwynne (1966) and the Kenya Atlas (S.o.K, 1970). In these surveys the transitions of ecozones II to III, III to IV and IV to V roughly corresponded to the r/Eo ratios of 67%, 52% and 37% (or 0.67, 0.52 and 0.37) respectively.

In the Kwale (Michieka et al, 1978), Makueni (Muchena and Njoroge, in prep.) and Busia (Michieka et al, in prep.) survey areas, it proved difficult to use the vegetation to delimit agro-climatic zones. However, in these survey areas, sufficient climatic data were available for the agro-climatic zonation to be based mainly on climatic data, using r/Eo ratios of 37%, 52% and 67% to delimit the zones. The vegetation was used as an aid in the drawing of boundaries in only a few cases.

Because the object of the agro-climatic zonation is in the first instance to provide broad zones of climatic land potential, it was decided to use round figures for the moisture availability (= rainfall divided by evaporation) zones. The boundary criteria for the moisture availability zones are given in column 2 of table A of appendix 2, and in table 4.

Table 4: Boundary criteria for the moisture availability zones and their climatic designation

Zone	r/Eo ratio	r/Eo ratio in %	climatic designation
I	> 0.8	> 80	humid
II	0.65 - 0.80	65 - 80	sub-humid
III	0.50 - 0.65	50 - 65	semi-humid
IV	0.40 - 0.50	40 - 50	semi-humid to semi-arid
V	0.25 - 0.40	25 - 40	semi-arid
VI	0.15 - 0.25	15 - 25	arid
VII	< 0.15	< 15	very arid

r = average annual rainfall

Eo = average annual potential evaporation

From zone I with a moisture availability ratio (r/Eo) of more than 80% (or 0.8) to zone VII with a ratio of less than 15% (0.15), the average annual amount of available moisture decreases from over 80% to less than 15% of the annual potential evaporation. If it is assumed that the potential evapotranspiration is 0.8 of the potential evaporation, then the values of 80% and 15% can be expressed as an average of $\frac{80}{0.8} = 100\%$ and $\frac{15}{0.8} = 20\%$ of full moisture days during the year, i.e. an average of 365 days and 70 days, respectively.

It should be realized that averages of 365 days and 70 days imply that in 50% of the years (generally even more) the number of days with sufficient moisture for plant growth is less than 365 and 70 respectively.

Table 5: Moisture range of crops, types of animal production and types of forestry species

The diagram illustrates the moisture range suitable for various crops across seven zones (I-VII) based on the r/E_o ratio. The x-axis represents the moisture range, and the y-axis lists the crops. Arrows indicate the range of each crop. The legend provides information on types of animal production and forestry species.

zone	r/E_o ratio (%)	moisture range suitable for various crops	types of animal production	types of forestry species
I	> 80	rice, tea, sugarcane, banana, cocoyam, Irish potatoes, pyrethrum, citrus, tobacco, coconut, wattle, pineapple, coffee, barley, finger millet, sweet potato, simsim, cashew, cotton, beans, wheat, sunflower, cowpea, groundnut, mango, pawpaw, sisal, grams, castor (perennial), sorghum, cassava, maize, pigeon pea, bulrush millet		
II	65 - 80		dairying	coniferous species
III	50 - 65		ranching	various Eucalyptus species
IV	40 - 50		nomadic pastoralism	various Acacia species
V	25 - 40			Prosopis sp.
VI	15 - 25			
VII	≤ 15			

Legend:

- types of animal production:**
 - Dairying (top arrow)
 - Ranching (middle arrow)
 - Nomadic pastoralism (bottom arrow)
- types of forestry species:**
 - Coniferous species (top arrow)
 - Various Eucalyptus species (middle arrow)
 - Various Acacia species (bottom arrow)

2.5.3 Map compilation and accuracy

The available rainfall evaporation ratios were plotted on 1:250,000 topographic base maps. The boundaries on these maps (which are available for consultation in the KSS data storage) were drawn by interpolation. In areas with few data, particularly the northern part of the country, the boundaries were partly inferred from LANDSAT/ERTS images, or altitude. The boundaries from the 1:250,000 maps were later transferred to the 1:1,000,000 map (appendix 2). The accuracy of the map is highest in those areas for which many rainfall station data (see appendix 4) are available. Notable areas where data are lacking are the hinterland of Lamu, Narok district and the hill areas of the dry northern parts of the country (including the Maralal and Marsabit areas).

2.5.4 Range of crops, types of animal production and forestry

In contrast to the temperature limits to crops (and to plants in general- see section 2.6.4) there are few precise published data on the moisture requirements of specific crops grown in Kenya. The moisture range suitable for various crops as given in table 5 is an assessment based on generalized data from Acland (1971), Purseglove (1968, 1972), Jätzold and Schmidt (in prep.) and the author's estimates based on field observations*. In the table the major growing zones are indicated by solid lines, while sub-optimal moisture conditions (too dry or too wet) are indicated by broken lines; the whole range for each crop is indicated by arrows. It must be stressed that these moisture ranges are only approximations.

In the table no varieties or cultivars have been mentioned. For nearly every crop there are varieties that are more suitable for the wetter or drier conditions.

In table 5, the suitability of various types of animal production for the moisture availability zones is also indicated. In the last column of this table some major types of forestry species are indicated. For purposes of forestry and agro-forestry this part of the table needs to be expanded.

2.5.5 Potential production

The maximum growth rate of a full vegetation cover can be between 200 and 600 kg ha⁻¹ day⁻¹ (FAO, 1978). If such growth rates were maintained for a whole year, then the total net dry matter production would be 70,000 to 220,000 kg ha⁻¹ year⁻¹. Indeed, yields exceeding 70,000 kg ha⁻¹ year⁻¹ have been obtained from sugar cane in Indonesia (de Wit, undated). For crops such as maize and sorghum, the potential net dry matter production for a growth period of 120 days is given as 22,400 kg ha⁻¹ which is an average growth rate of about 200 kg ha⁻¹ day⁻¹ (FAO, op. cit.). Yields will generally be much lower because of agro-climatic, soil and crop management constraints. In section 2.5.2 it was shown that a rough indication of the average annual number of growing days can be obtained by multiplying the rainfall/evaporation ratio by $\frac{365}{80}$. The potential average annual production can be estimated if daily production rates are available or can be estimated.

The daily production rate partly depends on plant factors (e.g. some plants grow faster than others; most annual plants stop growing when they have produced seeds; some plants use water more efficiently than others), partly on soil factors (e.g. availability of rooting space, nutrients, air and water) and partly on climatic factors (e.g. total annual rainfall and its distribution, evaporation, temperature). The plant and soil factors do vary from place to place and can be altered. The climatic conditions generally vary gradually (although rainfall can be very localized) and cannot be altered. For grasslands, yields determined by the author (Braun, 1973) varied from 5 to 80 kg ha⁻¹ day⁻¹, the variation partly depending on the kind of grass cover, partly on the amount and distribution of the rainfall and partly on the fertility of the soil. A downpour of 25 mm in the dry season sometimes

resulted in a growing period of 10 days and a production of 50 kg dry matter per ha. An extended growing season with some 700 mm rainfall on a sod with clover (*Trifolium massaiense*) produced some 12,000 kg of dry matter over a period of 150 days. Based on the author's grassland experiments and judgement, a very rough estimate of the potential daily net dry matter production is given in table 6 for each of the moisture availability zones, together with estimates of the potential annual dry matter production and the major factors limiting production in each zone.

The 5-fold decrease in potential daily dry matter production from zone I to zone VII (see column 5 of table 6) mainly results from the greater irregularity of the rainfall in the drier areas where growth periods are of shorter duration and are more often interrupted by dry periods than in the wetter areas. When permanent wilting has taken place after such an interruption, growth has to start from the beginning. Because growth is exponential, the aggregate dry matter production of for example 3 periods of 20 days is much less than the dry matter production of one period of 60 days. Compare for instance the total dry matter production of 370 kg ha⁻¹ in four dry season growing periods of in total about 50 days (i.e. approximately 7 kg ha⁻¹ day⁻¹) and 2380 kg ha⁻¹ during the first 55 days (i.e. 43 kg ha⁻¹ day⁻¹) of the rainy season, at the same site (Braun, 1973).

The potential production in zone I is in the order of 30,000 kg ha⁻¹ year⁻¹ and in zone VII is less than 1000 kg ha⁻¹ year⁻¹. For these amounts of dry matter production, 450 kg and 15 kg nitrogen respectively are required in these zones per hectare per year. Very few soils contain 450 kg N per hectare, and therefore the shortage of N (and of other nutrients) often reduces yields of crops and grasslands considerably. Fertility is the major constraint to actual production in the moisture availability zones I to III, and water is the major constraint in zones VI and VII. In zones IV and V production is constrained by both water and fertility.

The potential productivity of zone VII has been estimated at an average of less than 1000 kg dry matter per hectare per year. If, however, there is a rainy season with well distributed rainfall of some 350 mm and 100 growth days, then one could expect a production of $100 \times 35 = 3500$ kg ha⁻¹ in that particular season. If these 350 mm are spread over 10 showers of 35 mm, each of which gives 7 days of growth, then this total rainfall may result in $10 \times 7 \times 10 = 700$ kg ha⁻¹.

The production of the moisture availability zones is also given in descriptive terminology in the penultimate column of table A in appendix 2.

2.5.6 Potential carrying capacity

In Section 2.5.5 the potential dry matter production for each zone was estimated assuming that soil conditions are not limiting. Assuming that a stock unit (SU) of 300 kg liveweight has an annual dry matter consumption of 10 times its own weight (2.7% of its liveweight per day), the stock carrying capacity can be calculated if due allowance is made for the average amount of non-consumable dry matter (non-consumable either because of unpalatability or because some vegetation should be left intact to ensure its regrowth). Again, the percentage of consumable dry matter is thought to be very much lower in the drier zones than in the wetter zones.

The author's estimates of dry matter production and the resulting carrying capacities are given in table 7, which indicates that the potential average carrying capacity in zone VII is less than 0.05 SU ha⁻¹ and in zone I exceeds 8 SU ha⁻¹ (i.e. the potential carrying capacity in zone I is more than 100 times that of zone VII). The potential in zones I, II and III is generally not reached because of limitations in soil fertility and husbandry. In zones VI and VII the amount of rainfall is the single major limitation, while in zones IV and V rainfall, husbandry and fertility limit the carrying capacity. As indicated in section 2.5.5 when discussing potential production, it must be re-emphasized here that the carrying capacity can vary tremendously, depending on the soil conditions and the amount and distribution of the rainfall. The averages given in table 7 should therefore be used as a guide only.

*) Note: comments by Dr. P.A. Huxley of ICRAF are gratefully acknowledged.

Table 6: Potential production and major limitations of the moisture availability zones

	r/Eo ratio (%)	r/Et ratio (%)	average number of growing days	potential daily production (kg dm ha ⁻¹)	potential annual production (kg dm ha ⁻¹)	major limitations to maximum production in approximate order of importance
I	> 80	> 100	365	> 80	> 30,000	soil fertility, husbandry, drainage
II	65 - 80	80 - 100	290 - 365	65 - 80	20,000 - 30,000	soil fertility, husbandry, drainage
III	50 - 65	65 - 80	235 - 290	50 - 65	12,000 - 20,000	soil fertility, husbandry, rainfall
IV	40 - 50	50 - 65	180 - 235	40 - 50	7,000 - 12,000	husbandry, rainfall, soil fertility
V	25 - 40	30 - 50	110 - 180	25 - 40	3,000 - 7,000	rainfall, husbandry, soil fertility
VI	15 - 25	20 - 30	75 - 110	15 - 25	1,000 - 3,000	rainfall
VII	< 15	< 20	< 75	< 15	< 1,000	rainfall

Table 7: Carrying capacity estimates of the moisture availability zones

Zone	r/Eo (%)	potential dry matter production kg ha ⁻¹ year ⁻¹	consumable dry matter percentage	consumable dry matter kg ha ⁻¹ year ⁻¹	carrying capacity SU ha ⁻¹	carrying capacity ha SU ⁻¹	major limitations to maximum production in approximate order of importance
I	> 80	>30,000	> 80	> 24,000	> 8	< 0.125	fertility, grassland and stock husbandry, drainage
II	65 - 80	20,000 - 30,000	65 - 80	13,000 - 24,000	4 - 8	0.125 - 0.25	ditto
III	50 - 65	12,000 - 20,000	50 - 65	6,000 - 13,000	2 - 4	0.25 - 0.5	fertility, husbandry, rainfall
IV	40 - 50	7,000 - 12,000	40 - 50	3,000 - 6,000	1 - 2	0.5 - 1	husbandry, rainfall, fertility
V	25 - 40	3,000 - 7,000	25 - 40	750 - 3,000	0.25 - 1	1 - 4	rainfall, husbandry, fertility
VI	15 - 25	1000 - 3000	15 - 25	150 - 750	0.05 - 0.25	4 - 20	rainfall
VII	< 15	< 1000	< 15	< 150	< 0.05	> 20	rainfall

Note: one stock unit has an assumed weight of 300 kg and a dry matter intake of 3000 kg per year.

2.5.7 Relation to the vegetation

In addition to climatic conditions, soil conditions, biological and agronomic conditions greatly affect the vegetation and flora of a particular site. These conditions include the effects of infiltration, run-off, run-on, drainage, groundwater, salinity, fertility, acidity, depth and cracking characteristics of the soil and the effects of grazing, cutting, trampling, burning, planting, fertilization and many others, often interrelated, factors. Because of all these factors it is unlikely that there is a very clear relation between the vegetation and climatic conditions. By carefully comparing the distribution of vegetation types and of plant species with the moisture availability zones, the climatic range of the vegetation types and plant species can be established. However, the results of such a comparison should be viewed with caution because of the other influences mentioned above e.g. a forest may develop because of climatic conditions or because of the presence of adequate groundwater. Similarly, a particular plant species may occur in an atypical location e.g. *Combretum molle* may normally occur in moisture availability zone III, but because of run-on in rocky areas it may also occur in zone IV and even in zone V. These examples demonstrate that extrapolating the vegetation or flora according to climatic conditions is a complex business.

In table A of appendix 2 a very rough approximation of the natural vegetation occurring in each of the moisture availability zones is given.

2.5.8 Relation to seasonal moisture deficits

During the climatic analyses of the various survey areas it was found that in certain regions there was a good relationship between the annual r/Eo ratio and the probability of seasonal moisture deficits (Braun, 1977a). Table 8 gives the relationship between the annual r/Eo ratio and the probability of receiving an amount of rainfall during the single rainy season or both rainy seasons for five different regions in Kenya i.e. (a) Western Kenya, particularly the area Nakuru-Maralal-Lodwar-Busia, (b) Eastern Kenya, particularly the area Nairobi-Nyeri-Embu-Meru-Kitui-Voi, (c) the Northern coastal strip, approximately 10 km wide between Malindi and Kiunga, (d) the Southern coastal strip from Vanga to Msabaha and (e) the coastal Hinterland up to approximately 100 km from the Indian Ocean.

From table 8 it can be observed that there is an enormous variation in the probability of a seasonal moisture deficit, particularly at r/Eo ratios between 25% and 50%: for a r/Eo ratio of 40% the probability that the rainfall in both rainy seasons in Eastern Kenya will be less than 2/3 Eo is 20% (once per five years); for the same ratio in Western Kenya the probability that the rainfall in the rainy season will be less than 2/3 Eo is 65% (twice per three years). Zone IV in North-Western Kenya has the same probability range as zone V in Eastern Kenya, while zone V in North-Western Kenya (Baringo-Laikipia) has the same probability range as zone VI in Eastern Kenya (Voi-Garba Tula). Thus, with regard to crop production, zone V in North-Western Kenya is similar to zone VI in Eastern Kenya. Though no data are available it is thought that zones IV and V of Narok and Kajiado districts are similar to the coastal hinterland. The major reason for these differences is that in Eastern Kenya there is less rainfall outside the rainy seasons than in Northern Kenya. Thus for a given r/Eo ratio there is more rainfall during the rainy seasons in Eastern Kenya than in Northern Kenya and the potential for seasonal crops for zones IV, V and VI in Northern Kenya is less than for the same zones in Eastern Kenya. In zone III the probability of moisture deficits is still higher in Western Kenya but the longer growing season in Western Kenya makes that area more suitable for seasonal crops than Eastern Kenya. A generalization of the data given in table 8 is given as "the risk of failure of an adapted maize crop" in the last column in table A of appendix 2.

Table 8: The relation between the annual r/Eo ratio and the probability that the rainfall in the rainy season or in both rainy seasons (Pr) will be less than 2/3 Eo

Zone	annual r/Eo (%)	Seasonal Pr < 2/3 Eo (in %)					
		Western Kenya	Eastern Kenya	Coast			
				North	South	Hinterland	
I	> 80	0	0	n.a.	n.a.	n.a.	
II	65 - 80	0 - 2	0 - 1	0 - 1	0 - 1	0 - 1	
III	50 - 65	2 - 20	1 - 7	1 - 6	1 - 12	2 - 20	
IV	40 - 50	20 - 65	7 - 20	6 - 15	12 - 30	20 - 35	
V	25 - 40	65 - 90	20 - 70	15 - 50	n.a.	35 - 80	
VI	15 - 25	90 - 97	70 - 92	n.a.	n.a.	80 - 92	
VII	< 15	97 - 100	92 - 100	n.a.	n.a.	92 - 100	

Note: In Western Kenya the rainy season is April - August; in Eastern Kenya and the Coastal Hinterland it is March - May and October - December; on the north and south coasts it is April - June and October - December. For two rainy seasons the given probability is the product of the probabilities of the individual seasons.

2.5.9 Relation to soil moisture regimes (Soil Taxonomy)

Although the Soil Taxonomy classification (Soil Survey Staff, 1975) is not used in this report it may be useful for the reader to be able to relate the r/Eo ratios and the moisture availability zones (appendix 2) of this report to the soil moisture regimes of Soil Taxonomy. From determinations of the soil moisture regime according to the Franklin-Newhall system of computation for 45 stations in Kenya (van Wambeke, pers. comm.) and our calculated rainfall/evaporation ratios of the same stations, the following relationship appears:

Soil moisture regime	r/Eo ratio (in %)	Moisture availability zones
udic	> 55	I, II, part of III
ustic	31 - 55	part of III, IV, part of V
aridic	< 31	part of V, VI, VII

2.5.10 Extent of the moisture availability zones

The extent of the moisture availability zones was determined by means of dot screens. The extent of the zones (rounded off to 10,000 hectares) and each zone's percentage of the total is given in table 9. Table 9 shows that nearly half of Kenya consists of zone VII and that two-thirds of the country consists of zones VI and VII. The agriculturally favourable zones I, II and III constitute some 13% of the total land area with about 7.5 million hectares. It should be realized, however, that parts of these 7.5 million hectares are not suitable for agriculture because of temperature or soil limitations, or for other reasons (e.g. urban use, forest reserves).

Table 9: Extent of the moisture availability zones*

Zone	r/Eo (%)	area per zone	
		in 1000 ha	in %
I			
I	> 80	2540	4.3
II	65 - 80	2380	4.1
III	50 - 65	2570	4.4
IV	40 - 50	2870	4.9
V	25 - 40	8730	15.0
VI	15 - 25	12640	21.7
VII	< 15	26530	45.6
total		58,260	100.0

*for the extent of the moisture availability/temperature zone combinations see table 12.

2.6 Temperature zones

2.6.1 Data base

The average annual temperatures were calculated using the equation relating the temperature in degrees Celsius (centigrade) to altitude (EAMD, 1970) for all areas, except a 100 km wide strip along the coast for which a modified equation was developed (Braun, 1982). The basic equations for the relation between the altitude in feet or metres and the average annual temperatures in degrees Celsius are:

$$\begin{aligned} T \text{ mean (in } ^\circ\text{C)} &= 30.2 - 0.00198 h \text{ (feet)} \\ &= 30.2 - 0.00650 h \text{ (metres)} \end{aligned}$$

For areas within 100 km of the Indian Ocean the following equations relating the temperature to altitude in feet or metres and distance from the coast in kilometres were used:

$$\begin{aligned} T \text{ mean (in } ^\circ\text{C)} &= 26.1 - 0.00198 h \text{ (feet)} + 0.041 d \text{ (km)} \\ &= 26.1 - 0.00650 h \text{ (metres)} + 0.041 d \text{ (km)} \end{aligned}$$

example: Kwale which is at 400 m altitude and 18 km from the coast

$$T \text{ mean } = 26.1 - 2.6 + 0.7 = 24.2^\circ\text{C}$$

The mean maximum and the mean minimum temperatures given in table B of appendix 2 were also calculated using the equations given in EAMD (1970), while the equations for the absolute minimum temperatures were derived from data in the same publication. The general equations, not applicable to the 100 km wide strip along the coast, are given below, together with the temperatures on the coast:

	general	on the coast
T mean max. = 35.5 - 0.00181 h (feet)		29.5
= 35.5 - 0.00594 h (metres)		
T mean min. = 24.8 - 0.00215 h (feet)	22.8	
= 24.8 - 0.00705 h (metres)		
T abs. min. = 16.2 - 0.00200 h (feet)	17.5	
= 16.2 - 0.00656 h (metres)		

From these equations and the coast averages, new equations can be developed for the 100 km wide coastal strip. Recent work on the relationship between altitude and temperature has shown that west of a line running approximately from Loyengalani to Gilgil and Namanga (excluding Narok) the temperatures are higher than east of the line. This is particularly true for altitudes from 3000 to 5000 ft, where a site in Western Kenya is about 2°C warmer than a place in eastern Kenya at the same altitude (Braun, 1982).

2.6.2 Boundary criteria

As in the case of the moisture availability zones, the boundary criteria for the temperature zones were chosen to produce broad zones that could be used for assessing the potential of various crops. Since the average temperature drops by 1°C for each increase in altitude of 500 feet and since most of the topographical maps have their contours in feet, a multiple of 500 ft (or 1°C) is the most convenient interval.

Acland (1971) indicated the altitude range of various crops using 500 ft intervals between 3000 ft and 9500 ft. In order to reduce the number of zones to an acceptable number, the classes we chose are: 0-3000 ft, then 7 classes each of 1000 ft, up to 10,000 ft, and a final class covering all the land above 10,000 ft, (see table 10 or table B of appendix 2).

2.6.3 Map compilation and accuracy

The temperature (altitude) boundaries were plotted as contour lines on 1:500,000 base maps and transferred to the 1:1,000,000 maps, except in the case of areas where there were no contour lines on the 1:500,000 base maps. In the latter case the boundaries were transferred from 1:250,000 topographic maps, all of which have either contour or form lines. When comparing the boundaries of the temperature zones with those of the moisture availability zones it will be seen that in many cases they are different. Good examples are the Mt. Kenya area, where the temperature zones follow the circular contour line pattern while the moisture availability zones do not follow that pattern. In the whole map the temperature boundaries have, where possible, been shifted slightly to coincide with the moisture availability boundaries in order to avoid creating an overcomplicated mapping pattern.

Table 10: Boundary criteria for the temperature zones; their mean annual temperatures and their climatic designation

zone	altitude (feet)	mean annual temperature ($^{\circ}\text{C}$)	climatic designation
9	> 10,000	< 10	cold to very cold
8	9,000 - 10,000	10 - 12	very cool
7	8,000 - 9,000	12 - 14	cool
6	7,000 - 8,000	14 - 16	fairly cool
5	6,000 - 7,000	16 - 18	cool temperate
4	5,000 - 6,000	18 - 20	warm temperate
3	4,000 - 5,000	20 - 22	fairly warm
2	3,000 - 4,000	22 - 24	warm
1	0 - 3,000	24 - 30	fairly hot to very hot

2.6.4 Range of crops

Acland (1971) gave rather precise limits for the altitudinal range of crops. His limits are reproduced in table 11. The suitable altitude range is indicated by solid lines, while the sub-optimal altitude range is indicated by broken lines. The wide range for maize results from the different varieties available, e.g. coast composite 0-4000 ft, hybrid H622 4000-6000 ft, hybrid H611 6000-8000 ft and hybrid H708 7000-9500 ft. Similar situations exist for other crops and as new varieties appear information will have to be updated.

2.6.5 Potential production and carrying capacity

Temperature influences the types of crops that can be grown. It also has an effect on the potential production of these crops per unit of time, as is well known for maize at different altitudes in Kenya (Acland, 1971).

From data given in FAO (1978) it can be deduced that for maize and sorghum the total dry matter formed during a particular period is reduced by 50% between an altitude of 1500 and 3000 m, while below 1500 m there is no temperature dependency. As a general rule it has been assumed that the potential dry matter production of crops and natural vegetation between sea level and 4,000 ft (1200 m) is little affected, while between 4,000 ft (1200 m) and 10,000 ft (3000 m) the potential dry matter production decreases linearly by 60%. Compared with the enormous reduction in potential production caused by water shortage, (a factor of 30 between zones I and VII - see 2.5.5), the effect of temperature on potential production is fairly small.

To estimate the potential production of the temperature zones one can use the estimates of table 6 and reduce the dry matter production by 10% for every increase in altitude of one thousand feet between 4000 and 10,000 ft; e.g. at 7000 ft reduce the potential production of zone I by 30% or 9000 kg ha $^{-1}$ year $^{-1}$. The carrying capacity of the temperature zones can be assessed in a similar way.

2.6.6 Relation to vegetation and flora

Though it is well known that the flora changes with altitude and that some particular vegetation types are restricted to particular altitudes, there does not seem to be any general relation between altitude and vegetation types. Extensive data on the altitude range (and, by implication, the temperature range) of many plants have been given in various floristic publications (FTEA, 1952; Dale and Greenway, 1961; Agnew, 1974).

2.6.7 Relation to soil temperature regimes (Soil Taxonomy)

The Soil Taxonomy classification (Soil Survey Staff, 1975) is not used in this report. It may, however, be of use for readers to be able to relate the average annual temperatures and the temperature zones (appendix 2) of this report to the soil temperature regimes of Soil Taxonomy. According to a list of the soil temperature regimes of 45 stations in Kenya (van Wambeke, pers. comm.) and our calculated temperatures for the same stations, the following relationship appears:

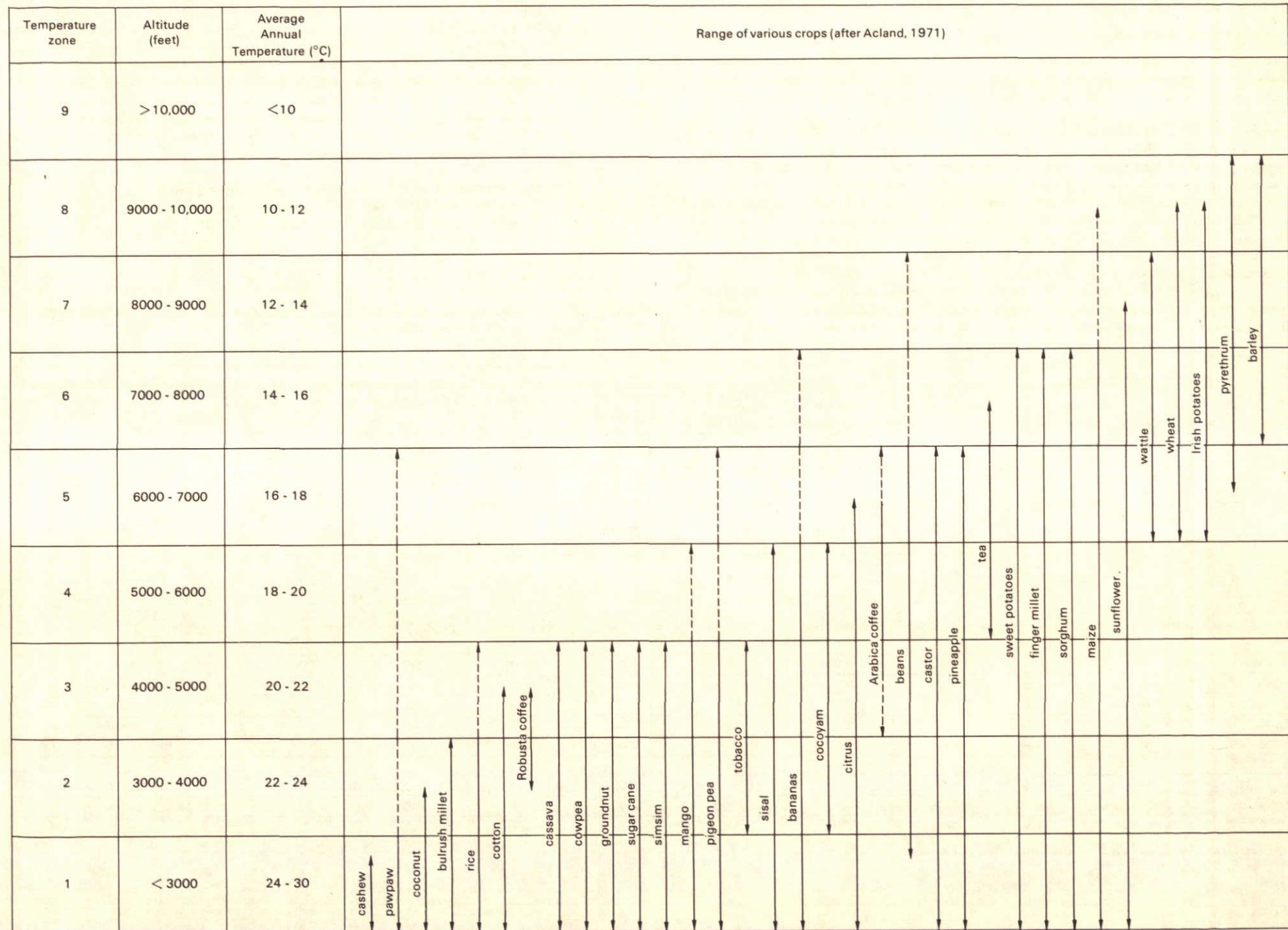
Soil temperature regime	average annual temperature (in $^{\circ}\text{C}$)	temperature zones
isofrigid	< 8	most of 9
isomesic	8 - 15	part of 6, 7, 8, part of 9
isothermic	15 - 22	3, 4, 5, part of 6
isohyperthermic	> 22	1, 2

2.6.8 Extent of the temperature zones and the moisture availability/temperature zone combinations

The extent of all units on the agro-climatic zone map was determined by means of dot screens. The extent and the percentage of each of the temperature zones is given in the bottom two rows of table 12. It can be observed from table 12 that more than two-thirds (i.e. 68.4%) of the country is in zone 1 while 1.9% (or 1,120,000 ha) is in zones 7, 8 and 9.

The other columns and rows of table 12 give a summary of the extent of the various moisture availability/temperature zone combinations (e.g. the total of all III-3 units is 580,000 ha).

Table 11: Altitude and temperature range of various crops



2.7 Other climatic aspects

2.7.1 Rainfall distribution

The distribution of the rainfall over the months of the year is of great importance to agriculture because it determines which are the periods of active plant growth. A distinction should be made between the average rainfall distribution over the months of the year and the variations in distribution from year to year.

The average distribution of rainfall in Kenya is complex (Griffiths 1972; Braun, 1977c). Attempts to classify and map the rainfall distribution are unsatisfactory in approach, applicability, accuracy and scale (e.g. map 15 in S.o.k 1970; Griffiths, 1972). The present author has tried a new approach using the percentage of the average annual rainfall that falls in each month. The classification is based on the percentage of the annual rainfall in the periods January-February, March-May, June-September and October-December. Six major distribution types and 25 sub-types have been mapped in draft. This map and its classification would provide a useful and necessary complement to the interpretation of the agro-climatic zone map, but further work will be done to investigate other alternatives of classification and presentation.

The second aspect of rainfall distribution is its variation from year to year. Though very little can be predicted on an ad hoc basis, if average monthly rainfall data are available, estimates can be made of the probability that particular rainfall totals per month or season will be exceeded (Braun 1977b).

2.7.2 Duration of growing season

The duration of the growing season depends partly on climatic factors (mainly rainfall, evaporation and temperature), partly on soil factors (mainly the amount of moisture that infiltrates and is retained

in the soil) and on crop factors (the most important being the rooting and intrinsic phenology - i.e. maturing - characteristics). Using certain assumptions, the agro-ecological zones project of FAO has calculated and mapped (at scale 1:40 million) the average duration of the growing period for the African continent (FAO, 1978). In connection with the FAO project "Land resources for populations of the future", the average duration of the growing period in Kenya has been calculated. Maps at a scale of 1:1 million will be available at KSS. More detailed information on the year to year variation in the length of the growing period has been calculated by FAO and will be available for consultation at KSS. An example of the variation in the duration of the growing period during the long and short rains is given in table 13.

Table 13: Percentage of rainy seasons in Embu with a growing period

less than 50, 70, 90, 120, 150 and 180 days long
(from 40 years' data 1927 - 1956, 1963 - 1968, 1970 - 1973)

	50	70	90	120	150	180	days
long rains	0	5	10	50	80	95	%
short rains	8	25	43	73	98	100	%

(Note: using average data the duration of the growing period was calculated to be 130 and 102 days for the long and short rains respectively).

Such data are very useful for assessing which crop or crop variety is suitable to be grown in the long and short rains with a certain degree of risk. The Farm Management Handbook (Jätzold and Schmidt, in prep.) will also contain further information on this subject.

Table 12: Extent (in 1000 hectares) of the moisture availability/temperature zone combinations of the agro-climatic zone map

average annual r/Eo (%)	temperature zone	average (°C) annual temperature	24 - 30	22 - 24	20 - 22	18 - 20	16 - 18	14 - 16	12 - 14	10 - 12	< 10	Total area per zone		
		moisture availability zone	altitude (feet)	0 - 3000	3000 - 4000	4000 - 5000	5000 - 6000	6000 - 7000	7000 - 8000	8000 - 9000	9000 - 10,000	> 10,000	in 1000 hectare	in per cent
				I	II	III	IV	V	VI	VII				
> 80	I	-	-	530	520	530	250	350	200	160	2540	4.3		
65 - 80	II	20	50	610	400	450	510	280	60	-	2380	4.1		
50 - 65	III	230	70	580	490	650	480	70	-	-	2570	4.4		
40 - 50	IV	480	360	840	450	590	150	-	-	-	2870	4.9		
25 - 40	V	3230	1940	1460	1260	840	-	-	-	-	8730	15.0		
15 - 25	VI	9540	2700	240	160	-	-	-	-	-	12640	21.7		
< 15	VII	26360	170	-	-	-	-	-	-	-	26530	45.6		
total area per zone	in 1000 hectares	39860	5290	4260	3280	3060	1390	700	260	160	58260			
	in percent	68.4	9.1	7.3	5.6	5.3	2.4	1.2	0.4	0.3		100.0		

- = combination does not occur on the agro-climatic zone map

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3. LAND EVALUATION

3.1 Introduction

Land evaluation is the assessment of the suitability of a tract of land for a particular use, be it smallholders cultivation of certain crops, irrigation of specified crops, forestry or large scale cultivation of sugarcane. This report and the maps accompanying it provide some of the major data to assess the suitability of tracts of land for purposes which the reader can specify. Generally some further data on demography, crops or availability of irrigation water are required.

The maps are intended for use at an exploratory level. For assessments at reconnaissance (e.g. district), semi-detailed or detailed (e.g. farm) level the maps should be used with caution and preferably more detailed information on soils and climate should be used.

3.2 The Use of the Exploratory Soil Map with Agro-climatic Zones (appendix 3)

The uncoloured Exploratory Soil Map with an overprint of Agro-climatic Zones (appendix 3) has been added to this report to facilitate land evaluation exercises.

On appendix 3, the boundaries and codes of the Agro-climatic Zones are given in red. The codes V-3, I-7 etc. are explained in tables A (Roman figures for the moisture availability zones) and B (Arabic numerals for the temperature zones) in the left hand lower corner of appendix 3.

Further information on the moisture availability zones and the temperature zones is given in sections 2.5 and 2.6 and particularly tables, 5, 6, 7, 8 and 11 of this report. The boundaries and codes of the soil units are in black. The soil mapping unit codes (Pn8, Ps3, F12, Y2 etc.) are explained in section 1.6.2 while section 1.6.3 (the legend) contains a description of each soil mapping unit.

In assessing the agricultural possibilities of a particular area it will generally be more efficient to look at the agro-climatic suitability first because it involves larger areas and because the climatic conditions often are the most restricting. For instance in moisture availability zones VI and VII arable agriculture is not feasible (see table 5 and 6) unless special water supply methods are applied (irrigation, water harvesting, water conservation). For the assessment of the potential for "traditional" types of agriculture in these zones it is unnecessary to look further into the soil conditions, but for irrigation, water conservation or water harvesting it is worthwhile looking at the descriptions of the soil units in the legend. For instance in the area north-east of Garissa (39°40' East, 0°30' South) the following soil units occur, starting from the river Tana: A8, W1, Ps20, Ps15, Ps3, Ps3 + Ps15. These units are described in the legend. Of the 5 single units and one complex unit, the units A8 and Ps3 are non-saline and non-sodic and might be suitable for crop growth. The units W1, Ps20 and Ps15 are sodic and have other characteristics (e.g. sealing) which cast doubts on their suitability for crop growth.

The presence of a sealing topsoil suggests that the soils of these units will produce substantial runoff. If this runoff could be channeled to mapping unit A8 or Ps3, then one could envisage runoff agriculture. From their classification it can be inferred that unit A8 is considerably more fertile than Ps3. Because of its low fertility unit Ps3 is probably even unsuitable for low input runoff-agriculture.

When a water harvesting plan is seriously considered, then more detailed field investigations are required. The exploratory soil map can be used to indicate which areas require further investigation. The soil map nor the agro-climatic zone map should ever be used for planning at detailed level. Examples of other assessments for which appendix 3 can be used, are:

- estimates of all land in the so-called marginal lands (moisture availability zone V) without soil limitations for arable farming
- distribution of soils per moisture availability and/or temperature zone for a region or district
- selection of the areas suitable for tea growing

Though in many cases the general slopes can be inferred from the physiography (M for mountains, P for plains, etc.), the slope classes as such cannot be obtained from the soil map. As slopes are important in the assessment of the land suitability for various alternatives, a slope class map might be a useful complement to the soil information.

Similarly, as indicated in section 2.7.2, a map and other information on the growing seasons might be a useful addition for the interpretation of the suitability of the agro-climatic zones for particular seasonal crops or crop varieties.

A separate publication dealing with land evaluation on the basis of the exploratory soil map and the agro-climatic zone map is planned for the near future. In this publication broad suitability ratings for various major land use alternatives will be given for each soil mapping unit.



