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

Exploratory Soil Survey Report No. E1, Kenya Soil Survey, Nairobi 1982

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Colophon

Kenya Soil Survey, P.O. Box 14733, Nairobi, Kenya

ISBN 90 327 0162 2

Map production by: Soil Survey Institute, the Netherlands

Printed in the Netherlands by Cartoprint BV, the Hague

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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 tot 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 seperate 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 suveys 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) - Footslopes (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	Footslopes	22
FY	Footslopes 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)	32
Psl	Lower-level sedimentary plain ("grey clay" plain)	32
Psx	Sedimentary plains of undifferentiated levels	33
Pv	Volcanic plains	33
Pc	Coastal plains	34
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	37
La	Lava flows	38
S	Swamps	38
T	Mangrove swamps	38
V	Minor valleys	38
W	Badlands	38
Z	Coastal or lake-side beach ridges	38

Geology

The geology (parent rock) forms the second entry in the legend. The geological subdivisons 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 subdivisons 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 NH_4Cl) 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 NH_4Cl 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**
ac	chromic* Acrisols
ag	gleyic Acrisols
ah	humic Acrisols
ai	ferralo-chromic* Acrisols
ai	ferralo-ferric Acrisols
ai	ferralo-orthic Acrisols
ao	orthic Acrisols
ap	plinthic Acrisols
at	ando-humic Acrisols
b	**Cambisols**
bc	chromic Cambisols
bd	dystric Cambisols
be	eutric Cambisols
bf	ferralic Cambisols
bg	gleyic Cambisols
bh	humic Cambisols
bk	calcic Cambisols
bn	nito-chromic Cambisols
bt	ando-chromic Cambisols
bt	ando-eutric Cambisols
bv	vertic Cambisols
c	**Chernozems**
ch	haplic Chernozems
ck	calcic Chernozems
e	**Rendzinas**
ec	cambic Rendzinas
eo	orthic Rendzinas
f	**Ferralsols**
fa	acric Ferralsols
fh	humic Ferralsols
fn	nito-humic Ferralsols
fn	nito-rhodic Ferralsols
fo	orthic Ferralsols
fr	rhodic Ferralsols
fx	xanthic Ferralsols
g	**Gleysols**
gc	calcaric Gleysols
gd	dystric Gleysols
gh	humic Gleysols
gm	mollic Gleysols
gv	vertic* Gleysols
h	**Phaeozems**
hg	gleyic Phaeozems
hh	haplic Phaeozems
hn	nito-luvic Phaeozems
ho	ortho-luvic Phaeozems
hr	chromo-luvic Phaeozems
ht	ando-haplic Phaeozems
ht	ando-luvic Phaeozems
hv	verto-luvic Phaeozems
i	**Lithosols**
j	**Fluvisols**
jc	calcaric Fluvisols
je	eutric Fluvisols
jt	thionic Fluvisols
k	**Kastanozems**
kh	haplic Kastanozems
l	**Luvisols**
la	albic Luvisols
lc	chromic Luvisols
lf	ferric Luvisols
lg	gleyic Luvisols
li	ferralo-chromic Luvisols
li	ferralo-ferric Luvisols
li	ferralo-orthic Luvisols
lk	calcic Luvisols
ln	nito-chromic Luvisols
ln	nito-ferric Luvisols
lo	orthic Luvisols
lv	vertic Luvisols
m	**Greyzems**
mo	orthic Greyzems
mv	verto-orthic Greyzems
n	**Nitisols**
nd	dystric Nitisols
ne	eutric Nitisols
nh	humic Nitisols
nm	mollic* Nitisols
nt	ando-humic Nitisols
nv	verto-eutric Nitisols
nv	verto-mollic* Nitisols
o	**Histosols**
od	dystric Histosols
q	**Arenosols**
qa	albic Arenosols
qc	cambic Arenosols
qf	ferralic Arenosols
qk	calcaro-cambic Arenosols
ql	luvic Arenosols
r	**Regosols**
rc	calcaric Regosols
rd	dystric Regosols
re	eutric Regosols
rt	ando-calcaric Regosols
s	**Solonetz**
sg	gleyic Solonetz
sl	luvo-orthic Solonetz
sm	mollic Solonetz
so	orthic Solonetz
t	**Andosols**
th	humic Andosols
tm	mollic Andosols
tv	vitric Andosols
u	**Rankers**
v	**Vertisols**
vc	chromic Vertisols
vp	pellic Vertisols
w	**Planosols**
wd	dystric Planosols
we	eutric Planosols
wh	humic Planosols
ws	solodic Planosols
wv	verto-eutric Planosols
x	**Xerosols/Yermosols** (see ch. 1.4.3)
xh	haplic Xerosols/Yermosols
xk	calcic Xerosols/Yermosols
xy	gypsic Xerosols/Yermosols
z	**Solonchaks**
zg	gleyic Solonchaks
zo	orthic Solonchaks
zt	takyric Solonchaks
	Miscellaneous
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 Nitosols) 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 Nitosols because of their characteristic shiny ped faces (Latin "nitidus" = shiny, bright, lustrous). Unfortunately these aspects are not adequately defined in the criteria for Nitosols 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, Nitosols *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 Nitosols 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 particulary 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 Nitosols - 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 Nitosols, 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 Nitosols *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.

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

ando (FAO, 1970)

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

calcaro (FAO, 1970)

A calcaric 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 consistence.
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 natric 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.

verto (FAO, 1970)

Vertic subunits are distinguished for luvic Phaeozems, orthic Greyzems, eutric and mollic* Nitisols and eutric Planosols. The prefix verto 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, pisoferric) 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 de 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 **pisoferric phase (new)**

The pisoferric 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:

a) 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

b) Inclusions of soils that differ from the main body in one or more characteristics.

c) 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) A soil mapping unit is classified as one classification unit only, e.g. soil mapping unit MI (standard code MPrt) 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.

b) 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.

c) 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.

d) 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.

e) 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).

f) 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.

g) 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.

h) 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 LIfr/(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 smeary, 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 smeary, 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 smeary 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 PHAEOZEMS, 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)

Unit	Symbol	Description
	MU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
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)
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)
	H	**HILLS AND MINOR SCARPS (slopes predominantly over 16%)**
	HB	**Soils developed on basic igneous rocks (serpentinites, basalts, nepheline phonolites, older basic tuffs included)**
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)
H2	HBbc (p)	well drained, shallow, dark reddish brown, friable, rocky and stony, clay loam (chromic CAMBISOLS, lithic phase; with Rock Outcrops)
H3	HBi	well drained, shallow to moderately deep, very dark brown, firm, stony and rocky, clay loam (LITHOSOLS; with verto-luvic PHAEOZEMS, lithic phase and Rock Outcrops)
	HP	**Soils developed on ashes and other pyroclastic rocks of Recent volcanoes**
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)
H5	HPtm	well drained, moderately deep to deep, black, very friable and smeary, very gravelly loam, with a humic topsoil (mollic ANDOSOLS)
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
	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 PHAEOZEMS, bouldery and partly lithic phase)
	HY+	**Soils developed on acid igneous rocks (rhyolites, aplites), with volcanic ash admixture**
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 PHAEOZEMS, lithic phase and LITHOSOLS)
	HV	**Soils developed on undifferentiated Tertiary volcanic rocks (olivine basalts, rhyolites, andesites)**
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)
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 PHAEOZEMS, partly lithic phase)
	HG	**Soils developed on granites**
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)
	HU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
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)
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)
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)
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)

	HQ	**Soils developed on quartzites**
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)
	HX	**Soils developed on various parent materials (mixed igneous and metamorphic rocks)**
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)
	HL	**Soils developed on Precambrian to Jurassic limestones and calcitic mudstones**
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)
H19	HLeo (p)	somewhat excessively drained, shallow, dark grey, firm, moderately calcareous, stony clay; on crystalline limestones (orthic RENDZINAS, 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)
	HK	**Soils developed on Jurassic-Cretaceous fine sandstones, siltstones and sandy limestones**
H21	HKi	somewhat excessively drained, shallow, dark brown, friable, rocky and stony, clay loam; on hills and plateau remnants (LITHOSOLS)
	HS	**Soils developed on Jurassic sandstones, grits and conglomerates**
H22	HSre (p)	well drained, shallow, brown, friable, rocky and stony, sandy clay loam; on hills and plateau remnants (eutric REGOSOLS, lithic phase)
	Hs	**STEP-FAULTED SCARPS OF THE RIFT VALLEY (slopes variable)**
	HsV	**Soils developed on undifferentiated Tertiary volcanic rocks (olivine basalts, rhyolites, andesites)**
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)

	L	**PLATEAUS AND HIGH-LEVEL STRUCTURAL PLAINS (flat to gently undulating; slopes in general less than 8%)**
	LB	**Soils developed on Tertiary basic igneous rocks (olivine basalts, nepheline phonolites; older, basic tuffs included)**
L1	LBfn	well drained, very deep, dark red, very friable clay (nito-rhodic FERRALSOLS)
L2	LBnv	well drained, very deep, dark reddish brown to dark brown, friable to firm, clay; in places with a humic topsoil (verto-eutric NITISOLS; with mollic* NITISOLS)
L3	LBho	well drained, moderately deep to deep, dark brown, firm clay, with a thick humic topsoil (ortho-luvic PHAEOZEMS)
L4	LBfn+bc	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)
L5	LBhr	well drained, shallow to moderately deep, reddish brown, firm clay loam, with a humic topsoil (chromo-luvic PHAEOZEMS, partly lithic phase)
L6	LBxk (bm)	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 (calcic XEROSOLS, boulder-mantle and partly lithic and saline-sodic phase)
L7	LBbc (bm)	well drained, shallow, brown, firm, gravelly clay, with a stony to bouldery surface (chromic CAMBISOLS, lithic and boulder-mantle phase)
L8	LBhv1	well drained to moderately well drained, deep, very dark greyish brown, firm cracking clay, with a thick humic topsoil (verto-luvic PHAEOZEMS)
L9	LBhv2	moderately well drained, very deep, dark greyish brown, firm clay (verto-luvic PHAEOZEMS; with eutric PLANOSOLS)
L10	LBmv	imperfectly drained, very deep, very dark greyish brown to black, very firm, cracking clay, with a topsoil of friable, humic clay loam (verto-orthic GREYZEMS)
L11	LBvp (s)	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)
L12	LBvp+hv	imperfectly drained, deep, black to dark grey, very firm, cracking clay (pellic VERTISOLS and verto-luvic PHAEOZEMS)
L13	LBvc	imperfectly drained, deep, very dark greyish brown, very firm, cracking clay (chromic VERTISOLS)

Colour	Symbol	Description
L14	LBwe	imperfectly drained, deep, dark greyish brown, firm clay (hardpan), abruptly underlying a topsoil of sandy clay loam (eutric PLANOSOLS)
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)
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)
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* GLEYSOLS)
	LP	**Soils developed on ashes and other pyroclastic rocks of Recent volcanoes**
L18		This unit has been deleted.
L19	LPtm	well drained, deep to very deep, very dark greyish brown, friable and smeary, loam to clay loam, with a thick humic topsoil (mollic ANDOSOLS)
L20	LPht	well drained, moderately deep to very deep, dark brown, friable and slightly smeary, clay loam to clay (ando-luvic PHAEOZEMS)
L21	LPws	imperfectly drained, deep very dark greyish brown, mottled, firm clay, abruptly underlying a thick topsoil of friable silty clay loam (solodic PLANOSOLS)
L22	LPht+hv	complex of: - well drained, deep to very deep, very dark greyish brown to dark brown, friable and slightly smeary, clay loam (ando-luvic PHAEOZEMS) - imperfectly drained, deep, very dark greyish brown to black, firm, moderately calcareous, cracking clay (verto-luvic PHAEOZEMS)
	LI	**Soils developed on intermediate igneous rocks (syenites, trachytes, phonolites, etc.)**
L23	LIfn	well drained, very deep, dark reddish brown to dark red, friable clay (nito-rhodic FERRALSOLS)
L24	LIfr (m)	well drained, moderately deep to deep, dark red, friable clay, over petroplinthite; with inclusions of small bottomlands of unit B2 (rhodic FERRALSOLS, petroferric phase)
	LGF+	**Soils developed on biotite-hornblende granites, with volcanic ash admixture**
L25	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)
	LR	**Soil developed on quartz-feldspar gneisses**
L26	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)
	LQ	**Soils developed on quartzites**
L27	LQfh	well drained, deep to very deep, reddish brown, friable clay, with an acid humic topsoil (humic FERRALSOLS)
	LL	**Soils developed on Jurassic limestones** ("Muguda surface", structural plain)
L28	LLlk (K)	well drained, shallow to moderately deep, dark reddish brown, firm, moderately calcareous clay, over petrocalcic material; on oolithic limestones (calcic LUVISOLS, petrocalcic phase)
L29	LLbk (p)	well drained, shallow, red, friable, moderately calcareous sandy loam; on dolomitic limestones (calcic CAMBISOLS, lithic phase)
L30	LLi (b)	well drained, shallow, dark reddish brown, firm, moderately calcareous, bouldery clay loam; on non-oolithic limestones and calcitic mudstones (LITHOSOLS, bouldery phase)
	LD	**Soils developed on Tertiary claystones** (Banissa beds, "intermediate" peneplain)
L31	LDfr (m)	well drained, deep, dark red, friable clay, over petroplinthite (rhodic FERRALSOLS, petroferric phase)
	Ls	**STEP-FAULTED FLOOR OF THE RIFT VALLEY** (flat to gently undulating, with minor scarps)
	LsB	**Soils developed on Tertiary basic igneous rocks (olivine basalts, nepheline phonolites; older basic tuffs included)**
Ls1	LsBbt (b)	well drained, moderately deep, dark reddish brown to reddish brown, friable to firm and slightly smeary, bouldery and stony, clay loam to clay; in places calcareous (ando-chromic CAMBISOLS, bouldery phase; with calcic XEROSOLS)
Ls2	LsBxk (b)	as in Ls1, but mainly calcic XEROSOLS

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

Map unit	Symbol	Description
	RV	**Soils developed on olivine basalts and pyroclastic rocks**
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%)
	FB	**Soils developed on colluvium from basic igneous rocks (serpentinites, basalts, etc.)**
F1	FBne	well drained, very deep, dark reddish brown, friable clay (eutric NITISOLS)
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-mollic* NITISOLS)
F3	FBbk	well drained, deep to very deep, dark reddish brown, firm, moderately calcareous clay (calcic CAMBISOLS)
	FP	**Soils developed on colluvium from ashes and other pyroclastic rocks of Recent volcanoes**
F4	FPht	well drained to moderately well drained, very deep, dark brown, friable and slightly smeary clay, with a humic topsoil (ando-luvic PHAEOZEMS)
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)
	FY+	**Soils developed on colluvium from acid igneous rocks (rhyolites), with volcanic ash admixture**
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 (gleyic PHAEOZEMS)
	FV	**Soils developed on colluvium from various volcanic rocks (mainly basalts)**
F7	FVat	well drained, deep to very deep, reddish brown, friable clay, with an acid humic topsoil (ando-humic ACRISOLS)
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)
F9	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 PHAEOZEMS and chromic VERTISOLS)
	FL	**Soils developed on colluvium from crystalline limestones**
F10	FLlc (o)	well drained, very deep, dark reddish brown, firm, slightly calcareous clay, with a slightly to moderately sodic deeper subsoil (chromic LUVISOLS, sodic phase)
F11	FLlv (o)	well drained, very deep, dark brown, firm, moderately to strongly calcareous, slightly to moderately sodic, cracking clay (vertic LUVISOLS, sodic phase)
	FU	**Soils developed on colluvium from undifferentiated Basement System rocks (predominantly gneisses)**
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)
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)
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)
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)
F16	FUqf	complex of well drained, deep to very deep, dark reddish brown to dark yellowish brown soils of varying consistence and texture; in places gravelly and stratified (ferralic ARENOSOLS; with ferralo-chromic/orthic LUVISOLS)
	FQ	**Soils developed on colluvium from quartzites**
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)
	FX	**Soils developed on colluvium from various rocks**
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)

Map unit	Symbol	Description
	FS	**Soils developed on colluvium from sandstones, grits and conglomerates (Taru grits and Mazeras sandstone)**
F19	FSql	excessively drained, very deep, reddish yellow, loose, sand to loamy sand (luvic ARENOSOLS; with ferralic and albic ARENOSOLS)
	FY	**FOOTSLOPES AND PIEDMONT PLAINS UNDIFFERENTIATED** (nearly flat to sloping; slopes 0-8%)
	FYU	**Soils developed on colluvium and 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)
	FYL	**Soils developed on colluvium and alluvium from crystalline limestones**
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)
	FYK	**Soils developed on colluvium and alluvium from fine sandstones, siltstones and sandy limestones**
FY3	FYKbk	well drained, very deep, dark red, friable, moderately calcareous, very fine sandy clay loam (calcic CAMBISOLS)
	Y	**PIEDMONT PLAINS** (nearly flat to gently sloping; slopes 0-5%)
	YP	**Soils developed on alluvium from ashes and other pyroclastic rocks of Recent volcanoes**
Y1	YPtm+ch (r)	complex of well drained, shallow to deep, greyish brown to black, very friable and smeary, rocky or bouldery, gravelly, sandy clay loam to clay (mollic ANDOSOLS, rocky phase and haplic CHERNOZEMS, stony and partly lithic phase)
	YV	**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)
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)
	YL	**Soils developed on alluvium from crystalline limestones**
Y6	YLli+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)
	YU	**Soils developed on alluvium from undifferentiated Basement System rocks (predominantly gneisses)**
Y7	YUli	well drained, very deep, dark red, friable, sandy clay to clay (ferralo-chromic LUVISOLS)
Y8	YUlo	well drained, very deep, dark reddish brown to dark brown, loose sandy loam to friable to firm, sandy clay (orthic LUVISOLS; with luvic ARENOSOLS)
Y9	YUbk (o)	well drained, deep, dark brown, friable, moderately calcareous clay loam, with a sodic deeper subsoil (calcic CAMBISOLS, sodic phase)
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)
Y11	YUwv	imperfectly drained, very deep, very dark grey to black, very firm, cracking, clay, with a calcareous deeper subsoil; in places gravelly (verto-eutric PLANOSOLS)
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)
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, GLEYSOLS, SOLONETZ, VERTISOLS and FLUVISOLS)

Unit	Symbol	Description
	U	**UPLANDS**
	Uu	**UPPER-LEVEL UPLANDS** (usually rolling to hilly; altitudes 6500-11,000 feet; about 4,000 feet above local base level)
	Uu I+	**Soils developed on intermediate igneous rocks (syenites, trachytes, andesites), with volcanic ash admixture**
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 PHAEOZEMS)
	UuY +	**Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture**
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 PHAEOZEMS)
	UuU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
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)
	Uh	**UPPER MIDDLE-LEVEL UPLANDS** (usually undulating to rolling; altitudes 5000-8000 feet; about 2500 feet above local base level)
	UhB	**Soils developed on Tertiary or older basic igneous rocks (basalts, nepheline phonolites, etc.; basic tuffs included)**
Uh1	UhBnh	well drained, extremely deep, dark reddish brown to dark red, friable clay, with an acid humic topsoil (humic NITISOLS)
Uh2	UhBnm	well drained, extremely deep, dark reddish brown, friable clay, with a humic topsoil (mollic* NITISOLS)
Uh3	UhBne	well drained, extremely deep, dark reddish brown, friable clay (eutric NITISOLS)
Uh4	UhBbn	well drained, shallow to moderately deep, dark reddish brown, to dark red, friable clay (nito-chromic CAMBISOLS; with chromic CAMBISOLS, lithic phase)
Uh3 + Uh4	UhBne+bn	complex of soils of units Uh3 and Uh4
	Uh I+	**Soils developed on intermediate igneous rocks (syenites, andesites, etc.), with volcanic ash admixture**
Uh5	Uh I+nm	well drained, extremely deep, reddish brown, friable clay, with a thick humic topsoil (mollic* NITISOLS)
	UhY +	**Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture**
Uh6	UhY +fn	well drained, very deep, dark red to dark reddish brown, friable, sandy clay to clay (nito-rhodic FERRALSOLS)
	UhG	**Soils developed on granites**
Uh7	UhGah	well drained, very deep, dark red to yellowish red, friable to firm, sandy clay to clay, with an acid humic topsoil (humic ACRISOLS)
Uh8	UhGah (r)	as in Uh7, but rocky (humic ACRISOLS, rocky phase)
Uh9	UhGbh	well drained, deep, yellowish red to brown, friable clay loam, with an acid humic topsoil (humic CAMBISOLS; with humic ACRISOLS)
	UhF	**Soils developed on hornblende gneisses**
Uh10	UhFnh	well drained, extremely deep, dark reddish brown, friable clay, with a thick acid humic topsoil (humic NITISOLS)
	UhN	**Soils developed on biotite gneisses**
Uh11	UhNnh	well drained, extremely deep, dark reddish brown, friable clay, with a thick acid humic topsoil (humic NITISOLS)
Uh12	UhNah+bh	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)
	UhU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
Uh13	UhUai	well drained, deep, red to yellowish red, friable sandy clay (ferralo-chromic* ACRISOLS)
Uh14	UhUlc	well drained, deep, red, firm sandy clay, with a topsoil of sandy loam (chromic LUVISOLS)
Uh15	UhUac (r)	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)
	UhQ	**Soils developed on quartzites**
Uh16	UhQhr	well drained, very deep, dark reddish brown, friable to firm, sandy clay to clay, with a humic topsoil (chromo-luvic PHAEOZEMS)
Uh17	UhQbh	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	UhXai	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)

Legend	Symbol	Description
	UhX+	**as in UhX, but with volcanic ash admixture**
Uh18	UhX+ht	moderately well drained, moderately deep, reddish brown to red, firm clay loam, with a humic topsoil (ando-luvic PHAEOZEMS)
	Um	**LOWER MIDDLE-LEVEL UPLANDS** (usually undulating; altitudes 3500-6500 feet; about 1500 feet above local base level)
	UmB	**Soils developed on basic igneous rocks (basalts, etc.)**
Um1	UmBnd	well drained, extremely deep, dark reddish brown, friable clay (dystric NITISOLS)
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)
Um3	UmBnm	well drained, deep to extremely deep, dark red, friable clay, with a thick humic topsoil (mollic* NITISOLS; with nito-luvic PHAEOZEMS)
	UmP	**Soils developed on ashes and other pyroclastic rocks of Recent volcanoes**
Um4	UmPtm	well drained, deep to very deep, dark reddish brown, friable and smeary, silty clay to clay, with a humic topsoil (mollic ANDOSOLS)
	Um I	**Soils developed on intermediate igneous rocks (andesites, etc.)**
Um5	Um Inh	well drained, extremely deep, dusky red to dark reddish brown, friable clay, with an acid humic topsoil (humic NITISOLS)
Um6	Um Ifn	well drained, very deep, dusky red to dark red, friable clay (nito-rhodic FERRALSOLS)
Um7	Um Ibf	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)
	UmY	**Soils developed on acid igneous rocks (rhyolites, etc.)**
Um8	UmYhr	well drained, deep to extremely deep, reddish brown, friable clay, with a humic topsoil (chromo-luvic PHAEOZEMS; with mollic* NITISOLS)
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)
	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)
Um12	UmGag	imperfectly drained, moderately-deep, brown to dark yellowish brown, mottled, friable, gravelly sandy clay loam; in places rocky and shallow (gleyic ACRISOLS, partly paralithic and rocky phase)
	UmGF	**Soils developed on biotite/hornblende granites**
Um13	UmGFfn	well drained, very deep, reddish brown to red, friable clay, with a thick acid humic topsoil (nito-humic FERRALSOLS)
Um14	UmGFah/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)
	UmF	**Soils developed on Basement System rocks rich in ferromagnesian minerals**
Um15	UmFfn	well drained, very deep, dark red, friable to firm, clay (nito-rhodic FERRALSOLS)
	UmN	**Soils developed on biotite gneisses**
Um16	UmNfr	well drained, deep, red, friable clay (rhodic FERRALSOLS; with ferralo-chromic* ACRISOLS)
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)
Um18	UmNlo	well drained, moderately deep to deep, brown to dark yellowish brown, firm sandy clay loam (orthic LUVISOLS)
	UmU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
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)
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)
Um21	UmUlc+li	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)
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)

Um–Ul

Colour	Symbol	Description
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)
Um24	UmUlc+li	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)
Um25	UmUlc+bd	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)
	UmU+	**as in UmU, but with volcanic ash admixture**
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 PHAEOZEMS)
	UmQ	**Soils developed on quartzites**
Um27	UmQqf	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)
	UmX	**Soils developed on various rocks (Kavirondian sediments, often mudstones**
Um28	UmXfr/o	well drained, deep to very deep, dark reddish brown to strong brown, friable clay (rhodic to orthic FERRALSOLS)
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)
	Ul	**LOWER-LEVEL UPLANDS** (usually gently undulating; altitudes 2500-6000 feet; about 500 feet above local base level)
	UlB	**Soils developed on basic igneous rocks (basalts, etc.)**
Ul1	UlBne	well drained, extremely deep, dark red, friable clay (eutric NITISOLS)
Ul2	UlBhr	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 PHAEOZEMS; with gleyic LUVISOLS)
Ul3	UlBhv	moderately well drained, shallow to moderately deep, dark brown, firm clay (verto-luvic PHAEOZEMS, partly lithic phase)
	UlI	**Soils developed on intermediate igneous rocks (andesites, etc.)**
Ul4	UlIlc (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*)
Ul5	UlIir+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)
Ul6	UlIir+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)
	UlY	**Soils developed on acid igneous rocks (rhyolites, etc.)**
Ul7	UlYfo (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*)
Ul8	UlYhg+hh	well drained to moderately well drained, moderately deep to deep, reddish brown to dark grey, friable clay, with a humic topsoil (gleyic and haplic PHAEOZEMS)
Ul9	UlYir	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)
Ul10	UlYhr+l (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 PHAEOZEMS and orthic and chromic LUVISOLS, partly petroferric phase; with IRONSTONE SOILS*)
	UlG	**Soils developed on granites**
Ul11	UlGfo+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*)
Ul12	UlGah+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*)

Map unit	Code	Description
	UlGR	**Soils developed on granites and quartz-feldspar gneisses**
Ul13	UlGRfo	well drained, deep, strong brown to reddish yellow, very friable, sandy clay loam to sandy clay (orthic FERRALSOLS; with ferralic CAMBISOLS)
	UlF	**Soils developed on Basement System rocks rich in ferromagnesian minerals**
Ul14	UlFlc	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)
	UlN	**Soils developed on biotite gneisses**
Ul15	UlNfr	well drained, very deep, dark red to dark reddish brown, very friable, sandy clay loam to clay (rhodic FERRALSOLS)
Ul16	UlNfr+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*)
	UlU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
Ul17	UlUfr	well drained, very deep, red to dark red, very friable to friable, clay (rhodic FERRALSOLS)
Ul18	UlUlc+f	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)
Ul19	UlUao (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)
	UlX	**Soils developed on various rocks (Kavirondian sediments, often mudstones)**
Ul20	UlXf+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*)
Ul21	UlXhh+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 PHAEOZEMS, petroferric phase and IRONSTONE SOILS*)
	Ux	**UPLANDS, UNDIFFERENTIATED LEVELS** (undulating to rolling; altitudes and base level variable)
	UxB	**Soils developed on basic igneous rocks (basalts, etc.)**
Ux1	UxBbk (b)	well drained, shallow to moderately deep, dark greyish brown, friable to firm, calcareous, very rocky and bouldery clay (calcic CAMBISOLS, lithic and bouldery phase)
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 (verto-luvic PHAEOZEMS, stony and saline-sodic phase)
	UxBP	**Soils developed on basic igneous rocks (basalts, etc.), but with influence of volcanic ash predominant**
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 (nito-ferric/chromic LUVISOLS; with gleyic LUVISOLS)
	UxP	**Soils developed on pyroclastic rocks**
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)
	UxV	**Soils developed on undifferentiated volcanic rocks (mainly basalts)**
Ux5	UxVht	well drained, very deep, dark reddish brown to very dark greyish brown, friable and slightly smeary clay, with a humic topsoil (ando-luvic PHAEOZEMS)
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)

Ux8	UxVne+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 severy 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)
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 PHAEOZEMS, partly lithic phase) - imperfectly drained, moderately deep, very dark greyish brown to black, very firm, cracking clay (chromic VERTISOLS)
	UxU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
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)
	Uc	**COASTAL UPLANDS** (undulating to rolling; altitude 1000 feet or less
	Uc I	**Soils developed on intermediate igneous rocks rich in ferro-magnesian minerals (intrusives)**
Uc1	Uc Ine	well drained, extremely deep, dark red to yellowish red, friable clay (eutric NITISOLS)
	UcT	**Soils developed on shales**
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 (verto-luvic PHAEOZEMS, sodic phase; with vertic CAMBISOLS, sodic phase)
	UcK	**Soils developed on fine sandstones and siltstones (Mariakani sandstone and Upper Maji-ya-Chumvi 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)
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)
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)
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)
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)
	UcS	**Soils developed on coarse sandstones and grits (Mazeras sandstone and Shimba grits)**
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)
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)
	UcO	**Soils developed on Plio-Pleistocene bay sediments (Marafa beds)**
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 PHAEOZEMS)
	UcX	**Soils developed on undifferentiated sedimentary rocks (Mazeras and Mariakani sandstones and Marafa beds)**
Uc11	UcXl	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 PHAEOZEMS)

Up — **UPLAND/HIGH-LEVEL PLAIN TRANSITIONAL LANDS** (gently undulating; altitude 5000-7000 ft)

UpB — **Soils developed on basic igneous rocks (basalts, etc.)**

Up1 — UpBwv+vc — 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)

UpB+ — **as in UpB, but with volcanic ash admixture**

Up2 — UpB+we+vc — 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)

UpY+ — **Soils developed on acid igneous rocks (rhyolites), with volcanic ash admixture**

Up3 — UpY+we+hr — 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)

UpF — **Soils developed on gneisses rich in ferromagnesian minerals**

Up4 — UpFvp — 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)

UpN — **Soils developed on biotite gneisses**

Up5 — UpNwv+vp — 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)

UpN+ — **as in UpN, but with volcanic ash admixture**

Up6 — UpN+hv (o) — imperfectly drained, deep, very dark greyish brown to black, firm clay, with a sodic deeper subsoil (verto-luvic PHAEOZEMS, sodic phase)

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)

UpU — **Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**

Up8 — UpUlc+we — 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)

P — **PLAINS**

Pn — **NON-DISSECTED EROSIONAL PLAINS**

PnB — **Soils developed on basic igneous rocks (basalts, etc.)**

Pn1 — PnBfn — well drained, very deep, dark reddish brown to dusky red, friable clay; in places bouldery (nito-rhodic FERRALSOLS)

Pn2 — PnBbc (p) — well drained, shallow, very dark reddish brown, friable, slightly calcareous, stony and bouldery, clay loam to clay (chromic CAMBISOLS, lithic and bouldery phase)

Pn3 — PnBvp/c (o) — 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)

PnB+ — **as in PnB, but with volcanic ash admixture**

Pn4 — PnB+vp — 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)

Pn5 — PnB+wv — imperfectly drained, deep, dark brown to dark grey, firm, sandy clay to clay (verto-eutric PLANOSOLS)

PnG+ — **Soils developed on granites, with volcanic ash admixture**

Pn6 — PnG+we — imperfectly drained, deep, dark greyish brown, mottled, very firm, gravelly clay loam to clay, abruptly underlying a thick topsoil of friable loam (eutric PLANOSOLS)

PnGP — **Soils developed on granites, but with influence of volcanic ash predominant**

Pn7 — PnGPws — imperfectly drained, moderately deep, very dark greyish brown, very firm, slightly sodic, gravelly clay, abruptly underlying a topsoil of friable loam (solodic PLANOSOLS)

Legend	Symbol	Description
	PnF	**Soils developed on Basement System rocks rich in ferromagnesian minerals**
Pn8	PnFfr	well drained, deep to very deep, dusky red to dark red, friable sandy clay (rhodic FERRALSOLS)
Pn9	PnFlc+ho	well drained, moderately deep, dark reddish brown, firm, slightly calcareous, sandy clay loam (chromic LUVISOLS and ortho-luvic PHAEOZEMS)
	PnN+	**Soils developed on biotite gneisses, with volcanic ash admixture**
Pn10	PnN+wv (o)	imperfectly drained, deep, brown to dark grey, firm clay, with a calcareous and sodic deeper subsoil (verto-eutric PLANOSOLS, sodic phase)
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)
	PnU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
Pn12	PnUfr+fo	well drained, deep to very deep, dark red to strong brown, friable, sandy clay to clay (rhodic and orthic FERRALSOLS)
Pn13	PnUlf+lc	well drained, moderately deep to deep, dark red to strong brown, friable to firm, sandy clay loam to clay (ferric and chromic LUVISOLS)
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)
Pn15	PnUvp (o)	imperfectly drained, deep, black to very dark grey, very firm, slightly to moderately sodic, cracking clay (pellic VERTISOLS, sodic phase)
	PnU+	**as in PnU, but with volcanic ash admixture**
Pn16	PnU+lf+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)
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)
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)
	PnUP	**Soils developed on undifferentiated Basement System rocks, but with influence of volcanic ash predominant**
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)
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)
	PnX	**Soils developed on various rocks (Kavirondian sediments, often mudstones)**
Pn22	PnXsl	imperfectly drained, very deep, very dark brown to black, firm, moderately sodic clay (luvo-orthic SOLONETZ)
Pn23	PnXwe+ws	imperfectly drained to poorly drained, deep, dark gery, firm clay, abruptly underlying a topsoil of friable silt loam; in many places with a sodic deeper subsoil (eutric and solodic PLANOSOLS)
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)
	PnL	**Soils developed on crystalline or Plio-Pleistocene sedimentary limestones and gypsiferous rocks (Wajir-El Wak beds)**
Pn25	PnLbc	well drained, moderately deep, dark reddish brown, friable clay (chromic CAMBISOLS)
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 (calcic LUVISOLS, petrocalcic phase)
Pn27	PnLi	imperfectly drained, shallow, pale brown, firm, moderately calcareous, stony loam, over petrocalcic or petrogypsic material (LITHOSOLS; with calcic CAMBISOLS, petrocalcic phase)
	PnT	**Soils developed on Permian-Triassic shales (Lower Maji-ya-Chumvi beds and Taru carbonaceous shales)**
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)

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 (verto-luvic PHAEOZEMS, sodic phase)
	PnKT	**Soils developed on Triassic siltstones and shales (Lower Maji-ya-Chumvi beds)**
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)
	PnK	**Soils developed on Triassic fine sandstones and siltstones (Mariakani sandstone)**
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)
	PnS	**Soils developed on Carboniferous-Permian gritty sandstones (Taru grits)**
Pn32	PnSlc	well drained, deep, red, firm, sandy clay loam to clay (chromic LUVISOLS)
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)
Pn34	PnSql	well drained, deep, yellowish red to reddish brown, friable, loamy coarse sand to sandy clay loam (luvic ARENOSOLS; with orthic LUVISOLS)
Pn35	PnSi (gm)	well drained, shallow, dark brown, friable gravelly sandy clay loam, with a gravel surface (LITHOSOLS, gravel-mantle phase)
	Pd	**DISSECTED EROSIONAL PLAINS**
	PdV	**Soils developed on various volcanic rocks**
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 PHAEOZEMS, lithic phase; with Rock Outcrops)
	PdN	**Soils developed on biotite gneisses**
Pd2	PdNhv (p)	well drained to moderately well drained, shallow, dark brown to black, very firm, gravelly and stony clay (verto-luvic PHAEOZEMS, lithic and stony phase)
	PdU	**Soils developed on undifferentiated Basement System rocks (predominantly gneisses)**
Pd3	PdUbc (p)	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)
Pd4	PdUbk (p)	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)
	PdW	**Soils developed on Jurassic marly limestones, gypsiferous shales and sandy limestones (Shangalla and Asaharbito beds of Mandera)**
Pd5	PdWxy (s)	well drained, deep, pale brown to yellowish brown, firm, strongly calcareous and gypsiferous, stony loam (gypsic XEROSOLS, stony phase)
	PdX	**Soils developed on undifferentiated sedimentary rocks**
Pd6	PdXbc/lo (p)	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)
	Ps	**SEDIMENTARY PLAINS** (mainly from sheetwash)
	Psh	HIGHER-LEVEL SEDIMENTARY PLAIN ("RED SAND" PLAIN)
	PshU	**Soils developed on sheetwash and aeolian deposits from undifferentiated Basement System rocks (predominantly gneisses)**
Ps1	PshUqf	well drained, very deep, dark red to dusky red, loose loamy sand to very friable sandy loam (ferralic ARENOSOLS)
Ps2	PshUli	well drained, deep to very deep, dark red to dusky red, friable, sandy loam to sandy clay loam (ferralo-chromic LUVISOLS,; with ferralic ARENOSOLS)
Ps3	PshUai	as in Ps2, but predominantly more acid (ferralo-chromic* ACRISOLS; with ferralic ARENOSOLS and ferric LUVISOLS)
Ps3+Ps15	PshUai+PsmOsl	complex of soils of units Ps3 and Ps15
	PshK	**Soils developed on sheetwash and aeolian deposits from fine sandstones, siltstones and sandy limestones**
Ps4	PshKqc	well drained, deep, red, friable, loamy fine sand to fine sandy loam (cambic ARENOSOLS)

Ps5	PshKws+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)
	PshS	**Soils developed on sheetwash deposits mainly from gritty sandstones**
Ps6	PshSlo	well drained, very deep, dark brown to reddish brown, friable, sandy clay loam to sandy clay (orthic LUVISOLS)
	Psm	**MIDDLE-LEVEL SEDIMENTARY PLAINS "ENCLOSED" PLAIN**
	PsmF	**Soils developed on sheetwash deposits from Basement System rocks rich in ferromagnesian minerals**
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)
Ps8	PsmFlf	well drained, deep to very deep, red to dark red, friable firm, sandy clay to clay, over pisocalcic material; on sheetwash and fluviatile sediments (ferric LUVISOLS)
	PsmU	**Soils developed on sheetwash deposits mainly from undifferentiated Basement System rocks (predominantly gneisses)**
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)
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)
	PsmX	**Soils developed on sheetwash deposits mainly from undifferentiated Basement System rocks, with admixture of sediments from olivine basalts and possibly old lacustrine deposits**
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)
Ps12	PsmXzo	poorly drained, deep, dark reddish brown, firm, moderately calcareous, moderately saline clay, with a crusted and puffed surface (orthic SOLONCHAKS)
Ps13		This unit has been deleted
Ps11 + D1	PsmXso+Dqk	complex of soils of units Ps11 and D1
	PsmS	**Soils developed on sheetwash deposits from gritty sandstones**
Ps14	PsmSlk (k)	moderately well drained, deep, dark reddish brown, firm, slightly calcareous, sandy clay to clay, over pisocalcic material (calcic LUVISOLS, pisocalcic phase)
		"SEALING LOAM" PLAIN
	PsmO	**Soils developed on Plio-Pleistocene bay sediments (Marafa beds)**
Ps15	PsmOsl	imperfectly drained, moderately deep, brown, extremely firm, moderately calcareous, moderately sodic clay loam, with a topsoil of sealing sandy loam (luvo-orthic SOLONETZ)
Ps16	PsmOsg (a)	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 (gleyic SOLONETZ, saline phase)
Ps17	PsmOgc (o)	poorly drained, deep, dark grey, firm, moderately calcareous, slightly sodic clay, with a soft surface (calcaric GLEYSOLS, sodic phase)
Ps18	PsmOvp (o)	poorly drained, deep, black to very dark grey, firm to very firm, calcareous, sodic, cracking clay (pellic VERTISOLS, sodic phase)
Ps19	PsmOsl+sg	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 (gleyic SOLONETZ, saline phase)
		Soils developed on sheetwash deposits from Plio-Pleistocene bay sediments (Marafa beds)
Ps20	PsmOws	imperfectly drained, deep, brown, extremely firm, slightly calcareous, slightly sodic clay loam, abruptly underlying a thick topsoil of sealing sandy loam (solodic PLANOSOLS)
	Psl	**LOWER-LEVEL SEDIMENTARY PLAIN ("GREY CLAY" PLAIN)**
	PslV	**Soils developed on sediments mainly from various volcanic rocks**
Ps21	PslVso	moderately well drained to imperfectly drained, very deep, dark brown, firm, strongly calcareous, non to slightly saline and strongly sodic, sandy clay (orthic SOLONETZ)

[1] generally less than 5 cm.

Unit	Code	Description
	PsIO	**Soils developed on remodelled Plio-Pleistocene bay sediments (Marafa beds)**
Ps22	PsIOxh	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)
Ps23	PsIOsl (a)	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)
Ps24	PsIOso (a)	imperfectly drained to poorly drained, very deep, dark greyish brown, very firm, slightly calcareous, moderately to strongly saline, strongly sodic clay; in places strongly calcareous and/or gypsic (orthic SOLONETZ, saline phase)
Ps25	PsIOvp (ao)	poorly drained, very deep, very dark grey to black, very firm, slightly calcareous, moderately saline, moderately sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)
	PsIA	**Soils developed on sediments from various sources**
Ps26	PsIAqc	well drained, very deep, reddish brown, non to slightly calcareous, loose fine sand to very friable fine sandy loam (cambic ARENOSOLS)
Ps27	PsIAxk (ao)	well drained, very deep, dark reddish brown, very firm, strongly calcareous, slightly saline, slightly sodic clay, with a soft surface (calcic XEROSOLS, saline-sodic phase)
	Psx	**SEDIMENTARY PLAINS OF UNDIFFERENTIATED LEVELS**
	PsxE	**Soils developed on cover sands**
Ps28	PsxElk/c (o)	well drained, very deep, reddish brown, friable, moderately calcareous, moderately sodic sandy clay loam, with a thick topsoil of loamy sand (calcic to chromic LUVISOLS, sodic phase)
Ps28+D1	PsxElk+Dqk	complex of soils of units Ps28 and D1
	PsxW	**Soils developed on sediments from marl deposits (Asaharbito beds)**
Ps29	PsxWxy (a)	moderately well drained to imperfectly drained, pale brown, firm, strongly calcareous and gypsiferous, slightly saline clay loam (gypsic XEROSOLS, saline phase)

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Unit	Code	Description
	Pv	**VOLCANIC PLAINS**
	PvB	**Soils developed on alluvium from early Pleistocene volcanic rocks (mainly olivine basalts)**
Pv1	PvBne	well drained, extremely deep, dusky red to dark reddish brown, friable clay (eutric NITISOLS)
Pv2	PvBlc (b)	well drained, very deep, dark red, friable, stony and bouldery clay (chromic LUVISOLS, bouldery phase)
Pv3	PvBxk (sm)	well drained, deep, dark red, friable, strongly calcareous, moderately sodic clay loam, with a stone surface (calcic XEROSOLS, stone-mantle and sodic phase)
Pv4	PvBzo (o)	imperfectly drained, deep, dark reddish brown to dark greyish brown, firm, strongly calcareous, moderately saline, strongly sodic clay (orthic SOLONCHAKS, sodic phase)
Pv5	PvBvp (ao)	poorly drained, deep, dark grey, very firm, moderately saline and sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)
	PvP	**Soils developed on ashes and other pyroclastic rocks of Recent volcanoes**
* Pv6	PvPrt	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)
Pv7	PvPtm (o)	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)
Pv8	PvPtm	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)
Pv9	PvPtv	well drained, moderately deep to deep, brown to dark brown, very friable, loam to sandy clay loam (vitric ANDOSOLS)
Pv10	PvPsg (a)	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 (gleyic SOLONETZ, saline and fragipan phase)
Pv11	PvPws	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)
Pv12	PvPwe	poorly drained, deep, black, very firm clay, abruptly underlying a topsoil of friable loam; with a calcareous deeper subsoil (eutric PLANOSOLS)

Legend	Code	Description
	Pc	**COASTAL PLAINS**
	Pch	**HIGHER-LEVEL COASTAL PLAIN**
	PchJ	**Soils developed on lagoonal deposits (Kilindini sands)**
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)
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)
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)
	Pcl	**LOWER-LEVEL COASTAL PLAIN**
	PclJ	**Soils developed on lagoonal deposits** (Kilindini sands)
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 (gleyic to albic LUVISOLS, sodic phase; with ferralo-chromic LUVISOLS, dystric or solodic PLANOSOLS and cambic ARENOSOLS)
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 (gleyic SOLONETZ, saline phase; with gleyic or verto-luvic PHAEOZEMS, saline-sodic phase)
Pc6	PclJC	complex of very deep soils of varying drainage condition, colour, consistence, texture and salinity (albic ARENOSOLS, orthic FERRALSOLS, gleyic LUVISOLS, solodic PLANOSOLS, pellic VERTISOLS)
	PclJ	**Soils developed on aeolian deposits (reworked lagoonal deposits)**
Pc7	PclJfo	well drained, very deep, yellowish red, very friable, fine sandy loam to fine sandy clay loam (orthic FERRALSOLS)

Legend	Code	Description
	Pcr	**REEF COASTAL PLAIN**
	PcrL	**Soils developed on raised-coral-reef limestone, with admixture of lagoonal deposits**
Pc8	PcrLfr	well drained, deep, dark red to reddish brown, friable, sandy clay loam to sandy clay, with a topsoil of loamy sand (rhodic FERRALSOLS)
Pc9	PcrLi	well drained, shallow, dark brown to dark reddish brown, friable, rocky, sandy clay loam to sandy clay (LITHOSOLS; with ferralic CAMBISOLS, lithic phase)
Pc10	PcrLws	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)
	Pl	**LACUSTRINE PLAINS**
	PlV	**Soils developed on sediments from pyroclastic rocks and olivine basalts**
Pl1	PlVz (gm)	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)
	PlL	**Soils developed on sediments from limestone**
Pl2	PlLi (K)	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)
	PlA	**Soils developed on sediments from various sources**
Pl3	PlAz (o)	poorly drained, very deep, dark greyish brown, friable to firm, moderately calcareous, moderately saline, strongly sodic, loam to clay loam, in places gypsiferous; with common low sand dunes; lower level of Chalbi (undifferentiated SOLONCHAKS, sodic phase)
Pl4	PlAzt	poorly drained, deep, dark brown, very firm, excessively saline, cracking clay; lower level of Chalbi (takyric SOLONCHAKS)
Pl5	PlAzo	very poorly drained, deep, greyish brown, firm, excessively saline clay, with a crusted and puffed, saline surface; lower level of Chalbi (orthic SOLONCHAKS)
	PlX	**Soils developed on sediments from volcanic ashes and other sources**

Pl6 PlXvc (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)

Pl7 PlXs (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)

Pl8 PlXzg (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 (gleyic SOLONCHAKS, sodic phase)

Pl9 PlXsm (a) — very poorly drained, very deep, very dark grey, very firm, slightly to moderately calcareous, gypsiferous, slightly saline, strongly sodic clay, with a humic topsoil; lower level of Lambwe valley (mollic SOLONETZ, saline phase)

Pl10 PlXzo+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)

Soils developed on sediments mainly from volcanic ashes

PlP

Pl11 PlPht+bg — complex of:
- well drained, moderately deep to deep, dark brown, friable and slightly smeary, fine gravelly, sandy clay loam to sandy clay, with a humic topsoil (ando-haplic PHAEOZEMS)
- imperfectly drained, moderately deep to deep, strong brown, mottled, firm and brittle, sandy clay to clay (Gamblian lake of the Central Rift Valley), (gleyic CAMBISOLS, fragipan phase)

Soils developed on sediments from lacustrine mudstones

PlD

Pl12 PlDvp (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)

Pl13 PlDvc (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)

SEDIMENTARY PLAINS OF UPPER RIVER TERRACES

Pt

Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)

PtU

Pt1 PtUlk (k) — well drained, deep, dark reddish brown to reddish brown, friable, sandy clay loam to sandy clay, over pisocalcic material (calcic LUVISOLS, pisocalcic phase; with chromic LUVISOLS, and pellic to chromic VERTISOLS, saline-sodic phase)

Pt2 PtUbe — well drained to moderately well drained, deep, dark brown, friable to firm, slightly calcareous, clay loam to clay (eutric CAMBISOLS)

Soils developed on sediments mainly from limestones and marls

PtL

Pt3 PtLqk — well drained, very deep, dark red, friable, strongly calcareous, loamy sand to sandy loam; in places clayey (calcaro-cambic ARENOSOLS; with calcic XEROSOLS)

Soils developed on sediments mainly from Plio-Pleistocene bay deposits

PtO

Pt4 PtOso (a) — 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)

SEDIMENTARY PLAINS OF LARGE ALLUVIAL FANS

Pf

OLDER FANS

Pf1

Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)

Pf1U

Pf1 Pf1Ul — well drained, very deep, dark red to dark brown, firm, sandy clay loam to clay (undifferentiated LUVISOLS)

Soils developed on sediments mainly derived from bay deposits

Pf1O

Pf2 Pf1Oxk (ao) — 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)

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)

YOUNGER FANS

Pf2

Soils developed on sediments mainly derived from bay deposits

Pf2O

Pf4 Pf2Oso (a) — 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)

A FLOODPLAINS

AB **Soils developed on sediments from basic igneous rocks (basalts, etc.)**

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)

AP **Soils developed on sediments mainly from volcanic ashes**

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)

AV **Soils developed on sediments from various volcanic and pyroclastic rocks**

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)

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)

AU **Soils developed on sediments mainly from undifferentiated Basement System rocks (predominantly gneisses)**

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)

AL **Soils developed on sediments mainly from limestones and marls**

A6 **ALjc+zg** 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 (gleyic SOLONCHAKS, sodic phase)

AO **Soils developed on sediments mainly from bay deposits** (older floodplains)

A7 **AOgv (ao)** imperfectly drained, very deep, dark grey, very firm, slightly calcareous, cracking clay, with a slightly to moderately saline and sodic deeper subsoil (vertic* GLEYSOLS, saline-sodic phase)

AA **Soils developed on sediments from various sources** (recent floodplains)

A8 **AAjc** well drained to imperfectly drained, very deep, dark brown to yellowish brown, stratified, micaceous, strongly calcareous, predominantly loamy soils (calcaric FLUVISOLS)

A9 **AAjc (a)** as in AAjc, but slightly to moderately saline (calcaric FLUVISOLS, saline phase)

A10 **AAbk (K)** moderately well drained, shallow to moderately deep, dark brown, friable, strongly calcareous, sandy clay to clay loam, over petrocalcic material (calcic CAMBISOLS, petrocalcic phase)

A11 **AAlk (ao)** imperfectly drained, very deep, dark brown, firm, strongly calcareous, moderately saline, strongly sodic clay, with a topsoil of sandy clay loam (calcic LUVISOLS, saline-sodic phase)

A12 **AAvc (ao)** 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)

A13 **AAvp (ao)** poorly drained, very deep, very dark grey, very firm, moderately calcareous, slightly saline, slightly to moderately sodic, cracking clay (pellic VERTISOLS, saline-sodic phase)

A14 **AAgh** poorly drained, deep, dark greyish brown, mottled, firm clay, with an acid humic topsoil (humic GLEYSOLS)

A15 **AAgm** poorly drained, deep, very dark grey, mottled, firm clay, with a humic topsoil and a sulfidic deeper subsoil (mollic GLEYSOLS)

A16 **AAjt (a)** very poorly drained, deep, dark grey, soft (unripe), strongly saline, strongly sulfidic, clay (thionic FLUVISOLS, saline phase)

A17 **AAlk+vp (ao)** 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 (calcic 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 **AAje** 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)

A8+A12 — AAjc+vc (ao) — complex of soils of units A8 and A12

B — **BOTTOMLANDS**

BP — **Soils developed on infill from volcanic ashes**

B1 — BPwh — 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)**

B2 — BIgm — poorly drained, moderately deep, dark grey to grey, mottled, firm clay, with a humic topsoil; in many places over petroplinthite (mollic GLEYSOLS, partly petroferric phase)

BV — **Soils developed in infill from undifferentiated volcanic rocks**

B3 — 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)

B4 — BVv+z — 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)

B5 — BVwe — poorly drained, deep, grey to light olive brown, mottled, firm clay, abruptly underlying a thick topsoil of silt loam (eutric PLANOSOLS)

B6 — 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)

BU — **Soils developed on infill mainly from undifferentiated Basement System rocks (predominantly gneisses)**

B7 — 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)

B8 — BUso — imperfectly drained to poorly drained, very deep, brown to dark brown, very firm, slightly calcareous, strongly sodic clay (orthic SOLONETZ)

B9 — 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* GLEYSOLS)

B10 — 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 GLEYSOLS and plinthic ACRISOLS)

B11 — 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 GLEYSOLS; with eutric PLANOSOLS and some dystric HISTOSOLS)

BL — **Soils developed on infill from limestones**

B12 — BLzt — imperfectly drained to poorly drained, deep, very firm, greyish brown to dark reddish brown, strongly calcareous, strongly saline, cracking clay loam (takyric SOLONCHAKS)

B13 — BLch — poorly drained, deep, very dark grey to very dark brown, firm, moderately calcareous, clay loam to clay, with a humic topsoil (haplic CHERNOZEMS)

BS — **Soils developed on infill from gritty sandstones (Taru grits)**

B14 — 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)

BJ — **Soils developed on infill from lagoonal deposits (Kilindini sands)**

B15 — 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 (gleyic PHAEOZEMS; with verto-luvic PHAEOZEMS and pellic VERTISOLS, sodic phase)

B16 — 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)

MISCELLANEOUS LAND TYPES

D — **DUNES**

D1 — Dqk — excessively drained, very deep, brown, loose, moderately calcareous, loamy sand to sandy loam (calcaro-cambic ARENOSOLS)

D2 — Dqc — excessively drained, very deep, brown to pale brown, loose, sand to loamy sand (cambic ARENOSOLS)

D3 — Dbk (a) — 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)

D1+PI3 — Dqk+PIAz — complex of soils of units D1 and PI3

La–S–T–V–W–Z

La — **LAVA FLOWS**

Lava — La: excessively drained, exceedingly bouldery to stony, extremely rocky land (Boulders and Rock Outcrops)

S — **SWAMPS**

S1 — Szg (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 (gleyic SOLONCHAKS, sodic phase and partly fragipan phase)

S2 — Sgh: very poorly drained, very deep, very dark grey to black, firm, cracking clay, with an acid humic topsoil; seasonal swamps (humic GLEYSOLS)

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 GLEYSOLS and dystric HISTOSOLS)

T — **MANGROVE SWAMPS**

T — 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 gleyic 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)

Z — **COASTAL OR LAKE-SIDE BEACH RIDGES**

Z1 — **Soils developed on older coastal beach ridges**

Z1 — Z1fr: well drained, very deep, red, very friable, sandy clay loam (rhodic FERRALSOLS)

Z2 — **Soils developed on younger coastal beach ridges often covering coral rock**

Z2 — 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)

Z3 — **Soils developed on lake-side beach ridges**

Z3 — 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)

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 *Kindaruma* 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 *Kapenguria* 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 Kwale-Mombasa-Lunga lunga area (quarter degree sheets *200, 201, 202*)	1:100,000
R4	W.G. Wielemaker and W.H. Boxem, 1982, Soils of the *Kisii* area (quarter degree sheet *130*)	1:100,000
R5	F.N. Muchena and C.R.K. Njoroge, in prep., Soils of the *Makueni* area (quarter degree sheet *163*)	1:100,000
R6	L. Touber, 1982, Soils and vegetation of the *Amboseli-Kibwezi* area (quarter degree sheets *173, 174, 181, 182*)	1:250,000
R7	W. van Wijngaarden, 1982 Soils and vegetation of the *Tsavo* 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 *Busia* 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 *Bura East* Irrigation Settlement Scheme	1:100,000

(b) **Semi-detailed soil surveys**

S1* J. Thorp et al., 1960, Soil survey of the *Songhor* area. Govt. Printer, Nairobi 1: 50,000
S2* F.T. Miller et al., 1961, Soil survey of the *East Konyango* 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 *Muhoroni* area 1: 50,000

(c) **Detailed soil surveys**

D2 F.N. Muchena and G. Ngari, 1975, Soils of the proposed *Wamumu* 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 *Kimala* Irrigation Scheme (Taita-Taveta District) 1: 5,000
D4 H. Bonarius and E.N.K. Mugai, 1977, Detailed soil survey of the *Jara-Jara* Irrigation Scheme (Mbalambala) 1: 2,500
D5 E.N.K. Mugai and H. Bonarius, 1977, Detailed soil Survey of the *Kainuk* I Irrigation Scheme (Turkwel river) 1: 5,000
D6 P.J.K. Kanake and E.N.K. Mugai, 1977, Detailed soil survey of the *Mnazini* Irrigation Scheme (Lower Tana area) 1: 2,500
D7 W. Siderius and R.M. Muriuki, 1977, Detailed soil survey of the Seeds Testing Station, *Lanet* (Nakuru) 1: 5,000
D8 P.J.K. Kanake and E.N.K. Mugai, 1977, Detailed soil survey of the *Wema* and *Hewani* Irrigation Schemes (Lower Tana) 1: 5,000
D9 E.N.K. Mugai, 1977, Detailed soil survey of the *Malka Daka* Irrigation Scheme (Ewaso Nyiro) 1: 5,000
D10 O.O. Oswago, 1979, Detailed soil survey of *Kibirigwi* 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 *Bura* Irrigation Settlement Project 1: 5,000
D14 H.C.K. Kinyanjui, 1980, Detailed soil survey of *Tatton Farm*, 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 *Lanet* (Nakuru) 1: 5,000
D17 P.J.K. Kanake, 1981, Detailed sóil survey of the *Oda* Irrigation Scheme 1: 5,000
D18 P.J.K. Kanake, 1981, Detailed soil survey of the *Ngao* Irrigation Scheme 1: 5,000

(d) **Site evaluations**

P2 R.F. van de Weg, 1972, Report of a site evaluation trip to *Lake Kenyatta* Cotton Scheme (Lamu District)
P3 H.M.H. Braun and S.M. Wokabi, 1973, Irrigation suitability of the *Olkeramatian* experimental area 1: 50,000
P4 H.F. Gelens and G. Ngari, 1973, Report of a site evaluation of the proposed location of *Alupe* sub-station 1: 12,500
P5 N.N. Nyandat, 1973, A reconnaissance survey of arable land in the area *East of Meru* town 1: 50,000
P6 H.M.H. Braun and N.N. Nyandat, 1972, Report of a visit to the experiment area of the *Ishiara* 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 *Merti* area (Isiolo District) 1: 50,000

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

P8 H.F. Gelens and G. Ngari, 1973, Report of a site evaluation for a proposed irrigation project at *Kunati* (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 *Mandera-Ramu* area (North Eastern Province) 1: 55,000
P11 H.M.H. Braun and H.W. Okwaro, 1974, Drainage problems of soils in the *Bomet* area 1:100,000
P12 J.J. Vleeshouwer and J.P. Mbuvi, 1974, A preliminary evaluation of the irrigation suitability of the soils and the waters of *Katilo* irrigation Scheme With a photo-interpretation map of the middle *Turkwel* valley 1: 20,000 1:100,000
P14 W.G. Sombroek, J.P. Mbuvi, J.M. Kibe and H.W. Okwaro, 1974, A preliminary evaluation of the irrigation suitability of the lands in the *middle-lower Tana Valley* 1:100,000
P15 W.G. Sombroek, J.P. Mbuvi and H.W. Okwaro, 1973, A preliminary evaluation of the irrigation suitability of the lands in the *pre-delta Tana floodplain* 1: 50,000
P17 J.J. Vleeshouwer and D.O. Michieka, 1975, Irrigation suitability of the soils and waters of the floodplain of the *Kerio* river NE of *Lokori* (Turkana District) 1: 40,000
P18 J.P. Mbuvi, 1975, A preliminary evaluation on the suitability of the area of *Busia* District for sugarcane development 1:100,000
P19 J.P. Mbuvi and R.F. van de Weg, 1974, A preliminary evaluation of the soils around *Nyangoma Mission* (Bondo Division) 1: 50,000
P20 H. Bonarius and P.N. Njoroge, 1974, A preliminary evaluation of the irrigation suitability of lands in the *Kanjoo* area (Meru District) 1: 25,000
P21 W.G. Sombroek, J.P. Mbuvi and R.A. Leyder, 1975, Preliminary evaluation of soil conditions on the East bank of the lower Tana (*Bura East area*) 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. Mbuvi, 1975, Evaluation of *Tana delta* soils for large scale irrigation development 1:100,000
P24 W. Siderius, 1978, Soils resources of the *Upper Kerio Valley* - a preliminary investigation 1:100,000
P25 J.P. Mbuvi and R.F. van de Weg, 1975, Some preliminary notes on the soils of *Katumani, Kampi ya Mawe, Embu* and *Murinduko* Agricultural Research Stations 1: 10,000 1: 3,750 1: 3,000
P26 W. Siderius and E.B. Njeru, 1976, Soil conditions in the *Muthangene Location* (Meru District) 1: 25,000
P27 F.N. Muchena, 1976, Soil resources of *Maseno* Division (Kisumu District); a preliminary investigation 1:100,000
P28 W. Siderius and E.B. Njeru, 1976, Soils of *Trans-Nzoia* District 1:100,000
P29 J.P. Mbuvi and E.B. Njeru, 1977, Soil resources of the *Mau Narok* area (Narok District); a preliminary assessment 1:100,000
P30 R.F. van de Weg and W.G. Sombroek, 1976, Soil conditions of the *Marafa-Magarini* 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 *Mitunguu-Materi* 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 *Kenya Inspection Service for Seeds*, Lanet (Nakuru) 1: 12,500
P33 W. Siderius, 1977, Soil conditions in the *Kimalewa area* (Bungoma District) 1: 25,000
P34 J.R. Rachilo, 1978, Soil conditions of the *Kinangop Plateau* 1:100,000

P35 F.N. Muchena and C.R.K. Njoroge, 1977, The soil resources of *Kiteta* Location (Machakos District); a preliminary investigation — 1: 50,000

P36 D.O. Michieka, 1977, Soils of the Valley bottoms of the *Kabete Veterinary Labs.*, Nairobi; a preliminary assessment for irrigation suitability — 1: 10,000; 1: 50,000

P37 D.O. Michieka and W. Siderius, 1978, The soil and land suitability for irrigation of three sites in the Upper Tana catchment area (*Kunati, Ishiara* and *Rupingazi* - Eastern Province) — 1: 10,000; 1: 40,000

P38 B.J.A. van der Pouw (ed.), 1978, Soil conditions of the *Kinna-Rapsu* area (Isiolo/Meru Districts) — 1: 50,000

B. **Maps and reports by other agencies**

(a) **Reconnaissance soil surveys**

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Rc USAID, 1978, Kenya marginal/semi-arid lands pre-investment inventory. Vol. 10, part I, *Machakos-Kitui-Embu* area, Min. of Agric., Nairobi — 1:250,000

Rd Do., part II, *Baringo-Kerio valley* area — 1:250,000

(b) **Semi-detailed soil surveys**

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Sb J. Makin and N.N. Nyandat, 1965, A reconnaissance investigation of the agricultural potential of the Lambwe valley. Govt. Report — 1: 50,000

Se J. Makin and V. D'Costa, 1966, The soils of the country around Mumias. Govt. Report — 1: 12,500; 1: 30,000

Sg G.A. Woodruff, 1967, Reconnaissance soil map of Sotik area

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

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

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Di N.N. Nyandat, 1968, The soils of the *Wamumu* cotton scheme (Kirinyaga district). Govt. Report — 1: 6,250

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- 53 Baragoi area, 1963
- 57 Wajir-Wajir Bor area, 1963
- 60 South Horr area, 1963
- 72 Karasuk area, 1966

74 Loperot area, 1966
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87 South of Lodwar, 1971
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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 fulfils 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 Mbuvi, 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 Mbuvi, 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:

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

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:

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

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

zone	r/Eo ratio (%)
I	> 80
II	65 - 80
III	50 - 65
IV	40 - 50
V	25 - 40
VI	15 - 25
VII	< 15

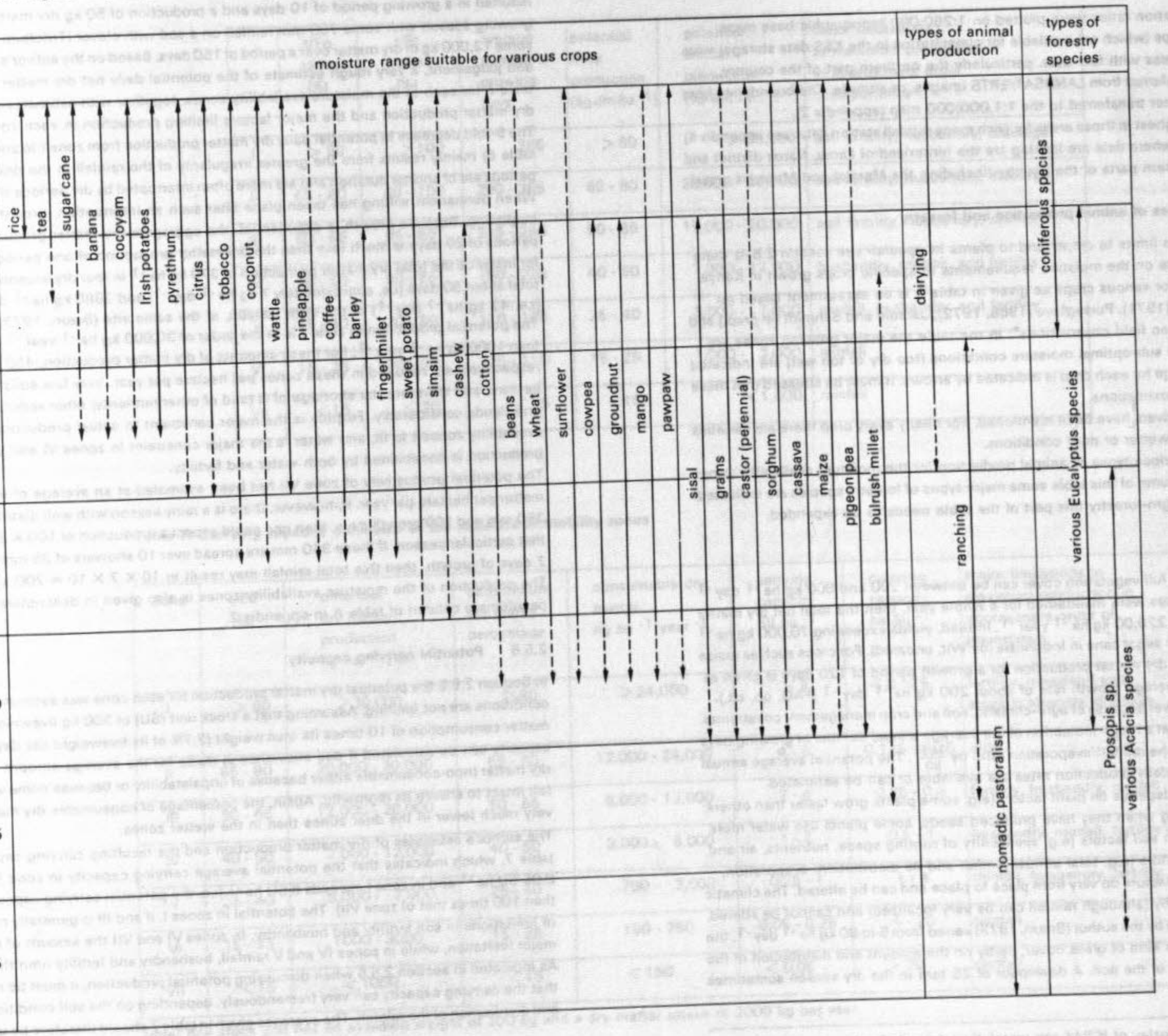
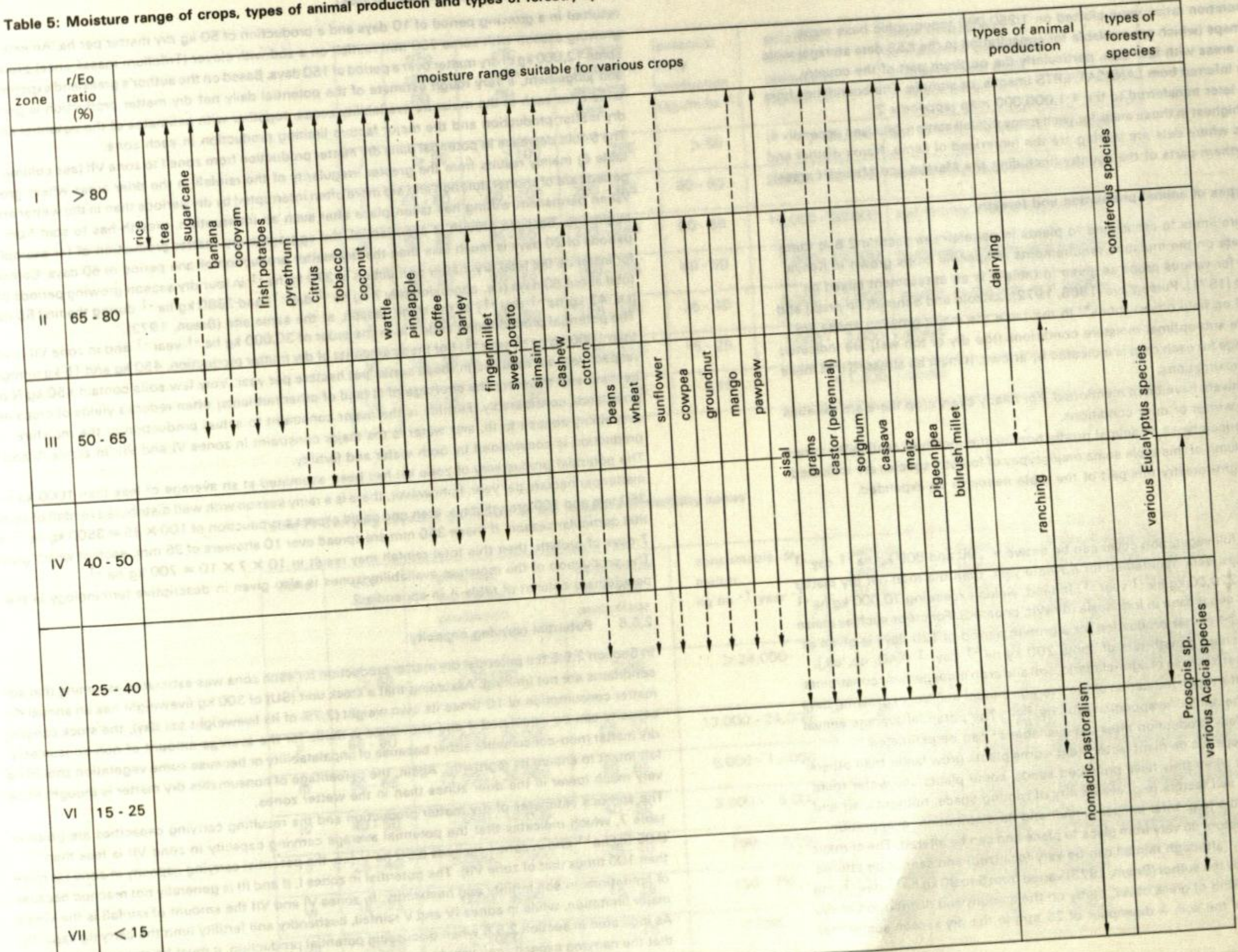


Table 5: Moisture range of crops, types of animal production and types of forestry species



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 wich 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 220,00 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.

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*) 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 2/3Eo 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 2/3Eo

Zone	annual r/Eo (%)	Seasonal P r < 2/3Eo (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	
I		in 1000 ha	in %
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:

$$T \text{ mean (in °C)} = 30.2 - 0.00198 \text{ h (feet)}$$
$$= 30.2 - 0.00650 \text{ h (metres)}$$

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:

$$T \text{ mean (in °C)} = 26.1 - 0.00198 \text{ h (feet)} + 0.041 \text{ d (km)}$$
$$= 26.1 - 0.00650 \text{ h (metres)} + 0.041 \text{ d (km)}$$

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

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

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 (°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 exsist 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°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

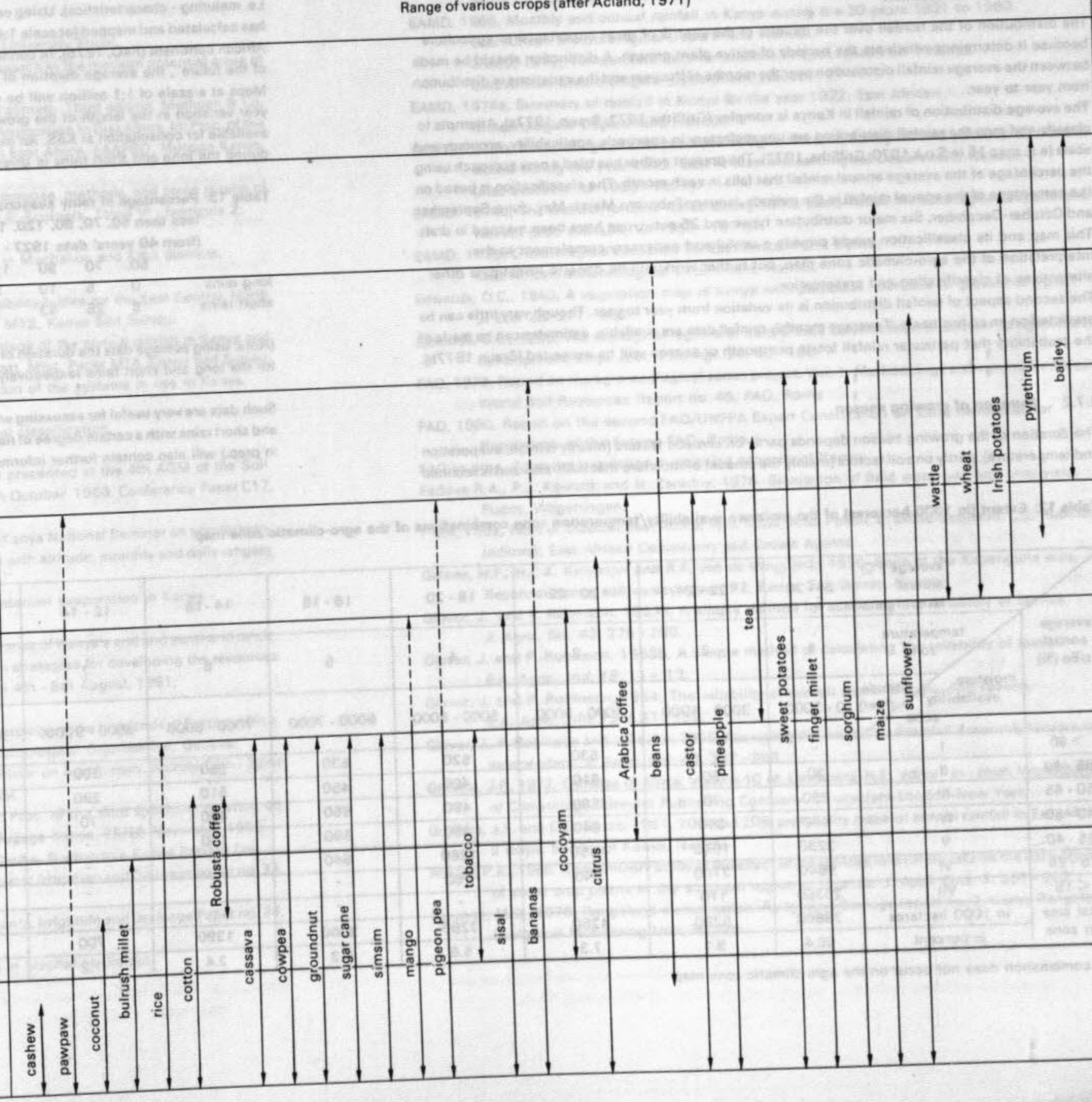
2.6.8 Extent of the temperature zones and the moisture availability/temperature zone combinations

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

Temperature zone	Altitude (feet)	Average Annual Temperature (°C)
9	>10,000	<10
8	9000 - 10,000	10 - 12
7	8000 - 9000	12 - 14
6	7000 - 8000	14 - 16
5	6000 - 7000	16 - 18
4	5000 - 6000	18 - 20
3	4000 - 5000	20 - 22
2	3000 - 4000	22 - 24
1	< 3000	24 - 30

Range of various crops (after Acland, 1971)



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 (%)	average annual temperature (°C)	24 - 30	22 - 24	20 - 22	18 - 20	16 - 18	14 - 16	12 - 14	10 - 12	<10	Total area per zone	
	temperature zone	1	2	3	4	5	6	7	8	9	in 1000 hectare	in per cent
	moisture availability zone / altitude (feet)	0 - 3000	3000 - 4000	4000 - 5000	5000 - 6000	6000 - 7000	7000 - 8000	8000 - 9000	9000 - 10,000	>10,000		
>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 per cent	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.

Vegetation and Climate Maps of South-Western Kenya

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VEGETATION AND CLIMATE MAPS OF SOUTH WESTERN KENYA

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1987

CONTENTS

INTRODUCTION

This note accompanies two sets of maps of the South-western Kenya highlands at 1/250 000 scale, showing vegetation and climate-vegetation respectively. These maps, originally commissioned by the Kenya Government to provide an aid for strategic agricultural planning, have been produced by the Land Resources Development Centre (previously the Land Resources Division) of the British Government's Overseas Development Administration and the Overseas Surveys Directorate of the Ordnance Survey (previously the Directorate of Overseas Surveys). The first of these maps was published in 1966 and the last in 1986.

The background to the undertaking is outlined below.

BACKGROUND

The climate of the south-western Kenya highlands is extremely variable, resulting in a quite exceptional range of vegetation types, and an equally marked diversity in agricultural potential. This was recognised by the early workers (e.g. Edwards, 1940), and led the Department of Agriculture in the 1950's, upon a basis produced by L H Brown, to adopt a number of broad ecological zones as a practical guide to land potential for agricultural planning purposes. As part of the process of agricultural planning at District level, District Agricultural Officers were required to produce gazeteers for their Districts, in which development plans and extension programmes were to be based on these zones. This was of some importance as at this time very considerable investment in agricultural development was being made under the Swynnerton Plan, including a considerable extension of cash crop production (tea, coffee, pyrethrum etc.), the areas to be planted being largely based on the zonal mapping in the District Gazetteers.

The use of ecological zones for agricultural development planning rested on the concept that climax vegetation communities develop in response to local limitations of climate and soil. In the absence of detailed soil survey and a complete network of climatic stations, mapping climax vegetation is therefore an indirect means of establishing the limits of different eco-climatic zones, each suitable for a specific range of crops.

It became apparent, however, that the pattern of variation was in many cases less simple than appeared and, in some regions, could not well be accommodated in the L H Brown scheme. In consequence the Department of Agriculture asked the East African Agricultural and Forestry Research Organisation (EAAFRO) whether its ecologist - C G Trapnell - could resolve the discrepancies in the District ecological zones. To this end he carried out a series of reconnaissance traverses of the vegetation in south western Kenya in 1957, in cooperation with local officers of the Department of Agriculture. The reconnaissance showed that the range of vegetation types was considerably greater than previously recognised. In addition the pattern was complicated by large-scale invasions of species proper to other zones, as a sequel to the effects of human occupation. It was thus clear that a fresh survey ab initio would be required, if a full ecological framework for strategic agricultural planning was to be produced.

This led in 1958 to a formal request from the Kenya Ministry of Agriculture for assistance from EAAFRO and the British Government Directorate of Overseas Surveys (DOS) for a new ecological survey, with certain assistance from members of the Agricultural Department. The area to be covered was to be approximately 40 000 square miles, which would include all the areas of high potential in Kenya other than the coastal strip. The survey was directed by C G Trapnell (ecologist, EAAFRO) with the help of the following seconded staff: M A Brunt (land use officer, DOS, later LRDC), and W R Birch (pasture research officer, Kenya Department of Agriculture). Additional help for shorter periods was given by Mr D J Pratt (pasture research officer, Kenya Department of Agriculture), Mr E C Trump (ecologist, Kenya Veterinary Department) and Dr R Lawton (ecologist, LRDC).

The main field work was carried out between 1959 and 1961, combined with preliminary air photograph studies at EAAFRO. After C G Trapnell's retirement in 1962, further field work was undertaken by him in 1964 (with M A Brunt), 1972 (with R Lawton) and 1976 (with E C Trump) and again in 1980. Following field work, Trapnell undertook re-interpretation of the air-photography, and revision of the 137 1/50 000 scale field maps. The Directorate of Overseas Surveys, with the assistance of the Cartographic Section of LRDC, carried out the plotting work and reduced the field sheets to the publication scale of 1/250 000. In addition a supplementary set of 1/250 000 scale climatic maps on a topographic base was prepared at the Directorate from data specially provided by the East African Meteorological Department. The maps were printed by the Ordnance Survey and published as follows:

Sheet 1	Vegetation	1966	Sheet 2	Vegetation	1976
Sheet 3	Vegetation	1969	Sheet 2	Climate	1976
Sheet 1	Climate	1969	Sheet 4	Vegetation	1986
Sheet 3	Climate	1970	Sheet 4	Climate	1986

As each map was published, copies were distributed to Kenya Government Departments and internationally to scientific institutions. Copies of the maps, and relevant 1/50 000 field sheets, were also supplied to help with the planning of specific major developments: e.g. the Cherangani tea scheme, and the Tana river basin project. The extended period of publication was mainly due to the magnitude of the undertaking and to Trapnell's retirement in 1962. The subsequent work was carried out in England in his own time.

THE VEGETATION MAPS

A broad provisional classification of the natural vegetation - reflecting variations in climate - was established during the 1957 reconnaissance work. Thirteen major communities were then recognised:

1. Montane Moorland
2. Montane Open Grassland
3. Montane Bamboo Forest
4. Montane Sclerophyll Forest
5. Moist Montane Forests
6. Moist Intermediate Forests
7. Dry Intermediate Forests
8. Upland Evergreen Bushland
9. Intermediate Semi-Evergreen Thicket
10. Broad-leaved Savanna Woodland
11. Thorn Woodland and Savanna
12. Thorn Bushland
13. Desert Thorn Scrub

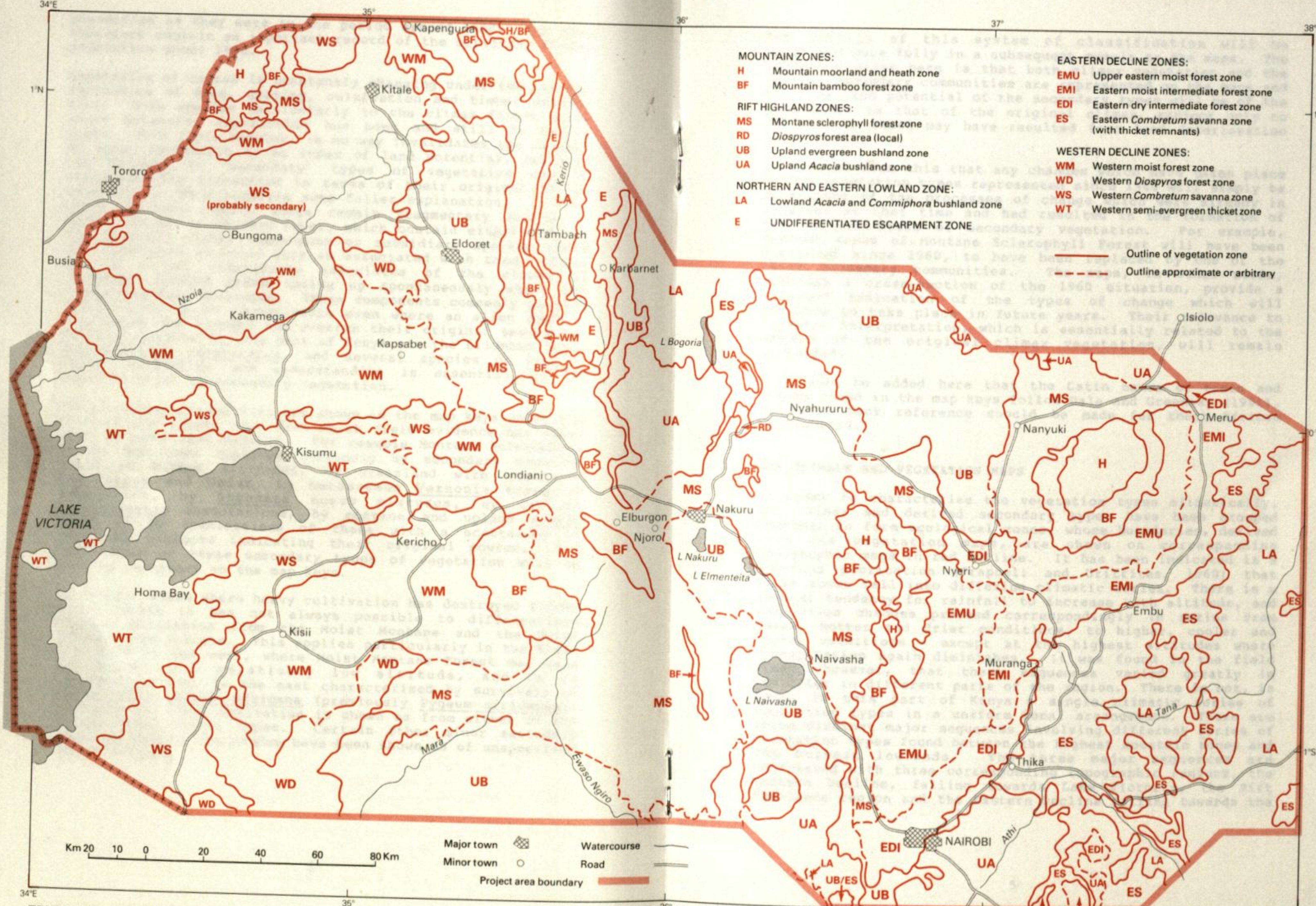
Using this provisional classification, field work was carried out during a series of Land Rover traverses along all the tracks in the less accessible areas, and in a close network over the remainder of the area. Traverses were as close as a mile apart in the most densely populated and altered areas of the former Kikuyu, Embu and Meru Reserves. Changes in vegetation were recorded by plotting the detailed traverse observations on 1/50 000 maps in the field, including the results of field glass observations on either side of the traverse route. The field observations were subsequently transferred from the field maps to air photographs, and used as the basis for a stereoscopic study of the vegetation pattern on the air photographs.

During this study the boundaries of the vegetation zones were plotted and extrapolated, before being transferred to 1/50 000 maps. The air photographs used initially were the RAF 1/30 000 scale ones taken between 1945 and 1950. These, however, were of very varying quality and were supplemented extensively by RAF 1/50 000 scale photographs taken between 1957 and 1963. Some of the 1967 RAF photography was also used, together with Hunting Surveys Ltd 1969 air photography of vegetation sheets 2 and 4, and, in certain cases, Canadian Air Survey air photography of the forest reserves. Thus although as many as three sets of air photography have been used in interpretation over large areas of the maps, it has been attempted as far as possible to plot vegetation boundaries as they were in the period around 1960. The maps therefore contain an important record of the surviving climax vegetation about 1960.

Vegetation of course is constantly changing under the several influences of fire, grazing, cultivation and timber extraction. This applies particularly to the climax forest areas where extensive destruction has been and still is taking place. This fact, however, in no way invalidates the concept of using vegetation as an index of land potential, provided the derived or 'secondary' types of vegetation can be satisfactorily classified in terms of their original climax vegetation. This requires some fuller explanation. In most parts of this region there remain fragmentary relics of former forest or thicket cover, which contain either some of the original climax components or subsidiary species which are observable in field work as associated with them. These may be either understorey associates of the climax or 'pioneer' species which spring up spontaneously where the climax has been destroyed. These components commonly persist sufficiently to be recognisable even where an alien bush or tree cover has invaded and overrun their original territory. Notable invaders is this part of Kenya are the Lileshwa bush, Tarchonanthus camphoratus, and several species of Acacia. Their recognition and understanding is essential in the classification of secondary vegetation.

The secondary communities are shown in the map keys under the head of the climax type from which field evidence has shown them to have been derived. For example Montane Sclerophyll Forest has been replaced variously by secondary mountain scrub at higher altitudes, by grassland with scattered Podocarpus and Cedar, by herbaceous Vernonia types of vegetation, by Dodonaea scrub mixtures, by various Tarchonanthus associations, by montane and upland Acacia types or by combinations of these with a scattering of evergreen elements indicating their original source. The full range of these secondary types of vegetation will be seen by reference to the map keys.

In certain areas where heavy cultivation has destroyed former moist forest it was not always possible to differentiate between derivation from the Moist Montane and the Moist Intermediate forests. This applies particularly in the Kisii highlands in the west, where Moist Montane Forest may have descended to a relatively low altitude, and to an intermediate belt in the east characterised by survivals of the hardwood Prunus africana (previously Pygeum africanum). In these two cases derivation is shown as from either of the climax moist forest types. Certain other minor secondary types of limited occurrence have been shown as of unspecified forest origin.



TEXT MAP 1 Zonal grouping of vegetation types

Prepared by Land Resources Development Centre 1986

The details of this system of classification will be described more fully in a subsequent memoir to the maps. The important point here is that both climax vegetation and the related secondary communities are represented on the maps and that the land potential of the secondary types will be of the same order as that of the original climax, subject only to differences which may have resulted from land deterioration and erosion.

It follows from this that any changes which have taken place in the vegetation types represented since 1960 will simply be extensions of the processes of change which were already in progress at that time and had resulted in the formation of the various areas of secondary vegetation. For example, further areas of Montane Sclerophyll Forest will have been disturbed since 1960, to have been replaced by one of the above secondary communities. The maps, in other words, although a cross-section of the 1960 situation, provide a detailed indication of the types of change which will continue to take place in future years. Their relevance to climatic interpretation, which is essentially related to the nature of the original climax vegetation, will remain unchanged.

It should be added here that the Latin names of trees and shrubs cited in the map keys follow Dale and Greenway (1961), to whose book reference should be made for their African equivalents.

THE CLIMATE AND VEGETATION MAPS

In order to characterise the vegetation types climatically, the climax and derived secondary types have been grouped together to form ecological zones, whose boundaries, derived from the vegetation maps, are shown on corresponding topographic maps in red outline. It has been indicated in a previous publication (Trapnell and Griffiths, 1960) that these zones fall into differing climatic series. There is a general tendency for rainfall to increase with altitude, and vegetation changes proceed correspondingly in series from lower, hotter and drier conditions, to higher, cooler and wetter conditions - except at the highest altitudes where precipitation again diminishes. It was found in the field study, however, that these sequences varied greatly in character in different parts of the region. There is not, in fact, in this part of Kenya a single climatic series of vegetation types in a uniform zonal arrangement. There are three distinct major sequences involving different series of vegetation types found between the highest mountain zones and the hottest lowlands. The three major sequences are associated with three corresponding topographic regions, the Western Decline, falling towards Lake Victoria, the Rift Highlands region and the Eastern Decline falling towards the

Indian Ocean. The climates of these three regions are subject to differing monsoon controls and both seasonal rainfall and the seasonal temperature curves are affected. The regional zonal groupings adopted are therefore as follows.

Mountain Zones

H Mountain moorland and heath
BF Mountain bamboo forest

Western Decline Zones	Rift Highland Zones	Eastern Decline Zones
WM Western moist forest	MS Montane sclerophyll forest	EMU Upper eastern moist forest
WD Western *Diospyros* forest	RD *Diospyros* forest area (local)	EMI Eastern moist intermediate forest
WS Western *Combretum* savanna	UB Upland evergreen bushland	EDI Eastern dry intermediate forest
WT Western semi-evergreen thicket	UA Upland *Acacia* bushland	ES Eastern *Combretum* savanna

Northern and Eastern Lowland Zone

LA Lowland *Acacia* and *Commiphora* bushland

These zonal groupings are shown on the second series of 1/250 000 scale maps of climate and vegetation, which supplement the vegetation maps. They are summarised in Text Map 1. The symbols on this text map are the same as those used on the larger maps. The latter however, also have a number, which is simply a convenient locational reference for use when studying local climatic variations.

To provide the information for these climatic maps the Meteorological Department undertook the screening of their records and the preparation of a tabulation of the altitudes, mean monthly rainfall and yearly rainfall totals for all recording stations with records of eight years or more in 1960. This undertaking involved a total of some 550 stations, which were arranged under their reference numbers for each of the 1/50 000 map sheets. The rainfall/altitude ratios, i.e. the number of inches per thousand feet of altitude, were also calculated for every station (see EA Meteorological Department, 1961). For the relevance of this ratio see Trapnell and Griffiths, 1960. Its importance lies in the fact that it has produced a striking correlation with the vegetation zones of the Rift Highland region and that it provides a means of assessing differences in rainfall-temperature combinations in areas where temperature-recording stations are few and far between.

Using the records of the Meteorological Department, histograms of seasonal rainfall patterns were also prepared for selected stations and classified according to similarities of pattern. The classification was then extended to a scatter of other stations on the map so as to provide an overall picture of the distribution of each pattern. Potential evaporation, taken from Woodhead's figures (reference, 1968) was also superimposed on the histograms of certain stations for which the source data are complete. At the same time graphs were produced from the Meteorological Department's records (ref. 1961) to show monthly mean maximum and minimum temperatures for the main stations for which records are available. The object has been the production of a climatic map which shows, against its topographic and vegetational background, the available climatic data, without the hypothetical interpolation normally used in producing maps of climatic factors. The data shown on the climatic vegetation map therefore show for each recording station the mean annual rainfall as at 1961, the type of seasonal rainfall pattern, and locally the seasonal temperature pattern, together with the rainfall-altitude ratio. Other vital data relating to atmospheric humidity, wind strength and direction, cloud cover, insolation and hours of sunshine, are available only from the very few First Order Stations - see EA Meteorological Department (1947) and Woodhead (1968); in some instances, such as the occurrence of mists and of frost at higher altitudes, there is little more than verbal information. It is hoped to produce a coordinated account of the climatic regimes of each zone, based on the available data, at a later date.

With regard to the zones shown on the accompanying small-scale map, two modifications should be noted:-

(1) In the Western Savanna zone the greater part of the northern sector has been differentiated as 'probably secondary'. This has been done because later evidence suggests that much of the Combretum vegetation of this part may have originated in the distant past from former forest cover, or, in an area between Bungoma and the Uganda border, from semi-evergreen thicket.

(2) On the line of division between Sheets 2 and 4 a revised boundary has been inserted separating the Eastern Savanna from the Lowland Acacia zone. This demarcation is necessarily arbitrary as it crosses extensive impeded drainage areas with Acacia drepanolobium, a type which recurs in both zones. It may be mentioned, also, that the small belt of former Diospyros forest, RD on Sheet 2, may formerly have extended south towards Menengai through what is now Erythrina and Acacia vegetation.

The small-scale map is intended as a guide for picking up the zones on the larger sheets. The application of these to crop potentialities will be obvious - areas suited to specific crops can readily be determined. In recent years, however, with the pressures of an ever-growing population, the emphasis has moved away from cash crop development towards the necessities of extended subsistence settlement and of land conservation. The vegetation maps will provide a measure of the rate and extent of destruction of forests and natural vegetation cover since 1960. At the same time they should contribute to the understanding of the processes of change, which is essential for conservation management. The parallel climatic maps offer a unique basis for the further analysis and understanding of the climate in south western Kenya. As noted above, further work on this is projected and will be reported elsewhere. The results should provide valuable base-line information for work at other institutions, including the projected African Centre for Meteorological Applications for Development (ACMAD).

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