Ministry of Agriculture

National Agricultural Laboratories

Fertilizer Use Recommendation Project (Phase I)

Final Report

Annex III

Description of the First Priority Sites in the Various Districts

Volume 12

West Pokot District

District No.: 12

Nairobi, June 1987

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Project Team

Team of Consultants[1]		Professional Staff from NAL[2]
	Project Coordination	
H. Ströbel (ed.) Project Coordinator		G.Hinga Director NAL S.W.Nandwa Counterpart Coordinator
	Agro-Climatologists	
R. Jätzold R. Rötter		J.W. Onyango
	Soil Scientists / Surveyors	
R.F. van de Weg E.M.A. Smaling		F.N. Muchena C.K.K. Gachene J.M. Kibe
	Soil Chemists	
P. Pietrowicz		J.N. Qureshi P.O.S. Oduor
	Agronomists	
A.Y. Allan		J.O. Owuor
	Data Processing	
H. Mayr R. Dölger A. Muliro		R.L. Milikau D.K. Wamae
	Land Surveyors	
R. Rötter		B. Mwangi S. Wataka
	Animal Production	
W. Bayer		

1) German Agency for Technical Cooperation (GTZ) (German Agricultural Team (GAT))

2) National Agricultural Laboratories

Fertilizer Use Recommendation Project (Phase I)

Contents of the Final Report

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Annex III, Volume 12

West Pokot District

Please note the following numbering mode of Tables and Maps:
First Number : District Number
Second Number: Trial Site Number
Third Number : Number of Table or Map within Chapter.

Contents of Chapter 12.0:

General Aspects

List of Tables

List of Maps

1. Climate and Soils of the District

The West Pokot District stretches from the Cherengani Hills in the south, to the lava mountains of the Karasuk Hills and their surroundings in the north. This rugged area beyond 2°N has agricultural possibilities in only a few pockets, so that the agro-ecological zonation was confined to the southern part of West Pokot.
Annual rainfall in this part of the District is variable, averaging from 500 to >1200 mm.

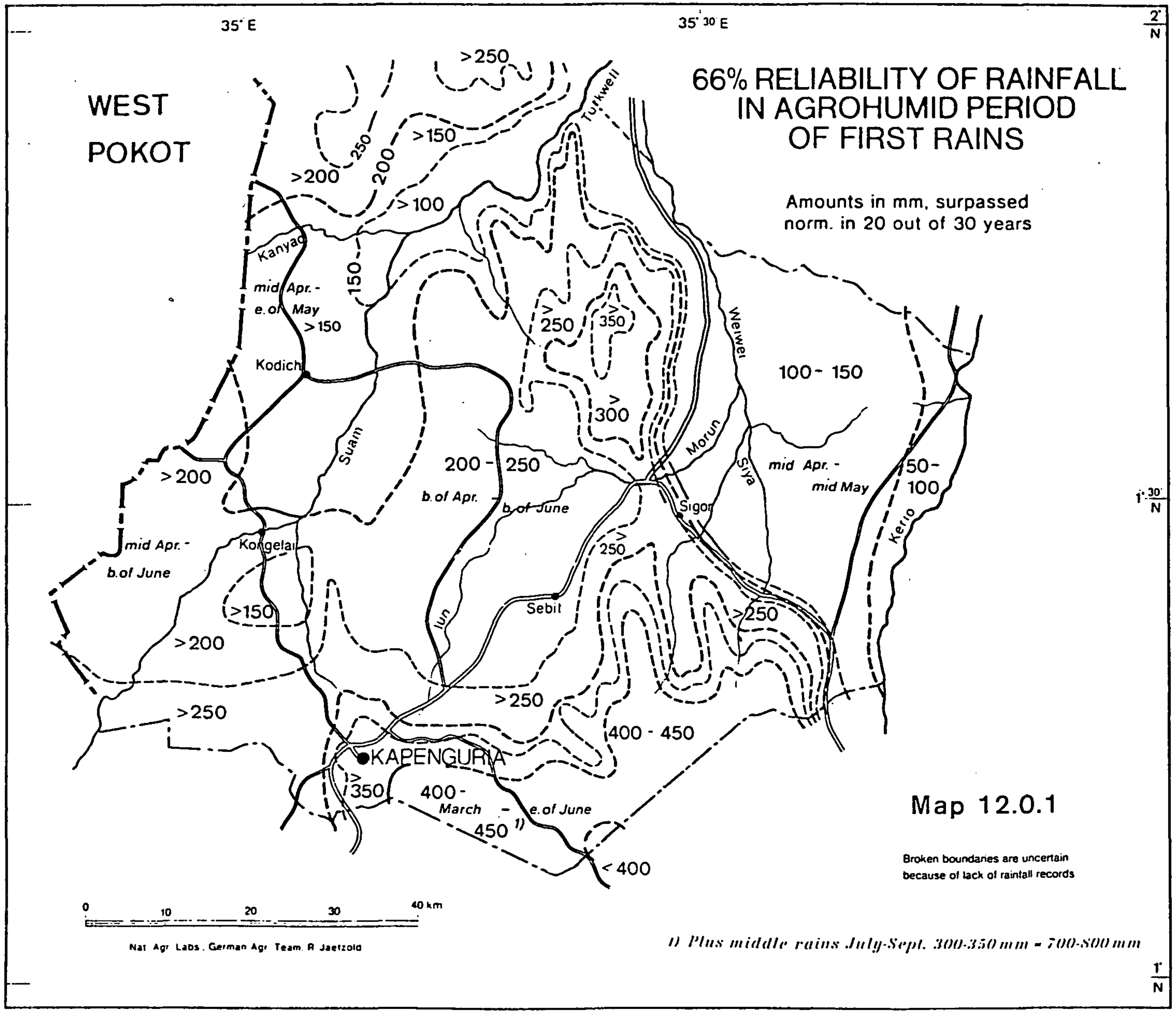
In this southern part, there are many areas which are also unsuitable for agriculture because of steep slopes, shallow soils and/ or too little rain. In the Cherengani Hills, some places are even too cold for cultivation due to sharp night frosts. There can be either very high ridges >3000 m (up to 3365 m), or micro-climatically unsuitable basins in which the cold air flows in and accumulates during the night. Xerophytic tropical-alpine grasses are mixed with grassland patches of zone UH 2, caused by relatively weak humid seasons and enforced water stress due to strong wind.
Slightly lower towards the west, the moisture availability is high enough for a potential tea zone (LH 1). Unfortunately, the forests there are being cleared and this potential is gradually declining. Without forests, rainfall is likely to decrease and there will be less relative humidity, lower temperatures during the night and the water holding capacity of the soils will be reduced. A perennial crop like pyrethrum would also be suitable in LH 2.
In the Upper and Lower Midland Zones, the annual average rainfall of 700-1200 mm seems relatively high, but evaporation is also high and the distribution of rainfall during the year is not parallel to the water requirements of the important crops. Moreover, a lot of rain is lost by run-off even in less sloping areas and the water holding capacity of the soils is variable. For this reason there are mixed zones: UM 4-5 and LM 5-6, whereby the more favourable potentials are found only on the better soils.

The rift valley floor is generally unsuitable for agriculture except for a slightly better strip of land near the escarpment and a few areas where irrigation is possibile.

The 66% reliability of rainfall, i.e. amount surpassed in 20 out of 30 years, is shown in Map 12.0.1 for the first and middle rains and in Map 12.0.2 for the second or third rains.

A summary of climatic data is compiled in Table 12.0.1, which can be used as a key to the Agro-Ecological Zones Map 12.0.3.

One of the best areas for agriculture in the District, the Wheat/Maize - Pyrethrum Zone (LH 2) is represented by the Kapenguria trial site (site No. 12.1).



66% RELIABILITY OF RAINFALL IN AGROHUMID PERIOD OF FIRST RAINS
Amounts in mm, surpassed norm. in 20 out of 30 years
WEST POKOT
35° E
35° 30 E
2° N
1° 30' N
1° N
Turkwell
Weiwei
Morun
Siya
Kerio
Suam
Iun
Kanyao
Kodich
Kongelai
Sigor
Sebit
KAPENGURIA
>250
>200
>150
>100
250
200
150
> 250
> 350
> 300
100 - 150
200 - 250
50 - 100
mid Apr. - e. of May
mid Apr. - mid May
b. of Apr. - b. of June
mid Apr. - b. of June
> 150
> 200
> 250
> 350
400 - 450
400 - March - e. of June 450 1)
< 400
Map 12.0.1
Broken boundaries are uncertain because of lack of rainfall records
0
10
20
30
40 km
Nat. Agr. Labs., German Agr. Team, R. Jaetzold
1) Plus middle rains July-Sept. 300-350 mm = 700-800 mm

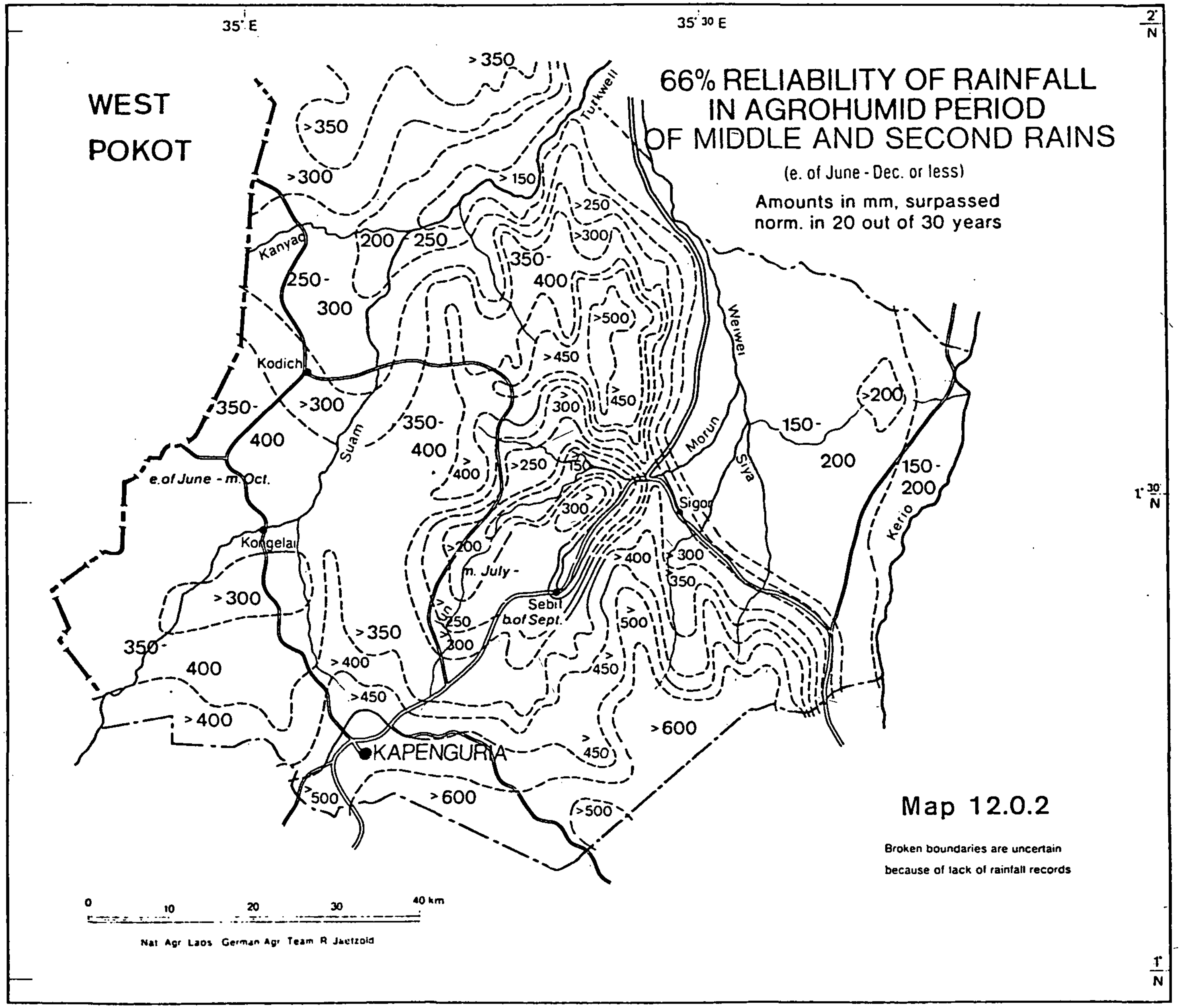

66% RELIABILITY OF RAINFALL
IN AGROHUMID PERIOD
OF MIDDLE AND SECOND RAINS
(e. of June - Dec. or less)
Amounts in mm, surpassed
norm. in 20 out of 30 years
WEST
POKOT
35° E
35° 30 E
2° N
1° 30' N
1° N
>350
>300
>150
>250
>300
200
250
250-
300
350-
400
>500
>450
>300
>450
Kodich
Kanyao
>300
350-
400
Suam
350-
400
>400
>250
150
e. of June - m. Oct.
>300
Kongelai
>200
m. July -
Sebit
b. of Sept.
250
300
>300
>350
350-
400
>400
>450
>400
>400
>350
>500
>450
>600
>450
KAPENGURIA
>500
>600
>500
Turkwell
Weiwei
Morun
Siya
Sigor
Kerio
>200
150-
200
150-
200
>300
350
Map 12.0.2
Broken boundaries are uncertain
because of lack of rainfall records
0
10
20
30
40 km
Nat Agr Labs German Agr Team R Jaetzold

Table 12.0.1 : Climate in the Agro-Ecological Zones of West Pokot District

Agro-Ecological Zone	Subzone	Altitude in m	Annual mean temperature in °C	Annual av. rainfall in mm	66 % reliability of rainfall[1]		66 % reliability of growing period		
					1st rains in mm	2nd rains in mm	1st rains[2] in days	2nd rains in days	Total[3] in days
TA I and TA II Tropical Alpine Zone		Unimportant grazing zones							
UH 1 Sheep-Dairy Zone	(vl)i or two	2 600–3 200	13.6–10.0	>1 250	370–450	550–650	110 or more	165–185	275–295
UH 1–2	(vl)i	2 400–3 000	14.8–11.2	>1 200	360–450	500–620	110 or more	155–175	265–290
UH 2 Wheat-Pyrethrum-Zone	(vl)i	Small steep strip, water catchment area, figures see Elgeyo-Marakwet							
LH 1 Tea-Dairy-Zone	(vl)i	2 100–2 370	16.6–15.0	>1 300	420–450	550–>600	110 or more	180–200	290–310
LH 2 Wheat/Maize-Pyrethrum Zone	vl/i or two (vl/l)i or two	1 900–2 400	17.9–14.8	>1 200 >1 150	360–420 320–410	520–600 480–600	110 or more 100 or more	160–180 130–160	270–290 230–260
LH 3 Wheat/Maize-Barley Zone	(l/vl)i	Mainly unsuitable soil or topography, figures see Uasin-Gishu							
LH 4 Cattle-Sheep-Barley Zone	(l)i	1 700–2 300	19.0–15.4	900–1 100	190–300	350–450	75 or more	120–130	195–205
UM 3 Marginal Coffee Zone	(l/vl)i or two	1 950–2 100	17.5–16.6	1 100–>1 200	280–360	460–600	90 or more	130–150	220–240
UM 4 Sunflower-Maize Zone	(l/vl)i (m/l)i	1 670–2 000	19.2–17.9	1 050–1 100 1 000–1 100	270–290 250–280	440–540 370–410	85 or more 70 or more	120–140 90–100	205–235 160–170
UM 4–5 Maize-Sunflower to Livestock-Sorghum-Zone (transition)	(l/m)i (m/l)i or (vs ⌐ s/m)i (m)i or (vs/s ⌐ fvs)i (m/l)i	1 380–1 850	21.0–18.1	950–1 100 880–1 000 800–1 050 860– 950	240–290 210–270 210–270 180–300	380–450 350–400 300–400 350–400	70 or more 55 or more 65 or more 65 or more	100–120 90–110 60– 80 75–105	170–190 145–170 125–145 140–170
UM 5 Livestock-Sorghum Zone	(m)i or two	1 380–2 100	21.0–16.6	680– 950	200–260	200–350	65 or more	60– 75	125–145
LM 4 Marginal Cotton Zone	(m/l)i or two	1 100–1 400	22.6–21.0	880– 950	240–300	350–400	70 or more	85–100	155–170
LM 4–5	(m/l)i or two	1 300–1 400	21.4–21.0	900–1 000	200–230	330–380	60 or more	80–110	150–170
LM 5 Lower Midland Livestock-Millet Zone	(m)i or (vs ⌐ s/vs)i (vs ⌐ fvs)i i(vs)i	1 150–1 500	22.3–20.5	780– 920 750– 800 700– 800	170–220 150–220 120–160	300–370 250–350 160–230	50 or more 45 or more <45	80– 90 60– 70 45– 60	130–140 100–110

cont'd

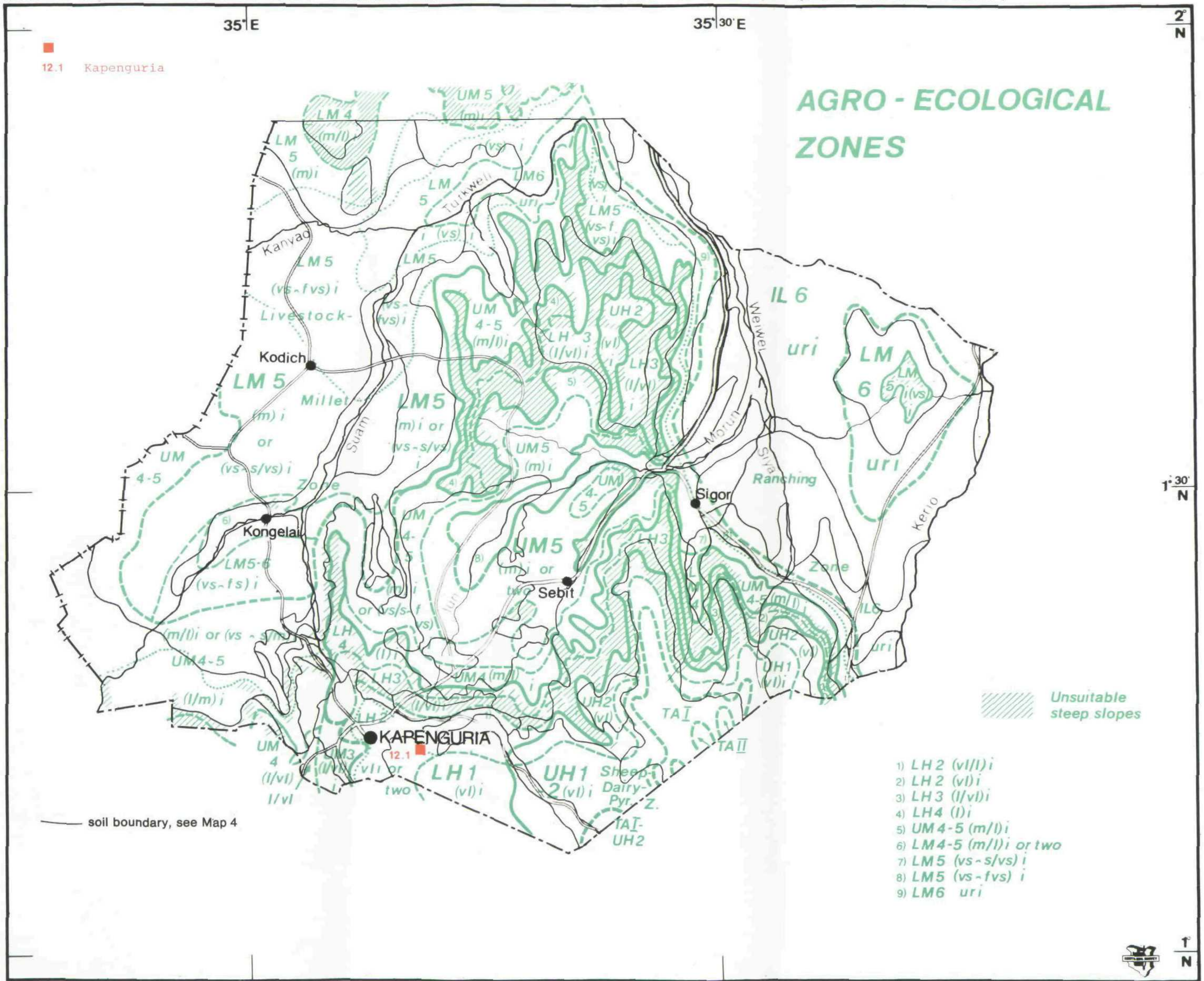
Table 12.0.1 : Climate in the Agro-Ecological Zones of West Pokot District

Agro-Ecological Zone	Subzone	Altitude in m	Annual mean temperature in °C	Annual av. rainfall in mm	66 % reliability of rainfall 1)		66 % reliability of growing period		
					1st rains in mm	2nd rains in mm	1st rains 2) in days	2nd rains in days	Total 3) in days
LM 5–6	(vs – fs)i	1 350–1 450	21.1–20.7	850– 930	150–230	290–360	45 or more	75–110	130–155
LM 6 Lower Midland Ranching Zone	ur i	1 000–1 350	23.6–21.2	630– 750	80–150	130–200	<45	<45 4)	
IL 6 Ranching Zone	ur i	800–1 000	24.8–23.6	500– 800	50–150	100–220	<45	<45 4)	

1) Amounts surpassed normally in 6 out of 10 years, falling during the agro-humid period which allows growing of most cultivated plants
2) More if growing cycle of cultivated plants continues into the period of second rains
3) Only added if agro-humid conditions continue from first to second rains
4) Continuously, with interruption it may be more

Source: Jaetzold R., and H. Schmidt, eds. (1982): Farm Management Handbook of Kenya, Volume II/B Central Kenya, page 183 - 184.

MAP 12.0.3 AEZs AND TRIAL SITES IN WEST POKOT DISTRICT (SOUTHERN PART)



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The soils of the southern part of West Pokot District are shown in Map 12.0.4.

The majority of the soils in West Pokot District are developed on undifferentiated basement system gneisses, and are not deeper than 80 cm (shallow to moderately deep).

In the northern, central and eastern areas of the southern part of West Pokot District, soils are shallow to moderately deep and/or saline-sodic.

The following map units comprise extensive acreages: Unit UU4 with calcaric Regosols, which are both saline and sodic; unit UUC4 with mainly shallow to moderately deep orthic Acrisols; unit MU1 with mainly shallow to moderately deep eutric Cambisols; unit UUC5 with moderately deep chromic Luvisols and orthic Acrisols. The soils of piedmont plain units YU1 and YU2 are saline and sodic.
Crop cultivation is concentrated in the southernmost part of the District, around Kapenguria. The soils are moderately deep to deep Acrisols and Cambisols, in unit UN2 with a thick acid humic topsoil (trial site 12.1), and in unit UN3 without or with a thin acid humic topsoil. Unit UU5 represents the transition to the rhodic Ferralsols of Trans Nzoia District (cf. trial site 10.1, Trans Nzoia District).

Further to the east, shallow and moderately deep soils with an acid humic topsoil prevail: unit MU2 has humic Cambisols and unit UUC3 has a complex of shallow Rankers and moderately deep humic Cambisols. These soils extend into the northern parts of Elgeyo Marakwet District.

The basic climatic and soil designations of the trial site in West Pokot District are summarized in Table 12.0.2.

Table 12.0.2: Agro-Ecological Zone and Soil Classification of the Trial Site in West Pokot District

Site No.	Site Name	Agro-Ecological Zone	Soil Classification
12.1	Kapenguria	Wheat/Maize-Pyrethrum Zone (LH 2)	humic CAMBISOL

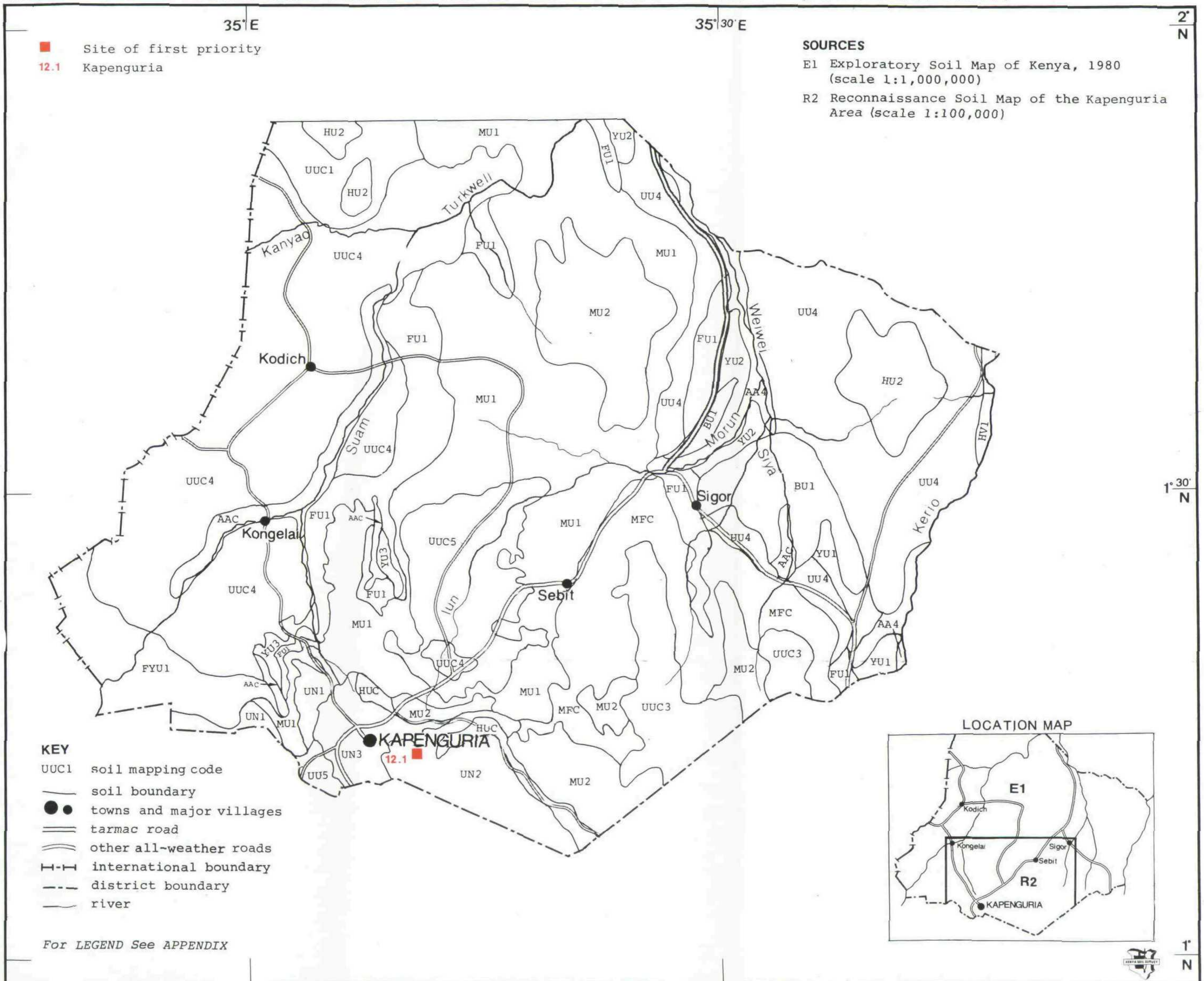
2. Location of the Trial Site and Criteria for its Final Position

In West Pokot District, one first priority site was selected as shown in Map 12.0.3. The site is located approximately 5 km east of Kapenguria in an area only recently settled.
A trial plot was established on sloping land. It is rectangular, apart from one end which had to be surveyed parallelogram-wise.
The soils on the upper slopes are humic Cambisols with abundant weatherable minerals within a depth of one metre. On the middle and lower slopes soils are humic Cambisols to Acrisols, without this pronounced presence of weatherable minerals. Accessibility of the trial site is moderate. The demonstration effect, however, is high, as the site is situated along a road in an increasingly densely populated area. The next long-term rainfall recording station: 08835004, Kapenguria D.O. is located 5 km WNW of the trial site.
Farmers' fields are within walking distance, all along the same road. Some are very close to the trial plot, others a little more distant (see Figure 12.1.4).
The criteria for the final position of the trial site are listed in Table 12.0.3, which is self-explanatory. Criteria have been rated very good (1), good (2), moderate (3), poor (4) or non-relevant (nr).

Table 12.0.3 Ratings of Criteria Used for Trial Site Selection in West Pokot District

Criterion	Site number
	12.1
1. Representativeness Agro-Ecological Zone	1
2. Representativeness Soils	1
3. Representativeness Topography	1
4. Adequacy of size and shape of the trial plot	3
5. Absence of trees and hedges	2
6. Absence of rocks and boulders	1
7. Absence of termite mounds	1
8. Uniformity of previous land use	1
9. Accessibility	3
10. Demonstration effect	2
11. Proximity to a long-term rainfall station	2
12. Availability of storage facilities	1
13. Availability of sturdy fences	2
14. Availability of housing facilities for T.A.s	2
15. Farmer's willingness to cooperate	1
16. Security - theft	2
17. Security - intruding animals	2
18. Proximity of on-farm trials	2-3
19. Representativeness of soils at on-farm trials	2

MAP 12.0.4 SOILS AND TRIAL SITES IN WEST POKOT DISTRICT (SOUTHERN PART)



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0 10 20 30 40 km

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Areas which are not represented by any one trial site with respect to soils are coded C. This involves the majority of the soils in the District, which are too shallow, too saline-sodic or which are not represented for a different reason.

The second representativeness map, Map 12.0.6, shows the integrated representativeness of FURP trial sites involving both soils and climate. The map units are named "Agro-Ecological Units", and they represent a specific soil-climate environment, typified by FURP trial sites.

All combinations of the different soil-climate environments occurring in West Pokot District are shown in the Agro-Ecological Unit Map (Map 12.0.6) and are explained in Table 12.0.5. The codes for the Agro-Ecological Units consist of three parts: site, soil representativeness and climatic representativeness. Site and soil representativeness are taken from Map 12.0.5. In addition, Map 12.0.6 and Table 12.0.5 indicate the codes which refer to the representativeness of the climatic environment (small letters).

Several degrees of representativeness are given according to the prevailing temperature regime and the rainfall in the agro-humid period of the long rains.

All areas in Map 12.0.6 which are marked with code "a" (highly representative) are within the same temperature belt and receive the same amount of rainfall (+/- 10%) in the agro-humid period of the long rains as the trial site to which the code refers.

The map units marked with code "b" (e.g.: b++, b+- ,b+*) are only moderately represented by trial sites. In the AEU 12.1.A.b++, for instance, the soils are highly represented by the Kapenguria Trial Site (12.1.A), but the climate (b++) indicates that this Agro-Ecological Unit belongs to the next warmer temperature belt and receives 10-20% more rainfall than the Kapenguria Trial Site.

Areas which are not represented by any one trial site, i.e. soils and/or climate not represented by any site, are coded 0.

The criteria set for sub-division of the various degrees of representativeness with respect to soils and climate are further elaborated upon in Chapter IV.2 of the main report.

5. Areas in West Pokot District Represented by FURP Trial Sites

The aim of FURP Phase I is to select trial sites which, as far as possible, are representative of the agriculturally high and medium potential areas of Kenya. This consideration constituted the backbone for making decisions as to where to establish these FURP trial sites.

Two representativeness maps are drawn per district. One refers to the soils only (Map 12.0.5: Groupings of Soil Mapping Units), and in the second (Map 12.0.6) Agro-Ecological Units (AEUs) are shown in which, according to the information available, the soils and the climate can be considered homogeneous.

Map 12.0.5 shows the representativeness of FURP trial sites for West Pokot District only as far as soils are concerned. Since FURP can only cover major physiographic units (mainly uplands, plateaus and plains), minor units such as mountains, hills, floodplains and bottomlands indicated in the Soil Map (Map 12.0.4) and described in the accompanying Legend (cf. Appendix: M, H, A and B units), are beyond consideration when it comes to representativeness.

The explanation for Map 12.0.5 shows 5 generalized "Groupings of Soil Mapping Units". These groupings have the same or similar soil properties and, as such, represent a specific soil environment, typified by one of the FURP trial sites.

The codes in the explanation to Map 12.0.5 refer to a specific trial site (12.1, etc.) and to a specific degree of representativeness of soils (A, B+, B-). The combination of both forms a "Soil Representativeness Code". Unit 12.1.A, for instance, covers an area which is highly represented (A) by the Kapenguria Trial Site (12.1). Unit 12.1.B-, however, covers an area which is moderately represented (B) by the Kapenguria Trial Site, although info-rmation on soil properties reveals slightly less favourable conditions in the represented area in the District than at the trial site itself (B-).

The explanation to Map 12.0.5 also lists those units of the Soil Map (Map 12.0.4) which are considered in the various groupings.
A breakdown of soil properties referring to the Groupings of Soil Mapping Units is given as part of Table 12.0.5.

The soils of West Pokot District are only represented by FURP trial sites in the southernmost part of the district. This is testified by Map 12.0.5 which only shows Groupings around Kapenguria and in the South-East.

The trial site in West Pokot District itself is highly representative (Grouping 12.1.A) for soil map unit UN2 (humic Cambisols and Acrisols), in which the trial site is situated.
Neighbouring soil map unit UN3 consists only partly of humic Cambisols and Acrisols and is therefore rated 12.1.B-.

Small areas are coded either 10.1.A/B- (rhodic Ferralsols represented by the Kitale N.A.R.S. trial site in Trans Nzoia District) or 13.1.A/B- (calcic Cambisols, represented by the Tot K.V.D.A. trial site in Elgeyo Marakwet District).

4. Trial Design and Execution Plan, West Pokot

(Full details of the methodology for carrying out the trials are shown in Chapter IV of the main report.)

Selection of Crops: the proposed crop sequences in each of the 3 modules, for the Kapenguria site are:

Site 12.1 Kapenguria.	RAINY SEASONS 1st, long, March	 2nd, short, Aug.
S1 Standard Maize	Hybrid 625	
S2 Maize & Beans	Hybrid 625 + Beans GLP 2	
S3 Pot./Cabb./For.Oats	Pot. B53/Cabb. Copenh.	/For. Oats

The 1st sequence or module is continuous, pure maize, once/year.
The 2nd is intercropped maize and beans, also once/year.
The 3rd is potatoes or cabbages in 1st rains, and forage oats in 2nd rains.

Each module contains 2 experiments, namely Experiment 1 and Experiment 2.

Experiment 1 is a 4N x 4P factorial, with 2 replications in each module.
Experiment 2 is a 2N x 2P x 2K x 2 FYM factorial, also with 2 replications in each module.

Each module thus consists of 64 plots, and the total for the 3 modules is 192 plots.

Fertilizer and FYM will be applied only to the crops during the first rains. Where maize and beans are intercropped, the fertilizer will go on the maize. The intercropped beans will not receive any fertilizer directly, but will "scavenge" from the maize and from residual fertilizer left in the relevant plots after the first season. Similarly, the crop during the second rains i.e. forage oats, will not receive any fertilizer directly.

3. Names and Addresses of Government Officers Involved in FURP Activities in the District

The names and addresses of the agricultural staff members of the District are listed in Table 12.0.4.

Table 12.0.4: Names and Addresses of Government Officers in the District

OFFICER	SITE	NAME	P.O. BOX	TEL. NO.
DISTRICT				
D.C.		P. Lagat*		
D.A.O.		J.P. Kiptoon	14-Kapenguria	7-Kapenguria
D.C.O.		J.K. Meli		
DIVISION				
Div. Ext. Officer	12.1	F.I. Muguro	14-Kapenguria	7-Kapenguria
Loc. Ext. Officer	12.1	John Ayepa	14-Kapenguria	7-Kapenguria
Technical Assistant	12.1	not met		

* not met during site selection.

Period of site selection in the District: March 1986.

E X P L A N A T I O N   T O   M A P 12.0.5

Degree of representativeness

A	highly representative
B+	moderately representative (soils of map unit are slightly more favourable than soils at the trial site)
B-	moderately representative (soils of map unit are slightly less favourable than soils at the trial site)
C	non-representative

Groupings of soil map units

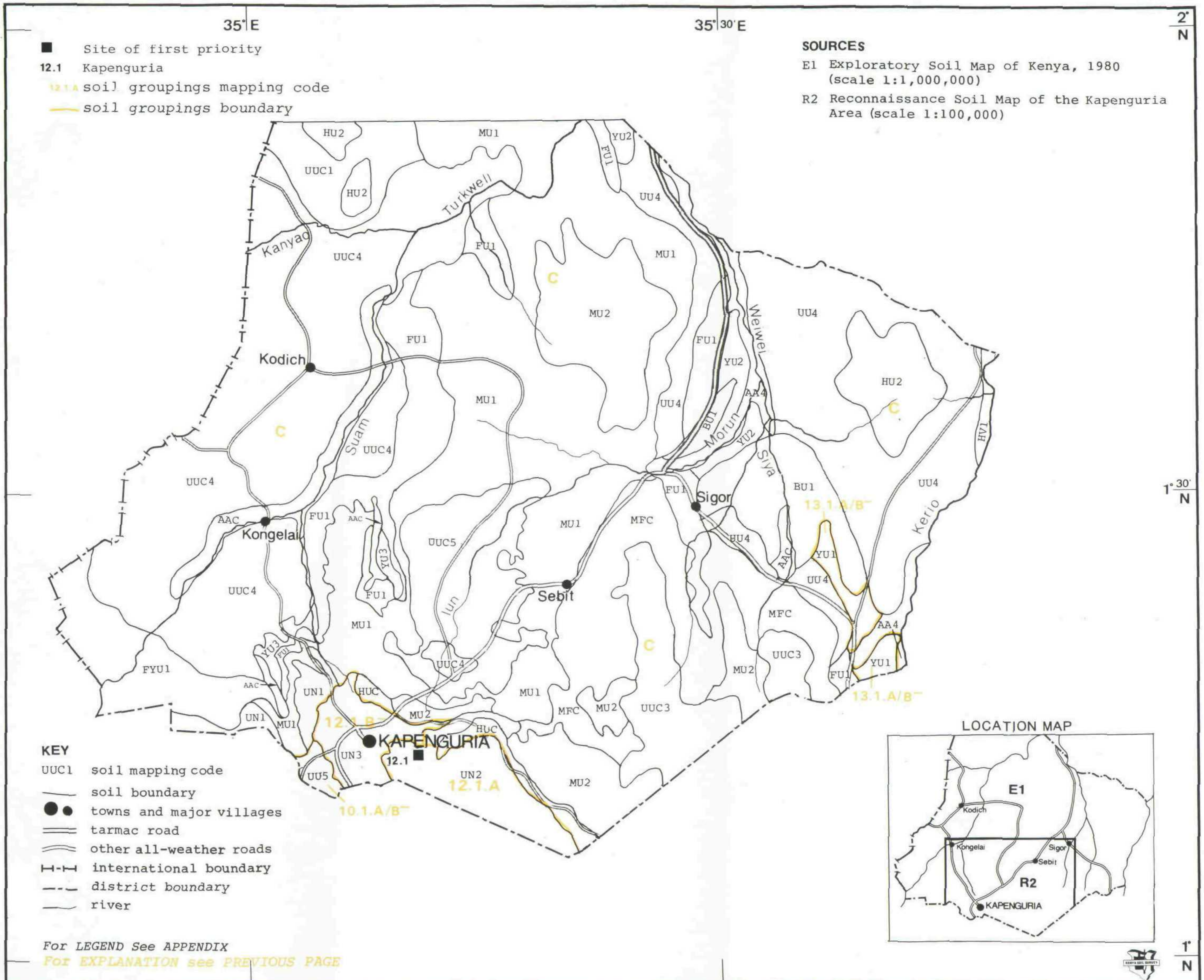
Soil Representativeness Code (Map 12.0.5) [1]	Soil Map Units Included (Map 12.0.4)
10.1.A/B-	UU5
12.1.A	UN2
12.1.B-	UN3
13.1.A/B-	YU1
C	others

Trial sites

10.1 Kitale NARS - Trans Nzoia District
12.1 Kapenguria - West Pokot District
13.1 Tot KVDA - Elgeyo Marakwet District

1) Digits show trial site number; letters indicate degree of representativeness.
For cartographic reasons, Soil Representativeness Code C is not indicated for the many scattered hills, bottomlands, and flood plains. These areas should be considered inclusions of units with Representativeness Codes A, B+, and B-.

MAP 12.0.5 GROUPINGS OF SOIL MAPPING UNITS REPRESENTED BY TRIAL SITES IN WEST POKOT DISTRICT (SOUTHERN PART)



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0 10 20 30 40 km

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Table 12.0.5: Major Soil Properties and Climatic Conditions of the Agro-Ecological Units in the West Pokot District

Agro-Ecological Unit		Soil properties						Climatic Conditions				
Site No. Soil Code	Climate Code	drainage	eff. depth	nutr. avail.	topsoil	moist. st.cap.	classification	temp.[1]) mean ann.	temp.[1]) mean min.	rainfall 66% prob.[2])	Agro-Ec. Subzone[3])	Agro-Ec. Zone
10.1.A/B-		w	vd	l	0	h-vh	rh Fe					
	a							18-21	11-14	790-970 4)	l/vl to (l/vl) i	UM 3-4
	b*-							18-21	11-14	700-790 4)	l/vl	UM 4
12.1.A		w	d	l-m	2ah	h	hu Ac + hu Ca					
	a							15-18	8-11	730-890	(vl/l)i to vl i or two	LH 2
	b*+							15-18	8-11	890-970	(vl) i	LH 1
	b-*							10-15	8-11	730-890	(vl) i	UH 1-2
12.1.B-		w	md-d	l-m	0-1ah	m-h	fe-or Ac (+ dy + hu Ca + hu Ac)					
	a							15-18	8-11	730-890	(vl/l)i to vl i or two	LH 2
	b*-							15-18	8-11	650-730	(l/vl) i	LH 3
	b+*							15-18	8-11	730-890	(l/vl) i	UM 3
	b+-							15-18	8-11	650-730	l/vl	UM 4
13.1.A/B-		w-mw	d	l-m	0	m-h	ca Ca, sodic subsoil					
	(a)							23-25	16-18	Irrigation nesseary LM 5 - IL 6		
C		soil not representative										
0		soil and/or climate are not representative										

Key:

Drainage

se somewhat excessive
w well
mw moderately well
i imperfect
p poor

Moisture storage capacity

vh very high > 160 mm.
h high 120-160 mm.
m moderate 80-120 mm.
l low < 80 mm.

Effective soil depth

ed extremely deep > 180 cm.
vd very deep 120-180 cm.
d deep 80-120 cm.
md moderately deep 50- 80 cm.
sh shallow 25- 50 cm.
vsh very shallow < 25 cm.

Nutrient availability

h high
m moderate
l low
vl very low
Specification given in Chapter IV.2 (main report)

Topsoil Properties

h humic (base saturation >50 %)
ah acid humic (base saturation <50%)
2 thick (30-60 cm.)
1 thin (<30 cm.)
0 non-humic

Soil classification

Ca Cambisols
Ac Acrisols
Fe Ferralsols
hu humic
ca calcic
rh rhodic
dy dystric
fe-or ferralo-orthic

1) **Temperature (°C)**
(differentiated according to AEZ belts)

2) **Rainfall 66% probability (in mm.)**
-referring to agro-humid period of long and middle rains only (e.of March-September except in 10.1.,see in footnote 4)
-for definition of rainfall ranges see explanation to Map 12.0.6;
-66% probability means that amount of rainfall will be exceeded in at least 20 out of 30 years.

3) **Agro-Ecological Subzone**
-approximative indication only, since subzones are not directly related to amount of rainfall;
-"--" in formula means "followed by";
-for further explanation of subzones see Chapter IV on methodology;
-Agro-ecological zones and subzones are shown in Map 12.0.3.

4) **Comparable time: mid March-September.**

EXPLANATION TO MAP 12.0.6

Soil Codes

= A = highly representative

= B+ = moderately representative (soils of map unit are slightly more favourable than soils at the trial site)

= B- = moderately representative (soils of map unit are slightly less favourable than soils at the trial site)

Trial sites

10.1 Kitale NARS (Trans Nzoia District)
12.1 Kapenguria (West Pokot District)
13.1 Tot KVDA (Elgeyo MNarakwet District)

Climatic Codes

a highly representative,i.e. same Agro-Ecol.Zones Belt and long rains (+/-10%) as at trial site

b moderately representative

++ = 1 AEZ Belt warmer, long rains 10-20% higher
+* = 1 AEZ Belt warmer, long rains similar (+/-10%)
+- = 1 AEZ Belt warmer, long rains 10-20% lower
-+ = 1 AEZ Belt cooler, long rains 10-20% higher
-* = 1 AEZ Belt cooler, long rains similar (+/-10%)
-- = 1 AEZ Belt cooler, long rains 10-20% lower
*+ = AEZ Belt the same, long rains 10-20% higher
*- = AEZ Belt the same, long rains 10-20% lower
xx = 2 AEZ Belts warmer, long rains 20-30% higher
xx = 2 AEZ Belts cooler, long rains 20-30% lower

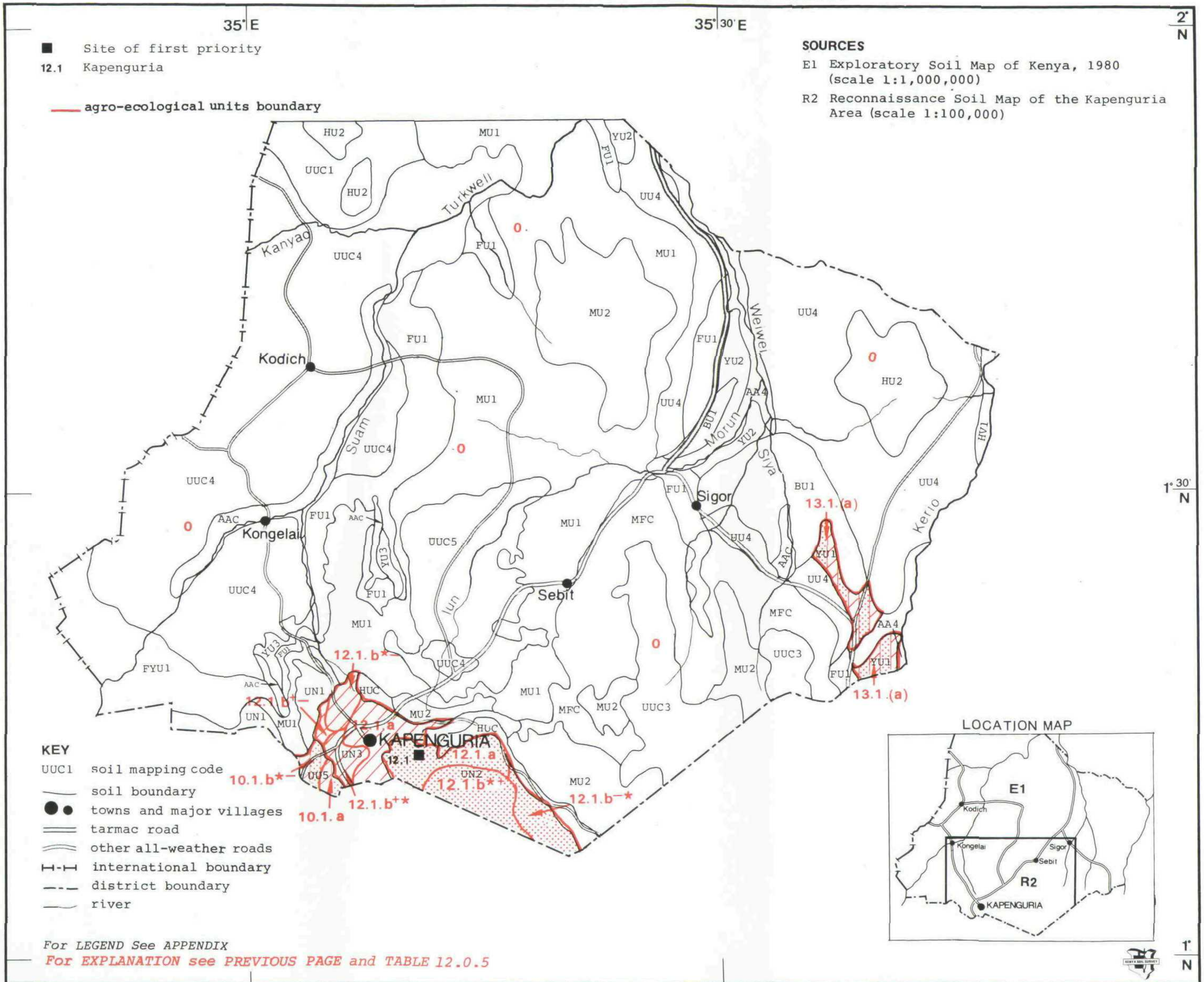
Areas not represented

0 = not represented by soils and/or climate

For further explanation see Table 12.0.5

MAP 12.0.6

AGRO–ECOLOGICAL UNITS REPRESENTED BY TRIAL SITES IN WEST POKOT DISTRICT (SOUTHERN PART)



FERTILIZER USE RECOMMENDATION PROJECT (1987)

0 10 20 30 40 km

Ministry of Agriculture
National Agricultural Laboratories
German Agricultural Team

LEGEND TO THE SOIL MAP OF WEST POKOT DISTRICT

1----Explanation of first character (physiography)

M Mountains and Major Scarps
H Hills and Minor Scarps
F Footslopes
FY Footslopes and Piedmont Plains Undifferentiated
Y Piedmont Plains
U Uplands, Upper, Middle and Lower Levels
A Floodplains
B Bottomlands

2----Explanation of second character (lithology):

A Alluvial Sediments from Various Sources
F Gneisses Rich in Ferromagnesian Minerals and Hornblende Gneisses
N Biotite Gneisses
U Undifferentiated Basement System Rocks (predominantly Gneisses)
V Undifferentiated or Various Igneous Rocks

3----Soil descriptions

MFC 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

MU1 Somewhat excessively drained, shallow to moderately deep, reddish brown, friable, rocky and stony, sandy clay loam
--- eutric CAMBISOLS, partly lithic phase; with LITHOSOLS, orthic LUVISOLS, eutric REGOSOLS and Rock Outcrops

MU2 Well drained, moderately deep, reddish brown to brown, friable, stony sandy clay loam, with an acid humic topsoil
--- humic CAMBISOLS; with humic NITISOLS, dystric REGOSOLS and Rock Outcrops

HU2 Somewhat excessively drained, shallow, reddish brown, friable, rocky or stony, sandy clay loam
--- eutric REGOSOLS, lithic phase; with Rock Outcrops and calcic CAMBISOLS

HUC 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

HV1 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

FU1 Well drained, very deep, yellowish red to dark reddish brown, loose, loamy coarse sand to friable sandy clay loam
--- chromic LUVISOLS, rhodic FERRALSOLS and luvic to ferralic ARENOSOLS

FYU1 Well drained, moderately deep to deep, red to dark reddish brown, firm, sandy clay loam to clay
--- chromic and vertic LUVISOLS

YU1 Well drained, deep, dark brown, friable, moderately calcareous clay loam, with a sodic deeper subsoil
--- calcic CAMBISOLS, sodic phase

YU2 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

YU3 Well drained, deep, dark brown to dark reddish brown, friable to firm, compact sandy clay to clay
--- vertic and chromic LUVISOLS

UN1 Well drained, moderately deep to deep, brown to dark yellowish brown, firm sandy clay loam
--- orthic LUVISOLS

UN2 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

UN3 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

UU4 Well drained, shallow, brown, friable, strongly calcareous, moderately to strongly sodic and saline, gravelly sandy clay loam; with a gravelly surface
--- calcaric REGOSOLS, gravel-mantle and saline-sodic phase; with gleyic SOLONETZ

UU5 Well drained, very deep, red to dark red, very friable to friable clay
--- rhodic FERRALSOLS

UUC1 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

UUC3 Complex of:
well drained, shallow, black to very dark brown, very friable loam, with an acid humic topsoil; in places rocky
--- RANKERS
and:
well drained, moderately deep, dark brown, friable clay loam, with a very thick acid humic topsoil
--- humic CAMBISOLS

UUC4 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

UUC5 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

AA4 Well drained to imperfectly drained, very deep, dark brown to yellowish brown, stratified, micaceous, strongly calcareous, predominantly loamy soils
--- calcaric FLUVISOLS

AAC Complex of:
well drained to imperfectly drained, very deep, dark greyish brown to dark reddish brown, stratified soils of varying consistency and texture
--- eutric FLUVISOLS

BU1 Imperfectly drained to poorly drained, very deep, brown to dark brown, very firm, slightly calcareous, strongly sodic clay
--- orthic SOLONETZ

<u>NOTES</u>:

1. mollic Nitisols <u>and</u> chromo-luvic Phaeozems: soils are equally important
2. mollic Nitisols, <u>with</u> chromo-luvic Phaeozems: Nitisols are prevalent
3. <u>in places</u>: in <30% of the area
4. <u>in many places</u>: in 30-50% of the area
5. <u>predominantly</u>: in >50% of the area
6. <u>deeper subsoil</u>: below 80 cm.

Contents of Chapter 12.1:

Detailed Description of the Kapenguria Trial Site

List of Tables[1])

1) See Footnote next page.

List of Figures[1])

1) Numbering mode of Tables and Figures:
First Number: District Number
Second Number: Trial Site Number
Third Number: Number of Table or Figure within Chapter.

1. Geographical and Additional Technical Information

1.1 Final Position of the Trial Site

The position of the site at Kapenguria is shown in Figure 12.1.1, extracted from Map No. 75/3 - Kitale. Its UTM grid coordinates are E 40.2 and N 35.9. The elevation is 2140 m. Further details on the final position are shown in Figure 12.1.2 and the sketch map of the trial plot in Figure 12.1.3.

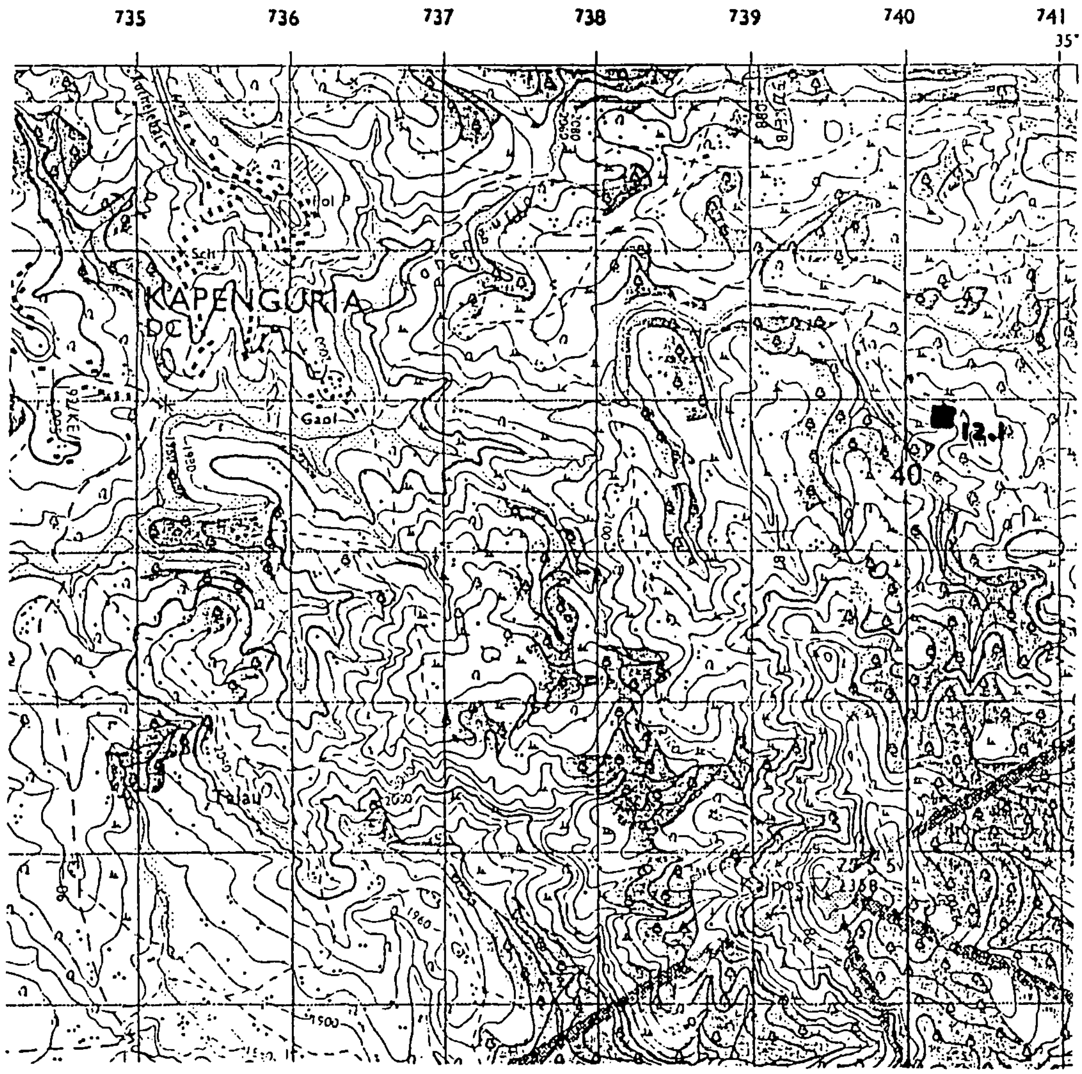


Figure 12.1.1: Demarcation of the Kapenguria Trial Site on the 1:50,000 Topographic Map

1.2 Sketch of the Trial Site.

The location of and the access route to the Kapenguria site are shown in Figures 12.1.2 and the map of the trial plot in Figure 12.1.3.

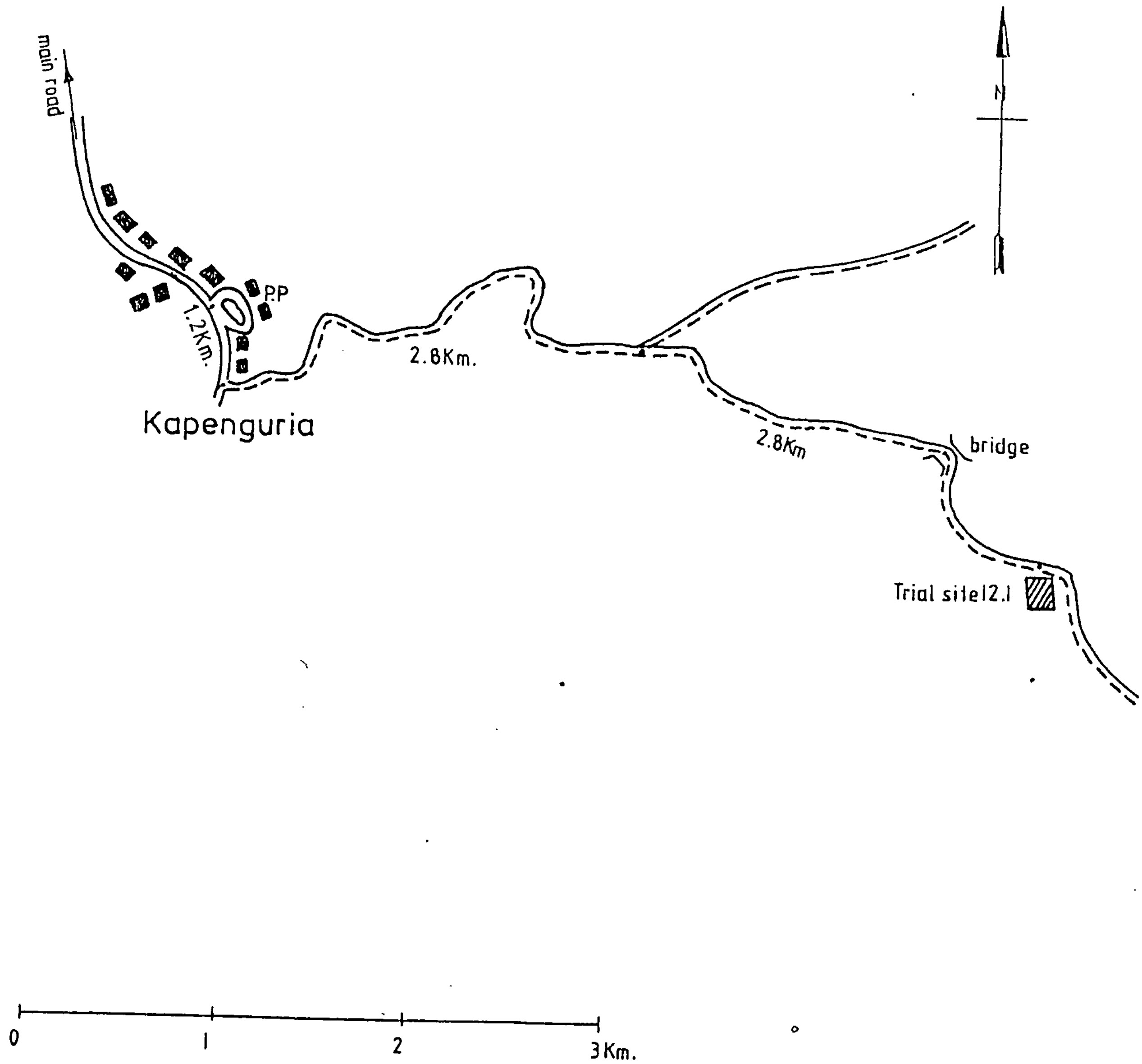


Figure 12.1.2: Access Map of the Kapenguria Trial Site

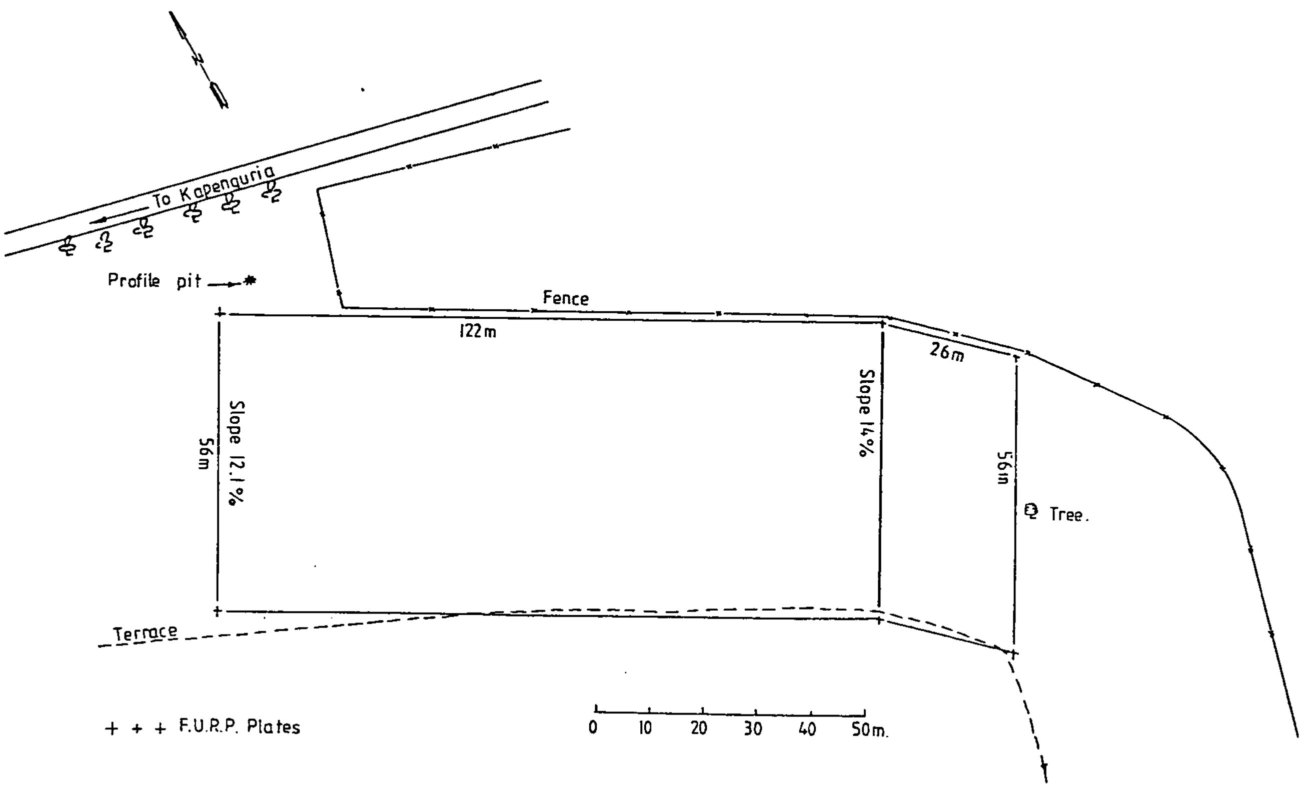


Figure 12.1.3: Map of the Trial Plot, Kapenguria

The approximate location of the on-farm trials is indicated in Figure 12.1.4.

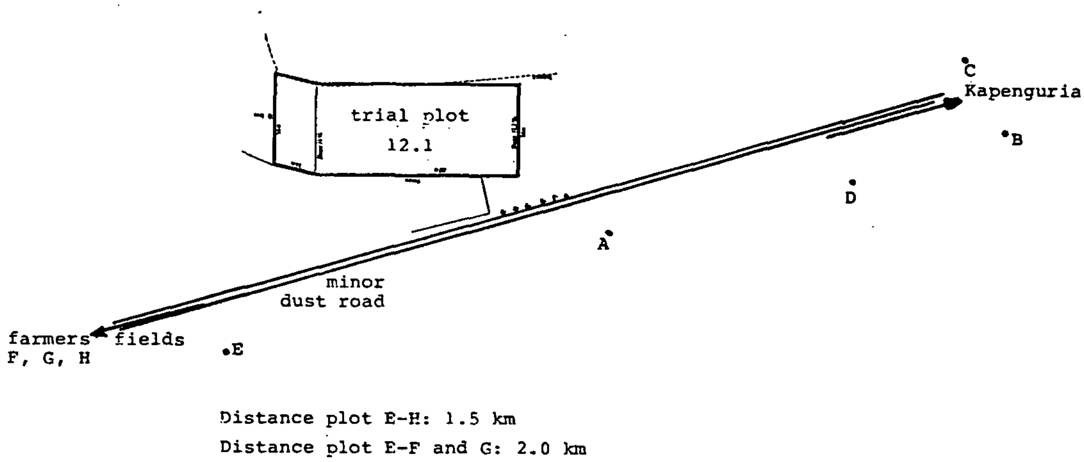


Figure 12.1.4: Location of Farmers' Fields for On-Farm Trials, Kapenguria

1.3 Physiography

Information on the physiography of the trial site and its surroundings is summarized in Table 12.1.1 below.

Table 12.1.1: Physiography of the Kapenguria Trial Site

Elevation	2140 m
Landform	Uplands (dissected pene-plains at various levels)
Physiographic position of the site	middle slope (terraced)
Topography of surrounding country	rolling to hilly (slopes 8-30%)
Slope on which trial plot is sited	12-14%
Aspect	SSW
Microtopography	terrace cutting southern plot boundary

1.4 Vegetation, Past and Present Land Use

Information on vegetation, past and present land use is summarized in Table 12.1.2 below.

Table 12.1.2: Vegetation, Past and Present Land Use of the Kapenguria Trial Site

Vegetation	Montane Acacia Vegetation from montane Sclerophyll forest
Cropping system	
(a) cleared since:	1972; previously forest
(b) crops grown:	maize, maize/beans, potatoes
(c) fallow periods:	none
(d) present land use:	maize/beans
Inputs	
(a) mineral fertilizers:	D.A.P
(b) organic manure:	not applied
(c) means of land preparation:	tractor; sometimes oxen
(d) means of weeding:	manual
(e) frequency of weeding:	twice per crop stand
(f) other capital inputs:	DDT against stalk borer
(g) level of know-how:	high
Produce	
(a) maize	15-20 bags/acre (90 kg bags)
Livestock	cows and sheep
Remarks Maize yields have gone declined steadily since the land was opened up.	

1.5 Names and Addresses of Government Officers Involved in FURP Activities

Names and addresses of the divisional staff members and of all farmers involved are given in Table 12.1.3.

The codes used for the additional "on-farm" farmers refer to the location of their farms as indicated in Figure 12.1.4.

Table 12.1.3: Names and Addresses of Divisional Staff Members and Farmers of the Kapenguria Trial Site

Divisional Staff	Name	Address
D.E.O. L.E.O. T.A.	B.M. Kiboi John Ayepa not met	Box 14, Kapenguria Box 14, Kapenguria
Farmers	**Name**	**Address**
Trial plot	Joshua M. Lokorwa	Box 280, Kapenguria
	LOCATION: SUB-LOCATION:	Kapenguria Siyoi
On-Farm trials	**Name**	**Remarks**
12.1.A	Jacob Parklea	upper slope
12.1.B	Steven Limo	middle slope,sandy
12.1.C	Daniel Mutua	middle slope
12.1.D	Yaralima Lomuyuara	middle slope
12.1.E	Benson Koech	middle slope
12.1.F	Gitau Murima	middle slope
12.1.G	Thomas Saisi	middle sl, gravelly
12.1.H	William Kitiyo	middle slope

Period of site selection: March 1986.

2. Climate

2.1 Prevailing Climatic Conditions

2.1.1 Agro-Climatic Classification of the Area Represented by the Kapenguria Trial Site

The following brief climatic description refers to the existing information:

ACZ : II5 (H.M.H. BRAUN, 1982)[1])

AEZ : LH 2, vl i or two (R. JÄTZOLD, 1983)[2])

Next long-term rainfall station: 08835004, Kapenguria D.O.

<u>Agro-Climatic Zone (ACZ):</u>

Moisture availability Zone II (r/Eo): annual average precipitation is 65-80% of the potential evaporation (Eo).

Temperature Zone 5: mean annual temperature is 16-18°C

<u>Agro-Ecological Zone (AEZ):</u>

LH 2 = Wheat/Maize - Pyrethrum Zone

LH = Lower Highland Zone: mean annual temperature 15-18°C, mean minimum 8-11°C

2 = sub-humid; annual average precipitation is 65-80% of the potential evaporation (Eo)

<u>Sub-zone</u> according to growing periods for annual crops (calculated for a "normal" crop in 60% probability)

vl i or two = with a very long cropping season, which can be divided into two variable cropping seasons

---

1) According to H.M.H. BRAUN in: W.G. SOMBROEK, et al. (1982): Exploratory Soil Map and Agro-Climatic Zone Map of Kenya, scale 1:1,000,000 - Rep. El, Nairobi

2) According to R. JÄTZOLD, and H. SCHMIDT, eds. (1983): Farm Management Handbook of Kenya, Vol. II/B CENTRAL KENYA - Nairobi and Trier

Formula	Cropping season	Lengths of growing period (exceeded in 6 out of 10 years)
vl	very long	285-364 days

i = intermediate rains (at least 5 decades more than 0.2 Eo); this means moisture conditions are above wilting point for most crops.

2.1.2 Relevant Meteorological Data for the Kapenguria Trial Site

In this section a breakdown is given of the following climatic parameters: rainfall, potential evaporation and temperature.

Rainfall:

Rainfall data are obtained from the nearest long-term rainfall station: 08835004, Kapenguria D.O. (elevation: 2100 m), 5 km WNW of the trial site (elevation: 2140 m). The data are listed in Table 12.1.4.. At the trial site rainfall amounts are almost similar: in 20 out of 30 years the Kapenguria trial site gets about 810 mm during the agro-humid period of first and middle rains (March/April - September/October), and 160 mm from October to November.

The methods of rainfall-data analysis are described in Chapter IV.2.2 of the main report.

Temperature and potential evaporation(Eo):
Temperature data are obtained from temperature recording station 08835033, Cheywoyet School (elevation: 2130 m), 7 km W of the trial site (elevation: 2140 m). Potential evaporation (Eo) is calculated using the PENMAN formula, modified by MC CULLOCH (1965). The input parameters employed : windrun, sunshine hours and relative humidity are obtained from 08835024, Kitale Meteorological Station (elevation: 1890 m), 30 km SSW of the trial site.

Temperature and evaporation data for the Kapenguria site are given in Tables 12.1.5 and 12.1.6, and the rainfall pattern and potential evaporation are shown in Figure 12.1.5.

For more detailed information on the methodology of climatic description see Chapter IV.2.2 of the main report.

Table 12.1.4 : Data of the Nearest Long-Term Rainfall Station

Station No.: 08835004
Kapenguria D.O.
Elevation: 2100 m

Total years for calculation: 22
First year included: 1961
Last year included: 1985

Average annual rainfall: 1374 mm

Rainfall surpassed in 20 out of 30 years (≈66% Probability):

1st rains: 780 mm
(beg. of Apr. - end of Sep.)

2nd rains: 150 mm
(beg. of Oct. -end of NOv.)

Decades and Month	Arithmetic Mean (mm)	Average Number of Rainy Days with Rainfall >= 1 mm	>= 5 mm	≈66% Probability of exceeding ...mm	Years analized
1 JAN	6.5	0.5	0.5	1.3	19
2	2.5	0.4	0.4	0.0	19
3	13.1	1.0	1.0	4.3	19
4 FEB	10.6	1.2	1.1	5.0	19
5	8.9	0.9	0.9	2.9	19
6	15.7	1.1	1.0	3.2	19
7 MAR	8.7	0.9	0.9	1.4	20
8	18.1	1.5	1.5	6.1	20
9	33.4	1.9	1.9	15.6	20
10 APR	51.5	2.2	2.2	29.1	19
11	69.6	3.2	3.1	40.0	19
12	65.1	3.2	3.1	38.8	19
13 MAY	98.5	4.0	4.0	71.4	21
14	56.1	3.3	3.3	40.1	21
15	36.8	2.7	2.7	25.6	21
16 JUN	35.4	2.0	2.0	22.3	21
17	39.8	2.8	2.8	26.7	21
18	47.6	3.1	3.0	30.1	21
19 JUL	67.2	4.1	4.1	48.3	20
20	69.2	4.0	4.0	44.2	20
21	67.9	4.3	4.2	52.5	20
22 AUG	63.8	3.6	3.6	42.9	21
23	59.6	4.0	3.9	42.0	21
24	45.8	3.3	3.2	27.4	21
25 SEP	49.3	3.1	3.1	30.0	21
26	33.2	2.5	2.5	19.9	21
27	56.6	1.8	1.8	21.8	21
28 OCT	25.8	2.0	2.0	10.8	18
29	28.6	2.2	2.1	17.5	18
30	34.4	2.5	2.5	18.8	18
31 NOV	33.9	1.9	1.9	15.1	15
32	43.0	1.8	1.8	23.1	15
33	44.0	1.9	1.8	21.3	15
34 DEC	15.6	1.0	1.0	3.6	17
35	10.5	1.0	1.0	3.2	17
36	8.2	0.5	0.4	0.0	17

Table 12.1.5: Temperature (°C)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.
Mean temp.	16.6	17.1	17.5	16.8	16.7	15.9
Mean max.temp.	25.5	25.7	25.9	26.1	23.4	22.8
Mean min.temp.	8.2	8.7	9.2	9.9	10.6	9.3
	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
Mean temp.	15.4	15.5	15.8	16.1	16.0	16.1
Mean max.temp.	22.0	22.1	22.2	24.4	25.4	24.3
Mean min.temp.	9.6	9.4	9.1	9.3	9.1	8.6

annual mean: 16.3 mean max.: 23.4 mean min.: 9.3

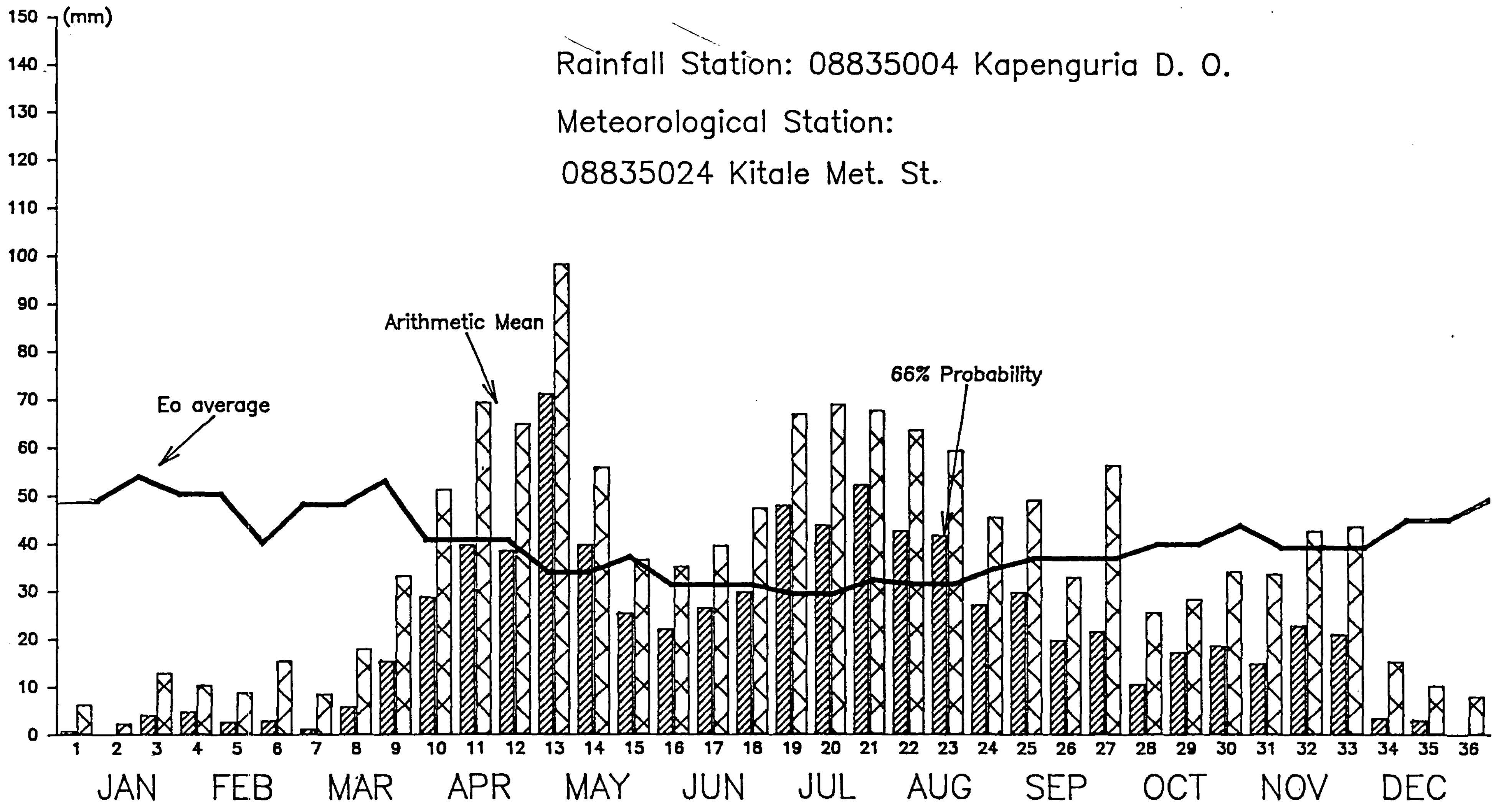
Table 12.1.6: Potential Evaporation (Eo) in mm per Decade:

	JAN.	FEB.	MAR.	APR.	MAY	JUN.
1st decade	49	50	48	41	34	31
2nd decade	49	50	48	41	34	31
3rd decade	54	40	53	41	37	31
Total:	152	140	149	123	105	93
	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1st decade	29	32	37	40	39	45
2nd decade	29	32	37	40	39	45
3rd decade	32	35	37	44	39	50
Total:	90	99	111	124	117	140

average annual potential evaporation: 1443 mm.

For all the climatic data published in this Section, a data bank has been established by FURP on Personal Computers at the National Agricultural Laboratories in Nairobi.

Figure 12.1.5: Rainfall and Potential Evaporation



2.1.3 Crop Suitability from the Climatic Point of View

A summary of the agro-climatic suitability of the most important seasonal food crops is given in Table 12.1.7. below. Additional information on other crops, considered suitable from the agro-climatic viewpoint, is given in the Farm Management Handbook, Vol.II B, Central Kenya [1]).

Table 12.1.7: Agro-Climatological Crop List for Kapenguria

Crop/variety (or place of breeding) e = early m = medium l = late	Av.No.of days to physiol. maturity	Altitudes[2]) according to growing period (m.)	Requirem.of well distributed rainfall [3]) in grow.period (mm.)	Yield potential acc. to water availability [4]) a = 1st rains b = 2nd rains
Maize/l.mat. like H 625	170-200	1500-2100	600-950	a) good/very good (Apr-Oct)
Maize/l.mat. like H 613	160-180	1500-2100	600-950	a) good/very good (Apr-Sep)
Barley/ m. mat.	120-140	2100-2400	400-600	b) good/ very good (May-Oct.)
Garden Peas like meteor	90-130	1800-2700	250-400	a) good b) good (Jun.-Sep.)
Potatoes/ m. mat.	140-170	1800-2900	450-750	good (beg. of Apr.- Sep.)

---

1) R. JÄTZOLD, and H. SCHMIDT, eds.(1983): Farm Management Handbook of Kenya, Vol. II/B, Central Kenya - Nairobi and Trier

2) Most suitable altitudes; the length of the growing period increases with altitude; growth is also possible beyond the indicated altitude range, as long as the ecological limits have not been reached.

3) Lower figure for fair results, higher for very good results with some corrections due to rainfall distribution, evaporation and run-off losses.

4) Estimated yield potential: very good >80%, good = 60-80%, fair = 40-60% and poor <40% of the expected yield under optimum water availability, adapted from R. JÄTZOLD and H. SCHMIDT, eds. (1982): Farm Management Handbook of Kenya, Vol. II/A, West Kenya.

For the most important food crops in the area around the Kapenguria trial site, the crop coefficients (kc) are shown in Table 12.1.8, differentiated according to decades (10 day periods) of the growing season which is the time between planting or sowing and the physiological maturity. Furthermore, four crop development stages are distinguished in Table 12.1.8.

The crop coefficients for the climatic conditions at the Kapenguria trial site were estimated on the basis of data obtained from DOORENBOS and PRUITT (1977)[1]) and DOORENBOS and KASSAM (1979)[2]).

The data on the duration of each of the growing seasons and on the various development stages of each crop were assessed on the basis of local observations made under average climatic conditions.

The crop coefficients estimated for the various decades of the growing seasons were used to estimate the maximum (potential) evapotranspiration (ETm) under the prevailing climate, assuming that water was not a limiting factor for plant growth. For this calculation the following approximative formula was employed:

$$ETm = kc * Eo$$

whereby: ETm= maximum (potential) evapotranspiration
kc = crop coefficient
Eo = potential evaporation (climatic evaporative demand)

In Figure 12.1.6 the ETm-values are used to indicate the estimated maximum water requirements of the maize crop for optimum growth. Furthermore, the rainfall data at 66% reliability are shown in Figure 12.1.6 to give an indication of the water availability. However, when reading these figures, it must be borne in mind that the actual availability of water for the plants also depends, to a large degree, on factors such as the run-off, the moisture storage capacity of the soil, the deep percolation of water etc..

The placement of the growing seasons of the various crops on the time axis as presented in Figure 12.1.6 was mainly based on the pattern of rainfall, whereby the peak water requirements of the plants should be met by high, reliable rainfall.

Detailed information on the calculation procedures and references are given in Chapter IV.2.2 of the main report. The interpretation of the diagram mentioned above follows in Section 4 of this Volume (Conclusions from the analyses of climate and soils).

---

1) FAO (1977): Crop Water Requirements - (= Irrigation and Drainage Paper, 24), Rome

2) FAO (1979): Yield Response to Water - (= Irrigation and Drainage Paper, 33), Rome

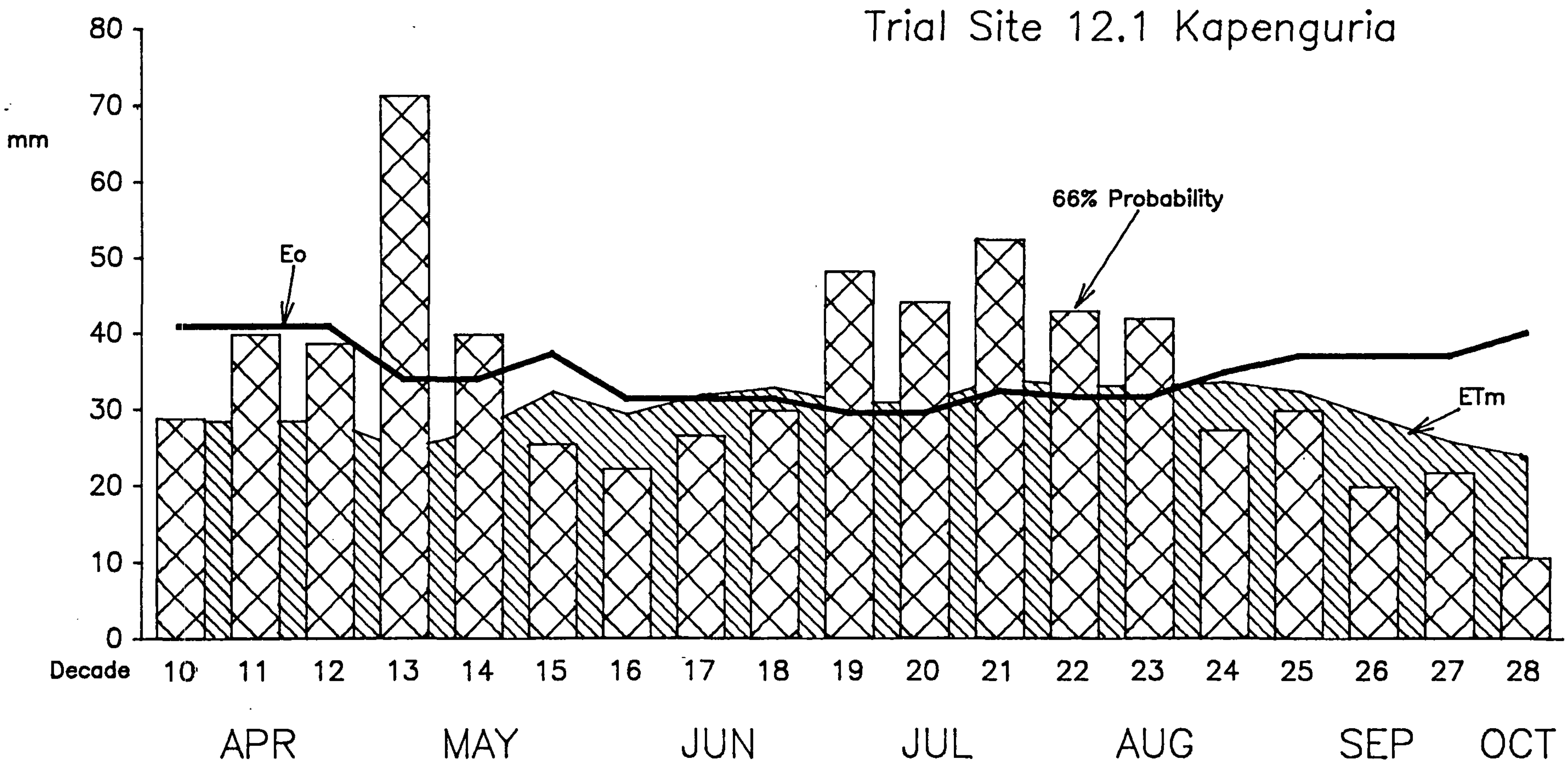
Table 12.1.8 : Crop development stages 1) and crop coefficients (Kc) 2) for approx. maximum (potential) crop evapotranspiration of the most important seasonal crops grown at Kapenguria (site no. 12.1)

Crop/ Variety	Number of decades from seeding resp. planting to (physiological) maturity																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
MAIZE	0.65	0.7	0.7	0.73	0.81	0.87	0.94	1.02	1.05	1.05	1.05	1.05	1.05	1.05	0.97	0.88	0.79	0.7	0.6					
H625	I	I	I	II	II	II	II	II	III	III	III	III	III	III	IV	IV	IV	IV	IV					
POTATOES	0.65	0.7	0.7	0.75	0.84	0.93	1.01	1.05	1.05	1.05	1.05	1.05	1.05	0.99	0.89	0.76								
	I	I	I	II	II	II	II	III	III	III	III	III	III	IV	IV	IV								
BEANS	0.65	0.7	0.77	0.89	1.01	1.05	1.05	1.05	1.05	0.92	0.67	0.43												
GLP 24	I	I	II	II	II	III	III	III	III	IV	IV	IV												
GARDEN	0.65	0.7	0.77	0.89	1.01	1.05	1.05	1.05	0.92	0.67	0.43													
PEAS	I	I	II	II	II	III	III	III	IV	IV	IV													

1) Crop development stages as defined in chapter IV 2.2 (main report)
I = initial stage II = development stage III = mid season IV = late season
2) Kc = crop coefficient as defined in chapter IV 2.2 (main report)

Figure 12.1.6: Water requirements and availability for crop Maize H 625, first rains

Rainfall Station: 08835004
Kapenguria D. O.



2.2 Proposal for the Monitoring of Agro-Climatic Conditions in Phase II

For Phase II the agro-climatic recording programme should include:

1) **Rainfall records**:

A rain gauge has to be installed at the Kapenguria trial site to measure actual preci-pitation on the spot. Subsequently, the data can be compared with both rainfall for a particular year and the long-term average of the nearest rainfall recording station of the Meteorological Department: 08835004, Kapenguria D.O.

2) **Records on other relevant meteorological parameters:**

Data on temperature, relative humidity, windrun and sunshine hours can be obtained from the Kitale Agro-Meteorological station: 08834098, (elevation: 1850 m), in order to calculate Eo (climatic evaporative demand). Temperature data have to be adjusted to the altitude of the trial site (elevation: 2140 m). The temperature gradient in this area is on average 0.6°C.

3) **Phenological records:**

Dates of planting or sowing of each crop, emergence, start of tasselling (for maize crop), budding (for bean or pea crop), flowering, ripeness or physiological maturity and harvest have to be recorded. Additionally the leaf area index (LAI) has to be determined every week (at least for the cereal crops), in order to provide a sound basis for water balance calculations. Other important features should also be recorded, above all rolling and wilting leaves, which indicate water stress and wilting point respectively before physiological maturity has been reached.

Moreover, soil moisture checks and observations on rooting depth at the above-mentioned growing stages and run-off measurements would be needed to estimate actual evapotranspiration of the various crops properly.

For most of the data to be recorded, official forms from the Meteorological Department are available.

Detailed information on calculation procedures, as proposed for the monitoring of agro-climatic conditions, is given in Chapter IV.2.2 of the main report.

3. Soils

In this Section, survey and laboratory data concerning the trial site and, more specifically, the soil profile are given. The evaluation of these data is shown in Sub-Section 3.3.

3.1 Survey Data

3.1.1 Brief Soil Description and General Information on the Soil

The brief description of the soils of the trial plot is followed by a rating of relevant soil-related land factors. The classes for these factors have been adapted from Andriesse and van der Pouw (1985), and a key for them is to be found in Chapter IV.2.3 of the main report.

Brief soil description

The soils are deep, dark yellowish brown in colour, and consist of friable, sandy clay loam to clay, with a thick acid humic topsoil. They have a weak, sub-angular blocky structure, and a high bioporosity.

Rating of soil-related land factors

- Parent rock	1 rich 2 moderately rich: biotite gneisses 3 poor
- Drainage	1 (somewhat) excessively drained 2 well drained 3 moderately well drained 4 imperfectly drained 5 (very) poorly drained
- Effective soil depth	1 extremely deep 2 very deep 3 deep 4 moderately deep 5 shallow 6 very shallow
- Inherent fertility	1 high 2 moderate 3 poor 4 very poor
- Topsoil properties	0 non-humic 1 humic 2 thick humic 1a acid humic 2a thick acid humic

- Salinity	<u>0 non-saline</u> 1 slightly saline 2 saline
- Sodicity	<u>0 non-sodic</u> 1 slightly sodic 2 sodic
- Stoniness	<u>0 non-stony</u> 1 slightly stony 2 stony 3 very stony
- Rockiness	<u>0 non-rocky</u> 1 slightly rocky 2 rocky 3 very rocky
- Consistency (moist)	1 half-ripe 2 loose 3 very friable <u>4 friable</u> 5 firm 6 very firm
- Moisture storage capacity	1 very high <u>2 high</u> 3 moderate 4 low
- Excess surface water	<u>0 none</u> 1 occasional 2 seasonal 3 permanent

3.1.2 Detailed Profile Description and Soil Classification

Detailed information on the various soil properties as they occur in the different horizons is given in Table 12.1.9.
The location of the profile near the trial plot is shown in Figure 12.1.7.

The soil profile is classified according to two systems, which are explained in Chapter II.2.2 of the main report.

1. Legend to the Soil Map of the World (FAO-Unesco, 1974), with adjustments according to the Kenya Concept (Siderius and van der Pouw, 1980): <u>humic Cambisol</u>.

2. USDA Soil Taxonomy (Soil Survey Staff, 1975): <u>typic Humitropept, fine-clayey family</u>.

Table 12.1.9: Detailed Profile Description of Trial Plot Kapenguria

Profile number: 12.1
Date of examination: 14-3-1986
Author: Shaling

Sample No.	Horizon: Genetic	Horizon: Depth	Horizon: Boundary	Colour (Moist)	Mottling	Texture	Cutans	Structure	Biopores	Consistence	Field pH	Concretions	Other Features
12.1.1	Ah1	0 - 19	clear smooth	10 YR 2/1 black	---	sandy clay	---	crumb-weak fine subangular blocky	many v.f. many f. many m. many c.	soft; friable; sl.sticky-sl.plastic	4.4	---	few quartz crystals and micas
12.1.2	Ah2	19 - 48	clear wavy	10 YR 2/2 dark redd. brown	---	sandy clay	---	weak medium subangular blocky	many v.f. many f. common m. no c.	sl.hard; friable; sl.sticky-st.plastic	4.5	---	common quartz crystals and micas
12.1.3	BA	48 - 63	gradual wavy	10 YR 3/4 dark yell. brown	---	sandy clay	---	weak medium subangular blocky	many v.f. many f. common m. no c.	sl.hard; friable; sl.sticky-sl.plastic	4.5	---	common quartz crystals and micas
12.1.4	Bw	63 - 80	abrupt smooth	2.5 YR 4/6 red	---	clay	---	weak medium subangular blocky	many v.f. many f. common m. no c.	sl.hard; friable; sl.sticky-sl.plastic	0.8	---	common quartz crystals and micas
---	C/R	80 - 130			---	very gravelly sandy clay	---	massive, indurated	few v.f. few f. no m. no c.	n.d.	4.7	---	many quartz crystals common micas and bedrock fragments
12.1.5	Ah1	(control											
12.1.6	Ah2	samples)											

Remarks: Colour: redd. = reddish
Biopores: v.f. = very fine; f. = fine; m. = medium; c. = coarse
Consistence: sl. = slightly

3.1.3 Soil Sampling

Soil samples (profile, composite, farmers' fields, pF rings) are listed in Sub-Section 3.2.

Figure 12.1.7 shows the location of the composite sampling blocks (I to IV) as well as the location of the profile pit.

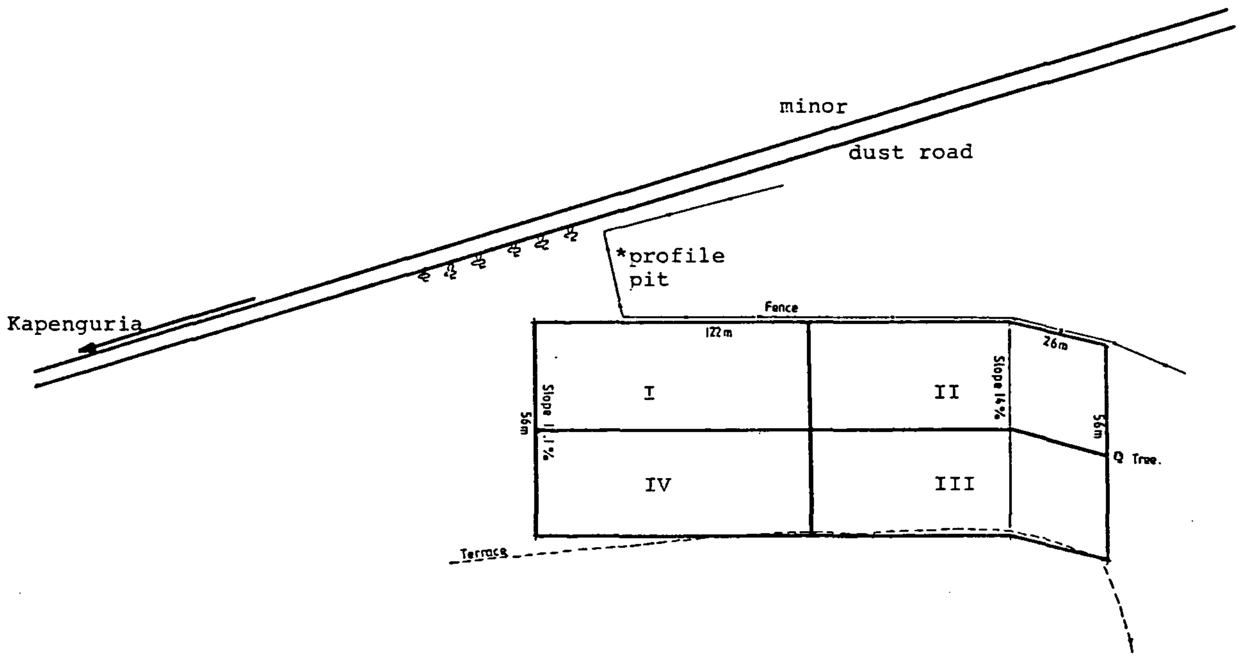


Figure 12.1.7 Location of Composite Sampling Blocks and Profile Pit at the Kapenguria Trial Plot

3.2 Laboratory Data

The soil samples from the profile and the composite samples from the various blocks of the main trial site and from the farmers' fields were analyzed in the laboratory. The results are compiled in Tables 12.1.10 to 12.1.12. The methodology applied for obtaining these results is described in detail in Chapter IV.2 of the main report.

Table 12.1.10 : Analytical Results (physical and chemical analysis, results on air dry soil basis)
Profile Samples from Trial Site

	Horizon	Depth cm.	Field No.	Lab. No.	> 2 mm. %	Sand %	Silt %	Clay %	Texture Class	pH KCl	pH H2O	Diff. pH	Cond. H2O
1	Ah1	0-19	12.1.1	3176/86	--	52	8	40	SC	6.0	7.5	1.5	0.0
2	Ah2	19-48	12.1.2	3177	--	46	12	42	SC	4.8	6.5	1.7	0.0
3	BA	48-63	12.1.3	3178	--	42	12	40	SC	4.7	6.4	1.7	0.0
4	Bw	63-80	12.1.4	3179	--	20	18	62	C	4.7	6.2	1.5	0.0
5													
6	Ah1	Control	12.1.5	3180	--	52	18	30	SC	4.8	5.9	1.1	0.1
7	Ah2	Control	12.1.6	3181	--	46	12	42	SC	4.2	5.2	1.0	0.2
8													

	Saturation Extract % water	pH	El.Cond.	Na	K	Mg	Ca	Mn	ECEC	Bases %	Al %	Al me./100gm.	H+Al KCl
				me./100gm. AgTU									
1	NA	NA	NA	0.16	4.31	4.85	22.00	0.36	27.8	112.7	0.7	0.20	0.38
2	NA	NA	NA									0.84	1.08
3	NA	NA	NA	0.06	0.11	2.45	6.80	0.70	10.6	88.9	6.0	0.64	0.92
4	NA	NA	NA									0.48	0.82
5													
6	NA	NA	NA									0.20	0.36
7	NA	NA	NA									0.82	1.06
8													

	Na	K	Mg	Ca	CEC pH8.2	Bases %	Bases+Al me./100gm.	Al %	Org. C %	N %	C/N	P Olsen ppm.	105 deg.C in rel.to air dry
	me./100gm. Acetate												
1	0.85	5.12	3.88	16.90	32.20	83.07	26.95	0.74	3.21	0.31	10.4		0.89
2	0.61	0.14	3.50	8.90	27.60	47.64	13.99	6.00	2.61	0.25	10.4		0.95
3	0.32	0.08	2.20	6.60	25.00	36.80	9.84	6.50	1.63	0.16	10.2		0.95
4	0.43	0.07	1.48	5.10	20.50	34.54	7.56	6.35	0.95	0.15	6.3		0.97
5													
6	0.35	0.42	4.32	8.30	23.40	57.22	13.59	1.47	5.02	0.57	8.8		0.94
7	0.62	0.14	2.75	4.10	26.50	28.72	8.43	9.73	3.30	0.29	11.4		0.95
8													

Moisture Retention Capacity

	Horizon	Depth cm.	Vol.% Moisture bar 0 pF 0	1/10 2	1/3 2.5	5 3.7	15 4.2	Avail. Moisture Capacity mm./10cm.	Bulk Dens gm./cc 105 deg.C
1	Ah1	5-10	61.4	34.5	28.7	16.8	15.4	19.1	0.87
2	BA/Bw	60-65	50.6	35.9	31.5	17.8	16.0	19.9	1.10
3									
4									

NA = not applicable
me./100gm. = milliequivalents per 100 gm. of soil
AgTU = Silver Thio Urea Extraction
Acetate = Bases by Ammonium Acetate of pH 7, CEC by Sodium Acetate pH 8.2
pH and conductivity in suspension 1:2.5

Table 12.1.11 : Analytical Results (chemical analysis, results on air dry soil basis)
Trial Site Composite Samples

No.		Depth cm.	Block number I	II	III	IV	V	VI	VII	x	s	Max. diff.
1	Lab. No. /86	20	3120	3122	3124	3126						
2		50	3121	3123	3125	3127						
3												
4	Fine earth %	20	100	100	100	100				100	0.00	0.00
5		50	100	100	100	100				100	0.00	0.00
6	Vol.weight gm./cc.	20	0.88	0.88	0.92	0.98				0.92	0.05	0.10
7		50	0.95	0.94	1.02	1.01				0.98	0.04	0.08
8	105 deg.C / air dry	20	0.94	0.93	0.94	0.93				0.94	0.01	0.01
9		50	0.95	0.93	0.95	0.94				0.94	0.01	0.02
10												
11	pH H20 1/1	20	5.8	5.8	6.1	6.2				5.98	0.21	0.40
12		50	5.7	5.9	6.5	6.7				6.20	0.48	1.00
13	pH H20 1/2.5	20	6.2	6.5	7.0	6.9				6.65	0.37	0.80
14		50	6.5	6.8	6.8	6.7				6.70	0.14	0.30
15	pH N KCl 1/2.5	20	5.2	5.1	5.3	5.3				5.23	0.10	0.20
16		50	4.9	5.1	5.4	5.1				5.13	0.21	0.50
17												
18	C org. %	20	5.40	5.27	4.62	4.69				5.00	0.40	0.78
19	N tot. %	20	0.58	0.57	0.50	0.54				0.55	0.04	0.08
20	C/N	20	9	9	9	9				9.12	0.29	0.63
21												
22	Mod.Olsen Abs. 260nm	20	200	200	180	220				200.00	16.33	40.00
23	(1/1000)	50	150	120	70	110				112.50	33.04	80.00
24												
25	SO4 soluble ppm.	20	8									
26		50	16									
27												
28	P Meh.1/5 ppm.	20	16	10	13	13				13.00	2.45	6.00
29		50	10	8	10	10				9.50	1.00	2.00
30	P Olsen ppm.	20	11.00									
31		50	5.00									
32	P mod.Olsen ppm.	20	13.00	12.00	5.00	7.00				9.25	3.86	8.00
33		50	2.50	1.60	1.50	2.00				1.90	0.45	1.00
34	P Citric ac. ppm.	20	33									
35		50	18									
36												
37	ECEC AgTU me./100gm.	20	20.8	20.8								
38	Bases %	20	99.7	95.4								
39	Al%	20	NA	NA								
40												
41	Hp BaCl2 me./100gm.	20	not applicable									
42		50	not applicable									
43	H & Al KCl me./100gm	20	not applicable									
44		50	not applicable									
45	Al 3- KCl me./100gm.	20	not applicable									
46		50	not applicable									
47	Al 3- AgTU me./100gm	20	not applicable									
48												
49	Sat.Ext. % H20	20	not applicable									
50		50	not applicable									
51	Sat.Ext. El.Cond.	20	not applicable									
52		50	not applicable									
53	Sat.Ext. pH	20	not applicable									
54		50	not applicable									
55												

cont.

District: West Pokot Trial Site: 12.1 Kapenguria

Table 12.1.11 : Analytical Results (chemical analysis, results on air dry soil basis)
Trial Site Composite Samples

		Depth cm.	Block number I	II	III	IV	V	VI	VII	x̄	s	Max. diff.
1	Lab. No. /86	20	3120	3122	3124	3126						
2		50	3121	3123	3125	3127						
3												
56	Na Meh.1/5 me./100gm	20	0.18	0.24	0.22	0.10				0.19	0.06	0.14
57		50	0.14	0.24	0.18	0.14				0.18	0.05	0.10
58	Na Ag-TU me./100gm.	20	0.12	0.11								
59												
60	K Meh.1/5 me./100gm.	20	0.75	0.78	0.72	0.86				0.78	0.06	0.14
61		50	0.72	0.36	0.42	0.90				0.60	0.25	0.54
62	K mod.Ol. me./100gm.	20	0.68	0.79	0.67	0.86				0.75	0.09	0.19
63		50	0.59	0.35	0.40	0.64				0.49	0.14	0.29
64	K Ag-TU me./100gm.	20	0.87	0.94								
65												
66	Mg Meh.1/5 me./100gm	20	4.60	4.70	4.50	6.00				4.95	0.70	1.50
67		50	3.00	5.00	4.50	5.00				4.38	0.95	2.00
68	Mg mod.Ol. me./100gm	20	4.53	4.11	3.70	6.17				4.63	1.08	2.47
69		50	5.76	4.53	7.82	8.23				6.58	1.75	3.70
70	Mg Ag-TU me./100gm.	20	4.55	4.20								
71												
72	Ca Meh.1/5 me./100gm	20	16.40	16.00	19.60	16.00				17.00	1.74	3.60
73		50	3.60	15.20	13.60	8.00				10.10	5.32	11.60
74	Ca mod.Ol. me./100gm	20	18.40	18.30	19.60	17.80				18.53	0.76	1.80
75		50	13.80	18.40	17.10	12.80				15.53	2.66	5.60
76	Ca Ag-TU me./100gm.	20	15.20	14.60								
77												
78	Mn Meh.1/5 me./100gm	20	0.26	0.36	0.44	0.60				0.42	0.14	0.34
79		50	0.50	0.30	0.52	0.46				0.45	0.10	0.22
80	Mn mod.Ol. me./100gm	20	0.27	0.30	0.30	0.39				0.32	0.05	0.12
81		50	0.13	0.36	0.26	0.15				0.23	0.11	0.23
82	Mn Ag-TU me./100gm.	20	0.25	0.40								
83												
84	Zn HCl ppm.	20	4.00									
85		50	2.60									
86	Zn mod. Ol. ppm.	20	6.00	4.00	5.00	4.00				4.75	0.96	2.00
87		50	1.00	3.00	1.00	0.00				1.25	1.26	3.00
88												
89	Cu HCl ppm.	20	1.70									
90		50	1.40									
91	Cu mod. Ol. ppm.	20	1.00	1.00	1.00	1.00				1.00	0.00	0.00
92		50	3.00	1.00	2.00	2.00				2.00	0.82	2.00
93												
94	Fe HCl ppm.	20	8									
95		50	11									
96	Fe mod. Ol. ppm.	20	65	65	40	55				56.25	11.81	25.00
97		50	70	55	35	80				60.00	19.58	45.00
98												
99	Fe Oxalate %	20	1.22									
100		50	1.47									
101	Al Oxalate %	20	1.40									
102		50	1.70									

NA = not applicable
me./100gm. = milliequivalents per 100 gm. of soil
Meh. = Mehlich Analysis
mod. Ol. = Modified Olsen Extraction
AgTU = Silver Thio Urea Extraction

Table 12.1.12 : Analytical Results (chemical analysis, results on air dry soil basis)
Farmers' Fields Composite Samples

		Depth cm.	Farmers' fields (code) A	B	C	D	E	F	G	H	Trial site average	$\bar{x}$	s	Max. diff.
1	Lab. No. /86	20	3128	3129	3130	3131	3132	3133	3134	3135				
2	Fine earth %	20	100	100	100	100	100	100	100	100	100	100.00	0.00	0.00
3	Vol.weight gm./cc.	20	0.91	0.97	1.06	0.96	1.03	1.00	0.82	0.91	0.92	0.95	0.07	0.24
4	105 deg. C / air dry	20	0.95	0.98	0.97	0.94	0.95	0.94	0.92	0.96	0.94	0.95	0.02	0.06
5														
6	pH H20 1/1	20	6.00	5.90	5.70	5.80	5.70	5.80	6.60	6.30	5.98	5.98	0.30	0.90
7	pH H20 1/2.5	20	6.50	6.40	6.40	6.30	6.40	6.80	7.00	6.90	6.65	6.59	0.25	0.70
8	pH N KCl 1/2.5	20	4.90	4.80	4.90	4.90	4.90	5.60	5.50	4.70	5.23	5.05	0.32	0.90
9														
10	C org. %	20	3.46	1.83	2.73	4.52	4.01	4.16	6.05	3.17	5.00	3.88	1.26	4.22
11	N tot. %	20	0.28	0.16	0.22	0.44	0.38	0.42	0.88	0.29	0.55	0.40	0.22	0.72
12	C/N	20	12	11	12	10	11	10	7	11	9	10.43	1.72	5.53
13														
14	Mod.Olsen Abs.260nm.	20	330	180	520	230	440	340	190	240	200	296.67	120.10	340.00
15														
16	P Meh. 1/5 ppm.	20	8.00	16.00	13.00	10.00	16.00	13.00	18.00	13.00	13.00	13.33	3.08	10.00
17	P mod.Olsen ppm.	20	5.00	22.00	13.00	5.00	16.00	9.00	9.00	7.00	9.25	10.58	5.56	17.00
18														
19	Na Meh.1/5 me./100gm.	20	0.14	0.18	0.18	0.22	0.18	0.28	0.28	0.14	0.19	0.20	0.05	0.14
20														
21	K Meh.1/5 me./100gm.	20	0.68	0.90	0.61	0.32	0.28	0.68	0.72	1.64	0.78	0.73	0.40	1.36
22	K mod.Ol. me./100gm.	20	0.60	0.93	0.42	0.24	0.22	0.56	0.70	0.73	0.75	0.57	0.24	0.72
23														
24	Mg Meh.1/5 me./100gm.	20	2.60	1.60	2.00	4.30	2.80	3.00	5.50	5.50	4.95	3.58	1.50	3.90
25	Mg mod.Ol. me./100gm.	20	4.94	4.11	3.70	5.76	4.94	5.35	4.53	6.58	4.63	4.95	0.87	2.88
26														
27	Ca Meh.1/5 me./100gm.	20	6.80	2.00	2.40	11.20	8.80	8.80	30.00	15.60	17.00	11.40	8.65	28.00
28	Ca mod.Ol. me./100gm.	20	10.60	3.50	5.60	15.50	13.50	14.40	21.20	16.50	18.53	13.26	5.80	17.70
29														
30	Mn Meh.1/5 me./100gm.	20	0.34	0.18	0.32	0.36	0.44	0.42	0.26	1.00	0.42	0.42	0.23	0.82
31	Mn mod.Ol. me./100gm.	20	0.34	0.18	0.26	0.43	0.36	0.31	0.40	0.24	0.32	0.32	0.08	0.25
32														
33	Zn mod.Ol. ppm.	20	3.60	3.30	2.70	3.30	5.30	2.90	4.10	4.90	4.75	3.87	0.93	2.60
34														
35	Cu mod.Ol. ppm.	20	3.00	2.00	2.00	2.00	2.00	4.00	1.00	2.00	1.00	2.11	0.93	3.00
36														
37	Fe mod.Ol. ppm.	20	145	225	200	100	170	150	50	80	56	130.69	62.63	175.00
38														
39	Hp BaCl2 me./100gm.	20												
40	H & Al KCl me./100gm.	20												
41	Al KCl me./100gm.	20												

NA = not applicable
me./100gm. = milliequivalents per 100 gm. of soil
ppm. = parts per million
Meh. = Mehlich Analysis
Mod. Ol. = Modified Olsen Extraction

3.3 Evaluation of Soil Data

3.3.1 Literature References and Soil Correlation

From 1972 onwards, the Kenya Soil Survey has carried out many soil surveys and site evaluations and, in addition, some surveys were conducted by other agencies.
A complete list of soil survey reports is given in Chapter II.2 of the main report. Those reports that refer to the area in which the trial site is situated are listed below.

Literature references:	
E1	W.G. Sombroek, H.M.H. Braun and B.J.A. van der Pouw (1982). Exploratory Soil Map and Agro-Climatic Zone Map of Kenya, 1980, scale 1:1,000,000.
LBDA	W. Andriesse, and B.J.A. van der Pouw (1985). Reconnaissance Soil Map of the Lake Basin Development Authority Area, Western Kenya, scale 1;250,000.
R2	H.F. Gelens, H.C. Kinyanjui and R.F. van de Weg (1976). Soils of the Kapenguria Area (with map, scale 1:100,000).

In order to correlate existing information with findings at the trial site, the map units and classification units in the above-mentioned reports have been grouped in Table 12.1.13. Moreover, the FURP soil map unit (Map 12.0.4) and the classification of the soil of the profile at the trial plot are given.

Table 12.1.13: Soil Correlation with Respect to the Kapenguria Trial Site

Reference	Map unit	Soil Classification
E1	Uh 12	humic Acrisols and Cambisols, partly lithic phases
LBDA	UhU1	humic Acrisols and Cambisols, partly lithic phases
R2	U3Gh	humic Acrisols and Cambisols
FURP	UN2	humic Acrisols and Cambisols, partly lithic phases
Trial plot profile		humic CAMBISOL

Regarding the trial site there is consensus between the various sources on humic Cambisols and humic Acrisols. The profile pit is a deep humic Cambisol, the trial plot has very deep soils with clay illuviation (humic Acrisols).

3.3.2 Representativeness

For two reasons, statements about the representativeness of the soils of the trial site should be made with care.
Firstly, soil classification units are mainly based on properties of a relatively permanent nature, i.e. those of the sub-surface horizons and not those of the topsoil.
Secondly, the generally high variability of topsoil properties within short distances is not reflected in relatively small-scale reconnaissance soil maps (1:100,000 to 1:1,000,000).

In this report, soils of a map unit considered to be within the "area of representativeness" must meet the following requirements:

(a) the soil-related land factors must have the same or similar ratings;

(b) soil classification must be the same or similar.

The extent to which all the FURP trial sites are representative of the soils of West Pokot District is shown in Map 12.0.5: "Groupings of Soil Mapping Units Represented by Trial Sites in West Pokot District". This map is discussed in Sub-Section 12.0.5.

Distinction is made between <u>high</u> representativeness - code A - and <u>moderate</u> representativeness - code B+ if soil conditions are slightly <u>more</u> favourable than at the trial site and code B- if soil conditions are slightly <u>less</u> favourable than at the trial site. Code C is applied for the remaining parts of the District, where <u>none</u> of the FURP trial sites are representative.

Within West Pokot District, the Kapenguria trial site has high representativeness (12.1.A) for soil map unit UN2, South-East of Kapenguria town. It refers to humic Cambisols and Acrisols.
It is moderately representative of the neighbouring soil map unit UN3, which only partly consists of humic Cambisols and Acrisols.

The Kapenguria trial site is also representative for areas outside West Pokot District (in particular in combination with trial site 6.2, in Bungoma and Kakamega Districts) for the humic Cambisols of soil association UlRA (Grouping 6.2.A/12.1.B-). Moreover, the site is representative for parts of Nandi District (soil map unit UhU4, Grouping 12.1.B-), Trans Nzoia District (soil map unit UhUl, Grouping 12.1.A), and Elgeyo Marakwet District (soil map unit UN2, Grouping 12.1.A).

3.3.3 Variability of Soil Properties within the Trial Site

The trial plot has a uniformly thick acid humic topsoil. The pit is situated on the upper slope and has fresh weathered rock fragments from about 80 cm (humic Cambisol). The plot is mainly on the middle and lower slopes and has a Bt-horizon without rock fragments (humic Acrisol).
Some local differences exist among the farmers' fields. Some have a slightly gravelly surface, and organic matter content of the topsoil varies between 1.8% and 6.0%. Mesotopography is indicated in Table 12.1.3.

A breakdown of the variability of soil fertility parameters pH-KCl and organic carbon content of the upper 20 cm. is given below. More details on soil test values are given in Tables 12.1.10 to 12.1.12.

<u>pH-KCl</u>:	profile pit:	6.0 (control sample: 4.8)
	composite samples:	5.1 - 5.3
	farmers' fields:	4.7 - 4.9 (fields A-E and H)
		5.5 - 5.6 (fields F and G)
<u>organic carbon content</u>:		
	profile pit:	3.2% (control sample: 5.0%)
	composite samples:	4.6% - 4.7% (Block III and IV)
		5.3% - 5.4% (Block I and II)
	farmers' fields:	1.8% (field B)
		2.7% - 3.5% (fields A, C and H)
		4.0% - 4.5% (fields D, E and F)
		6.0% (field G)

3.3.4 Fertility Status of the Soil

The criteria applied for the interpretation of the analytical data are outlined in Chapter IV.2 of the main report.

3.3.4.1 Soil Profile

The analytical data of the soil samples taken from the profile pit are presented in Table 12.1.10 and are interpreted in the following paragraphs. The pit is situated at the corner of a fenced pasture between the road and Block I (see Figure 12.1.7), but there is disagreement as to whether the pit is located inside or outside the fence. Furthermore, it is no longer known exactly from where the control samples (lines 6 and 7 in Table 12.1.10) were taken.

The main rooting depth of the soil is limited to 80 cm. by the massive C/R horizon. The capacity for plant available moisture in the solum may be roughly determined from the pF analyses carried out on the Ahl horizon and the BA/Bw transition. It attains approximately 150 mm., which is in the high range.

The CEC (pH 8.2) of the soil (profile pit) is high to medium. It declines from 32 me./100 gm. in the topsoil to 20 me./100 gm. in the subsoil. The base saturation is very high in the Ahl horizon (83 %) and moderate in the underlying soil. With depth it decreases to 35 % in the Bw.

With regard to the high humus content, the soil reaction (pH) is in accordance with the base saturation. The topsoil is slightly acid to neutral while the underlying horizons are moderately acid. Al is exchangeable only in minor amounts.

Even with respect to the high CEC, K is exchangeable in extremely high amounts (>4 me./100 gm.) in the uppermost horizon, whereas the soil below 20 cm is low to very low in K (<0.14 me./100 gm.). This pronounced accumulation of K in the topsoil is repeated neither in the control sample (see below) nor in the trial site composite samples, which contain less than 1 me./ 100 gm. in the respective depths of the Ah1 and Ah2 horizons.

Mg shows very high to high values in all horizons, decreasing with depth (>4 to 1.5 me./100 gm.); whereas Ca is high only in the Ah1 (>16 me./100 gm.), and medium to low in the underlying soil (<9 me./100 gm.). A similar difference in Ca between top- and subsoil is found in the trial site composite samples from Block I.
The organic matter content of the soil (profile) is high in the topsoil (3.2 % C in Ah1 and 2.6 % C in Ah2) and decreases with depth. The total N content is high in the Ah horizons and medium in the soil below 50 cm. where the C/N ratios are medium to wide.

The control samples from the Ah horizons were probably collected some distance from the profile pit, where the very high K and Ca concentrations are not present. In the Ah1, K is in the medium range (0.42 me./100 gm.), which should be normal for this soil and which is about a tenth of that found in the profile. Exchangeable Ca is about half that of the profile values. Consequently, the base saturation is moderate (53 % in Ah1 and 29 % in Ah2) and the soil is moderately to strongly acid. The C content is higher in the control samples than in the actual profile samples.

Without knowing much about the history of the field and of this pit in particular, it is very difficult to explain such findings sufficiently. Under the prevailing climate (humid, relatively cold), bases are normally not accumulated in the topsoil to the extent found in the profile. A possible explanation of these findings for the profile pit might be that wood and/or harvest residues were burnt at this spot which may have caused the elevated base status of the topsoil and additionally may have lowered the humus content. As the pit is placed just beside the main access to the trial site in the corner of a (recently ?) fenced pasture, the high K level may also be due to cattle droppings.

3.3.4.2 Soil Fertility Assessment of Composite Samples

The analytical results for the composite samples from the trial site (depths 0-20 cm. and 20-50 cm.) are presented in Table 12.1. 11. The data for the farmers' fields around this trial site are given in Table 12.1.12.

The composite samples were analyzed to assess the chemical fertility status of the soil, with special emphasis on the availability of the important nutrient elements to the plants. The "available nutrients" were estimated by means of two complementary methods, the "Mehlich" diluted double-acid method (NAL routine) and a "modified Olsen" bicarbonate + EDTA extraction.

The interpretation of the analytical data presented is in so far tentative for both methods as the validity of the applied ratings (ranges for Low, Medium, High) has not yet been verified by field trials in the various regions of Kenya.

The organic matter content of the soils investigated varies widely from moderately humic to rich in humus (1.8 % C to 5.4 % C). The trial site and farmer's field G are richer in humus than any other of the farmers' fields, probably because the mineralization of organic matter in the soil is slow. The total N content of the soils covers a wide range from medium to very high (0.2 - 0.6 % N). The C/N ratios are medium to wide. This and other prevailing soil conditions indicate that the N availability is probably low to moderate, depending on the humus content of the soil and the mineralization rate. The UV absorption of the modified Olsen extract indicates a moderate N supplying capacity for the trial site. This index is very erratic for the farmers' fields. It is low to moderate in most fields, but at least in fields C and E this method indicates a very high N supplying capacity of the soil.

SO_4 solubility was found to be low to adequate in Block I.

According to the Mehlich analysis, "available" P is low or low to moderate in all cases, whereas the modified Olsen method shows more variable results. According to this method, the topsoils in Blocks I and II are moderate in P, Blocks III and IV are poor in P, and the subsoil of the entire plot has a very low P status. In the farmers' fields, the modified Olsen method on average indicates a better P availability than the Mehlich analysis. Only fields A, D, and H fall into the low range while in field B, a high P status was reported.

The P availability encountered seems inadequate to the expected N supplying capacity of the soils other than in farmer's field B which might be an exception.

The "available" quantities of K are high in all samples, only farmers' fields D and E show a moderate K status. The Mg availability is in the high and very high range for all samples and according to both methods (Mehlich analysis and modified Olsen method), but the reported values are very erratic. "Available" Ca is in the high range in the trial site and in most farmers'fields except in fields B and C which show low to moderate Ca values.

According to the Mehlich analysis, Mn is available in appreciable amounts, whereas the modified Olsen method shows only low to medium values.

According to the modified Olsen method and the HCl-extraction, Zn and Cu are available in low to moderate amounts in general, but some of the farmers' fields seem to be slightly deficient in Zn (below 4-5 ppm.). While the modified Olsen method extracted moderate amounts of Fe, the oxalate extraction for amorphous oxides and hydroxides yielded moderate amounts of Fe and Al.

The composite soil samples investigated are generally of a similar pH as the profile samples and slightly to moderately acid (pH KCl 5.6 - 4.7).

The evaluation of the Mehlich Analysis data according to NAL standards is given in Table 12.1.14.

Table 12.1.14: Evaluation of the Mehlich Analysis Data According to NAL Standards

Parameter	Trial Site	Farmers' Fields
Soil reaction (pH)	Moderately acid to slightly acid	Moderately to slightly acid
Acidity (Hp)	Low	Low
Available nutrients		
Sodium	Adequate	Adequate
Potassium	Adequate	Adequate
Calcium	High	Adequate
Magnesium	High	Adequate
Manganese	Adequate	Adequate
Phosphorus	Low	Low
Total Nitrogen	Moderate to low	Moderate to low
Organic Carbon	High	High
C / N Ratio	Not favourable	Not favourable
Ca / Mg Ratio	Favourable	Favourable
Ca / K Ratio	Favourable	Favourable
K / Mg Ratio	Favourable	Favourable

Remarks on Trial Site:
Soil reaction is favourable. Positive yield responses to P applications are expected. Responses to lime, N and manure and K applications are unlikely.

Remarks on Farmer's Fields:
Same as the Trial site.

3.4 Sampling Programme for Laboratory Analyses during Phase II

3.4.1 Soil Samples

Soil samples will be collected once a year at the beginning of the long rains in March just after ploughing and before the fields are planted. The samples will be taken individually from two depths (0-20 cm. and 20-50 cm.) for each replication of the selected fertilizer treatments, and only from the plots in module 2 with maize/beans mixed cropping.

The treatments to be sampled are:

Trial I: N0:P0   N75:P75   N0:P75   N75:P0

Trial II: 0   N+P   FYM   FYM+P   FYM+N+P   N+P+K

Farmers' fields: farmers fields A, B and C are proposed

3.4.2. Plant Samples

Harvest samples from the maize/beans mixed crop include the individual samples of grain and straw from maize and beans respectively. Samples will be collected separately from each replication of the treatments where soil samples were collected, i.e.:

Trial I: N0:P0	N75:P75	N0:P75	N75:P0		
Trial II:0	N+P	FYM	FYM+P	FYM+N+P	N+P+K

Farmers' fields: Harvest samples will only be collected from those farmers' fields where soil samples were taken. Individual samples of grain and straw are only required from the maize crop.

3.4.3 Other Samples

From every batch of applied FYM three representative samples will be taken.

4. Conclusions from the Analyses of Climate and Soils

4.1 Moisture Availability

The amount of rainfall which is surpassed in 20 out of 30 years (i.e. 66% probability) constitutes the basis for estimating moisture availability during the growing periods. Other parameters of the water balance such as moisture storage capacity, run-off and deep percolation also have to be considered in order to obtain a comprehensive picture of the moisture availability.

For example, the water requirements and the water availability for maize H 625, planted at the beginning of April at the Kapenguria trial site, can be interpreted as follows.

Figure 12.1.6 shows that the maximum water requirements (ETm) of the maize crop are in line with the rainfall pattern at the 66% probability level.

Run-off is high: the trial site is located on sloping land (slopes: 12-14%), and the crop does not provide adequate ground cover at the time of high rainfall-intensity in April/ May. The weak terrace along the southern plot boundary cannot do much to prevent run-off.

Lateral sub-surface flow occurs to some extent. Deep percolation and run-on could be estimated, but can be omitted, since they are low. Within the plot, however, run-on and lateral sub-surface flow favour the lower parts.

For the Kapenguria trial site, the moisture storage capacity is rated high (i.e. 120-160 mm.). Thus, the water surplus, which is likely to occur in April/May and July/August, can to a large extent be stored, leading to a continuous agro-humid period from at least March to December. Summarizing the evaluation of the climatic factors, the yield potential from the climatic point of view can, for the maize crop (planted at the beginning of March), be rated good to very good on a "20 out of 30 year" basis.

4.2 Nutrient Availability in Relation to Possible Fertilizer Requirement

Except for P, nutrient availability and soil reaction generally appear at least moderately favourable for plant production. SO_4, Zn and Cu all seemed to be rather low but acute deficiencies are not expected at present. Availability of these elements should be verified during the trials.

Fertilizer applications should first of all involve P in the form of TSP or finely ground soft rock phosphate (e.g. Hyperphos). Under the moderately acid soil conditions the rock phosphate should be almost as effective as TSP even in the first season. P from rock phosphate is less subject to fixation than P from TSP. Nonetheless, the risk of P fixation into non-available forms is considered to be moderate. The efficiency of P application may be enhanced by the addition of small amounts of fresh FYM to stimulate soil biological activity.

Superphosphate contains about 12% S and therefore may act as a two-element fertilizer. Under farmers' conditions this might be very useful when a limited S availability is expected.

Mineral N applications are considered useful only in combination with adequate P supply, in which case reasonable responses to N application may be expected. Top dressings may prove more efficient than broadcast applications at planting time. The N supply from most soils analyzed should be sufficient to make starter N unnecessary.

During the excessively high rainfall in April/May losses of N through denitrification may occur, but this is probably only of minor intensity. Denitrification losses from NO_3 sources occur in greater amounts than from NH_4 sources. For a more reliable estimate of the extent to which denitrification may occur, more precise data on the soil moisture regime and its effects on N losses are required. N losses due to leaching seem to be rather low, as the base saturation of the profile indicates only a low or moderate leaching intensity.

Liberal applications of N and P may induce or intensify deficiencies of micro-elements, notably Zn and Cu.

The application of FYM will only have a limited effect if not combined with P. Green manuring with leguminous plants will depend even more on P fertilization. Organic manures will be important to maintain the humus content at the present high level. The organic matter is essential for a stable structure of the topsoil and a high water infiltration rate, thus avoiding topsoil sealing, surface run-off, and erosion. Additionally the humus prevents nutrients from fast leaching.

K applications are not required at the present stage and response to K may not be obtained. The analytical data give no estimation of the reserves of K beyond the exchangeable pool, but the mica present in the soil should be a lasting source of K.

Under the present soil conditions liming is not needed at all and the acidifying effects of the applied mineral or organic fertilizers will be sufficiently buffered by the soil for the duration of the trials over five years. If lime is applied, the solubility of P will be further reduced and availability of Zn, Cu and possibly Mn will become too low for adequate plant nutrition.

4.3 Other Relevant Land Qualities

In addition to an assessment of moisture and nutrient availability, the following land qualities are relevant in the context of fertilizer use:

a) Oxygen availability.
In wet years, the excess rainfall can lead to temporarily impeded soil aeration, which is a constraint to plant metabolism, notably at the crop emergence stage. The high structure stability of the topsoil prevents this from occurring too often.

b) Rootability.
The deep to very deep soils with stable blocky structures, heterogeneous pore size distribution and very high organic matter content provide a suitable environment for unhampered root development and tuber expansion.

c) Resistance to erosion.
The area has a moderate resistance to erosion, as long as the organic matter content remains as high as it is at present. The negative influence of high rainfall intensity and rolling topography are to some extent offset by a high structure stability (low erodibility) of the surface soil and the quick establishment of a crop cover.

d) Ease of cultivation and scope for agricultural implements.
Although the soils impose no serious limitations to any type of land preparation, the topography restricts the use of oxen plough and heavy machinery on the steep parts of the area around Kapenguria.

5. Trial Design and Execution Plan, Kapenguria

(Full details of the methodology for carrying out the trials are shown in Chapter IV of the main report.)

Selection of Crops. The proposed crop sequences in each of the 3 modules, for the Kapenguria site are:-

Site 12.1 Kapenguria.	RAINY SEASONS 1st, long, March 2nd, short, Aug.
S1 Standard Maize	Hybrid 625
S2 Maize & Beans	Hybrid 625 + Beans GLP 2
S3 Pot./Cabb./For.Oats	Pot. B53/Cabb. Copenh. /For Oats

The 1st sequence or module is continuous, pure maize, once/year.
The 2nd is intercropped maize and beans, also once/year.
The 3rd is potatoes or cabbages in the first rains, followed by a forage crop of oats in the August rains.

Each module contains 2 experiments, namely Experiment 1 and Experiment 2. Experiment 1 is a 4N x 4P factorial, with 2 replications in each module. Experiment 2 is a 2N x 2P x 2K x 2 FYM factorial, also with 2 replications in each module.

Each module thus consists of 64 plots, and the total for the 3 modules is 192 plots.

Fertilizer and FYM will be applied only to the crops during the 1st rains. Where maize and beans are intercropped, the fertilizer will go on the maize. The intercropped beans will not receive any fertilizer directly, but will "scavenge" from the maize, and from residual fertilizer left in the relevant plots after the first season. Similarly, the crops in the second rains i.e.: forage oats will not receive any fertilizer directly.