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 20

Kiambu District

District No.: 20

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Fertilizer Use Recommendation Project (Phase I)

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Fertilizer Use Recommendation Project (Phase I)

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Annex I : Compilation of results from Former Fertilizer Trials In Kenya (2 Volumes)

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Annex III : Detailed Description of the First Priority Sites in the Various Districts :

1. Kisii
2. South Nyanza
3. Kisumu
4. Siaya
5. Busia
6. Bungoma
7. Kakamega
8. Nandi
9. Kericho
10. Trans Nzoia
11. Uasin Gishu
12. West Pokot
13. Keyo Marakwet
14. Baringo
15. Laikipia
16. Nakuru
17. Narok
18. Samburu
19. Nyandarua
20. Kiambu
21. Muranga
22. Nyeri
23. Kirinyaga
24. Embu
25. Meru
26. Machakos
27. Kitui
28. Lamu
29. Kilifi
30. Taita Taveta
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Annex IV : Description of Computer Programmes Established in Phase I

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Chapter 20.0:

Chapter 20.1:

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 20.0:

General Aspects

List of Tables

List of Maps

1. Climate and Soils of the District

The Agro-Ecological Zones of Kiambu District extend in a typical pattern along the eastern slopes of the Nyandarua (Aberdare) Range parallel to the isohypses, as shown on Map 20.0.3.

Average annual rainfall in the District is variable, ranging from <600 mm in the south-east (Zone UM 5-6) to >2000 mm in the north-west (Zone UH 0) of the District. Rainfall steadily increases from east to west, almost in line with the increasing altitude, decreasing rapidly, however, in the rain-shadow of the Nyandarua Range. The rainfall pattern is bimodal and rainy seasons are clearly separated: first rains start mid to end of March, with their peaks in April/May. Second rains start mid to end of October with their peak in November.

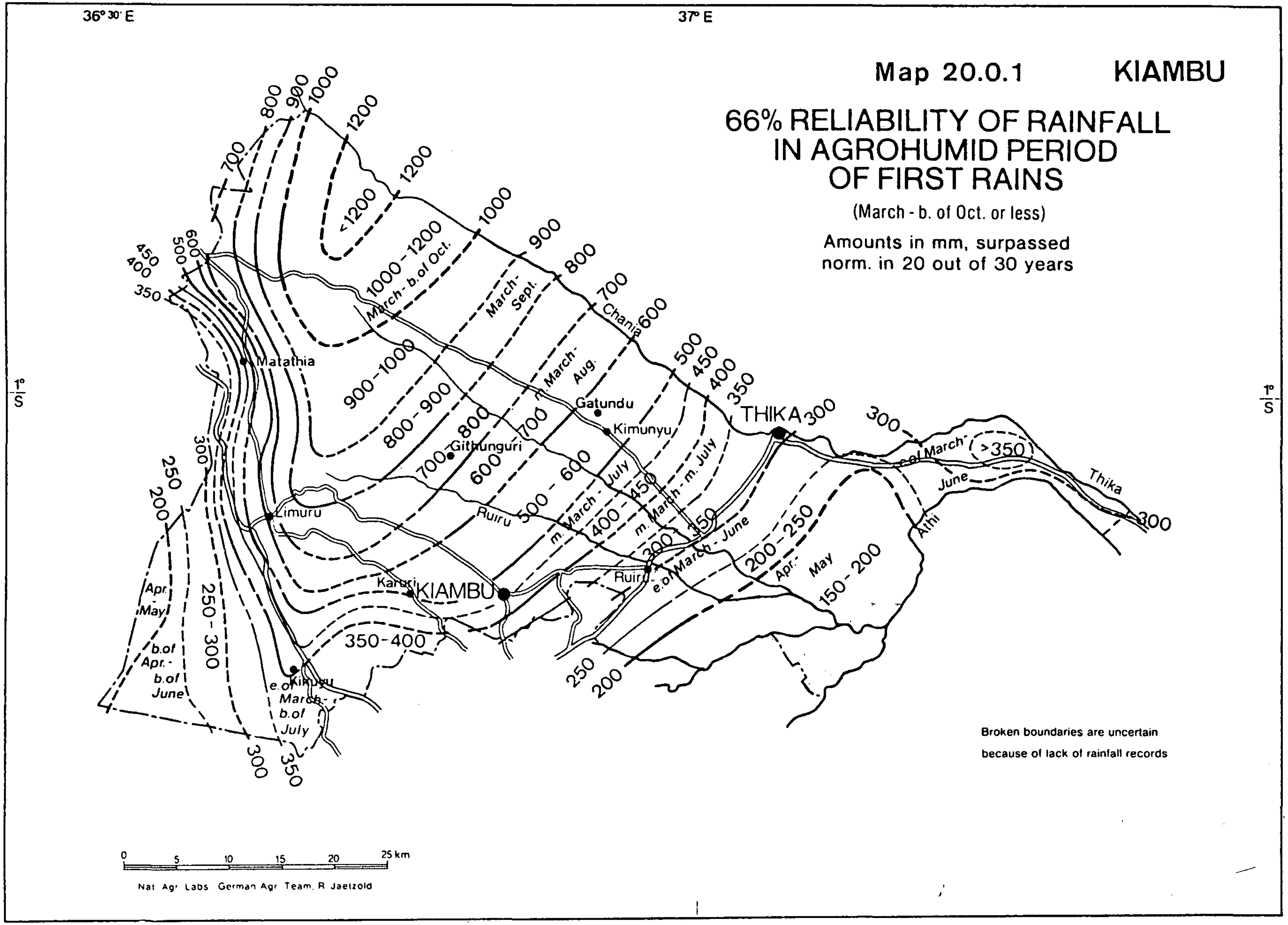
The 66% reliability of rainfall, i.e. amount surpassed in 20 out of 30 years, is shown in Map 20.0.1 for the first rains and in Map 20.0.2 for the second rains.

Evaporation, varying with altitude, ranges between 1800 mm. at 1400 m, and 1300 mm at 2500 m.

The mean annual temperature is 20°C at 1400 m and 14°C at 2500 m.
A summary of climatic data is compiled in Table 20.0.1, which can be used as a key to the Agro-Ecological Zones Map 20.0.3.

The Marginal Cotton Zone (LM 4) ends at about 1350 m. The Sunflower-Maize Zone (UM 4) starts immediately above it, except for the areas in the rain shadow of the Kamba Hills, where maize growing is feasible only above 1450m in the north-east and above 1550 m in the south-east. This omits the Athi Plains, which are in the Livestock-Sorghum Zone (UM 5).

The Agro-Ecological Zone UM 1 is represented by the Githunguri trial site (Site No. 20.1), as shown in Map 20.0.3.
Zones LH 1, 2, 3, UM 2 and 4 are represented by trial sites in Nyeri, Nakuru, Narok, Kirinyaga and Muranga Districts.
The Agro-Ecological Zone UM 3 (Marginal Coffee Zone) is not yet represented by any of the FURP first priority trial sites.



Map 20.0.1 KIAMBU

66% RELIABILITY OF RAINFALL IN AGROHUMID PERIOD OF FIRST RAINS

(March - b. of Oct. or less)

Amounts in mm, surpassed norm. in 20 out of 30 years

Broken boundaries are uncertain because of lack of rainfall records

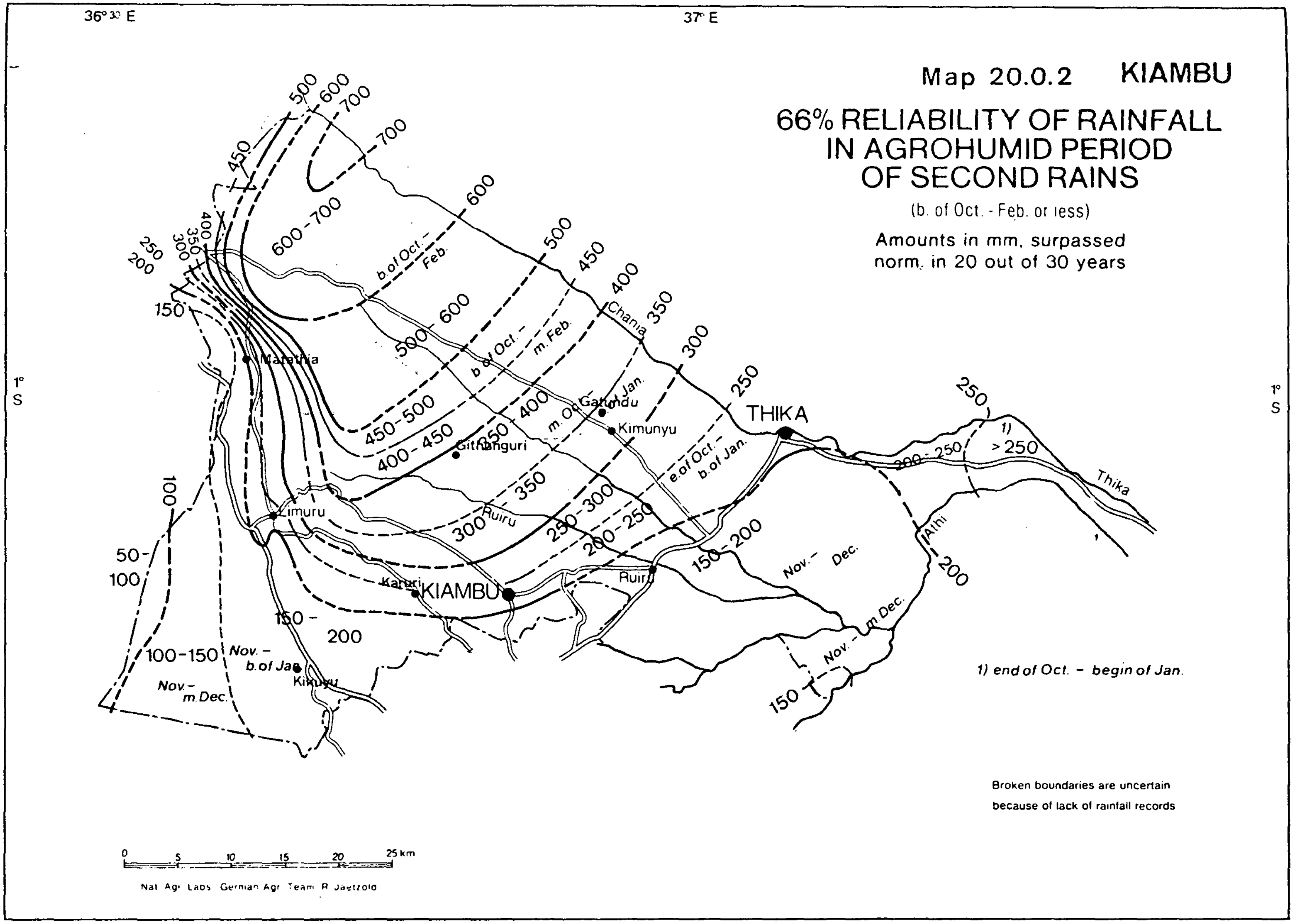
Nat Agr Labs German Agr Team. R Jaetzold

Map 20.0.2 KIAMBU

66% RELIABILITY OF RAINFALL IN AGROHUMID PERIOD OF SECOND RAINS

(b. of Oct. - Feb. or less)

Amounts in mm, surpassed norm. in 20 out of 30 years



1) end of Oct. - begin of Jan.

Broken boundaries are uncertain because of lack of rainfall records

Table 20.0.1 : Climate in the Agro-Ecological Zones of Kiambu 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
UH 0 Forest Zone		Forest Reserve							
UH 1 Sheep and Dairy Zone	p or l/vl – m	2 280–2 550	15.2–13.5	1 200–2 000	900–1 100	400–620	220 or more	135–145	355–365
	l/vl – m			1 200–1 600	700– 900	250–450	220 or more	130–140	350–360
UH 2 Pyrethrum-Wheat Zone	l i m/s	Very small, see Nyandarua District							
LH 1 Tea-Dairy Zone	p or l/vl – m	1 820–2 280	18.0–15.2	1 500–2 000	850–1 100	470–600	220 or more	135–145	355–365
	f l i m			1 300–1 500	700– 850	250–470	210 or more	130–140	340–350
LH 2 Wheat/Maize-Pyrethrum Zone	m + (s/m)	1 980–2 280	17.6–15.2	1 100–1 300	500– 700	170–280	140–150	105–120	–
	m/s + (s)			900–1 200	400– 500	150–220	115–135	85–100	–
LH 3 Wheat/(Maize)-Barley Zone	s/m + (s/vs)	1 950–2 070	17.4–16.4	900–1 200	350– 450	150–200	105–115	75– 80	–
	s/m + (vs/s)			800–1 000	280– 360	150–180	105–115	65– 70	–
LH 4 Cattle-Sheep-Barley Zone	s + (vs)	Small transitional strips							
LH 5 Lower Highland Ranching Zone	b r	Small, not suitable for rain-fed agriculture							
UM 1 Coffee-Tea Zone	f l i m	1 700–1 820	18.7–18.0	1 300–1 600	700– 850	400–480	180 or more	130–140	310–330
UM 2 Main Coffee Zone	m/l i m/s	1 580–1760	19.5–18.4	1 100–1 400	520– 700	300–400	160 or more	115–135	275–300
	m + s/m			1 000–1 300	480– 680	250–380	135–155	105–115	–
UM 3 Marginal Coffee Zone	m/s + s	1 520–1580	19.9–19.5	900–1 100	300– 480	210–280	115–135	85–105	–
	m/s + s/vs			800–1 200	300– 470	190–250	115–135	75– 85	–
UM 4 Sunflower Maize Zone	s/m + s	1 360–1 520	20.7–19.9	800– 900	350– 400	250–300	105–115	85–105	–
	s/m + (s/vs)			780– 880	300– 350	180–200	105–115	75– 80	–
	s + s			770– 870	260– 300	190–220	90–105	85–100	–
	s + s/vs			760– 850	250– 290	180–210	85–105	75– 85	–
	s + (vs/s)			750– 800	240– 280	150–180	85–100	65– 70	–
	s/vs + (vs/s)			730– 780	200– 250	150–170	75– 85	65– 70	–
UM 5 Livestock-Sorghum Zone	vs/s + vs	1 360–1 520	20.9–19.9	600– 730	170– 200	150–160	65– 75	50– 65	–
LM 4 Marginal Cotton Zone	s/vs + s/vs	1 200–1 360	21.9–20.9	800– 900	250– 320	200–250	75– 85	75– 85	–

[1] Amounts surpassed normally in 6 out of 10 years, falling during the agro-humid period which allows growing of most cultivated plants.

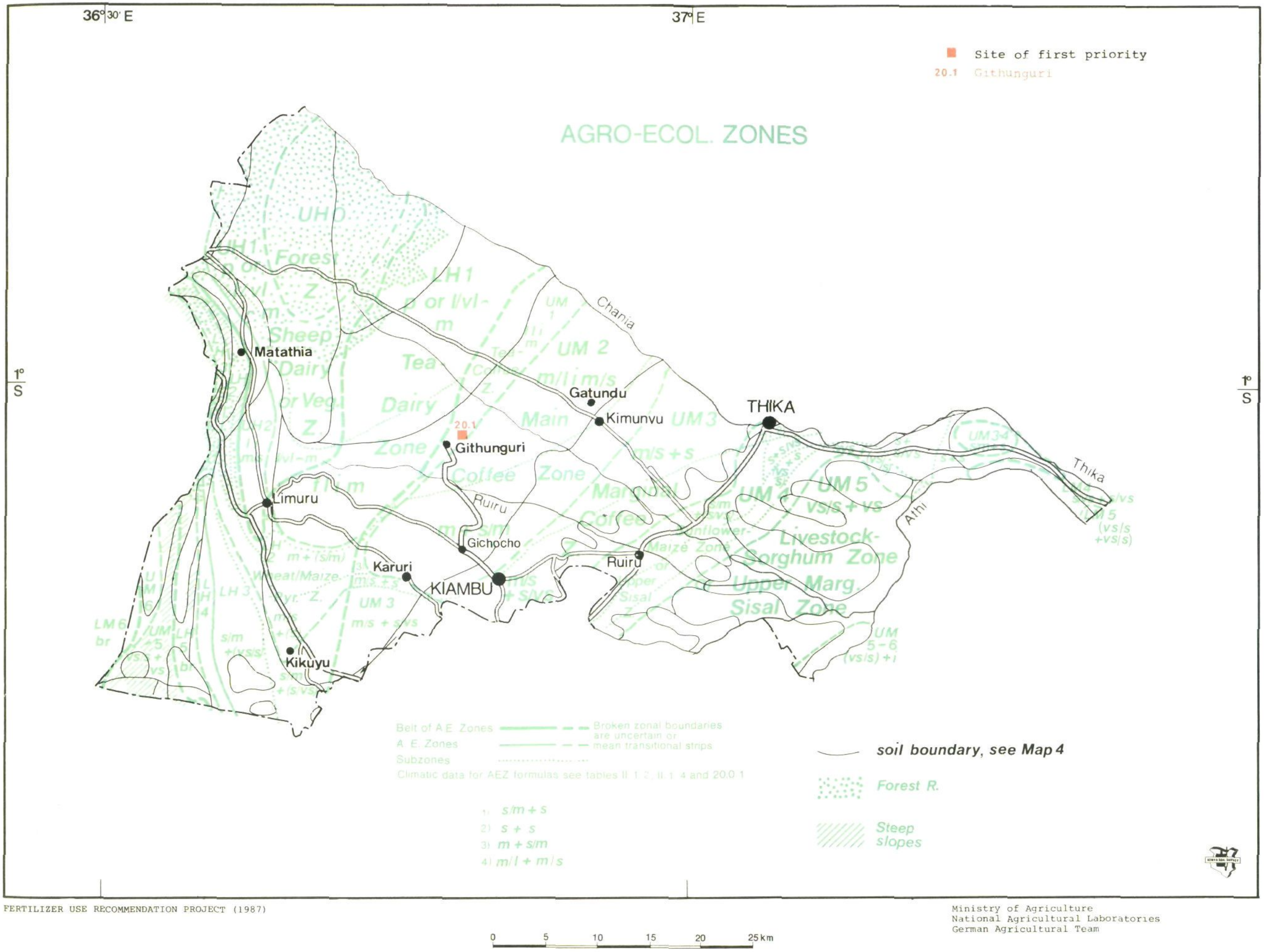
[2] More if growing cycle of cultivated plants continues into the period of second rains.

[3] Only added if rainfall continues at least for survival (> 0.2 E_0) of most long term crops.

Source: Jaetzold R., and H. Schmidt, eds. (1982): Farm Management Handbook of Kenya, Volume II/B Central Kenya, page 51o.

MAP 20.0.3

AEZs AND TRIAL SITES IN KIAMBU DISTRICT



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The soils of Kiambu District are shown on Map 20.0.4.
Almost the entire District is part of the Aberdares - Mount Kenya Toposequence, which involves all districts from Meru to Kiambu and Nyandarua.

Mountain unit MV2 (humic Andosols, partly lithic phase) is surrounded by extensive volcanic footridges (units RB1,2 and 3), which comprise more than 50% of the District. East of the Thika-Ruiru line, plateaus and high-level structural plains units LB8 and LBC are predominant. All soils are developed on basic igneous rocks.

In the north-west, unit UP1 prevails, with soils developed on ashes and other pyroclastics from recent volcanoes.

=== Soils developed on basic igneous rocks.

- Unit RB1: ando-humic Nitisols, with humic Andosols (cf. trial site 22.1, Nyeri District);
- Unit RB2: humic Nitisols (trial site 20.1);
- Unit RB3: eutric Nitisols, with shallower inclusions (cf. trial site 21.2, Muranga District).
- Units LB8 and LBC: a complex of partly saline, pellic Vertisols in depressions and ironstone soils on the level, somewhat higher parts.

=== Soils developed on ashes and other pyroclastics of recent volcanoes.

- Units UP1 and UV1: mollic Andosols and ando-luvic Phaeozems (cf. trial site 19.4, Nyandarua District).

The western-most part of the District forms the transition to the Rift Valley.

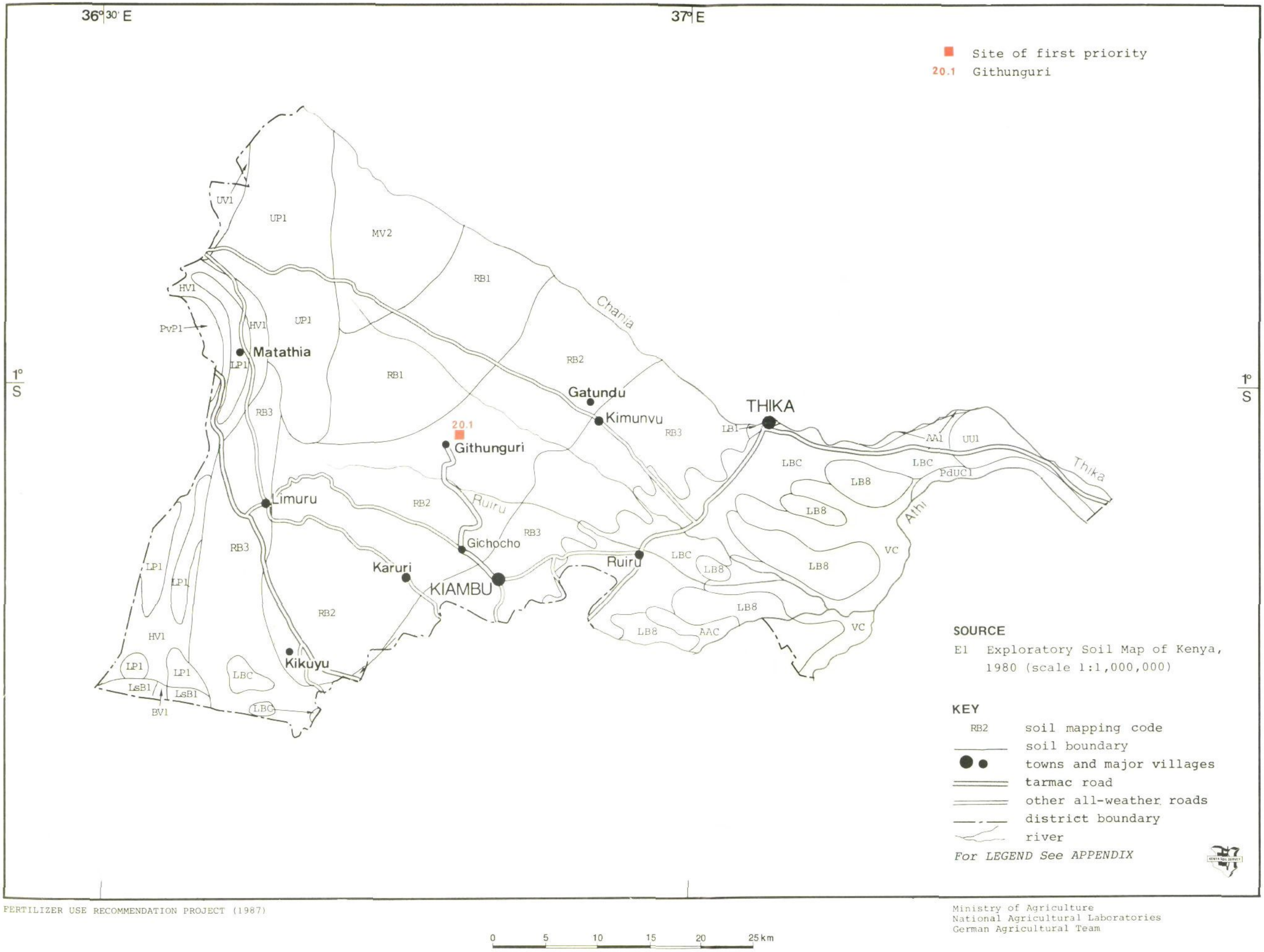
The basic climatic and soils designations referring to the trial site in Kiambu District are summarized in Table 20.0.2.

Table 20.0.2: Agro-Ecological Zone and Soil Classification of the Trial Site in Kiambu District

Site No.	Site Name	Agro-Ecological Zone	Soil Classification
20.1	Githunguri	Coffee-Tea Zone (UM 1)	humic NITISOL

MAP 20.0.4

SOILS AND TRIAL SITES IN KIAMBU DISTRICT



■ Site of first priority

20.1 Githunguri

SOURCE

E1 Exploratory Soil Map of Kenya, 1980 (scale 1:1,000,000)

KEY

RB2 soil mapping code

——— soil boundary

● ● towns and major villages

═══ tarmac road

═══ other all-weather roads

—·— district boundary

〰 river

For LEGEND See APPENDIX

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

In Kiambu District, one first priority site was selected as shown in Map 20.0.4. Since farmers in Kiambu District specialize in cash crop farming, it is quite uncommon to find a portion as large as 2 acres which is devoted to food crops only.
The selection team was, therefore, directed to St. Joseph's Secondary School in Githunguri, where it was agreed upon to use 2 acres of the school compound for FURP trials.
The plot consists of one large rectangular block and one adjacent smaller block. Accessibility is quite good (tarmac road up to Githunguri) and the demonstration effect is high.
The farmers' fields are somewhat scattered, but they adequately resemble the soils of the main plot.
The nearest long-term rainfall recording station: 09136064, Githunguri Divisonal Office is located 800 m SSW of the Githunguri trial plot. The criteria for the final position of the trial site are listed in Table 20.0.3, which is self-explanatory. Criteria have been rated very good (1), good (2), moderate (3), poor (4) or non-relevant (nr).

Table 20.0.3: Ratings of Criteria Used for Trial Site Selection in Kiambu District

Criterion	Site number
	20.1
1. Representativeness Agro-Ecological Zone	2
2. Representativeness Soils	1
3. Representativeness Topography	2
4. Adequacy of size and shape of the trial plot	2
5. Absence of trees and hedges	1
6. Absence of rocks and boulders	1
7. Absence of termite mounds	1
8. Uniformity of previous land use	3
9. Accessibility	1
10. Demonstration effect	2
11. Proximity to a long-term rainfall station	1
12. Availability of storage facilities	2
13. Availability of sturdy fences	2
14. Availability of housing facilities for T.A.s	2
15. Farmer's willingness to cooperate	2
16. Security - theft	2
17. Security - intruding animals	3
18. Proximity of on-farm trials	3
19. Representativeness of soils at on-farm trials	1

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

The names and addresses of the agricultural staff members of the District are listed in Table 20.0.4.

Table 20.0.4: Names and Addresses of Government Officers in the District

OFFICER	SITE	NAME	P.O. BOX	TEL. NO.
District				
D.C.		P. Githau*		
D.A.O.		F.K. Rimberia	-Kiambu	
D.C.O.		Miss J. Njiru	-Kiambu	
DIVISION				
Div. Ext. Officer	20.1	Paul Mbuni	31-Githunguri	4-Githunguri
Loc. Ext. Officer	20.1	not met		
Technical Assistant	20.1	William Wagura	31-Githunguri	4-Githunguri

* not met during site selection.

Period of site selection in the District: July 1986.

4. Trial Design and Execution Plan, Kiambu.

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

Selection of crops for each of the 3 modules at the Kiambu site:-

Site 20.1 Githunguri	RAINY SEASONS 1st, Long, March	 2nd, Short, Oct
S1 Standard maize	Hybrid 512	Hybrid 512
S2 Maize & beans	H.512 +GLP 2 Beans	H.512 + GLP 2 Beans
S3 Pot./Cabbages;Beans	Potat. or Cabbages	Beans, GLP 2

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

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 4 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.

The N and P fertilizers will be applied in both seasons, but the FYM will be applied only during the 1st rains. Where maize and beans are intercropped, the fertilizer will go on the maize. The inter-cropped 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.

5. Areas in Kiambu 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 20.0.5: Groupings of Soil Mapping Units), and in the second (Map 20.0.6) Agro-Ecological Units (AEUs) are shown in which, according to the information available, the soils and the climate can be considered homogeneous.

Map 20.0.5 shows the representativeness of FURP trial sites for the Kiambu District only as far as soils are concerned.

The explanation for this Map shows 9 generalized "Groupings of Soil Mapping Units". These Groupings have the same or similar soil properties and, as such, they represent a specific soil environment, typified by one of the FURP trial sites.

The codes in the explanation to Map 20.0.5 refer to a specific trial site (20.1, etc.) and to a specific degree of representativeness of soils (A, B+, B-). The combination of both forms a "Soil Representativeness Code". Unit 20.1.A, for instance, covers an area which is highly represented (A) by the Githunguri trial site (20.1). Unit 22.1.B- covers an area which is moderately represented (B) by the Muirungi trial site in Nyeri District (22.1), although information on soil properties reveals slightly less favourable conditions in the represented area in Kiambu District than at Muirungi itself (B-).

The explanation to Map 20.0.5 also lists those units of the Soil Map (Map 20.0.4) 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 20.0.5.

The soils of Kiambu District are well represented by the FURP trial sites. This is testified by Map 20.0.5 which shows a very high A cover (highly representative).

The different soils of the Aberdares - Mount Kenya Toposequence, discussed in Sub-Section 20.0.1, are represented in the following Groupings:

Volcanic Footridges:
<u>upper slopes</u>: humic Andosols (Grouping 22.1.B-) and ando-humic Nitisols (Grouping 22.1.A);
<u>middle slopes</u>: humic Nitisols (Grouping 20.1.A);
<u>lower slopes</u>: eutric Nitisols (Grouping 21.2.A);
Plateaus and high-level Structural Plains:
pellic Vertisols (Grouping (23.2).A) and shallow soils with a petroferric phase (not represented: Grouping C).

Trial site 23.2 is put in brackets, as it has not yet been identified. It is, however, advisable to have a site on the rather extensive Vertisol area in Central Province and Embu District.
As long as the site is not operational, the area should be considered as C (not represented by any trial site).
Trial site 19.4 (Njabini F.T.C., Nyandarua District) is highly representative for the North-Western parts of the District. Grouping 19.4.A stands for deep to very deep mollic Andosols and ando-luvic Phaeozems.

Areas which are not represented by any trial site with respect to soils are coded C. This involves the shallow soils on the fringes of the Rift Valley and the ironstone soils of the Athi Kapiti Plains.

The second representativeness map, Map 20.0.6, 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 Kiambu District are shown in the Agro-Ecological Unit Map (Map 20.0.6) and are explained in Table 20.0.5. 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 20.0.5. In addition, Map 20.0.6 and Table 20.0.5 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 20.0.6 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 20.1.A.b++, for instance, the soils are highly represented by the Githunguri trial site (20.1.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 Githunguri trial site.

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

E X P L A N A T I O N T O M A P 20.0.5

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

Trial sites

19.4 Njabini FTC - Nyandarua District
20.1 Githunguri - Kiambu District
21.2 Makuyu - Murang'a District
22.1 Muirungi - Nyeri District
(23.2) [2] Mwea-Tebere - Kirinyaga District
24.2 Gachoka - Embu District

Groupings of soil mapping units

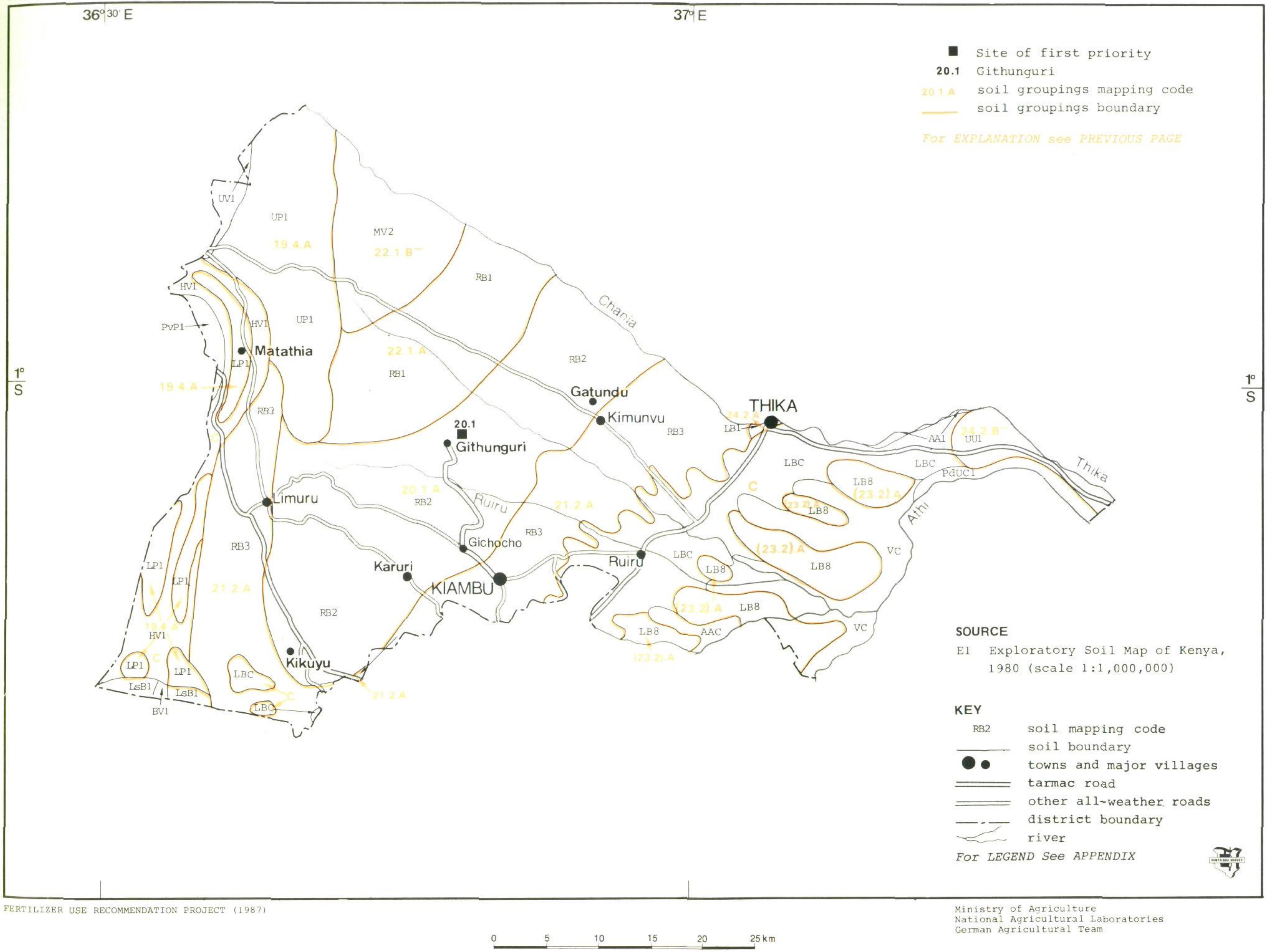
Soil Representativeness Code (Map 20.0.5)	Soil Map Units Included (Map 20.0.4)
19.4.A	LP1, UP1, UV1
20.1.A	RB2
21.2.A	RB3
22.1.A	RB1
22.1.B-	MV2
(23.2).A	LB8
24.2.A	LB1
24.2.B-	UU1
C	others

---

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-.

2) Site has not yet been identified. See Subsection 20.0.5 for explanation.

MAP 20.0.5 GROUPINGS OF SOIL MAPPING UNITS REPRESENTED BY TRIAL SITES IN KIAMBU DISTRICT



■	Site of first priority
20.1	Githunguri
20.1.A	soil groupings mapping code
——	soil groupings boundary

For EXPLANATION see PREVIOUS PAGE

SOURCE

E1 Exploratory Soil Map of Kenya,
1980 (scale 1:1,000,000)

KEY

RB2	soil mapping code
——	soil boundary
● ●	towns and major villages
═══	tarmac road
═══	other all-weather roads
—·—	district boundary
~	river

For LEGEND See APPENDIX

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Table 20.0.5: Major Soil Properties and Climatic Conditions of the Agro-Ecological Units in the Kiambu 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
19.4.	A		w	d-vd	h	lh	h-vh	an-lu Ph + mo An					
		a							10-15	3-8	675-825	p to l i m/s	UH 1-2
		b*+							10-15	3-8	825-900	p or l/vl--m	UH 1
		b*x							10-15	3-8	900-975	p or l/vl--m	UH 0-1
		b*x̲							10-15	3-8	525-600	l i m/s	UH 2
		b+x̲							15-18	8-11	525-600	m+(s/m)	LH 2
20.1.	A		w	ed	h	lah	vh	hu Ni					
		a							18-21	11-14	665-815	f l i m to m/l i m/s	UM 1-2
		b*-							18-21	11-14	590-665	m/l i m/s to m+s/m	UM 2
		b*x̲							18-21	11-14	515-590	m+s/m to m/s+s	UM 2-3
		b-*							15-18	8-11	665-815	f l i m to m+(s/m)	LH 1-2
		b--							15-18	8-11	590-665	m+(s/m)	LH 2
		b-x̲							15-18	8-11	515-590	m/s+(s) to s/m+(s/vs)	LH 2-3
		bx̲*							10-15	3-8	665-815	l/vl--m	UH 1
21.2.	A		w	ed	m-h	0	vh	eu Ni (+ ni-ch Ca + ch Lu + ch Ac)					
		a							18-21	11-14	370-450 5)	m/s+s	UM 3
		b*+							18-21	11-14	450-490 5)	m+s/m to m/s+s	UM 2-3
		b*x							18-21	11-14	490-530 5)	m+s/m	UM 2
		b*-							18-21	11-14	330-370 5)	m/s+s to s/m+(s/vs)	UM 3-4
		b-*							15-18	8-11	370-450 5)	m+(s/m)	LH 2
		b--							15-18	8-11	330-370 5)	s/m+(s/vs)	LH 3
		b-x̲							15-18	8-11	290-330 5)	s/m+(vs/s)	LH 3
		bx̲+							10-15	3-8	450-490 5)	l i m/s	UH 2
22.1.	A		w	ed	h	lah	vh	an-hu Ni (+ hu An)					
		a							15-18	8-11	880-1080	p or l/vl--m	LH 1
		b*-							15-18	8-11	780-880	l/vl--m to f l i m	LH 1
		b+-							18-21	11-14	780-880	f l i m	UH 1
22.1.	B-		w	vd	m-h	2ah	vh	hu An					
		a							15-18	8-11	880-1080	p or l/vl--m	LH 1
		b*+							15-18	8-11	1080-1180	p or l/vl--m	LH 1
		b-+							10-15	3-8	1080-1180	p or l/vl--m	UH 1-0
		b-x							10-15	3-8	1180-1280	Forest Reserve	
(23.2).	A		i	vd	h	0	h-vh	pe Ve					
		b-(x̲)							18-21	11-14	230-270 6)	s/vs+(vs/s)	UM 4
24.2.	A		w	vd	l	0	h-vh	ni-rh Fe					
24.2.	B-		w	md-d	l	0	m-h	rh + or Fe					
		b-*							18-21	11-14	320-400 7)	s+s to s/m+s	UM 3-4
		b*-							21-14	14-17	280-320 7)	s/vs+s/vs	LM 4
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

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

Ni	Nitisols	mo	mollic	ni-ch	nito-chromic
Ph	Phaeozems	hu	humic	ni-rh	nito-rhodic
Ca	Cambisols	or	orthic	an-hu	ando-humic
Lu	Luvisols	rh	rhodic	an-lu	ando-luvic
Ac	Acrisols	ch	chromic	pe	pellic
Fe	Ferralsols	eu	eutric		
An	Andosols				
Ve	Vertisols				

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

2) **Rainfall 66% probability (in mm.)**
-referring to agro-humid period of long rains only;
-for definition of rainfall ranges see explanation Map 20.0.6;
-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 20.0.3.

4) Comparable time: April- mid September.

5) Comparable time: mid March-end of June.

6) If the site is situated near the 350 mm. isohyete in LM 4

7) Comparable time: end of March-beginning of July.

EXPLANATION TO MAP 20.0.6

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)

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

Trial sites

19.4 Njabini FTC (Nyandarua District)
20.1 Githunguri (Kiambu District)
21.2 Makuyu (Murang'a District)
22.1 Muirungi (Nyeri District)
(23.2) Mwea-Tebere (Kirinyaga District)
24.2 Gachoka (Embu District)

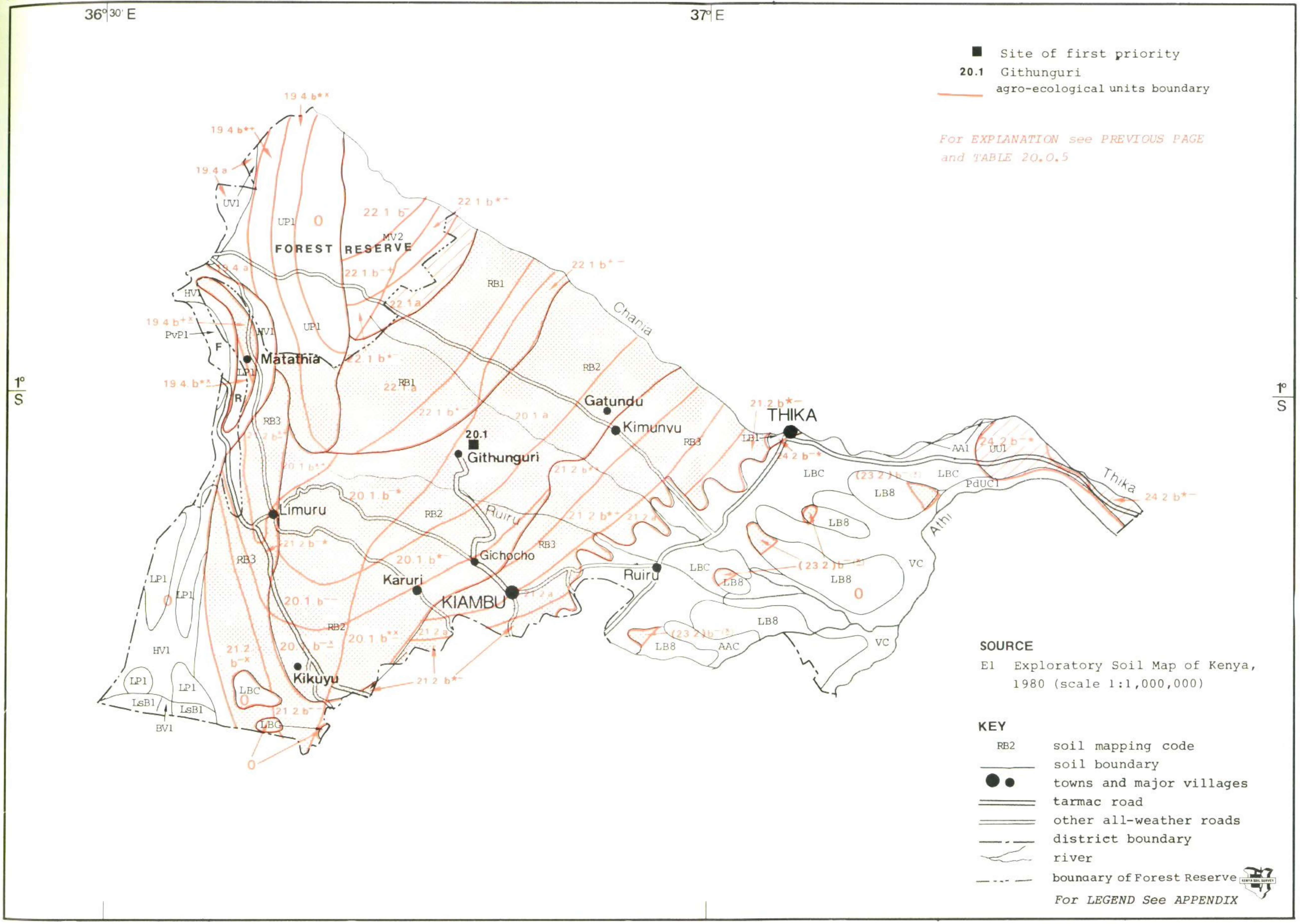
Areas not represented

0 = not represented by soils and/or climate

For further explanation see Table 20.0.5

MAP 20.0.6

AGRO—ECOLOGICAL UNITS REPRESENTED BY TRIAL SITES IN KIAMBU DISTRICT



SOURCE

E1 Exploratory Soil Map of Kenya, 1980 (scale 1:1,000,000)

For LEGEND See APPENDIX

FERTILIZER USE RECOMMENDATION PROJECT (1987)

0 5 10 15 20 25 km

Ministry of Agriculture
National Agricultural Laboratories
German Agricultural Team

LEGEND TO THE SOIL MAP OF KIAMBU DISTRICT

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

M	Mountains and Major Scarps
H	Hills and Minor Scarps
L	Plateaus and High-Level Structural Plains
Ls	Step-Faulted Floor of the Rift Valley
R	Volcanic Footridges
U	Uplands, Upper, Middle and Lower Levels
Pd	Dissected Erosional Plains
Pv	Volcanic Plains
A	Floodplains
B	Bottomlands
V	Minor Valleys

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

A	Alluvial Sediments from Various Sources
B	Basic and Ultra-Basic Igneous Rocks (basalts, nepheline phonolites; older basic tuffs included)
P	Pyroclastic Rocks
U	Undifferentiated Basement System Rocks (predominantly Gneisses)
V	Undifferentiated or Various Igneous Rocks

3----Soil descriptions

MV2	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
HV1	Well drained, shallow, dark reddish brown, friable, strongly calcareous, bouldery or stony, loam to clay loam; in many places saline
---	LITHOSOLS; with calcic XEROSOLS, lithic, bouldery and saline phase and Rock Outcrops
LB1	Well drained, very deep, dark red, very friable clay
---	nito-rhodic FERRALSOLS
LB8	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
LBC	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
	and: 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

LP1	Well drained, moderately deep to very deep, dark brown, friable and slightly smeary, clay loam to clay; with a humic topsoil
---	ando-luvic PHAEOZEMS
LsB1	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
RB1	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
RB2	Well drained, extremely deep, dusky red to dark reddish brown, friable clay, with an acid humic topsoil
---	humic NITISOLS
RB3	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 and LUVISOLS, partly lithic, pisoferric or petroferric phase
UP1	Well drained, very deep, dark reddish brown to dark brown, very friable and smeary, silty clay loam, with a humic topsoil
---	mollic ANDOSOLS
UU1	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
UV1	Well drained, deep to very deep, dark reddish brown to very dark greyish brown, friable and slightly smeary clay, with a humic topsoil
---	ando-luvic PHAEOZEMS
PdUC1	Complex of: 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
PvP1	Excessively drained to well drained, very deep, dark greyish brown to olive grey, stratified, calcareous, loose fine sand to very friable sandy loam or silt
---	ando-calcaric REGOSOLS
AA1	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
AAC	Complex of: well drained to imperfectly drained, very deep, dark greyish brown to dark reddish brown, stratified soils ot varying consistency and texture
---	eutric FLUVISOLS
BV1	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

VC Complex of:
well drained to poorly drained, shallow to deep, dark reddish brown to black, firm, silty clay to clay; in places calcareous and/or cracking; in places rocky and stony
--- GLEYSOLS, FLUVISOLS, CAMBISOLS, VERTISOLS etc.

NOTES:

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

Contents of Chapter 20.1:

Detailed Description of the Githunguri Trial Site

<u>List of Tables</u>[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 Githunguri is shown in Figure 20.1.1, extracted from Map No. 148/2 - Kiambu. Its UTM grid coordinates are E 53.5 and N 84.1. The elevation is 1930 m. Further details on the final position are shown in Figure 20.1.2 and the sketch map of the trial plot in Figure 20.1.3.

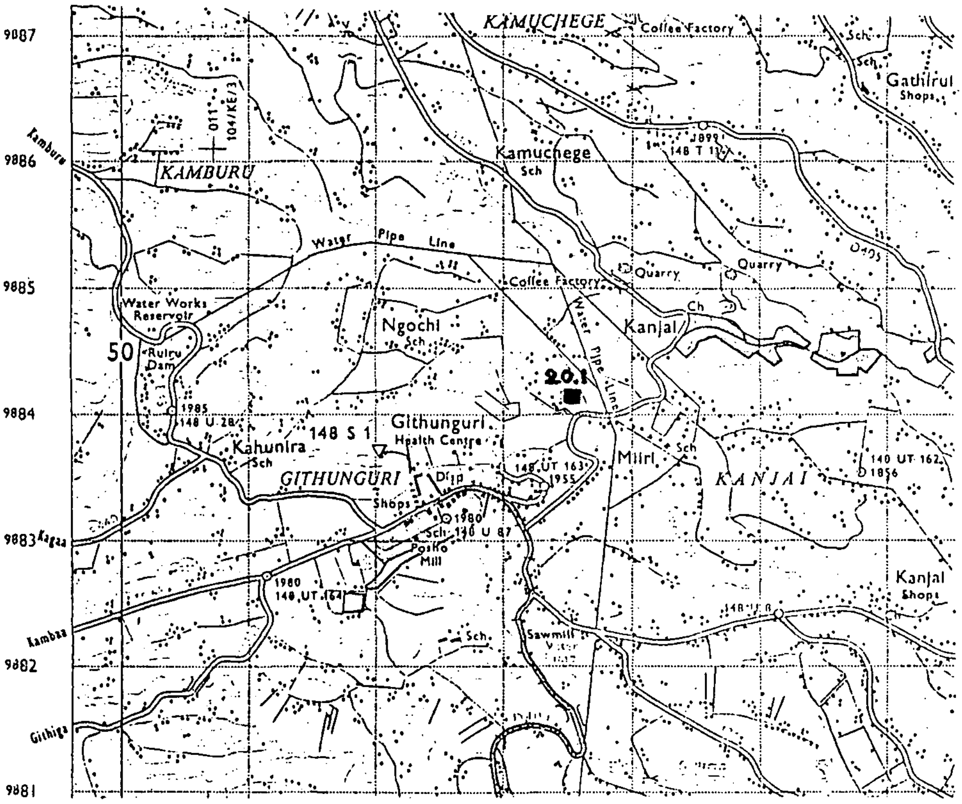


Figure 20.1.1: Demarcation of the Githunguri Trial Site on the 1:50,000 Topographic Map

1.2 Sketch of the Trial Site.

The location of and the access route to the Githunguri site are shown in Figure 20.1.2 and the map of the trial plot`in Figure 20.1.3.

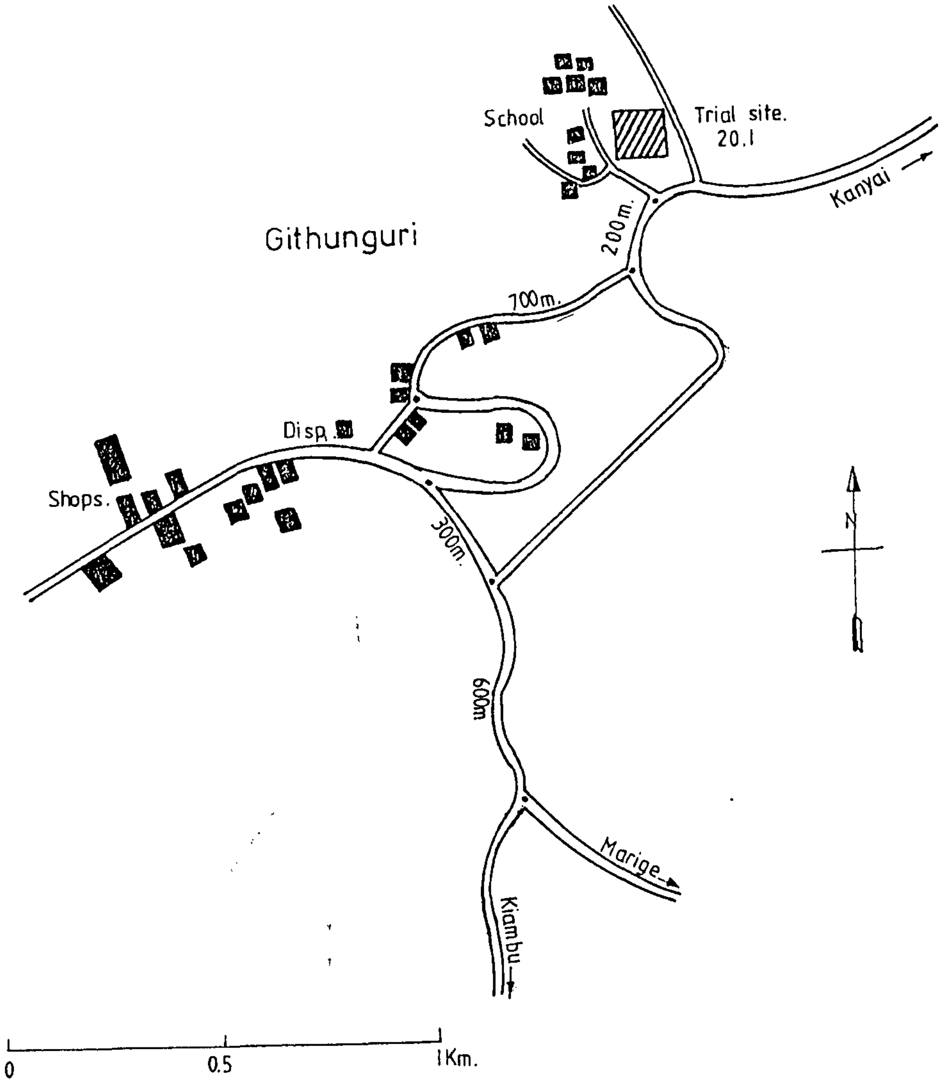


Figure 20.1.2: Access Map of the Trial Site, Githunguri

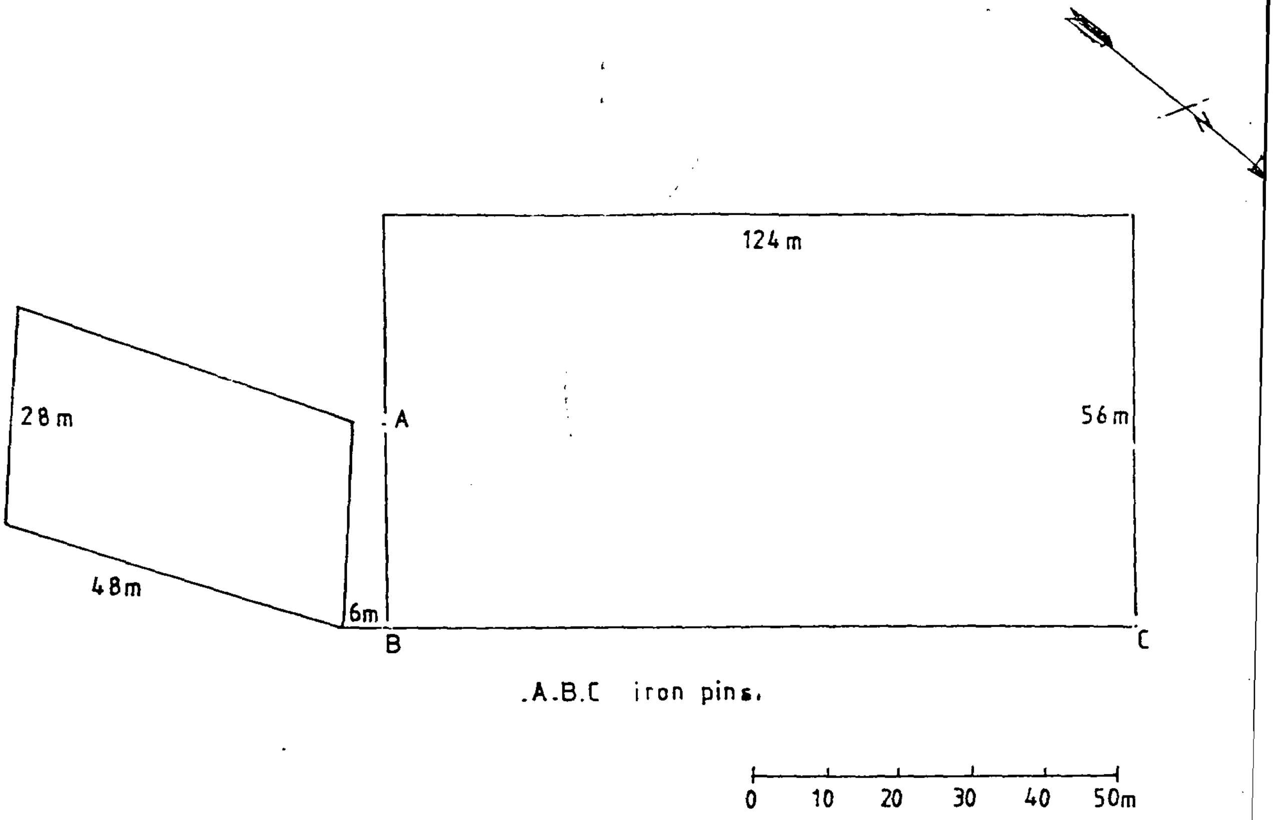


Figure 20.1.3: Map of the Trial Plot, Githunguri

The approximate location of the on-farm trials is indicated in Figure 20.1.4.

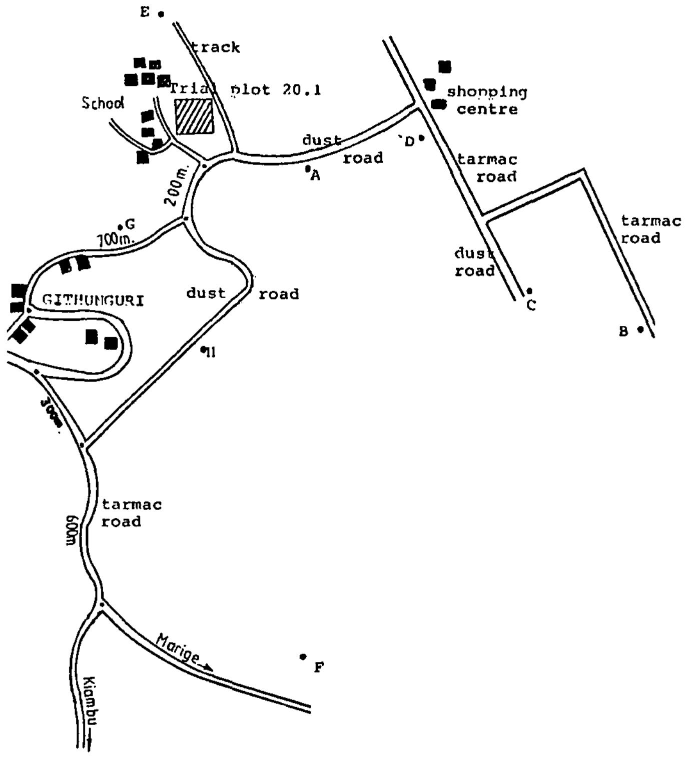


Figure 20.1.4: Location of Farmers' Fields for On-Farm Trials, Githunguri

1.3 Physiography

Information on the physiography of the trial site and its surroundings is summarized in Table 20.1.1 below.

Table 20.1.1: Physiography of the Githunguri Trial Site

Elevation	1930 m.
Landform	volcanic footridges
Physiographic position of the site	upper and middle slopes
Topography of surrounding country	undulating to hilly
Slope on which trial plot is sited	2-5%
Aspect	NNE (bigger block)
Microtopography	Nil

1.4 Vegetation, Past and Present Land Use

Information on vegetation, past and present land use is summarized in Table 20.1.2 below.

Table 20.1.2: Vegetation, Past and Present Land Use of the Githunguri Trial Site

Vegetation	Undifferentiated clearings and cultivations from moist montane forests
Cropping system	
(a) cleared since:	before 1970
(b) present land use:	pasture since 1978
Inputs	
(a) mineral fertilizers:	none
(b) organic manure:	cow dung
(c) other capital inputs:	none
(d) level of know-how:	low
Livestock	dairy cattle zero-grazing unit at present being established
Remarks Land should be opened up well before project implementation.	

1.5 Names and Addresses of Government Officers Involved in FURP Activities

Names and addresses of divisional staff members and of all farmers involved are given in Table 20.1.3.

The codes used for the additional "on-farm" farmers refer to the location of their farms as indicated in Figure 20.1.4.

Table 20.1.3: Names and Addresses of Divisional Staff Members and of Farmers at the Githunguri Trial Site

Divisional Staff	Name	Address
D.E.O.	Paul Mbuni	31-Githunguri
L.E.O.	not met	
T.A.	William Wagura	31-Githunguri
Farmers	**Name**	**Address**
Trial plot (Headmaster St. Joseph's High School)	P.J. Thuku	99-Githunguri
	LOCATION: SUB-LOCATION:	Githunguri Kajai
On-farm trials	**Name**	**Remarks**
20.1.A	Samuel Wararu Kanini	
20.1.B	Nancy Waithira Njenga	
20.1.C	Chuchu Wataku	
20.1.D	Wainaina Karugo	
20.1.E	Kariku Kunguru	
20.1.F	Loise Njeri Thuku	
20.1.G	Daniel Ndungu Kibunja	
20.1.H	R. Kamitha Kinuthia	

Period of site selection: July 1986.

2. Climate

2.1 Prevailing Climatic Conditions

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

The following brief climatic description refers to the existing information:

ACZ : I4	(H.M.H. BRAUN, 1982)[1])
AEZ : UM1, fl i m	(R. JÄTZOLD, 1983)[2])

Next long-term rainfall station: 09136064, Githunguri Agricultural Office

Agro-Climatic Zone (ACZ):

Moisture availability Zone I (r/Eo): annual average precipitation >80% of the potential evaporation (Eo).

Temperature Zone 4: mean annual temperature is 18-20°C

Agro-Ecological Zone (AEZ):

UM 1 = Coffee-Tea Zone

UM = Upper Midland Zone: mean annual temperature 18-21°C, mean minimum 11-14°C

1 = humid; annual average precipitation >80% of the potential evaporation (Eo)

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

fl i m = with a fully long cropping season, intermediate rains, and a medium cropping season.

---

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. E1, 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)
l	long	195 - 214 days
m	medium	135 - 154 days

f = full, i.e. no sub-division of growing periods, for instance, fl means 175-234 days.

2.1.2 Relevant Meteorological Data for the Githunguri 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: 09136064, Githunguri Agricultural Office (elevation: 1950 m), 800 m SSE of the Githunguri trial plot (elevation: 1930 m). The data are listed in Table 20.1.4.. At the trial site rainfall amounts are similar: in 20 out of 30 years Githunguri gets about 740 mm during the agro-humid period of first rains (see Map 20.0.1), and more than 390 mm during second rains (see Map 20.0.2). 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 extrapolated from the Jacaranda Coffee Research Meteorological Station (elevation: 1610 m), 14 km ESE of the trial site. The temperature gradient in this area is on average 0.6°C per 100 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 09136084, Jacaranda Coffee Research Meteorological Station.

Temperature and evaporation data for the Githunguri site are given in Tables 20.1.5 and 20.1.6, and the rainfall pattern and potential evaporation are shown in Figure 20.1.5.

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

Table 20.1.4 : Data of the Nearest Long-Term Rainfall Station

Station No.: 09136064		Total years for calculation:	26
Githunguri Agric. Office		First year included:	1957
Elevation: 1950 m		Last year included:	1982

Average annual rainfall: 1481 mm

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

1st rains: 760 mm (mid Mar. - mid Sep.)	2nd rains: 400 mm (mid Oct. - mid Feb.)

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	19.7	1.6	1.6	6.3	26
2	14.2	1.5	1.5	5.3	26
3	19.9	2.0	2.0	9.6	26
4 FEB	17.3	1.5	1.5	6.8	25
5	13.5	1.3	1.2	1.9	25
6	20.6	1.3	1.3	4.0	25
7 MAR	27.8	2.1	2.1	12.9	24
8	33.5	1.9	1.9	16.0	24
9	59.4	4.5	4.4	37.9	24
10 APR	88.2	5.0	5.0	53.5	24
11	137.0	6.2	6.1	93.2	24
12	148.9	6.0	5.9	109.4	24
13 MAY	123.9	6.2	6.2	87.8	25
14	91.0	5.2	5.2	61.5	25
15	51.5	4.1	4.0	33.4	25
16 JUN	25.0	2.4	2.4	15.1	26
17	23.6	2.4	2.4	13.1	26
18	17.2	2.1	2.0	9.4	26
19 JUL	21.2	2.1	2.0	7.5	23
20	12.6	1.9	1.9	4.4	23
21	17.2	2.1	2.1	9.9	23
22 AUG	14.6	2.0	1.9	5.9	26
23	10.0	1.9	1.9	5.4	26
24	14.1	1.8	1.8	4.4	26
25 SEP	21.0	1.9	1.9	9.2	26
26	10.1	1.6	1.6	4.0	26
27	16.1	1.8	1.8	6.6	26
28 OCT	15.7	1.9	1.8	8.1	25
29	30.5	3.1	3.1	17.1	25
30	68.8	4.2	4.1	43.5	25
31 NOV	69.1	4.7	4.5	45.2	24
32	73.7	5.1	5.1	46.3	24
33	74.4	5.0	4.9	45.9	24
34 DEC	38.8	2.5	2.5	13.4	22
35	21.4	2.1	2.1	13.9	22
36	19.5	1.7	1.7	6.2	22

Table 20.1.5: Temperature (°C)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.
Mean temp.	17.3	18.0	18.4	18.1	17.3	15.7
Mean max.temp.	24.2	25.7	25.2	23.4	22.2	21.2
Mean min.temp.	10.4	10.4	11.7	12.9	12.4	10.3
	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
Mean temp.	14.8	15.1	16.4	17.7	17.2	16.8
Mean max.temp.	20.4	20.6	22.9	24.1	22.3	22.4
Mean min.temp.	9.3	9.7	9.9	11.4	12.1	11.2

annual mean: 16.9 mean max.: 22.9 mean min.: 11.0

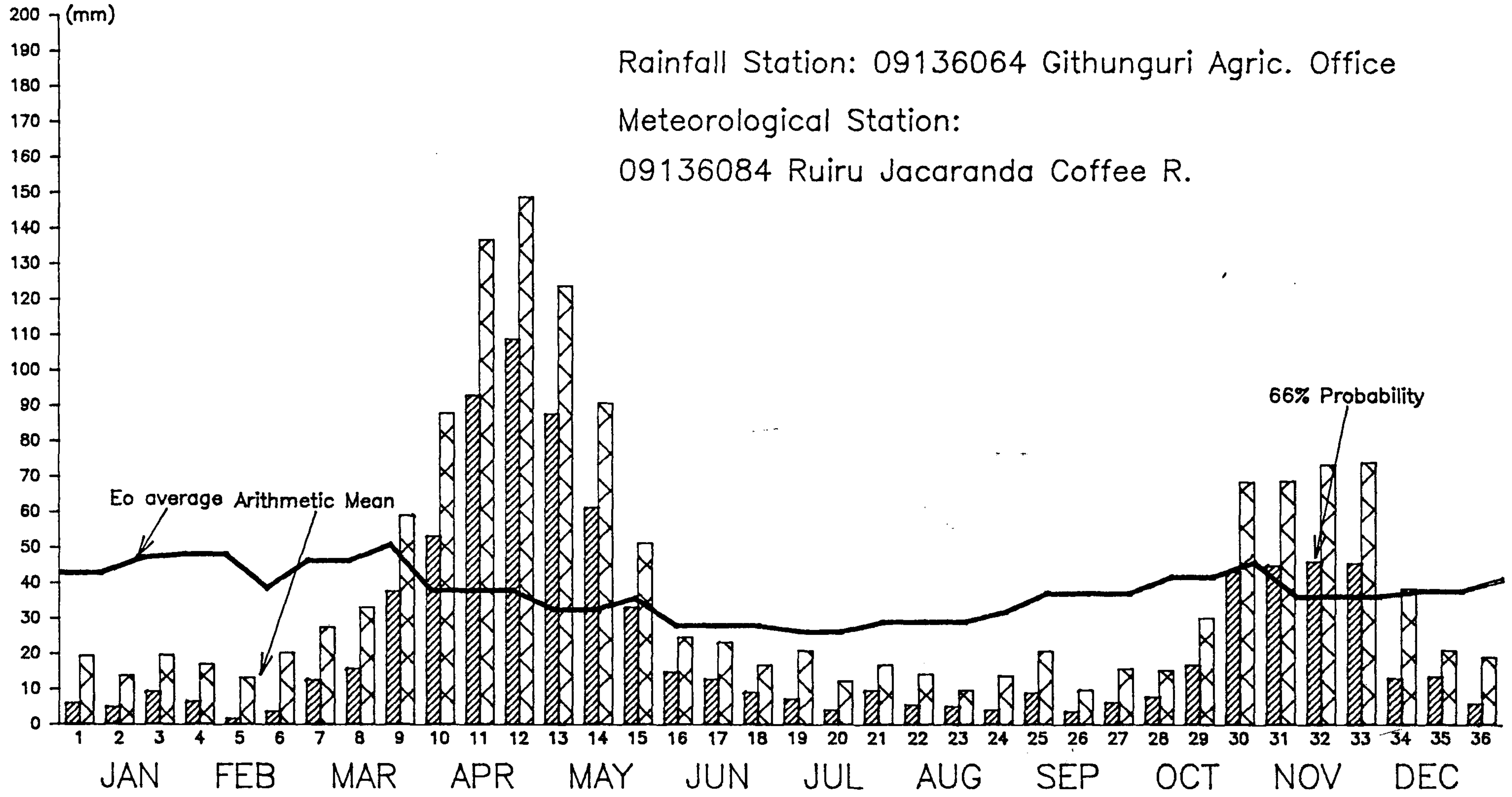
Table 20.1.6: Potential Evaporation (Eo) in mm per Decade:

	JAN.	FEB.	MAR.	APR.	MAY	JUN.
1st decade	43	48	46	38	33	28
2nd decade	43	48	46	38	33	28
3rd decade	47	39	51	38	36	28
Total:	133	135	143	114	102	84
	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1st decade	26	29	37	42	36	38
2nd decade	26	29	37	42	36	38
3rd decade	29	32	37	46	36	42
Total:	81	90	111	130	108	118

average annual potential evaporation: 1349 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 20.1.5: 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 20.1.7 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 20.1.7: Agro-Climatological Crop List for Githunguri

Crop/variety (or place of breeding) e = early m = medium 1 = 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 b) fair
Maize/m.mat. like H 511	130-160	1000-1700	500-750	a) good b) good/fair
Beans/e.mat. like GLP 92 =Mwitemania	90-110	700-1800	300-500	a) good to very good b) good
Beans/e.mat like GLP 2 =Rosecoco	80-100	700-1800	250-450	a) good to very good b) good
Peas	90-110	1800-2700	250-400	a) very good b) good

---

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 optimal 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 Githunguri trial site, the crop coefficients (kc) are shown in Table 20.1.8, 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 20.1.8.

The crop coefficients for the climatic conditions at the Githunguri 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:

$$\mathbf{ETm = kc * Eo}$$

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

In Figure 20.1.6, the ETm-values are used to indicate the estimated maximum water requirements of an important food crop for optimum growth. Furthermore, the rainfall data at 66% reliability are shown in Figure 20.1.6 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 20.1.6 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 diagrams mentioned above follows in Section 4 of this Volume (Conclusions from the analyses of climate and soils).

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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

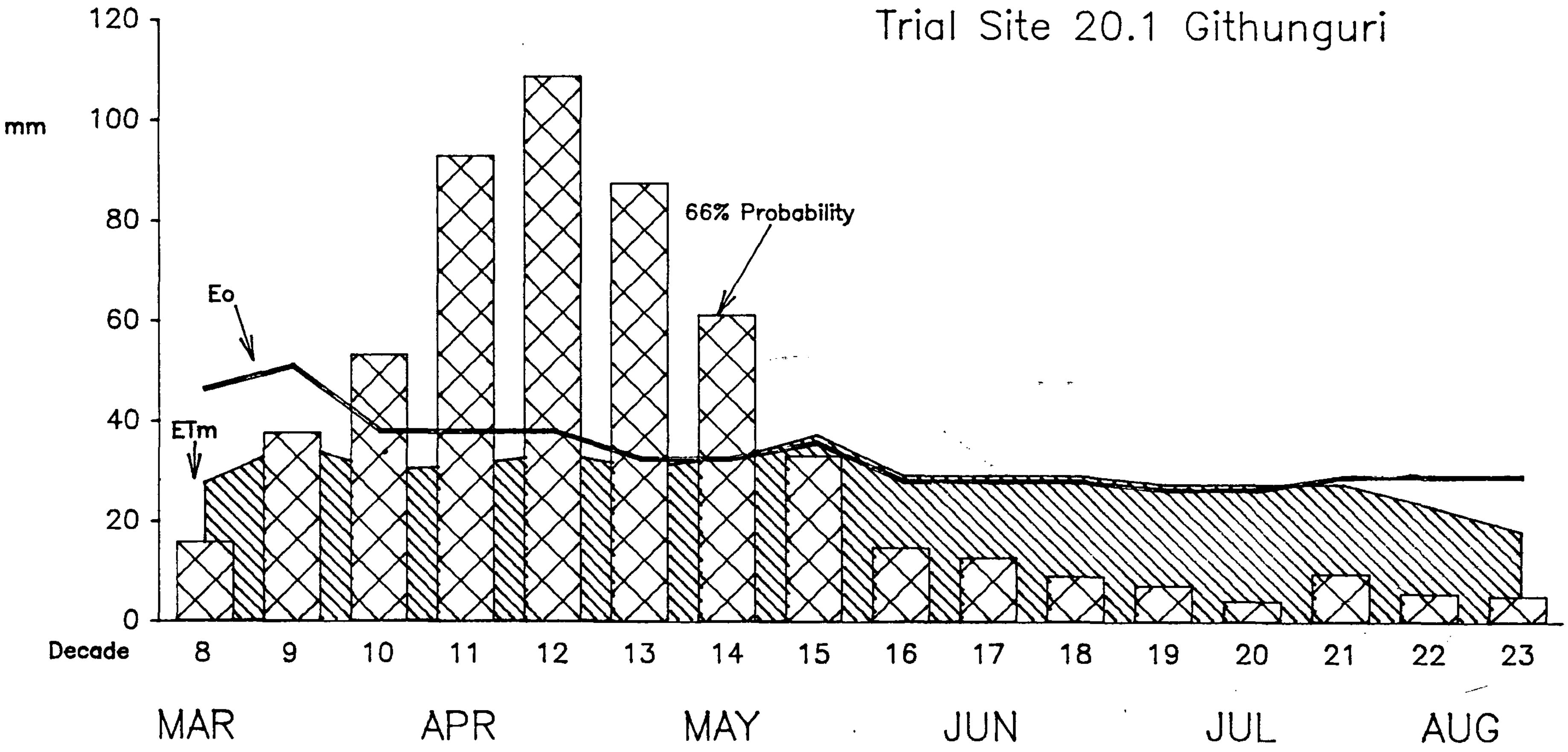
Table 20.1.8 : Crop development stages 1) and crop coefficients (Kc) 2) for approx. maximum (potential) crop evapotranspiration of the most important seasonal crops grown at Githunguri (site no. 20.1)

Crop/	Number of decades from seeding resp. planting to (physiological) maturity																						
Variety	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	0.6	0.7	0.8	0.83	0.89	-0.96	1.01	1.01	1.05	1.05	1.05	1.05	1.05	1.05	1.05	0.97	0.86	0.74	0.61					
H625	I	I	I	II	II	II	II	II	III	III	III	III	III	III	III	IV	IV	IV	IV					
MAIZE	0.6	0.7	0.8	0.83	0.89	0.96	1.01	1.05	1.05	1.05	1.05	1.05	1.05	0.96	0.8	0.63								
H512	I	I	I	II	II	II	II	III	III	III	III	III	III	IV	IV	IV								
BEANS	0.6	0.7	0.76	0.88	0.99	1.05	1.05	1.05	1.05	0.92	0.67	0.43												
Rose coco	I	I	II	II	II	III	III	III	III	IV	IV	IV												
GARDEN	0.6	0.7	0.79	0.94	1.05	1.05	1.05	1.05	0.92	0.67	0.43													
PEAS	I	I	II	II	III	III	III	III	IV	IV	IV													
BEANS	0.6	0.7	0.76	0.88	0.99	1.05	1.05	1.05	1.05	1.05	0.92	0.67	0.43	0.99	0.89	0.76								
GLP 92	I	I	II	II	II	III	III	III	III	III	IV	IV	IV	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 20.1.6: *Water requirements and availability for crop Maize H* 512, *first rains*

Rainfall Station: 09136064
Githunguri Agric. 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 Githunguri trial site to measure actual precipitation on the spot. Subsequently, 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: 09136064, Githunguri Agricultural Office.

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

Data on temperature, windrun, sunshine hours and relative humidity can be obtained from 09136084, Jacaranda Coffee Research Meteorological Station (elevation: 1610 m), in order to calculate Eo (climatic evaporative demand). The temperature data have to be adjusted to the altitude of the Githunguri trial site (elevation: 1930 m).

For calculating Eo, a computerized PENMAN formula, modified by MC CULLOCH (1965) is available on PC.

3) **Phenological records:**

Dates of planting or of sowing for each crop, emergence, start of tasselling (for maize crop), budding (for bean 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 properly the actual evapotranspiration of the various crops.

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 extremely deep, dark red to dusky red in colour, and consist of friable clay, with an acid humic topsoil.
The soil structure is predominantly weak sub-angular blocky, and a very high bioporosity is prevalent.

Rating of soil-related land factors

- Parent rock
  - [✓ 1 rich: basic igneous rocks]
  - 2 moderately rich
  - 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
  - [✓ 0 non-saline]

- Salinity	0	non-saline
	1	slightly saline
	2	saline
- Sodicity	0	non-sodic
	1	slightly sodic
	2	sodic
- Stoniness	0	non-stony
	1	slightly stony
	2	stony
	3	very stony
- Rockiness	0	non-rocky
	1	slightly rocky
	2	rocky
	3	very rocky
- Consistence (moist)	1	half-ripe
	2	loose
	3	very friable
	4	friable
	5	firm
	6	very firm
- Moisture storage capacity	1	very high
	2	high
	3	moderate
	4	low
- Excess surface water	0	none
	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 20.1.9. The location of the profile near the trial plot is shown in Figure 20.1.7.

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): humic Nitisol.

2. USDA Soil Taxonomy (Soil Survey Staff, 1975): typic Palehumult, very fine-clayey family.

Table 20.1.9: Detailed Profile Description of Trial Site Githunguri

Profile number: 20.1
Date of examination: 30-7-1986
Authors: Smaling/Kibe

Sample No.	Horizon			Colour (Moist)	Mottling	Texture	Cutans	Structure	Biopores	Consistence	Concretions	Other Features
	Genetic	Depth	Boundary									
20.1.1	Ah	0 - 20	clear smooth	5 YR 3/3 dark redd. brown	nil	clay	nil	weak fine subangular blocky	many v.f. many f. many m. common c.	soft; v.friable; sl.sticky-sl.plastic	nil	---
20.1.2	BA	20 - 50	gradual smooth	10 R 3/3 dusky red	nil	clay	patchy thin clay	weak fine subangular blocky	many v.f. many f. many m. many c.	soft; friable; sl.sticky-sl.plastic	nil	---
20.1.3	Bt1	50 - 78	diffuse	10 R 3/3 dusky red	nil	clay	broken moderately thick clay	weak fine subangular blocky	many v.f. many f. many m. many c.	sl.hard; friable; sl.sticky-sl.plastic	Mn, very few, small	---
20.1.4	Bt2	78 - 96	gradual smooth	10 R 3/4 dusky red	nil	clay	broken thick clay	weak fine subangular blocky	many v.f. many f. many m. common c.	sl.hard; friable; sl.sticky-sl.plastic	Mn, very few, small	---
20.1.5	Bt3	96 - 120		10 R 3/6 dark red	nil	clay	continuous thick clay	weak fine to medium subangular blocky	many v.f. many f. many m. many m.	sl.hard; friable; sl.sticky-sl.plastic	Mn, very few, small	---
20.1.6	Ah (control sample)				nil	clay						

Remarks: Colour: redd. = reddish
Biopores: v.f. = very fine; f. = fine; m. = medium; c. = coarse
Consistence: sl. = slightly; v. = very
Field pH was not determined.

3.1.3 Soil Sampling

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

Figure 20.1.7 shows the location of the composite sampling blocks (I to IV) as well as the location of the profile pit.

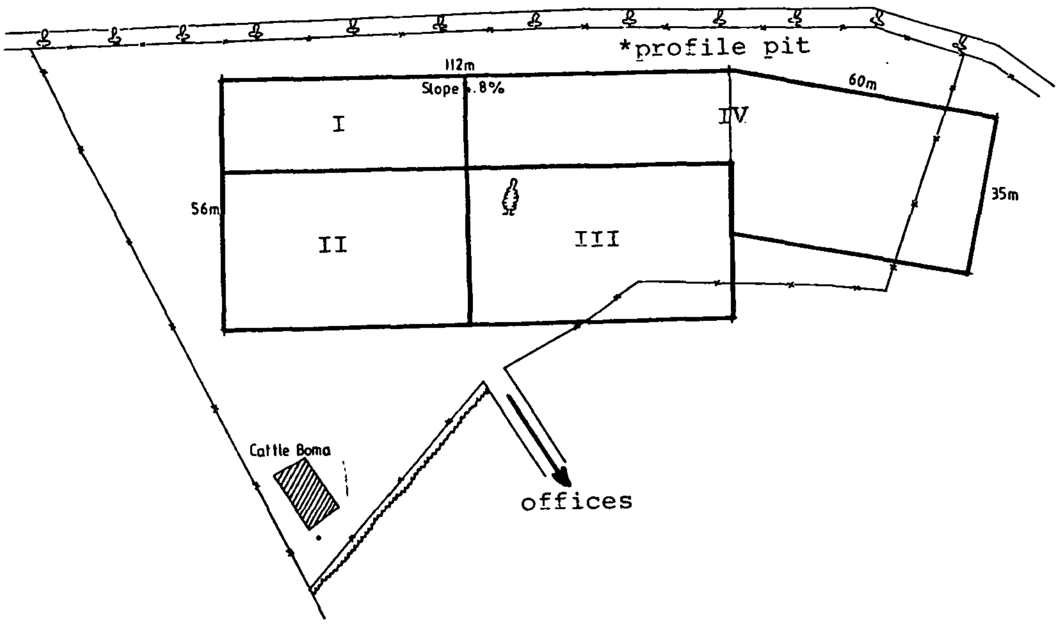


Figure 20.1.7: Location of Composite Sampling Blocks and Profile Pit at the Githunguri Trial Plot

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 20.1.10 to 20.1.12. The methodology applied for obtaining these result is described in detail in Chapter IV.2 of the main report.

Table 20.1.10 : 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	Ah	0-20	20.1.1	6863/86	--	20	25	55	C	5.0	5.9	0.9	0.09
2	BA	20-50	20.1.2	6864	--	14	19	67	C	5.0	5.6	0.6	0.04
3	Bt1	50-78	20.1.3	6865	--	14	15	71	C	5.2	6.5	1.3	0.05
4	Bt2	78-96	20.1.4	6866	--	14	11	75	C	5.1	6.3	1.2	0.05
5	Bt3	96-120	20.1.5	6867	--	14	9	77	C	5.2	5.8	0.6	
6													
7	Ah	Control	20.1.6	6868	--	20	25	55	C	5.0	5.8	0.8	
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	0.06	1.59	1.70	5.40	1.67	11.60	75.43	2.07	0.24	0.34
2	NA	NA	NA	0.05	0.63	2.15	5.60	1.36	9.90	85.15	1.62	0.16	0.32
3	NA	NA	NA									0.28	0.48
4	NA	NA	NA									0.36	0.62
5	NA	NA	NA									0.26	0.58
6													
7	NA	NA	NA									0.24	0.34
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	0.14	1.66	1.00	2.50	23.80	22.27	5.54	4.33	1.89	0.33	5.7		0.95
2	0.10	0.76	2.50	2.50	24.60	23.82	6.02	2.66	1.37	0.23	6.0		0.94
3	0.10	0.98	2.10	2.10	22.00	24.00	5.56	5.04	0.94	0.19	4.9		0.93
4	0.12	1.02	2.30	2.30	19.80	28.99	6.10	5.90	0.71	0.17	4.2		0.92
5	0.11	0.70	2.10	2.10	18.30	27.38	5.27	4.93	0.52	0.10	5.2		0.92
6													
7	0.16	1.54	2.30	2.30	24.00	26.25	6.54	3.67	1.99	0.26	7.7		0.94
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	Ah/BA	20-25	61.0	44.7	39.5	24.3	22.4	22.3	0.85
2	Bt1	65-70	62.9	44.7	39.5	24.2	22.6	22.1	0.85
3									
4									

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

Table 20.1.11 : Analytical Results (chemical analysis, results on air dry soil basis)
Trial Site Composite Samples

		Depth	Block number							$\bar{x}$	s	Max.
		cm.	I	II	III	IV	V	VI	VII			diff.
1	Lab. No. /86	20	6869	6871	6873	6875						
2		50	6870	6872	6874	6876						
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	0.95	0.98	0.96	0.91				0.95	0.03	0.07
7		50	0.99	0.96	0.98	1.01				0.99	0.02	0.05
8	105 deg.C / air dry	20	0.94	0.93	0.93	0.93				0.93	0.00	0.01
9		50	0.94	0.93	0.93	0.92				0.93	0.01	0.02
10												
11	pH H2O 1/1	20	6.4	6.5	6.5	6.2				6.40	0.14	0.30
12		50	6.4	6.3	6.2	6.0				6.23	0.17	0.40
13	pH H2O 1/2.5	20	5.7	5.9	5.7	5.5				5.70	0.16	0.40
14		50	5.8	5.4	5.5	5.4				5.53	0.19	0.40
15	pH N KCl 1/2.5	20	5.2	5.2	5.1	4.8				5.08	0.19	0.40
16		50	5.2	4.8	5.0	4.8				4.95	0.19	0.40
17												
18	C org. %	20	2.44	2.15	2.83	2.16				2.40	0.32	0.68
19		50	2.13	1.67	1.37	1.53				1.68	0.33	0.76
20	N tot. %	20	0.34	0.29	0.29	0.28				0.30	0.03	0.06
21		50	0.29	0.23	0.19	0.22				0.23	0.04	0.10
22	C/N	20	7	7	10	8				8.02	1.18	2.58
23		50	7	7	7	7				7.19	0.17	0.39
24												
25	Mod.Olsen Abs. 260nm	20										
26	(1/1000)	50										
27												
28	SO4 soluble ppm.	20	4									
29		50	8									
30												
31	P Meh.1/5 ppm.	20	5	2	2	2				2.75	1.50	3.00
32		50	5	2	2	30				9.75	13.57	28.00
33	P Olsen ppm.	20	5.40									
34		50	3.00									
35	P mod.Olsen ppm.	20	4.80	2.80	2.00	2.00				2.90	1.32	2.80
36		50	3.60	1.20	1.30	14.80				5.23	6.48	13.60
37	P Citric ac. ppm.	20	18									
38		50	14									
39												
40	ECEC AgTU me./100gm.	20	16.70	17.10								
41	Bases %	20	74.61	76.96								
42	Al%	20	NA	NA								
43												
44	Hp BaCl2 me./100gm.	20	not applicable									
45		50	not applicable									
46	H & Al KCl me./100gm	20	not applicable									
47		50	not applicable									
48	Al 3- KCl me./100gm.	20	not applicable									
49		50	not applicable									
50	Al 3- AgTU me./100gm	20	not applicable									
51												
52	Sat.Ext. % H2O	20	not applicable									
53		50	not applicable									
54	Sat\Ext. El.Cond.	20	not applicable									
55		50	not applicable									
56	Sat.Ext. pH	20	not applicable									
57		50	not applicable									
58												

Table 20.1.11 : 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	$\bar{x}$	s	Max. diff.
1	Lab. No. /86	20	6869	6871	6873	6875						
2		50	6870	6872	6874	6876						
3												
59	Na Meh.1/5 me./100gm	20	0.36	0.14	0.14	0.25				0.22	0.11	0.22
60		50	0.14	0.11	0.34	0.18				0.19	0.10	0.23
61	Na Ag-TU me./100gm.	20	0.06	0.09								
62												
63	K Meh.1/5 me./100gm.	20	2.00	1.58	1.86	2.00				1.86	0.20	0.42
64		50	1.25	1.43	1.29	1.16				1.28	0.11	0.27
65	K mod.Ol. me./100gm.	20	1.85	1.20	1.30	1.30				1.41	0.30	0.65
66		50	1.03	1.15	0.93	0.83				0.99	0.14	0.32
67	K Ag-TU me./100gm.	20	2.30	1.62								
68												
69	Mg Meh.1/5 me./100gm	20	1.70	2.10	2.30	1.50				1.90	0.37	0.80
70		50	1.80	2.10	1.90	1.40				1.80	0.29	0.70
71	Mg mod.Ol. me./100gm	20	1.90	2.10	2.20	1.70				1.98	0.22	0.50
72		50	2.00	2.20	1.70	1.70				1.90	0.24	0.50
73	Mg Ag-TU me./100gm.	20	2.30	2.45								
74												
75	Ca Meh.1/5 me./100gm	20	5.40	5.20	4.00	2.80				4.35	1.20	2.60
76		50	4.00	3.20	1.20	2.00				2.60	1.24	2.80
77	Ca mod.Ol. me./100gm	20	11.00	11.00	10.00	7.00				9.75	1.89	4.00
78		50	11.00	9.00	6.00	7.00				8.25	2.22	5.00
79	Ca Ag-TU me./100gm.	20	7.80	9.00								
80												
81	Mn Meh.1/5 me./100gm	20	0.82	0.43	0.91	0.64				0.70	0.21	0.48
82		50	0.64	0.83	0.77	0.76				0.75	0.08	0.19
83	Mn mod.Ol. me./100gm	20	1.10	0.90	0.80	0.70				0.88	0.17	0.40
84		50	1.30	0.60	0.60	0.80				0.83	0.33	0.70
85	Mn Ag-TU me./100gm.	20	1.09	1.09								
86												
87	Zn HCl ppm.	20	8.00									
88		50	8.80									
89	Zn mod. Ol. ppm.	20	6.00	5.00	5.00	5.00				5.25	0.50	1.00
90		50	7.00	7.00	4.00	6.00				6.00	1.41	3.00
91												
92	Cu HCl ppm.	20	1.00									
93		50	0.70									
94	Cu mod. Ol. ppm.	20	0.70	0.50	0.70	0.60				0.63	0.10	0.20
95		50	0.60	1.20	0.60	1.10				0.88	0.32	0.60
96												
97	Fe HCl ppm.	20	11									
98		50	21									
99	Fe mod. Ol. ppm.	20	268	204	207	237				229.00	29.97	64.00
100		50	279	249	243	265				259.00	16.25	36.00
101												
102	Fe Oxalate %	20	0.62									
103		50	1.37									
104	Al Oxalate %	20	8.40									
105		50	8.40									

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 20.1.12 : 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.	20	6877	6878	6879	6880	6881	6882	6883	6884				
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	0.94	0.86	0.89	0.90	0.90	0.91	0.81	1.00	0.95	0.91	0.05	0.19
4	105 deg. C / air dry	20	0.90	0.93	0.94	0.93	0.94	0.94	0.93	0.92	0.93	0.93	0.01	0.04
5														
6	pH H2O 1/1	20	5.80	6.50	5.30	6.40	5.60	5.80	5.80	6.40	6.40	6.00	0.43	1.20
7	pH H2O 1/2.5	20	5.30	5.90	5.10	6.00	5.20	5.40	5.40	6.00	5.70	5.56	0.35	0.90
8	pH N KCl 1/2.5	20	4.60	5.10	4.40	5.10	4.40	4.60	4.60	5.10	5.08	4.78	0.31	0.70
9														
10	C org. %	20	1.89	1.93	2.78	2.44	2.56	2.16	2.20	1.63	2.40	2.22	0.36	1.15
11	N tot. %	20	0.22	0.24	0.34	0.26	0.25	0.23	0.24	0.19	0.30	0.25	0.04	0.15
12	C/N	20	9	8	8	9	10	9	9	9	19	10.04	3.34	10.71
13														
14	Mod.Olsen Abs.260nm.	20										0.00	0.00	0.00
15														
16	P Meh. 1/5 ppm.	20	2.00	5.00	2.00	19.00	5.00	2.00	2.00	2.00	2.75	4.64	5.53	17.00
17	P mod.Olsen ppm.	20	10.30	10.80	11.50	57.00	13.20	6.30	3.30	1.00	2.90	12.92	17.09	56.00
18														
19	Na Meh.1/5 me./100gm.	20	0.12	0.21	0.14	0.21	0.19	0.18	0.67	0.19	0.22	0.24	0.17	0.55
20														
21	K Meh.1/5 me./100gm.	20	1.78	2.00	2.00	2.00	1.48	1.52	2.00	1.20	1.86	1.76	0.29	0.80
22	K mod.Ol. me./100gm.	20	1.07	1.25	1.85	1.39	0.90	1.05	1.95	0.80	1.41	1.30	0.40	1.15
23														
24	Mg Meh.1/5 me./100gm.	20	1.50	2.30	1.00	2.80	1.20	1.40	1.60	2.00	1.90	1.74	0.57	1.80
25	Mg mod.Ol. me./100gm.	20	1.50	2.30	1.40	2.40	1.30	1.40	2.30	2.00	1.98	1.84	0.44	1.10
26														
27	Ca Meh.1/5 me./100gm.	20	3.20	4.00	3.20	8.40	1.60	2.40	2.40	2.80	4.35	3.59	1.99	6.80
28	Ca mod.Ol. me./100gm.	20	8.00	10.00	4.00	15.00	6.00	8.00	8.00	9.00	9.75	8.64	3.03	11.00
29														
30	Mn Meh.1/5 me./100gm.	20	1.50	2.30	1.00	2.80	1.20	1.40	1.60	2.00	0.70	1.61	0.66	2.10
31	Mn mod.Ol. me./100gm.	20	1.30	0.70	1.90	0.30	0.90	1.00	1.40	0.50	0.88	0.99	0.49	1.60
32														
33	Zn mod.Ol. ppm.	20	13.00	5.00	5.00	7.00	4.00	6.00	10.00	5.00	5.25	6.69	2.94	9.00
35														
36	Cu mod.Ol. ppm.	20	0.72	0.45	0.91	0.53	0.45	0.60	0.12	0.50	0.63	0.55	0.22	0.79
38														
39	Fe mod.Ol. ppm.	20	271	170	354	116	328	250	295	224	229	248.56	74.85	238.00
41														
42	Hp BaCl2 me./100gm.	20			0.50									
43	H & Al KCl me./100gm.	20												
44	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.

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 20.1.13. Moreover, the FURP soil map unit (Map 20.0.4) and the classification of the soil of the profile at the trial plot are given.

Table 20.1.13: Soil Correlation with Respect to the Githunguri Trial Site

Reference	Map unit	Soil Classification
E1	R2	humic Nitisols
FURP	RB2	humic Nitisols
Trial plot profile		humic NITISOL

The only source for the area around Githunguri is E1. It indicates humic Nitisols for this area, which were confirmed at the trial site.

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 Kiambu District is shown in Map 20.0.5: "Groupings of Soil Mapping Units Represented by Trial Sites in Kiambu District". This map is discussed in Sub-section 20.0.5.

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

Within Kiambu District, the Githunguri trial site has high representativeness (Grouping 20.1.A) for the humic Nitisols of soil map unit RB2, which includes the Kikuyu, Karuri, Githunguri and Gatundu areas.

The Githunguri trial site is also representative for areas outside Kiambu District, but Groupings are not indicated as such, since trial sites 21.1 (Kareti, Muranga District), 23.1 (Kerugoya, Kirinyaga District), 24.3 (Embu A.R.S., Embu District), and 25.1 (Kaguru FTC, Meru District) also represent soil map unit RB2 in the respective Districts.

3.3.3 Variability of Soil Properties within the Trial Site

Trial plot 20.1 is a plot with a uniformly extremely deep soil. As it has been pasture land for a number of years, soil fertility is slightly better than at the farmers' fields.

A comprehensive listing of soil test values is given in Tables 20.1.10 to 20.1.12. In this sub-section, a breakdown is given on the pH and organic carbon content of the upper 20 cm. of the soils of the trial site. Apparently there are considerable discrepancies among the various farmers' fields.

pH-KCl: profile pit: 5.0
composite samples: 4.8 - 5.2
farmers' fields: 4.4 (fields C and E)
4.6 (fields A, F, G)
5.1 (fields B, D, H)

organic carbon content:
profile pit: 1.9%
composite samples: 2.2% (Block II, IV) - 2.8% (Block III)
farmers' fields: 1.6% - 1.9% (fields A, B, H)
2.2% - 2.4% (fields D, F, G)
2.6% - 2.8% (fields C, E)

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, situated on the side of the plot close to Block IV (see Figure 20.1.7), are presented in Table 20.1.10 and are interpreted in the following paragraphs.

The main rooting depth of the soil is limited neither by physical nor chemical obstacles in the subsoil. According to the pF determinations carried out on the Ah/AB and Bt1 horizons, the moisture storage capacity is very high. It attains approximately 220 mm. in the upper 100 cm.

The entire profile down to a depth of 120 cm. (maximum sampling depth) has a medium CEC (pH 8.2), decreasing with depth from 24 me./100 gm. in the Ah and AB to 18 me./100 gm. in the Bt3 horizon. The base saturation (by Ammonium-Acetate) is low to medium. It increases from 22 % in the Ah to 28 % in the Bt2 and Bt3. The base saturation appears too low for the reported slightly to moderately acid soil reaction, the variable (pH-dependent) charge of the soil would be exceptionally high. The low base saturation is probably caused by an underestimate of Ca, which is more than two times higher by Silver-Thiourea. The sum of bases by the latter method would result in a medium base saturation of the CEC (pH 8.2) of 37 % in the Ah and 34 % in the AB horizon. This is in better agreement with the soil pH.

With reference to the medium CEC, exchangeable K is very high (>1.6 me./100 gm.) in the topsoil and high to very high (0.7 - 1 me./100 gm.) in the subsoil. Mg appears almost constant over the entire profile and is in the very high range (>1.5 me./100 gm.). Ca is low in comparison to the other bases and, according to Ammonium-Acetate, in the very low to low range; Ca by Silver-Thiourea is medium (5.5 me./100 gm.). Exchangeable bases are well balanced with respect to plant nutrition, the Ca/Mg ratio is however, narrow.

The soil reaction is in the slightly to moderately acid range (pH KCl 5 - 5.2), and the exchangeable Al shows low values (<0.4 me./ 100 gm.). In the upper 100 cm. of the profile, the percentage of exchangeable Al is very low (3 - 6.5 % of exchangeable bases + Al). Consequently, Al should not affect even sensitive plants.

The organic matter content of the Ah and AB horizons (1.9 and 1.4 % C) is medium to high, the humus content decreases with depth to 0.5 % C in the Bt3. The N contents of the horizons decrease with depth in the same way as the organic matter content. N ranges from high in the topsoil (0.33 % N in Ah and 0.23 % N in AB) to medium/low in the Bt3 (0.1 % N). The C/N ratios are narrow.

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 20.1.11. The data for the farmers' fields (depth 0-20 cm. only) selected around this trial site are given in Table 20.1.12.

The composite samples were analyzed to assess the chemical fertility status of the soil, with special emphasis on the availability of 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 total N contents of the very humic soils are high, ranging from 0.28 to 0.34 % N in the topsoil of the trial site and from 0.19 to 0.34 % N in the farmers' fields. The medium C/N ratios and other prevailing soil factors indicate that the N availability is probably at least moderate.

The solubility of SO_4 was tested in Block I of the trial site only and appeared low and close to the critical level (<11 ppm.).

The trial site composite samples are very low in available P (2 -5 ppm. by Mehlich analysis and 1.3 - 4.8 ppm. by modified Olsen method). The subsoil sample from Block IV shows a much higher P value (30 ppm. by Mehlich analysis) than the other samples, this should be verified by a control sample. According to the Mehlich analysis, the farmers' fields are as poor in P as the trial site (2 - 5 ppm.). Only farmer's field D contains medium amounts (19 ppm.) of available P. According to the modified Olsen method however, only fields F, G, and H show a low to very low P status (6.3 ppm., 3.3 ppm., and 1 ppm., respectively). Fields A, B, C, and E have a moderate P status (10 - 13 ppm.), and field D shows a very high P value (57 ppm.). The availability of P is probably inadequate for the expected N supplying capacity of the soil in all fields, except in farmer's field D.

In all trial site composite samples, "available" K is in the (very) high range (1.2 - 2 me./100 gm.by Mehlich analysis and 0.8 - 1.9 me./100 gm. by modified Olsen method). The farmers' fields show similarly high K values.

The "available" quantities of Mg are high to very high (1.2 - 2.8 me./100 - gm. by Mehlich analysis, 1.3 - 2.4 me./100 gm. by modified Olsen method). The Ca levels vary in a wide range, from moderate to high (1.2 - 8.4 me./100 gm.) according to Mehlich analysis. Ca by the modified Olsen method covers the whole range from low to high (4 - 15 me./100 gm.). In the trial site the Ca status and the pH of the soil decreases continuously from Block I to Block IV. Similar to the exchangeable bases, the cations are adequately balanced for plant nutrition.

According to both the modified Olsen method and Mehlich analysis, "available" Mn is generally within the adequate range below 2 me./100 gm.. For farmers' fields B, D and H the two methods disagree. While Mehlich analysis indicates the possibility of excessive Mn (2 - 2.8 me./100 gm.), the values obtained by the modified Olsen method are much lower (0.3 - 0.7 me./100 gm.). Mn by the latter method is closely related to soil pH and extractable Ca.

According to the modified Olsen method, Zn is available in moderate to high amounts, the HCl extractable Zn determined in Block I is also far above the deficiency level, too. The modified Olsen method indicates low Cu levels for almost all samples and particularly for farmer's field G. HCl extractable Cu in Block I is just above the threshold.

The amount of Fe extracted by the modified Olsen method is high. The oxalate extraction for amorphous oxides and hydroxides yielded low quantities of Fe and high amounts of Al.

The trial site composite samples are slightly to moderately acid (pH KCl 4.8 - 5.2). The pH decreases slightly from Block I to Block IV. On average, the farmers' fields are more acid. Fields C and E show strongly acid pH values (4.4), fields B, D and H are slightly acid (pH KCl 5.1), the other fields intermediate. In no case is exchangeable acidity and especially exchangeable Al expected to have any effect on crop production.

The evaluation of the Mehlich Analysis data according to NAL standards is given in Table 20.1.14.

Table 20.1.14: Evaluation of the Mehlich Analysis Data According to NAL Standards

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

Remarks on Trial Site:
Soil reaction is favourable. Positive yield responses to P applications are expected. Yield responses to manure and N may not be expected in the first few seasons but are likely to occur later. Yield responses to K and lime applications are unlikely.

Remarks on Farmers' Fields:
Same as for Trial Site.

3.4 Sampling Programme for Laboratory Analyses

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:P0	N0:P75	N75:P75
Trial II:	0	FYM 1 (2.5 t/ha)	FYM 3 (7.5 t/ha)	
		FYM 1 + P	FYM 3 + P	
	N + P	FYM 1 + N + P		

Farmers' fields: Fields D, E and H 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 taken, i.e.:

Trial I:	N0:P0	N75:P0	N0:P75	N75:P75
Trial II:	0	FYM 1 (2.5 t/ha)	FYM 3 (7.5 t/ha)	
		FYM 1 + P	FYM 3 + P	
	N + P	FYM 1 + N + P		

Farmers' fields: Harvest samples will be collected only from those farmers' fields where soil samples were taken. Individual samples for 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 the crop maize H 512, first rains, at the Githunguri trial site, can be interpreted as follows:

Figure 20.1.6 shows that the maximum water requirements (ETm) of the maize crop are not in line with the rainfall pattern at the 66% probability level, but on the prevailing extremely deep soils, the considerable surplus of water (peak in April) can to a large extent be stored. The ratio of reliable rainfall (i.e. 66% probability) to maximum evapotranspiration (ETm) for maize H 512 is >1.0 for the total length of the growing period.

Run-off is considered to be moderate. The trial site is located on gently sloping land (2-5%) and the top soil has a very stable structure, i.e. a low susceptibility to sealing and crusting, but the crop does not provide an adequate ground cover at the time of maximum rainfall intensity in April and May.

Deep percolation and lateral sub-surface flow could be estimated, but can be omitted, since they are generally very low, except during the period of high rainfall intensity in April/May. The possible losses are roughly estimated: 10-20% of the precipitation.

Run-on is only relevant within the plot, favouring the lower parts in the northern edge of the plot.

For the Githunguri trial site, the moisture storage capacity is very high (i.e. >160 mm.). The water surplus of April and May is, therefore, stored to a large extent and offsets the rainfall deficits which are likely to occur from June onwards.

Summarizing the evaluation of the climatic factors, the yield potential from the climatic point of view can, for the maize crop, be rated as 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 appear at least moderately favourable for plant production. The high N availability at present on the trial site may decrease quickly after the field has been ploughed. The SO_4 solubility appeared low on the trial site. It is possible that after breaking up the grassland the first crops might suffer slightly from SO_4 deficiency, but this problem normally disappears after one or two seasons.

The availability of Cu 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 (Hyperphos). TSP or Superphosphate will probably be superior to rock phosphate in the slightly acid soils. Only under more acid conditions, which occur on many farmers' fields, will rock phosphate be readily available to plants. The tendency of P to become unavailable by fixation is difficult to estimate, but it is probably moderate; Fe by the modified Olsen method is not too high, and the soils may not contain amorphous materials like allophanes. The efficiency of P application may be enhanced by the addition of fresh FYM to stimulate soil biological activity.

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

When mineral N is applied regularly, it should be supplemented with mulch and other organic amendments to maintain the humus content of the soil at the present level. The humus plays an essential role in stabilizing the soil structure, infiltration rate, soil aeration and moisture retention capacity, and also prevents applied nutrients from leaching too quickly.

The application of FYM will have only limited effects if not combined with P. Green manuring with leguminous plants will depend even more on P fertilization.

K fertilizer is not needed at all. Although the analytical data give no estimate of the reserves of K beyond the exchangeable pool, K supply from the soil will support high yields over many years.

Under the present soil conditions liming is not required 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.

In more acid soils and over long periods of fertilizer use, the increasing soil acidity should be counter-balanced by liming. N-fertilizers have particularly high lime requirements, i.e. approximately 1.8 Kg. of $CaCO_3$ per Kg. of applied N; in the case of CAN, which contains Ca, only about 0.8 Kg. $CaCO_3$ per Kg. N or 0.2 Kg. lime per Kg. of CAN will be needed. TSP does not contribute substantially to the Ca budget of the soil; soft rock phosphate (30% P_2O_5) contains about 2.7 Kg. $CaCO_3$ equivalents per Kg. of P_2O_5.

If lime is applied, availability of P and Cu may become even lower and more severe deficiencies may be expected.

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 general, the topsoils of humic Nitisols have good physical properties. High porosity and stable structure maintain an environment in which no impeded gas exchange is to be expected.

b) Rootability.
The extremely deep soils with their stable blocky structures and high porosity provide an outstanding environment for unhampered root development and tuber expansion.

c) Resistance to erosion.
The area has a moderate to high resistance to erosion. The negative influence of high rainfall intensity and the undulating to rolling topography are largely offset by the high structure stability (low erodibility) of the surface soil.

d) Ease of cultivation and scope for agricultural implements.
Although the soils impose no serious limitations to manual land preparation and oxen ploughing, areas with a rolling topography are less suitable for tractor ploughing. Moreover, tractor ploughing generally leads to a deterioration of the physical properties of the topsoil (compaction).

5. Trial Design and Execution Plan, Githunguri.

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

Selection of crops for each of the 3 modules at the Githunguri site:

Site 20.1 Githunguri	RAINY SEASONS 1st, Long, March	 2nd Short, Oct
S1 Standard maize	Hybrid 512	Hybrid 512
S2 Maize & beans	H.512 +GLP 2 Beans	H.512 + GLP 2 Beans
S3 Pot./Cabbages;Beans	Potat. or Cabbages	Beans, GLP 2

The 1st sequence or module is continuous, pure maize, twice/year.
The 2nd is intercropped maize and beans, also twice/year.
The 3rd is potatoes or cabbages in 1st rains, and pure beans 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 4 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.

The N and P fertilizers will be applied in both seasons, but the FYM will be applied only during the 1st rains. Where maize and beans are intercropped, the fertilizer will go on the maize. The inter-cropped 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.