TRAINING PROJECT IN PEDOLOGY

KISII KENYA

SEMI- DETAILED SOIL SURVEY

of an area near Oyani Market,

and the

SUITABILITY

of this area for the growth of

SUGAR CANE

AGRICULTURAL UNIVERSITY

WAGENINGEN - THE NETHERLANDS

Semi - D E T A I L E D S O I L S U R V E Y

of an area near Oyani Market,

and the

S U I T A B I L I T Y
of this area for the growth of
S U G A R C A N E

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Kenya.

Contents.

Preface.

The report presented here, deals with the suitability of soils for growing sugarcane. The fieldwork was executed by Mr.E.O'Herne, a postgraduate of the agricultural university, during the end of February and the first weeks of March 1977. He also wrote the report.
Physical and chemical data were obtained from the laboratory of the Training Project in Pedology, at Kisii.

Summary of results.

150 ha. are highly suitable,
150 ha. are moderately suitable,
1500 ha. are marginally suitable and
3300 ha. are currently unsuitable for the growth of sugarcane.
Soils currently unsuitable may become suitable, if waterlogging and flooding hazard are eliminated. Soil conditions are such, that only with very high investments a moderate suitability can be obtained. It is therefore advised not to start reclamation before field-trials have been conducted, from results of which a rough estimate of improvement-costs and future returns can be made.

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1. Description of the area.

1.1 Location and extent.

The surveyed area is located between latitudes 58' and 1°04' South and longitudes 34°35' and 34°40' East, in the northwestern part of Narok District, Rift Valley Province, South West Kenya. It covers approximately 4800 ha. roughly in a triangle formed by Oyani Market, Keiyan and Sikawa mountain.

1.2 Population and infra-structure.

In the surveyed area no towns are found, except for some small villages, inhabited by members of the Masai-tribe. The area is reasonably accesible in the dry season; in the rainy season however, the area is inaccessible, due to the fact that there are no roads in this area, only some cattle-tracks.

1.3 Climate and meteorology.

The climatic conditions of the area are probably best described by data obtained from Kamagambo School (station nr 90.34-005) and Kitere (nr 90.34-040(meteorological stations. Both stations are at 5000ft altitude. Data of both stations show two dry seasons, one in December/January and a less pronounced one in July/August. Mean annual temperatures are about 22°C, with maxima of 29°C and minima of 16°C. For Kamagambo School a mean annual rainfall of 1565mm is found, for Kitere 1732mm. The rainfallprobability is, according to the Meteorological Department of the East African High Commission, more than 1250mm in four out of five years. Van Mourik (1974) calculated actual evapotranspiration and potential evapotranspiration for the Kamagambo School station. He found 1470 to 1570mm and 1890mm respectively as annual averages.

1.4 Physiography and topography.

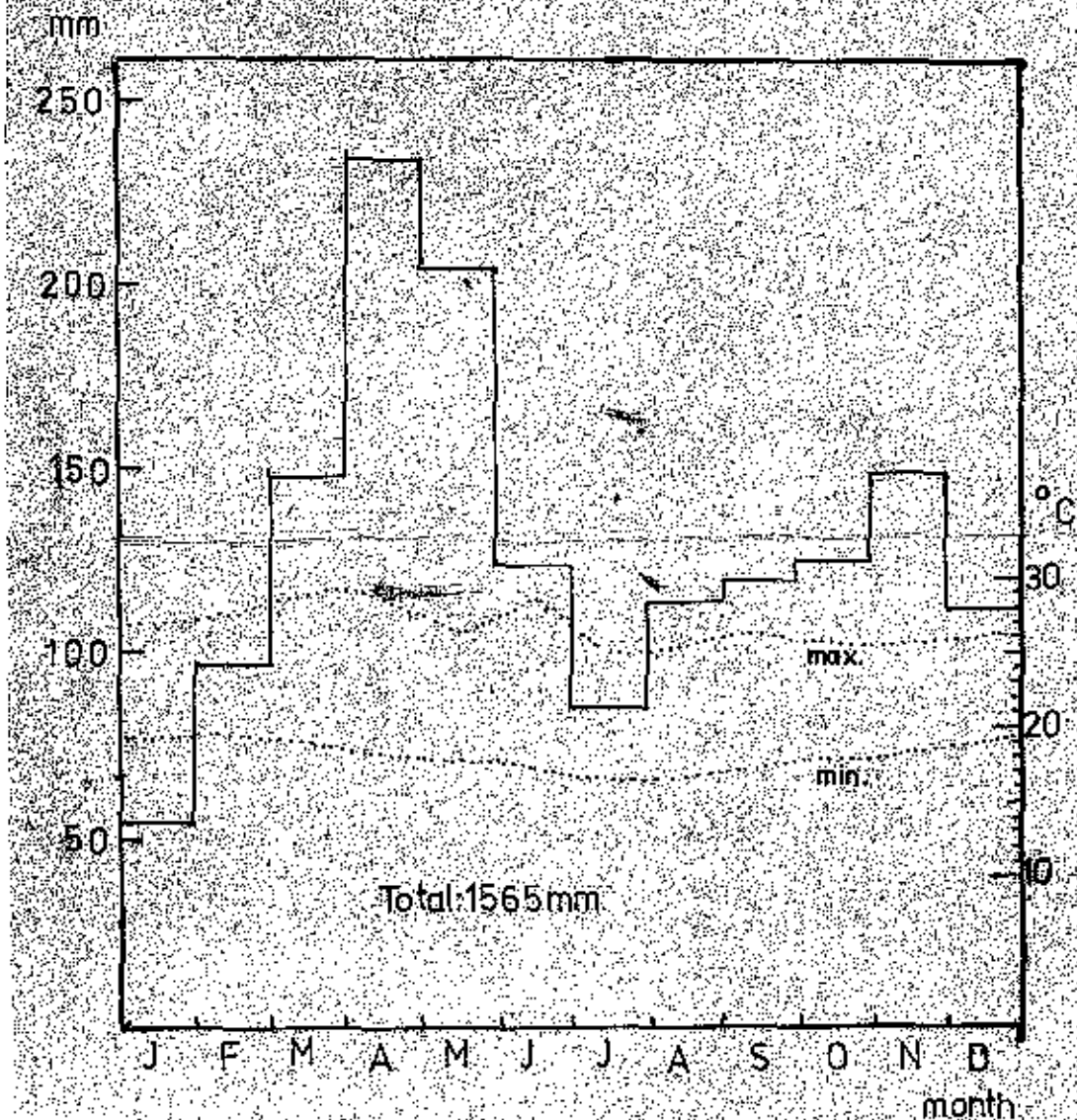
The area can be divided in two main physiographic units;
A. The lower lying plains, ridges and flat bottomed valleys and
B. The higher (mountainous) parts.
The parts of the area belonging to A. are mainly between 4800 and 5100ft altitude and characterized by an almost flat to undulating topography (steepest slopes less than 8%). The higher regions, B, are above 5000ft; they consist of footslopes and ridges with an almost flat (on top of ridges and lower parts of footslopes) to rolling(steepest slopes less than 16%) topography. Due to water running down from mountains, some gully erosion occurs here.

Average monthly rainfall

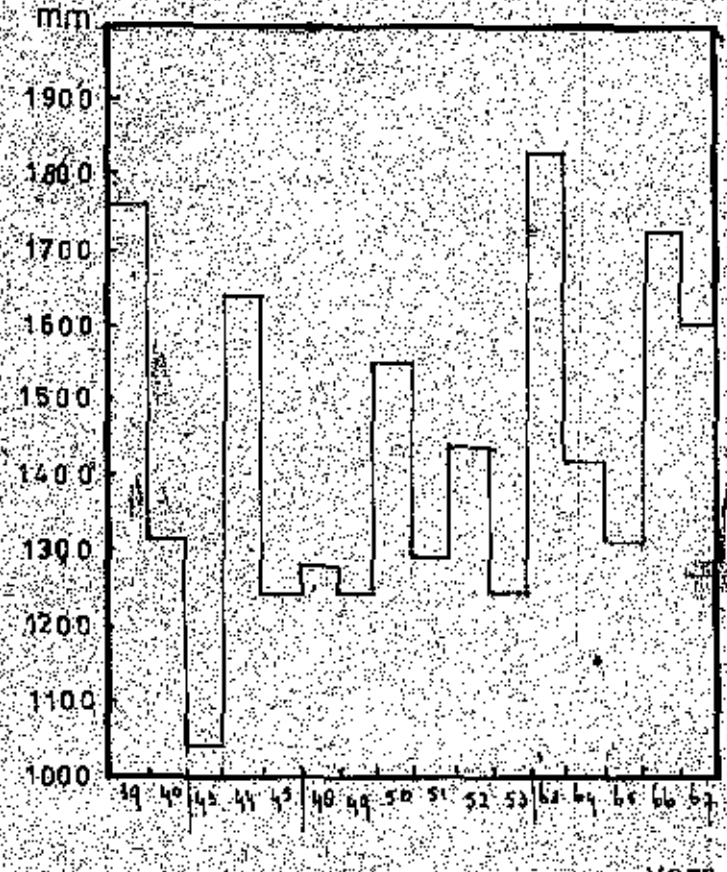
Average monthly temperature

Kamagambo School (90.34-005)

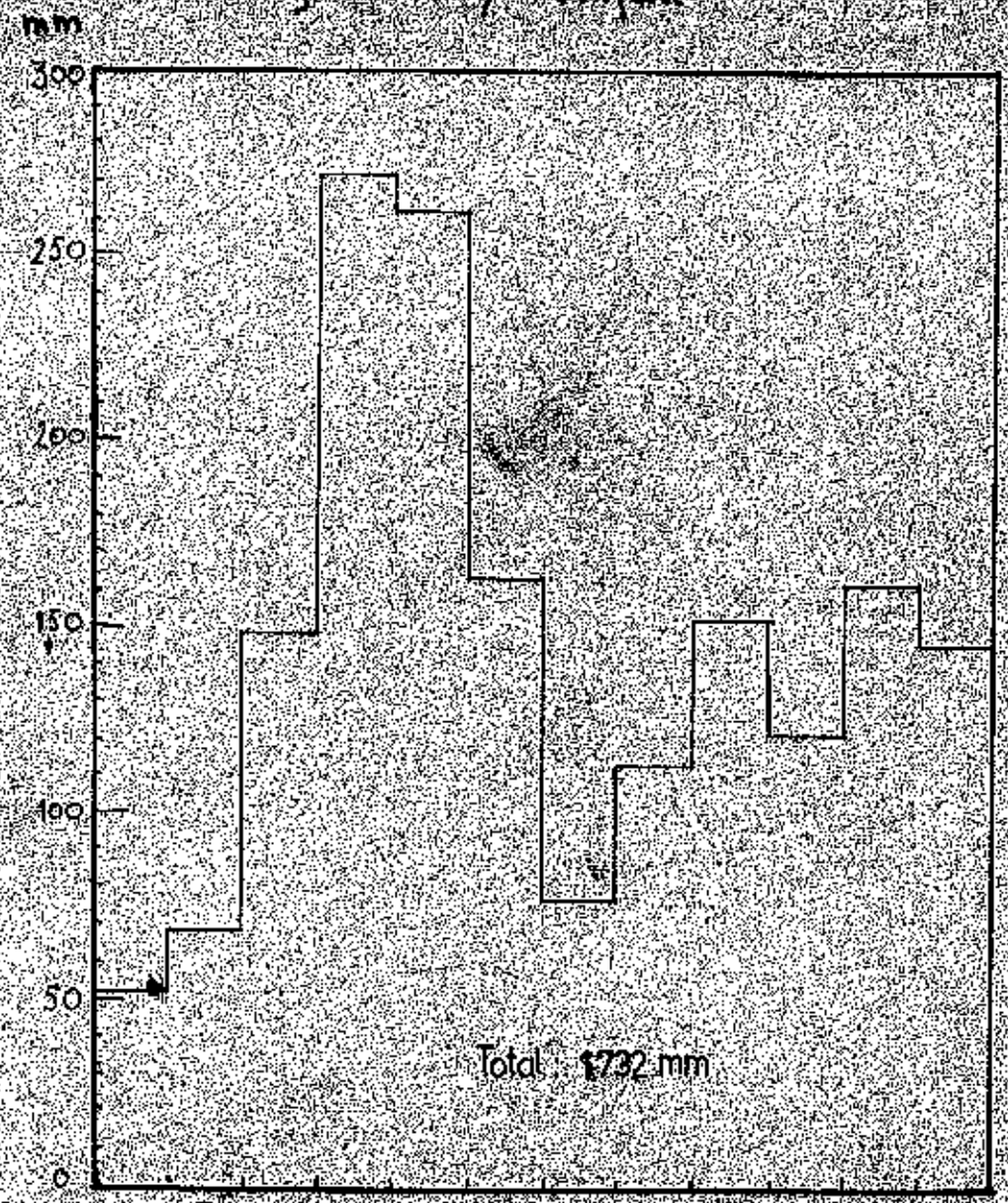
0°45'S 34°38'E ; 5000ft alt.



Total annual rainfall



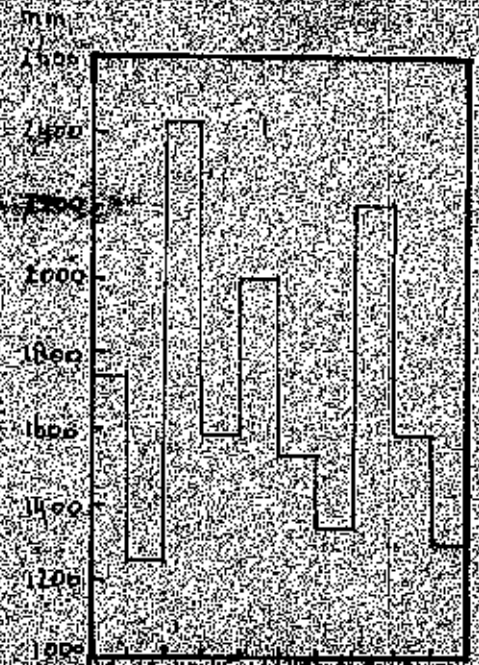
Average monthly rainfall



Total: 1732 mm

Kibere goldfield (00-34-04E)
0°48'S, 34°16'E; 5000ft alt.

Total annual rainfall



1.5 Geology and parent materials.

The lower plains and the flatbottomed valleys are filled with alluvial deposits, with volcanic ash admixture. These deposits overly Nyanzian and Kavirondian basalts and locally, Nyanzian banded ironstones. The higher psrts consist mainly of Bukoban basalts, all according to the geological map of the Migori area, surveyed by R.M. Shackleton (1942).

1.6 Vegetation and landuse.

According to the Ecological Zone Map of Southwestern Kenya (1:250,000), the surveyed area belongs to the Western Diospyros forest Zones (WD)/Western Combretum Savanne Zones (WS). The vegetation can be described as bushed to wooded grassland. The major part of the area is used for extensive grazing; however near Masai-villages sometimes maize-growing does occur.

2.

Execution of survey.

2.1 Survey methods and materials.

The area was surveyed with the aid of topographical maps, sheet nr.130/3 Kitere and sheet 144/1 Kihancha on a 1:50,000 scale. Other maps used were the above mentioned Geological Map of the Migori area, 1:250,000 and a physiographic reconnaissance map by W.G.Wielemaker (1974). Furthermore aerial photographs have been used, with a scale of approximately 1:50,000, the interpretation of which has been carried out with a Topcon stereoscope.

2.2 Procedure.

First a physiographic airphoto-interpretation was made, with the aid of which soilboundaries were checked in the field and next drawn on the photographs. The most important elements on the photographs were relief, vegetation, while greytones proved to be very helpfull.

2.3 Auger observations.

By using an Edelman-auger, about 80 augerholes were made to a depth of 120cm, where possible. The following properties of the soil and the surroundings were observed at each augering-site:

- depth of solum
- character and thickness of soilhorizons
- soil texture

- soil colour, by comparison to the Munsell Soil Colour Charts
- stoniness of the profile
- surface stoniness and rockiness
- slopegradient and slopeform
- landuse and/or vegetation

2.4 Pitobservations

For each unit of the soil legend a representative soilprofile was described in order to obtain detailed information about the different units in the legend. For this purpose five pits were dug to a depth of 0.5 to 1.2 m. The description was made according to the guidelines of the Kenya Soil Survey Project, derived from the Soil Survey Manual (1952).

The following observations of the soil and the surroundings were made:

- the properties mentioned under augerobservations
- soil structure and consistency
- biopores and rootdevelopment
- mottles and concrtetions
- presence of cutans, slickensides or pressureskins and cracks
- presence of salts and/or primary minerals.

2.5 Map compilation.

A semi-detailed soilmap on scale 1:50,000 has been compiled from data obtained in the above described ways. The soilboudaries and other data drawn on the aerial photographs were transferred to the topographical base map using the Vertical Sketchmaster of Keufel and Essen. A suitability map for the growth of sugarcane has been derived from the soilmap.

3. The soils.

3.1 The legend and a brief description of the soils.

Well drained soils:

RW Reddish brown to brown clay, predominantly with 20 cm humic topsoil.

topography: almost flat to rolling, mainly on lateral slopes of ridges and footslopes.

RW1 - moderately deep, 50-100 cm

RW2 - deep, 100 cm

classification: Soil Taxonomy: Typic Hapludoll
Typic Eutropept

FAO : Haplic Phaeozem
Chromic Cambisol

Moderately well drained soils:

RM Reddish brown to brown, friable clay, predominantly with 10 cm humic topsoil, usually with a concretionary layer over ironstone or rotten rock.

topography: almost flat to undulating, mainly on lower parts of lateral slopes and on top of ridges.

RM: shallow, 50 cm

classification: Soil Taxonomy: Lithic Hapludoll

FAO : Haplic Phaeozem
(petroferric phase)

Imperfectly to poorly drained soils:

P Pr: Dark gray, firm, compact, reddish mottled clay, abruptly underlying 30-60cm of gray clay loam, often with many iron manganese concretions on transition.

classification: Soil Taxonomy: Abruptic Tropaqualf

FAO : Eutric Planosol

Py: Light gray, deep, firm, yellowish mottled clay, abruptly underlying 30-60cm of gray clayloam, occasionally with many iron-manganese concretions on transition.

topography: flat to undulating plains.

classification: Soil Taxonomy: Abruptic Tropoqualf

FAO : Eutric Planosol

Pv: Gray - brown to dark brown deep, firm to very firm, mottled clay, predominantly with 10 - 20 cm humic topsoil.
topography: flat to almost flat valley bottoms.
classification: Soil Taxonomy: Vertic Troaquept
FAO : Eutric Gleysol

3.2 Criterions for distinction.

The first criterion to make a division between the soils was the drainage class. Three classes were distinguished, i.e.

well drained,
moderately well drained,
imperfectly to poorly drained soils.

The well drained and moderately well drained soils were subdivided according to depth of solum i.e. the penetrability of the soil with the auger, namely:

class 0 : less than 50 cm, shallow
- 1 : from 50 to 100 cm, moderately deep
- 2 : deeper tahn 100 cm, deep

It was found, that depth class 0 invariably was related to the moderately well drained soils, so the number indicating this class was omitted.

The imperfectly to poorly drained soils were subdivided in three types: two were distinguished from the third for the textural class of the topsoil and differences in pedogenetic processes.

The division between the first two was based upon field characteristics connected with chemical richness and age.

3.3 Physical and chemical data.

For physical and chemical data one is referred to the appendix. The data are discussed and used in the chapter dealing with suitability of soils for sugarcane.

Infiltration rates.

The infiltrationrates of the P-soils were measured by using infiltrationrings.

The following results were found:

Pr: 3 mm/hr = 7,2 cm/day

Py: 2 " = 4,8 "

Pv: 4 " = 9,6 "

For all P-soils the infiltration is slow, so in the rainy season superficial run-off is a quite common phenomenon.

4. The suitability for sugarcane.

4.1 Defenitions.

Terms used in this chapter, are defined according to FAO Soil Bulletin nr.32, 'A framework for land evaluation', which gives the following defenitions:

S1: Highly suitable, land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.

S2: Moderately suitable, land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits, and increase required inputs to the extent that the overall advantage to be gained from the use, althgugh still attractive, will be appreciably inferior to that expected on S1 - land.

S3: Marginally suitable, land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits or increase required inputs, that this expenditure will be only marginally justified.

U1: Currently not suitable, land having limitations which may be surmountable in time but which cannot be correc ted with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude succesfull sustained use of the land in the given manner.

In order to establish the suitability class for each unit of the soillegend, landqualities have been rated. In this context, a landquality is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use. Landqualities may be expressed in a positive or negative way. The following relevant landqualities have been rated:

- moisture availability
- nutrient availability
- oxygen availability
- flooding hazard

- temperature regime
- possibility for mechanization
- resistance against erosion
- local trafficability

4.2. Rating of landqualities.

The above mentioned eight different landqualities have been rated with respect to the cultivation of sugarcane. A division in three classes (i.e. 0-1-2) has been made; 0 indicates always the least favourable condition, e.g. low moisture availability, high flooding hazard. 2 indicates the most favourable condition, so e.g. high moisture availability, low flooding hazard; a 1 indicates a moderately favourable condition, e.g. a moderate moisture availability, moderate flooding hazard. To each unit of the soil-legend two ratings are given, the first one for the present quality, without improvement, the second rating indicating the potential suitability after land-improvement, as specified below.

Following this procedure, the next diagram has been compiled:

landquality/soilunit:	Rm	Rw1	Rw2	Pr	Py	Pv
moisture availability	0/0	1/1	2/2	1/1	1/1	2/2
nutrient availability	2/2	2/2	2/2	1/1	1/1	2/2
oxygen availability	2/2	2/2	2/2	0/1	0/1	0/2
flooding hazard	2/2	2/2	2/2	0/2	0/2	0/1
temperature regime	1/1	1/1	1/1	1/1	1/1	1/1
possibility for mechanization	1/1	1/1	1/1	0/1	0/1	0/1
resistance against erosion	1/1	1/1	1/1	0/1	0/1	1/1
local trafficability	2/2	2/2	2/2	0/1	0/1	0/1
present suitability	S3	S2	S1	U1	U1	U1
improvement B (cf.below)				B	B	B
potential suitability				S3	S3	S2

4.3 The improvements.

The improvements mentioned 'B' are the high-costs improvements, consisting of the lay-out of a parallel drainage system with 70cm. deep ditches, about 10 m. apart. A second possibility is a 'C'-rated improvement; at very high costs deep-ploughing and/or ripping to a depth of at least 100 cm. can be done, besides the lay-out of the above mentioned drainage system. This 'C'-improvement will bring the Pr and Py soilunits from a present current unsuitability (U1) to a potential moderate suitability (S2).

4.4 Discussion of landqualities.

1) Nutrient availability.

The withdrawal of nutrients will increase upon the cultivation of sugarcane, so the necessary amount of fertilizer should be given. Per 25 ton yield per ha., the removal is about 30kg N, 20kg P and 60kg K.

2) Oxygen availability.

The availability of oxygen in a soil depends on drainage conditions. In the moderately well to well drained soils, the aëration is sufficient. In the imperfectly to poorly drained units however, the availability of oxygen is impeded, at least some part of the year. A drainage system making use of ditches seems preferable, with ditches 5 to 10 m. apart, depending on the permeability of the soil. However im April and May still reduction in growth might occur due to waterlogging, although sugarcane seems rather tolerant to temporary waterlogging.

3) Temterature regime.

Due to the relatively high altitudes of the area, the temperature regime is only moderately suitable for the growth of sugarcane. When taking this landquality fully into account no soilunit would exceed moderately suitable (S2).

4) Moisture availability.

The water storagecapacity in the Rm, Pr and Py soil units varies between 65 and 85 mm. This amount of water is insufficient for the January/February dry season, when an estimated moisture deficit of 120 and 90 mm respectively will occur in these soils. In August/September a slight shortage may occur (approx. 20mm). The rainfall-probability is more than 1250mm in 4 out of 5 years, so in one out of 5 years an even much higger yield reduction may occur.

The moisture availability for the Pr and Py soil units can be improved by deep-ploughing or ripping of the soil to at least 100 cm; by doing this, the lighter textured topsoil will be mixed with the underlying heavy clay, which will allow the roots to extend to this depth.

This is however a very costly method and one is advised to compare in experiments the results of various improvements like:

a) ditches only

b) ditches and ripping

c) ditches and deep-ploughing.

5) Flooding hazard.

If drainage is improved, it is likely that flooding hazard can be controlled completely.

6) Resistance against erosion.

Since the infiltration rates are low, much superficial run-off takes place. Due to a permanent grass-cover, no severe erosion occurs at the moment; howeverm after removal of this grass-cover, gully and sheet-erosion will occur. Ditches should therefore be made along contourlines (intercepting draines) and ploughing should be done along the contours.

7) Possibility for mechanization.

Mechanization will be adversily influenced by the density of the drainage ditches and the soil condition during the rainy season.

8) Local trafficability.

Depending on the grade of mechanization investments in roads in the area will behigh to very high since rather heavy foundations are necessary.

4.5 Final conclusions.

Regarding the potential suitability of the major part of the area, it is clear that only at high to very high costs this area can be made marginal to moderately suitable. When a fairly rational and mechanized production is aimed at, even higher capital and labour investments are required.

Therefore, and because the conduct of the soils upon the proposed improvements is not known, it is advisable to lay-out some pilot-plots in order to assess the physical and economical feasability.

5. Literature.

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APPENDIX I

Profile description Rw1/Rw2.

Location: between Olesheeri and Sikawa mountains.

Coordinates: 681.600 E, 9884.000 N.

Elevation: approx. 5100 ft. (1554 m.)

Parent material: basalt.

Topography: upper part of footslope, slopegradient 1%,
slopeform: convex and regular.

Vegetation: open shrubland with some trees.

Soil fauna: termites, ants and worms; moderately dense termite hills 15-30 cm. high, sparse termite hills 30-100 cm. high.

Landuse: extensive grazing.

Erosion: very slight gully erosion, due to presence of mountains.

Surface run-off: slow.

Drainage class: well drained.

Effective soildepth: more than 100 cm.

Horizons:

A1, From 0 to 20 cm, dark reddish brown (5 YR 3/2) when dry; clay; medium moderate subangular blocky structure, falling a part to very fine strong crumbly; many micro and very fine pores, common fine pores; consistence soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; very frequent very fine, common roots; clear and wavy on.

AB, From 20 to 35 cm, reddish brown (5 YR 4/3) when dry; clay; coarse moderate subangular blocky structure, falling apart to fine moderate subangular blocky; many micro and very fine pores, common fine pores; consistence is soft when dry, friable when moist, sticky and plastic when wet; frequent very fine and few fine roots; gradual and smooth on.

B2 From 35 to 100cm, reddish brown (5 YR 4/4) when dry; clay; coarse strong subangular blocky structure, falling apart to fine moderate subangular blocky; many micro and very fine pores, common fine pores; consistence is soft when dry, friable when moist sticky and plastic when wet; frequent very fine few fine and very few coarse roots; abrupt and wavy on.

Appendix I I.

Profile description Rw1/Rw2.

B3, Deeper than 100 cm, reddish brown (5 YR 4/4) when dry; clay; common fine faint mottles, over 70% rounded gravels.

Classification: Soil Taxonomy: Typic Eutropept
Typic Hapludoll
FAO : Chromic Cambisol
Haplic Phaeozem

Profile description Rm.

Location: 200m. east of Oyani-Kihancha road, approx. 4km south of Oyani.

Coordinates: 678.850 E, 9882.750 N.

Elevation: approx. 4960 ft. (1512 m.)

Parent material: probably basalt (as Rm).

Topography: almost flat, slope gradient 2%, slope from linear to slightly convex and regular.

Vegetation: open shrublamd with isolated trees.

Soil fauna: termites, moderately dense hills 15-30 cm. high, sparse hills above 100 cm in height.

Land use: extensive grazing.

Erosion: no signs found

Surface run-off: medium

Drainage class: moderately well drained.

Effective soil depth: 30 cm.

Horizons:

A1, From 0 to 15 cm dark brown (7.5 YR 4/2) when dry, brown(7,5YR3/2) when moist; clayloam to clay; moderate to strong very fine sub-angular blocky structure; common fine and common very fine pores; consistence is soft when dry, friable when moist, non-sticky and slightly plastic when wet; abundant fine roots; clear and wavy on.

B2 From 22-30cm, brown when dry and moist (resp.7.5 YR 5/4 and 4/4) clay; with many very fine faint reddish brown mottles; weak fine angular blocky structure; few very fine pores; consistence is slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; common fine roots, very few coarse roots; abrupt and wavy on.

Appendix III.

Profile description Rm.

B31, From 30-38 cm, brown (7.5 YR 4/4) when dry, clay, over 50% medium rounded gravels and medium to coarse blocky gravels, very few very fine roots, clear and wavy on.

Cm, From 38-47 cm; same gravels as in B31, but cemented by iron and manganese, with very few very fine roots, abrupt and wavy on.

Cx, Ironstone from 47 cm.

Classification: Lithic Hapludoll (petroferric phase)
Haplic Phaeozem.

Profile description Py.

Location: 200 m. South of Oynai river, approx. 5 km stream upwards of Oyani.

Coordinates: 681.300 E, 9887.550 N.

Elevation: Approx. 4940 ft (1505 m)

Parent material:

Topography: lower river terrace of Osani (Reiyan)river, pit halfway a long linear and regular slope; slope gradient 1%.

Vegetation: Open shrubland (shrub over 30%).

Soil fauna: extensive grazing.

Erosion: slight gully erosion, small gullies towards river.

Surface run-off: medium to rapid.

Drainage class: poorly drained.

Effective soil depth: 50 cm.

Horizons:

A1, From 0 to 23cm, dark gray (10 YR 4/1) when moist; common distinct brownish mottles, fine, moderate angular blocky structure, common very fine pores, many fine roots; consistence hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt and wavy on.

Appendix IV.

Profile description Py.

B21, From 23 to 50 cm, very dark gray (5 YR 3/1) when moist, clay to clayloam; silty clayloam; strong medium prismatic structure, falling apart to moderate, fine subangular blocky; common very fine, common fine roots; consistence is firm when moist, sticky and plastic when wet, many white spots, manganese cutans on pedfaces; clear and smooth on.

B22, From 50 tp 120 cm, light gray to light brown gray (10 YR 6/1 to 2.5 YR 6/2), clay, with common fine distinct brown mottles; moderate, fine, angular blocky structure, few very fine pores, few fine and few very fine roots, consistence firm when moist, sticky and plastic when wet, clear and smooth on.

B23, 120 cm same colour as B22, moderate medium angular blocky structure, falling apart to moderate fine angular blocky; few very fine pores, very few very fine roots, iron and manganese concretions, 1-5 mm, up to 10%; slickenside like features.

Profile description Pv.

Location: 30m E of constributary of Osani river, 1500m E Oyani-Kihancha road, approx. 3 km South of Oyani.
Coordinates: 679.100 E, 9884.050 N.
Elevation: approx. 4870 ft (1484 m)
Parent material:
Topography: youngest river sediments, on short distance gently undulating (with irregular slope form); pit on upper part of 10m long 2-3% slope.
Vegetation: forest; the profile pit is situated in a part that has been burnt and is now covered by bushland thicket.
Soilfauna: termites and ants; moderately dense mounts 30-60cm high.
Landuse: none
Erosion: no signs found.
Surface run-off: medium; flooding lower parts might be flooded during rainy season.
Drainage dass: poorly drained.
Effective soil depth: 60 cm.

Appendix V.

Profile description Pv.

Horizons:

A11, From 0 to 5cm, very dark brown (10 YR 2/2) when dry; black (10 YR 2/1) when moist, clay; moderate, fine, crumbly structure; many micro and many very fine pores; abundant very fine, many fine roots; consistence is soft when dry, very friable when moist, slightly sticky and slightly plastic when wet, clear and smooth on.

A12, From 5 to 20cm, very dark grayish brown (10 YR 3/2) when moist clay, common fine faint mottles, moderate fine, angular blocky structure; common micro and common very fine pores; common very fine, few medium roots; consistence is hard when dry, firm when moist, sticky and plastic when wet, clear and wavy on.

B1, From 20 to 36cm, dark gray (10 YR 4/1) when moist, clay; common fine faint mottles; weak, medium, presmatic structure, falling apart to weak, fine angular blocky; few fine, common very fine pores;few fine, common very fine roots; consistence is hard when dry, very sticky and very plastic when wet; gradual and smooth on.

B21, From 36 tp 63cm, dark brown (10 YR 4/3) when moist; clay; common fine faint mottles, moderate fine subangular blocky structure; few micro and few very fine pores; very few fine, few fine roots; consistence is very hard when dry, very sticky and very plastic when wet; clear and smooth on.

B22, From 63 to 76 cm, grayish brown (2.5 YR 5/2) when moist;structure is almost massive, no pores, no roots, consistence is hard when dry, very firm when moist, very sticky and very plastic when wet; gradual and wavy on.

B23, 76 cm, same as B22, except for common weak manganese cutans and slickenside faces.

Classification. Vertic Tropaquept
Eutric Gleysol.

Appendix VI.

Profile description Pr.

Location: 800 m E. of Oyani-Kihancha road; approx. 2,5km S. of Oyani.

Coordinates: 678.250 E, 9884.500 N.

Elevation: approx. 4875 ft. (1485 m)

Parent material:

Topography: slope towards valley-bottom, slope gradient 2%, pit on lower part of slope, which is convex and regular.

Vegetation: open shrubland, only few shrubs (10%).

Soil fauna: few termites and some worms.

Land use: extensive grazing.

Erosion: small gullies towards water convex.

Surface run-off: rapid; probably little erosion due to permanent grass vegetation.

Drainage class:

Effective soil depth: (less than 50 cm)

Horizons:

A1, From 0 to 15cm, datk gray (7.5 YR 4/1) when dry, very dark gray (7.5 YR 3/1) when moist; silty clay-loam to clayloam; fine, moderate, subangular blocky structure; few fine pores; consistence slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet, few fine roots, clear and wavy on.

A2, From 15 to 30cm, dark gray (7.5 YR 4/1) when moist, clay loam, many fine faint brown (7.5 YR 4/4) mottles, medium moderate, subangular blocky structure, few fine pores; consistence hard when dry, friable when moist, sticky and slightly plastic when wet; few fine roots, abrupt and smooth on.

B21 From 30 to 50 cm, dark gray (7.5 YR 4/1) when moist; clay, common fine prominent red (2.5 YR 5/6) mottles; medium weak, prismatic structure; no pores; very hard when dry, firm when moist, very sticky and very plastic when wet; very few very fine roots, clear and smooth on.

Appendix VII.

Profile description Pr.

B22, Deeper than 50cm, dark gray (7.5 YR 4/1) when moist; clay, few fine prominent red (2.5 YR 5/6) mottles; almost massive structure, few gravels, consistence is very hard when dry, very firm when moist, very sticky and very plastic when wet, some slickenside like features at 100cm.

Classification: Soil Taxonomy : Abruptic Tropaqualf

FAO : Eutric Palnosol.

Appendix VIII.

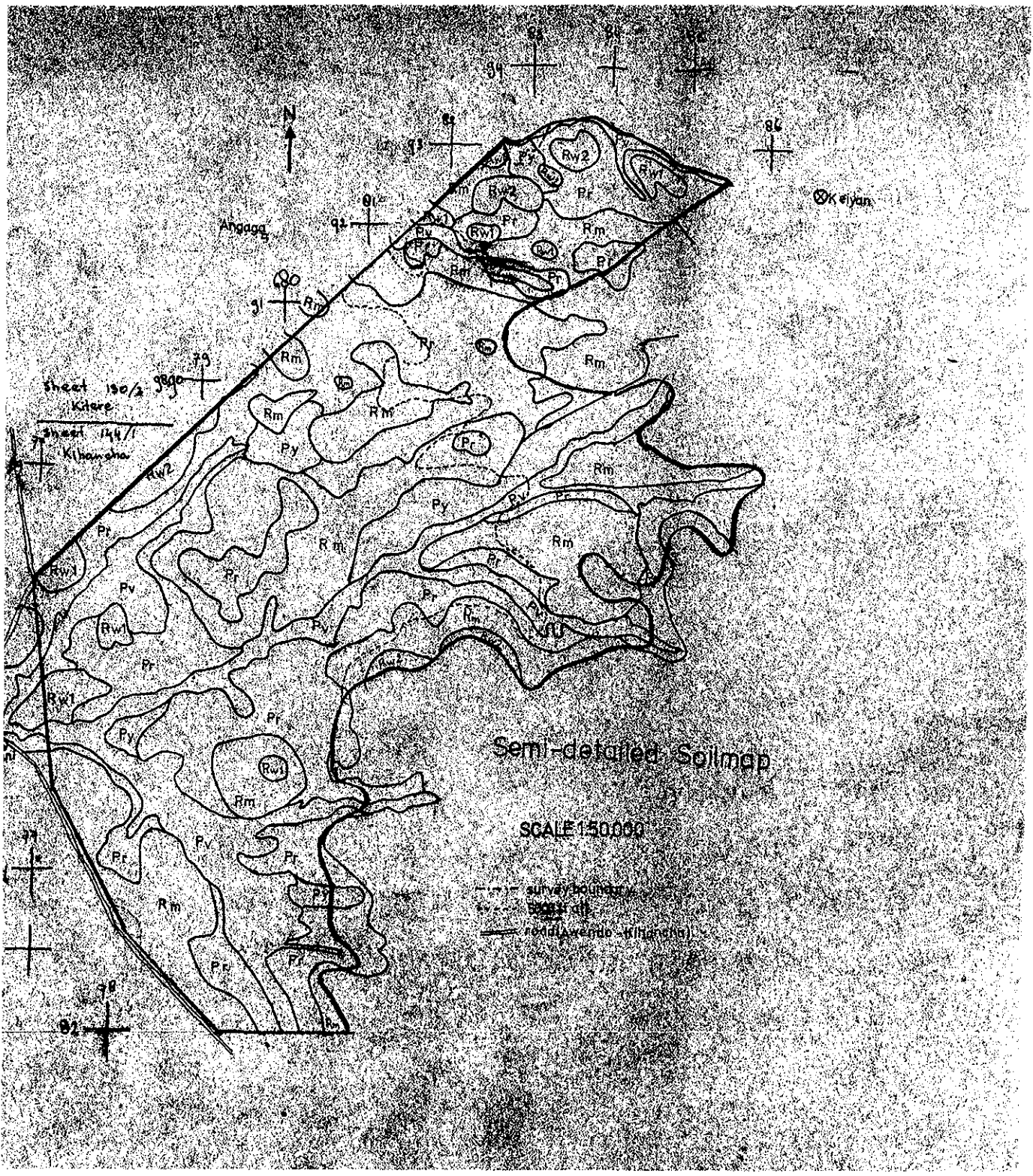
Chemical data.

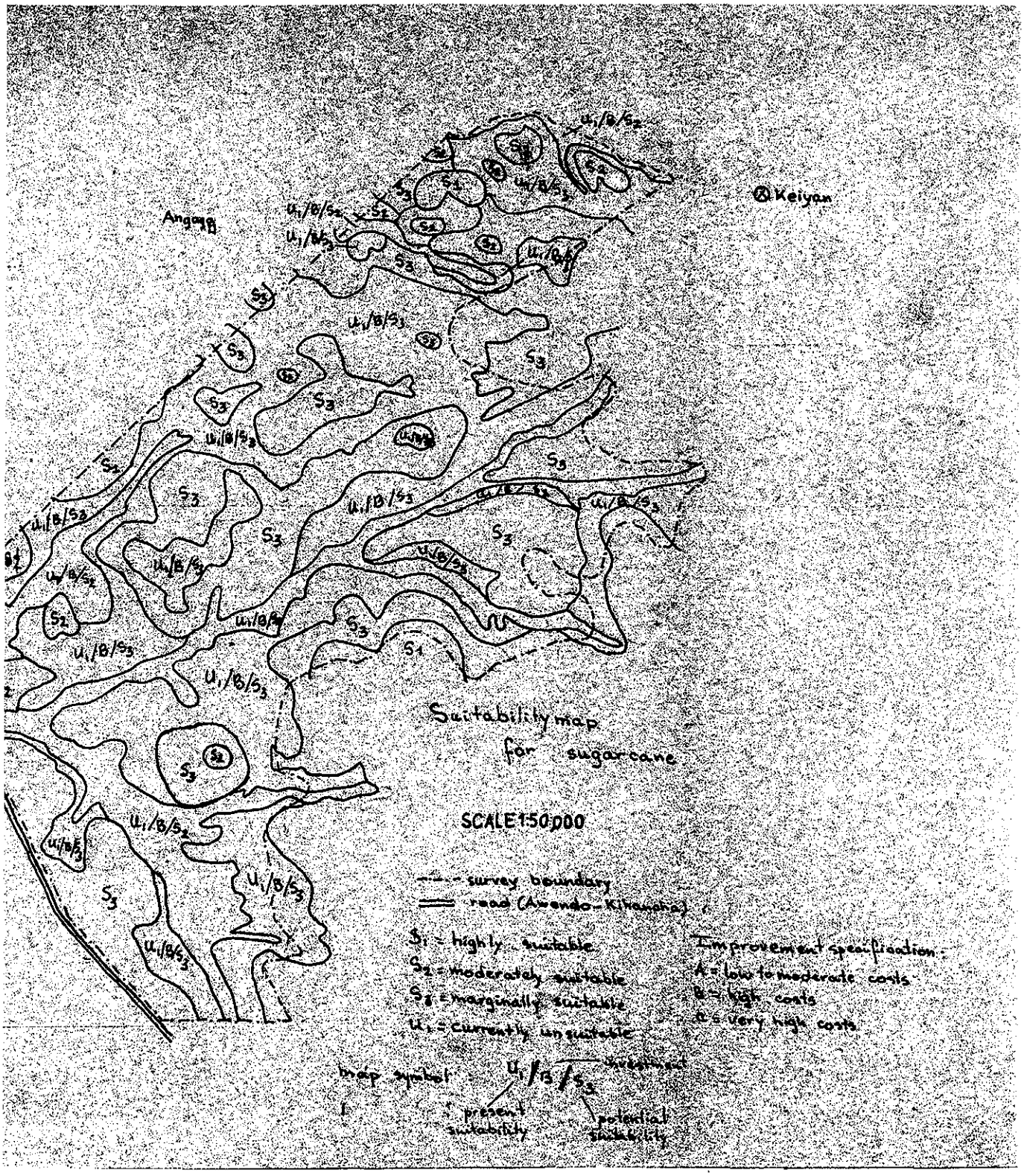
Profile & depth(cm)	pH-H2O	pH-KCl	sand	silt	clay	text.	weight % org.matter
Rm							
0 - 12	5,1	4.05	33.2	27.5	39.2	cl.loam	2.5
12 - 20	5.25	4.2	31.9	25.5	42.5	clay	2.4
20 - 30	5.05	4.4	29.6	27.7	42.7	clay	2.3
Pr							
0 - 10	4.6	4.0	17.2	44.1	38.7	silty cl. loam	2.4
10 - 30	4.65	3.8	28.0	32.5	39.5	cl.loam	2.2
30 - 50	5.35	3.95	11.6	17.2	71.4	clay	1.5
50 +	5.4	4.0	10.5	20.8	68.8	clay	0.5
Py							
0 - 23	4.8	3.9	23.1	44.5	32.4	cl.loam	1.7
23 - 50	5.6	4.1	20.1	48.0	31.8	cl.loam	1.3
50 - 120	5.55	3.9	12.4	3.2	84.5	clay	0.6
120 +	6.9	5.35	11.1	11.2	77.7	clay	0.2
Pv							
5 - 20	6.9	5.7	19.1	34.5	46.4	clay	2.2
20 - 36	5.9	4.6	18.8	24.2	57.0	clay	1.3
36 - 63	4.9	3.8	9.9	18.0	72.0	clay	1.5
63 +	6.4	5.2	8.2	17.3	74.6	clay	0.9

Appendix IX

Moisture % by volume

		bulk-density g/cm^3	Saturation	0.4	2	3.7	readily available Moisture vol %	mm
Rm	0 - 12	1.26	51.2?	51.6	46.5	22.3	24.2	29.0
	12 - 22	1.24	51.0	50.1	41.9	20.1	21.8	21.8
	22 - 30	1.50	53.0	49.9	37.2	17.7	19.5	15.6
							Total	66.4
Pr	0 - 10	0.96	59.7	59.7	52.3	20.2	32.1	32.1
	10 - 30	1.13	52.7	52.9	44.9	20.1	24.8	49.6
	30 - 50	1.19	47.1	46.6	46.0	33.3	12.7	
	50$^+$	1.15	55.0	54.5	53.9	42.1	11.8	
							Total	81.7
Py	0 - 23	1.26	49.2	48.2	41.5	24.1	17.4	40.0
	23 - 50	1.28	48.6	46.9	38.8	23.6	15.2	41.0
	50 -120	1.40	51.2	48.0	47.0	37.7	9.3	
							Total	81.1
Pv	5 - 20	1.17	55.7	52.9	47.7	31.3	16.4	24.6
	20 - 36	1.08	59.3	54.7	53.4	47.3	6.1	9.8
	36 - 70	1.42	55.4	51.3	50.2	44.8	5.4	21.6
							Total	56.0


N
Ahgaga
Kelyan
Sheet 130/2
Kitere
Sheet 144/1
Kilhamsha
Rw2
Rw1
Rm
Py
Pr
Pv
Semi-detailed Soilmap
SCALE 1:50000
survey boundary
road (Avendo - Kilhamsha)


Angata
Keiyan
Suitability map for sugarcane
SCALE 1:50,000
survey boundary
road (Awendo-Kitwamba)
S1 = highly suitable
S2 = moderately suitable
S3 = marginally suitable
U1 = Currently unsuitable
Improvement specification:
A = low to moderate costs
B = high costs
C = very high costs
map symbol
present suitability
potential suitability
investment