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A RECONNAISSANCE INVESTIGATION OF THE AGRICULTURAL POTENTIAL OF THE LAMBWE VALLEY.

M. J. MAKIN AND N. N. NYANDAT.

SOIL SURVEY UNIT

1965.

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INDEX

1. INTRODUCTION.

This investigation was instigated at the request of the Senior Soil Chemist and carried out between May and August, 1965. The first objective of indicating the distribution of soil types was **overtaken** by events in the form of an urgent need to determine the potential of the valley so as to assess several conflicting proposals.

The Report aims to highlight background information necessary for a rational consideration of several approaches to land utilisation in the valley and indicates subjects for experimentation or economic analysis.

The investigation was necessarily limited by time and no formal mapping was attempted; the extent of the soils outlined in Appendix 2 is not known with any degree of accuracy. The soils have been grouped into 8 Land Utilisation Classes (in Appendix 1) and a land class sketch map has been produced at a scale of 1:50,000.

Acknowledgements are due to Messrs. BELLIS, GACOKA, GILLETT, GLOVER, HASTIE, HILL, HINGA, LE ROUX, OGADA, OLANG, PEREIRA, ROBERTSON AND THEISEN who assisted on the project in many ways; and to the pit diggers who worked well at a task that must have seemed outrageously unrewarding.

2. LAMBWE VALLEY.

(a) STRUCTURE.

Lambwe Valley covers about 125 square miles. During this investigation, the Valley was assumed to correspond with the geographical unit sensu stricto, comprising the Olambwe River, its tributaries and their respective catchment areas, lying North of Magunga and stretching to the shores of Lake Victoria. Thus the Valley of this Report is quite unrelated to the local authority boundaries and only contains a part of the existing Settlement Scheme. The settlement areas of North Ruri and the Samunyu Valley descending to Homa Bay have not been examined.

The valley is to the West dominated by the Gwasi and Gembe Hills rising to between 5,000 feet and 7,000 feet whilst the Ruri Hills rise to around 5,500 feet in the East. A series of low hills largely serve to seal off the major valley from the South while the Kaniamwea escarpment(to 5,500 feet) provides a wall along the East side of the valley and to the South of the Ruri Hills. The Olambwe meanders (actually conveying water only during the rainy seasons) within a gently sloping U-shaped valley, the floor of which varies from 4,200 feet to 3,900 feet and descends in a broadly North Easterly direction until met from the East by the valley of the Ogongo which forms the natural divide between the Ruri Hills and the Kaniamwea scarp.

Nearer the Lake the valley is dominated by a number of conical hills ("GOT"), each one rising a few hundred feet above a phonolitic plateau covering much of the area between the Ruri Hills and Gembe. The obstruction caused by the rise of the Ruri Hills deflects the Olambwe into a constricted Northerly course through the phonolite; it only emerges onto a confined alluvial flat a short distance before the stream passes through swamp and enters the Lake at about 3,720 feet.

(b) GEOLOGY.

Much of the valley bottom is covered by a considerable depth of Pleistocene lacustrine deposit. A borehole in the Ruma Bush (No. C 1269) disclosed the following section:-

	FEET.
Black Soil	from 0 to 20
Buff Clay	from 20 to 70
Diatomaceous Lake Beds	from 70 to 343

Similar sections have been revealed by shallow bore holes on the Eastern side of the valley. This lake extension matches that East of Kisumu on the Kano Plains where over 500 feet of lake beds accumulated (McCall, 1958).

Towards the valley sides the lacustrine deposit may well be incorporated with outwash materials from the hills above and would presumably have been laid down on lake shores and in swamps. These lacustrine materials thin out towards the North presumably as a result of continuing erosion following uplift.

The lacustrine deposits are replaced by shallow phonolite plateaux accompanied by derived rubble and breccia. Here the soil cover may be relatively deep on level sites, but is shallower or non-existent on slopes, giving rise to large tracts of boulders. The phonolites are apparently associated with the Ruri complex; they are rich in Sodium, Potassium, Calcium and Magnesium. In many instances derived alluvial gravels and rubbly colluvium have suffered secondary calcification. Very occasional phonolite gravel or rubble deposits occur near the base of the valley itself.

The main masses of the Kaniamwea scarp and the Gwasi foot-slopes are composed of layers of laval melanephelinites; these contain high concentrations of Sodium, Calcium and Magnesium. The actual core of the Ruri Hills is formed from Carbonatite rings containing some 70% of calcite. Associated with these outcrops are deposits of apatite.(a natural source of phosphate) ironstone and quartz viens and radioactive thorium, besides minor quantities of columbium, niobium, tantalum etc.

Because the valley is surrounded by alkali rock formations, the ground waters are rich in Sodium and many of the lower lying subsoils are consequently alkaline.

(c). RAINFALL.

The tables accompanying this section provide an outline of the rainfall distribution in and around the valley. It will be noted that the rain generally falls in two seasons, March/May and September/November; near the lake, however, only one "rain" occurs (March/May). Total precipitation varies from 57.3 inches at the District Officer's Office on the col between the Ogongo and Samunyu valleys to around 35 inches at the Southern end of Lambwe valley. On the lake shore the rain cannot be expected to exceed 35 inches and may be little more than 30 inches. Considerable fluctuations are recorded from year to year and prolonged dry spells should be regarded as the rule rather than the exception.

A rainguage was recorded in the Ruma Bush in the heart of the Lambwe Valley during 1959. Fortunatly this year proved to be an "average" one so far as rainfall was concerned, and the rainfall recorded at the Lambwe R.G.A.'s office was 55.6 inches, only 1.7" below the 10 year mean. A Comparison is shown below, of this station and that in the Ruma Bush. This serves to demonstrate the decline in rainfall towards the middle of the valley.

	FEET	NO. OF DAYS RAIN	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.
RUMA PUMP HOUSE	4000	121	1.5	2.0	8.1	7.8	3.0	0.9
D.O.OFFICE	4000	117	1.5	2.1	8.9	7.7	4.6	3.1

	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL YEAR.
RUMA PUMP HOUSE	1.1	2.2	6.7	2.6	1.7	1.0	38.7
D.O.OFFICE	2.2	1.5	8.5	8.5	4.9	1.9	55.6

Over 14 years, the annual rainfall total at the R.G.A's office, Lambwe, has varied from 85.3 inches to 43.9 inches. Rainfall can be expected to drop below 40 inches about one year in twenty. This indicates that the corresponding rainfall in the valley middle will be only 25 inches for one year in twenty, whilst nearer the lake-shore the rain total might be nearer 20 inches. However, figures for the Lambwe E.A.T.T.R.O. station do show that rainfall is considerably higher than this around the flanks of the Gwasi Hills (Mean Annual Fall = 51.1 inches).

	1961		1962		1963		1964	
	1	2	1	2	1	2	1	2
January	0.8	0.4	2.4	2.6	3.9	4.3	2.5	1.2
February	3.0	4.0	1.4	2.1	2.7	2.9	4.7	3.9
March	5.8	5.7	3.4	4.4	3.5	3.3	4.4	1.6
April	8.3	5.5	9.6	7.8	9.0	9.9	10.5	5.9
May	4.8	8.9	7.5	5.8	9.9	8.9	7.4	4.9
June	4.6	0.5	2.0	2.7	2.6	1.6	2.7	0.9
July	3.1	3.6	1.5	1.9	1.4	0.6	4.3	1.5
August	3.2	4.5	5.6	1.9	1.3	0.8	6.3	6.0
September	6.5	6.8	7.0	2.4	0.4	2.0	5.5	7.8
October	7.7	6.0	6.5	6.3	4.6	4.0	5.9	3.1
November	15.8	14.0	7.3	4.0	7.7	5.5	2.0	1.0
December	4.9	4.9	3.6	2.1	9.0	5.2	8.5	6.2
Total	68.5	65.0	57.9	44.0	56.1	49.0	64.7	43.9

Station 1. Lambwe Forest Research Station.

2. Lambwe : D.O.'s Office.

"RAINFALL MEANS"

STATION	NO. OF YEARS RECORDED	ALTITUDE FEET	NO OF DAYS RAIN RECORDED	JAN.	FEB.	MARCH.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL YEAR
LAMBWE FOREST RESEARCH.	5	4400	156	1.9	3.4	5.8	8.9	5.7	3.0	1.9	3.1	5.7	5.5	7.1	4.7	56.5
LAMBWE D.O. OFFICE	10	4000	90	2.6	1.8	5.8	9.8	9.2	3.3	3.0	3.1	4.4	5.4	6.3	2.6	57.3
SOKOYAMO E.A.T.T.R.O.	7	4000	81	1.7	1.6	3.5	7.4	6.9	3.4	2.3	2.8	3.2	3.5	3.8	3.0	43.0
SEKKA	3	4000	-	0.6	0.8	3.0	6.3	6.0	1.5	2.3	2.8	2.9	2.4	2.8	3.9	35.2
E.A.T.T.R.O. LAMBWE VALLEY 0.40'S; 34 17'E	11	4000	123	1.7	2.2	4.5	8.3	6.8	2.9	2.4	3.2	5.0	5.1	5.8	3.1	51.1
WEST NYOKAL CHIEF'S CAMP	6	4300	-	0.8	3.3	4.6	7.4	6.9	2.6	1.4	2.9	5.4	8.1	11.4	4.1	58.8
HOMA BAY	3	3800	66	2.9	1.8	5.1	9.1	6.1	5.2	1.7	2.5	3.6	3.3	2.7	6.7	50.7
MBITA POINT DISPENSARY	13	4300	57	1.6	1.9	4.0	6.2	4.5	2.0	1.8	2.0	2.0	2.6	2.7	3.1	34.4

d) TSETSE SITUATION.

Depending on the season, high concentrations of tsetse may be encountered in the thicket areas of not only the valley bottom (e.g. Ruma Bush), but also in the bush of the valleys descending the Eastern slopes of the Gwasi Hills, the Sindo Pass, the Roo Valley and the savannah up to 6000 feet on the Gembe and Gwasi hill complexes. As many as 1½ million flies to the square mile have been estimated, and the highest numbers occur after the long rains (May to July). Dispersal into the hill thickets is most marked in dry seasons and these thickets may be regarded as fly reservoirs, though it is the valley bush that provides permanent breeding sites, the fly preferring open glades in the bush rather than the densest cover.

A tsetse habitat (bush exceeding 4 feet in height) can regenerate in as little as 3 years and tsetse is currently spreading back into the previously cleared and settled Samunyu Valley. This is because the settlers have not succeeded in cultivating more than a small proportion of their allotted 25 acres and is occurring despite the presence of a 2 mile fly barrier, the ostensible purpose of which was to protect 29,000 acres from Ruma Bush tsetse.

The tsetse are carriers of trypanosomiasis (T.congolense) and there is a 20% infection rate amongst cattle in the Samunyu Valley. There are also 3 foci of human sleeping sickness all on the West side of the valley in the Wiga valley, the Roo valley and in Kasigunga. Game animals may well be implicated as reservoir sources of these diseases.

Complete bush clearance for the elimination of tsetse will be expensive and largely unrewarding since the bush will rapidly re-generate unless settlement and development keep pace with clearance, and that is an unlikely proposition. The tsetse question is now the subject of experimentation by the Veterinary Department. Their line of approach involves the preliminary use of defoliants followed up by insecticide, sprayed by aeroplane. This should prove afair method of control near-elimination may follow the natural erosion of the thickets for fuel and hut poles. For the sleeping sickness foci however, more drastic treatment will be required. The tsetse must be eliminated by clearing all the bush in the valley affected and measures taken to prevent incursions of fly from neighbouring hill thickets. Fortunately the valleys concerned generally coincide with reasonable soils so that intensive arable can follow bush clearance. Clearance on the hill sides themselves will however be an agriculturally valueless proposition because of the underlying boulders and the skeletal nature of the soils.

e) LAND USE.

Agricultural standards in the valley are generally low and there is hardly a single farm which is producing at anywhere near the optimum level. A high proportion of each of the settled farms is made up of virgin bush and grassland, whilst on some even the previously cultivated areas are returning to bush. The most im-portant food crop is millet whilst the cash income to the valley mostly derives from cotton. Sugar is only found in dry stream beds where underground sources of water maintain the crop through the dry season. A few bananas may be seen on the side of South Ruri, but they are not impressive. Groundnuts are found on the hillslopes often intercropped with millet. Some of the more progressive farmers are growing maize. Cotton is variable, stunted and very low yielding. The yields are limited by low standards of cultivation, insect attack, a cheerful disregard for drainage and fertilizers and also by late planting. On the poorer drained soils and at Luanda in the vicinity of the swamp edges, sweet potato is the main crop. This is often planted on small mounds of soil or ridges. Sisal is rarely grown in the mass but is often used for boundary demarcation and is perhaps the best looking crop from the agronomic viewpoint. An acre of the Wiga valley irrigated by primitive methods is used for mixed cropping of cabbage and tomato beneath fine stands of banana and sugar, thereby demonstrating the limiting nature of the dry season in Lambwe Valley for crops with a high water requirement.

Crop trials were started on 5ecologically distinct sites in 1954, but the records have been mislaid. In 1955, 3 acres of Ruma thicket were cleared and planted to Eucalyptus, Cassia, maize and Cynodon grass on heavy grey clay. In 1956, the sugar and Cynodon were reported as giving "excellent results, forming dense cover which went far towards suppressing the natural regrowth". The grain crops were not successful owing to the depredation of animals.

f) SETTLEMENT.

Tsetse was eradicated from the Ruri and Nyamaji hill complexes in 1952 - 1956, so that by June 1956, 667 families had been settled mostly on 50 acres. It was only after a subsequent survey that the allocated plot size was reduced to 25 acres. Most of the plots then settled were subdivided. There was little or no agricultural planning on this scheme and plot demarcation was haphazard. There was also a general failure of people to enter the scheme due to an absence of local population pressure. This resulted in the continuing problem of bush regeneration especially since many of the settlers are absentee land holders.

At the time of writing about 1100 farmers are registered as having settled in the valley - mostly in a circular belt on the slopes around the base of the Ruri Hills, whilst a few are now spreading South Westwards along the base of the escarpment. Some have settled in the foot slope valley of the Owiga and around Magunga in the extreme South West.

29,000 acres are enclosed by the Ruma fly barrier. Of these, about 11,000 acres are officially settled.

Enzootic cattle diseases include trypanosomiasis, East Coast Fever, Heartwater and Redwater. Malaria is rife throughout the valley, whilst sleeping sickness is largely confined to 3 foci - Wiga Valley, Roo Valley and Kasigunga.

g) WATER SUPPLY.

The following boreholes have been drilled in the area:-

P.W.D. CONTRACT NO.	LOCALITY.	DEPTH (FEET)	YIELD GALLONS/DAY.
C 1191	OBUARI, ANGUGA VALLEY	415	50,688
C 1239	LUANDA, N.E. OF KARUNGU	570	48,000
C 1268	CHABI-CHABI, GWASI	560	55,200
C 1269	LAMBWE VALLEY: RUMA PUMP HOUSE	343	52,800

Account must of course be taken of the need to operate at only 60 % of capacity, so as to reduce pump maintenance costs. Nevertheless drilling in these soft sediments may be said to have been very successful. Numerous shallow bore holes to depths of 100 to 150 feet have been sunk by the African Land Development Board in the Lambwe Valley and on the slopes of Ruri.

There is a considerable depth of Pleistocene sediments of lacustrine origin beneath the Lambwe valley and conditions are said to be ideal for the natural storage of ground water (McCall; 1958). The only limiting factor is the depth of the hydrostatic level, and the few failures experienced by the Board must be attributed to too shallow drilling - deeper drilling with a power-operated drill should be successful anywhere in the valley. Despite an above normal fluoride content, this water is fit for human consumption.

Water coming off the Ruri Hills is however contaminated by radio active thorium and is consequently unsafe to drink. The local people living around North Ruri may walk several miles to the lake for their water.

The small perennial streams - OGONGO, GOYO, SIWALO, KAMKWAGI and OWIGA could be provided with minor dams to provide surface water storage.

h) FORESTRY RESEARCH.

260 acres of existing experiments occur on the Kaniamwea scarp. The shallow rooting *Pinus* spp. are best for the scarp soils, especially *P.radiata*, *P.halepensis*, *P.elliottii* and *P.patula*. *P.patula* can be established even in a poor planting season. Other successful trees include *Auracaria cunninghamii*, *Callitris calcarata*, *C.hugelii*, *Cupressus arizonica*, *C.lusitanica*, *Eucalyptus saligna*, *E.robusta*, and *Gmelina arborea*. Establishment of the seedlings proved difficult and planting is now performed in polythene bags. Experiments are proceeding on the elimination of grass competition by means of dalapon.

Other problems include:-

1) Termite attack.
2) Shallowness of scarp soils and their low moisture holding capacity.
3) Dangerous grass fires.
4) Hail Risk.
5) Unreliable rainfall.

3. THE VALLEY VEGETATION.

a) VEGETATION ASSOCIATIONS:-

No formal attempt has been made here to classify the valley vegetation. Observations are confined to aspects of ecological significance.

1. The shallow, rocky and well drained soils of Gwasi side, Ruri Hills, the phonolitic cones and the Kaniamwia escarpment may be described as supporting a Combretum - type savannah. The major grass species include Hyparrhenia filipendula and Themeda triandra. It was observed that these grasses grew tall over deeper pockets of soil and on areas receiving drainage, but were stunted on shallow stony soils. Indeed it was a general observation throughout the area that the quality of the site could be judged by the height of the grass e.g. Stunted stands of Themeda triandra accompanied by Eragrostis racemosa were an indication of a stony soil. Grass height was also depressed on the strongly alkaline soils and on areas subject to flooding. On rocky soils at the driest end of the valley - the Wiga and Magunga areas - the most prominent plant is Ipomoea kituiensis kituiensis.

The common species of Aloe in the valley, first believed to give an indication of shallow soils on plateau sites in the North, is also found on the very heavy alkaline clays near the Olambwe.

Grasses found commonly on deeper pockets of soil or in areas receiving drainage on the escarpment include Brachiaria brizantha and B.soluta, Eragrostis cilianensis, Heteropogon contortus, Panicum maximum, Rhynchelytrum repens and Sorghum verticilliflorum.

Bush species of the Combretum savannah include Acacia hockii, A.macrothyrsa, A.sieberiana sieberiana, Annona senegalensis, Combretum binderianum, C.molle, Ficus capensis, F.gnaphalocarpa, F.kitubalu, Heeria reticulata, Kigelia aethiopum, Piliostigma thoningii, Rhus vulgaris, Stereospermum kunthianum, Trichilia emetica and Vitex doniana. Along watercourses flowing off the escarpment are lines of Acacia polyacantha campylacanthum. One Tamarindus indica was observed on reddish soils below Gwasi.

2. A particular bush association is encountered on the lowest slopes of the Gwasi spurs in the vicinity of Wiga and Magunga, components of which include Cordia ovalis, Grewia trichocarpa, Harrisonia abyssinica, Maerua triphylla calophylla, Ormocarpum trichocarpa, Rhus vulgaris and Securinega virosa. The association is accompanied by Hyparrhenia filipendula.

3. On the deep black medium clays which form an apron below the escarpment, the Ruri Hills and Gwasi side is a grass association of Setaria sphacelata and Themeda triandra accompanied by an open savannah of Balanites aegyptiaca and occasional Acacia drepanolobium. Where ground waters seasonally approach the soil surface and subsoils are alkaline, this association becomes one of patchy Acacia drepanolobium thicket with Setaria sphacelata. Valley bottoms are invaded by clumps of Rhus natalensis.

10. Seasonally flooded areas outside the dense thickets of the valley bottom are marked by stands of open Acacia seyal fistula woodland. This is often encountered as a belt of open woodland surrounding lower lying dense thicket, and particularly occurs on the escarpment side of the Olambwe Valley and lower lying sites in the Ogongo valley. Understory shrubs include Cadaba adenotricha, Capparis tomentosa, Grewia similis, Harrisonia abyssinica and Rhus natalensis. Herbaceous cover is provided by Aspilia sp. Commelina sp., Cyperus rotundus, Pennisetum mezianum, stunted Setaria sphacelata and Sporobolus pyramidalis. On the base of the alluvial fans below the Wiga and Magunga valleys Acacia polyacantha is a component of this woodland; grasses are much taller and dominated by Rottboellia exaltata. Medium Acacia seyal fistula woodland also occurs on the lowest Olambwe alluvium where a species of Aloe is common.

11. Surface soils are affected by alkali in three situations.

a) Soils in valley bottoms subject to seasonal floods. These are covered by Aspilia sp. and Pennisetum mezianum with occasional tufts of the Setaria. A few scattered and stunted specimens of Acacia drepanolobium and A.seyal fistula also occur.

b) Soils on convex slopes affected by horizontal alkali seepage in wet seasons, carry an extremely short and stunted cover of Pennisetum mezianum and Sporobolus marginatus.

c) Soils at the escarpment base subject to rising seepage water may be completely devoid of any vegetation. Circular or elongated bare patches are surrounded by extremely stunted Setaria sphacelata and Themeda triandra.

12. On the Gwasi side of the Olambwe and above the main area of dense bush is a belt of open country on a slight slope where bush is clumped into islands of thicket surrounded by grassland. This has been termed grouped - Bush grassland. The islands may have developed originally due to some slight advantage in drainage, but may now be maintained because fire is unable to penetrate the thicket areas due to lack of combustible grass and merely kills off bush on the outer fringe of the "island". The bush "islands" are primarily composed of Acacia seyal fistula, Balanites aegyptiaca, Cadaba adenotricha, Cissus rotundifolia, Euclea schimperi, Euphorbia candelabrum, Grewia similis, Harrisonia abyssinica, Rhus natalensis and Scolopia sp. (= Druffy Lam/13). The intervening grass areas are covered by Setaria and Themeda of a moderate height.

13. Impenetrable thickets at the base of the Olambwe valley (e.g. Ruma, Otuok, Nyaboro etc.,) are essentially composed of medium bush containing Acacia brevispica, Capparis tomentosa, Euclea schimperi, Euphorbia candelabrum, Oncoba spinosa, Pseudospondias microcarpa, Rhus natalensis and Scutia myrtina. Clearings within the thicket on these exceedingly heavy alkaline and poorly drained dark grey clays are mostly occupied by Setaria sphacelata. This is accompanied by Aspilia sp., Echinochloa haploclada and Sporobolus pyramidalis. A minor association of Panicum maximum and Pergularia daemia has also been described close to the Olambwe. Strangely enough the bush in the Roo

Valley on good well drained, deep, dark brown soils has much the same composition, though the accompanying grasses in the Roo Valley include Chloris gayana, Cynodon dactylon and Setaria sphacelata.

It cannot be said therefore that this bush is purely a feature of the worst drainage sites. Possibly the bush was never cleared because of the tsetse (the Roo valley is a major focus of sleeping sickness). The suspicion remains however that the bush is a fire climax and maintains itself wherever it is sufficiently dense to shade out grasses.

Rather dense bush occurs in some of the gullied valleys of gravelly alluvium and bouldery rubble leading Eastwards off Gwasi towards Lambwe Valley. Components of this bush include Acacia seyal fistula and A.polyacantha, Balanites aegyptiaca, Euphorbia candelabrum, Grewia similis and G.trichocarpa, Harrisonia abyssinica Heeria reticulata, Lannea stuhlmanii, Maytenus senegalensis, Piliostigma thoningii and Rhus natalensis; accompanied by Aerva lanata, Cadaba farinosa, Chloris gayana, C.pycnothrix and Hyparrhenia filipendula.

b) BUSH CLEARANCE:-

On the savannah areas outside the valley bottom thickets, bush clearance should be relatively inexpensive since it is rare for the bush to exceed 10 % of the total vegetation cover and then only in thickets of ACACIA DREPANOLOBIUM which is easy to clear. The main task would involve the removal of scattered stands of BALANITES AEGYPTIACA, and of ACACIA SEYAL FISTULA and ACACIA SIEBERIANA VERMOESENII in lower lying sites.

Clearing dense thicket in the Roo Valley will be expensive, but worthwhile both from the agricultural standpoint and from the point of view of tsetse control. The dense Ruma and Nyaboro thickets and the other dense bush areas near the Olambwe will also be expensive to clear. Furthermore regeneration prevention will be a continuing problem because the thickets cover intractable soils subject to seasonal flooding and only suitable for low value grazing. Since the settlers could be encouraged to meet their fuel and timber requirements from thickets like Ruma, tiding them over until the forestry projects mature, and since tsetse can be controlled without bush clearance, it is not recommended that any of the major valley thickets should be cleared.

Dr.Ivens carried out investigations in an area of dense bush including the following species.

Acacia brevispica, Allophylus africana, Cadaba adenotricha, Capparis tomentosa, Erythroxylum sp., Euclea schimperi, Euphorbia candelabrum, Grewia similis, Gymnosporia sp., Jasminum mauritianum, Lecaniodiscus sp., Mystroxylum aethiopicum, Oncoba spinosa, Rhus natalensis and Scutia myrtina.

Of these, Lecaniodiscus was eliminated by cutting alone. Some specimens of Acacia, Gymnosporia, Scutea, Capparis, Grewia, Euclea and Jasminum were resistant to 5 % 2,4,5-T in oil applied to stumps cut at ground level or at 3 feet, applied either with a sprayer or a brush. The methods of cutting and spraying did not much affect the susceptibility. The most resistant species were Acacia and Euclea. Similar treatments with a 10 % solution of 2,4,5-T appeared to leave only Euclea and Acacia when the stumps were sprayed, while some Capparis tomentosa survived the brush-applied treatments. Euclea was more or less completely resistant, and while Acacia brevispica was susceptible when the stumps were large, small stumps were resistant. Stumps were cut and treated in January.

Of areas treated in March, only Acacia, a few Capparis, and all the Euclea trees were resistant to 5 % 2,4,5-T sprayed onto the stumps. The brush technique left a few Euclea stumps, Gymnosporia and Grewia more or less unaffected.

A 10 % solution sprayed onto stumps cut at ground level failed to kill only a few of the Euclea bushes, while on stumps cut at 3 feet from the ground all were killed by 10 % 2,4,5-T except for 3 Eucleas (out of 14 sprayed) and 4 Mystroxylon stumps.

In summary, it appears that early March spraying is probably the most effective. Most of the species present could be killed by 5 or 10 % 2,4,5-T in oil, but Euclea sp., Acacia brevispica, Mystroxylon and a few trees of other species survived.

Euclea sp., has been killed by pocloram ("Tordon") and any clearing programme involving the spraying of cut bush will have to include the use of Tordon on Euclea. Dr.Ivens calculated that between 60 and 90 % of all the species except Euclea could be killed by one application, whereas only 30 % of the Euclea stumps were killed.

4. THE VALLEY SOILS.

a) SOIL DISTRIBUTION.

For the purpose of this section, the Lambwe valley has been divided up into 13 hypothetical sectors. The precise position of these sectors can be easily ascertained by having resource to the 1:50,000 maps - Numbers 115/IV, 129/1 and 129/II. The system of land classes is explained in Appendix 1.

Sector 1.

From the Roo Valley North to the Lakeshore: between the Olambwe River and the Gembe Hills.

This country consists of alternate valleys and ridges, with a narrow strip of heavy alluvium along the Olambwe River. The ridges are all bouldery with shallow soils, and are clearly unsuitable for agriculture and forestry. On the steeper slopes there is evidence for erosion. The valley immediately North of the ROO contains a good deep dark grey brown soil with somewhat restricted rooting. This valley might be included with the ROO valley in the area suitable for arable agriculture. Analyses of a soil in the Olando Valley suggest that the valley soils will be alkali below about 20 inches.

The other small valleys along the side of Gembe are too scattered and of too limited extent to be worth further consideration. The only extensive arable area is the Ogono valley; this is about 350 acres of gently sloping deep alluvium. The soil is a dark brown light calcareous clay, except near the stream bed where coarse lenses of sands and gravels are found. The valley soil is prized by the local people and 50% is under maize, millet and cotton. Where, however, the slope exceeds 2°, a stony phase occurs. Since this area (between Obaluanda and Luanda) is relatively intensely settled, it is inconveivable that further settlement would be appropriate.

The soils to the West and South West of Luanda are too stony for any form of development.

Sector 2.

The Olambwe Valley alluvium towards the Lakeshore.

This area is mostly covered by medium *Acacia fistula* woodland, and is subject to seasonal flooding, which would require the introduction of an expensive system of drainage. The dark grey rocky clays experience reasonable root penetration (to 30" at least). Calcium concretions are invariably found in the profile and may even appear at the soil surface. Surface pH: 7 to 8. Subsoil pH: 7.8 to 8.6. Gypsum deposition is associated with the lime concretions. Both occur closer to the surface with proximity to the Olambwe. 8 out of 10 analyses showed alkaline subsoils (more than 15% exchange sodium). Textures range from 70 to 90% clay. Salt levels are negligible.

These soils are unsatisfactory for both agriculture and forestry. Though highly charged with gypsum, their prevailing alkalinity would render irrigation a hazardous enterprice.

Sector 3.

Map 115/IV; Area to the East of the Olambwe alluvium.

Map 129/II, Area North of latitude 9941, and East of the Olambwe.

Whilst it is officially settled, there are enough settlements in the area for any major change in land tenure to cause local disruption.

Deep (over 3 feet) dark brown light plateau clays occur to the North of Obando, but these become shallower towards Waondo. In this area there are about 1200 acres of class 2 (arable) soils, though locally occasional boulders occur close to the soil surface. The more Northerly plateau soils, covering about a quarter of this sector, average 3 to 12 inches in depth and are unsuitable for development. A mile to the North West of Waondo a rocky hillock maintains the division between the Olambwe and the Asina valleys. The phonolite cones standing to the West of the Ruri Hills (e.g. Got Opolo) are clearly too steep and stony for any form of land use.

To the West of the Mbita Road are a succession of shallow valleys descending towards the Olambwe in a North Westerly direction. Somewhere near a quarter of these slopes are covered in bouldery debris and are consequently good for nothing. Boulders can be expected below the convex slope crests, but have even been found to occur on the lower parts of the slope. The better hillslope soils are dark brown moderate clays (topsoil 65% clay; subsoils 70% clay) containing calcium concretions distributed through the profile and exhibiting signs of good drainage. Less good soils are dark greyish brown and contain calcium concretions concentrated in an alkaline subsoil (70% clay). Although the acreage of class 2 soils this side of the Mbita Road is considerable, the areas are interspersed with patches of surface boulders. The valley bottoms are floored by less heavy soils in terms of clay content (average 55% clay) but possess a higher proportion of silt. The soils are generally alkali; in the lower lying areas they are subject to seasonal flooding and even the topsoils are alkali. These valley bottoms should be reserved for low potential grazing or forestry (classes 5 and 6).

In this sector the Olambwe is downcutting. Consequently the hillslopes above the narrow alluvial flats (which average 150 yards in width) are relatively steep and invariably bouldery.

To the East of the Mbita Road, a major valley (The Asina valley) runs North and contains the Asina Dam. The valley comprises about 1500 acres of potential arable soils of classes 2 and 3 with the latter predominating. The head (South end) of this valley has a somewhat gravelly dark brown clay with common calcium concretions below 40 inches. This is resorted alluvium. On either side of the valley at this level are reddish brown gravelly clays bearing somewhat desiccated vegetation. On the North side of Got Obilo however, is a remnant of the black lacustrine deposit providing class 2 soil (See Sector 4 below). Lower down the valley, the bottom land soils are dark greyish brown and have alkaline subsoils, whilst soil on the sides comprises a non-alkaline dark brown clay (60 - 65% clay). A rocky hill crest divides the valley from Mirunda Bay.

Gullying is evident on the slopes down to Mirunda Bay with steep slopes and stony outcrops alternating with heavy alkaline basin clays. Shallow soils are also found on the hills around Got Ngoche with alkali seepage zones below.

Sector 4.

Map 129/2; Between latitudes 9936 and 9940. East of the Olambwe River.

On slopes of around 2°, heavy clays spread like an apron to the West of South Ruri. These contain an average of 60% clay. Close to drainage lines, they show alkali subsoils with calcium concretions. The majority of the clays away from the drainage line are non-alkaline. Most of these soils are already settled by registered farmers, and have a good potential for arable. The soils are associated with Balanites savannah and are rather extensive

The soils occur on slopes less than 3° and are slightly acid (pH 5.5 surface; 6.5 subsoil) with 5% organic matter in the topsoil. Root penetration is excellent. Soil structure and consistence is such that cultivation will not be easy; timing will be critical.

Above these black clays, a narrow belt of dark reddish brown soil occurs in close association with the cones and plugs of the Ruri complex, and covers only a very small area. These clays are somewhat acid (pH 5 - 6), with 5% organic matter in the topsoil. Surface soil contains 55% clay; subsoil 65% clay. Range of slope 3° to 8°. Ideal for agriculture, although occasional boulders are found in the profile. The soil has an excellent structure and should prove easy to cultivate. Root penetration is excellent.

Towards the Olambwe River the valley sides level off and on slopes of around 1°, contemporary cultivation is confined to freer draining sites where cultivation is more quickly and more easily carried out after rains. The soils contain concentrations of calcium concretions in the alkaline subsoils and clay content ranges from 55 to 65%. Rooting is almost entirely restricted to the top 2 to 3 feet. An horizon of root galleries marks the level of root impedence ("root frustration"). When dry the soils are very hard and subject to cracking.

Given remedial measures this rather extensive area of land should prove amenable to arable (class 3), though the lowest areas of all will fall into the class 5 category.

Closer to the Olambwe soil alkalinity increases and the layer of root impedence occurs around 2 feet depth. Alkaline seepage tends to be concentrated in localities where there is a slight convex slope above the flood plain of the Olambwe. Such slopes tend to be almost devoid of vegetation save for a little stunted <u>PENNISETUM MEZIANUM</u> and <u>SPROBOLUS MARGINATUS</u>, grasses adapted to survive alkali conditions. These dark grey clays (50 - 60% clay) are strongly alkali to the surface and rooting is shallow. Consequently the topsoil organic content is low (around 2%).

<u>Sector 5.</u>

The Ogongo Valley; between the Settlement Office and the Olambwe River.

This sector includes all the settlement area between South Ruri and the Kaniamwia escarpment. The upper slope (3 - 9°) soils on both sides of the valley are deep dark reddish brown clays with a high potential for arable. As the slopes exceed 9° the soils become red, shallower and stony - such soils may be suitable for forestry.

As the slopes even out heavier black clays are encountered. Provided these are well drained they have a good arable potential (class 2). There are two associated snags however -

(i) Shallow soils overlying a calcified caliche. e.g. Near the Gemba Dam very abundant fine Calcium and Manganese concretions are found below 22 inches. The bare soil surfaces round the dam are strewn with calcium nodules and provide evidence for surface soil wash. Some gullying can be seen to the North of the dam. On a settlement farm in the vicinity of stunted <u>SETARIA</u>, masses of Manganese and Calcium concretions were being brought to the surface by the plough, though at the other side of the same field close to tall <u>HYPARRHENIA</u> was a deep dark brown clay growing excellent sisal. The calcified caliche was found only 3 inches below the soil surface. It appears to be associated with stream lines flowing South off South Ruri where the land has been subject to sheet erosion possibly resulting from overgrazing. Perhaps afforestation should be tried on some of these areas.

d) Skeletal soils on slopes exceeding 12°, generally red or brown. Where there is less than 6" of soil over a stony subsoil containing inadequately weathered rock material, the water holding capacity is such that the soil is unsuitable for trees or crops.

All the above soils except (d) could be used for forestry (class 6).

Sector 7.

Below the scarp slopes on the East side of the Olambwe River, South West of the Komojo Valley for 15 miles.

(1) The soils on slopes of over 1½° and not subject to either colluviation or seepage are very heavy dark grey brown (60 - 75% clay) clays, non-calcareous and generally containing few calcium concretions. These clays are subject to cracking in dry seasons with some root impedence in the third foot. Where these soils are well drained they should be suitable for arable. cultivations will be difficult and require a high degree of skill, since the topsoils and subsoils are both somewhat alkaline.

(2) These soils on slopes over 1½°, but subject to colluviation, are very much better drained than (1) above, due to the presence of gravel lenses in the brown clay. Lenses of boulders are rare except near the top (steeper slopes) of the alluvial fans. The soils are highly suitable for arable (class 2) and are marked out by areas of denser bush (Rhus etc.) One problem is the danger of flash floods off the escarpment: this could be reduced by planting trees on the escarpment above.

(3) Seepage areas occur where small streams flow off the hills and are absorbed into the lacustrine deposit. The areas are marked by the growth of Imperata cylindrica and Acacia fistula; the grasses remain green longer than on other soils. Rarely in minor gullies, the water table approaches the surface of the soil and forms small ponds. The subsoil is only seasonally poorly drained. Rust mottles in areas affected are evidence for partial and temporary soil oxidation. The salt content of these soils is no higher than for surrounding non-seepage areas. The soils have a high organic content (8% at the surface). Waterlogging appears to occur at a considerable depth, and there is evidence for Root impedence (presumably, due to local waterlogging) at an average depth of 30". The black soils are very heavy (60 to 80% clay) and the lentil structures with marked slickensides are evidence for considerable swelling and shrinking. These seepage zones cover only a limited area, and may be suitable for tree crops (e.g. some species of Eucalyptus).

(4) Heavy lower lying very dark grey clays generally contain about 50% clay in the surface 6": below this the clay content exceeds 70%, rising to 80% below 20". They cover an extensive area South and West of the Goyo stream. The subsoils below 3 feet show evidence of poor drainage, glei, and mobilised clay and manganese. A layer of caliche lies below the glei, this layer appearing closer to the soil surface as the Olambwe River is approached. Where these soils are over a mile from the river their subsoils are relatively free of alkali. With proximity to the Olambwe, alkali levels increase and some intense concentrations have been recorded, the soil being suitable for grass (class 4)

(5) Within ½ mile of the Olambwe, soils are subject to a fluctuating water table during rains. This results in calcium concretions scattered throughout the profile rather than being confined to a deep caliche. Associated soils are dark grey and alkaline to the surface. They are unsuitable for any use other than low potential grassland and are, moreover, covered with dense thicket, expensive to clear. In the near vicinity of the Olambwe the soils are calcareous to the surface.

Sector 8.

Map 129/1. South East side of Valley.

The soils gradually degenerate as one travels South West. To the East of the escarpment hill Rachar is a large area of rather level heavy very dark grey clays like those described in Sector 7 (4) above, but on proceeding South West occasional alkali seepage zones can be observed (beneath Gendo Hill); these result in patches bald of vegetation. The valley becomes asymmetrical with the Olambwe flowing close to the escarpment.

Limited areas of black soils occur close up against the scarp (e.g. 50% clay and non-alkaline), but the potential arable belt is a narrow one. The main area stretching down to the Olambwe is alkali below 2 feet. The presence high in the profile of phonolite rubble however,(common in an area to the North and West of Rachar) assists drainage and prevents the accumulation of alkali. These latter soils, though patchily distributed, are suitable for arable.

Towards the South East Corner of Lambwe Valley alkali is often encountered in the surface foot; in dry seasons intense cracking can be observed right to the soil surface and the soil units have blue faces in the deeper horizons (? reduced forms of iron phosphate). The soils beneath the medium density Riamkanga bush and beneath the Acacia fistula woodland adjoining the dense Nyaboro thicket have similar properties. All these soils are subject to seasonal flooding and are valueless for development. They are characterised by a peculiar absence of more than a few calcium concretions in the profile. It can only be concluded that the ground water in this upper end of the valley is inadequately charged with calcium. This explanation is really unsatisfactory and only serves to underline how little is understood concerning the required conditions for soil calcium precipitation.

Sector 9.

The Roo Valley.

Along both sides of this valley are about 1000 acres of dark brown light clays exhibiting most excellent root penetration. This should prove a good soil for arable despite a high cost for bush clearance. These soils do not extend all the way down to the Olambwe nor do they occur far up the valley sides where, both on Kwoyo Hill and on Gembe, there is a shallow stony soil.

At the head of the valley around the Roo/Sindo col there is a very heavy dark brown clay with abundant calcium concretions at depth although the surface is decalcified. This soil is alkali below 2 feet where it appears to be subject to seasonal ground water and consequent root impedence.

Sector 10. Between Kwoyo Hill and the Olambwe River.

A succession of soils are found in this hill sequence, the soil type varying with topographic position. On the steeper slopes, and near the hill top, the soils are less than 18" deep and may be very shallow. On lesser slopes is a deep dark grey brown clay with strongly developed prisms. Surface texture is 40% clay; subsoil 60% clay. This soil is only slightly alkaline and is highly fertile, yet the Themeda grass cover is rather stunted. This may be due to extensive cracking. At all events the soil should be suitable for growing food crops. On slopes intermediate between the two above (i.e. 1^{o} - 2^{o}) are lesser occurrences of a dark brown clay with only moderately developed prisms: this is also non-alkaline.

Sector 11. This is the extensive and rather uniform area between the Gwasi Hills and the Olambwe River; North of Got Rabondo and South of Kwoyo Hill.

On slopes exceeding 2^{o}, where the nephelinite rubble outcrops through the lacustrine clays, is a very narrow local belt of dark brown or dark reddish brown clays (surface 50% clay; subsoil 70% clay). The soils are non-alkaline, demonstrate deep rooting and have a high potential for arable, but their distribution (coinciding with the occurrence of Combretum savannah) is limited. On slopes over 4^{o} a shallow phase occurs with boulders close to the surface and the clay acquiring a redder hue.

The valleys leading down off Gwasi are all quite different; these alluvial soils tend to contain stony layers or surface boulders, if

a) slopes exceed 3^{o}

or b) The alluvium is close to the flash flood deposition area of the hill streams.

Deep gullying in the Gwasi Hills has resulted in large quantities of boulders being deposited on the upper (steeper) slopes of the alluvial fans. Since these valleys are covered in dense bush and the total area cannot exceed 2000 acres, the hill valleys have no great significance.

In the Opuch Valley however, there are up to 300 acres of deep dark brown clays and clay loams deposited to some depth on top of the original lacustrine clay. These decalcified soils contain a few fine gravel lenses and show excellent root penetration. Where fine stones are not commonly found on the soil surface these soils will be first class for arable.

Far more extensive are the heavy black clays on the more gentle slopes lapping round the Gwasi Hills, on slopes exceeding 1^{o} 30'. They are non-alkaline throughout. Where, however, they occupy lower lying areas serving to drain Gwasi (slopes less than 1^{o}), the soils are somewhat alkaline at depth. The non-alkaline soils have some potential for arable; the lower lying flats are better suited for grass.

On lesser slopes (less than 30') are heavy very dark grey clays with alkaline subsoils. These soils are most extensive and very uniform, hardly differing morphologically whether they lie in shallow drainage ways or on low ridges. A typical profile had 69% clay in the top foot and 81% below this. The soil was strongly alkali below 3 feet. In drainage ways, however, the alkali may approach within a few inches of the surface. All these soils grow tall grass and would make highly productive grassland (class 4).

It was observed that the following sequence applies on traversing West to East down the Gwasi slopes towards the Olambwe River.

1. The slope gradually levels out.
2. The grass becomes shorter, Setaria replacing Hyparrhenia.
3. Calcium concretions start to appear at the base of the profile and are then encountered at ever shallower depths.
4. Concretions become coarser and more numerous.
5. The layer of Root Impedence becomes more clearly defined and is found nearer the surface.

6. The soil is subject to more extensive cracking, and the prismatic subsoil structures are more strongly developed.

Heavy dark grey clays of the valley bottom occupy level sites and suffer poor surface drainage (perched water table) for part of the year.

E.g.	Topsoil	- 83% Clay and 14% silt with 4% organic matter.
	Subsoil below 8"	- 74% Clay and 14% silt; alkaline.

These soils are unsuitable for agriculture. Nevertheless, if the bush were cleared, any subsequent grassland might prove a useful dry season reservoir of fodder.

Sector 12. Between Got Rabondo and Magunga.

This area includes the Owiga Valley. The Owiga flows down an alluvial fan (500 yards wide at its widest). The total cultivable area is some 500 acres from the hill to the end of the fan. Some parts of the valley are already planted to millet, sisal, Eucalyptus and Cassia, maize and cotton. In one small plot near the stream is an acre of irrigated banana, sugar, pawpaw, tomato and cabbage. The water table stood at 17 inches and the very dark brown clay bore evidence of organic reduction and was slightly alkali throughout. There might altogether be 100 or 150 acres with irrigation potential. The stream flow was about 2 cusecs (in the dry season), and some elementary structures would be required for a small diversion dam or a weir with measures for flood protection. These valley soils (average 55% clay) are very fertile.

Savannah on Kigoto spur covers very shallow and bouldery soils. Got Rabondo is also rocky.

The Magunga valley soils have similar attributes to those of the Owiga, and extend towards the Olambwe Valley on a similar alluvial fan. Some banana, millet, maize and cotton grow in the valley; there is intense millet cultivation on the better drained soils of the slope up to Magunga itself. The valley does not contain a perennel source of water. The soils are very dark brown with excellent rooting; fairly well drained with occasional fine gravel lenses. Near the base of the alluvial fan and on the edge of the Nyaboro thicket are deep very dark grey brown clays, decalicified and with reasonable rooting. There are perhaps 500 acres of this soil, which might be useful in support of a scheme further North, if it should justify the costs of access, transport and bush clearing.

On more level areas farther into the dense Nyaboro thicket the clays are very heavy, have alkaline subsoils and are poorly drained. This area has no potential.

Sector 13. The Hill Slopes at the Southern end of the Valley to the East of Magunga.

A narrow belt of deep, (only occasionally bouldery) dark reddish brown soil occurs on the lower slopes (less than 10^{o}) below hills such as Ochibo and Sanjweru. Deep, brown and very dark brown, clays (non-alkaline) occur in pockets between the dense hills. Since these soils are inaccessible due to the dense area of Nyaboro bush below them and, moreover, are of a scattered and limited distribution, though of high inherent potential, they cannot be considered for development.

(b) MINERALOGY

Without going into overmuch detail, the clay mineralogy may be simply presented in 3 categories.

1. The relatively light clays, well drained and of a reddish hue (deep and shallow phases) contain somewhere near equal proportions of halloysite, illite and well crystallized montmorillonite.

2. On intermediate slopes the medium black clays are composed of illite and montmorillonite in almost equal amounts.

3. On the lower slopes, valley bottoms and alluvial flats the clay is almost entirely made up of well crystallized montmorillonite. With depth the degree of crystallinity of the montmorillonite increases.

The residual (reserve) minerals show no meaningful trends as a function of slope. All of the samples analysed contain varying proportions of quartz, felspars and apatite.

The percentage volume expansion on wetting follows a trend predictable from the clay mineralogy. The Group 1 clays with a relatively low content of montmorillonite expand by 20-25% on wetting (mean = 22%). Equivalent figures for the other 2 groups are:-

2. Expands by 25 - 40 % (mean = 34%)
3. Expands by 40 - 60 % (mean = 50%)

It would appear that a proportion of the complex is taken up by exchange acidity (on sites of variable charge) and this should alleviate the alkali problem. Nevertheless the high total exchange capacity is bound to render soil improvement a more difficult process than might otherwise have been the case. Colloid exchange capacity ranges from 60 to 105 m. eq./100 grams soil.

(c) MOISTURE STATUS.

Moisture studies were carried out on a wide range of soils. The results are presented below.

Ref.	Depth	% Sand	% Silt	% Clay	% Moisture ⅓ atmosphere	% Moisture 15 atmosphere	% Available water
7604/65	0- 7"	16.4	14.0	69.6	49 4	34.1	15.3
7605	7-18"	18.4	14.0	67.6	48.3	34.4	13.9
7628	0- 7"	14.0	28.0	58.0	54.5	33.9	20.6
7629	7-22"	14.0	20.0	66.0	61.3	38.3	23.0
7642	0-24"	18.0	12.0	70.0	70.9	42.6	28.3
7643	24-45"	18.0	16.0	66.0	71.0	42.4	28.6
7656	0- 9"	22.0	28.0	50.0	52.6	28.9	23.7
7657	9-23"	20.0	14.0	66.0	61.6	38.9	22.7
7672	0- 7"	22.0	14.0	64.0	69.3	47.2	22.1
7673	7-22"	18.0	12.0	70.0	75.0	57.6	17.4
7689	0- 6"	14.0	20.0	66.0	52.8	33.7	19.1
7690	6-24"	16.0	18.0	66.0	58.6	37.0	21.6
7705	0-22"	34.0	4.0	62.0	70.4	40.5	29.9
7706	22-30"	36.0	8.0	56.0	81.5	44.8	36.7
6819	0- 5"	21.0	14.0	65.0	52.5	34.7	17.8
6820	5-22"	17.4	14.0	68.6	53.2	36.9	16.3
6823	5-12"	25.4	18.0	56.6	49.1	32.7	16.4
6826	0- 5"	25.4	14.0	60.6	52.0	32.8	19.2

6827	5-22"	27.7	12.0	60.6	56.8	36.1	20.7
6829	0-11"	29.4	12.0	58.6	44.4	27.7	16.7
6830	11-43"	31.4	12.0	56.6	49.2	30.0	19.2
6530	5-18"	16.6	20.0	63.4	52.2	32.1	20.1
6796	0- 5"	23.0	12.0	65.0	56.4	35.1	21.3
6797	5-12"	27.0	10.0	63.0	62.3	37.7	24.6
6822	0- 5"	21.4	18.0	60.6	53.2	33.3	19.9
5410	0- 2"	24.4	8.0	67.6	65.7	40.7	25.0
5411	2-12"	16.4	14.0	69.6	78.5	47.4	31.1
6529	0- 5"	16.6	26.0	57.4	51.7	27.7	24.0
4793	0- 3"	28.6	22.0	49.4	52.3	26.5	25.8
4794	3-33"	20.6	16.0	63.4	56.8	32.9	23.9
7709/65	5-44"	20.0	18.0	62.0	62.2	36.4	25.8

These clay soils have high available moisture percentages. They compare favourably with the sugar growing area soils of Nyanza; Muhoroni, Patel and Kibigori clays whose available moisture percentages for 0-24" profiles range from 19-24. This is in contrast to a clay loam soil which would normally have about 13 percent available water.

The bulk density of this soil can be assumed to be <u>1.2</u>. The available water over a one-foot profile would then work out as <u>2.0</u> to <u>4.0</u> inches. On the other hand the amount of water required to bring this profile to field capacity would vary from <u>6</u> to <u>10</u> inches.

It was observed in the laboratory that the soils rapidly take up moisture when they are in the dried state. The wet soil however, closes up and assumes an extremely low permeability with a very slow rate of leaching.

In the field signs of glei were observed in some of the deeper layers of the cracking clays. The presence of precipitated calcium in the form of concretions is further evidence for the movement of alkaline water through the subsoils in wet seasons. Given some degree of slope the potential rooting zone rarely conveys the impression of poor internal drainage. It seems that the process of soil wetting follows the sequence:-

1. In early rains water travels down cracks and macro-drainage is good.
2. The soil mass absorbs moisture rapidly, the cracks close up and the peds move mechanically under stress to achieve a state of near **maximum packing.**
3. Once the soil is closed internal drainage very largely ceases to exist; water sits in the root mat of the surface few inches and gradually evaporates.

Drainage is a function of slope and as one goes up slope surface drainage improves. On slopes less than $1\frac{1}{2}^{0}$ root impedence is a consequence of a combination of fine texture and moderate alkali such that root penetration is prevented:

(a) In wet seasons due to the lack of pore space.

(b) In dry seasons as a result of the very hard consistence coupled with inter-pad cracking.

(d) SOIL FERTILITY.

This is not a factor to limit development. The levels of phosphate, calcium and magnesium are all exceptionally high. In all but the lowest parts of the valley a high proportion of the contained phosphate should be available to plants and a response to phosphate fertilizer should not be anticipated.

Whilst is is doubtful if boron will be present in toxic quantities there is strong evidence that sodium occurs at toxic levels in all the lower slope soils. Gypsum applications would of course displace the sodium in time, given adequate drainage, but in the early years whilst a low permeability persists only the more alkali tolerant crops can be expected to thrive and even these may suffer retarded horizontal rooting patterns.

Potassium levels are generally high and no potash response can be expected.

Nitrogen and Sulphur are everywhere deficient, nitrogen especially so. Heavy nitrogen applications will be required in the early years. Ammonium sulphate is the most suitable form of nitrogen since it also reduces the pH of alkali soils and at the same time should raise the sulphur to acceptable levels. Sulphur will also be provided by the gypsum in those soils treated with the amendement.

pH levels range from 5.5. to 6 along the edges of the Ruri Hills to 8.5 and higher on the alluvial flats close to the Olambwe River. Most of the higher lying areas of the Ogongo Settlement Scheme (and indeed much of the Lambwe Valley) have a pH range of 6 to 7 with 7 to 7.5 in the subsoil. pHs in the potential rooting zone rarely exceed 7.5 except in alkali seepage zones and close to the Olambwe.

5. AGRICULTURAL DEVELOPMENT:

(a) PROSPECTS FOR ARABLE: AGRICULTURAL RECOMMENDATIONS

(i) Summary of recent.proposals:-

'A Draft Report on Lambwe Valley' (Department of Settlement; 1965) envisaged the creation of a new settlement area (whereabouts undecided) of some 10,000 acres based on the conception that such an area comprises a "reasonable administrative unit". Of these 10,000 acres, 1000 would be under sugar and 2000 in cotton. The Department of Settlement is concerned to achieve an annual income target per family of £100 (plus subsistence and annual development charges), and it was believed that cotton on its own yielding in the order of 1000 lbs per acre would not meet this target; hence the need for a "high priced" cash crop like sugar.

The Cotton Board have proposed a 10,000 acre "mechanised cotton" project. For this the Board requires large blocks (minimum area 250 acres , but each block preferably exceeding 1000 acres). Whether to employ rotations with a mechanised short-term cash catch-crop or practice a system of monoculture has still to be decided. Clearly the second cash crop should be quick maturing. This scheme would involve a further 2000 acres for subsistence cropping. An input of around 10,000 bales is ideal for ginnery operation and, depending on average yields, this might require the planting of 7500 acres to cotton. The cotton board aims at a net income per family of £75 a year from cotton alone.

Proposals emanating from the East African Livestock Survey and the Ministry of Agriculture envisage a 20,000 to 30,000 acre livestock ranch crossing the Central part of the valley from the Kaniamwia escarpment to Gwasi side. Young dairy stock would bought from farmers in South Nyanza so as to enable them to concentrate on milk production; the cattle would then be correctly reared in Lambwe Valley and would form a reservoir of stock for the area. This would provide an opportunity for improving and grading-up the Nyanza dairy herd.

(ii) Discussion:-

The Senior Sugar Officer is of the opinion that the rainfall over the Lambwe Valley as a whole is sub-marginal for sugar. Not only is the annual total close to the limit in Central Areas (about 40 inches) and inadequate at the Northern and Southern extremities (about 35 inches) but the rainfall pattern is unsatisfactory and in many years a protracted dry spell will occur at some time or other. Whilst sugar should be a success in limited areas on the Eastern (escarpment) side and towards the heads of the Ogongo and Samunyu valleys where rainfall is adequate (55 inches) or where the soil is endowed with an additional source of moisture (as on seepage zones and underground streams), the acreages concerned closely correspond to areas of existing settlement. Where the soils are really heavy, they will be subject to waterlogging in prolonged rains and this will be detrimental to rooting.

CONTD/26......

The rainfall pattern is however suited to grass or cotton. There can be little disagreement as to the suitability of soil classes 1 and 2 for cotton nor doubt as to the potential of Class 3. (See Appendix 1 for definitions of Soil Classes and for the acreages involved). Soil classes 5,6,7 and 8 are certainly unsuited to commercial cotton production due either to the shallowness of the soils concerned or to such a combination of alkalinity, clay composition and heavy texture as to render cultivation most difficult and costly and cause crops to suffer restricted rooting as a consequence of poor drainage, low permeability and root tearing during soil cracking. These factors would tend to accentuate the dryness of dry periods. A minority of soils are subject to seasonal flooding; these are valueless except for dry season grazing.

Reference to Appendix 1 shows that the pattern of land use in the Lambwe Valley largely depends on the status of the 18000 acres of class 4 so called "High Potential Grassland" soils. The use of the term "Grassland " is not intended to imply that the soils are incapable of growing crops like cotton. What it does suggest is that inadequate potential may exist for achieving cotton yields of a level at which there can be confidence in obtaining a reasonable return compared, say, with the possibilities inherent in a ranch. It would surely be unfortunate were "Grassland" to be looked upon as an agricultural term of abuse rather than as a high value crop. It might also be something of a tragedy were the area in question to be ploughed up (thus destroying the current ecological balance) only to find that, after all, the existing <u>Setaria/Themeda</u> grass association constitutes the most economic form of land use.

Before embarking on a detailed treatment of the complex of factors associated with the prospects for arable, it should be emphasised that, from the point of view of the soils, these extensive areas of Class 4 clays are naturally suited to the growing of grass and that cultivation will be complicated and success uncertain.

It should also be stressed that the farther arable development proceeds down the slope, the greater the problems to be encountered from heavy texture, alkalinity and poor drainage. The topographic limit below which reclamation ceases to be feasible falls somewhere around the 1° slope, i.e. The relatively level areas near the valley bottoms on slopes less that 1° cannot be effectively used for arable. On this basis it is estimated (without accurate survey) that about two thirds of the Class 4 soils should be susceptible to improvement i.e. Some 12,000 acres. Assuming that 10,000acres are successfully reclaimed, the <u>arable classes</u> are revised as follows:-

Class 1	2500 acres
Class 2	8000 acres
Class 3	8000 acres
Class 4	10000 acres
Arable total	28,500 acres

CONTD/27.......

It is estimated that about 8000 of these acres fall within the existing area of Settlement. Thus a maximum additional 21,000 acres of arable potential lie outside the Settlement boundary.

Now the agricultural plans for the valley (outlined above) need not of course be conflicting. Within the economics of ranching, account will have to be taken of a possible loss in grass production or grass utilisation caused by clay puddling during rains. If the economics of ranching appear satisfactory (and the East African Livestock Survey shows this to be the case), even though arable soils on the hill slopes above the ranching area will need to be used for the production of dry season fodder crops or leys, these can be grown in rotation with cotton; provided the cotton is grown in blocks exceeding 250 acres the Cotton Board requirements for their scheme are still feasible. Its association with the ranching activity could well realise the net income requirement of the Settlement Department.

Whilst experience gained elsewhere can assist in the formulation of proposals for virgin land, should a decision be taken to go ahead with soil reclamation and extensive arable cultivation, then it is important to conduct preliminary soil and crop trials costed under local conditions. Without such trials it is doubtful if financial support would be forthcoming from external agencies.

If extensive arable is contemplated for Lambwe , then properly costed trials should be initiated prior to the 1966 long rains. This would require preliminary cultivations in January 1966. Even the yields resulting from one cropping would be valuable in assessing the prospects for arable. Ideally the trials should be continued for a minimum of 2 years before a final decision is taken. The following points should be considered in devising such trials:-

1. Trial plots should be sited on 2 soil types considered marginal for cotton. Soils from the upper and lower drainage limits of classes 3 and 4 should be chosen.

Both these plots should be sited on the Gwasi side of the valley . If, however, emphasis is to be placed on ranching, then trials should be embarked upon as a part of the programme for the proposed pilot farm (to be discussed in sub-section (iii)).

2 . The trials should be based on the concept of the 6 foot ridge with intervening ditches. This set-up provides an opportunity for inter-cropping (with beans?) along the middle of the ridge. A spacing trial will be needed in conjunction with this system of ridging. It would also be appropriate to assess the optimum dressing of nitrogen (as ammonium sulphate) in this same trial.

3. Trials should be conducted with a view to soil improvement, in particular - (a) Assessing the most advantageous timing and techniques of cultivation.

(b) Determining the minimum level of heavy equipment that can be effectively employed on each operation.

CONTD/28..

(c) Estimating the average gypsum reqhirement for soil reclamation on these land classes.

(d) Calcium nitrate (more soluble than gypsum) should be tried out on an experimental basis to provide some indication as to the long term effects of gypsum.

4. It would be valuable if a section of the trial were set aside for estimating the relative merits. of

(a) Cotton monoculture.
(b) Sown leys after cotton.
(c) A short term cash catch-crop rotation with cotton.

5. The optimum economic level of insecticide spray should be determined, since the greater the frequency of sprayingthe lower the proportion of stained Grade B Cotton and the higher the overall yields.

6. The trial will form an area of cultivation in an agricultural void. Vigilant attention will be required against animal pests of all descriptions.

The details of reclamation and cultivation are described in later sections.

(iii) <u>The existing Settlement Scheme</u>

The future of this scheme will inevitably be a subject for speculation. Having regard to the guarantees given to the existing tenants and taking account of the scheme infrastructure developed on the basis of the existing set-up, any reallocation of land on the settlement area is really out of the question. Since the present scheme is continuing at a low level of output (and in many places the bush is gaining the upper hand), it would seem reasonable to concentrate effort upon raising the standards of the existing farm structure . Income levels would be most significantly raised by the cultivation of sugar accompanied by the introduction of jaggery factories. It is now thought that the rainfall around the col between the Samunyu and Ogongo valleys and extending for some distance along the Southern and Eastern flanks of South Ruri is adequate for sugar, though it would be prudent for the local agricultural officer to test this presumption with a properly conducted trial. Here on the better soils sugar might become the mainstay of the settlement farm. Elsewhere, and over the greater part of the acreage cultivations should be based on cotton; with groundnuts, maize and sorghum on the better drained soils (classes 1 and 2),sisal as a valuable subsidiary enterprise for the Homa Bay Sisal Plant and sweet potato on the poorer drained soils.

The farm advisory service, already numerous on the ground, could be strengthened by the acquisition of a Pilot Farm of 50 acres sited on the marginal class 3 soils. This would have both educational and research tasks. It would conduct weekly farm courses and lay out demonstration plots. It could also be used as a centre for the sugar trials proposed above. Emphasis should be placed on the need for early planting, the use of nitrogen fertilizer and the importance of pest control. Instruction should also be given in the gentle art of cultivation.

CONTD/29

(b) <u>Reclamation Techniques.</u>

Gypsum should be applied after initial soil breaking by crawler tractor. Assuming a need to reduce the exchangeable sodium percentage from 15 to 10 and an existing colloid exchange capacity of 75 m. eq per 100 grams, the theoretical gypsum requirement for the amelioration of the top 2 feet should be 5.7 tons/acre. Experience on the Kano Plains suggests that optimum results may be obtained with approximately half this requirement - i.e, about 3 tons per acre of gypsum (calcium sulphate)

The method of soil reclamation recommended for Lambwe need not in fact make use of anything like this amount of gypsum if the amendment is applied in separate doses of ½ tons per acre per cropping season. The result of each application could then be carefully noted and the deflocculated and still partially impermeable patches of bad soil demarcated during the season. Additional applications of ½ ton. need then be applied only to these difficult spots. This can be explained by the familiar observation that alkali tends to be concentrated into distinct local areas. Thus by the second and third cropping season the overall gypsum application will be considerably less than ½ ton an acre. It is possible that the final gypsum requirement might not exceed 1½ to 2 tons per acre. A definite estimate cannot be made without preliminary trials.

The class 4 soils contain between 50 and 100% montmorillonite a clay mineral with a propensity for swelling and shrinking (2:1 Type). The percentage of montmorillonite increases with proximity to the valley bottom. Nevertheless, of the 2:1 type minerals, the species montmorillonite has shown itself amenable to reclamation. The relatively high figures for soil exchange acidity lend support to the view that reclamation will prove successful.

Unless the soil units are in intimate association with gypsum results may be disappointing. Gypsum is therefore applied by hand and is thoroughly incorporated with the soil . It is proposed that a Towner Plough be used for ploughing to 20 inches - pulled by a D. 9 (References to the form of traction required are only estimates which require to be proven in trials; as time goes by it is expected that it will be possible to use less heavy equipment than that proposed in this report.)

Drainage is essential for success in reclamation - i.e. Displaced sodium must be allowed to make a getaway . Surface drains should be placed 6 feet apart and could be provided by a Ditcher pulled by a D.4. Standing water must be prevented at all times since this is inimical to cotton rooting.

A significant response has been obtained with sugar on similar soils in Central Nyanza by means of subsoiling when the soil is dry so as to obtain maximum shattering effect. The subsoiler may be pulled by a D. 8, and the cost will come to 70/= an acre. If the soil is the slightest bit moist, a puddling effect is evident on soil units which have come into contact with the tines. Another possible technique consists of 2 foot interval soil ripping to 18 inches and would cost 50/= an acre.

CONTD/30..

(c) Cultivation Costs.

The most important initial cost is that of the gypsum. There is no estimate for the cost of gypsum after transport to Lambwe. Two sources of gypsum would appear to be available - those West of Garissa in the Coast Province and those in North Tanzania (Tanganyika). Gypsum ex-Tanzania is delivered at Muhoroni (Kano Plains) at 100/= a ton. The gypsum could be transported from the Kisumu railhead by lorry so as to avoid the double handling which would be involved were gypsum to be sent by barge to Homa Bay. Final cost for a ton of gypsum in Lambwe might well amount to 120/=. At an application rate of 1½ tons per acre for 10,000 acres, this implies an investment of £90,000.

Other cost estimates are presented below. These have been determined after considerable discussion.

	Cost in Shillings per acre.
Deep ploughing	70
Gypsum application	50
Harrowing	20
Ditching and Ridging	60
Planting	10
Fertilizer	65
Pre-emergent Herbicide	40
Insecticide	40

Savings might be achieved by combining the planting, fertilizing and herbicide application into one operation. It might also prove possible to integrate ploughing and harrowing by the use of a power-driven disc plough. Such a machine could be valuable in widening the range of soil moisture within which cultivations can be satisfactorily performed.

According to the figures above, the basic cost of cultivation will total 355/= per acre disregarding the cost of the gypsum itself. These estimates also take no account of the relatively large numbers of agricultural officers that will be required to function in a supervisory capacity.

The Cotton Research Officer is convinced that the Class 3 and Class 4 soils would produce at least 1500 lbs rain-grown cotton to the acre after a few years of treatment, providing good drainage has been achieved. In the early years however, farmers may be fortunate to harvest half this amount and probably 5 years will elapse before the 1500 lbs target is achieved.

CONTD/31...

The returns are not easy to predict since these depend on the proportion of stained cotton. Over the next 3 years Grade A Cotton will fetch 50 cents a pound; Grade B, 25 cents a pound. Assuming 33% of the crop is Grade B then the mean return is around 41 cents a pound. At 1500 lbs per acre this would indicate a gross return of 615/=, providing a gross margin of 260/= an acre. At a more conservative scheme average yield level of 1250 lbs, the gross margin comes out at 157/= an acre

(d) Prospects for Irrigation.

A Report by Sir Alexander Gibbs (1956) proposed the irrigation of 290 acres (on the lowest alluvial flats around the Olambwe near Luanda) by pumping from the lake, assuming a 30 foot pump lift. This proposal aimed to grow paddy rice in the rains and rotation food crops in the dry season. Net returns (with interest included) were estimated at £75 per acre per year for a capital outlay of £70 per acre. It is probable that the Gibbs Report underestimated the costs of drainage and the complications involved in irrigating such a relatively small acreage of intensely alkaline and extremely heavy clays.

Even less promising is a recent proposal for pumping lake water up from the Homa Bay to irrigate the Samunyu valley and the South side of South Ruri. This would involve a pump lift of about 300 feet and a 4 mile haul which is most unlikely to prove economic. The proposal should be submitted to economic analysis before adoption.

There remains ground water as a source for irrigation. Figures were provided in Section 2 (g). for probable yields from boreholes. Unfortunately less information is available concerning the quality of the borehole waters.

Borehole water C 1269 was analysed as Sample 172 on the 18th J-anuary, 1951, with the following results:-

Turbidity: None Odour: None
Colour : Clear Suspension: Small amount of inorganic material.

pH : 7.3

		PARTS PER MILLION.
Alkalinity (as Ca CO_3).	(CO_3	Nil
	(HCO_3	462
Ammonia :	Saline	0.04
	Albuminoid	Trace
O_2 absorbed; 4 hours at 80°F		Trace
	Cl	10
	SO_4	Trace
	NO_2	NIL
	NO_3	Trace
	Ca	55
	Mg	33
	Fe	0.2
	SiO_2	23
Total Hardness		273
Permanent Hardness		NIL
Temporary Hardness		273
Total Solids		555
	Fluoride	2.3

No analysis was perfomed to determine sodium content, most crucial for assessing irrigation prospects. However, from the above figures it can be assumed that the sodium is about 50 parts per million.

Based on this assumption, the sodium adsorption ratio is 1.32 milli equivalents per litre, whilst the figure for residual sodium carbonate is 2.65 milli equivalents per litre.

The sodium hazard per se is negligible, but the high concentration of bicarbonate in these waters will cause calcium and magnesium to be lost from the soil solution by precipitation. With good management however, it might be possible to use the water for irrigation. This would require the addition of gypsum into the water in order to :

1. Maintain soil permeability so as to ensure the adequate leaching of the bicarbonate.
2. Directly reduce the sodium hazard by the supply of calcium.

In view of the marginal nature of these waters for irrigation, it is urged that a further sample is taken from Borehole No. 4., Lambwe Valley and sent to these laboratories for analysis, should irrigation from ground waters be seriously considered.

6. <u>SUMMARY OF PHYSICAL RESOURCES</u>

The Lambwe Valley covers about 125 square miles. The Southern and Central areas are covered by thick lacustrine deposits. In the North however, the deposits have very largely been removed giving rise to shallow soils and even bouldery outcrops.

a) <u>SOILS</u>:

The lacustrine deposits are all clays which become heavier as the valley bottom is approached. Only close to the surrounding hills are more recently weathered and coarser textured materials found: even these comprise reddish brown light clays. On the slopes near the hills internal soil drainage is generally good and the soils are free of alkali. Though deficient in Nitrogen and Sulphur, the soils are considered to have a reasonable potential for arable. This category comprises some <u>11,000 acres</u> of soils scattered round the valley edges, but concentrated to some extent in the existing area of Settlement. If one includes the heavier soils downslope which are also free of alkali but require a skilful approach to cultivation and measures for external drainage, then the area of total potential arable is raised to <u>19,000 acres</u>. These acres corresponding to hillslopes coincide with sites receiving the highest rainfall (45" - 55"). Locations with over 50" should prove suitable for sugar - this would therefore be grown on the col between the Samunyu and Ogongo valleys. Elsewhere suitable crops from the purely agronomic point of view might include cotton, sisal, soya bean, groundnut, sunflower, kenaf, maize, beans and sorghum.

On lesser slopes are heavier clays (65 % to 75 % clay) with somewhat alkaline subsoils. The potential land use pattern for these soils is a somewhat controversial subject since no crop trials have yet been attempted. Land use may well be decided by economic considerations. The soils under discussion are on both sides of the valley mostly in the Central area. The farther down slope one goes, the greater are the problems arising from alkalinity, poor drainage etc. Indeed such is the combination of heavy texture, clay composition and alkalinity that cultivations will prove difficult and costly, whilst plants will suffer droughting as a result of impeded rooting due to poor drainage, low permeability and root tearing during soil cracking. On the other hand the clays demonstrate high available moisture percentages, and in this respect compare favourably with sugar growing soils in other parts of Nyanza. The area involved is some <u>18,000 acres</u> under an estimated rainfall of 40" - 45" falling in 2 distinct seasons (March/May and September/November).

It is considered (without experimentation) that about <u>10,000</u> of these acres could be reclaimed for arable. Reclamation would involve inexpensive bush clearance but costly initial soil breaking. Gypsum would be applied at ½ ton an acre (i.e. £3 an acre). Further applications each of ½ ton will be required on some of the more alkali spots and it is calculated that as much as 2 to 3 tons may be eventually applied. This might involve an overall investment (for 10,000 acres) of up to £100,000 for gypsum. Costs for heavy land cultivations, ditching and ridging, planting, fertilizer (ammonium sulphate) herbicides and insecticides (assuming cotton is the chosen crop) come to an estimated 355/- per acre.

This figure could be slightly reduced by combining ploughing and harrowing in one operation using a power driven disc plough. It might also prove possible to incorporate fertilizing, planting and herbicides into one treatment. After 5 years of soil improvement, given adequate drainage measures, yields of cotton should top 1500 lbs.

The soils at present grow a fine association of tall SETARIA and THEMEDA grasses. With nitrogen top-dressings the grass could be expected to be highly productive though its composition might be altered under rotational grazing or a cutting regime. The soils are well suited for growing grass, though they might deteriorate during the 3 months of the "long rains" when soil puddling would tend to damage the grass and the surface soil structures. Factors in favour of grazing the land include the simplicity of the operation compared with soil reclamation (requiring fewer agriculture officers) and the absence of any need for bush clearance. A further 4000 acres of poorly drained and stunted low potential grassland might provide reserves of dry season grazing.

Of the remaining land, some 11,000 acres is probably best suited to forestry for reasons of slope, stoniness, seepage or a positive need for soil and water conservation. The area involved comprises the less bouldery hillsides on both sides of the valley and certain areas of limited extent and shallow soil towards the Northern end of the valley. About one third of the entire valley (30,000 acres) is unsuitable for development. This may be due to dense bush covering poorly drained lands which do not merit expenditure on bush clearance (8000 acres); or due to surface alkalinity, poor drainage or a combination of the two in level areas of the valley bottom where the high clay content (70 - 90 %) renders reclamation and drainage out of the question whilst severely restricting the rooting of naturally occurring grasses; or due to the shallowness of the soil cover, gullying and bouldery surface horizons.

b) WATER.

Lake waters are of excellent quality, but the slopes involved probably render pump irrigation from the lake uneconomic except on a small area of very heavy clays near the mouth of the Olambwe river. Here the soils (80 - 90 % clay) are poorly drained and extremely alkaline and it is hard to visualise irrigation justifying the costs of pumping, drainage and infrastructure.

Water from the valley sides generally passes under the lacustrine deposit and the Olambwe river rarely flows outside the period of the long rains. 5 perennial streams flow off the hillsides and each of these could be dammed to provide surface water. Water derived from the Ruri Hills is often contaminated by radio active thorium and is consequently unsafe to drink.

The main potential source of water lies beneath the lacustrine deposits, where conditions are ideal for natural storage, the only limiting factor being the depth of the hydrostatic level. Deep drilling should be successful anywhere in the valley and a yield of 50,000 gallons a day may be anticipated. Despite a higher than normal content of fluoride, the water is fit for human consumption. It does however contain a relatively high bicarbonate concentration. Before being used for irrigation the waters would require to be fortified with gypsum.

c) TIMBER.

Apart from natural forest near the summits of the Gwasi Hills and a few acres of experimental forestry (mostly Pinus radiata), the only sources of wood for fuel and hut poles are the mid-valley areas of dense bush; with savannah trees on the escarpment, the Ruri Hills and associated phonolitic cones. An increased valley population would have the effect of assisting in bush reduction (and hence tsetse control), but would necessitate the growing of forests along the hillslopes.

7. GENERAL RECOMMENDATIONS.

1. Automatic rainfall recorders should be installed in the valley to provide a more sophisticated assessment of rainfall patterns. A Rainguage should be established on the trial plots.

2. The escarpment in the East and the slopes of the GWASI HILLS where these are not already too strongly eroded should be planted to trees as a matter of priority. Afforestation should also be contemplated on many of the shallower soils between OBANDO MARKET and the LAKE. Research is sufficiently far advanced for proposals to be made regarding suitable tree species. Planting should significantly contribute to the conservation of soil and water resources, besides providing a source of fuel and timber for an expanding valley population.

3. Much attention has been paid to the problems posed by trypanosomiasis and the need to control, though not eliminate, the tsetse. The control of malaria is an equally urgent problem. Cattle could be kept on the proposed ranch even with the present tsetse population provided they were well drugged. Attention should be paid to other enzootic cattle diseases prevalent in the valley.

4. The cattle disease question will be the more easily resolved by the elimination of the game animals. This is an admittedly controversial point but it should be clearly recognised that any increase in settlement sows the seeds of game destruction. Since it is unlikely that the few remaining herds of game can be successfully resettled on the MARA, elimination is the logical step. Game and Pest control would ensure the successful establishment of poultry enterprises.

5. The dynamics of bush regeneration are not as yet clear. Whilst bush is rapidly spreading in parts of the Settlement scheme, especially the SAMUNYU valley, it may be that the spread of the major valley thickets is prevented by fire and the local needs for fuel and for hut construction. Research has shown that a tsetse habitat can regenerate in as little as 3 years. Immediate action should be taken to prevent the further spread of bush on the Settlement Scheme and in the RUMA fly barrier.

6. Communications within the Valley should be greatly improved.

7. The provision of further boreholes and water points will be essential for ranching. The streams - OGONGO, GOYO, SIWALO and KAMKWAGI - should be provided with dams for dry season watering. A dam with sluice gates might also be constructed in the WIGA VALLEY: this could be used for cattle and for the minor irrigation of some 100 acres.

8. Dissension amongst the Ministries as to the future pattern of land use taken together with potential conflict between the Central Government and the local valley authorities over the heated question of land tenure only emphasise the need for an overall Lambwe Development Committee. Such a committee would provide an instrument for ensuring mutual understanding amongst the interested parties and joint consultation prior to effective action.

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APPENDIX. 1.

SUMMARY OF SOIL SURVEY LAND CLASSES

CLASS 1. HIGH POTENTIAL ARABLE

1. Roo Valley. 1000 acres
2. Magunga Valley 150 acres
3. Ogongo Valley 350 acres
4. Wiga Valley 300 acres
5. The narrow belts of occasional higher-lying reddish clays below the Gwasi foot-hills, the lower slopes of the escarpment and of certain volcanic plugs.

Total :- 3%

2500 acres.

CLASS 2. SUITABLE FOR CASH CROPS OR LEYS

1. Higher lying black and very dark grey clays of 50 - 60% Clay content, reasonably well drained, on slopes exceeding $1\frac{1}{2}^{o}$. These soils occur on both sides of the valley to the South of a line through WAONDO and the SINDO PASS and North of a line through SIGAMA to GOT RABONDO. These class 2 soils generally occur as a narrow belt along each side of the valley.

2. Deep dark brown clays of a similar texture on plateau sites on both sides of the main MBITA Road for 2 miles to the North of Obando.

3. The lower alluvial fans below
   (a) The WIGA Valley
   (b) The Magunga Valley

4. An area of Colluvium-affected soil below SIGAMA Hill. 600 acres.

A fair proportion of these soils are already incorporated into the existing settlement area, or are otherwise cultivated. The soils should be cultivable by relatively light equipment and require no special remedial treatment other than fertilizer applications (ammonium sulphate) and attention to good husbandry.

Total :- 10%

8000 acres.

CLASS 3. SOILS EASILY AND ECONOMICALLY RECLAIMABLE; THEN SUITABLE FOR CASH CROPPING, FODDER CROPS OR LEYS.

1. Slopes generally exceeding 1^{o}, excluding seepage zones and an area of heavy clays North West of SIGAMA Hill.

2. Lower lying areas of the OGONGO Valley.

3. The ASINA Valley; 1500 acres.

These soils should be surface drained with open ditches, deep ploughed with crawler tractors and fertilized with ammonium sulphate prior to planting on ridges (assuming that cotton is the cash crop).

Total :- 10 %

8000 acres.

CLASS 4. HIGH POTENTIAL GRASSLAND

These large areas of very heavy slightly poorly drained black or very dark grey clays have alkaline subsoils. Surface layers non-alkaline.

They occur on both sides of Central areas of the valley, but the largest extent lies to the East of GWASI and RINGA ANYUMBA.

Total :- 22%

18,000 acres.

CLASS 5. LOW POTENTIAL GRASSLAND

Lower lying sites on slopes of less than 30'. Site development is limited by a combination of heavy texture, alkalinity and seasonal waterlogging.

1. Areas of low lying land towards the Olambwe.

2. OGONGO flood plain and environs.

Over two thirds of this land is covered by dense low thicket, expensive and unrewarding to clear. If the thicket remains (and tsetse is reduced by means of aerial spray) then much of this dense bushland must be considered "unsuitable" for development.

Total :- 14%)
11,500 acres) assuming bush clearance.

4%)
3,500 acres) Bush uncleared.

CLASS 6. "LAND BETTER SUITED TO FORESTRY"
For reasons of either.

a) Slope.
or b) Stoniness and local nature of soil distribution.
or c) Seepage.
or d) Need for soil or water conservation.

1. Kaniamwia escarpment.

i Deeper soil pockets.
ii Areas of weathered lavas.
iii Seepage zones near scarp base; though these might be tried for sugar.

2. Gwasi foot hills.

3. Rolling topography unsuitable for agriculture for reasons of seasonal flooding, alkali, or stony hill slopes; between GOT OPOLO and the Lakeshore.

Total : - 14 %

11,500 acres.

CLASS 7. "HIGHER LYING SWAMP"

Insignificant areas of lake shore, especially round the mouth of the Olambwe River. Small patches capable of reclamation, ridging and preparation for sweet potato or rice.

Total :- Negligible.

CLASS 8. "UNSUITABLE FOR ANY DEVELOPMENT"

1. Lake shores.
2. Very shallow stony soils on the Kaniamwia scarp and in the Gwasi foothills, including KIGOTO spur and GOT RABONDO.
3. The shallowest soils on the upper slopes of KWOYO Hill.
4. All the soils, due to the boulders, between the ROO Valley and Obaluanda.
5. The stony ridges on each side of the OGONGO valley and above Luanda.
6. Low lying alkali flats of OLAMBWE alluvium subject to seasonal floods.

   i. Alluvium at the North end of the valley and associated tributaries - due to intense alkali.

   ii. Certain middle reaches, South of GOT JOPE, which are under thicket, and subject to flooding.

   iii. The Nyaboro Bush and associated areas of ACACIA SEYAL woodland in the South of the valley - due to surface alkali and seasonal flooding.

7. Bouldery areas on slopes and hill tops between GOT OPOLO and the lake.
8. Phonolitic cones.
9. Plateau sites around WAONDO and towards GOT ARIYO.
10. Alkali flats and gullied valleys between GOD NGOCHE and MIRUNDA BAY.

Total:- 26 %)
21,500 acres) Assuming valley cleared of bush.

34 %)
29,500 acres) bush uncleared.

4. Very dark brown medium calcareous clays over weathered and secondarily calcified phonolites or calcareous tuffaceous rocks.

Plateau sites around Waondo. Poor soils for cropping and food crops. Should be considered Class 8 so far as highly capitalised agriculture is concerned. Grows the best cotton in Lambwe at present on 6 to 12 inches of soil, presumably because good permeability permits the deep rooting which is restricted by alkalinity and poor cultural methods on deeper soils.

Class 6 or 8.

5. Very dark greyish brown soils over melanephelinite lavas.

a) Strongly weathered clays.

b) Poorly weathered rubble of clay loam texture.

Class 6.

6. Black alkali clays over calcified gravels and caliche. These gravels are exposed by erosion along minor gullies flowing off the South of South Ruri and form part of the settlement scheme area.

Class 5.

7. Heavy black clays near seepage lines with a relatively high organic content. Over melanephelinite boulders.

Class 8.

B. DEEP SOILS.

1. Heavy Black neutral clays. In small pockets on the side of the escarpment. Deep rooting mostly of IMPERATA CYLINDRICA 65 - 75% clay. Fine soils for forest trees.

Class 6.

2. Well drained somewhat gravelly clays and clay loams of a reddish hue, and of a lowish moisture holding capacity.

a) Acid gravel beds of limited extent in the Olambwe valley, covered in very stunted and dried up THEMEDA TRIANDRA.

Class 8.

b) A calcareous subangular blocky clay forming sides to the extreme South end of the Asina Valley, occuring along the road round the North side of North Ruri. This clay is alkaline below about 20 inches, and has a very hard consistence.

Class 3.

3. Dark Reddish Brown to Brown medium clays. Slopes exceed 2° on the Gwasi Side and 3° on the South Ruri side. Good root penetration. 50 to 60% clay. Occasional melanepheline boulders at depth. Forms a narrow border to the South Ruri slopes and is also found, rarely, on Gwasi Side. Hard consistence. The only material containing significant amounts of halloysite in addition to illite and montmorillonite.

Class 1.

4. Dark Brown medium clays of a more friable consistence than (3) above. Found extensively on both sides of the Roo valley on slopes less than 5°. Covered in thicket and occasional clearings with <u>CHLORIS GAYANA</u>, <u>CYNODON DACTYLON</u> and <u>SETARIA SPHACELATA</u>. Excellent root penetration. 55 to 70% Clay.

Class 1.

e.g. "PONGE 2" : Data follows.

5. Very dark greyish brown heavy clays receiving drainage and hill wash gravels from off the Kaniamwia escarpment. Dominated by low thickets of <u>RHUS</u>. Gravel layers within the well drained profile.

Class 2.

6. Relatively friable alluvial clays and sandy clays with fine gravel lenses. Well drained. Excellent root penetration.

a) Deeply decalcified very dark brown material e.g. The Magunga and Opuch Valleys.

b) Very dark greyish brown material calcareous throughout. e.g. The Ogono Valley.

Class 1.

7. Very dark brown plateau clays with good root penetration. Boulders at a very great depth (more than 5 feet). 65 - 70% clay. Matrix decalcified, but with calcium concretions quite high in the profile. When dry possesses consistences no harder than "Hard" and has only weakly developed prisms.

Class 2.

e.g. "MBITA 6" : Data follows.

8. Very dark greyish brown plateau crest clays with fairly good root penetration. 65 - 70% clay. Matrix decalcified, but with calcium concretions deep down in the profile.

When dry possesses consistences harder than "Hard" and has weakly to moderately developed prisms. Occurs in belts below plateaux and flattish hill tops along and to the West of the main road to Luanda. Also found on the tails of the Magunga and Wiga Valley alluvial fans.

Class 2.

e.g. "L 1. P. 2" : Data follows.

9. Very dark brown calcareous clays of slope situations with calcium concretions high in the profile. 60 - 65% clay. Both sides of the Asina valley and on the upper slopes stretching towards the Olambwe Valley below the main road to Luanda. Fairly good root penetration, though containing occasional fine and medium stones.

Class 2.

e.g. "ASINA 2" : Data follows.

10. Very dark greyish brown clays containing alkaline subsoils associated with calcium concretions. Severely impeded rooting.

a) With 65 - 70 % clay.

i) With approximately 20% Sand. On slope situations receiving drainage. Strongly alkaline subsoils. North of Got Jope.

Class 3.

e.g. L 11. P. 2 : Data follows.

ii) With approximately 10% Sand. Alkali subsoils. On, and in proximity to, valley bottoms receiving drainage. Asina Valley.

Class 3.

e.g. Waonda 2 : Data follows.

b) With 55 - 65% Clay. Very dark grey. On slopes receiving drainage down drainage channels off the Ruri Hills, often associated with thickets of ACACIA DREPANOLOBIUM.

Class 3.

11. Black or Very dark grey medium clays of sloping situations (3° - 1°). Moderately developed prisms when dry. 5 - 6% organic matter. Rooting somewhat impeded. 65 - 70% clay, but with a relatively high sand content in the surface 6 inches (50% clay). Subsoils not alkaline or only slightly so. The soils occur along the upper slopes of the lacustrine apron enveloping the South and West sides of the Ruri Hills and the East side of Gwasi. Contain Montmorillonite and Illite in proportions about 50 : 50.

a) Deeply decalcified.

Class 2.

e.g. Wiga 3 : Data follows.

b) Matrix decalcified, but with calcium concretions below one metre.

Class 2.

12. Mixed Black clay alluvium in active stream gullies (v - shaped). Resorted material. Often with lines of calcium concretions differentiating layers of separate origin. Very local and of negligible extent.

Class 5, 6 or 8.

13. Medium Black clays of local seepage zones. Surface layers contain about 60% clay and 8% organic matter. Subsoils 70% clay with strongly pronounced lentil structures bearing well marked slickensides. Non-saline; non-alkaline. Rust mottles scattered through the profile with incipient gleisation at depth. Especially found along the base of the Kaniamwia escarpment; only North of Sigama. Some standing water in rainy seasons, especially where these zones form the base of active streams flowing off the escarpment. e.g. The Goyo and the Siwalo. Associated with <u>Imperata cylindrica</u> and occasional stands of <u>Acacia fistula</u>.

Class 6
Class 3 with drainage: ? suitable for sugar.

e.g. Scarp 6: Data follows

14. Very dark greyish brown light clays with alkali in the potential rooting zone. On colluvial slopes at the base of the South Eastern end of the Kaniamwia escarpment. ? out-wash material 50 - 60% clay. Hard and strongly prismatic to the surface when dry. Restricted vegetation cover with impeded rooting. Area confined to a narrow belt by the Scarp on the East and the Olambwe to the West.

Class 5 or 8.

15. Heavy very dark grey clays of the lower valley slopes (range 2° - 1/2°). These soils are extensively found in the valley, and Soil Group 15 is by far the most important in terms of acreage, covering most of the Central areas. 4 - 5% organic matter. Topsoils black and somewhat lighter in texture than the very dark grey moderate to strongly developed prismatic second layers. Consistence when dry is at least as hard as "Very Hard". Below the prismatic layer is a dense very hard material often alkali, containing a mat of root galleries. Few roots venture below this into the dark grey alkaline subsoil. These subsoils are often blotched and contain manganese cutans

and concretions, a result of mobilization and partial gleisation. Matrix deeply decalcified, but the alkali layers are generally associated with at least common manganese and calcium concretions. Lentil structures are normally found in the subsoil. Clay content 60-80%.

a) Slopes normally exceeding 1°. Subsoils only slightly alkali or not alkali at all. Light clays or clay loam surface 6 inches cover 75% clay subsurface layers. Calcium concretions, mobilized manganese and evidence for glei are concentrated below one metre. The proportion of illite to montmorillonite is about 50:50.

Class 4.
Class 3, if required for arable. Extensive surface drainage will be required.

e.g. Forest 7: Data follows.

i) As for 15 (a); and containing a layer in the subsoil of weathered phonolitic rubble. This rubble maintains an improved drainage and a lower level of alkalinity. Calcium concretions occur below 2 feet. 70 - 75% clay throughout. The extent of this soil has not been ascertained, but it would appear to cover about one square mile on the East side of the Olambwe (North East of Gendo Hill and around the South East end of the path across the valley from Got Rabondo).

Class 3 or 4.

ii) As for 15 (a), but generally heavier with scattered rust mottles in the profile. Contains an extremely labile montmorillonite - like clay "mineral" accompanied by illite. More than 65% clay in the topsoil and with 80% clay in the subsoil. Again the area of this soil has not been accurately delimited, but it would appear to cover about 2 square miles to the North and North West of Sigama Hill and to the East of the Olambwe.

Class 4.
Class 3, if required for arable.

e.g. Scarp 11; Data follows.

b) Slopes normally less than 1°. Subsoils strongly alkali. Extremely hard with marked vertical cracking when dry. Sometimes a few rust mottles in profile. Calcium concretions occur in the surface metre and below this there is weakly developed glei of a dark grey and dark greyish brown somewhat blotched material. The clay fraction is dominated by well crystallised montmorillonite. Between 60 and 80% clay.

Class 4.

e.g. Forest 11 : Data follows.

i) As for 15 (b), but with surface layers also somewhat alkali. Strongly developed prismatic structures extend to the soil surface. The alkalinity is not intimately associated with calcium concretions, but fine calcium concretions and gypsum crystals occur below one metre. Subsoil structural units characterised by blueish faces (? Reduced form of iron phosphate). Occurs beneath much of the Nyaboro and Riamkanga thickets, and also locally at the lower ends of the Northern tributaries flowing into the Right Side of the Olambwe. 70 - 80% clay. Subject to seasonal flooding.

Class 8.

e.g. L 1. P 1 : Data follows.

16. Heavy very dark grey clays with calcium concretions tending to be more or less distributed through the profile. (with the frequent exception of the surface horizon alone). Many calcium concretions coarser than "Fine". Profile seasonally affected by ground waters and therefore generally found on slopes less than 30' and not far above the level of the Olambwe or other streams (e.g. The Ogongo alluvium). With closer proximity to the streams, calcium concretions become more numerous and coarser in size. Away from streams as much as the surface 2 feet may be free of alkali. Usually signs of greyish brown glei and blotches at depth. Topsoil 65% clay; subsoils 70 - 75% clay. The alkali may be intense in the subsoil.

Classes 4 and 5.

e.g. Junction 1.: Data follows.

17. Strongly alkaline Black clays of seepage lines close to the Olambwe, and occasionally beneath the Kaniamwia escarpment (towards the Southern end). Severely restricted vegetation; often bare patches or scattered stands of Sporobolus marginatus and Pennisetum mezianum. Weakly developed sub-angular blocky structures. 50-60% clay.

Class 8.

18. Very dark grey exceedingly heavy gypsiferous clays severely alkaline to the surface. The gypsum crystallizes out closer to the soil surface the nearer the Olambwe is approached. The deposition of calcium concretions follow the same tendency. Hard when dry with weakly developed prisms. 80 - 90% clay throughout the profile. Occurs on the lower alluvial flats of the Olambwe and is associated with medium woodland of Acacia seyal and certain definitive herbs like Aloe.

Class 8.

e.g. L 13. P 2 : Data follows.

19. Lake shores and Swamps.

SOIL DATA AND PROFILE DESCRIPTIONS:-

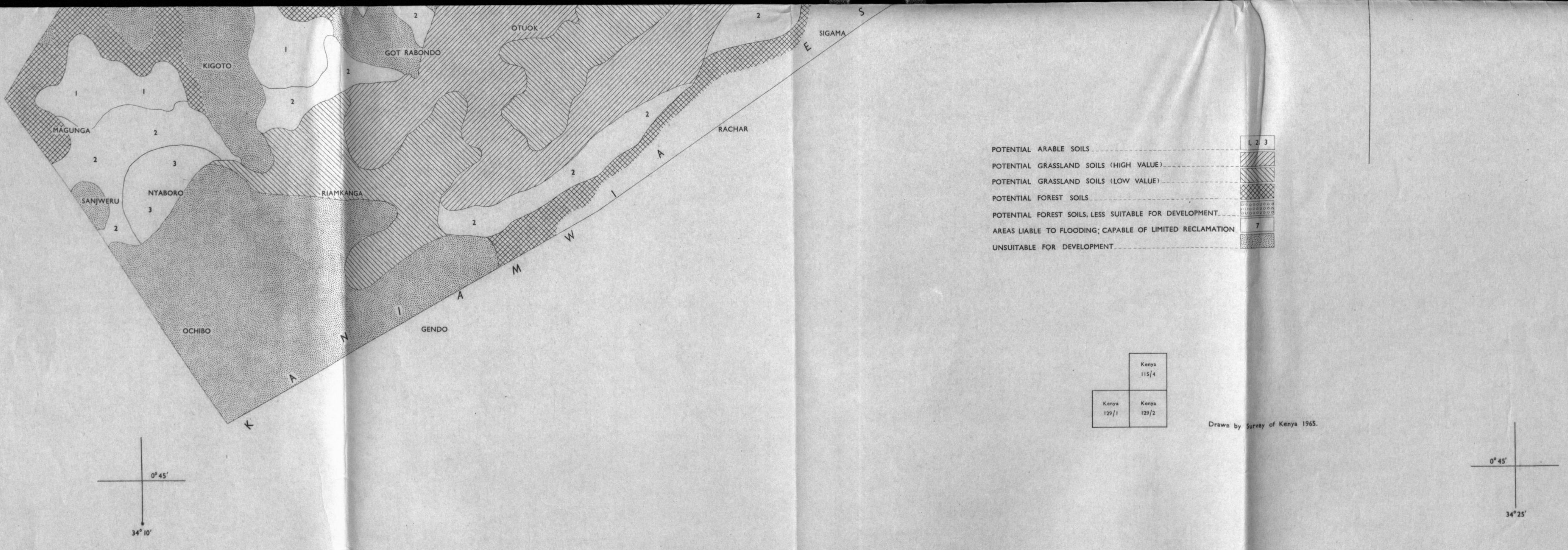
The detail of the field profile descriptions and the data of the soil chemical analyses are not included with this report. A limited number of copies of a supplement containing these items will be produced in due course and kept in the library of the Soil Chemistry Section, National Agriculture Laboratories, Nairobi.

LAMBWE VALLEY

AGRICULTURAL RECONNAISSANCE SURVEY LAND UTILISATION MAP

SOIL SURVEY UNIT 1965

SCALE 1/50,000


KIGOTO
GOT RABONDO
OTUOK
SIGAMA
MAGUNGA
SANJWERU
NYABORO
RIAMKANGA
RACHAR
OCHIBO
GENDO
K A N I A M W I A E S
POTENTIAL ARABLE SOILS 1, 2, 3
POTENTIAL GRASSLAND SOILS (HIGH VALUE)
POTENTIAL GRASSLAND SOILS (LOW VALUE)
POTENTIAL FOREST SOILS
POTENTIAL FOREST SOILS, LESS SUITABLE FOR DEVELOPMENT
AREAS LIABLE TO FLOODING; CAPABLE OF LIMITED RECLAMATION 7
UNSUITABLE FOR DEVELOPMENT
Kenya 115/4
Kenya 129/1
Kenya 129/2
Drawn by Survey of Kenya 1965.
0° 45′
34° 10′
0° 45′
34° 25′