Overseas Development Administration

SOIL AND WATER CONSERVATION IN EMBU AND MERU DISTRICTS, KENYA

MAIN REPORT

T F SHAXSON

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TEXT MAPS

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I would like to express my sincere appreciation to all those who so generously gave their time to accompany me on wide-ranging field visits and to discuss the many matters that arose during the course of my visit. I am also most grateful to the staff of the British High Commission and others who provided administrative assistance and made the various arrangements for travel, accommodation and other matters.

T F Shaxson

PART 1. INTRODUCTION

1.1 ORIGINS OF THE VISIT

In October 1980 the Kenya Government submitted a request to the British High Commission in Nairobi for the services of Mr T F Shaxson, Soil and Water Conservation Specialist and ODA Corps of Specialists Officer, in connection with the Embu/Meru Project. This request was granted and Mr Shaxson made a reconnaissance visit to Kenya during the period 3 November 1980 and 9 December 1980, which included a 2-week trip to the field.

1.2 TERMS OF REFERENCE

Mr Shaxson's Terms of Reference, drawn up and agreed to by the Kenya Ministry of Agriculture and the East Africa Development Division of ODA, were to:-

- Determine the extent of the soil erosion problem in and adjacent to Embu and Meru Districts, with particular reference to the medium and low potential areas in those Districts.

- Define the project area.

- Determine the underlying reasons for and causes of the soil erosion.

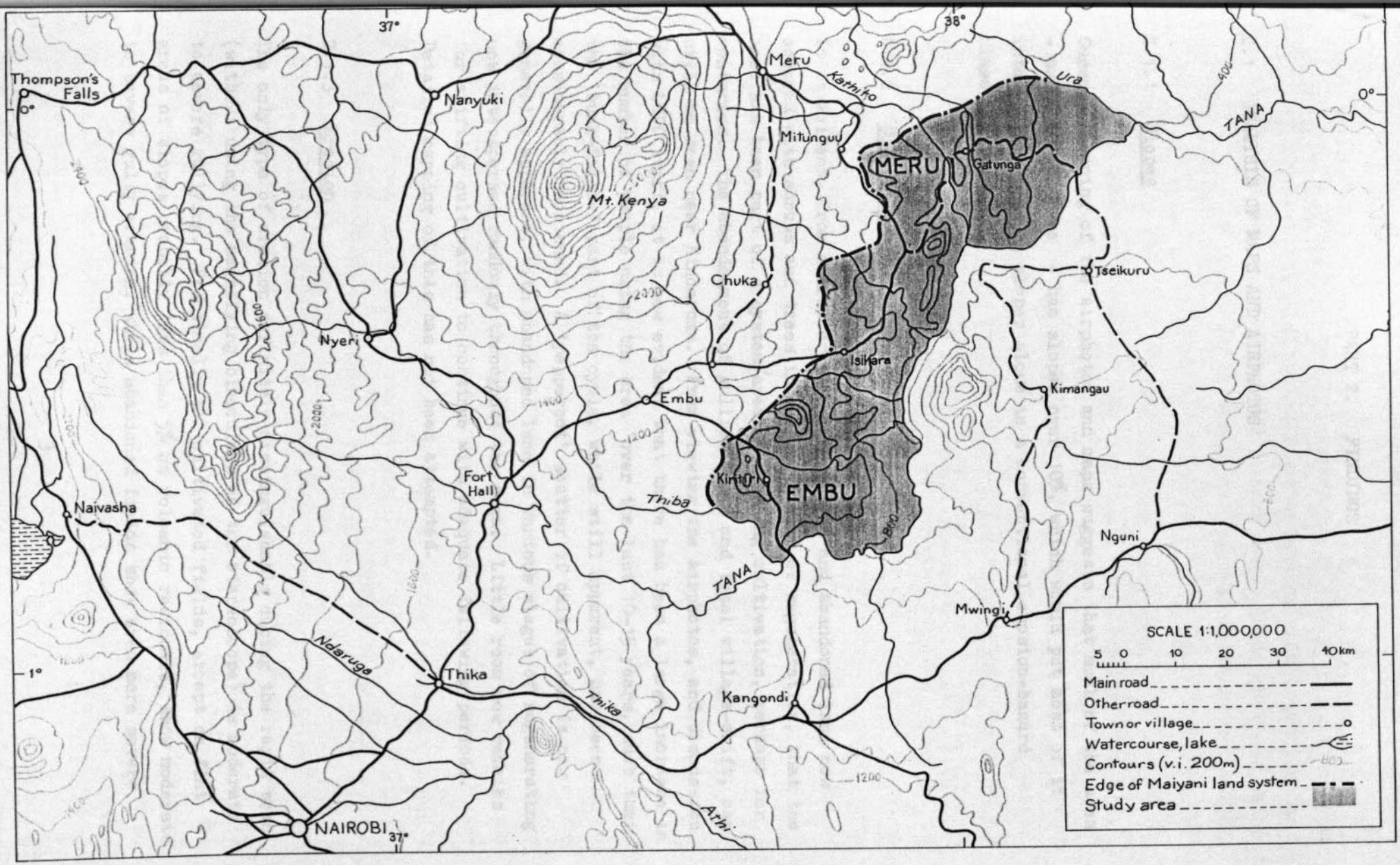
- In the light of the above, draw up proposals for UK assistance with the control of soil erosion at an acceptable level within the project area.

1.3 PROJECT AREA

For environmental reasons erosion problems are less catastrophic at altitudes above 4 500 ft in Embu and Meru Districts, so the study was confined to areas lying below this level.

Following aerial photographic interpretation at Tolworth and field visits and discussions in Kenya, an area of approximately 3 200 km^2 with particularly severe land use problems was identified for closer study (Text Map 1). It extends from Mitunguu to Kiritiri, and from Ishiara to the Tana River. It is underlain by Basement Complex rocks and has the broken topography with steep side slopes and dentritic drainage pattern of the Maiyani Land System.

The dominant vegetation is Acacia/Commiphora shrubland and thicket with herbs and shrubs but very little grass. Much of the area has a 10-20% chance of receiving less than 20 inches of rain annually. It is widely used under a system of shifting agriculture and communal grazing and is suffering from heavy grazing pressure and cattle trampling. There is evidence of sharply increased population pressure over the past 10-15 years and an associated shortening of the bush fallow part of the cultivation cycle.



TEXT MAP 1 Study area

Rep 109/KEN/TFS/1

Prepared by Land Resources Development Centre 1981

PART 2. FINDINGS

2.1 ANALYSIS OF MAPS AND AIRPHOTOS

2.1.1 Slopes

Cursory scanning of the airphotos and maps suggests that much of the area - maybe 60% or more - has slopes over 10%, which would put most of it into 'non-arable' on slopes alone in a conventional erosion-hazard classification.

2.1.2 Cultivation

It is evident, from characteristics of gullied and abandoned land now covered with shrubs and trees in various stages of regeneration, that the area has been part of a system/area of shifting cultivation, perhaps for centuries. The abandonment of gullied land, and total village-shift, can still be seen near Kindaruma. From viewing the airphotos, and discussion with LRDC staff, it is now evident that there has been a large increase in the number of people using the area over the last 10-15 years, such that the 'bush-fallow' part of the cycle, while still apparent, has been considerably shortened. A 'pepperpot' scatter of cultivation is now generally apparent, with abandoned land in various stages of regenerating now interspersed randomly throughout the area. Little room now remains for shifting cultivation to continue with adequate fallowing periods. Detailed mapping of this has not been attempted.

2.1.3 Erosion

The only type of erosion definitely distinguishable during the rapid scan (without using the magnifying binoculars on the stereoscope) is moderate to severe gullying. Practically all cultivated fields, except on flat areas of slopes probably less than 5% on volcanic residuals, show moderate to severe gully erosion, while abandoned fields show even more severe

gullies from past cycles of cultivation. Though no figures are to hand, I am told that highly-erosive rainfall occurs at intervals during the rains, the short sharp storms causing most of the erosion. Few if any physical conservation measures can be seen on the airphotos.

2.1.4 Grazing

Except in a few areas, the presence of large numbers of livestock is indicated by very high reflectance from trails and gathering-grounds, which may be in the apparently uncultivated shrublands, or more commonly on recently-abandoned land. Gullies in such areas were probably initiated during the cultivation phase. Cattle effects have been more to remove grass and shrub regrowth and to trample and compact the surface over large areas, taken in aggregate between the cultivated fields. There appears to be almost no evidence of grazing on the volcanics of Chuka and Kiambu Land Systems.

2.1.5 Erodibilities

In a few places very erodible soils and rocks obviously suffer worse gullying per unit area per unit intensity of use. It appears that the bulk of the gullying damage in any particular place is fairly closely related to the percentage area under current cultivation and the severity of slope. These two features are probably far more significant than relatively small variations in soil erodibility in determining the severity of gully erosion.

2.1.6 Sediment in streams

Apart from volcanic-outwash tongues (which are clearly seen as flat areas on the airphotos) there is little or no evidence that sediment is re-deposited within the general area. These are no large deposition areas, and presumably it all moves into and along the Tana River during the rains. While it is obvious that a lot of sediment in streamflow comes from this land on the Maiyani Land System, it cannot be discerned as yet whether the steep scarp faces and gorge-sides of the volcanics of the Kiambu and Chuka

Land systems are also actively eroding and contributing sediment of different character.

2.1.7 Surface runoff

The drainage pattern on the volcanic-derived soils above is often relatively diffuse or even not discernible on flat lands. This suggests very porous materials into and through which rainwater moves rapidly. While this seems to support dense cultivation and vegetation in higher-rainfall areas over 4 000 ft, it may also result in severely 'droughty' soil conditions under lower rainfall, as seen in the northern part of the Meru Game Park. On the Basement Complex materials, surface runoff appears much higher, both from landscape form and evidence from eroded cultivated lands. Because crop cover is likely much worse than that of the (relatively) undisturbed bush country (e.g. southern part of Meru Game Park) agricultural use encourages a higher ratio of runoff : rainfall. Trampling and compaction by cattle evidently make matters worse on abandoned land. All the signs are that an increasing proportion of the already scarce and erratic rainfall is being lost as runoff, to the detriment of vegetation, soils, crops, livestock and man.

2.2 INFORMATION FROM FIELD VISITS

2.2.1 Soil compaction

The actual severity of soil-surface compaction is however worse and more widespread than was apparent from the airphotos. Even the soil beneath the tree/shrub canopy was seriously affected by grazing and trampling, as was that of areas recently abandoned from the previous season's cultivation which then became subject to 'uncontrolled' grazing.

2.2.2 Cultivation : grazing variation

Although not quantified by precise measurement on the airphotos or on the ground, it is apparent that the ratio of land used for shifting cultivation

to that used for grazing was higher to the west and lower to the east. This is correlated with lower and more erratic rainfall in the east at lower altitudes. If the same density of stocking per km^2 of cattle, sheep and goats obtains over the entire area, then one could deduce that animal-keeping was relatively an increasingly important human activity under drier conditions. Because of the increasing fragility of the ecosystems in the drier areas, it is likely that a constant degree of excess grazing 'pressure' will cause greater damage in drier areas than in wetter areas.

2.2.3 Predominance of grazing

In the study area, cultivation for subsistence cropping is inextricably mixed with grazing activities. On the basis of airphoto analysis, some 60–70% of the area is affected by these activities (cultivated and reverting fields plus obviously denuded/trampled areas identified both on airphotos, and by ground check). Of the areas thus affected, around 10 to 20% might be in cultivation in any crop season, and therefore protected from stock. Thus some 80–90% of the affected area is subjected to more or less continuous grazing pressure.

2.2.4 Length of shifting cultivation cycle

It was difficult to tell the length of shifting cultivation cycle, though the original airphoto interpretation indicated that it was in most places only a few years, rather than so long as to allow full-canopy regeneration and shifting of whole villages. One informant near Marimanti indicated that he would have to return to the shamba he was then cultivating in about 4 years' time. At a guess, the cycle is nowhere more than 10 years in this area and probably nearer 4–5.

2.2.5 Vegetation and changes

The dominant vegetation is Acacia/Commiphora shrubland and thicket, with herbs and shrubs but very little grass. There is some evidence that some 50 years ago this was a parkland/savanna type of grassland and that thorn

thicket has been increasing to the detriment of grassy cover as grazing pressure has increased (Brokenshaw, 1971).

2.2.6 Rainfall intensities

We have not seen the available information on actual short-period rainfall intensities expected in the area. However, there is a publication 'Rainfall Frequency Atlas of Kenya for durations from 10 mins to 24 hrs, and return periods of 5-100 years', from Director, MOWD. The description of rain as 'coming in heavy downpours' indicates, as one expects in such areas in the erratic/low-rainfall areas of the tropics, that short term intensities are indeed high.

2.2.7 Effective and ineffective rainfall

Water runoff, and associated losses of soil from the overall surface and from gullies, is serious and probably worsening as pressure of human and animal populations continues to rise. Rainwater, scarce in amount and erratic, does not completely soak into the soil where it falls, and maybe 50% of all incident rainfall is lost as runoff, causing erosion as it goes, i.e. only (say) 50% of rainwater becomes soil moisture available for plant growth. For an annual rainfall of (say) 600 mm, 300 mm would thus be 'ineffective', while only 300 mm would be 'effective'. This has serious implications for plant growth.

2.2.8 Topsoil loss

In many areas it appears that much of the biologically-active topsoil has already been lost by erosion, judged on colour gradations of the remaining material on the areas near gullies, and the presence of many stones and gravel on the surface, among rills and small gullies which have cut into the profile for varying depths.

2.2.9 Rates of soil loss

There are few indications of actual rates of soil loss from this area. Ongweny (1979) has indicated that over 4 000 tons per km^2 (40 tons per hectare) are being lost from steep cultivated lands in the NW portion of th Tana catchment, but this is from volcanic soils of very different characteristics. Data from the study area was not seen. One can judge however from the appearance of the land that losses by accelerated erosion in this area are far in excess of the rate of A-horizon formation, let alone the rate of subsurface rock-weathering. Both of these soil-forming processes are in any case undoubtedly slower in these drier areas than on wetter area near Mt Kenya and the Nyambeni mountains. Truncation of the soil profiles by erosion is occurring at a rapid and possibly accelerating rate, and is well in excess of 11 tons/ha/ann, the conventional figure for a stable situation. In these conditions, so unlike those for which the method was developed, the use of the Universal Soil Loss Equation to calculate soil losses is not applicable. Attempts to calculate soil losses in this way produce answers which are not verifiable. It is sufficient to say that the situation is so serious that any activity which diminishes runoff and soil loss is worth applying even if actual soil loss rates are not known.

2.2.10 Population increase

Although there is some movement of people into the area from higher altitudes as well as from across the Tana River, there is apparently also movement of people out of the area, and the two effects cancel each other out. Moreover, such migrations are small, so that the net increase in population over the last 10-15 years is due to natural increase of the local population.

2.2.11 Need for water

We were informed by many that the prime need of the area was for water supplies for domestic and stock-drinking purposes. In drought conditions people have to walk as much as 8-10 kms in each direction to collect water, an activity that seriously diminishes the time available for other activities in farm and home.

2.2.12 Attitudes towards domestic stock

Most herds we saw were mixtures of cattle, sheep and goats. The people of the area like keeping stock. Amongst other reasons they are also kept as a 'walking bank account', animals being sold when cash is needed for various purposes. In times of drought many people wish to sell off animals, and prices are very low - one informant said he would expect to get only Shs 500/- for a bull, Shs 300/- for a cow and Shs 150/- for a calf, or even less, at such a time. Conversely, in times of drought food prices are high, so the exchange rate is then particularly bad. People wish to increase their herds so as to have more 'cash on the hoof', a hope that is at variance with the amount of feed available. A special problem relating to this method of keeping cashable assets is that the assets fluctuate wildly in value, and are usually realised when market values are very low.

2.2.13 Farmers' enthusiasm for improvement

On two occasions we were informed of the tremendous interest in improvement shown by specific farmers' groups who attended training courses specially arranged for them. Not only did several more arrive than were expected but they showed enormous keenness to learn new methods. We spoke at length with a farmers' group in Tharaka who showed clear understanding of the need to, and possible benefits of, change if feasible and acceptable improvements could be demonstrated.

Further examples of enthusiasm of farmers in the area is the apparently insatiable demand for trees - fruit, fuel and timber trees - and for grasses for fodder, particularly Napier grass var. Bana which seems better suited than many to survive the harsh conditions. All are very concerned about the lack of grass for the animals, but have no idea what can be done about it. We believe that this enthusiasm is probably widespread, even though not yet widely recognised.

2.2.14 Land adjudication

Little or no land adjudication and issue of legal title to land has been done in the dry areas of Meru - Tharaka and Nithi - though it has been largely completed in the Mbere division, a fairly similar area in Embu district. We were informed that where adjudication had taken place in other parts of Meru and Embu, and farmers were no longer free to undertake shifting cultivation and communal grazing, they began to take more care of their land, and were able to raise commercial loans for farming and other improvements against the security of the title deeds. Nevertheless, adjudication was viewed with some misgiving by one farmers' group in Tharaka who feared the effects of being confined to specified pieces of land especially in times of drought, fearing particularly the difficulties of feeding their animals, and the declining ability of more-frequently cultivated land to support their food crops. This has important implication which are discussed later.

2.2.15 Terraces and cutoffs

In the shifting-cultivation area of Meru District, few cutoffs or terraces have been made as part of the conservation programme. If a field is to be cultivated for one or two seasons before being abandoned once again to the trampling and grazing of animals, farmers see little point in exerting so much effort for so little apparent benefit, soon to be destroyed again. The real value of such measures under conditions of shifting cultivation and communal grazing is open to doubt.

2.2.16 Trash lines on the contour

These were often seen across fields, but unfortunately had little real effect, especially (again) where animal-movements etc. soon destroyed or removed them after cultivation had shifted elsewhere. If they <u>are</u> permanently maintained they can have a fairly spectacular terracing effect, as we saw in Mbere division.

2.3 EFFECTS OF EROSION AND RUNOFF LOSSES FROM THE AREA

2.3.1 Surface erosion

Erosion of soil surface layers by rainfall and runoff selectively removes available plant nutrients, thus diminishing whatever store of indigenous fertility the soil may have had, and lessening its potential to support adequate growth of plants.

2.3.2 Gully erosion

Gully erosion not only cuts down through the soil profile, removing cross-sections of the soil layers along narrow bands downslope, but also, by lowering the drainage base level, permits the subsoil more readily to dry out, as well as permitting the further extension of lateral gullies until they reach a new equilibrium.

2.3.3 Runoff loss

In these semi-arid lands, any runoff is a loss to potential soil moisture. This unnecessarily increases the severity and duration of root-zone drought stress, and thus adversely affects plant growth and survival more seriously than would otherwise be the case.

PART 3. ANALYSIS AND DISCUSSION

3.1 CAUSES OF THE OBSERVED SOIL EROSION IN THE AREA

3.1.1 Surface erosion

The chief causes of the surface erosion in the area are the impacts of high-energy raindrops in intense rainstorms falling onto soil surfaces which are inadequately protected by vegetation or litter, and/or whose surface structural conditions are readily broken down by such impacts.

3.1.2 Runoff

The chief cause of the high runoff percentage is the compacted and relatively impermeable soil surface, widespread throughout the area, which lets only a small proportion of rainwater enter the soil.

3.1.3 Compacted soil surfaces

The chief causes of the compact, impermeable soil surfaces are the hammering effects of intense rainfall and the compacting and trampling effects of animals' hooves.

3.1.4 Gully erosion

The chief causes of the gully erosion are the rapid, high-peak runoff events resulting from the bulk of the intense rainfall, which has not entered the soil, running off the impermeable soil surfaces.

3.2 CORE REASONS FOR THE PROBLEM

3.2.1 Inadequate recycling

Traditional systems of managing land, crops and stock depended in the past on long-cycle regeneration of vegetation and soil conditons, and the cycling of plant nutrients. The continuation of such low-input, low-output systems under conditions of increasing pressures of population and land use, accompanied by more frequent cropping and greater numbers of anima per unit area, now prevents adequate regeneration and recycling, and permits and encourages high losses of water and soil.

3.2.2 Erosion as a symptom of distress

Plant production and soil structural conditions have deteriorated, because they have not been adequately compensated by the essential improvements in management and production skills. Runoff and erosion become more severe, and can thus be seen to be a symptom not only of the land's distress, but also of the people themselves, unable to find ways of improvement to a situation they can no longer control.

3.2.3 Ecological imbalance

Traditional management systems of land, crops and animals in this area are no longer sufficient, under expanding populations and diminished bush-fallow cycle length, to maintain their productivity in the face of accelerating erosion, declining soil fertility and failing groundwater recharge. The continuation of inappropriate or inadequate management method is apparently also causing undesirable vegetational change towards unpalatable species. These are all symptoms of imbalance in the dynamic and ever-varying ecological relationships between men and land.

3.3 CORE OF THE SOLUTION

There are no purely mechanical/physical measures which will, on their own, significantly and permanently improve the erosion and runoff situation in the area. A package of physical and social measures will be required.

3.3.1 Rainwater into soil

The serious problems of water - and soil - loss can only be significantly diminished if most or all the rainwater soaks into the soil. This will be achieved through:-

- maintaining the soil surface in a porous condition
- ensuring detention of water on the surface to allow infiltration
- maximising the degree of cover to the porous surface afforded by growing plants, their residues and litter.

3.3.2 Improve crop and pasture husbandry, animal husbandry, land husbandry

The above can only be achieved on a lasting basis if all aspects of farming and land-use, in addition to physical conservation measures, are improved and made more productive and protective, and if 'conservation' becomes an integral part of better farming and other forms of land use.

3.3.3 Improve land management skills

The people of the area are the ultimate land managers, and improvement can only come about if their knowledge and skills increase, and if the necessary support - advice and training, infrastructural support, supplies of inputs, access to markets, etc. - becomes much more readily available to them. Specialised water and soil-conservation measures must be complements to, not substitutes for, an interdisciplinary approach to effective land husbandry.

3.3.4 Decision-making on an ecological basis

Those responsible for making in-field judgements and decisions about the means of achieving conservation farming on such lands need to make them fro ecological viewpoints - using an understanding of basic ecological principl which govern environmental relationships; and fostering an 'ecology of disciplines whose various specialisations will need to be used in harmony to serve the farmers in these areas.

3.3.5 Importance of management over time

Failure to identify the nature, direction, magnitude and rate of decline in agricultural/pastoral ecosystems due to erosion has too often precluded the specifying of positive overall ecosystem management as a vital and overriding necessity in programmes aimed at diminishing erosion and runoff. Such management implies both a continuation over time and the need for interdisciplinary approaches.

3.3.6 Gaining farmers' interest

Since the farmers are the ultimate day-to-day managers of these agricultural pastoral ecosystems, successful and lasting improvements in their capabiliti as managers can come about only if:

i. they have the knowledge and facilities to allow improvement

ii. their interest in improvement has been gained, by attention being given to solving their problems in what they consider to be the proper order of removing limiting factors.

3.4 THE PSYCHOLOGY OF WATER - AND SOIL - CONSERVATION

3.4.1 Soil and water conservation as part of a package of improvement

There is a heartening awareness in Kenya of the urgent need for effective

conservation of soil and water. However, physical soil conservation measures - such as cutoffs, terraces, etc. - do not usually result in rapid, obvious improvements in production of crops, pastures, trees, no matter how beneficial they may prove to be in the long run. Thus if the first evidence of Government's (or others') desire to help improvement in such areas is to undertake such conservation works, the response is usually less than enthusiastic. If however such an approach is accompanied by, or even preceded by, other effective parts of an improvement package which particularly also relate to betterment of water, crops and/or stock, the relevance and importance of conservation measures as part of the package are much more readily accepted, and the farmers' support more readily gained.

(For instance, everybody knows that an integral part of how to grow coffee successfully is to put it on contour terraces.)

3.4.2 Need for visible benefits

Unless this approach is followed, farmers are entitled to their doubts about the worth of 'conventional' conservation measures if they do not see any immediate real improvements happening as a result.

3.4.3 Farmers participate in decision-making

The most effective and lasting solutions to problems of the area will be those which are identified and decided in the closest collaboration with the farmers themselves. Technical know-how married to farmers' enthusiasm to improve their condition is a prowerful mix, if the result is keenly implemented by the farmers themselves. The self-confidence that can be generated in this way, among staff as much as among the farmers they serve, can be a potent means of achieving effective conservation as a part of better farming. Alternatively soil conservation alone without better farming is very often counter-productive, by generating apathetic or even negative attitudes, not only to erosion and runoff control but to other forms of advice and assistance as well. Effective and lasting conservation of water and soil is seldom achieved by frontal assault or by rote. More often it will be successfully achieved by stealth and by sensitive selection

of the most suitable strategy in each particular situation, based on careful analysis of ecological indications.

3.4.4 'No-failure' demonstrations

The key to good demonstrations is that they should not fail to show what is intended, and that this should emphasise positive benefits rather than negative or wrong practices. In such situations as these, one important criterion by which a subsistence farmer will judge demonstrations and recommendations is whether their adoption will increase or decrease his risk of disaster in bad years. Farmers in these areas are skilled artists in annual survival under difficult and erratic conditions. Apparent resista to change is much more usually motivated by praiseworthy caution than it is by lack of enthusiasm or ability to make improvements. Farmers' attitudes often are not necessarily 'problems' but rather they are alternative valid points of view within the framework of their available knowledge.

While considerable success in conservation work has been achieved in the higher-potential areas of Kenya, there is much less certainty about the most appropriate techniques of conservation farming in the arid and semi-arid lands. It is important therefore that some caution be exercised in deciding what can or should be demonstrated to farmers in order to satisfy the above 'no-failure' condition. The success of various practices will depend not only on technical suitability for the area or given situation, but also on its social acceptability or workability by the people themselves as the land managers.

3.5 PAST, PRESENT AND FUTURE TRENDS

3.5.1 Sequence of change

The present condition should be considered as a short term view of a long-term sequence of change in the ecosystems in response to rising populations and associated pressures. When there were few people and much land, the ecosystem was much more resilient to the effects of recurrent drought than

it is now. Man's demands on the land are relatively constant, while the ability of the land to satisfy those needs - water, food, pasturage - vary widely from season to season in response to weather conditions.

3.5.2 Population increase

If net population growth in the area is assumed to be say 2% then the population will have doubled in 35 years. Can the area sustain such a number of people even at subsistence level? Consideration must be given to determining what is the potential carrying capacity of the land for humans and their stock under erratic rainfall conditions even when all rainwater enters the soil? Under present low-level management, more and more land is being opened to cultivation (and ever-steeper and rapidly-erodible areas being used) as old land goes out of production due to erosion and as population increases. Without improvement in present management skills, the present decline will continue unchecked and at an increasing pace. One unlimited resource is solar energy. Another, not yet fully exploited, is rainwater. How can these, together with the soil and the fruits of appropriate research, be put together to slow down, or even reverse, the decline by improving plant production?

Lateral spread onto ever-more unsuitable areas can only be countered effectively by generating increased plant production - and hence better land protection - per unit area of land already in use.

3.5.3 Develop human and natural resource potentials

Unless effective and acceptable solutions to the problems can be identified and implemented, the present decline - in soil fertility, water loss, gullying, vegetation change - will continue. What is presently termed 'overgrazing' and 'excessive cultivation' are not necessarily irreversible, because they are conditioned by the level of management expertise. Improvement in management expertise could have a major effect on productivity, improve land husbandry, and lessen the present severity of drought effects. Improvement can be wrought by careful development of both human and natural resource potentials.

3.6 EFFECTIVENESS OF PRESENT CONSERVATION ACTIVITIES IN THE AREA

3.6.1 Trees and grasses

Praiseworthy efforts are under way to increase the output of tree seedlings, and grass 'splits', to satisfy farmers' demands for fruits, timber, fuel and fodder, and to supply material for hill-protection plantings. Very much larger areas would have to be covered with plantings of grasses and trees, and managed appropriately so as to develop and maintain a porous soil surface beneath a good cover of leaves and litter, before they will have any significant effect on erosion and runoff. The expansion of these efforts deserves every encouragement.

3.6.2 Subsurface dams/sand weirs

When appropriately sited, such structures can be of markedly beneficial effect in helping to stabilise water availability throughout the year. Because they are cheap and simple to construct, much wider scatter of large numbers of this type of water-retaining structure is most desirable and efforts in expanding this activity must be encouraged.

3.6.3 Dams and deserts

Large bodies of water scattered at rather infrequent intervals across the countryside are powerful 'magnets' to cattle, sheep and goats, which tend to concentrate their grazing nearby. This can seriously damage the environment and cause even greater runoff and erosion in the surrounding area by vegetation denudation and trampling than there had been before the dam was built. Without adequate protection of the catchment, these rather expensive storages usually silt-up rapidly and lose much or all their capacity to store water throughout the year. They can be better justified after catchment conditions have been stabilised than before. First-stage wide scatter of subsurface dams and gully-control structures (see below) will likely be more effective in stabilising many small stream flows and lessening the distances that people have to walk to get water

than would a concentration on larger dams at this stage.

3.6.4 Physical soil and water conservation works

Present 'conventional' physical measures to control soil erosion and runoff loss in this area are unfortunately not sufficiently comprehensive either in scope or area to tackle the problems effectively. Basically they do not address the core where it falls, and thus minimise the amount available for runoff. This would benefit not only plant growth but also groundwater recharge. Cutoff drains can be effective in preventing gullying from beginning as long as they are of sufficient design capacity and are adequately and regularly maintained. Similarly 'fanya jun' terraces, if sufficiently closely spaced, and regularly built up and maintained over several years, can have marked beneficial effects on water retention, crop growth and erosion control (see e.g. excellent examples in Machakos District). Very few either cutoff drains or 'fanya jun' terraces are yet installed in the Tharaka/Nithi/Mbere area.

3.6.5 'Soil conservation' as a separate activity

Because soil erosion is so visible and the need for its control so urgent, there is a tendency to consider erosion control/soil conservation activies as a discipline on its own. Consequently it tends to operate in a degree of isolation from other activities. As this analysis shows, effective control of soil and water losses needs an integrated approach if it is to be successful, because of the many and complex social, as well as technical, reasons why the environment has become so degraded in this area.

3.7 POSSIBLE EFFECTS OF LAND ADJUDICATION

On the one hand land adjudication on an individual basis in these marginal areas could encourage better husbandry of crops, livestock and land - but only if preceded by or accompanied by tested workable and acceptable packages of improvements which would enable farmers to maintain productivity of their holdings without shifting. On the other hand, without such

possibilities for improvement, drought distress, particularly among animals, could be worse than when communal grazing systems allowed free range in search of fodder.

3.8 ELEMENTS OF THE A.S.A.L. DEVELOPMENT 'PACKAGE' AFFECTING WATER - AND SOIL - CONSERVATION

3.8.1 Conservation strategies and development

The Summary of the GOK paper 'Arid and Semi-Arid Land Development in Kenya - the Framework for Planning, Implementation and Evaluation' states that:

> ' ... the emphasis is on poverty alleviation through providing basic needs and increasing employment and income-earning opportunities. The welfare of the peoples of A.S.A.L. and the development of productive opportunities are the fundamental objectives.'

In this document resource conservation is cited as a specific objective. I suggest that unless effective Resource Conservation is achieved - particularly conservation of water and soil - the other specific objectives, listed as:

- Human resource development
- Exploitation of productive potential
- Integration with the national economy

will not be capable of being sustained. Effective land husbandry is essential for stability of rural improvements.

3.8.2 Multiple activities materially affect water and soil conservation

A two-week field visit is too short a time for a newcomer to specify in

detail every one of the activities appropriate to the Meru/Embu area which will lead to effective resource conservation to under-pin the development drive. Purely technical, conventional, mechanistic soils and water-conservation applications alone will however be insufficient to achieve this on their own. Other aspects of the overall development package will have major effects on resource conservation - either positive or negative according to the manner in which they are applied. Examples are:

i. Measures modifying people's attitudes to and management of their animals, pastures, forage etc. as affecting pasture quality and quantity, and soil compaction, e.g.

- water supply distribution
- marketing arrangements and methods of maximising sale proceeds (e.g. rural savings banks)
- animal health
- acceptable methods of pasture-productivity improvement, e.g. open rotational grazing; introduction of improved adapted species of fodder grasses, shrubs and trees; charcoal burning to clear woody vegetation; etc.
- manipulation of selective fodder use by differential management of cattle vs sheep vs goats
- special attention to effective management of goats as effective converters of otherwise unusable vegetation

etc.

ii. Measures affecting plant-cover density on cropped and pasture lands, <u>for</u> better plant production, <u>against</u> rainfall and runoff effects, e.g.

- tillage methods aimed at maximising rainwater detention and infiltration into the soil (including development of bullock-power to pull implements) while improving crop germination, establishment and growth

- biological and/or mechanical means of beaking-up crusted surfaces on grazing lands.

- use of fertiliser/compost materials

- availability of appropriate inputs, advice and market opportunities

- improved seed varieties etc. a/c duration and yield for for food and animal fodder e.g. short-duration maize, high-yield pigeon-peas, leguminous trees etc.

- advice on optimum plant densities, planting times, weed management, mixed cropping etc.

iii. Measures maximising water availability throughout the year by a. groundwater recharge and use, and b. roof-water collection and storage.

- tillage methods for water infiltration (as above)

- improvement in rainwater-acceptance by grazing lands (as above)

- subsurface dams/sand weirs widespread

- contouring of planting and other farm operations

- construction, buildup and maintenance of 'terracing' works where appropriate

- tapping groundwater by wells, boreholes

- methods of concentrating, collecting and storing rainwater from roofs and other impermeable surfaces

iv. Measures aimed at stablising availability of money, food, from good to bad years

- fodder 'banks'
- food-grain storage facilities
- sale-price stabilisation/food crops surpluses as cash crops
- seed-loss insurance
- rural savings banks
- planning in expectation of drought
- emphasise carry-over via perennial crops, forage shrubs and trees etc.
- etc.

v. Measures to integrate better farming with better conservation e.g.

- working on catchment basis for multiple demonstrations of better cropping, pastures, cutoffs, terracing, water conservation, tree plantings etc. in hydrologically-distinct land units
- adopting socially-acceptable sequence of change rather than insisting on technically-optimum sequence. Probably catch interest via attention to crops and stock first, for quick results, then show relevance of physical conservation works as needed
- etc.

vi. Other measures specifically aimed at stablisation

- forest reserves and plantations on slopes
- gully-stablisation structures, silt traps
- Crest- and controlled-grade alignment of roads to tie road drainage with physical conservation layout, integration of stream-crossings with water-detaining and gully-control structures etc.
- etc.

3.9 WHAT ARE THE MESSAGES APPROPRIATE TO THE AREA?

While it is fairly clear what sort of information is required in this type of area, the actual site-specific details are much less readily identified.

- What improved systems of grazing management are a. technically appropriate to the area and b. socially acceptable to the people?
- What sale arrangements etc.are a. economically feasible b. socially workable, for return on investment in animals?
- What species/varieties of trees, shrubs, grasses, crops are best suited to these environmental and social conditions, and how best can/should they be planted and managed?
- What is the ultimate carrying capacity of this area with regard to a. expectation of drought b. lowest acceptable standard of living with regard to nutrition, money income in the face of rising populations?
- Which tillage implements/methods/systems are a. most effective b. most practicable to maximise water infiltration and crop growth with regard to available or potential power sources?
- What are the most effective methods of maximising rainwater infiltration on grazing lands? Can they be justified economically?

- What fertiliser rates are a. appropriate b. economic for the crops and drought-proneness of this area?

- What proportion of total potential water and soil conservation can be achieved by physical measures alone, without the other improvements?

- What are the most appropriate physical conservation works with regard to minimising erosional effects of a. rainfall and b. runoff?

- Which land-based criteria would be most valuable in physical planning of the most effective, useful and equitable allocation of land under any adjudication requirements?

- To what degree, if any, must the already proven effective (?) conservation activities from the high-potential areas be modified before equivalent effective application in these areas?

3.10 WHO ARE THE FARMERS?

3.10.1 Identification, attitudes, capabilities

Before success can be achieved with development programmes in the area there may be a need for adjustment and learning on both sides. Farmers and rural people should be enabled to learn about the sorts of improved practices which are available but of which they do not know at present. The development agencies may also need to learn more about rural peoples' attitudes, priorities, preferences and abilities.

The role of rural women may be of special importance in the development process, because they often outnumber the men in these areas, because there is short- or long-term out-migration of men to seek non-farm employment. (See Brokenshaw 1971 p 9 a men:women ratio of between 100:117 and 100:140 in parts of Tharaka; also Luning 1973; in lower areas of Mbere (SRDP) 'the adult male:female ratio is as low as 0.4.') Women have non-farm, family duties as well as farming activities to cope with, in which water collection may play a major part. This work-load is further

increased at certain times of year by the farm-labour peak needs governed by effects of erratic rainfall conditions on farming activities (see Luning, op. cit.). Women's attitudes, as well as the degree to which they make decisions, the time and energy available to them to undertake alternative or additional development work etc. may all have considerable effects on what development can and will in fact occur.

3.10.2 Farmer-training

Discussion with farmers, and their training in new and appropriate techniques will necessarily be an important part of the process of knowledge-transfer and consequent development of the people-potential.

PART 4. INDICATIONS FOR OUTSIDE ASSISTANCE

Combining the intentions for ASAL development contained in the GOK 'Green book' with my own observations about the study/problem area of 'marginal' land on Basement Complex rocks in Meru and Embu, I have come to the following conclusions:

4.1 IDENTIFICATION AND MAPPING OF POTENTIALS AND HAZARDS

Exploitation of productive potential requires the identification, quantification and, where appropriate, mapping of the constituents of these potentials. This must have special reference to the possibilities and limitations offered by (among others) meteorological conditions, surface- and ground-water, soils, natural vegetation, three-dimensional landscape and erosion hazard. There appears to be an insufficient technical capacity at Provincial or District levels to undertake such work with sufficient speed or in sufficient detail to provide relevant information in advance of development planning for this area.

4.2 PHYSICAL PLANNING IN ADVANCE FOR CONSERVATION AND RURAL DEVELOPMENT ACTIVITIES

Development of the human and resource potential of the area will require that public infrastructure be improved so that information, inputs, goods and services can readily move in, and produce etc. can readily move out. The most appropriate siting of new market centres and other public facilities, roads, bridges, subsurface dams, checkdams, dip-tanks etc. should be physically planned with special regard to the site-specific location and extent of population groups, potentially-productive soils, landscape characteristics etc. Effective physical planning requires the early and rapid development of a physical three-dimensional overview of interrelated features and patterns - of soils, vegetation, landscape, village lands and settlements etc. - as can be speedily provided by interpretation of maps, airphotos and on-ground surveys and checks. It also provides the opportunity to undertake the advance costing and

plan the most appropriate phasing over time, of the complete development programme once worked out. With less time needed for effective survey and planning, more time is available for implementing the planned activities and works. At present there does not appear to be any organisation or capability for forward physical planning of rural areas. Thus there is as yet no specific means of translating the proposals about what ought or needs to be done into site-specific and logical proposals for where it should be done. (Physical planning appears to be concentrated on urban development, while planning of rural development is based on economic assessments).

4.3 PRACTICALITIES OF THE CATCHMENT APPROACH

Similarly, while development is to be planned and undertaken 'on a catchment basis' there is at present no formal procedure presently followed by staff which uses the catchment - of whatever size - as the three-dimensional framework of the landscape for site-specific physical planning. Airphotos, orthophotos, line maps, and ground survey should all be used for planning and designing the specific positioning of necessary areas, lines and points for integration of conservation and development activities, with special regard to catchment topography. The concentration of demonstrations of various improved practices - including but not exclusively conservation works - within individual small catchments is likely to have a synergistic effect on farmers' appreciation of likely benefits of an integrated approach.

4.4 IDENTIFICATION OF ALREADY-AVAILABLE ENVIRONMENTAL AND RESEARCH INFORMATION. GENERATION OF VALID DATA-BASE

Over the years a considerable amount of work, both to characterise environmental conditions and to work out appropriate technical recommendations for specific situations, has been completed in Kenya. Much of this material is apparently not known about or not readily available to technical staff in the Provincial or District offices. This needs to be identified, analysed, assessed, mapped (where appropriate) and indexed for use in the planning process. Similarly all relevant new information emergi

from research and survey organisations, as well as that generated by workers from the District and Provincial offices, should be indexed and added to this information store. With such information to hand, optimum strategies for effective and lasting improvements in crop husbandry, animal husbandry and land husbandry can be identified up to the limits of available knowledge and information.

4.5 NEED FOR ACCURACY IN APPLYING PHYSICAL CONSERVATION MEASURES

Because of the extreme need to retain all rainwater where it falls if at all possible, and because all demonstrations of improved practices - with special reference to the lasting effectiveness of physical soil and water conservation works, - should show positive and worthwhile benefit, and should not fail, extreme precision must be achieved in the identification, siting, survey, calculation, design, layout and construction of all physical conservation works with strict respect to the contours of the land.

There appears to be a lack of staff who have sufficient practical training and experience in these matters to achieve this on a wide scale.

4.6 NEED FOR CAREFUL PRE-RELEASE TESTING AND 'OPERATIONAL RESEARCH'

Because of a. the known fragility of the ecosystems in these areas, b. the necessity that demonstrations should be positive and not fail, and c. the need to prevent any further degradation, the various recommendations about improved practices which are specifically applicable to this and similar areas must have been sufficiently carefully tested before release. At present there appears to be some uncertainty about the exact nature of many of the necessary recommendations. Additionally there is not yet a detailed testing-system which takes the recommendations from problem-oriented, small-plot research and then subjects them to a. testing for technical feasibility on hectare-scale plots, then b. offers technically-proven recommendations for testing of social acceptability/workability as no-fail demonstrations in farmers' fields. This procedure needs to be formalised, and all recommendations (where applicable) subjected to such

tests, before being made into broad recommendations for general release. The initial delays occasioned by such a procedure will nevertheless provide more time for appropriate problem-oriented research to be completed, analysed and framed as preliminary recommendations - which are not yet available. Opportunities would then exist for feedback of information to the station(s) from such an operational research activity for further adjustment or refinement as needs dictated.

4.7 GULLY STABILISATION AND EMPLOYMENT GENERATION

Airphoto analysis and ground-check shows the widespread occurrence of gullies over the entire area. Their stabilisation, to prevent further down-cutting and lateral spread, is an essential prerequisite to achieving and maintaining stability of increased production from the lands making up their mini-catchments. The use of simple and effective gully-control rock checkdams, either of unconfined packed loose rock, gabion structures and (in some cases) small masonry checkdams and subsurface dams, is clearly indicated. (Structures which do not require cement are indicated for waterless places.) This could be initiated as a widespread, worthwhile continuous, and employment-generating activity as it would take many years effectively to complete.

4.8 STRENGTHENING OF PROBLEM-ORIENTED RESEARCH AND TRAINING ACTIVITIES OF UNIVERSITY OF NAIROBI, AS APPROPRIATE TO EMBU/MERU CONDITIONS

Opportunities are needed for students in land husbandry/water- and soil-conservation courses to gain practical experience of field-work in resource survey, topographic assessment and conservation planning. There is a need to gain more information from the specific area about rainfall amounts and intensities, and of rates and variations of runoff and sediment loads in streams and rivers. Simple, small-plot demonstrations of the effects of alternative physical and biological/vegetational conservation treatments, set up at various Farmers' Training Centres, could also provide preliminary information (which is lacking at present) on losses of water, soil and plant nutrients in this area.

Some of the very basic questions which require problem-oriented research to provide the answers are:

i. What are the absolute and relative effects of various physical and biological activities on losses/conservation of water, soil and plant nutrients under stated conditions of rainfall intensity, the amount of plant cover and of soil impermeability and erodibility?

ii. Which approach - statistical (USLE) or mathematical modelling (e.g. SLEMSA) provides the best prediction of soil losses?

iii. What are absolute rates of

- A horizon formation, from the top down

- Soil-formation by rock-weathering, from below upwards.

iv. Critical evaluation of real effectiveness of past conservation activities in these conditions.

4.9 SUPPORT OF ON-GOING APPROPRIATE CONSERVATION ACTIVITIES

Some appropriate conservation activities are hindered in current progress due to lack of money for small tools, casual labour, construction materials. These activities are particularly:

i. expansion of nurseries producing tree seedlings and bulking-up of fodder grasses

ii. construction of subsurface dams/sand-weirs for water conservation

iii. construction of cutoffs and terraces at appropriate places

iv. protective management of certain hillslopes accompanied by tree-planting

4.10 DOMESTIC WATER SUPPLIES FROM ROOFS AND OTHER IMPERMEABLE CATCHMENT SURFACES

The need for stored supplies of water for at least domestic use is so acute and so much at the head of everyone's priorities that every assistance should be given to the devising and construction/erection of water-catching and water-storage facilities from house-roofs and other natural and artificial impermeable small catchments.

4.11 REQUESTED ASSISTANCE IN PRACTICAL TRAINING AND EXPERIENCE IN CONSERVATION PLANNING AND ACTIVITIES

Specific requests were made that Kenyans' own capabilities to undertake the planning and execution of effective conservation activities be increased by assistance with training in the practicalities of the work. This was emphasised by staff-members of the Land Development Division, the University, the Embu Institute of Agriculture, and District Agricultural Officer both in Meru and Embu. Both in-country and overseas training opportunities are indicated. Assistance with certain aspects of farmer-training relating to conservation was also mentioned.

PART 5. SPECIFIC RECOMMENDATIONS FOR OUTSIDE ASSISTANCE

5.1 FRAMEWORK

The recommendations which follow have been framed with particular regard to the apparent needs for:

i. The training of Kenyan staff to increase their practical skills in land resource assessment, land use planning and basic water- and soil-conservation activities

ii. The introduction, use and dissemination of rapid yet effective means of area-wide resource appraisal and physical planning as an essential and logical precondition to subsequent implementation of conservation and development activities on a catchment basis. It is apparent that, if a planned and co-ordinated approach to these problems of rural improvement are to be followed, there is a specific need for Kenyan staff to be trained in the techniques of area-wide physical planning for rural development and conservation activities. This involves the use of rapid land-resource survey and land-use planning methods based on air-photo analysis and limited ground survey, with a view to minimising the time required for effective investigations and planning, and maximising the time available for implementation. Such physical planning encourages the matching of proposed activities and works to the specific characteristics of the land as a three-dimensional framework

iii. The need carefully to identify the various components of recommended improvements at an early stage and to ensure that they have been adequately tested for technical effectiveness and social workability before general release in this area

iv. The acknowledgement that, since not many of the necessary and appropriate recommendations for effective conservation and lasting development in this area have yet been precisely identified, a stepwise buildup of information and activity

is more desirable than attempting to frame a total and comprehensive programme at the outset, many of whose components are as yet not clearly known

v. The belief that, in the stimulation of improvements in conservation and rural life, village lands should seldom, if ever, be used for speculative experimentation or the testing of uncertain ideas. Demonstrations of improvements on such lands should be only of well-tested recommendations which have a high chance of being both socially acceptable as well as technically effective. In this way credibility in the abilities of extension agents is maintained, and farmers' self-confidence builds up

vi. The desirability of encouraging wider application of ecological approaches to the solution of problems of land degradation and of human distress in these drought-prone areas. Awareness of the ecological fragility of these should be paralleled by the sensitivity with which appropriate solutions are matched to the problems

vii. The need to diminish as far as possible any hindrances to rapid expansion of appropriate already-operating conservation programmes in the area, and to identify and foster new ones as and when appropriate.

5.2 STAFF

5.2.1 Technical Cooperation Officers from UK

The appointment of two expatriate officers for a 3-year period to Provincial Headquarters at Embu,

- a Land Use Planning Specialist
- a Conservation Engineering Specialist (small structures)

responsible for assisting and training Kenyan staff in these particular types of activity (draft Job Descriptions and required qualifications and experience attached). These two persons should be closely counterparted by Kenyan officers on a full-time basis, so that they work as a team both for practical duties and information-transfer. It is envisaged that the Kenyan staff would then carry on the work detailed below on completion of the expatriates' tours of duty. Their prime functions, in general terms, would be:

i. To strengthen conservation-execution capabilities of Ministry of Agriculture staff in Embu and Meru (and Isiolo?) Districts. Initially this would relate to the current syllabi, guidelines, techniques, etc. now in use, but could also later involve adjustment and refinement of such material and techniques to make them more specifically relevant to the marginal areas of Embu, Meru and Isiolo. We have been told that there is a great need to increase the practical skills of field staff at all levels in technical aspects of water and soil conservation work. Assistance with formal training of both pre-service and in-service staff in soil and water conservation methods, has been specifically requested in both districts. There is also a need to increase the skills of field staff in the selection, location, design, survey and construction of appropriate small-scale conservation works, with special emphasis on catchment-based development. This would be done in close consultation with other Government units concerned with conservation education and training

ii. To further develop a training capability among Kenyan staff in land resource appraisal and catchment-based land-use planning. This would have special reference to the use of airphotos plus associated groundwork and to the use of ecological topographical and other natural-resource guidelines in the preparation of effective plans for erosion/runoff control and better land husbandry as a part of rural life improvement

iii. To assist Provincial and District staff in identifying and crystallising various components of appropriate recommendations

for improvement of conservation and related aspects of land use in this particular area. This would involve, among other activities

- assessment of the effectiveness of current conservation approaches in the area

- locating, interpreting, indexing and presenting relevant information from research and surveys appropriate to the needs of the situation

Such activities would involve close liaison with organisations such as the Kenya Soil Survey, Meteorological Department, units of the University of Nairobi, the Kenya Agricultural Research Institute, Katamani Research Station and Substations, and other relevant sources of already-available information and research. (In this regard, very interesting research is now starting at Katumani on methods of tillage, and on new approaches to risk-avoiding crop systems, which could be of specific relevance to the lowlands of Embu and Meru.)

iv. Using specific rapid techniques, to identify, assess and map the land resources of the marginal areas of lower Meru and Embu, both from already-available materials and from airphoto analysis with associated groundwork, as a basis for the physical planning of conservation and development activities in the area. In so doing they would develop and record the most appropriate rapid methodology then to be taught in appropriate training courses (as above).

v. In collaboration with District and Provincial staff, to use these findings in formulating appropriate parts of an overall physical plan for the area's development, their input being particularly related to activities related to improvement of water and soil conditions (e.g. location of roadlines, sub-surface- and check-dam sites, cultivation-, forest- and pasture-improvement areas etc).

vi. In collaboration with District staff, to identify, assess, measure and map in greater detail an appropriate selection of small catchments into which multiple and coordinated demonstrations of fully-tested and improved land-use, tillage, cropping, conservation etc. techniques would be made, as recommendations became available. There is an expressed desire to demonstrate, both to staff and farmers, the value of integrated improvements within specified catchments as opposed to or in addition to uncoordinated demonstrations scattered over wide areas. It is envisaged that such 'pilot' catchments would be the areas in which recommendations undergo their final test - for social acceptability. It is anticipated that the good news emanating from convinced farmers in such catchments would spread the benefits to neighbouring areas. It is envisaged that the team would assist District staff in design and implementation of such programmes.

5.2.2 Air photo interpretation and land use planning

Training in airphoto use and land use planning in Kenya by R G B Jones and K Davies of the LRDC, ODA, has been undertaken in 1971, 1973 and 1977. With rapid movements and promotion of the staff so trained both in airphoto method, and related training technique, there is a continuing need to train Kenyan staff to run the necessary training courses themselves, as well as to provide more specific, detailed and field-oriented training to selected field staff with special reference to the intentions of the GOK 'Green Book' on ASAL development. Consideration should be given to the possibility of another course similar to that of 1977 being mounted in the near future, and this could provide the pattern for similar courses to be run subsequently on a regular basis by expatriate and Kenyan staff over the next 3+ years as required.

5.3 FINANCIAL ASSISTANCE TO ON-GOING AND NEW CONSERVATION PROGRAMMES

5.3.1 On-going activities

Financial assistance should be provided to relevant on-going conservation programmes e.g.

- expansion of nurseries for trees and grasses
- widespread construction of subsurface dams for water supplies
- construction of cutoffs and terraces where appropriate
- protective management of hillslopes

This would mainly involve funds for

- small tools
- casual labour
- construction materials

Some of these are already the subjects of project submissions and I recommend early and positive response to such requests where appropriate.

5.3.2 Suggested new activities

Two straightforward and valuable activities which could be worked up immediately into projects and implemented early are

- support for a widespread simple gully-stabilisation programme using loose rock and/or gabion structures
- support for collection and storage of rainwater from roofs and other natural or artificial impermeable mini-catchment areas.

5.3.3 As-yet-unidentified subprojects

Consonant with the proposal that the Project should take a stepwise approach in assisting the development of appropriate conservation activities, I recommend that the financing programme be made flexible enough to accommodate future proposals for relevant subprojects as they are identified by Project staff, and as the need for further assistance becomes apparent within the overall intentions. The character and scope of such requests may well broaden as development planning activities cyrstallise specific requirements.

5.4 FELLOWSHIPS AND TRAVEL GRANTS

5.4.1 Fellowships for MSc studies overseas

Since conservation activities for a given situation require to be planned with full regard to environmental conditions, clear identification of problems, and full knowledge of the most appropriate solutions, opportunities for further training should be offered for Kenyan staff who will be reaching positions of responsibility and decision-taking with regard to conservation policies and practices. Suitable study awards should be made available to enable Kenyans to study, at appropriate institutions, both the ecological and mechanical aspects of conservation planning and development. Some appropriate UK institutions are:

i. Department of Geography, University of Sheffield (land resource appraisal for development)

ii. University of Reading (ecological aspects of tropical rural development)

iii. National College of Agricultural Engineering, Silsoe (land resource appraisal, water and soil conservation etc.)

Once more-specific training needs have been identified and discussed, the most appropriate institutions can be identified.

5.4.2 Grants for third-country travel

Conservation and land development activities of the sort envisaged for the ASAL are also under way in different parts of the tropical world. Opportunities should be provided for appropriate Kenyan staff to visit and discuss such activities on site as a means of comparing the success of different approaches. Examples of relevant places to visit are:

i. Botswana : Interlinked dryland farming research and extension projects

ii. Malawi : Land Husbandry Training Centre; integrated rural development projects with conservation components

iii. Swaziland : integrated rural development projects where cattle form a major part of agricultural wealth; CDC Management Training School

iv. India : Central Arid Zone Research Station; International Crops Research Institute for the Semi-Arid Tropics; Indo (-UK) Dryland Farming Operational Research Project, Central Soil and Water Conservation Research and Training Institute's substations

v. Zimbabwe : Agricultural Engineering Institute, very significant erosion research

vi. et al.

5.5 ASSISTANCE TO THE UNIVERSITY OF NAIROBI

In view of the lack of sufficient degree-trained staff, and of critical problem-oriented research in the field of water- and soil-conservation/land husbandry, particularly as related to the needs of ASAL in Meru and Embu, I suggest that appropriate assistance be provided to the work of sections of the University of Nairobi, (particularly for example the Faculty of Agriculture/Departments of Agricultural Engineering, and

Soil Science) in furthering training and research activities in soil and water conservation, land husbandry, dryland farming etc. Such assistance would have special reference to the needs of, and the training/research opportunities offered by, the marginal areas of Embu and Meru.

With effective collaboration, the development of in-field resource-survey and conservation-planning capacity in Meru/Embu under the Project could provide useful opportunities for practical training of University students specialising in this work.

PART 6. CONFIRMATION OF VIEWS

The writer's views on which this proposal is based were independently confirmed, after the field visits in Embu and Meru, in a visit to and discussions of progress made at Machakos:-

- the need to fully involve local people in decision-making
- the value of integrated development on small catchment basis
- the importance and effectiveness of widespread distribution of small simple sub-surface dams and gully control structures
- the need for area-wide physical planning to promote effective programming of future activities and requirements
- the need for an integrated, interdisciplinary approach to effective conservation farming which both increase production and minimise losses of water and soil.

APPENDIXES

APPENDIX I

Sources consulted at LRDC before going to Kenya

a. 207 airphotos Dec 79/Jan 80 - from contract DOS-183, flight KE-1 were received from BHC Nairobi. These covered all Meru and most of Embu Districts, except the SW portion of Embu. Scale app. 1:45 000

b. The SW portion of Embu was scanned using 73 further photos of V 13 B RAF 1967 loaned by DOS. Scale app. 1:45 000

c. Two LANDSAT images in colour were prepared, 24/1/76, scale ca 1:800 000. Cloud mainly obscures the E part of both districts.

d. National Atlas of Kenya provided background on

- Probabilities of 20 ins. and 30 ins. average annual rainfall (see Text Map 3)
- Ecologic potential (see Text Map 5)
- Geology (see Text Map 4)
- Soils

and other features, at 1:3 000 000 or smaller

e. Vegetation zones, and detailed vegetation types (Trapnell et al) (see Text Map 8)

f. Land systems (Scott, Webster and Lawrence) 1:500 000 (see Text Map 6 & block diagrams)

g. Overlays were prepared from 1:500 000 maps to show

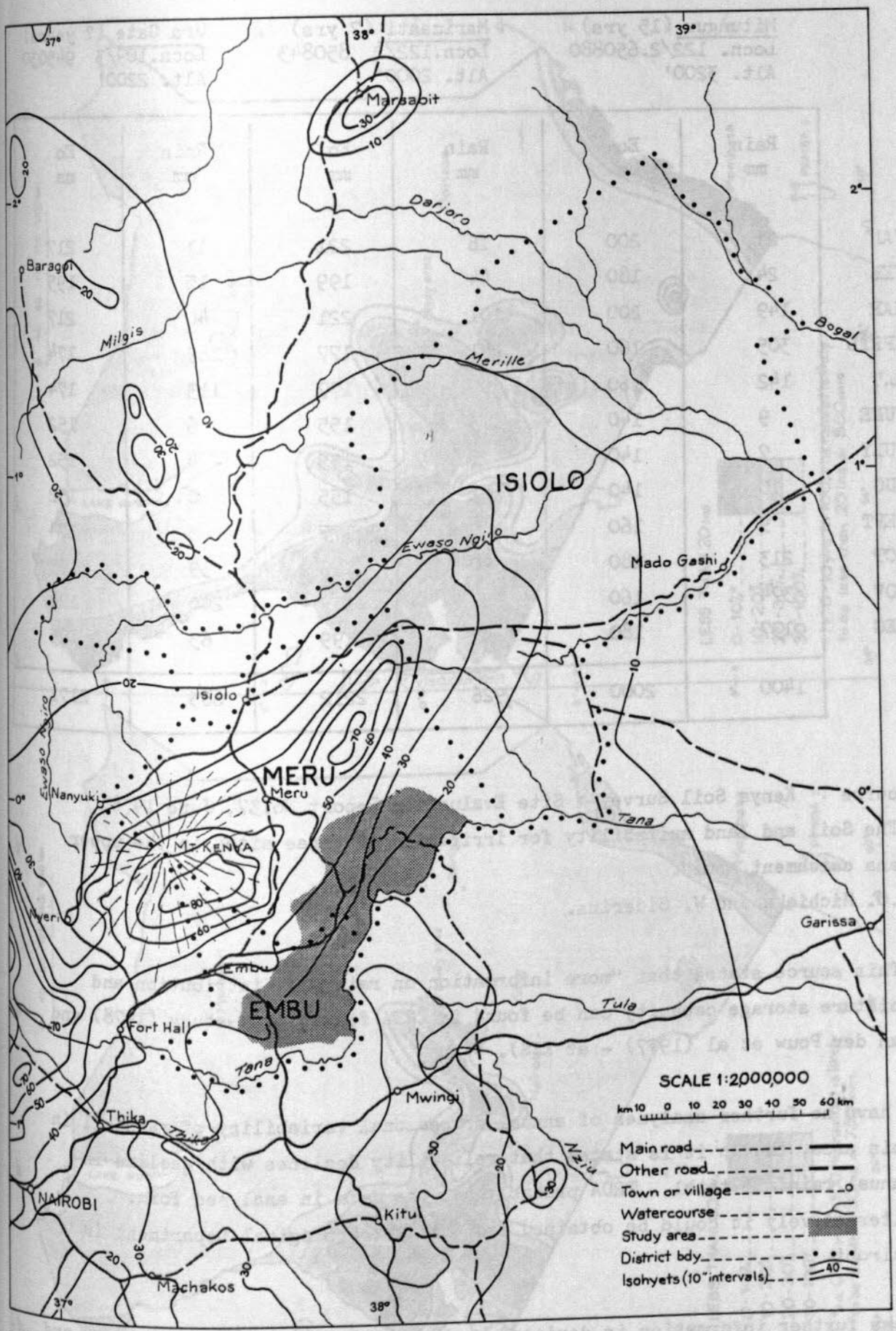
- flight diagrams 1979, 1967 airphotos (see Text Map 9)
- drainage pattern (Text Map 7 - see also Text Map 2)
- 200 m VI contours (see Text Map 2)

h. 1:50 000 map sheets: 30 were scanned

Preliminary overlays, with comments derived from airphoto analysis, were prepared for 19 out of the 30 maps (after preliminary decision as to appropriate 'project area', for study - see below) - see Text Map

i. The Lesslie-Mitchell report 'Kenya Hydrology Project - Project Record 32. KENYA-03/REC-32/79' provided useful information on general conditions in Machakos and Kitui Districts adjacent

j. Discussions with Mr Lesslie, Mr Brunt and Mr Wills were most valuable in providing background information.



TEXT MAP 2 Mean annual rainfall, and districts

Prepared by Land Resources Development Centre 1981

SOME INDICATIONS OF RAINFALL IN THE AREA

	Mitunguu (15 yrs) Locn. 122/2.650880 Alt. 3200'		Marimanti (7 yrs) Locn.122/2 850843 Alt. 2000'		Ura Gate (? years) Locn.109/3 945030 Alt. 2200'	
	Rain mm	Eo mm	Rain mm	Eo mm	Rain mm	Eo mm
JAN	21	200	16	221	11	217
FEB	24	180	44	199	15	195
MAR	149	200	101	221	40	217
APRIL	305	160	281	177	169	174
MAY	142	160	97	177	113	174
JUNE	9	140	3	155	6	152
JULY	7	140	1	155	4	152
AUG	10	140	1	155	0	152
SEPT	9	160	0	177	5	174
OCT	213	180	90	199	39	195
NOV	374	160	250	177	200	174
DEC	137	180	42	199	63	195
	1400	2000	926	2212	663	2171

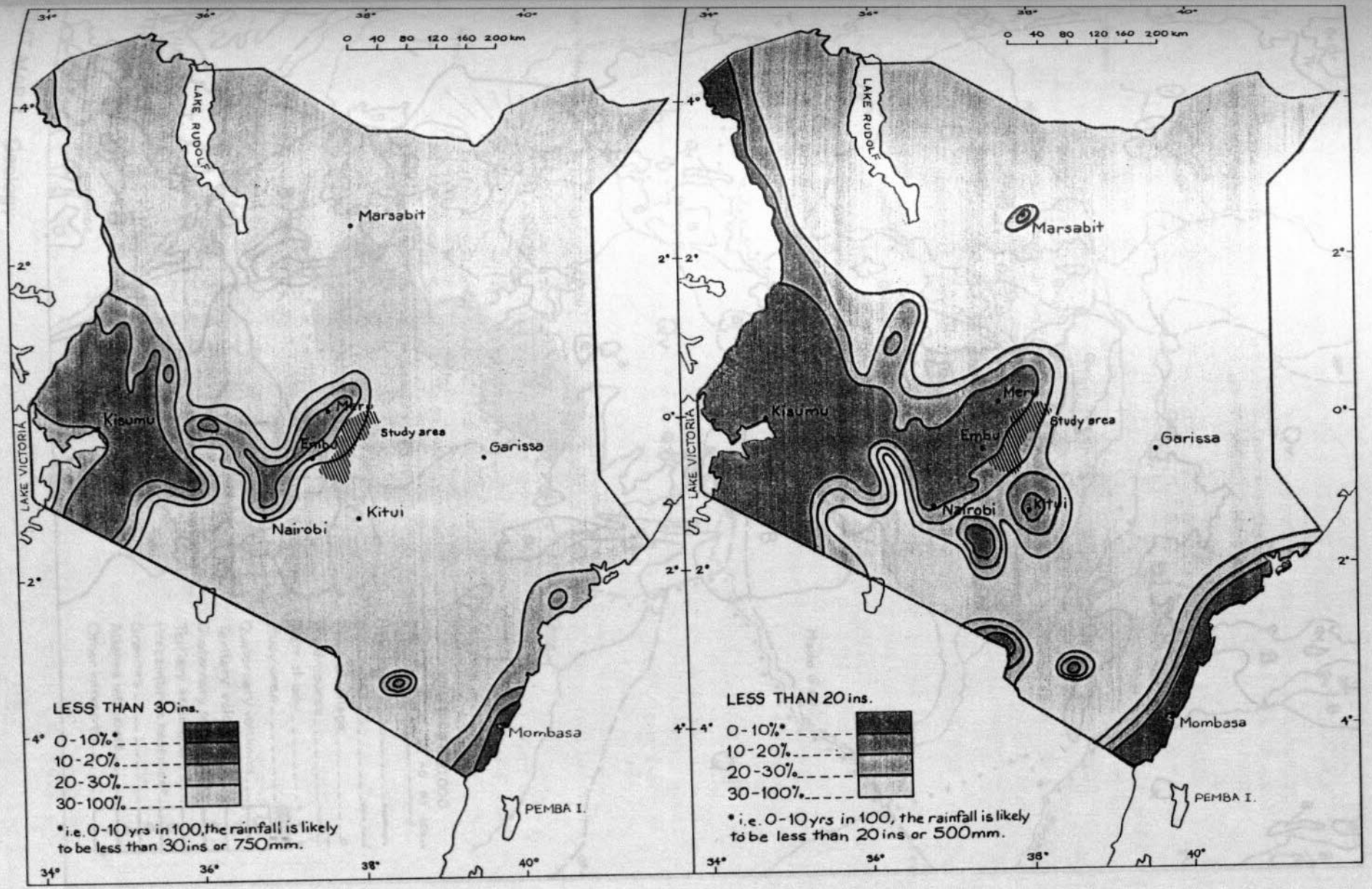
Source : Kenya Soil Survey : Site Evaluation Report No.37, June 1978. "The Soil and land suitability for irrigation of three sites in the upper Tana catchment area".
D.O. Michieka and W. Siderins.

(This source states that "more information on rainfall distribution and moisture storage capacity can be found in TRDA feasibility study (1978) and van der Pouw et al (1977) - at KSS).

I have no further analyses of annual or seasonal variability of rainfall in this area, though it is stated that reliability declines with decline in annual rainfall total. TRDA probably has the data in analysed form. Alternatively it could be obtained from the Meteorological Department in Nairobi.

Some further information is depicted on the 1:250,000 map "Kenya Climate and Vegetation", Sheet 2 - DOS LR 3059, 1976.

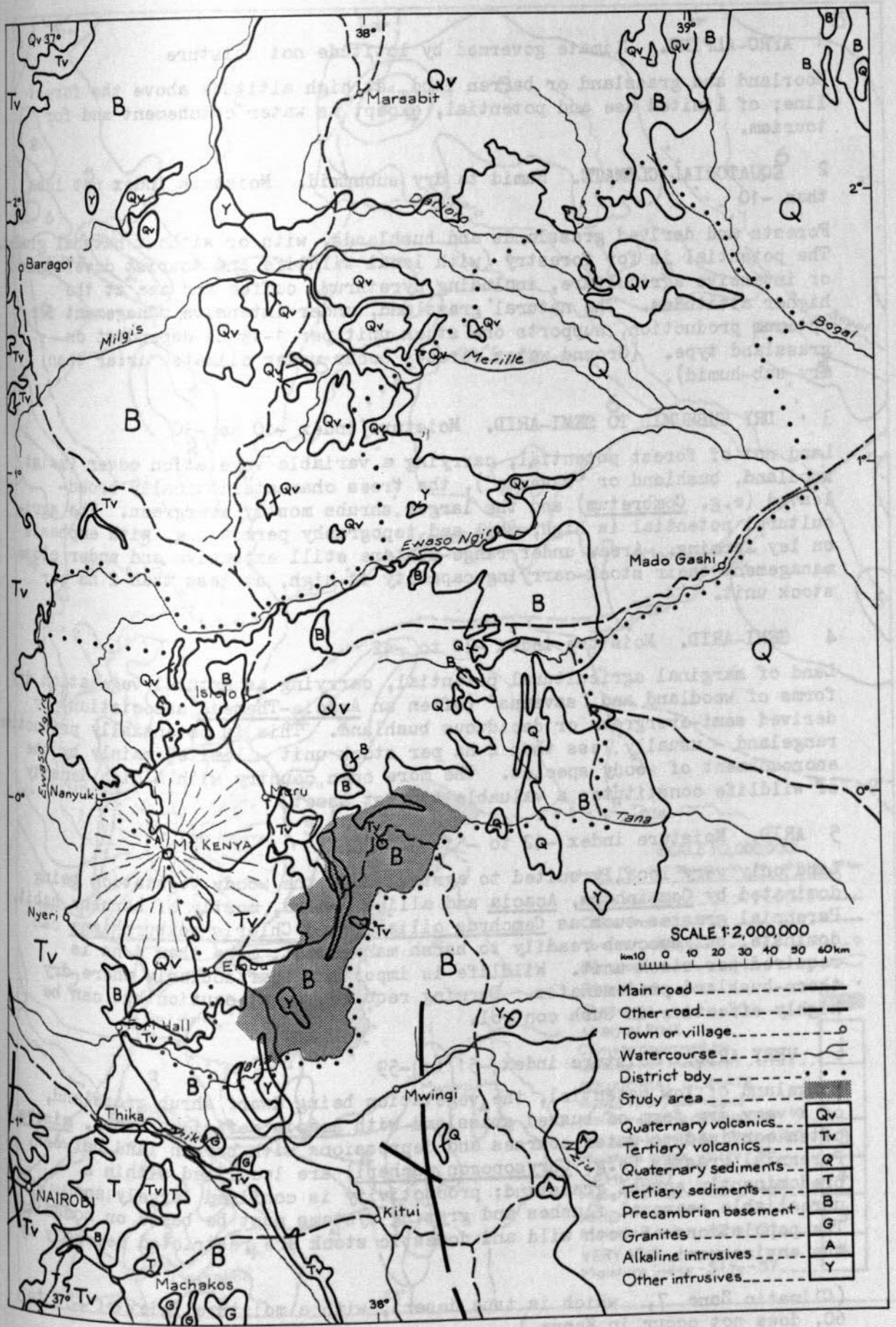
See also the National Atlas of Kenya.



TEXT MAP 3 Rainfall probability

Prepared by Land Resources Development Centre 1981

Rep 109/KEN/TFS/3



TEXT MAP 4 Geology

Prepared by Land Resources Development Centre 1981

ECOLOGICAL ZONES - CLIMATE, VEGETATION AND LAND-USE

1 AFRO-ALPINE. Climate governed by latitude not moisture

Moorland and grassland or barren land, at high altitude above the forest line; of limited use and potential, except as water catchement and for tourism.

2 EQUATORIAL CLIMATE. Humid to dry subhumid. Moisture index not less than -10

Forests and derived grasslands and bushlands, with or without natural glade The potential is for forestry (with local wildlife and tourist development) or intensive agriculture, including pyrethrum, coffee and tea at the higher altitudes. The natural grassland, under intensive management for optimum production, supports one stock unit per 1-1½ ha dependent on grassland type. (Ground water forests occur under climates drier than dry sub-humid).

3 DRY SUBHUMID TO SEMI-ARID. Moisture index -10 to -30

Land not of forest potential, carrying a variable vegetation cover (moist woodland, bushland or 'savanna'), the trees characteristically broad-leaved (e.g. Combretum) and the larger shrubs mostly evergreen. The agricultural potential is high, soil and topography permitting, with emphasis on ley farming. Areas under range-use are still extensive and under close management their stock-carrying capacity is high, at less than 2 ha per stock unit.

4 SEMI-ARID. Moisture index -30 to -42

Land of marginal agricultural potential, carrying as natural vegetation dry forms of woodland and 'savanna' (often an Acacia-Themeda association) or derived semi-evergreen or deciduous bushland. This is potentially productive rangeland - usually less than 4 ha per stock unit - limited mainly by the encroachment of woody species. The more open country with a high density of wildlife constitutes a valuable tourist asset.

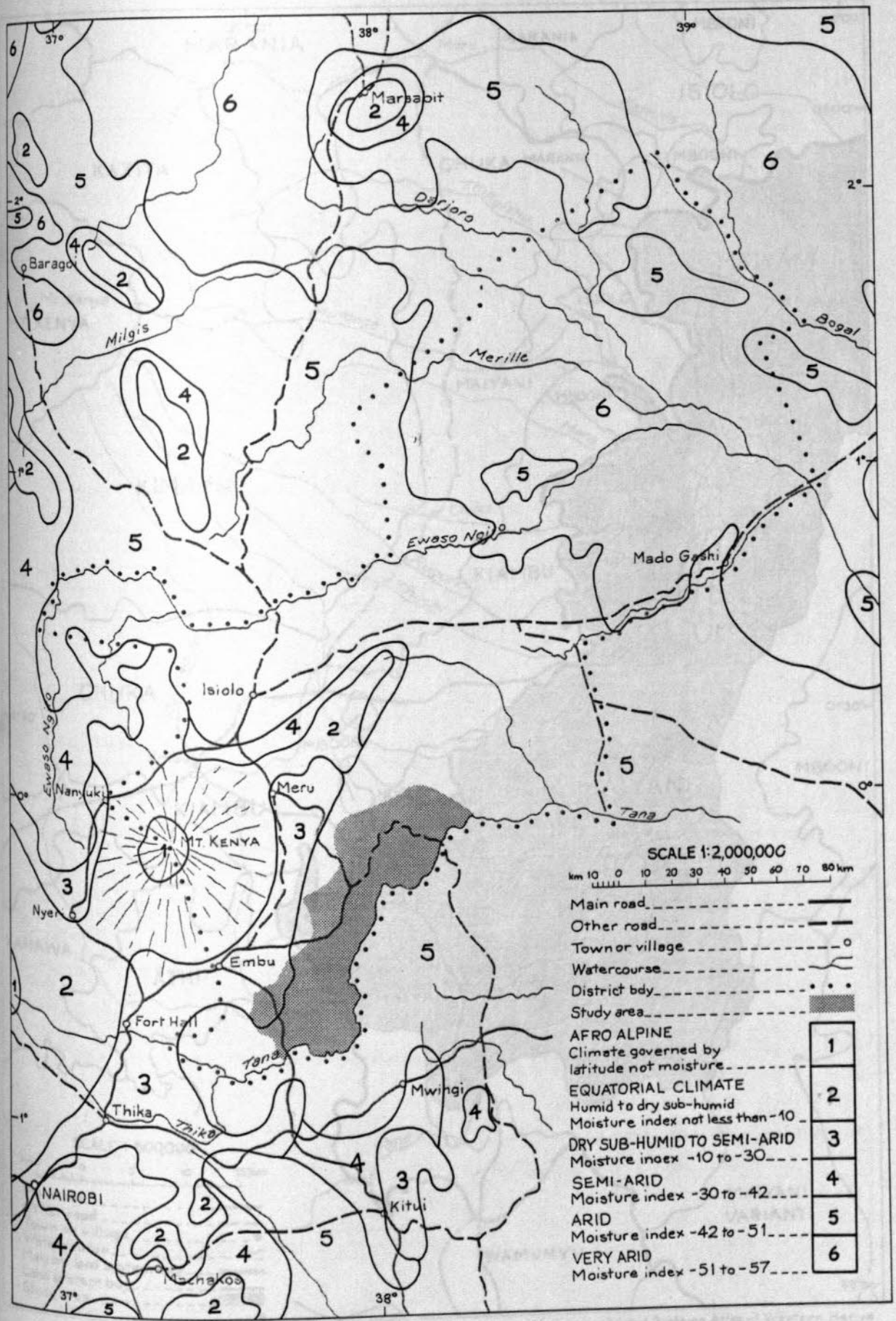
5 ARID. Moisture index -42 to -51

Land only very locally suited to agriculture, the woody vegetation being dominated by Commiphora, Acacia and allied genera, mostly of shrubby habit. Perennial grasses such as Cemchrus ciliaris and Chloris roxburghiana can dominate, but succumb readily to harsh management; more than 4 ha is required per stock unit. Wildlife is important, particularly where dry thorn-bushland predominates. Burning requires great caution but can be highly effective in bush control.

6 VERY ARID. Moisture index -51 to -59

Rangeland of low potential, the vegetation being dwarf shrub grassland, or a very dry form of bushed grassland with Acacia reficiens subsp. misera often confined to water courses and depressions with barren land between. Perennial grasses (e.g. Chrysopogon aucheri) are localised within a predominantly annual grassland; productivity is confined largely to unrealiable seasonal flushes and grazing systems must be based on nomadism. The populations of both wild and domestic stock are restricted severely by the environment.

(Climatic Zone 7, which is true desert, with a moisture index of -57 to -60, does not occur in Kenya.)



TEXT MAP 5 Ecological zones

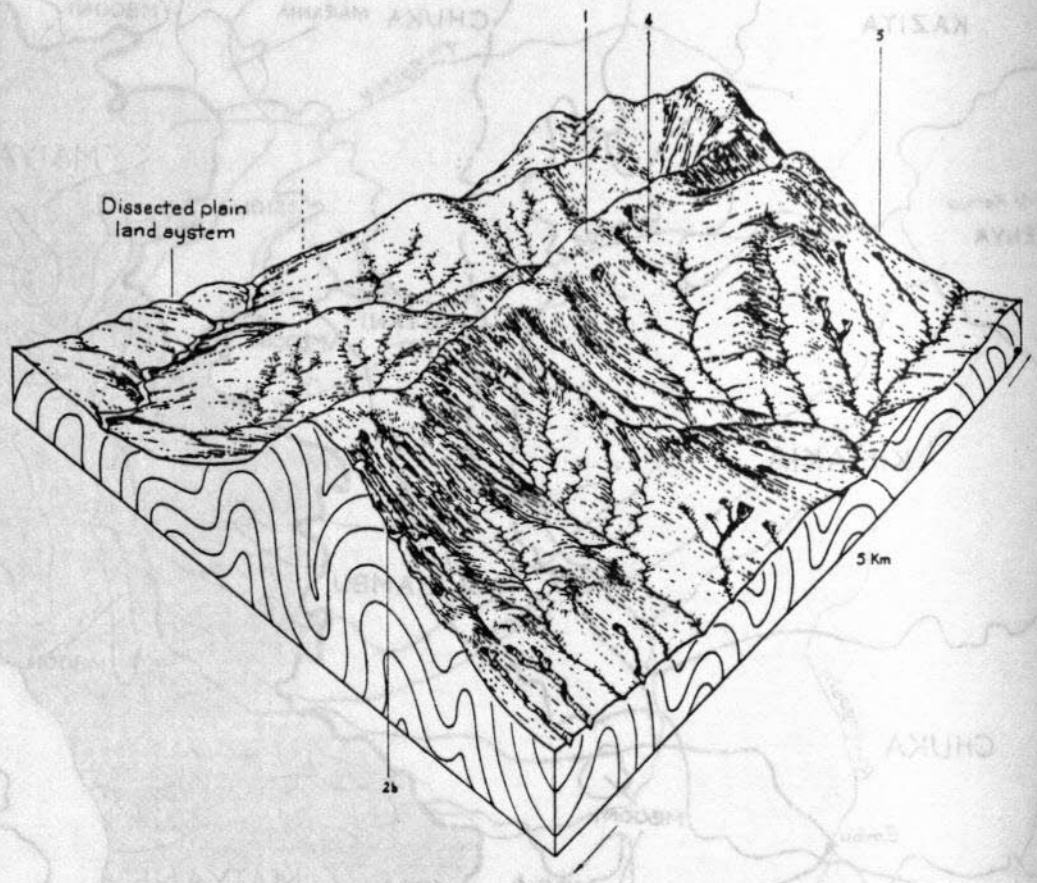
Rep 109/KEN/TFS/5

Prepared by Land Resources Development Centre 1981

after: Scott, Webster and Lawrance. A Land Systems Atlas of Western Kenya.

TEXT MAP 6 Maiyani land system, relative to Embu, Meru and the Tana river

Prepared by Land Resources Development Centre 1981



MBOONI KE 92

Climate: Rainfall 500–1,300 m. Highest on hill tops, lowest on footslopes. November–December. March, April.

Geology: Gneisses of Basement Complex, mainly granitic and micaceous but including basic intrusives.

Landscape: This land system includes a number of isolated high hill masses with steep, often deeply dissected margins. The larger occurrences rise to a summit plane closely dissected into a series of closely spaced rounded ridges and spurs separated by narrow valleys. The summit level at 1,700 m to 2,100 m represents a pre-Micocene erosion surface, probably of end-Cretaceous age.

Soil: Red friable clays and reddish yellow sandy clay loams (Ferrisols) and shallow stony soils with rock outcrop.

Vegetation: Cultivated or scrub.

Relief: Maximum (from crest to hill foot) 300–450 m.

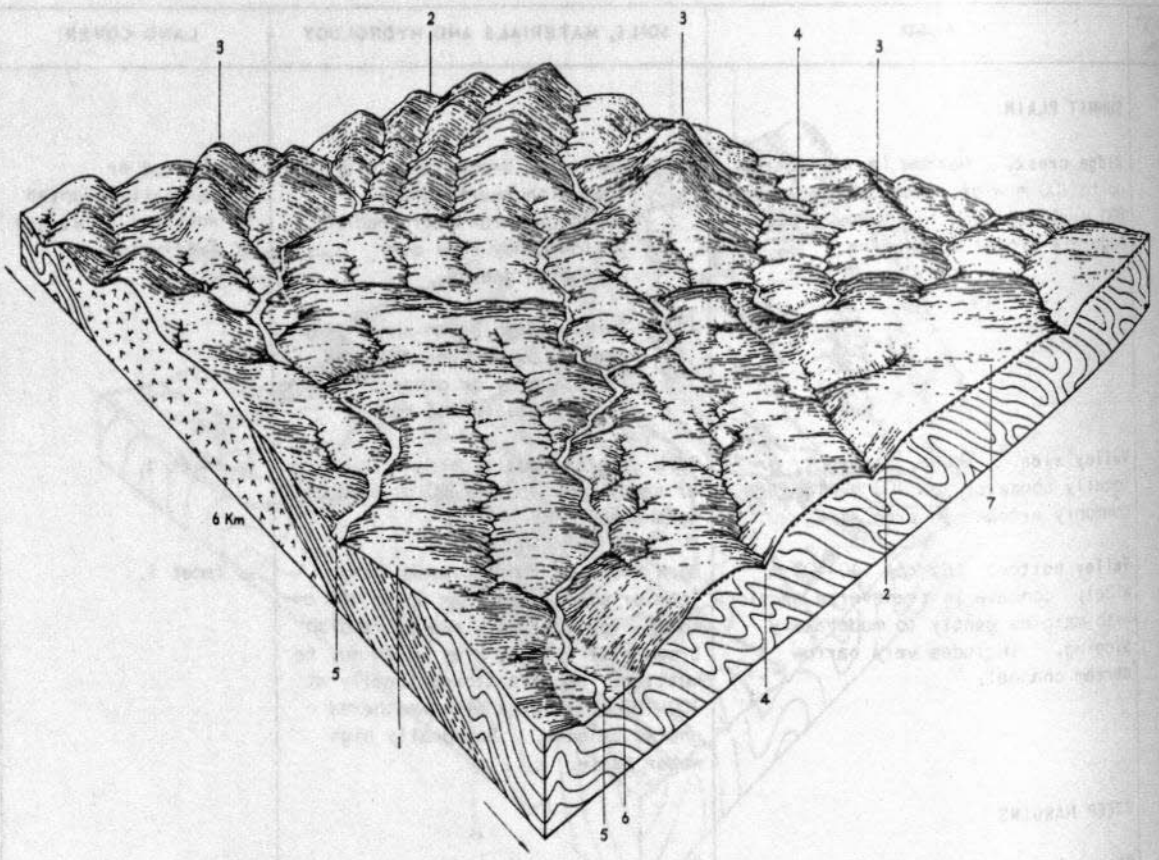
On summit plane ca 100 m.

Altitude: 1,200–2,125 m.

Source: Scott, Webster and Lawrance

FACET No.	FORM	SOILS, MATERIALS AND HYDROLOGY	LAND COVER
	SUMMIT PLAIN		
1	**Ridge crest.** Narrow (a few metres up to 100 m wide, less commonly up to 500 m wide); gently convex with moderate slopes at margins.	(i) Dark grey brown sandy clay loam with quartz gravel 30–40 cm thick over reddish yellow sandy clay over weathered gneiss. (ii) Dark reddish brown sandy clay loam to 30 cm over dark red friable clay or sandy clay to 2 m over weathered rock.	Cultivated or occasionally planted to wattle (*Acacia* sp) or *Eucalyptus*.
2	**Valley side.** Steep, straight, or locally concave; ca 100 m high; commonly arcuate in plan.	Dark greyish-reddish brown clay loam or sandy clay loam 20–80 cm deep over weathered rock.	As facet 1.
3	**Valley bottom.** Narrow (10–100 m wide); concave in transverse section with margins gently to moderately sloping. Includes very narrow stream channel.	Dark brown or reddish brown clay loam or sandy clay loam up to 100 cm thick over red, dark red or reddish brown clay loam or clay which may be mottled. Quartz stones locally at 100–150 cm usually with weathered gneiss beneath. Seasonally high water table.	As facet 1.
	STEEP MARGINS		
4	**Steep slope.** Long, straight or slightly irregular, usually ca 300 m high; frequently indented by long straight gullies; locally very irregular, rough or precipitous.	Reddish brown sandy loam with more or less rock and stones over red friable sandy clay loam to clay frequently with quartz stone line at 30 cm or more with rock beneath. Rough and precipitous slope having very shallow stony soil with frequent rock outcrop.	Scrub.
5	**Major footslope.** Gently to moderately sloping; usually concave; up to 600 m long, very steep to precipitous sided gullies locally.	As facet 2.	Mainly cultivated.
6	**River channel.** Narrow (20–50 m wide) with very small occurrences of terrace.	Rock and boulders. Flow seasonal or perennial.	Banks tree lined.

Source: Scott, Webster and Lawrance



MAIYANI and MAIYANI VARIANT

Climate: Rainfall 500–750 mm. November–December, March–April.

Geology: A variety of gneisses of the Basement Complex, together with smaller amounts of basic intrusions and Post-Archaean pelitic rocks (Embur series).

Landscape: Extensive areas of ridges and valleys with a dendritic pattern. The ridges may have either sharp crests or broader rounded crests. Occasional high conical or elongated hills.

Maiyani Variant has broad crests carrying black clay soils (facet 7). These represent remnants of a formerly more extensive black clay landscape overlying volcanic rocks, mainly phonolites, of the kind characteristic of several neighbouring land systems (cf. Athi, Ndola, Rumuruti).

Soil: Red friable clays (Ferruginous Tropical Soils and Ferrisols).

Vegetation: *Acacia* savanna, cultivated or scrub.

Relief: ca. 100 m, where hills present 200 m.

Altitude: 610–1,820 m in South.
1,200–1,950 m in North.

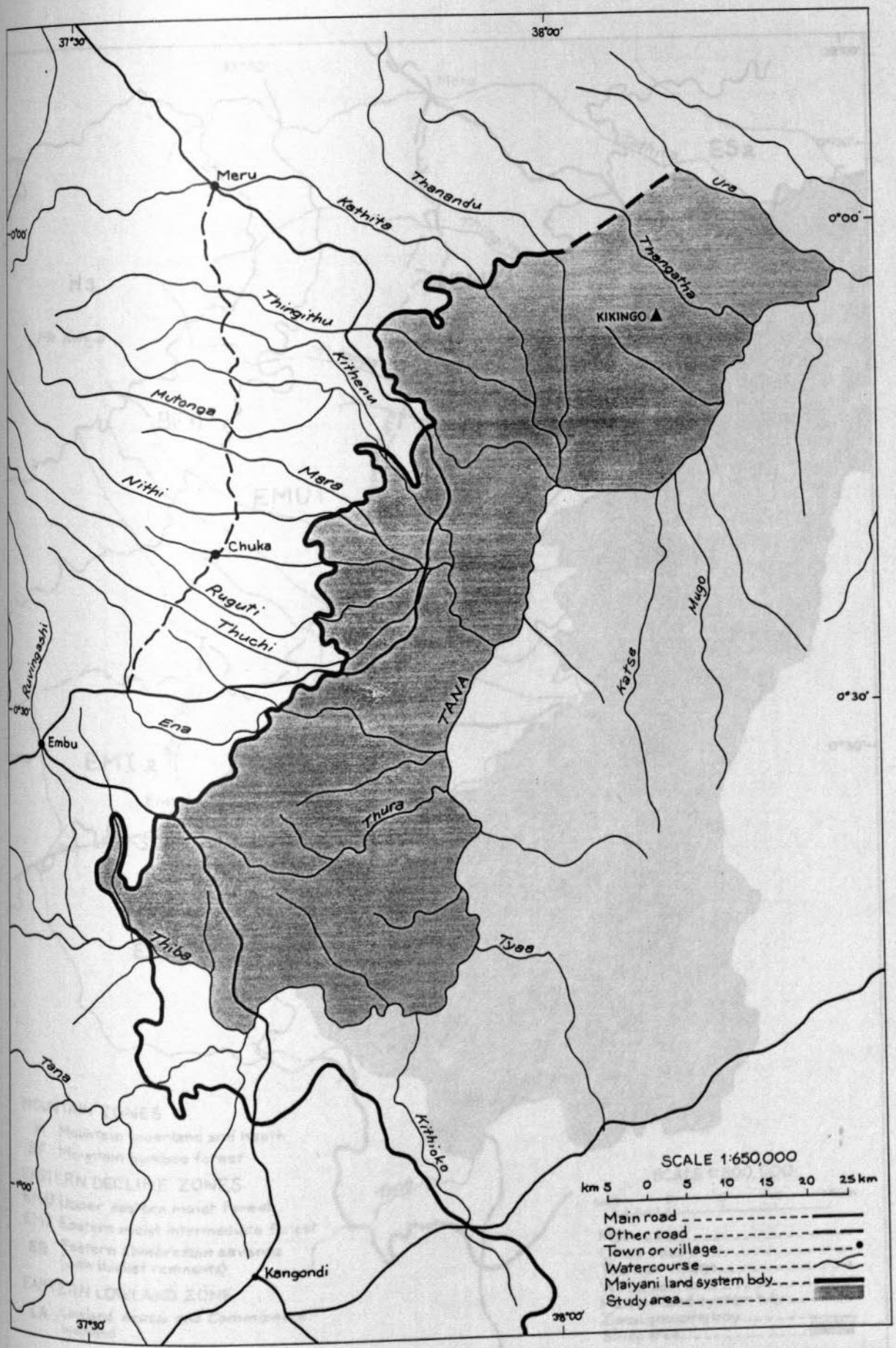
Source : Scott, Webster and Lawrance

MAIYANI & MAIYANI VARIANT

KE 93

FACET No.	FORM	SOILS, MATERIALS AND HYDROLOGY	LAND COVER
1	**Ridge crest.** Level to gently sloping, even convex, 100–600 m across.	Brown sandy loam to sandy clay loam 15–20 cms thick over yellow red to red friable sandy clay loam to clay. Generally weathered gneiss occurs at about 120 cms.	*Acacia* savanna, or occasionally cultivated.
2	**Slopes.** Steep or moderately steep but with convex upper portion. 30–100 m high.	Dark reddish brown friable sandy clay loam to clay up to 15 cms over red friable sandy clay. A quartz stone line occurs above weathered gneiss at depths varying from 50–90 cms.	As 1.
3	**Hills.** Steep or very steep, straight sided, either conical or elongated ridges; may be strongly gullied or very irregular due to rock outcrop. Very variable in height from 10–200 m.	Shallow, stony, brown to reddish brown loams over weathered gneiss at depths generally less than 30 cms.	Scrub or thicket.
4	**Minor drainage lines.** Very narrow valley bottoms (5–30 m across) including stream channel.	Mainly exposed rock, shallow pockets of loose brown sands and gravel beds. Subject to seasonal flow.	Thicket.
5	**Main river channel.** 30–100 m across, with nearly vertical banks 1.5–3 m high.	Loose brown sands of variable depth with occasional rock bars. Subject to seasonal flow.	Tree-lined banks.
6	**Valley flats.** Level to very gently sloping with abrupt margins at river bank and upper margins concave; discontinuous, sporadic in occurence, up to 200 m on either side of river.	Brown sandy loams up to 30 cms over reddish brown sandy loams to sandy clay loams generally over 190 cms deep. Quartz stone lines may be present at about 90 cms.	As 1.
7	**Clay flats.** Level to gentle sloping, occurring as ridge crests and occasionally as benches below facet 1. Up to 500 m wide and sporadic in occurrence. **N.B.** Occurs in Maiyani variant only.	Dark grey plastic sandy loam with angular quartz gravel over 100 cms deep. (This is a remnant of a former much more extensive black clay plain).	Wet grassland with scattered *Acacia drepanolobium*.

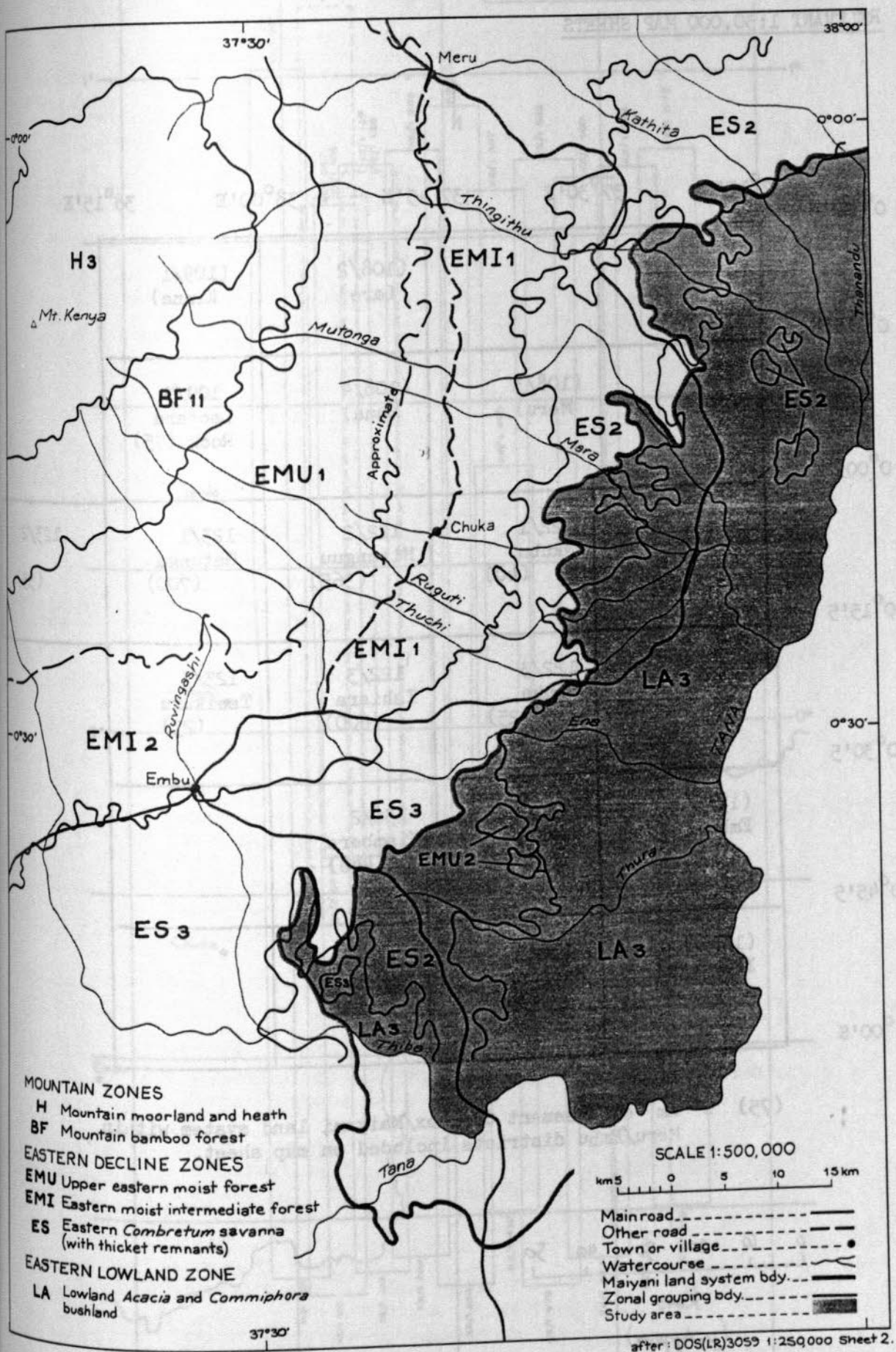
Source: Scott, Webster and Lawrance



TEXT MAP 7 Drainage

Reg 109/KEN/TFS/7

Prepared by Land Resources Development Centre 1981



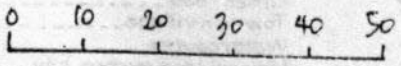
TEXT MAP 8 Zonal grouping of vegetation types (C G Trapnell)

Prepared by Land Resources Development Centre 1981

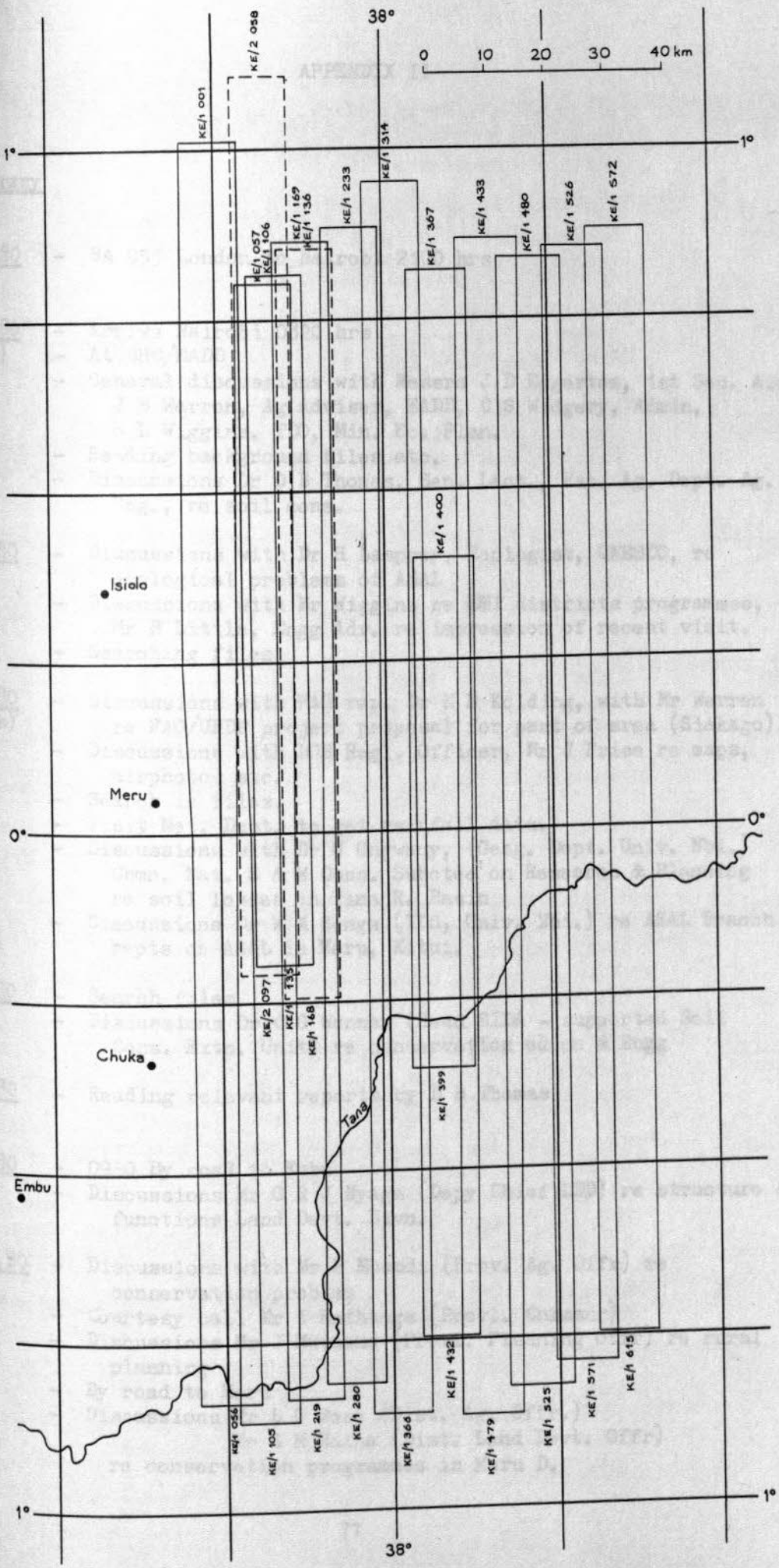
RELEVANT 1:50,000 MAP SHEETS

	37°15'E	37°30'E	37°45'E	38°00'E	38°15'E
0°30'N			(108/2 Lare)	(109/1 Kinna)	
0°15'N		(108/3 Meru)	(108/4 Maua)	109/3 Leopard Rock (75)	
0°00'		122/1 Nkubu (40)	122/2 Mitunguu (365)	123/1 Gatunga (700)	123/2 (35)
0°15'5		122/3 Chuka (25)	122/3 Ishiara (600)	123/3 Tseikuru (25)	
0°30'5	(135/2 Embu)	136/1 Siakago (392)	136/2 Kiambere (448)		
0°45'5	(135/4 Ithanga)	136/3 Massinga (399)	136/4 Kindaruma (98)		
1°00'S					

(75) = Km^2 of Basement Complex/Maiyani land system within Meru/Embu districts included on map sheet.



Kms
(v. approx)



TEXT MAP 9 Airphoto cover, 1979-80, D.O.S. contract 183, 1:40,000

Prepared by Land Resources Development Centre 1981

APPENDIX II

Itinerary

3.11.80 (Mon) - BA 055 London to Nairobi 2100 hrs

4.11.80 (Tues)
- Arrive Nairobi 0820 hrs
- At BHC/EADD
- General discussions with Messrs J D Edgerton, 1st Sec. Aid J B Warren, Ag Adviser, EADD, C S Widgery, Admin, S L Wiggins, TCO, Min. Ec. Plan.
- Reading background files etc.
- Discussions Dr D B Thomas, Sen. Lect., Fac. Ag. Dept. Ag. Eng., re soil cons.

5.11.80 (Wed)
- Discussions with Dr H Lamprey, Ecologist, UNESCO, re ecological problems of ASAL
- Discussions with Mr Wiggins re EMI districts programmes, Mr B Little, Engg Adv. re impression of recent visit.
- Searching files.

6.11.80 (Thurs)
- Discussions with FAO rep. Dr K E Kolding, with Mr Warren re FAO/UNDP project proposal for part of area (Siakago).
- Discussions with DOS Regl. Officer, Mr J Price re maps, airphotos etc.
- Search in files.
- Visit Met. Dept. to get rainfall data.
- Discussions with Dr G Ongweny, (Geog. Dept. Univ. Nbi.) Chmn. Nat. S & W Cons. Subctee on Research & Planning re soil losses in Tana R. Basin
- Discussions Dr W M Senga (IDS, Univ. Nbi.) re ASAL Branch repts on ASAL in Meru, Kitui.

7.11.80 (Fri)
- Search files
- Discussions Dr C G Wenner (Head SIDA - supported Soil Cons. Extn. Unit) re conservation educn & Engg

8.11.80 (Sat) - Reading relevant reports by D B Thomas

9.11.80 (Sun)
- 0930 By road to Embu
- Discussions Mr G R J Nyaga (Depy Chief LDD) re structure & functions Land Devt. Divn.

10.11.80 (Mon)
- Discussions with Mr P Mbandi (Prov. Ag. Offr) re conservation problem
- Courtesy call Mr I Mathanga (Provl. Commsnr)
- Discussions Mr J Mwinamo (Provl. Planning Offr) re rural planning
- By road to Meru
- Discussions Mr L O Sese (Dist. Ag. Offr.)
  Mr S M Maina (Dist. Land Devt. Offr)
  re conservation programmes in Meru D.

10.11.80 (cont) - Courtesy call Mr B Mogaka (Ag. DC, Meru)
- Discussions Mr R Reese (Oxfam agriculturist) re farmers' needs and responses

11.11.80 (Tues) - Field visit: Meru - Gaitu - Gichera - Makandune - Marimanti FTC - Gatanga - Ura Gate road - Kikingo FR - Kathanganchini - return to Meru

12.11.80 (Weds) - Field trip: Meru - Kianjai hill - Oringo - Ntombo nsy - Kieiga - Thuuri slopes - Kamjeni nsy - Nyambeni - Mana - Kangeta - Kuani hill - Meru

13.11.80 (Thurs) - Field trip: Meru - Misunguu nsy - Karani waterhole - Chiokarige sandweirs - DO's office, Mr C M E Akiboya - Kianjuki dam - Kamainde - Kamanyaki farmers' group - Meru

14.11.80 (Fri) - Field trip N. Imenti/Ruiri settlements - Meru
- Roundup meeting Mr Getonga (Dist. Prog. Coordr) re impressions after field visit
- By road Meru - Timau - Nanyuki - Karatina - Embu

15.11.80 (Sat) - Discussions with Mr D Mwangi (Dist. Ag. Offr.), Miss J Kagwa (DLDO) re cons. problems, Embu
- Courtesy call Mr A K Githinje (DC)
- Discussion Mr E Kamau-Munia (Principal, Embu Ag. Inst.) re cons. education needs & capabilities
- Discussion Mr Mboga, (Provl. Planning Asst) re planning

16.11.80 (Sun) - Reading papers, indexing information

17.11.80 (Mon) - By road - Embu - Nanyuki - Timau - Meru
- Roundup discussions Mr L O Sese (DAO) re impressions & likely approaches
- By road Meru - Mitunguu - Ishiara (meet DLDO, Embu) - Siakago - Itira catchment - return to Embu

18.11.80 (Tues) - Field trip: Embu - Gachoka/Mbeti - Rianjeru farm - Kiritiri - Machanga - Igumore dam - Kirima - Mwea/Tebere irrigation area - Embu

19.11.80 (Wed) - Field trip: Embu - Runyenjes - Thunga valley - Ena waterfall - Irangi Forest Sta. - Embu
- Roundup discussions Mr P Mbandi (PAO), Mr M N Thiomeo (Provl. Program. Coordr), Mr D N Nyasani (Provl. Extn. & Trng. Offr) re impressions and likely recommendations
- By road Embu - Nairobi
- Discussions with Mr J B Warren (EADD) on impressions and project formulation

20.11.80 (Thurs) - By road - Nairobi - Machakos Int. Devt. Project
- Discussions Dr P Neunhaeuser (PM)
- Field trip and discussions Mr M Zobisch re consn. activities
- Discussions Mr G Cattermole (FAO - Machinery)

21.11.80 (Fri)
- Visit Katumani Res. Sta.
- Discussions Dr T G Strachwitz (Tillage) & Dr P Whiteman (FAO Dryland Fmg) re recommendations for ASAL
- Return Machakos - Nairobi

22.11.80 (Sat)
- Discussions Dr D B Thomas (Univ. Nbi) & Dr R Barber re grad. training programs & research

23.11.80 (Sun)
- Prepare notes for Monday descriptive meeting

24.11.80 (Mon)
- Descriptive meeting at EADD - Messrs Crompton, Duff, Warren, White, Little
- Drafting brief discussion paper for Min. of Ag. Mr Mukolwe

25.11.80 (Tues)
- Preparation & reprodn brief discn. paper (above)

26.11.80 (Wed)
- Preparation of maps for report

27.11.80 (Thurs)
- Report preparation

28.11.80
- Talks on 'Brief discussion paper ...' with Mr M Mukolwe, Head, Land Devt Divn
- Report preparation

29.11.80 (Sat)
- Report preparation

30.11.80 (Sun)
- Report preparation

1.12.80 (Mon)
- Photocopy report
- By road Nairobi - Embu. Report copy to Mr Wiggins
- Return to Nairobi

2.12.80 (Tues)
- Additional notes for report
- Discussions Mr B Little (EADD) re implications of recommendations

3.12.80
- Additional notes & amendments to report
- Prepare seminar material
- Discussions ICRAF Dr Steppler (DG), Dr Torres (AH) re agro-forestry

4.12.80
- Photocopy amended report for ODA & collate
- Lead seminar 'Planning for Conservation in the Future' at Ag. Eng. Dept., Fac. of Agric., Univ. Nbi, Kabete
- Discussion with Mr J Muchaena (Head of Kenya Soil Svy)

5.12.80 (Fri)
- Checking/editing/indexing draft report for EADD, ODA with Mr Wiggins
- Discussions with Mr C M Gichohi (Head, ASAL Branch, MOD)
- 1900 - depart for airport

5.12.80 (cont) - 2210 - direct flight Nairobi - Rome, 24 hrs delay, ∴ Ticket re-routed by BA
- 2330 - BA 055 Nairobi - London

6.12.80 (Sat) - 0640 arrive Heathrow
- 0930 depart Heathrow BA 502 to Rome
- 1215 (local) arrive Rome

7.12.80 (Sun) - Preparing Abstract and Covering Report

8.12.80 (Mon) - FAO Land Devt. Divn.
- Discussions with Dr Hauck (Head, Soil Resources Management & Conservation Service)
- Mr D Sanders, Mr J Alexander, re FAO's approaches to soil conservation. Also Dr J Pacheca re FAO's remote-sensing unit and services
- Preparation Covering Report

9.12.80 (Tues) - 1330 depart Rome, arrive Heathrow 1530
- Reach home 1940.

APPENDIX III

Areas and populations of Embu and Meru

District	Total area km^2	Area in Ecological Zones[1], kg. km			Total population '000s	Population in Zones IV - VI '000s
		IV	V	VI		
Embu	2 871	270	1 590	-	262	112
Meru	9 528	810	538	-	833	86

Sources : Provisional data 1979 Census
GOK, 'ASAL : the framework for programme planning, implementations and evaluation'

Note : 1. Zone IV = 'Semi-arid', rainfall between 500 and 800 mm a year
Zone V = 'Arid', " " 350 " 500 mm " "
Zone VI = 'Very arid', " " 200 " 350 mm " "

APPENDIX IV

TECHNICAL COOPERATION OFFICERS : PROPOSED TERMS OF REFERENCE, QUALIFICATIONS AND EXPERIENCE

1. LAND USE PLANNER

Attached to PDA's office in Embu. Counterpart to PLDO.

Terms of Reference (within the Districts of Embu, Meru, and Isiolo and with special attention to the problems of semi-arid and arid lands).

1. To work with counterpart in developing appropriate methods of rapid land resource survey and land use and conservation planning, emphasising the use of air photographs and maps.

2. To assist District staff in the production of detailed plans for cropping, grazing, afforestation and conservation for selected small pilot catchments in close collaboration with the farmers.

3. To advise District staff on the implementation of the pilot catchment plans. Such catchments should act as demonstrations of the benefit of conservation considered as an integral part of agricultural production.

4. In collaboration with the proposed Agricultural Engineer, to devise and teach short courses in land use planning and air photograph interpretation to senior District and Provincial staff associated with land development in general. The emphasis will be on training trainers, who in turn will teach other staff.

5. To assist as requested by District Staff in the preparation and teaching of soil conservation courses for junior staff and others.

6. To help as requested with similar courses in conservation already taught at the Embu Institute of Agriculture.

7. To compile a mapped index of land resource information in the three Districts, and recommended land use practices.

8. To help produce additional relevant conservation training and reference material as may be required.

9. In conjunction with the Provincial Planning Office, to help prepare development plans for the semi-arid and arid lands, including the recommendation and preparation of additional land use and conservation projects for funding by foreign donors.

Qualifications and Experience

- 1st degree or equivalent in agriculture, soils, physical geography, or other appropriate natural resource subject.

- Preferably higher diploma or degree in land resource appraisal and land use planning with particular reference to tropical/subtropical agricultural and pastoral conditions - or equivalent experience proven during field service in such areas.

- Field experience of at least five years in the tropics/subtropics in the general area of land husbandry including land resource survey and appraisal, and land use planning preferably in marginal/semi-arid areas. This should have had special reference to the identification of ecologically-appropriate systems of agriculture and other land uses, choosing the optimum strategies and techniques of water and soil conservation, and the planning and layout of suitable rural infrastructure on a catchment basis. Familiarity with soil erosion processes and competence in the use of air photos in office and field for such work are essential.

- The ability to effectively transmit knowledge to counterparts and others, in the course of normal duties and formal training courses in which he/she would take part, is an important attribute.

2. SOIL AND WATER CONSERVATION ENGINEER

Attached to PDA's office in Embu, with the PLDO as counterpart.

Terms of reference

In the Districts of Embu, Meru, and Isiolo and with special attention to the problems of semi-arid and arid lands:-

1. To assist Provincial and District staff in the siting and design of small structures for conservation of soil and water, for example: subsurface dams/sand weirs, gabion and rock check-dams, and other appropriate physical soil and water conservation works.

2. To cost the above structures and measures.

3. To assist the proposed Land Use Planner in training activities as requested by him and other Provincial and District staff.

4. To help establish demonstration plots of appropriate erosion control measures, including experimental measurements and analysis of results. These will be set up at strategic locations, for example Farmer Training Centres, etc.

5. To help design and lay-out suitable structures in the proposed pilot demonstration catchments.

6. To assist in the planning and design of other simple engineering structures for example access routes and farm buildings, as needed.

7. In conjunction with the Provincial Planning Officer, to help prepare development plans for the semi-arid lands, including the recommendation and preparation of additional conservation projects for funding by foreign donors.

Qualifications and experience

- First degree or equivalent in agriculture, forestry, agricultural engineering or other appropriate subject in which engineering is considered in the context of applications to natural resource/ agricultural management.

- Preferably a higher diploma or degree in soil and water conservation, field engineering or related subject with particular reference to applications to rural development activities in the tropics and subtropics - or equivalent ability proven during field service in such areas.

- Field experience in the tropics/subtropics of at least five years in land husbandry activities, in particular the selection, location, design, survey, layout and construction of small-scale physical water- and soil-conservation and reclamation works appropriate to various situations, within the framework of catchment-based rural development plans. An understanding of soil erosion processes and methods of runoff calculation; competence in using basic topographic survey techniques in the field and in the office - and field-use of airphotos, are essential.

- The ability effectively to transmit knowledge to counterparts and others, in the course of normal duties and of formal training courses in which he/she would take part, is an important attribute.

APPENDIX V

NOTES ON THE ECONOMICS OF GULLY CONTROL

1. A formal cost-benefit analysis is barely possible for gully control owing to the indeterminacy of technical parameters of gully development. Too many dubious assumptions would have to be made to provide the specific data required for cost-benefit analysis. Any such analysis would thus be specious.

This remark would apply to individual gullies, but is all the more pertinent in the present case where a programme of stabilising gullies is contemplated, including a great number of individual gullies with varying characteristics.

Nevertheless some qualitative guidelines can be offered based on an economic viewpoint.

2. The main negative effects of gullies can be summarised as follows:

2.1 By lowering the base drainage level, gullies encourage the drying-out of the soil. This proceeds either by lowering the water table, or by allowing lateral drying-out of the soil.

2.2 Loss of land due to slumping and erosion of gulley sides and the extension of lateral gullies. The amount of land so affected depends upon soil characteristics, amongst others, soil erodibility and angle of repose. These influence the relationship between depth of vertical cut and width of resultant valleys, and the extent and degree of development of lateral gullies. The loss of land is especially important in relation to the loss of plant nutrients contained in the soil.

2.3 In some situations, gullies may interrupt access across farmland. Similarly some gullies may threaten valuable roads, buildings, and other structures.

2.4 The material cut out by gullies may contribute to sedimentation problems downstream - in dams, ports, etc.

3. Thus, just as the measures employed to control a particular gully, and hence the costs of control, will depend on the specific characteristics of the gully, so will the benefits of effecting such control vary. Put simply, the economic sense of stabilising one gully or another will have to be assessed case by case. In practice, the land use planners should be able to make judgements by giving priority to controlling gullies which have the following characteristics:

3.1 Any gully whose development threatens to destroy or render useless physical structures. For example, a gully cutting back into a tarmac road, or undermining buildings.

3.2 Gullies which remove high potential cropland, especially in densely populated areas. The morphology of the gully will greatly affect the judgement. For example, a deep trench without lateral channels may look spectacular, but may not remove a great deal of land. Conversely, a shallow gully with gently-sloping sides and widespread development of lateral feeder gullies would affect large areas. Shallow laterals also remove a disproportionate quantity of nutrient-rich topsoil.

3.3 Lastly, stabilising gullies surrounded by poor quality land, degraded rough grazing, and in areas of sparse population should be treated with circumspection. In the worst cases it may not be worth expending resources on control.

4. Two qualifications need to be made. First, gully control measures will only stablise the gully. They will not remove the causes of gullying, and for this purpose other complementary land management activities will be needed to stablise the condition of the gully catchment.

Second, the costs of control must be borne in mind. The higher the priority of controlling a gully, the more that can be spent on control - either in terms of the number of structures or the sophistication of their design. Thus for gullies in category 3.3, only minimal expenditure may be justified.

APPENDIX VI TECHNICAL NOTES

A. DISENTANGLING EFFECTS OF RAINFALL FROM THOSE OF RUNOFF

A much clearer understanding of erosion is obtained - and more precise means of controlling it are possible - if rainfall effects are separated from runoff effects:

Rainfall : Strike surface/seal surface/splash soil particles about/ stir runoff to maintain turbidity

Runoff : Carry eroded materials/cut downwards rills and gullies/ drown lowlands/dump sediment

In this regard, recent papers by Foster, Meyer, Mannering, Romkens, Mutchler, and other 'whizz-kid' researchers in US are very enlightening.

B. CLIMATIC ANALYSIS

An important early task to help quantify the rain environment, will be to get hold of all the daily rainfall data from appropriate raingauge stations and do an analysis of 'rainy pentads' (5-day chunks) or 'rainy weeks' (7-day chunks) (as specifically defined) to gain an idea of the statistical likelihood of rain of stated amount in a given week. Everyone says the rainfall is erratic and unpredictable from year to year. Rain is usually quoted as monthly totals, which are fairly meaningless/ useless figures if you are considering crop growth patterns.

This may have been done already, but if not, it ought to be a priority task.

C. SIGNIFICANCE OF ICRAF (INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY) - 5TH FLOOR OF BRUCE HOUSE, NAIROBI

Discussions with Dr Howard Steppler (Director-General, Interim) and Dr Filemon Torres (Range Management and Fodder Production Specialist)

revealed a close concensus between my conception of an appropriate approach to the problems of the area, and that of ICRAF. These were:

i. Try to understand the socio-economics of the present land use systems as well as the environmental components; find out how the farmers/land-users view the present situation - the 'why' and 'how' and 'what-are-the-problems' of the present. In the first instance, find out what are the key questions to ask about any system in order to characterise it.

ii. Determine what is the most appropriate form of land-use in an area from both the environmental and socio-economic points of view - is it forest production particularly? or is it crop/animal production particularly? or is it integrated agro-forestry production particularly?

iii. Identify the parts of the overall systems and sub-systems where already-proven and appropriate recommendations could be introduced with likelihood of positive benefit. What do we already know? - Conversely, identify where there are gaps in understanding and knowledge which point the directions for problem-oriented research.

This multiple-usage concept and the multi- and interdisciplinary team approach being developed by ICRAF are very concordant with the overall approaches of Land Husbandry. Both are fostering the appropriate uses of land according to both environmental and socio-economic guidelines as to what is needed to ensure stability.

The TCOs and associates in Embu would do well to make and maintain close contact with ICRAF. It may well be that ICRAF could have a joint and practical role in helping to determine what are the most appropriate forms of land use in the project area. I consider that (unconsciously) the farmers are actually operating an agro-forestry system - integrated cropping and livestock and trees, in which each satisfies several needs, and all are interrelated.

There could therefore be fruitful collaboration in characterising of, and identifying improvements for, the systems of the area.

D. EROSION-HAZARD CLASSIFICATION AS GUIDE TO OPTIMUM TYPES OF USE

Not only will resource-survey activities identify and map where different degrees of erosion are already to be found, but should also map the land area according to hazard of being excessively-rapidly eroded under particular land-use methods - land-use incapability classification. The minimum needs for protection, both biological and physical, must be specified for each area, to provide guidelines to the maximum permissible intensity/type of land use which should not be exceeded if erosion is to be kept to lowest levels. (See for instance 'A Land Husbandry Manual' in EADD Library).

E. SOME GUIDELINES TO PROPER PROCEDURE

The TCOs should approach the land-resource survey and land-use planning work for the area in a systematic manner, emphasising and mapping, (among other such relevant points as spatial variations in climate, vegetation, settlement distribution etc.):

i. Land-use incapability classification, based on hazard of being eroded

ii. (subsequent to i.) Land-use suitability classification with regard to suitability ranking for various alternative uses.

The systematic approach as taught by R G B Jones is particularly relevant. This is also contained and expanded, with detailed stepwise instructions in the practicalities of correct use of airphotos, field techniques for subsequent land resource characterisation, drawing up 3-D land use plans etc. in: 'A Land Husbandry Manual' by Shaxson, Hunter, Jackson and Alder, published by Government Printer, Box 37, Zomba, Malawi. Unless a similarly-detailed, explicit and more locally-relevant manual is available, I strongly suggest the use of the above in order to standardise and

systemise procedures until local experience in the EMI area provides a basis for improving it.

Unless systematic procedures are followed in this work a lot of time can be wasted in accumulating unrelated or uncoordinated information, in a manner that is confusing to those (counterparts) who are trying to learn how to do the job.

I'd suggest that a number of copies are obtained so that each member of the team can have one, and all operate in the same way.

F. PURCHASE SETS OF ALL AIRPHOTOS OF MERU-EMBU AREA TO CHARACTERISE CHANGES IN LAND-USE OVER TIME

In order to undertake valuable studies of the changes in land use taking place over time in the EMI area, and to use this as a training tool in the Ag. Eng/Soils Departments of the University (Dr Thomas, Mr Barber), I suggest that one set of (at least the relevant photos of) each airphoto flight of the area - 1945 (or earlier?) onwards be purchased and lodged at the University for their use and the Project's reference. This could provide a very valuable basis for collaboration.

G. 'RANGE PITTING' ON GRAZING AREAS TO INCREASE RAINWATER ABSORPTION

The digging of discontinuous shallow/small pits to detain runoff water, yet allow unconcentrated runoff if they filled up, might be a useful famine-relief type of work to provide employment for cash with which food could be bought (see comment re Rob Reese's Oxfam request N Meru). I don't know if it has been tried and if so whether it had the hoped-for beneficial effect of getting more water into the soil in such areas. It wouldn't avoid the trampling problem, but might be useful. Worth trying.

Apart from that, (or massive deep ripping with a D7 Cat - which I don't think could possibly be justified, until much progress had been made in better herd/pasture management) I don't think there are any other viable

mechanical measures likely to help on the grazing areas (?80% of the 70% which is subjected to heavy grazing pressure annually).

H. SOME REASONS FOR EROSION CONTROL

Note : Two main reasons for wishing to control soil erosion are usually advanced, to be considered either separately or together:

i. Loss of topsoil and associated plant nutrients diminishes the productive potential of the land and increases the distress of the people living thereon

ii. High sediment loads carried by tributary rivers and streams into the Tana River are causing, and will continue to cause, unacceptably high rates of sedimentation and loss of water-storage in the capacity reservoirs behind the present and proposed dams.

It is worth noting that, in a study of the disbenefits of soil erosion in the Acelhuate catchment in El Salvador, Wiggins (1980) found that loss of agricultural potential from the soils in the catchment was economically and socially much more serious than loss of water-storage capacity of a large hydro-electric dam. This was because the primary purpose of the dam was to provide a constant head of water to the turbines, rather than to regulate flow to even levels throughout the year. In the case of the Tana River dams, the prime function of each dam - standardisation of head of water vs. regulation of even river flow - must be specified before a similar analysis of disbenefits of soil erosion could be undertaken.

Wiggins S L (1980) : 'The Economics of Soil Conservation in the Acelhuate River Basin, El Salvador'. Proc. confer. 'Conservation '80'. Nat. Coll. Ag. Eng., Silsoe, UK, July 1980. 399-417. Wiley.

Overseas Development Administration

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Soil and water conservation in Embu and Meru Districts, Kenya: summary

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Overseas Development Administration

SOIL AND WATER CONSERVATION IN EMBU AND MERU DISTRICTS, KENYA

Summary report on a reconnaissance visit 3 November-9 December 1980

T F SHAXSON

Summarised by LRDC

Project Report 109

KENYA-04/REP-109/81

Land Resources Development Centre
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1. INTRODUCTION

1.1 Origins of the visit

In October 1980 the Kenya Government submitted a request to the British High Commission in Nairobi for the services of Mr T F Shaxson, Soil and Water Conservation Specialist and ODA Corps of Specialists Officer, in connection with the Embu/Meru Project. This request was granted and Mr Shaxson made a reconnaissance visit to Kenya during the period 3 November 1980 to 9 December 1980, which included a 2-week trip to the field.

1.2 Terms of Reference

Mr Shaxson's Terms of Reference, drawn up and agreed to by the Kenya Ministry of Agriculture and the East Africa Development Division of ODA, were to:-

- Determine the extent of the soil erosion problem in and adjacent to Embu and Meru districts, with particular reference to the medium and low potential areas in those districts.

- Define the project area.

- Determine the underlying reasons for and causes of the soil erosion.

- In the light of the above, draw up proposals for UK assistance with the control of soil erosion at an acceptable level within the project area.

1.3 The Study Area

For environmental reasons erosion problems are less catastrophic at altitudes above 4 500 ft in Embu and Meru Districts, so the study was confined to areas lying below this level.

Following aerial photographic interpretation at Tolworth and field visits and discussions in Kenya, an area of approximately 3 200 km^2 with particularly severe land use problems was identified for closer study (Map 1). It extends from Mitunguu to Kiritiri, and from Ishiara to the Tana River. It is underlain by Basement Complex rocks and has the broken topography with steep side slopes and dentritic drainage pattern of the Maiyani Land System.

The dominant vegetation is Acacia/Commiphora shrubland and thicket with herbs and shrubs but very little grass. Much of the area has a 10-20% chance of receiving less than 20 inches of rain annually. It is widely used under a system of shifting agriculture and communal grazing and is suffering from heavy grazing pressure and cattle trampling. There is evidence of sharply increased population pressure over the past 10-15 years and an associated shortening of the bush fallow part of the cultivation cycle.

2. CAUSES AND EFFECTS OF SOIL EROSION

2.1 The direct cause of soil erosion is the high runoff resulting from the interaction between (i) intensive rainfall, and (ii) severely compacted and relatively impermeable soil surfaces. These surfaces are a particular feature of grazing lands, but they also occur on cultivated land. They cause a high proportion of the rainfall to become runoff rather than soil moisture, resulting in increased drought severity as well as loss of nutrient-rich top soil.

2.2 The soils of the area compact readily, a property that is aggravated by the paucity of vegetation and the trampling of animals. The latter factor reflects the importance of livestock production, nearly all of the area being subject to more or less continuous grazing pressure. Most herds of domestic livestock seem to comprise a mixture of cattle, sheep and goats. Apart from their role as providers of milk and meat, livestock are also kept as a source of ready cash in time of need.

2.3 The desire of individuals to increase the size of their herds so as to have more "cash on the hoof" is clearly at variance with the desirability of limiting livestock numbers in the context of an overall soil and water conservation programme in the area. Herds of livestock are maintained within the traditional management system involving land, crops and animals, and this system is clearly no longer capable of sustaining productivity in the face of accelerating erosion, declining soil fertility and falling groundwater recharge. The area as a whole is now showing signs of severe degradation due to water loss and soil erosion, and in many places much of the biologically active top soil already appears to have been lost by erosion.

2.4 In this context there are a number of constraints on development of the area which are distinct from those associated with the physical environment. They include:

- lack of proven recommendations for improving farming systems
- inadequate rural infrastructure
- lack of physical inputs
- insufficiently trained or experienced extension staff
- inadequate marketing arrangements

3. CONCLUSIONS

3.1 The serious problems of water and soil loss can only be significantly diminished if most or all of the rainwater soaks into the soil as a result of:

- maintaining the soil surface in a porous condition
- ensuring detention of water on the surface to allow infiltration
- maximising the degree of surface cover provided by growing plants, and by plant residues and litter

3.2 The above can only be achieved on a lasting basis if all aspects of farming and land use, in addition to purely physical conservation measures, are improved and made more protective, and if conservation becomes an integral part of better farming and other forms of land use.

3.3 The means by which this can be achieved depend on both social and technical approaches, and on both physical and biological conservation measures being implemented as integral parts of improved systems of husbandry of crops, animals and land.

3.4 The people of the area are the ultimate land managers, and improvement can only come about if their knowledge and skill increase and if the necessary advice and training, infrastructural support, supplies of inputs, access to markets and other necessary support becomes available. Those responsible for making in-field judgements and decisions about the means of achieving conservation farming on such lands need to make them from ecological viewpoints, using an understanding of basic ecological principles which govern environmental relationships; and fostering an ecology of disciplines whose various specialisations will need to be used in harmony to serve the farmers in these areas.

3.5 Any conservation approach based on the lines outlined above will involve assistance to the inhabitants of the area, in various forms which will aim to increase the people's knowledge and expertise in improved husbandry practices. Implementation of any such activities will have to be preceded by planning (both physical and economic/financial), realistically based on adequate background data.

3.6 Information about the area appears to be somewhat sparse or uncertain, both about the basic land resources and about the nature of the recommendations for the various types of improvements that could be made. Additionally there appears to be an inadequate number of staff trained in the practicalities of undertaking rapid resource surveys and subsequent physical conservation planning of rural areas and the implementation of agreed programmes on a catchment/topographic basis.

3.7 Having regard to the above, to the stated aims of the Government of Kenya (GOK) to promote the stabilisation and development of the Arid and Semi-Arid Lands (ASAL), and to the need to proceed stepwise from data collection and analysis through planning to catchment-based implementation of conservation farming activities, this document proposes a programme of assistance which, it is suggested, GOK might seek from an appropriate donor:

3.7.1 Provide financial support as soon as possible for inputs to on-going conservation programmes, including expansion of nurseries for tree crops and grasses, construction of subsurface dams for water supplies and check dams for gully control, construction of cutoffs and terraces, protective management of hillslopes. This would involve mainly funds for small tools, casual labour, and construction materials.

3.7.2 Offer to provide support for appropriate new subprogrammes relating to water - and soil - conservation as they may be identified from time to time as the work develops, e.g. check dams for gully stabilisation, collection and storage of rainwater from roofs and other impermeable catchments, and others as yet not clearly in focus.

3.7.3 Provide financial support if requested for appropriate aspects of the work of the University of Nairobi as applicable to the needs of Embu and Meru marginal areas (with special reference to the activities of the Agricultural Engineering Department in this field of work).

3.7.4 Provide as soon as possible a repeat of earlier short-term airphoto/conservation planning courses to train Kenyan staff at appropriate levels as previously conducted by R G B Jones of ODA's Land Resources Development Centre.

3.7.5 Provide two TCOs, in land use planning and in small-scale conservation engineering respectively, who with Kenyan counterparts would:

- Assist GOK staff in developing and using an appropriate and rapid methodology for land resource appraisal, physical planning of conservation, and development on a three-dimensional land surface, with special emphasis on the value of airphotos combined with relevant groundwork. The methodology will include the practical implementation of agreed plans and acceptable recommendations in selected catchment areas, as pre-extension testing before promotion on a wider basis.

- Train GOK staff at various levels in appropriate aspects of conservation activity as above, including the training of Kenyan trainers for such work so that it may extend on a continuing basis.

- Assist in the collection, interpreting and indexing of already-available information on resources of the area as a basis for conservation planning.

The proposed Terms of Reference for the two TCOs are shown in Appendix 1.

3.7.6 Offer grants for Kenyan staff to travel out of Kenya to:

(a) undertake degree/postgraduate study in relevant fields of work

(b) to travel to third countries to see other aspects and examples of conservation activities which may have relevance to the ASAL situation in Kenya

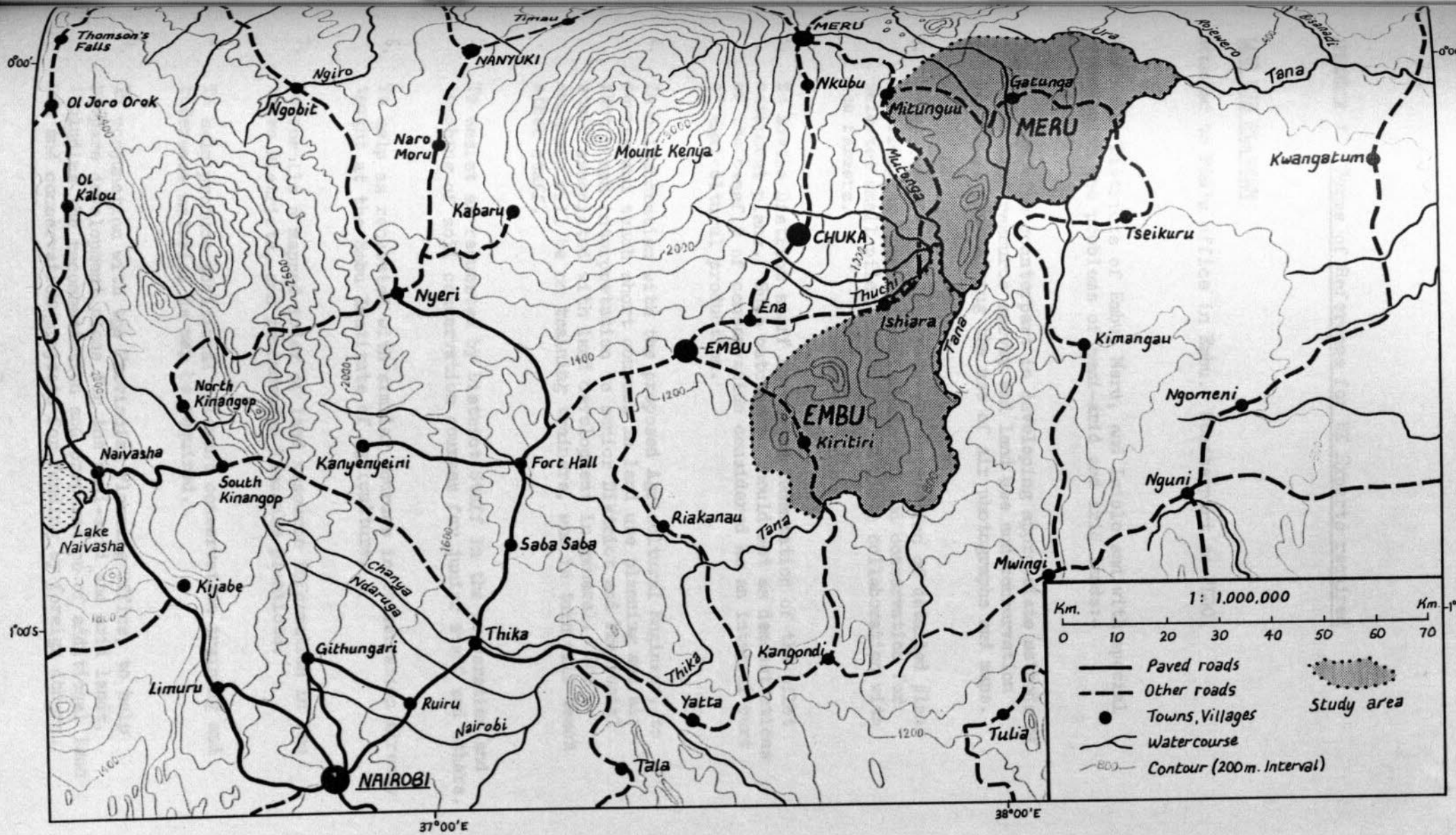
3.7.7 Offer short-term consultant advice from time to time as the needs become apparent, with a view to developing effective responses to conservation requirements within the wider evolution of rural development.

3.8 Particular characteristics of the above proposals are:

- They aim to strengthen the local capabilities of GOK staff to deal with the problems of the area from within the present arrangements as far as possible, rather than by suggesting radical changes in organisation as may be the case in more 'monolithic' projects

- The planning of future programmes of activity - and the types of future donor assistance - should proceed on a rolling basis so as to provide for a flexible and appropriate response to needs as they are identified

3.9 It is hoped that these approaches will help the Kenyan staff in the area effectively to marry together both the social-needs approach of Extension, the 3-dimensional, site-specific, topographic approach of physical conservation planning, and the farming-systems/land-use systems approach of Katumani Research Station and the International Council for Research in Agro-Forestry (ICRAF).



TEXT MAP 1 Study area

Prepared by Land Resources Development Centre 1981

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APPENDIX 1 Terms of Reference for UK Experts required

LAND USE PLANNER

Attached to PDA's office in Embu. Counterpart to PLDO.

Within the Districts of Embu, Meru, and Isiolo and with special attention to the problems of semi-arid and arid lands:-

1. To work with counterpart in developing appropriate methods of rapid land resource survey and land use and conservation planning, emphasising the use of air photographs and maps.

2. To assist District staff in the production of detailed plans for cropping, grazing, afforestation and conservation for selected small pilot catchments in close collaboration with the farmers.

3. To advise District staff on the implementation of the pilot catchment plans. Such catchments should act as demonstrations of the benefit of conservation considered as an integral part of agricultural production.

4. In collaboration with the proposed Agricultural Engineer, to devise and teach short courses in land use planning and air photograph interpretation to senior District and Provincial staff associated with land development in general. The emphasis will be on training trainers, who in turn will teach other staff.

5. To assist as requested by District Staff in the preparation and teaching of soil conservation courses for junior staff and others.

6. To help as requested with similar courses in conservation already taught at the Embu Institute of Agriculture.

7. To compile a mapped index of land resource information in the three Districts, and recommended land use practices.

8. To help produce additional relevant conservation training and reference material as may be required.

9. In conjunction with the Provincial Planning Office, to help prepare development plans for the semi-arid and arid lands, including the recommendation and preparation of additional land use and conservation projects for funding by foreign donors.

Qualifications and Experience

- 1st degree or equivalent in agriculture, soils, physical geography, or other appropriate natural resource subject.

- Preferably higher diploma or degree in land resource appraisal and land use planning with particular reference to tropical/subtropical agricultural and pastoral conditions - or equivalent experience proven during field service in such areas.

- Field experience of at least five years in the tropics/subtropics in the general area of land husbandry including land resource survey and appraisal, and land use planning preferably in marginal/semi-arid areas. This should have had special reference to the identification of ecologically-appropriate systems of agriculture and other land uses, choosing the optimum strategies and techniques of water and soil conservation, and the planning and layout of suitable rural infrastructure on a catchment basis. Familiarity with soil erosion processes and competence in the use of air photos in office and field for such work are essential.

- The ability effectively to transmit knowledge to counterparts and others, in the course of normal duties and formal training courses in which he/she would take part, as an important attribute.

SOIL AND WATER CONSERVATION ENGINEER

Attached to PDA's office in Embu, with the PLDO as counterpart.

In the Districts of Embu, Meru, and Isiolo and with special attention to the problems of semi-arid and arid lands:-

1. To assist Provincial and District staff in the siting and design of small structures for conservation of soil and water, for example: subsurface dams/sand weirs, gabion and rock check-dams, and other appropriate physical soil and water conservation works.

2. To cost the above structures and measures.

3. To assist the proposed Land Use Planner in training activities as requested by him and other Provincial and District staff.

4. To help establish demonstration plots of appropriate erosion control measures, including experimental measurements and analysis of results. These will be set up at strategic locations, for example Farmer Training Centres, etc.

5. To help design and lay-out suitable structures in the proposed pilot demonstration catchments.

6. To assist in the planning and design of other simple engineering structures for example access routes and farm buildings, as needed.

7. In conjunction with the Provincial Planning Officer, to help prepare development plans for the semi-arid lands, including the recommendation and preparation of additional conservation projects for funding by foreign donors.

Qualifications and experience

- First degree or equivalent in agriculture, forestry, agricultural engineering or other appropriate subject in which engineering is considered in the context of applications to natural resource/agricultural management.

- Preferably a higher diploma or degree in soil and water conservation, field engineering or related subject with particular reference to applications to rural development activities in the tropics and subtropics - or equivalent ability proven during field service in such areas.

- Field experience in the tropics/subtropics of at least five years in land husbandry activities, in particular the selection, location, design, survey, layout and construction of small-scale physical water- and soil-conservation and reclamation works appropriate to various situations, within the framework of catchment-based rural development plans. An understanding of soil erosion processes and methods of runoff calculation; competence in using basic topographic survey techniques in the field; and in the office - and field-use of airphotos, are essential.

- The ability effectively to transmit knowledge to counterparts and others, in the course of normal duties and of formal training courses in which he/she would take part, is an important attribute.