A SURVEY OF THE EFFECTS OF IMPROVING MAJOR ENVIRONMENTAL FACTORS TO AGRICULTURE IN EAST AFRICA

W. Rugumamu

INTRODUCTION

This review was prompted by the recent decline in productivity in most of our economic sectors. The paper attempts to review somewhat selectively, research work related to the development of agriculture in East Africa through the improvement of some elements of the physical environment, and aims at showing the ways man is changing his environment to meet his own ends i.e. increasing productivity. It is contended here that apart from social, economic and political factors, soils and related environmental parameters mitigate against the farming progress in the tropics (Moss, 1968).

The role of soils in planning for agricultural development cannot be overemphasized. From the soils for example, plant roots receive essential nutrients, water, air as well as mechanical support. It is against this background that the following parameters have been selected for discussion: soil fertility, soil moisture availability, soil erosion, and pests and diseases. On the whole the paper will highlight major areas of research in advancing agriculture.

A somewhat narrow definition of soil fertility will be employed in order to allow for individual parameter assessment. Fertility here means the quantity of nutrients present in the soil in forms available to plants.

A somewhat narrow definition of soil fertility will be employed in order to allow for individual parameter assessment. Fertility here means the quantity of nutrients present in the soil in forms available to plants. An understanding of the soil nutrient status indeed forms the basis for a sound evaluation of fertilizer requirements and crop rotation systems.

On soil moisture availability, the discussion centres around methods of utilising unreliable rains of a semi-arid environment. Further, soil moisture conservation through irrigation is considered. The effects of soil moisture conservation on crop yields are shown empirically.

Since agricultural production may be hampered by erosion hazards, soil erosion and its conservation should be considered in the development of agriculture. Although studies on soil erosion and conservation are available in East Africa, it is difficult to conclude whether the results of the experiments are solely a function of soil erosion control, though it is indeed due to the interrelationships of the factors under discussion.

The handling of soil may greatly affect its virulence. Note for example that the burning of residues, the order of crops grown and the addition of chemicals (insecticides) are a reflection of the relation of soil management to insect and disease control. The very fact that some of the pests spend part or the whole of their life cycle in the soil makes their consideration here worthwhile. Studies on the effects of pests and diseases on crop yields are cited and crop varieties resistant to East African hazards are also mentioned.

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There are obvious interrelationships between the parameters considered in this paper. For example by trying to improve soil moisture availability and soil fertility the problem of soil erosion is simultaneously solved. Logically therefore, one of the main shortcomings of the results on individual experimental plots as shown in the proceeding discussion originates from the interrelationships between the factors being investigated. By and large the yield response of a crop to a soil amendment depends upon the particular crop, climatic conditions and management practices as well as the chemical, physical and biological conditions of the soil.

SOIL FERTILITY

In assessing the fertility of the soil, one has to broadly examine the quality of the land properties within the context of the current agricultural and technological development as well as economic conditions. Notwithstanding the links with other environmental factors, technology and economics, it is possible to assess the contribution of soil *sesu stricto* to the productive potential of land. It is on this basis that this subsection will deal with the effects of improved natural fertility on crop productivity. The main features considered include the effect on yields of: different fertilizers and the rate of their application, appropriate rotation and spacing.

Experiments were conducted in Nachingwea, Tanzania to evaluate the responses of maize, groundnuts, soya and sorghum to different types of fertilizers. The crops were planted in a production farm. Evans and Wilson (1956) report that the fertility level of soils and the soil productivity varied from place to place. Fields were subdivided into blocks for convenience of cropping and access and into panels by conservation terraces. Maize was planted on two fields, one of which had a belt of very poor soil running through it. Results clearly showed that on poor soils, fertilizer did not give any increase in yield. On the good soil, seedbed and top dressing applications alone had no significant effects but when both types were applied, a highly significant response of 614 lb per acre was obtained. On the other good soil, the seedbed application alone and with the top dressing, gave highly significant responses, in the latter case of 877 lb per acre.

Mere application of fertilizer is not enough if high yields are to be obtained. It is equally important to consider the quantity of fertilizer per unit area to be applied as well as the cropping system practiced (Ekpete, 1976). Experiments to determine the rate and time of fertilizer application were carried out at Uru and Msaranga in Kilimanjaro (Szymerton 1948). The rate of application of ammonium sulphate to onions was studied and the following results were obtained.

At Msaranga a very significant decrease in yield resulted as more fertilizer was applied. It was noted that the application of the sulphate of ammonia at a low rate of 1½ cwt per acre was quite adequate. At Uru, however, the application of 3 cwt per acre was superior to the lower and higher rate. It could thus be deduced that low rates of application of ammonium sulphate of the order 1 to 2 cwt per acre may be expected to make substantial and economic increases in the yields of onions over untreated plots.

Onions were again used in the experiment to establish the best time for fertilizer application. At Msaranga the application of sulphate of ammonia later than 15 days after transplanting showed a significant decrease in yields. The decrease was significantly greater 45 days after transplanting, than 30 days after. At Uru it was noted that fertilizer applications (S).

From the sulphate of ammonia, 3 cwt were applied, and 3 cwt were appreciably, well, and in any sense, it is being expected to increase after transplanting. The soil was continuously rainfall

The forest and agriculture if it is necessary to investigate the effect of various crops and techniques on soil fertility. Under the principles of crop rotation, available in the described experiment account the establishment marked in grain crops.

Experiments showed that oats and clover were the

The above table shows the effect of the crops on maize. However, the differences are not always significant. Most soils seem to respond well.

In East Africa, a large number of trials carried out in the area.

The following charges were used:

- Naivasha: 10 shillings
- Nakuru: 5 shillings
- Uasin Gishu: 15 shillings
- Trans-Nzoia: 5 shillings

Where $G = G$ is the

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that fertilizer application 30 days after transplanting was superior to earlier or later applications (Swymerton, 1948).

From the results above it can be concluded that an early application of ammonium sulphate, (within 30 days of transplanting) may be expected to raise the yields of onions appreciably, while later application would show little advantage over untreated plots. In a sense, it is better to apply ammonium sulphate in two instalments, at 15 and 30 days after transplanting but application should be avoided during periods of heavy and continuous rainfall.

The foregoing discussion shows the justification for the use of fertilizer in agriculture if crop yields are to be increased. The remaining problem is to further investigate the appropriate dosage, season and method of application of fertilizers on various crops and soil types in given ecosystems in East Africa.

Under the subheading “crop rotation”, only case studies that reveal a significant variation in requirements have been cited.

Crop rotation ensures among other things, an economic use of plant nutrients available in the soil. Further, when studying crop rotation it is important to take into account the economics of the crops under consideration. This relationship is very marked in grain crops as shown by Clayton (1956).

Experiments conducted outside East Africa on the appropriate rotations of maize, oats and clover as reported by Clayton (1956) produced the following results.

**TABLE I**

<table>
<thead>
<tr>
<th>Location</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naivasha</td>
<td>G-G-G-G-G-G-G-G-L</td>
</tr>
<tr>
<td>Nakuru</td>
<td>M-G-G-G-L</td>
</tr>
<tr>
<td>Trans-Nzoia</td>
<td>M-M-G-M-L</td>
</tr>
</tbody>
</table>

Where G = Grains; M = Maize; L = Rotational forage.
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There appears to be a variation in the cropping systems of the four named areas. In Nakuru and Trans-Nzoia, the system is soil conserving, resembling what is termed ley farming.

In Uasin Gishu the system is soil depleting. The ley shift in Naivasha and Uasin Gishu is so infrequent that the system is not far removed from grain monoculture. Owing to the undeveloped farms with reserves of untilled land which are used when yields begin to fall in the village areas of the farm, it is difficult to estimate accurately the period of land resting.

The course of wheat and maize yields in the cropping pattern was traced and yields since 1943-54 were collected. During this period, yields of both crops have clearly been maintained and in some areas, slight increases were shown. It was difficult, however, to ascribe the causal relationship between current cropping system and the trend in crop yields because of important changes that occurred in the period. Of prime importance was the increased area devoted to these crops between the period. For wheat, this amounted to 51.52% in Naivasha, 44% in Nakuru, and 43% in Uasin Gishu; For maize 26% in Nakuru, 109% in Uasin Gishu and 45% in Trans-Nzoia. The breakage of new land helped to maintain yields per unit area. Other important changes in the period that tended to prevent a fall in yield were a substantial increase in the use of fertilizers and improved seed varieties. These factors, therefore, masked the effects that might have been expected from inadequate resting of crop land.

Experiments on the effects of cultivation of rice land between successive rice crops were conducted in Zanzibar at Kizimbi experimental station. Smith (1964) observed that the following treatments were used on the land between successive annual rice crops.

(1) Control — allowed to revert to weeds and grass growth
(2) Sweet potatoes with farmyard manure at 20 tons an acre grown on the ridges.
(3) Sweet potatoes with no manure grown on ridges
(4) Groundnuts grown on ridges
(5) Green gram on the flat
(6) Clean cultivation throughout the fallow season.

Since 1954, the following alterations have been made: 1958 the dressing of farm yard manure applied to sweet potatoes was reduced to 10 tons per acre. Following the 1959 rice harvest, the clean cultivation treatment was replaced by growing cowpeas on the flat. Prior to 1959 the local variety of rice — Mnazi — was grown. After 1959, Red American was grown in both experiments and also D.52 was used at Njuruwagi. All plots of rice received standard fertilizer dressing for rice which consisted of 2 cwt per acre of single superphosphate before sowing. Transplanting was later followed by sulphate of ammonia at 1 cwt per acre applied as top dressing.

It was observed that intensive cultivation of rice land is not detrimental to the maintenance of soil fertility when fertilizers are applied to the rice. But for obvious reasons cultivation between rice crops should be given preference for it provides a return from land which would otherwise be lying idle, facilities cultivation, assist in the control of weeds and results in heavier rice yields (Smith, 1964). Sweet potatoes and groundnuts are recommended to be grown during the fallow season and farm manure dressing should be practised if yields are to excel.

Related to cropping system is spacing. Appropriate spacing is essential if high yields are to be expected. Experiments on onion was reported by Swindells.

According to the results, the constant at 4 1/2", the close cropping, either the 6" or 7 1/2" spacing significantly different.

Crop rotation has a major role as soil aggregation is most important growing plant canopy. An increased micro-bial activity because the roots of the plants also reduce the rainfall. It can be noted here that crop yields per unit land. Experimental density and spacing are a factor in the regime (Leakey and Rubaihi).

A distinction should be made between experimental stations and that, results need to reflect a long term — an ecological zone. Over use of fertilizer is profitable, for instance.

Soil fertility studies and soil moisture availability. As yet, there are no respects as one of the plant's needs, most often deficient in the tropical areas.

SOIL MOISTURE AVAILABILITY

It has been argued that the limiting crop yields (Hann). The disadvantages accrued from the soil lost all its organic contents. Noticing the deteriorating soil, the dangers of clean weeding are apparent, the conservation of moisture was of great importance.

To show that the conservation was carried out on the Giriama lands, it is advisable to record the results of the treatment was conducted on:

A  Clean weeding
B  green manure (tv)
C  banana leaf mulch
D  weed cover
yields are to be expected. Experiments carried out in Kilimanjaro on the best spacing for onions were reported by Suvynneston (1948).

Table 2: Effects of Spacing to Yield

According to the results on the above table where spacing within rows was constant at 4½", the close spacing of 4½" between rows was markedly superior to either the 6" or 7½" spacing yields. The yields between the 6" and 7½" spacing are not significantly different.

Crop rotation has a marked effect on the increase of the degree of soil aggregation as soil aggregation is most frequently found on land that is supporting an actively growing plant canopy. An actively growing plant canopy is associated with more micro-bial activity because there is continuous addition of organic matter to the soil which serves as food for micro-organisms and helps to maintain soil humus. With all this the plants also reduce the rain drop impact on the soil surface thereby reducing erosion. It can be noted here that crop rotation if appropriately carried out will increase crop yields per unit land. Experiments conducted in Uganda, however, have shown that crop density and spacing are a function of environmental conditions, especially moisture regime (Leakey and Rubaihayo, 1972).

A distinction should be made between the evidence of fertilizer trials on experimental stations and the information relating to results on farms. In essence the results need to reflect a long period of observation carried out on a large expanse of land—an ecological zone. Over and above, it should be established whether increased use of fertilizer is profitable, for increased yields is not an end in itself.

Soil fertility studies are incomplete in the tropics without an assessment of soil moisture availability. As Young (1976) notes it is instructive to consider water in some respects as one of the plant nutrients, in which case it displaces nitrogen as the nutrient most often deficient in the tropics.

SOIL MOISTURE AVAILABILITY

It has been argued that in East Africa, soil moisture is one of the important factors limiting crop yields (Hanna, 1974). Martin in 1925 observed that in Uganda, grave disadvantages accrued from clean weeding of permanent crops. Erosion was severe and the soil lost all its organic matter. Crop yields, (mainly coffee) fell below average, noticing the deteriorating situation, the agricultural department called attention to the dangers of clean weeding and recommended the use of artificial mulch. The conservation of moisture was the basic idea behind the practise of mulching.

To show that the conservation of soil moisture increase crop yields, an experiment was carried out on the Government Station at Bugusege, Uganda. The following treatment was conducted on a 5 x 5 latin square:

A Clean weeding
B green manure (two crops a year)
C banana leaf mulch
D weed cover
Table III:
Effects of Ground Treatment on the Yield of Coffee

The results to date show that treatments A and C are significantly better than others whilst treatment E is better than B and D. It was further observed that the picking season of C is longer than that of the other treatments, but 80% of its crop was picked within a period of one month. This has to be attributed to the die-back and failure to ripen of all the crop under the clean weeding of 1925. There are indications to show that mulching is giving a more even annual crop as opposed to the big fluctuations normally met in Uganda.

The effect of mulch together with other treatments on young coffee was tested in Lukumbi, Uganda (Hanna, 1971) with the following results: it was observed that there was no significant difference in yields between mulch and the two manuring treatments. The difference in the appearance of trees, however, was remarkable; the trees of the mulched plots carried their crop well while the other plots all showed the typical signs of overbearing.

The proceeding demonstrations show the significance of mulching if soil moisture is to be conserved and crop yields increased. These studies therefore commend the use of mulching as the best treatment for coffee yet discovered.

In areas where there is an uncertainty of adequate rainfall, conservation is one of the primary activities in farm operations. Given this constraint such measures as drought-resistant and quick maturing crops have been introduced in semi-arid areas in order that yields may be satisfactory.

Better farming techniques have proved successful in semi-arid areas in various experimental stations in Tanzania. While preparing land for cropping, one of the most essential measures to be taken is adequate dispersal of the surplus storm water during sudden heavy down pours. A convenient way of doing this is to construct sloping contour banks, where surplus water is shed into gullies with farm regular drainage basins. This is a good measure especially when the drainage lines are protected by suitable grass growth. Thorough ridge-cultivation, parallel to the sloping contour banks, would allow for better penetration of moisture and would further assist in gradual dispersion of excess water.

Adequate soil moisture penetration is the most important aspect in farming improvement in these areas where soil compaction is so prevalent. This can be achieved either by thorough cultivation to allow water to penetrate into the soil, or by obtaining a satisfactory grass cover whose fibrous rooting system reduces surface runoff to a great extent by facilitating structural development.

The reduction of the runoff volume and its subsequent hydraulic force automatically reduce the rate of soil erosion. The case of soil moisture conservation in areas of torrential rains is therefore part and parcel of soil erosion control.

As regards crop varieties for these semi-arid regions, the undermentioned crops have been tested and proved valuable by Rensburg (1955).

Sorghum is said to be a most valuable grain in semi-arid regions that receive precarious and erratic rainfall, and it is the white-seeded kind. The Hegari 750 have given good results.

Sorghum plants have high resistance to adverse effects and even though despite of two severe successive seasons obtained from D.D. S.

Bulrush millet is widely grown in central Tanzania. It has a long period to mature.

Cowpeas are good in crops even when planted in semi-arid areas. Apart from a number of varieties of cowpeas, their seeds are shelled seeds.

Semi-arid areas are, however, not related to rainfall relief, as in say near the rain-gauge, that have a mean of 1,200 kernels per acre and 600 per acre, where rainfall provided them with ample for planting. Further field results will be obtained in 1975 when an average of 80% of the plants are near a fortnights. On the other hand, a normal harvest when an average of 180 kernels to the season of sorghum begins in May averaging 17.11" (400m) per acre of D.D. S. This should give good yields of 200 to 300 per cent when planting in only 50% of seeds are planted.

The foregoing demonstrates how as mulching, manuring and drought-resistant and quick maturing crops are used, there is a great likelihood to increase yields.

Where irrigation is possible, it becomes the key to increase productivity; but broadly speaking it is not very easily applied in this country as the technology is not as yet available. Where irrigation is possible, it is only a key to increase productivity; but broadly speaking it is not very easily applied in this country as the technology is not as yet available. Where irrigation is possible, it is only a key to increase productivity; but broadly speaking it is not very easily applied in this country as the technology is not as yet available. Where irrigation is possible, it is only a key to increase productivity; but broadly speaking it is not very easily applied in this country as the technology is not as yet available.
Sorghum plants have been proven to resist long drought spells with little apparent adverse effects and even under most adverse conditions they produce a crop of sorts. In spite of two severe successive drought seasons, yields of up to 1279 lb per acre have been obtained from D.D. Shali and up to 1806 lb per acre from R.S. Tall sorghum.

Bulrush millet is a very hard and drought resistant crop found in most areas in central Tanzania. It has proved to be a sturdy crop in drought years, however it takes a long period to mature.

Cowpeas are generally most satisfactory in semi-arid areas and may yield fair crops even when planted as late in the season as March. Groundnuts also do well in semi-arid areas. Apart from being excellent food it is also valuable as a cash crop. A number of varieties of velvet beans tried at Mpwapwa, Tanzania, yielded 1508 lb per acre of shelled seeds.

Sorhohm, plantation begins early February with the seasonal totals from 10 February to 4 May averaging 17.1". Data on the relationship between rainfall totals and good yields (1800 lb per acre of Dubbs, a tall growing variety) is scanty but suggest that 17" and over should give good yields. Thus after 10 February good crops could be expected for planting in only 50% of the season (Rensburg, 1955).

The foregoing discussion shows that if such soil moisture conservation techniques as mulching, manuring, adequate dispersal of surplus storm water, planting of drought resistant and quick maturing crops and the establishment of proper dates for planting, there is a great likelihood of increasing in crop yields.

Where irrigation is planned, a study of soil moisture conditions has an added significance. Irrigation of agricultural land is an example of soil moisture control on the broadest possible scale. It diminishes one of the great hazards in crop production, namely inadequate and unreliable water supply, and ensures a more stable and higher crop.

Irrigation is by no means a simple a process as is supposed by those who have not studied it in practice (Boeree 1971). Wherever irrigation has been successfully conducted, there appears to be an increased crop production per unit of land. Studies reviewed here, have been conducted in Tanzania and aim at showing the success and failure of irrigation schemes at village level. (Large scale irrigation schemes have been overlooked as they are both capital intensive and operate under high level managerial
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skills which are beyond the capability of the peasants in rural East Africa). The villages are located in the semi-arid regions of Tanzania, namely Dodoma and Singida, where soil moisture availability is a major limiting factor in agricultural production. (Berry et al, 1970).

Mang'onyi, a village in Singida, was by 1956 served by irrigation water from the Mianji river. The dam built by Water Development and Irrigation Department could maintain a flow of 25 cubic. The canal was constructed to make irrigation possible. After laying down the basic irrigation structures, experiments were carried out to prove that crop yields increase with the availability of soil moisture obtained by irrigation methods. The results of the experiments were found to be quite promising. Coffee, a perennial crop, was grown with some success. Also other crops such as bananas, chillies and onions produced high yields.

The results of these experiments were promising, attracting commercial farmers and a peasant cash-cropping irrigated agriculture was planned.

By 1960, there were about 80 farmers on the site and everybody was encouraged to take up 1.25 hectares of irrigated plots with other land not under irrigation made available. This marked the start of small holder irrigation.

1961 saw the coming of an exceedingly dry season which forced the dam to dry up and most farmers abandoned the scheme. Other problems also contributed to the closure of the scheme: land tenure, water salinity, elephants and other wild animals looking for drinking water caused great crop destruction. This was the first phase of the scheme.

After 1962 some slow progress was noted but the scheme continued to operate well below its maximum capacity. By 1967, there were 68 farmers on the scheme and about 87 hectares were under irrigation. Water shortages, however, continued to be a problem during the dry years and some of the soils in the scheme deteriorated due to lack of drainage.

In 1968 there were 101 households cultivating 166 hectares of land of which approximately 51% was under irrigation, with the rest in rain fed agriculture.

Crops grown in Mang'onyi village consisted of maize, groundnuts, beans, sugar cane, maize-bean mixture, cotton and small amounts of tobacco, potatoes, cassava and millet. Sugar cane and most of the beans were grown both with and without the aid of irrigation.

Studies made in 1969 on the Mang'onyi settlement showed that a good food supply for the farmers and some small cash crops were gained from the project. With an estimated cost of Sls. 1,140/= per capita it is doubtful if these gains could justify the cost. It is obvious that a higher input is necessary to make the project a viable economic venture.

From the study of Mang'onyi settlement the following observations can be made: (i) Lack of integrated planning led to partial miscarriage of the project; (ii) the 1961 drought season caused water shortage, therefore irrigation could no longer be carried out. As season like that of 1961 are likely to reoccur there is a need for a careful study of the water supply for irrigation to ensure that there is sufficient water even in the dry years: (iii) There was not an adequate market to stimulate the growth of more cash crops. An irrigation scheme should encourage the growth of crops that will command a supraregional market, in order that the cost of the scheme may be met. The problems of food shortage in Tanzania would be largely solved if the irrigation potential is tapped.

SOIL EROSION

The removal of top soil is a major cause in the unproductivity of land. The damaging action of wind and sheet erosion is becoming more and more evident. The success in the agricultural development in Tanzania is dependent on the prevention of soil erosion. In order to prevent soil erosion, the cultivation of the hill top will be stopped for cotton growing.

According to the government methods, the antierosion measures include covering the top with the liquid manure which not only reduces percolation but also that any sort of erosion is prevented. The crops and reduced labor is required.

Studies made on the hill top can be dealt with using various combinations, which is the stationary surface run-off.
SOIL EROSION

The removal of the top soil means less soil is available to hold water and nutrients and for the mechanical support of the crop. This automatically leads to soil unproductivity and subsequently, low yield of crops.

The damage done to agricultural land by soil erosion has been studied at Lubaga experimental station in Shinyanga, Tanzania (Harrison, 1935). The area is subject to wind and sheet erosion and gully formation. One of the best methods that has proved successful in this 'cotton region' is the use of contour ridges. They should not be continuous but furrows below the ridges should be filled in at intervals of 10 feet or so in order to prevent flow. With hills, it is wise to make a high contour bank all around, near the top and not to allow cultivation above such a bank. Acassia or other trees should be planted on the contour and within a few years the land between the belt and the scrub on the hill top will be protected. The above measures are recommended in land preparation for cotton growing.

According to the studies made in Uganda it was deduced that mulch as an antierosion measure is very effective from a purely mechanical standpoint. It is evident that the force of the rain on reaching the soil is sufficient to detach the clay particles so that the liquid percolating is muddy and tends to clog the soil pores. Muddy water reduces percolation and enhances the possibility of surface runoff. It is clear, therefore, that any sort of artificial mulch will protect the surface soil from the force of the rain drops and reduce the chances of muddy percolating liquid.

Studies made in Kenya on the general fertility of a coffee soil showed that the soil can be dealt with by preventing soil erosion and maintaining the humus content of the stationary surface soil (Gethin-Jones 1935).

A suitable level of humus in the soil aids percolation of water and hence reduces surface runoff. The growth of subsidiary crops during rains helps to conserve much of the nitrates which would otherwise be leached from the surface soil by percolating water. The availability of humus and nitrates in the soil gives it better physical properties and makes it more resistant to erosion. It can therefore be deduced that the conservation of general fertility is the summation of the conservation of the surface soil, soil humus, soil moisture, desirable physical factors, and the resistance to erosion.

Experiments carried out at Mpwapwa, Tanzania in 1946 showed that as soil erosion increases, crop yields diminish (Van Ransburg, 1955 p. 228-31). It was discovered that although the erosion figures were highest on bare uncultivated land, followed by bare flat cultivated land, even when cropped, and using the usual methods of flat cultivation, erosion was extremely serious, especially in areas where moisture is the chief limiting factor in crop yields and where fertility of soil is generally low. It was further noticed that as the duration of cultivation increased, the crop yields deteriorated, while during the past two drought years the sorghum plants were barely 12' high and did not bear any seed. The same variety planted on fields where continuous cropping was not being carried out for so long and where thorough cultivation with ridge planting for optimum water conservation was practiced, the grain yield amounted to 1279 lb and other varieties 1806 lb per acre.

Further observations in Kenya by Maher (1935) revealed that constant ploughing in the light soils derived from gneisses and schists resulted in the loss of the crumb structure of the soil, the acceleration of soil erosion and the washing out of the valuable...
soil colloids which retain most of the phosphate and lime reserves of the soil.

The soil condition deteriorates further, if ploughing is carried out for many years in the dry season, during which the crumb structure of the soil is destroyed. The consequence of this is the creation of a state whereby maximum amount of soil wash occurs with the onset of the long rains.

In maize growing areas of Kenya it was further observed that an interplanted crop of green manure, say cowpeas, when planted and left on the soil over the dry weather, may shield the soil form the baking sun thereby maintaining a soil structure that is resistant to erosion. Similarly the weeds which might have grown among the maize subsequent to the last cultivation may produce the same result.

Most experiments on soil erosion have been designed to measure the amount of both water and soil loss. Since data on crop yields is inadequate, little data has so far been quoted in this text.

If by conserving the general fertility of the soil, soil moisture and soil humus are maintained, with a consequent diminishing of soil erosion, then it can be deduced that by controlling soil erosion, crop yields can be increased per unit area of cultivatable land.

PESTS AND DISEASES

Even if the moisture available in the soil was conserved, fertilizers applied, crop rotation practiced and soil erosion controlled, crop production would be affected by yet another factor — pests and diseases. There are numerous pests and diseases so far recorded in East Africa and numerous others that have not reached the attention of researchers. A few examples will be cited to prove that by preventing pests and diseases crop yields can be raised.

At the experimental station in Amani, Tanzania, Fuggles — Couchman (1935) reported a parasitic plant whose several roots were found attached to the roots of sorghum. The parasite was identified as *Bhampicarpus veronicaefolia vatke*. This weed is widespread in Kilosa, and is known by peasants as "Lalizi". The plant is well supplied with foliage and has chlorophyll 11 which makes it semi-parasitic. Attachment to the sorghum roots is by means of small haustoria. It has no marked effect during the growing season but appears in great numbers at the time when the plant is seeding. It affects the crop by producing light grains and poorly fitted heads.

To control this parasite peasants were advised to uproot and burn all the stalks after harvesting. It has been found that wherever energetic uprooting has been carried out, very small stands are seen. When gazetting it under the Plant Pests and Diseases Ordinance the plant was classified as an noxious weed. (Fuggles — Couchman, 1935).

At Kamolet and Mboga Vale, Kenya in 1922, a leaf eating catapillar of coffee was first recorded (Notley, 1935). Similar pests have been recorded in Bukoba and Buganda. Outbreaks of the *Metadrepans andersoni* used to occur between the months of July and November but have since occurred every month of the year. If steps are not taken it is reported that the outbreak may defoliate 50 to 100 acres of coffee. After a tree has been defoliated results show that coffee yield is below average for a considerable number of years. Owing to the lack of data the total loss of the crop due to the pest cannot be estimated but it is considerably greater than would be expected.

The most convenient method of combating coffee plants is to apply a systemic poison. It is estimated that 10-10.5 trees.

Further experiments are necessary to determine the effect of insecticides and the effect of insecticides and tests were made on cotton.

The effect of planting cotton in rows on unprotected crops. Although it was noted that early planting of cotton would be most profitable, it demonstrates. This study on cotton as soon as rainfall begins and proved useful in an East African context. A Rosette-resistant variety, *R. sativa* (McKinion, 1956). The variety has been useful in combating rosette disease in the Nachingwea area the disease was more severe than at the early stages of disease. This observation is confirmed by experiments carried out on crop - loss (Brown and others).

Experiments carried out on this variety. The first trials were made on Natural Common, (the Rosette disease was severe. There was a great need for a resistant variety.

There is a great need for disease-resistant varieties of coffee beans in East African countries. Efforts are being made by the Kenyan government to introduce resistant varieties.

CONCLUSION

This paper contains a detailed account of the agricultural land use practices in East Africa and the effect of agricultural practices on soil erosion. The data collected from different regions of East Africa shows that the most common agricultural practices are crop rotation, intercropping, and the use of green manures. These practices help in maintaining soil fertility, improving soil structure, and reducing soil erosion. However, the data also shows that there is a need for more research to understand the long-term effects of agricultural practices on soil erosion. The most convenient method of combating rosette disease is to apply a systemic poison. Further experiments are necessary to determine the effect of insecticides.

The effect of planting cotton in rows on unprotected crops. Although it was noted that early planting of cotton would be most profitable, it demonstrates. This study on cotton as soon as rainfall begins and proved useful in an East African context. A Rosette-resistant variety, *R. sativa* (McKinion, 1956). The variety has been useful in combating rosette disease in the Nachingwea area the disease was more severe than at the early stages of disease. This observation is confirmed by experiments carried out on crop - loss (Brown and others).

Experiments carried out on this variety. The first trials were made on Natural Common, (the Rosette disease was severe. There was a great need for a resistant variety. There is a great need for disease-resistant varieties of coffee beans in East African countries. Efforts are being made by the Kenyan government to introduce resistant varieties.
The most convenient method to induce rapid recovery so far known, is by stamping the tree. The use of insecticides is recommended, the most effective being stomach poison. It is estimated that on the average 100 gallons of spray are sufficient for 200 - 300 trees.

Further experiments have been designed to establish the optimum growing season and the effect of insecticides on crop yields. At Ilonga experimental station in Tanzania, tests were made on cotton with the following results:

**Table IV Effect of Spraying to Yield**

The effect of planting time on yields is important on both protected and unprotected crops. Although insects caused heavy damage on all the cotton crop, it was noted that early planting resulted in good yields in spite of this constraint. Economically it would be most profitable to plant early and to use insecticides as the above table demonstrates. This study clearly stated that the best yields were obtained by planting the cotton as soon as rainfall made this possible.

Peasants, assisted by field agricultural officers, should be responsible for the control of pests and diseases. If the peasants could control pests and disease by alteration of planting dates, better pruning techniques, weeding and removal of alternate hosts, crop yields would definitely be raised, other things being equal. In other words, insecticides, costly as they are, should be applied as the last resort.

In an attempt to combat pests and diseases certain crop varieties have been bred and proved useful in an East African environment.

A Rosette-resistant groundnut variety was bred in Nachingwea area, Tanzania (McKinley, 1956). The variety is known as 'Asrya Mwitunde' and has proved useful in combating rosette disease of groundnuts which was severe in Urambo area. In Nachingwea area the disease is reported to have once almost eliminated the crop. Other than at the early stages of growth, Asrya Mwitunde is very tolerant to the disease. This observation is confirmed by simulated experiments on the effects of armyworm damage on crop - loss (Brown and Mohamed, 1972).

Experiments carried out in Nachingwea in 1963 clearly mark the significance of this variety. The first trial yielded 710 to 1040 lb of Kernels per acre compared with the Natural Common, (the other variety) which yielded 0 to 650 lb per acre in a year when rosette was severe. Thereafter, the variety was grown generally and in a few instances the diseased crops could be identified.

There is a great need for research on better breeds which are able to withstand the East African hazards if crop production is to be raised (de Purry, 1968).

**CONCLUSION**

This paper contends that a sound knowledge of soils forms the basis for agricultural land use planning. Our knowledge about the nature and properties of tropical soils is too scanty (Smith 1965) for agricultural planning. There is an urgent need to carry out intensive soil survey works throughout areas of agricultural potential. There are very few such studies in Tanzania (Cook, 1975) as well as in Kenya and Uganda. It is also important that soils information available in a given region be incorporated in the planning document and implementation, in order to bridge the gap.
between regional planners on the one hand and soil surveyors on the other (Rugumamu, 1979).

In maintaining soil fertility, research should be directed towards the determination of the fallow period. Studies on how the fallow period could be reduced or eliminated altogether and substituted with a rotation which keeps the soils constantly productive should be undertaken by agronomists. Furthermore the advantages of animal and compost manure over chemical fertilizers cannot be overemphasized. Research should be carried out on the treatment of different plant and animal residues in order to maintain and/or improve soil fertility.

Soil moisture availability research should be directed towards investigating the exact amount of water requirements by crops and crop varieties at different stages of growth in East Africa. This will form the basis for crop selection and breeding, especially in the marginal areas where rainfall is both low and erratic. The unreliability and inadequacy of available moisture can be offset by irrigation.

A successful irrigation agriculture requires among other things, a knowledge of the soil properties of the area (Rugumamu, 1975) and the consumptive use requirements of the crop in order to regulate water supply to the farm (Israelsen and Hansen, 1965). As for soils, attention should be paid to slope of the land, soil texture and presence of salts, especially sulphate, and chlorides which might be increased to toxic levels with use.

Soil erosion should be studied in the context of its damage potential as well as economics of conservation works. The less the cost of such works the more appropriate the recommendations are. This calls for training of agricultural engineers at all levels and the creation of an engineering base. Soil surveys should identify processes both genetic and man-made which result in soil erosion and chart out the extent of different types of soil erosion in a region.

At the background of all these improvements stands the peasant. Experience has shown that most of the results of research work cited above have been made available to too few peasants in rural East Africa (Sprague, 1971). Of what value then is research if it cannot be used to enhance a change for the better? In agriculture, the transmission of new knowledge lies in the hands of agricultural extension officers who are expected to act as middlemen between research officers on the one hand and peasants on the other.

Vigorous agricultural growth is needed to give impetus to social and economic development, by relieving food shortages, combating malnutrition, curbing inflation and above all, alleviating pressure on the balance of payments.
TABLE I
Effect of Crop Rotation on Yield

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Total Production</th>
<th>Percentage Hay</th>
<th>Grain</th>
<th>Hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) C</td>
<td></td>
<td>0</td>
<td>180,320</td>
<td></td>
</tr>
<tr>
<td>(ii) C-O-O-Cl</td>
<td></td>
<td>25</td>
<td>217,360</td>
<td>85000</td>
</tr>
<tr>
<td>(iii) C-O-Cl</td>
<td></td>
<td>35</td>
<td>182,333</td>
<td>132660</td>
</tr>
</tbody>
</table>

C = Maize; O = Oats; Cl = Cloves
Source: East African Agricultural Journal: 22 No.1 p.33

TABLE II
Effects of Spacing on Yield

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Tons of dry onions per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uru</td>
</tr>
<tr>
<td>4 1/2&quot;</td>
<td>7.85</td>
</tr>
<tr>
<td>6&quot;</td>
<td>7.01</td>
</tr>
<tr>
<td>7 1/2&quot;</td>
<td>6.79</td>
</tr>
</tbody>
</table>

Source: East African Agricultural Journal: 22 No.1 p.23

TABLE III
Effects of Ground Treatment on the Yield of Coffee

<table>
<thead>
<tr>
<th>Yields in Pounds of Cherry</th>
<th>1930</th>
<th>1931</th>
<th>1932</th>
<th>1933</th>
<th>1934</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>190</td>
<td>408</td>
<td>3731</td>
<td>2798</td>
<td>1512</td>
<td>8630</td>
</tr>
<tr>
<td>B</td>
<td>184</td>
<td>315</td>
<td>3713</td>
<td>1707</td>
<td>1202</td>
<td>7116</td>
</tr>
<tr>
<td>C</td>
<td>168</td>
<td>390</td>
<td>4211</td>
<td>1988</td>
<td>1760</td>
<td>8517</td>
</tr>
<tr>
<td>D</td>
<td>205</td>
<td>255</td>
<td>2844</td>
<td>1909</td>
<td>558</td>
<td>5771</td>
</tr>
<tr>
<td>E</td>
<td>192</td>
<td>405</td>
<td>4465</td>
<td>2290</td>
<td>493</td>
<td>7845</td>
</tr>
</tbody>
</table>

Source: East African Agricultural Journal 1 p.132
### Table IV

**Effect of Spraying on Yield**

<table>
<thead>
<tr>
<th>Date of Planting</th>
<th>Sprayed (lb)</th>
<th>Not sprayed (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 28th 1955</td>
<td>3191</td>
<td>1733</td>
</tr>
<tr>
<td>February 25th 1955</td>
<td>2469</td>
<td>482</td>
</tr>
<tr>
<td>March 29th 1955</td>
<td>1620</td>
<td>94</td>
</tr>
</tbody>
</table>

Last significant difference

- 5% level: 262
- 1% level: 257

Source: East African Agricultural Journal: 22 No 1, p.20
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ECOLOGICAL CRISIS IN TANZANIA

Colonial Efforts in Bushmanland

L.E.Y. Mbogoni.**

Introduction

"Everybody talks about the effects of drought on agriculture; but the real truth of societies which have been affected by drought is that they can do nothing to change their situation, except to adjust to it. No matter how much water, and soil moisture depends on the land. The effect of drought can be disastrous. Unsuccessful experiments on soil conservation were conducted at Kongwa, Dodoma, and at Amboseli, Kenya between 1950 and 1960. The results of all these experiments were inconclusive.

Besides such experimental efforts, governments were forced to employ various methods to improve the situation. This included constructing contour banking, terraces, and ditches. In semi-arid areas, Native Authorities attempted to control water sources, which in some cases could be dangerous.

In semi-arid areas, water is scarce and hence against soil erosion. On the other hand, the effects of drought are often more disastrous, causing soil erosion, while in the wet season, the land is cleared and the land is left bare and the soil is exposed to cultivation. The government had to encourage the Native to intensify agriculture in order to conserve water and prevent soil erosion. The drive to change their ways was supported by providing new farm tools. Thus the government was able to change the methods of the peasants but also sought to satisfy the land demands of the Native population.

Native Agricultural Practices

The condemnation of the traditional methods of coffee cultivation are no longer applicable to the labour involved with such production of high-quality coffee beans since the mid-1950s. The driving force behind this change was the government's desire to increase coffee production and improve the quality of the beans. The government began to promote modern methods of coffee cultivation, which included the use of new farming practices and technologies. These methods included the use of improved coffee varieties, soil conservation practices, and the use of chemical fertilizers and pesticides. The government also provided training programs for coffee farmers to help them adopt these new methods.

* This is a revised Chapter of a thesis submitted for the degree of Master of Arts, University of Dar es Salaam, 1982.

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