

**CONFIDENTIAL**

TANZANIA

File No. ~~44789~~

Station .....

**WOSSAC File 44789**

**THE SOILS OF TANZANIA**

By

**R.M. Baker Senior Soil Scientist  
Ministry of Agriculture Foods and Cooperatives  
Dar-es-Salaam**

FAO LIBRARY AN: 125083

44789

THE SOILS OF TANZANIA

by

R. M. BAKER

January, 1970

## PREFACE

Mr. R. M. Baker, Technical Officer of the Food and Agriculture Organisation of United Nations, was appointed Senior Soil Scientist with the Ministry of Agriculture, Food and Co-operatives, Dar es Salaam, in April, 1966.

Part of his duties were:-

"To examine and evaluate soil survey work which has been done over the past years and to advise on future soil survey and land classification work".

Early in his assignment it became evident that one of the main deficiencies in the country was the lack of a nation wide appraisal of land resources. Following discussions with the Hon. D. N. M. Bryceson, Minister for Agriculture, Food and Co-operatives, and Mr. D. A. Mwakosya, then Director of Agriculture and later Principal Secretary, an approach was made to the United States Peace Corps for suitably trained personnel to carry out the necessary nation wide survey of soils and vegetation under the direction of the Senior Soil Scientist.

As a result, eight United States Peace Corps graduate volunteers, four of whom majored in soil science, were recruited on two year contracts for the period September, 1967, to August, 1969, to carry out what came to be known as the National Soil Survey of Tanzania.

The composite map of the Soils of Tanzania at a scale of 1:2,000,000 which appears in this bulletin and the four separate bulletins, describing the Land Resources of North-East, South-East, South-West and North-West Tanzania are the results of their work. The four bulletins of Land Resources which include a map of land units at a scale of 1:1,000,000 should be read in conjunction with this report.

## TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
Soil surveys	3
Soil analyses	5
Soil classification	7
Soil fertility	8
Soil erosion	14
Bibliography	15
SOIL MAP LEGEND	27-32
SOIL MAP	33

## INTRODUCTION

Previous soils maps of Tanzania have been prepared by Milne, 1935, Calton, 1954, Scott, 1963, D'Hoore, 1964, as part of his Soil Map of Africa, and most recently by Anderson in the "Atlas of Tanzania" 1967.

These are all small scale maps, those in the "Atlas of Tanganyika" 1966 and the "Atlas of Tanzania" 1967 being at a scale of 1:3,000,000 and the others smaller still. In all cases the authors had a limited personal knowledge of soils in field, and the maps have been drawn following the collection of information from individuals, the literature, and where there is no specific soils information available, based on the assumption that major topographic, geological and vegetation changes also reflect soil differences.

This is a reasonable approach, in fact it has been the only method possible for the authors concerned, but it has led to misconceptions. One of these is the undue emphasis placed on the catena as a mapping unit. This term which describes the sequence of soils from hill top to valley bottom was originally proposed by Milne, 1935, for the mapping of complex soil associations.

Since then the catenary concept has been accepted by most soils workers in Tanzania and it has been used as a mapping unit by most authors, particularly by Scott, 1963 and Anderson, 1967 in drawing up their soils maps of Tanzania. In actual fact no simple catena is evident in most parts of the country, Ukiriguru which provides the classic catena, and the surrounding country being an outstanding exception. In general the soils are more closely associated with the underlying rocks or parent material than with any topographic sequence.

### Survey Methods

The eight United States Peace Corps Volunteers were stationed in pairs at four country centres, namely the Research Centres at Tengeru (Arusha), Ilonga (Kilosa) and Ukiriguru (Mwanza), where both library and mapping facilities were available, and at the Regional Agricultural Office, Mbeya. Each team became responsible for mapping approximately one quarter of the country at a scale of

1:1,000,000 using the International Map of the World, Series 1301, as the base map.

The four individual maps of land units are at this scale and in the land resource bulletins the mapping units have been described in terms of physiography, geology, rainfall, soils and vegetation. The unit boundaries are based on field inspection and air photo interpretation, a complete set of aerial photographs covering the whole country, and mosaics and print lay downs where available, being provided by the Tanzania Government. Field traversing covered all the roads and tracks, and the country without roads and tracks which was accessible by four wheel drive vehicle, but even so, many parts were inaccessible and the boundaries here were down from aerial photographs.

The composite soils map of Tanzania at a scale of 1:2000,000 which is included in this bulletin was compiled from the four individual 1:1,000,000 maps of land resources. Although there are brief accounts of the physiography, geology, climate and vegetation in the introductory sections of each bulletin further information on these subjects is available in the "Atlas of Tanzania", 1967.

#### Standard Definitions

With four relatively inexperienced survey groups the rigid use of standard technical terms became essential. In this respect all soil terms used are as defined in the F.A.O. "Guide lines for Soil Profile Descriptions"<sup>1</sup>. When they are not covered by this, as for example, soil reaction, reference is made to the appropriate section of the "U.S.D.A. Soil Survey Manual"<sup>2</sup>.

Soil colours are those used in the "Munsell Soil Color Charts"<sup>3</sup>, and a "Classification of East African Rangeland"<sup>4</sup> has been used to describe the vegetation communities.

1. Guidelines for soil profile description F.A.O. Rome
2. Soil Survey Manual (1951). Soil survey staff U.S.D.A.
3. Munsell soil colour charts (1954). Baltimore, U.S.A.
4. ~~Bratt~~ D. J., Greenway P. J., and ~~Gwynne~~ M. D. (1966) A classification of East African Rangeland ~~L. appl. Ec.~~ ~~J. appl. Ecol.~~ 3, 369.

# TANZANIA

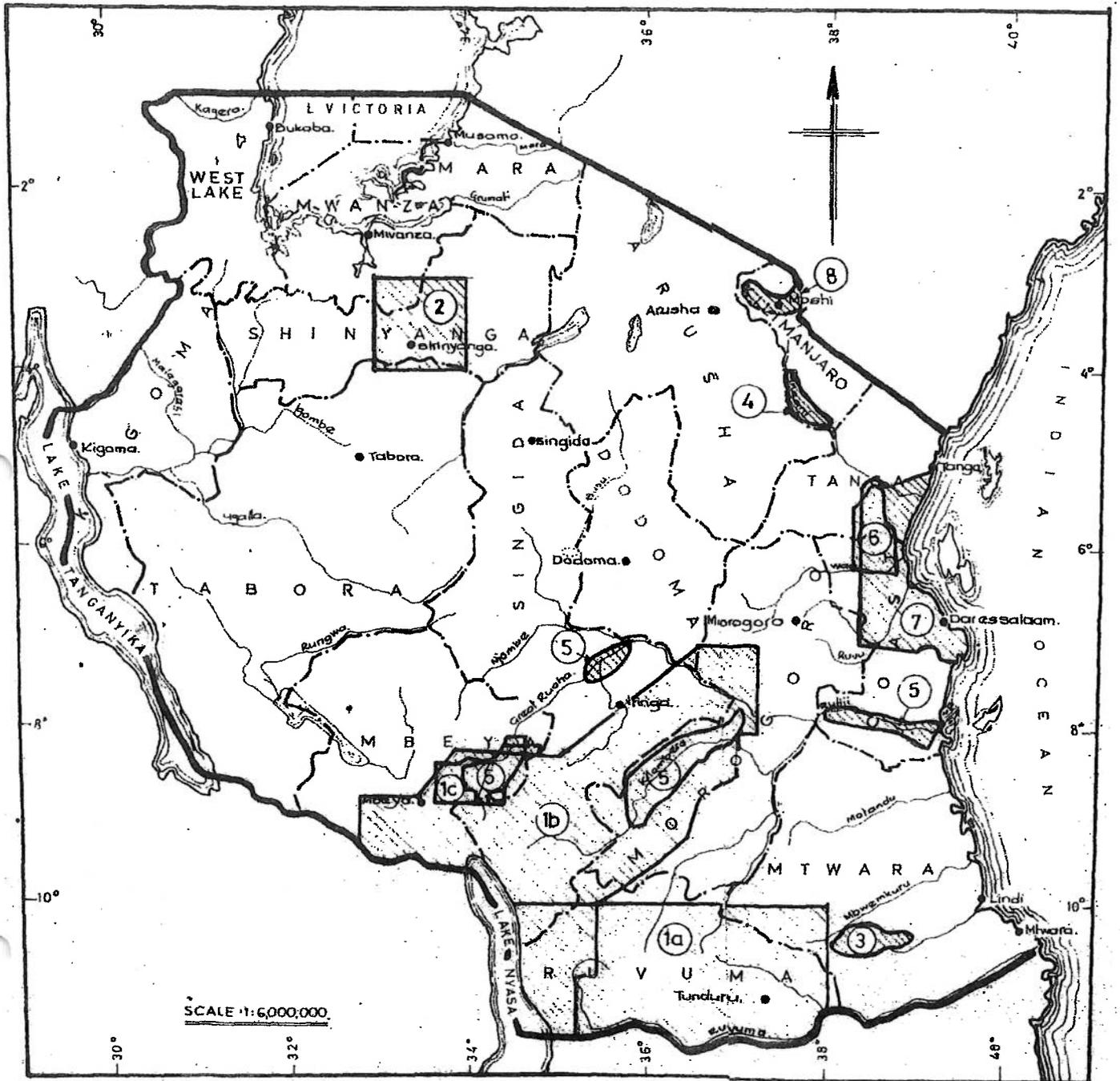


FIGURE I: SHOWING THE LOCATION OF THE MORE IMPORTANT SOIL SURVEYS CARRIED OUT IN TANZANIA

SCIL SURVEYS

Soil surveys have been carried out for specific purposes in many different parts of Tanzania, and Figure I shows the location of the more important of these surveys which are listed below:-

1. Sir Alexander Gibb and Partners. (1952) Report on the Central African rail link development survey.  
Vol. 1 and 2.  
1a. 1:1,000,000.  
1b. 1:500,000.  
1c. 1:125,000.
  
2. Malcolm D. W. (1953) Sukumaland.  
An African people and their country.  
1:125,000.
  
3. Grantham D. R. and Pilson R. D. (1955) The geology and ecology of the Nachingwea Region.  
A reconnaissance survey of the topography, soils, vegetation and geology in the Southern Province of Tanganyika.  
1:125,000.
  
4. F.A.O. Report No. 970. (1959) Report to the Government of Tanganyika on the soils of the Pangani valley.  
1:100,000.
  
5. F.A.O. Report No. 1269. (1961) The Rufiji basin Tanganyika.  
Report to the Government of Tanganyika on the preliminary reconnaissance survey of the Rufiji basin.  
Vol. VII. Soils of the main irrigable areas.  
1:125,000.
  
6. ILACO. (1965) Report on the development possibilities of the Handeni preserved area.  
1:100,000.

7. Proctor J. Anderson G. D., and Dick J. (1968) A brief account of the soils and land use potential of the northern coastal area of Tanzania.  
Unpublished - Ministry of Agriculture, Food and Co-operatives, Dar es Salaam.  
1:100,000.
8. Anderson G. D. (1968) A survey of the soils and land use potential of the southern and eastern slopes of Mt. Kilimanjaro, Tanzania  
Unpublished - Ministry of Agriculture, Food and Co-operatives, Dar es Salaam.  
1:50,000.

SOIL ANALYSES

Ten profile pits were dug and sampled by each of the survey teams and the analysis of soil samples was carried out by the Sisal Research Station at Mlingano.

The analytical methods used were:-

The air dried soil is screened through a 2 m.m. sieve. For N, P, and organic carbon a sub sample is ground in a porcelain mortar until all passes through a 70 mesh sieve.

1. pH

The pH measurements are carried out with glass/calomel electrode system using a Cambridge portable pH metre. Both soil: water and soil: 0.01 M  $\text{CaCl}_2$  solution are 1:2.5.

2. Total Nitrogen:

By Kjeldahl method (A.O.A.C.)

0.5 gms. soil is wetted with 2 ml. water, 1 gm. digestion salt (20 parts  $\text{K}_2\text{SO}_4$ ) added, followed by 2 ml. concentrated  $\text{H}_2\text{SO}_4$ . After digestion ammonia is distilled off with 10 ml. of 50% NaOH using Markham Still into 5% Boric acid containing mixed indicator.

3. Phosphate:

(a) Soils with pH above 7 treated for available P by Olsen's method as described in the book 'Methods of Soil Analysis' (1945) published by the Amer. Soc. of Agron.

(b) Neutral or acidic soils extracted for acid soluble and adsorbed P by Bray and Kurtz's method (Soil Science 59:39, 1945) Bray and Kurtz solution No. 4 is used. Modification includes the addition of ammonium fluoride in the form of acid/fluoride solution instead of solid  $\text{NH}_4\text{F}$ .

P Estimated colour - ~~metrially~~ using molybdophosphoric blue colour method in HCl (Dickman S. R. and Bray R. M. Ind. Eng. Chem. Anal. Ed.: 1940, 12, 665.

4. Organic Carbon:

Walkley and Black method. (Soil Sci. 1934, 37, 29)  
77% recovery factor is used to evaluate C/N ratio.

5. Particle Size Analysis:

~~Bouyoucos hydrometer~~ method using 5% Calgon solution as dispersing agent. End over end machine used for shaking samples overnight. International system is used and coarse and fine sand fractionated by wet sieving.

6. Exchangeable Bases:

Soils extracted with neutral N ammonium acetate using soil: extractant ratio of 1:10. Organic matter destroyed with HCl/HNO<sub>3</sub> mixture. The chloride solution of bases after filtering through a sinter glass funnel is sprayed into flame using Hilger medium spectrograph. The spectra are recorded on Ilford Zenith plate (Ca, Mg, K, Mn, ) and Ilford Chromatic plate (Na).

7. Exchangeable Hydrogen:

Brown I. C. (Soil Sci. 1943, 56, 353). Determined by drop in pH of ammonium acetate used for leaching out bases in 6.pH measurements carried on 50 ml. remaining from ammonium acetate extraction. Standard calibration curve prepared for each batch by addition of 1N HCl to 25 ml. of extracting solution.

## SOIL CLASSIFICATION

Except for the individual soil profile descriptions which form an appendix to each of the four land resources reports, no attempt has been made to classify the soils according to some higher category classification, as unless one is thoroughly conversant with the terms used, confusion can easily arise.

In the soil profile descriptions each soil has been classified according to D'Hoore, 1964, although many of the soils do not fit readily into his established groupings. As an example, most of the deep reddish brown to red clay loams and clays which are found throughout the country and which show little variation in colour and texture down the profile and have no reserves of weatherable minerals, have been classed as Ferrallitic soils, but almost invariably the base saturation is more than 40%. D'Hoore's system of classification obviously cannot accommodate all the soils found in Tanzania, nevertheless all the soils described and analysed have been fitted into one or other of his categories, but in many cases could just as easily have been put into another.

## SOIL FERTILITY

As would be expected from the extreme range in environment which includes such diverse environments as tropical sandy coastal plains and the perennial snows of Mt. Kilimanjaro, there is also a corresponding variety of soils, and D'Hoore's Soil Map of Africa 1964 shows more mapping units for Tanzania than for any other country in Africa.

In spite of this the chemical analyses and the nutrient deficiencies exhibited by many of the soils are very similar and the following generalisations are based both on analytical figures, and the fairly extensive fertilizer trials which have been carried out with various crops in many parts of the country.

In this regard it is of interest to note that the Sisal Research Centre at Mlingano has developed a soils advisory service for growers which is based on soil analysis, and is backed by information from field manural trials and leaf analysis. The service provides advice on nitrogen, phosphorus, potassium and lime, and two rates of fertiliser application are recommended depending on whether a soil is low, or very low, in one or more of these nutrients. The samples for analysis are taken from the first 20 centimetres of the top soil.

No mention is specifically made here of soil physical properties as these are covered in the four bulletins of land resources.

### Phosphorus:

Phosphorus is a widespread soil deficiency throughout Tanzania and it is estimated that 80 -90% of the country would give economic responses to phosphatic fertilizers with annual crops in the presence of adequate nitrogen. Phosphorus and nitrogen must normally be applied together for best results and when either element is applied in the absence of the other the responses are likely to be disappointing with non legumes.

The standard recommendations for phosphorus vary from 125 kgs. per hectare of single superphosphate for cotton on the older granite sands of the Western Research Zone, to 250 kgs. per hectare for maize on most of area, except the recent volcanic soils, covered by the Northern Research Zone. At Nachingwea, groundnuts have shown economic responses to 10 lbs. of P per acre (approximately 125 kgs. of single superphosphate per hectare) whilst 30 lbs. of P per acre is needed for maize.

Other annual crops such as sorghum, sunflowers and tobacco have shown similar responses to phosphatic fertilizers throughout the country.

Among the perennial crops, sisal on the red soils on calcareous parent materials, tea, and coconuts have responded to phosphatic fertilisers. They are not, however, recommended for coffee, but most coffee plantations are found on soils which are naturally high in P.

Responses to P in the marginal rainfall areas have often proved economic when N response has been restricted by low rainfall. The only soils on which annual crops are not likely to respond to P are the more recent volcanic soils of northern Tanzania, some of the black soils of valley bottoms, and some alluvial-colluvial soils.

Although most Tanzanian soils are slightly to medium acid, water soluble phosphorus has been proved most effective, and disappointing results have followed the use of rock phosphate and similar acid soluble fertilisers. Phosphatic fertilisers are applied at seeding time in contact with or in close proximity to the seed or at the beginning of the growing season with perennial crops. They can have a considerable residual effect from one year to the next.

One aspect of the continued use of phosphatic fertilisers which has become evident at Tanga under coconuts, and has also occurred elsewhere, is the marked influence of P on the growth and survival of natural legumes, which could lead to quite considerable nitrogen fixation.

The scope for the increased use of phosphatic fertilisers in Tanzania is enormous.

### Nitrogen:

As with phosphorus, nitrogen deficiency is widespread throughout Tanzania but responses are largely conditioned by rainfall. In the marginal areas or in dry years when crop yields are low, responses to nitrogen are minimal.

Being a very mobile element there is no residual effect as there is with phosphorus, and crop response occurs in the year of application only.

Recommended rates of application for annual crops are similar to those for phosphate and are in the range 20 - 40 lbs. of N per acre which is equivalent to 125 - 250 kgs. per hectare of ammonium sulphate. The rate varies with the rainfall and the crop, the higher rates being recommended in the higher rainfall areas with higher nitrogen demanding crops such as maize, which in field trials has given economic responses to 80 lbs. of N per acre. In the marginal areas where response is limited by rainfall, 20 lbs. N per acre is standard for most annual crops.

For perennial crops the rates of application are higher, 50 - 100 kgs. of N per hectare is recommended for sisal where soil tests have shown nitrogen to be low or very low, whereas 100 kgs. of N. per hectare is the standard dressing for coffee. Trials with the various forms of nitrogenous fertilisers have shown that the total amount of N is important, rather than the type of fertiliser used, although it is usual to recommend calcium-ammonium-nitrate rather than ammonium sulphate on acid soils. In practice the cheapest form of N is the best.

The time of application is important with nitrogenous fertilisers. At the beginning of the rains there is a nitrogen flush because of the increased microbial activity due to favourable moisture conditions and nitrogen is usually adequate at this stage. This is usually followed by a period of fairly intense leaching, so that the best time to apply nitrogenous fertilisers is during the growing period, with maize when the crop is 45 - 60 centimetres high, and with cotton at flowering.

Because of the leaching factor split dressings are recommended for perennial crops particularly on sandy soils.

Apart from some sisal estates where the use of leguminous cover crops has become standard practice little attention has been paid to legumes as a source of nitrogen. Nitrogen fixation by tropical legumes can be quite considerable. At the Sisal Research Station, Mlingano, tropical kudzu, Pueria phaseoloides, added more than 300 kgs. of N per hectare per annum over a period of 74 months, Hopkinson 1967, whilst at Tengeru, Anderson. 1967, calculated that Desmodium uncinatum and D. sandwicense fixed 192 and 175 lbs. N per acre (175 - 154 kgs. per hectare) respectively in just less than 15 months.

In general the soils which are high in phosphorus, namely the volcanic and alluvial-colluvial soils are also high in nitrogen. As pointed out previously, however, response to nitrogen is conditioned by the rainfall pattern and factors like the C/N ratio, as well as by soil nitrogen.

The use of di-ammonium phosphate (18% N, 47% soluble  $P_2O_5$ ) has much to recommend it where both N and P are deficient.

#### Potassium:

Most ~~Tanzanian~~ soils developed on rocks of the basement complex have sufficient potassium for normal plant growth, and with the exception of flue cured tobacco, where high potassium levels are necessary for the production of high quality leaf, it is not normally needed for annual crops, although maize under continuous cropping for 5 years at Sambwa has shown increasing response to K. Also, in trials with Canadian Wonder Beans on the eastern side of Mt. Kilimanjaro potassium deficiencies have frequently occurred.

For flue cured tobacco the standard recommendation is 5 cwt. per acre per annum of a 3:27:18. NPK mixture, the potassium in this being equivalent to 225 kgs. per hectare of potassium sulphate.

Among perennial crops, sisal, tea and coconuts, have all shown responses to potassium fertilisers.

The characteristic symptom of K deficiency in sisal is banding disease and potassium fertiliser should be applied at a rate which will prevent its appearance. This is 50 - 100 kgs. of potassium chloride per hectare per year depending on whether the soil has a low or very low K status.

With tea it is usual to place triple superphosphate and potassium sulphate in the planting holes at rates of 220 kgs. per hectare for each fertiliser, and for mature tea recommended dressings of compound fertilisers, usually 25:5:5, are 460 kgs. per hectare per annum.

Potassium has also been shown to be deficient for the growth of coconuts on the coastal sands at Tanga and 135 kgs. per hectare per annum of potassium chloride, together with half this amount of calcium-ammonium-nitrate and double superphosphate is suggested as a standard dressing.

In general the soils most deficient in potassium are the coastal sands and the soils developed on deep unconsolidated sands derived from sedimentary rocks.

#### Lime:

Although most soils are medium to slightly acid there have been few recorded responses to lime and the only crop on which liming is practised on acid soils and soils low in calcium, is sisal. The recommended rates of application which can be indicated by soil analyses are 2 - 5 tons of ground limestone per hectare, broadcast before planting.

Increased yields of groundnuts, soy beans, and maize have followed the topdressing of 2,500 kgs. per hectare of burnt lime on very strongly acid and calcium deficient patches of land at Nachingwea, and 1,000 kgs. of ground limestone per hectare has given similar results on very strongly acid soils at Kongwa. Canadian Wonder Beans have also responded to lime dressings on Mt. Kilimanjaro.

Responses to lime may be due to the supply of calcium or the correction of acidity, but heavy liming of acid soils should be approached with caution as it may lead to induced trace element deficiencies, and also many tropical crops are adapted to slightly or medium acid soils.

On the Kitulo Plateau near Mbeya, 110 kgs. per hectare of ground limestone is used with superphosphate when seeding pasture mixtures which include white clover, Trifolium repens. If the use of legumes in pasture mixtures or to improve soil fertility becomes accepted, it is possible that small dressings of ground limestone

at seeding could be used to aid establishment.

Trace Elements:

Until the major nutrient deficiencies are corrected there is little point in conducting trials with trace elements and little work has been done along these lines.

At Ukerewe, cotton has responded to boron where nitrogen and phosphorus levels are high and black wattle, Acacia mollissima, at Njombe, has also showed boron deficiency symptoms.

On highly calcareous soils at Kongwa groundnuts have responded to ferrous sulphate sprays, indicating a lime induced iron deficiency.

As most soils are slightly to medium acid it is probable that molybdenum would be needed for the establishment of legumes.

### SOIL EROSION

Water erosion occurs in every region of Tanzania and has in places, for example Kondoa, led to the complete destruction of the soil asset. In restricted areas elsewhere the land is also so badly eroded that it is beyond reclamation. Fortunately these completely devastated areas are localised and over the country as a whole erosion is not widespread, nor where it does occur, has it reached the stage where it can not be controlled by recognised soil conservation practices.

This is not due to good soil management but to the fact that most of the country is still woodland, and where it is cleared the standard system of farming is bush fallow, where only small scattered areas are worked up by hand for cropping.

With the introduction of mechanised cultivation and the clearing of large **contiguous** areas of land the erosion hazard will increase enormously, and unless development is accompanied by sound land planning based on conservation principles the results could prove disastrous.

Most Tanzania soils are extremely erodible once the surface cover is removed.

BIBLIOGRAPHY

The following is a selected and comprehensive bibliography of all publications which have proved useful in compiling this bulletin and the four bulletins on the land resources of Tanzania.

For ease of reference it is subdivided into sections dealing with specific aspects of information on soils and vegetation, or listing the publications produced by different organisations.

Other bibliographies are:-

1. Bibliography on soils of Tanganyika (1962 - 1933)  
Commonwealth Bureau of Soils, 1962.
2. Relevant articles on soils and pastures and some economic and livestock material.

E. Afr. Agric. J.            Vols. I - XXXIII

Emp. J. Exp. Agric.        Vols. V - XXXII

Exp. Agric.                Vols. I - III

P. J. Skerman FAO/UNDP Live-  
stock Mission, 1968.

3. A regional bibliography of Tanzania.

P. J. Skerman FAO/UNDP Live-  
stock Mission, 1968.



- F.A.O. Report No. 1886. Possibilities for agricultural and  
(1964) related development of the Kilombero  
valley.
- F.A.O./U.N.S.F. (a) Reconnaissance soil survey of the  
Pangani - Wami river Wami coastal plain.  
basins project. (b) A summary of semidetailed soil  
(1965) surveys for the Naururu and Ngage  
areas in the Pagani Valley.  
(c) Summary of soil surveys and recommen-  
dations for the Kahe area.
- Directorate of Overseas Land resource study No. 1.  
Surveys. The development of the lower Mgeta  
(1966) river area of the United Republic of  
Tanzania.
- ILACO. Report on the regional development of the  
(1967) Msolwa and lower Ruembe Valleys.
- Anderson G. D. A soil survey of Maramba Estate with  
(1961) a particular view to the cocoa potential.  
Unpublished report to Min. of Agric.
- " (1967) A reconnaissance survey of the land use  
potential of Mkomazi game reserve and  
an appraisal of factors affecting present  
and potential land use and productivity  
in its environs.  
Unpublished report to Min. of Agric.
- " Soil survey of the Usambara foothills  
unpublished report 50,000 acres
- Land Planning Office A reconnaissance survey of Oljoro Region  
Arusha Tanganyika. 30,000 acres  
Arusha Development Plan - Phase II Part I
- " Reconnaissance survey of Ardai - Lokisale  
Makuyuni. 700 sq. miles.

REPORTS

- Sir A. Gibbs and partners. (1956) Water resources survey of the Nile basin in Tanganyika.
- F.A.O. Report No. 1316. (1961) An outline plan for the development of the Ruvu basin.
- J. F. Glennie & W. D. I.D. (1961) Bubu river basin-interim report.
- Sir W. Halcrow and partners. (1962) Report to the Government of Tanganyika on the development of the Pangani river basin.
- French technical mission. (1962) (a) Report for the development of the Ruvu basin.  
(b) Development of the Ruvu basin - Kwala pilot scheme.
- Netherlands centre of African studies Leyden. (1966) Report on a general soil and agricultural reconnaissance of the Rungwe district Tanzania.
- Bureau of Reclamation U.S.D.I. (1967) Rufiji river basin.

SOILS GENERAL BIBLIOGRAPHY

- Milne G. (1935) Composite units for the mapping of complex soil associations. Trans. 3rd Int. Con. Soil Sc. 1, 135.
- " " (1936) Normal erosion as a factor in soil profile development.  
Nature 138, 548.
- " " (1937) Notes on soil conditions in two East African vegetation types.  
J. Ecol. 25, 255.

- Milne G. (1937 - 38) Essays in applied pedology I, II, III.  
E. Afr. agric. J. V. III.
- " (1938) Essay in applied pedology V, IV.  
E. Afr. agric. J. No. 1.
- " (1947) Soil reconnaissance journey through parts of  
Tanganyika Territory.  
J. Ecol. V 35, No. 1 and 2.
- " " Rukwa soils.  
Unpublished: I.R.L.C.S. Abercorn 100307.  
A/LIB/E/O.
- " " The soils from the flood plains of Lake Rukwa.  
Unpublished: P/SOI folio 66. Reg. Agric.  
Office, Mbeya.
- Milne G. Calton W. E. Mechanical composition of East African soils.  
(1943) E. Afr. agric. J. V, VIII, 202.
- Overseas Food Corporation. The topography, climate, geology and soils  
(1949) at Kongwa and Urambo.  
Rep. Sci. Dept. E.A. 1947 - 48. 27 - 29.  
Fertility studies. 29 - 41.
- Darby G. D. (1954) The wattle soils of Tanganyika Southern  
Highlands.  
Rep. with Tanganyika Wattle Company, Njombe.
- Calton W. E. (1954) The catena in relation to the classification  
of East African soils.
- " " Some East African Soil Complexes. Zanzibar  
protectorate. II Tanganyika.  
Trans. 5th Int. Cong. Soil Sc. 4, 58 - 61.  
62 - 69.

- Calton W. E. (1959) Generalisations on some Tanganyika soil data.  
Soil Sci. V 10, No. 2.
- Le Mare P. H. (1953) Responses to fertilisers in areas of  
Tanganyika farmed by the Overseas Food  
Corporation.  
E. Afr. agric. J. V XIX, 40.
- " (1959) Soil fertility studies in three areas of  
Tanganyika.  
Emp. J. Exp. agric. V XXVII, 197.
- Calton W. E., Vail J.W. (1956) Micronutrient problems in Tanganyika.  
VI<sup>o</sup> Con. Int. Sci. Sol. Rapp. D 31 - 35 (E.g.f.)
- Anderson B. (1956) Two red earth profiles from S. Tanganyika  
showing the influence of parent material  
on profile character.  
VI<sup>o</sup> Con. Int. Sci. Sol. Rapp. E. 93 - 98.
- " (1963) Soils of Tanganyika.  
Min. of Agric. Bull. 16.
- Muir A., Anderson B.,  
Stephen I. (1957) Characteristics of some Tanganyika soils.  
J. Soil Sci. V 8, 1 - 18.
- Charter C. F. (1958) Report on the environmental conditions  
prevailing in Block A, Southern Province,  
Tanganyika Territory, with special reference  
to the large scale production of groundnuts.  
Ghana Dep. Soil - Land use Survey. occ.  
Pap. 1, 37.
- Anderson G. D. (1963) Some weakly developed soils of the eastern  
Serengati plains, Tanganyika.  
A comparison of red and yellowish red upper  
slope soils of the eastern Usumbara foothills,  
Tanganyika.  
Afr. Soils V 8, No. 3 339, 431.

- Anderson G. D. (1964) Kilimanjaro soil survey - the use of leaf analysis in assessing fertiliser responses on related soil types.  
E. Afr. soil fert. spec. conf.
- " (1964) Difference in response to fertilisers between genetic soil groups on the slopes of Mt. Kilimanjaro, Tanganyika.  
Proc. 8th Int. Con. Soil Sc. Com. 4.
- " (1965) Estimates of the potential productivity of some pastures in the Mbulu Highlands of Tanganyika by application of fertilisers.  
E. Afr. agric. J. V XXX, 206.
- " (1966) A brief account of the geography and land use potential of Monduli. Masailand, pilot range management area.  
Unpublished report - Min. of Agric.
- " (1967) Increasing coconut yields and income on the sandy soils of the Tanganyika coast.  
E. Afr. agric. for J. V XXXII, No. 3.
- " (1967) Promising pasture plants for northern Tanzania.  
East, Afr. agri. for J. V XXXII, No. 3
- " (1968) Effects of fertilisers on botanical composition and productivity of pasture on the sandy soils of the Tanganyika coast.  
E. Afr. agric. for. J. V XXXIV, 207.
- " (1969) Responses of maize to application of compound fertilisers on farmers fields in ten districts of Tanzania.  
E. Afr. agric. for J. V XXXIV, No. 3.

- Anderson G. D.  
in press
- Soil fertility studies on a sandy loam soil in semi arid Tanzania.  
I Effects of nitrogen, phosphorus and potassium on yields of maize.  
Ibid III; Effects of fertiliser applications on soil nutrient status under maize cropping.
- Feat J. F. and  
Brown K. J. (1962)
- The yield responses of rain grown cotton at Ukiriguru, Lake Province, Tanganyika Parts I and II.  
Emp. J. Exp. agric. 30; 215 - 231, 305 - 314
- Evans A. C.,  
Mitchell H. W. (1962)
- Soil fertility studies in Tanganyika I. Improvement to crop and grass production on a leached sandy soil in Bukoba.  
E. Afr. agric. for J. V XXVII, 189.
- Evans A. C. (1963)
- Soil fertility studies in Tanganyika II. Continued applications of fertilisers in the red and red-brown loams of the Nachinwea district.  
Soil fertility studies in Tanganyika III. On the Kikungu and Luseni soil types of the Lake and Western Regions.  
E. Afr. agric. for J. XXVIII, 228, 231.
- Akehurst B. C. ,  
Sreedharan A. (1966)
- Application of mineral fertilisers to flue cured tobacco in Iringa district, Tanzania.  
Exp. Agric. II, 265.
- Dirschl H. J. (1966)
- Management and development plan for the Ngorongoro Conservation area.  
Report to Min. of Agric.

- Anderson G. D.,  
Houston B. G.,  
and Northwood P. J.  
(1966) Effects of soil cultivation history and  
weather on response of wheat to fertilisers  
in northern Tanzania.  
Exp. agric. II, 183.
- Scaife M. A.  
(1968) Maize fertiliser experiments in Western  
Tanzania.  
J. agric. Sci. 70, 209.
- " (1969) A simple means of determining maize  
fertiliser requirements.  
E. Afr. agric. for J. V XXXIII No. 4.

ECOLOGICAL PUBLICATIONS

- Phillips J.  
(1930) Some important vegetation communities in  
the Central Province of Tanganyika Territory.  
J. Ecol. XVIII, 193 - 234.
- Michelmore A. P. G.  
(1939) Observations on tropical African grasslands.  
J. Ecol. 27 - 282 - 312.
- Burt D. D. (1942). The East African vegetation communities.  
J. Ecol. 30, 65 - 146.
- Michelmore A. P. G.  
(1949) The outbreak areas of the red locusts  
I.R.L.C.S. Abercorn.
- Gillman C. (1949) A vegetation types map of Tanganyika  
Territory.  
Geog. Review V XXXIX, No. 1.
- Pielou E. C. (1952) Notes on the vegetation of the Rukwa Rift  
Valley, Tanganyika.  
J. Ecol. 40, 383 - 392.

- Grantham D. R. and Pilson R. D. (1954) Plant ecology as an aid to colonial development.  
Col. Pl. Anim. Prod. 4, 110 - 136.
- Greenway P. J. (1955) Ecological observations on an extinct East African volcanic mountain.  
J. Ecol. 43, 544 - 563.
- Vesey-Fitzgerald D. F. (1955) The vegetation of the outbreak areas of the red locust in Tanganyika and N. Rhodesia.  
Antilocust bulletin No. 20.
- " (1963) Central African grasslands.  
J. Ecol. 51 - 243 - 274.
- Backlund, Helge O. (1956) Aspects and successions of some grassland vegetation in the Rukwa Valley.  
Oikos, Supplement 2.
- Pearsell W. H. (1957) Report on an ecological survey of the Serengeti National Park, Tanganyika.  
Oryx 4, 71 - 146.
- Anderson G. D. and Talbot L. M. (1965) Soil factors effecting the distribution of the grassland types and the utilisation by wild animals on the Serengeti Plains.  
J. Ecol. V 53, 33 - 56.
- Pratt D. J., Greenway P. J., Gwynne M. D. (1966) A classification of East African rangeland.  
J. Appl. Ecol 3, 369 - 382.
- Dean G. J. W. (1967) Grasslands of the Rukwa Valley.  
J. Appl. Ecol. 4, 45 - 59.

GEOLOGICAL SURVEY DEPARTMENT

Publications containing soils information.

Soil and geological sketch maps.

G. S.	200	Iringa to Ruaha river ...	...	1:100,000.
G.S.	201	Iringa district ...	...	1:100,000.
G.S.	<del>202</del>	Mbozi-Mbeya - Tukuyu ...	...	1:300,000.
		Buhuru region		
G.S.	204	Sao Region ...	...	1:100,000.
G.S.	207	Malangeli area ...	...	1:100,000.
G.S.	<del>209</del>	Dodoma to Ruaha river ...	...	1:150,000.
G.S.	210	Kidegula - Buanga region ...	...	1:100,000.

Short ~~papers~~ No. 4

(1929) The soil and agricultural development in relation to the geology of portions of the N. Kigoma and S. Bukoba provinces.

Short ~~papers~~

No. 29 (1947)

The geology of the country around Mwanza gulf.

Morrison C. G.  
and Wright B.

(1951)

The soils of Sukumaland.

File 6430.

Spurr A. M.

(1954)

A basis of classification of soils of the areas of composite topography in C. Africa with special reference to the soils of the Southern Highlands of Tanganyika.

Proc. 2nd Inter. Afric. Soils Conf.

1, 175 - 192.

"

Notes on the formation of laterite in the Mbozi area, Mbeya district.

Rec. G. S. 1, 30 - 34.

"

A guide to the Uwemba soil museum.

AMMS/26, 20.

- Spurr A. M. (1955) A note on the soils of the Tanganyika wattle estates - Njombe.  
AMMS/29 3.
- " The soils of Mbozi -  
Bull. 24.
- Spurr A. M. The soils of central Uwemba.  
1537
- Spurr G. The soils of south Uwemba.  
1538
- Grantham D. R. and  
Pilson R. D. (1955) The geology and ecology of the Nachingwea region.  
Bull. 26.
- Grantham D. R. (1955) The Tunduru - Ruvuma area of the Southern Province.  
  
A reconnaissance of the geology, soils  
vegetation and hydro-electric potential.  
Report 1: 14.
- Lambert J. L. M. Soil erosion of Kinyasi ridge, Chungai  
(1956) resettlement area.  
Rec. C.S. 3.
- Spence J. (1957) The geology of part of the Eastern Province  
of Tanganyika.  
Bull. 28.

TANGANYIKA SISAL GROWERS' ASSOCIATION  
SISAL RESEARCH STATION, MLINGANO

Research bulletins dealing with soils include:-  
1, 9, 12 - 19, 30, 33 and particularly 39.

Research Bulletin 39

Rijkebusch P. A. H.            Interpretation of soil analyses in relation  
Osborne J. F.    (1965)    to the manuring of sisal fields.

Other publications are:-  
Other publications are:-  
Staff of the Sisal            A hand-book for sisal growers.  
Research Station,  
Mlingano            (1965)

Hopkinson D.    (1967)    Studies on the use of leguminous cover crops  
for the maintenance of soil fertility in  
sisal in Tanganyika.  
E. Afr. spec. com. soil fert.

TANGANYIKA COFFEE BOARD

Annual research reports of Coffee Research Station, Lyamungu.

EMPIRE COTTON GROWING CORPORATION AND COTTON  
RESEARCH CORPORATION

Progress reports from experimental stations.

Tanganyika Lake Region.

Tanganyika Coast Region.

Tanzania Western Cotton Growing Area.

NORTHERN RESEARCH CENTRE, TENGERU

Tengeru reports:-

4, 11, 12, 22, 28, 30, 40, 45, 61, 66, 82, 90, 91, 92, 96, 104, 113,  
115, 119, 124.

WESTERN RESEARCH CENTRE, UKIRIGURU

Progress reports: 7, 8, 14.

LEGEND

- |   |  |   |
|---|--|---|
| 1 | <p>a. Permanent swamps.</p> <p>b. Tidal mangrove swamps</p>  | <p>a. Peats overlying grey sandy clay loams and sandy clays.</p> <p>b. Black saline clays.</p>  |
| 2 | Flat alluvial flood plains.  | <p>a. Black cracking clays.</p> <p>b. Black cracking clays and brown sandy loams.</p> <p>c. Yellowish brown clays.</p> <p>d. Reddish brown to dark brown clays with sands and silt loams.</p>   |
| 3 | Flat alluvial flood plains.  | <p>a. Grey and brown sands and sandy loams with dark grey clays in the lower areas.</p> <p>b. Dark brown loams and sandy loams.</p>   |
| 4 | Flat or almost flat seasonally flooded alluvial-lacustrine plain.  | Dark grey to black clays with sandy loams on the higher areas.  |
| 5 | <p>a. Flat to gently sloping alluvium and colluvium.</p> <p>b. Flat to undulating alluvial plain.</p>  | <p>a. Reddish brown sandy loams to black loams and clays.</p> <p>b. Dark reddish brown loams and sandy loams.</p>   |
| 6 | <p>a. Flat to gently sloping alluvial fans and flood plains.</p> <p>b. "</p> <p>c. Flat to gently undulating alluvial plains and terraces.</p> | <p>a. Brown silt loams to dark grey clays which are alkaline and often saline. Sands and sandy loams on the higher parts.</p> <p>b. Reddish brown to dark grey clays with sands and silt loams often saline.</p> <p>c. Hard grey and brown sands and sandy loams over neutral to alkaline sandy clay.</p> |
| 7 | Flat or almost flat plain with low limestone escarpments.  | Dark grey clay loams over limestone.  |
| 8 | Flat to undulating plain with occasional low granite outcrops.   | <p>a. Dark grey sandy clays over clay.</p> <p>b. Dark grey sandy clay loams over sandy clay.</p>  |

9

- a. Flat to undulating plain.
- b. Flat to undulating with occasional granite outcrops.

- a. Dark brown fine sandy loams.
- b. Dark grey to dark brown fine sandy loams.

10

- c. Undulating to rolling.
- a. Flat to undulating
- b. Flat to undulating with scattered hills.
- c. " "
- d. Undulating with solitary hills and low ridges.

- c. Dark brown loams to clays.
- a. Dark brown to dusky red loams.
- b. Brown to reddish brown loams.
- d. Dark reddish brown sandy loams.

11

Flat to undulating with occasional granite outcrops.

- d. Dark reddish brown loams, brown sandy loams and black clays.

Dark greyish to reddish brown sands and sandy loams over sandy clay loams.

- a. Woodland.
- b. Bushland - thicket.
- c. Bushland.

12

Flat to undulating with occasional granite outcrops.

Black to red sandy clay loams over sandy clays.

13

Flat to undulating with occasional small hills.

Dusky red sandy clay loams and shallow dark grey clays.

14

- a. Gently undulating coastal plain.
- b. Flat to undulating with poorly drained areas.

- a. Brown loamy sands and shallow red brown loams.
- b. Yellowish to reddish brown sands and sandy loams and dark brown sandy clays.

15

Undulating plain with occasional granite outcrops.

- a. Dark brown to black, cracking, sandy clay loams and clays.

- b. Dark reddish brown sandy clay loams and black clays.
- c. Dark reddish brown sandy loams over sandy clay loams and dark grey sandy clays.

16

- a. Undulating to rolling with numerous granite outcrops.
- b. Undulating with low granite outcrops.
- c. Undulating with wide drainage ways.

- a. Reddish brown to grey loamy sands and sandy loams and black cracking clays.
- b. Reddish brown sandy loams over sandy clay loams, and dark grey sandy clay loams.
- c. Dark brown sandy loams over sandy clay loams and dark grey clays.

17

- a. Undulating on unconsolidated sands and sandstones.
- b. Rolling on unconsolidated sands and sandstones.
- c. Undulating to rolling on unconsolidated sands and sandstones.

18

- a. Undulating with rock outcrops on basement complex.

- a. Yellowish brown to dark reddish brown loamy sands over sandy loams.

- b. Yellowish brown to dark reddish brown loamy sands over sandy loams.

- c. Reddish brown loamy sands and yellowish red sandy clay loams over sandy loams to sandy clays.

- a. Dark reddish brown loamy sands over sandy clay loams and sandy clays.

- b. Dark reddish brown to brown loamy sands and sandy loams over sandy loams.

- c. Deep, yellowish red loamy sands.

- d. Shallow, fairly rocky, dark brown loamy sands to sandy clays.

- |     |  |  |
|-----|--|--|
| 19  | <p>a. Undulating to rolling with rock outcrops on basement complex.</p> <p>b. " "</p> <p>c. " "</p> <p>d. Gently undulating with low hills and rock outcrops.</p>                            | <p>a. Dark brown and reddish brown coarse loamy sands over sandy loams.</p> <p>b. Severely eroded, yellowish to reddish brown coarse loamy sands and sandy loams.</p> <p>c. Greyish brown over yellowish red sandy loams; reddish brown loams.</p> <p>d. Red sandy clay loams over dark red sandy loams.</p> |
| 20. | <p>a. Undulating with even slopes.</p> <p>b. Gently rolling with occasional rock outcrops and some hills.</p>  | <p>a. Dark greyish brown clay loams over greyish brown sandy clays.</p> <p>b. Dark grey to black, cracking calcareous clays.</p>   |
| 21  | <p>Undulating to rolling with some rocky and hilly land.</p>   | <p>Dark reddish grey sands and loamy sands.</p>  |
| 22  | <p>Undulating to rolling river valley.</p>   | <p>Yellowish red fine sandy loams over sandy clay loams; dark red sandy clay loams; clay loams.</p>  |
| 23  | <p>a. Rolling to hilly with sandstone escarpments.</p> <p>b. Rolling to hilly with long steep sided and flat topped ridges.</p> <p>c. Rolling to hilly with some steeply dissected land.</p> | <p>a. Dark reddish brown fine sandy loams over sandy clay loams, often shallow.</p> <p>b. Shallow, dark reddish brown sandy loams over sandy clay loams.</p> <p>c. Shallow, very dark brown loamy sands and dark reddish brown fine sandy loams over sandy clay loams.</p>                                   |
| 24  | <p>a. Rounded hills with gentle foot slopes.</p> <p>b. Rolling to hilly.</p> <p>c. " "</p> <p>d. " "</p>   | <p>a. Dark reddish brown loams over dark red clay loams.</p> <p>b. Dark reddish brown clay loams, dark brown loams and black clays.</p> <p>c. Dark reddish brown loams.</p> <p>d. Shallow, stony, dark reddish brown clay loams and clays.</p>   |
| 25  | <p>a. Rolling to hilly</p> <p>b. " "</p> <p>c. Gently rolling.</p>   | <p>a. Yellowish red to dark brown loamy sands and sandy loams over sandy clay loams and sandy clays.</p> <p>b. Yellowish red to dark brown sands over sandy loams.</p> <p>c. Shallow, stony, and rocky, yellowish brown sandy loams to clay loams and sandy clays.</p>                                       |

26

Rolling to hilly.

- a. Dark grey to dark reddish brown sands to sandy loams, sometimes shallow.
- b. Dark greyish brown to dark reddish brown loamy sands over sandy clays.
- c. Grey brown to grey loamy sands and sandy loams over sandy clay loams and sandy clays.

27

- a. Highlands - undulating to rolling plateau.
- b. Highlands - undulating to hilly plateau.

- a. Reddish brown sandy clay loams to dusky red clays, sometimes shallow and stony.
- b. Brown sandy clay loams and clay loams.

28

- a. Highlands - rolling to hilly plateau.
- b. Highlands - undulating to rolling.
- c. "

- a. Dark red loams, reddish brown loams and black clays.
- b. Dark reddish grey to reddish brown loams and clay loams.
- c. Yellowish red to dark reddish brown sandy clay loams and clays, often shallow.

29

- a. Highlands - undulating plateau.
- b. Highlands - undulating to rolling.

- a. Dark reddish brown loams and black clays.
- b. Black to dark brown loams to clay loams over silty clay loams and silty clays.

30

Hilly to steeply dissected with escarpments and narrow drainage ways.

Brown to reddish brown loamy sands often shallow, stony and rocky.

31

- a. Hilly to steeply dissected with some undulating and rolling land.
- b. "
- c. "

- a. Dark brown to reddish brown sandy loams and sandy clay loams often shallow, stony, and rocky.
- b. Dark reddish brown to red sandy clay loams and clays often shallow, stony, and rocky.
- c. Yellowish red to dark brown loams, clay loams and clays, often shallow, stony, and rocky.

32

Steep escarpments and associated hills.

Shallow, stony and rocky, reddish brown to brown sandy loams and loams.

33

Steeply dissected to mountainous.

- a. Shallow, stony and rocky reddish brown to brown sandy loams to clays.
- b. Deep, dark reddish brown clay loams occasionally shallow and rocky.

34

Steeply dissected to mountainous volcanic areas.

- a. Shallow, stony and rocky dark brown to dark reddish brown sandy loams and loams.
- b. Deep, dark reddish brown to dark brown loams and clay loams, occasionally shallow, stony and rocky.

# SOILS OF TANZANIA



Scale 1:2,000,000  
Kilometres 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300  
Miles 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300  
Polyconic Projection