STATUS AND CAUSES OF LAND DEGRADATION IN MBULU, KONDOA AND SINGIDA DISTRICTS, TANZANIA AND STRATEGIES FOR CONSERVATION AND REHABILITATION

Juvent Magoggo
Samwel Mugogo

Draft

July, 1996

CONTENTS

List of tables

List of figures

List of boxes

Acknowledgements

1 BACKGROUND

Tanzania has an area of 939,701 km² and a human population estimated at 28 million. The overall population density is estimated at 25 persons per km² but locally population densities vary tremendously depending mainly on agroclimatic conditions. There is enough productive land for agricultural expansion in the immediate and future use. This population is estimated to be growing at the rate of 3% per annum (NEMC, 1992).

About 90% of the population depend on agriculture for subsistence, employment and economic sustenance. Agriculture contributes about 50% to the GDP and 75% of the total foreign exchange earnings of Tanzania. The nature of agricultural activities includes crop-based agriculture and livestock keeping. In general crop-based agriculture is dominant in the higher rainfall zones; in the drier zones livestock keeping is dominant. It is estimated that 420,000 km² has potential for arable agriculture and about 600,000 km² (about 60% of the total area of Tanzania) has grazing potential for livestock. The rangelands support more than 13 million cattle and 10 million sheep and goats. At present only 15% of the potentially arable land is under cultivation and nearly 60% of all livestock production is taking place on only 10% of the potential grazing land (MLHUD, 1995).

Forestry resources are closely linked with agriculture, livestock, bee-keeping, energy, water resources and biological diversity. Forest resources account for about 50% of the total land area in Tanzania. Only a small proportion of this area is true forest as distinct from woodlands which predominate. According to the energy policy of 1992, it is estimated that fuel wood, charcoal and agricultural residue account for 92% of the total energy consumption in Tanzania. Forests supply about 80% of the domestic energy in the form of wood and charcoal. The estimated fuel wood requirement stands at 45 million cubic meters per year out of which 43.8 million cubic meters are consumed in the rural areas. The natural forests can only sustain a supply of about 20 million cubic meters per year (NEMC, 1992). Fuel wood is also required in the processing of some (export) crops such as in the curing of tobacco.

Increasing population in the last years has led to increased pressure on land. This has led to encroachment on natural and other forest areas, cultivation of marginal areas, overstocking and land use conflicts which are more pronounced in areas of interface between livestock and crop-based agriculture. These factors have led to increased rates of land degradation especially in the drier parts of the country where the ecological balance is naturally delicate. The districts of Mbulu, Kondoa and Singida occur in this setting.

Mbulu, Kondoa and Singida districts, like others in the semi-arid central Tanzania, are now faced with the environmental problem of land degradation typified by severe depletion of vegetation cover, soil erosion, siltation of important open water bodies, declining soil fertility and desertification. There is no arguing that most problems have been brought on by improper land husbandry practices. Thus these districts have the major task of integrating livestock and crop land use systems into an environmental conservation strategy for sustainable economic growth. In recognition of the fact that this problem is almost universal in Africa, FAO in 1990, launched the International Scheme for the Rehabilitation of African Lands (ARC/90/4). The purpose of the scheme is to provide a means by which African countries can develop their own programmes to fight land degradation based on promoting sound land use planning.

The present study was contracted by FAO in order to assess the situation and causes of land degradation in Mbulu, Kondoa and Singida districts and to identify actionable land conservation issues for research and training and those related to policy within the context of the global strategy and the national environmental development plan. The terms of reference for this study were:

- assess the situation and causes of land degradation in all its aspects (erosion, declining soil fertility, chemical and physical degradation, deforestation, rangeland deterioration, acidification, salinization, pollution, urban land degradation, etc) in the districts of Mbulu, Kondoa and Singida;
- assess the impact of past and on-going programmes aiming at soil and water conservation;
- identify priority research programmes in the field of soil and water conservation;
- produce, taking into account the objectives of the national development plan, the national environmental plan and the result of the assessment made above, a programme of conservation and rehabilitation of lands in the three districts comprising:
  - a global strategy for implementing a rational national policy for conservation and rehabilitation of lands;
  - identification of priority areas of action;
  - training needs and institutional building up.

The duration of the consultancy will be three months.
The length of the report must not exceed 100 pages

This study was undertaken by S.E. Mugogo and J.P. Magoggo, Senior Soil Surveyors at the

National Soil Service, Agricultural Research Institute Mlingano on behalf of the Commissioner for Research and Training of the Ministry of Agriculture and Cooperatives. Literature on the physical environment of the three districts were consulted as well as literature on activities and scientific studies related to land degradation and conservation. This was followed by field visits to the districts where discussions were held with district authorities, land use planners, agricultural officers in various sectors, project administrators and a few farmers and school teachers. This study revealed that there is a severe lack of data on types and extent of land degradation in the three districts, except for Mbulu district.

This report presents the findings of the literature study and field visits and proposes a strategy for rehabilitation and conservation of land in the three districts.

2 ENVIRONMENTAL PROFILE OF MBULU, KONDOA AND SINGIDA

2.1 Location and Administrative Framework

The three districts selected in this study stretch from the footslopes of the Ngorongoro mountains in the north to the Dodoma peneplain (part of the Central African Plateau) in the south (Figure 1). Mbulu district in the north is part of Arusha region, Singida district is in Singida region with both the regional and district headquarters in Singida town while Kondoa district is part of Dodoma region. The three districts form almost a continuous block (see Figure 1) which is situated between latitudes 3°10' and 5°45' south of the Equator and longitudes 34°0' and 36°30' east. In total they cover an area of 33,895 km², of which only a minor part is water bodies.

The altitude ranges in absolute terms from 1,000 m, at the level of both Lake Manyara and Eyasi in Mbulu district, to nearly 2,400 m in the south eastern part of Mbulu district. The general altitude range in Kondoa and Singida is between 1,100 and 1,200 m above sea level with small parts of this peneplain rising to about 1,900 meters.

Mbulu district is located between approximately 3°10' and 4°16' south latitude and 34°47' and 25°56' east longitude. The total area is approximately 7,695 km² of which about 6,630 is land area, the rest being water bodies.

Kondoa district lies approximately between latitudes 4° and 5°45' south and longitudes 35° and 36°30' east. It is located in north-central Tanzania and is part of the four district of Dodoma region. The district covers an area of 13,210 km². Kondoa town, the capital of the district, is connected to Dodoma town, the regional headquarters, by an all weather road which is part of the great north road linking Cairo and Capetown.

Singida district is bounded between about 34°0' and 35°30' longitudes east and latitude 4°30' and 5°35' The district houses the regional headquarters, both of which bear the same name. It has an areal coverage of about 13,000 km².

Figure 1: Location map

2.2 Physiography

Almost the whole of Mbulu district is a plateau bounded on the west and east by rift grabens belonging to the East African Rift system. However, this plateau has undergone subsequent tectonic movement and dissection so that at the district scale several sub-divisions can be made. Due to this setting, the district is characterized by highly contrasting landscapes ranging from highly dissected hilly and mountainous areas (where parts of the old peneplain have been strongly uplifted and tilted), to extended alluvial and lacustrine plains. The northern part of the district belongs to the Central Crater Highlands (i.e. the extinct Loolmalasin [3,610 m], Olsirwa [3,150 m] and Olmoti volcanoes and Ngorongoro calderas) and their adjacent footslopes. The main structural feature is the Manyara escarpment. From Barai to Lositete the southern footridges of the Central Crater Highlands are characterised by fault lines that form small scarps, which generally face south-south east and divide the district into a series of blocks. The faults are thought to be of Plio-Pleistocene age.

The central part of Mbulu District consists of a huge plateau (uplifted block of country and gently tilted northwards) with altitudes up to 2,400 m. Towards the east the plateau descends to the Great Rift Valley (with Lake Manyara) that forms the border of the district in its entire length from north-north east to south-south west. The descent is abrupt across the Manyara escarpment, down to an altitude of 1,200 to 1,000 m. In the west the plateau is bounded by the Yaida escarpment. Below this scarp, a gentle dipslope (in which the Yaida valley is embedded) leads to the saltpans of Lake Eyasi at about the same altitude as Lake Manyara (1,000 m). In the north the descent of the plateau is to an altitude of about 1,400 m; in the south-west the descent is approximately to 1,600 m. On the northern slope-fall follows a new rise towards the Ngorongoro Northern Highlands, up to an altitude of about 3,650 m (Loolmalasin volcano; just north of the district). Several scarps up to 90 m high cut the plateau and trend NE, parallel to the main bounding scarps.

The heavily dissected area of Nou Forest in the south east is the highest part of the Mbulu Plateau, at an elevation of between about 2,135 and 2,440 m. It is bounded by a dissected fault scarp on nearly all sides.

The part of the Mbulu Plateau adjacent to the Manyara Escarpment is a hilly or highly dissected area with a surface that falls from 2,000 m in the south-west to just below 1,400 m in the north. A number of isolated mountain summits such as Guam-Dara (2,260 m) and Hassama (2,135 m) rise above the general level.

The southern and south-western parts of the Mbulu Plateau are much less dissected and at an elevation of 1,600 - 1,900 m asl. West of Dongobesh bare granitic hills or chains of hills rise to between 1,830 and 2,125 m above sea level.

Extensive mbuga[1] systems are a characteristic of the most level areas of the Mbulu Plateau.

Land resources studies have been carried out in Mbulu district (Magoggo *et al*, 1994) and in Kondoa district by Agra-Und-Hydrotechnik (1984). No similar study has been undertaken in Singida district. In general terms the following landscapes can be distinguished in the three districts: highlands, plateaux, plains and major valleys. These are described below and their spatial extent is shown in Figure 2.

Highlands

Highlands are hill blocks or otherwise highly dissected, high-altitude landscapes on granites and gneisses or on volcanic rocks as in the north of Mbulu district. These highlands occur at various altitudes ranging from 1,500 to 2,750 m above sea level. They are characterized by steep, rugged terrain with slopes generally in excess of 30%.

Isolated Hills and Inselbergs

These are isolated, small and scattered masses of land which rise to a height of 50 to 250 m above the surrounding landscapes. They are covered mainly by rock outcrops and shallow stony soils and have a sparse bushland. Hills and inselbergs, which are generally bare, occur widespread in the whole of Singida district.

Plateaux

Plateau surfaces at different levels in Mbulu district are a result of faulting resulting in downthrow and uplift of the old plateau surface which is mainly on gneiss. Two plateau levels are distinguished viz. the Nou plateau (altitude: 1,950 - 2,350) in the south-east and the Haidom-Endallah plateau (altitude: 1,700 - 1,950) in the south-west. This Mbulu plateau stretches southward into Kondoa

---

Mbuga is a term which describes flat, poorly drained inland drainage basins that do not have any outlet. The common vegetation on these landforms is grassland.

district, and extends from Bereko to Kondoa. It drops abruptly east by way of the Kunduse - Itololo - Kikore scarp into a broad plain (called the Masai steppe) at about 1,200 m, while the western part merges into an undulating to rolling landscape. The Mbulu plateau has been subdivided on the basis of degree of dissection into:

Dissected mountains and escarpments with elevation from 1,600 to 1,900 m. The dominant features in this part of the unit are very steep summits with slope gradients ranging from 25 to more 50 percent. This unit has mainly rock outcrops and shallow to moderately deep stony soils. There is a dense vegetation cover, mainly bushland or *Miombo* woodland on the deeper soils.

Rolling to undulating dissected plateau. This is the hilly part of the landscape, at lower elevations (1,400 to 1,600 m) with slope gradients ranging from 10 to 25 percent and is the western and southern extension of the Mbulu plateau. The soils are relatively deep, but stoniness also remains an important characteristic. This unit has undergone severe sheet and gully erosion as can be seen in the vicinity of Kondoa. The vegetation is a native bushland or an induced plant community which can be described as wooded and/or bushed grassland.

Undulating dissected plateau. This part consists of gently sloping ridges separated by deep drainage lines. Elevations range from 1,300 to 1,600 m.The dominant soils are deep, well-drained, reddish brown to yellowish red, sandy loam over sandy clay loam to sandy clays of moderate to high fertility. Induced open bushland cover a major part of the unit. In many parts of this unit, especially in Kolo and Mondo divisions, there is severe gully and sheet erosion.

Footslope of the escarpment. This unit refers to the land located below the sharp escarpment constituting the eastern boundary of the Mbulu plateau. It extends from the base of the escarpment to an extensive steppe in the east, with regular and gentle slopes, whose gradient gradually decreases towards the steppe. The unit has three types of soils: (a) red, reddish-brown or brown, well drained, sandy loam over sandy clay loam or sandy clay, with moderate fertility on the upper slopes; (b) brown and grey sandy soils with low fertility on the middle and some lower parts and (c) imperfectly drained, medium textured soils with moderate fertility in depressions. Some footslopes are affected by moderate gully and sheet erosion.

Plains

These are the gently undulating to flat (slopes less than 4%) landscapes. It includes the extensive flat alluvial and colluvial landscape of western Kondoa district at mean elevation of 1,200 m commonly known as the Masai steppe and flat landscape in the western part of the Singida district at a mean elevation of 1,300 m popularly known as the Mang'ati plain. For a major part, these plains belong to the Central East African Plateau. Mbuga are a common feature of the landscape. These are very large and flat depressions subject to seasonal flooding found to the east of the escarpment footslopes. The elevation is between 1,100 to 1,200 m. The streams draining the Mbulu Plateau empty into the mbuga. The soils developed on these clayey sediments are mostly Vertisols, characterized by deep and wide cracks in the dry season, a high chemical fertility and unfavourable physical properties. Secondary accumulation of calcium on the soil surface or throughout the profile is common; saline and/or sodic characteristics are less common.

Figure 2: Physiography of Mbulu, Kondoa and Singida districts

Three types of plains can be distinguished based on their origin. These are:

(a) plains formed on volcanic materials mainly in the north of the district. These are gently sloping landscapes that mark the outer reaches of the lava flows from the Ngorongoro volcanos;

(b) undulating parts of the peneplain which is formed on granitic basement rocks mainly in the southern parts towards Kondoa district; and

(c) extensive flat landscapes that are influenced by lacustrine and/or river processes. These occur mainly around Lake Eyasi in the west and the flood plains of the Barai river.

In the southern districts (Kondoa and Singida) the main underlying rocks consist mainly of grey-coloured synorogenic granites with well-developed granular texture. Soils are pale brown, yellowish-brown and grey, sand over loamy sand, sandy loam or sandy clay loam and have low fertility. Locally, red clayey soils occur on the weathering products of basic rocks. Bushland and thicket cover the greatest part of the plain.

Two types of soils are found on the high parts of the peneplains: (a) deep, well drained, friable, medium to fine-textured red soils developed on migmatitic gneiss and basic rocks and (b) moderately well drained, mainly coarse-textured brown soils often underlain by a plinthite layer. Extensive mbuga and other low-lying lands that have poor or very poor drainage conditions are a characteristic feature. The vegetation on these mbuga consists mainly of various types of grassland and bushland.

Major valleys

There is one main extensive trough bounded between two parallel blocks of highlands in Mbulu district. Its valley floor at an altitude of approximately 1,300 m. Large parts of this basin are water-logged for a considerable part of the year. In the basin rocks of the Basement complex are covered by lacustrine deposits and locally by alluvial and colluvial materials from the adjacent scarps and hill systems.

2.3 Climate

Due to the large differences in elevation there is a wide range of climatic conditions in the districts. Mbulu district has the largest variations in climatic conditions. The average annual rainfall in Mbulu District ranges from less than 400 mm, in the Eyasi Basin in the west, to over 1,200 mm in the mountainous area in the east, bordering the Manyara rift escarpment. The rainfall pattern is largely monomodal, i.e. with a single rainy season from November to April or May and dry conditions during the rest of the year. Table 1 shows the monthly average rainfall records for a number of stations in Mbulu, Kondoa and Singida districts. Except for the high mountainous parts of the districts, mainly in northern and south eastern Mbulu district, rainfall events are commonly torrential and of short duration. In the mountainous areas at high elevations the rain tends to fall as a drizzle and the rainfall events are of longer duration.

The mean annual temperature ranges from 15°C in Nou Forest to almost 24°C at the level of Lake Eyasi. The coldest month is July and the hottest month is March. About half of the district is warm or fairly warm, about one quarter is warm temperate, whereas the remaining part is cool temperate or fairly cool.

Kondoa district is characterized by an uneven and erratic distribution of rainfall both in time and space. The average annual rainfall in the district ranges from 400 to 900 mm. Rainfall is strongly controlled by topography. The Mbulu plateau receives the highest amount with an average annual precipitation between 700 and 900 mm. However, an absolute range of between 500 mm and 1,300 mm has been recorded. The footslopes of the escarpment have favourable rainfall conditions, due to their proximity to the Mbulu plateau. They have an average annual rainfall of 650 to 700 mm. The driest areas are the low-lying and flat Masai steppe in the eastern part with annual rainfall of less than 500 mm. Elsewhere in the surrounding plains the annual rainfall is between 500 and 600 mm and more erratic than in the highlands. Inadequate amounts and/or irregular distribution of the rainfall is the main hindrance to successful rainfed cultivation in the district.

The rainy season normally starts from the end of November to the end of April. The rainfall pattern is characterized by scattered, short but intense convection storms. The dry season lasts six to eight months from April to November.

Temperatures are highest just before the rains in November, averaging 22°C, and lowest in July, averaging 18°C. No records are available on wind speeds, but the months of June to about October are characterised by strong, dry monsoon winds which blow from the east.

In Singida district temperatures range from 15°C in July to about 30°C in October. Rainfall conditions are more or less the same in the district with a range of 600 to 700 mm per year. Potential evaporation is comparatively high, ranging between 2,000 and 2,200 mm per year and exceeds the mean monthly rainfall in each month.

Table 2 gives an overview of the (calculated) mean annual potential evaporation. It varies

between approximately 1,543 mm at Dongobesh in Mbulu and 2,345 mm at Singida. Figure 3 is a graphic presentation of the seasonal variations of rainfall in comparison to evaporation for a selected number of stations in the districts.

Table 1 Monthly average rainfall (mm) for some stations in Mbulu, Kondoa and Singida districts

DISTRICT	STATION	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	ANNUAL
Mbulu	Mbulumbulu	5	28	89	117	71	81	124	262	127	10	5	3	922
	Karatu	6	23	80	84	73	76	109	178	102	6	6	4	747
	Mbulu	4	26	82	122	104	87	150	164	65	4	2	2	812
	Tlawi	4	26	78	117	107	94	145	184	77	5	2	0	839
	Kainam	8	70	116	223	101	141	183	197	121	38	12	11	1221
	Nou	0	71	125	152	150	104	156	176	52	17	6	0	1009
	Dongobesh Mission	5	13	57	121	134	111	156	115	32	6	0	0	750
	Haidom	4	28	90	115	123	95	166	96	30	5	0	0	752
	Yaeda Chini	6	5	26	137	79	74	129	61	17	6	3	1	544
	Mang'ola	0	1	18	30	88	116	57	3	0	0	0	0	313
Singida	Singida D.O.	1	7	45	136	145	121	118	73	14	1	0	0	661
	St. Leos Mission	0	4	40	106	131	116	117	93	20	2	0	0	629
	Ushora Mission	0	0	25	172	118	63	102	194	5	0	0	0	679
	Wilwama Mission	1	2	11	185	107	137	73	48	19	0	1	1	585
	Mtinko	0	6	27	78	126	90	76	80	18	4	0	0	505
	Ilogero	0	4	39	130	133	107	96	67	12	0	0	0	588
	Mgori Mission	0	2	26	92	63	71	137	34	5	0	0	0	430
Kondoa	Mgimu P/School	11	5	50	107	110	99	84	91	7	0	0	0	564
	Mungaa P/School	0	7	56	95	78	69	129	58	17	1	0	0	510
	Ikungi	0	3	51	76	140	110	81	96	16	1	2	0	576

Sources: Magoggo *et al* (1994), Snowy Mt. Eng. Corp. (1978)

Table 2 Monthly average evaporation (mm) for some stations in Mbulu, Kondoa and Singida districts

DISTRICT	STATION	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	ANNUAL
Mbulu	Mbulumbulu	148	157	159	155	145	132	120	112	109	113	123	136	1609
	Endamaghai	153	162	165	161	151	139	127	118	115	118	128	140	1677
	Karatu Agricultural Office	152	161	163	159	150	137	125	116	114	118	128	140	1663
	Mbulu	148	156	158	153	143	131	118	110	108	113	123	136	1597
	Tlawi	145	153	154	149	139	126	114	106	105	110	120	133	1554
	Dongobesh Mission	144	152	153	148	138	125	113	105	104	109	120	132	1543
	Haidom	148	155	155	149	138	125	113	107	107	113	124	137	1571
Singida	Singida District Office	231	270	226	194	181	178	171	155	150	184	203	202	2345

Sources: Magoggo *et al* (1994); Snowy Mt. Eng. Corp. (1978)

Figure 3: Simple water balance diagrams at selected stations in Mbulu, Kondoa and Singida districts

2.4 Soils

Complete soil survey studies have not been carried out except in Mbulu district where the whole district has been mapped at the scale of 1:100,000. In addition to this reconnaissance scale map, detailed soil maps at 1:10,000 scale exist for ten villages in the central and northern parts of the district (Magoggo *et al*, 1994). In the other districts only scanty soil information is available. In these districts information on soils is derived mainly from the national soil map at 1:2 million scale (De Pauw, 1983) and the land resources survey study of Dodoma region (Agrar-Und HydroTechnik, 1984).

In this report a general description of the soils in the districts is based on the parent rocks found in the area. The soils are related to the underlying geological material. The geology of the three districts falls in two broad categories: the Mozambique belt and the Tanzania shield both of Pre-Cambrian origin (Agrar-Und HydroTechnik, 1984).

Rocks of the Mozambique belt are considered to belong to the Usagaran division of the Pre-Cambrian. The most common rock is migmatitic biotite/hornblende gneiss; quartzite, amphibolite, crystalline limestone, gabbro and dolerite are associated in various forms with the biotite/hornblende gneiss.

The predominance of biotite/hornblende gneiss and the occurrence of various basic or ultra-basic rocks has led to the development of red to yellowish-red, medium-textured soils of high to moderate fertility status and permeability.

The Tanzania shield consists of "synorogenic granites" which are commonly grey, coarse grained and foliated, composed of quartz, microcline and albite-oligoclase. They are the most extensive rocks on the peneplain and give rise to light coloured (grey, pale brown or yellowish-brown) coarse textured soils, with poor fertility.

In the mbuga, the soils are developed on the clayey sediments and are commonly characterized by deep, wide cracks in the dry season, a high chemical fertility and unfavourable physical properties. Secondary accumulation of calcium on the soil surface or throughout the profile is very common, saline and/or sodic characteristics are less common.

Volcanic rocks, mainly basalts of Neogene origin, occur in the northern part of Mbulu district. In minor parts of the districts soils are developed in superficial deposits, i.e. colluvial, fluvio-colluvial and lake deposits.

The major soils in the three districts can be generalised and described as follows:

Soils developed in volcanic materials

These are mainly very deep, well drained, dark reddish brown, highly fertile, friable and porous clays. These soils are mainly found in northern Mbulu district. The soils classify as Nitisols, Phaeozems, Cambisols and Luvisols). Associated with them are the relatively shallow Leptosols, Regosols and Cambisols. These very shallow to moderately deep soils are dark red, dark reddish brown or dark brown in colour and locally stony or gravelly. Soil surfaces are largely stony and rock outcrops are common. Topsoils are friable and generally have a moderate or moderately strong granular and subangular blocky structure. Where cultivated a 10 - 20 cm thick plough pan has developed immediately below the plough layer. This plough pan consists of coarse and very coarse structural elements.*Soils developed on granites and derived deposits*

Soils developed on granites are mainly shallow and moderately deep, (yellowish) brown or dark (greyish) brown sands, sandy loams or sandy clay loams and are gravelly to bouldery in places, commonly with stony and/or rocky surfaces. Plinthite layers are common in the subsoils. They classify as Leptosols and Regosols. On some parts the soils are deep or very deep, well drained, reddish sandy clay loams, sandy clays or clays that are largely gravelly; topsoils are sandy loams or sandy clay loams and they classify as Luvisols and Acrisols. These soils occur in large, gently undulating areas.

Soils developed on gneisses and derived deposits

The dominant soils are (very) shallow to moderately deep, brownish sandy loams, sandy clay loams and (sandy) clays, that are gravelly in places. Surfaces are dominantly stony and/or rocky. They are mainly located on steep slopes. They classify as Leptosols, Regosols and Cambisols.

Associated with them are (moderately) deep or very deep, well or somewhat excessively drained, dark reddish brown to dark red clay loams or (sandy) clays over deeply weathered, easily rootable, mica-rich saprolite or hard rock. They classify as Phaeozems, Alisols, Acrisols, Luvisols, Ferralsols and Cambisols.

Soils developed on schists and in derived deposits

Schists are confined to the southern-most part of Mbulu District, near Haidom and Haidarer,

and to the central part of the Kidero Highlands. Dominant soils are deep or very deep, well drained, moderately fertile, dark and dusky red or (dark) reddish brown clays which classify as Luvisols and Lixisols. They show little horizon colour differentiation.

Soils developed in fluvial and colluvial deposits

Colluvial deposits are on footslopes and in the plains. The soils are well drained, dark (reddish) brown or yellowish red sandy clay loams or clays and gravelly in places. They classify as Cambisols and Luvisols.

Soils developed in fluvial deposits comprise moderately well or well drained, dark (yellowish) brown, layered soils of variable texture (Fluvisols) and poorly or imperfectly drained, (very) dark (greyish) brown, calcareous, sodic, cracking clays (Vertisols).

Soils developed in lake deposits

Soils developed in lake deposits are invariably very deep and calcareous. Dominant soils are sodic clay loams and clays that are saline in most places. They are dark yellowish brown, very dark gray or black, (very) poorly or imperfectly drained and locally cracking in shallow depressions (Solonchaks, Solonetz, Vertisols). On higher grounds the soils are (moderately) well drained, pale or yellowish brown clay loams and clays (Regosols, Calcisols, Solonetz).

Table 3 gives a summary description of the main soils found in the districts. The spatial distribution of the main soils, taken from the generalized soil map (De Pauw, 1984) is shown in Figure 4.

Table 3 Description of the main soils in Mbulu, Kondoa and Singida districts

MAP UNIT	SOIL DESCRIPTION
EH1	Association of (a) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils (less than 25 cm deep) and (b) well drained, moderately deep to deep dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure and profile development low natural fertility and poor moisture storage properties due to tendency for surface sealing
EH2	Association of (a) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils and (b) moderately deep to deep, well drained dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure, low natural fertility and a tendency to surface sealing with inclusions of (c) deep, moderately well to imperfectly drained brown, pale yellow,light grey or white, mottled sands and loamy sands with poor structure and very low natural fertility
EPa1	Dominant soil is moderately deep to deep, well drained dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure, low natural fertility and a tendency to surface sealing; inclusions are (a) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils, (b) deep, moderately well to imperfectly drained brown, pale yellow,light grey or white, mottled sands and loamy sands with poor structure and very low natural fertility and (c) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil
EPa2	Dominant soil is moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil; inclusions are (a) moderately deep to deep, well drained dark reddish brown, yellowish red or red sandy clay loams and sandy clays with weak or moderate structure, low natural fertility and a tendency to surface sealing and (b) soils having high exchangeable sodium and/or soluble salts high enough to interfere with growth of most crops
NA9	Dominant soil is deep, well drained, dark brown loams, silty loams and clay loams with moderate structure and high natural fertility; inclusions are (a) shallow to deep, moderately well to imperfectly drained, usually calcareous black, dark grey or brown, cracking clays with good natural fertility and (b) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil
NP1	Dominant soil is deep, well drained, yellowish or reddish sandy clays with moderate to strong structure, usually with clay skins and moderate natural fertility; inclusions are (a) deep, well drained, reddish, friable or firm clay loams clays with strong structure and high natural fertility and (b) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils
NP2	Dominant soil is deep, well drained, yellowish or reddish sandy clays with moderate to strong structure, usually with clay skins and moderate natural fertility associated with complex of rock outcrops, surface ironstone, very stony soils and very shallow soils
NP3	Association of (a) deep, well drained, reddish, friable or firm clay loams clays with strong structure and high natural fertility and (d) deep, well drained, reddish, friable or firm clay loams clays with strong structure and high natural fertility (less organic matter than the associated soil)

NR1 Dominant soil is soils having high exchangeable sodium and/or soluble salts high enough to interfere with growth of most crops with inclusions of moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil

PH2 Dominant soil is a complex of rock outcrops, surface ironstone, very stony soils and very shallow soils and shallow to moderately deep, well drained, black or dark grey sandy loams to sandy clay loams with strong topsoil structure and high natural fertility associated with (a) moderately deep to deep, well drained red, yellowish red or orange sands and loamy sands with weak structure and low natural fertility and (b) moderately deep to deep, well drained, red or brown, often gravelly, sandy loams and sandy clay loams with weak structure and low natural fertility.

PH4 Dominant soil is moderately deep to deep, well drained,yellowish or reddish sandy clays to clays with weak structure and low to very low natural fertility associated with complex of rock outcrops, surface ironstone, very stony soils and very shallow soils

PPp2 Moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil with inclusions of shallow, imperfectly drained, dark grey or brown sands to sandy clays with hard pan within 50 cm from the soil surface, often calcareous and sodic in the subsoil, having moderate natural fertility

PPs3 Dominant soil is imperfectly drained, shallow, dark grey or brown sands to sandy clays with hard pan within 50 cm of the surface, often calcareous and usually sodic in the subsoil, with moderate natural fertility and poor moisture storage properties due to shallow depth of hard pan with associations of (a) well drained moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth with poor structure and profile development, very low natural fertility and moderate moisture storing properties, (b) moderately well to imperfectly drained, deep, brown pale yellow, light gray or white mottled sands and loamy sands with poor structure and profile development, very low natural fertility and poor moisture storing properties. Inclusions include (c) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils (less than 25 cm deep) and (d) moderately well to imperfectly drained, deep, dark cracking clays. usually calcareous, often overlying paler subsoil with ephemeral structure and good natural fertility. Often high ESP in the subsoil

PPw1 Dominant soil is moderately deep to deep, well drained red, yellowish red or orange sands and loamy sands with weak structure and low natural fertility associated with moderately deep to deep, well drained, red or brown, often gravelly, sandy loams and sandy clay loams with weak structure and low natural fertility and inclusions of (a) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils, deep, moderately well to imperfectly drained brown, pale yellow, light grey or white, mottled sands and loamy sands with poor structure and very low natural fertility, (b) deep, imperfectly to poorly drained, non-calcareous grey or brown sandy loams to sandy clays with strongly mottled and compact subsoils having moderate natural fertility and (c) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil

PPw2	Moderately deep to deep, well drained, yellowish or reddish sandy clays to clays with weak structure and low to very low natural fertility with inclusions of (a) complex of rock outcrops, surface ironstone, very stony soils and very shallow soils, (b) deep, imperfectly to poorly drained, non-calcareous grey or brown sandy loams to sandy clays with strongly mottled and compact subsoils having moderate natural fertility and (c) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil
PPw8	Deep, imperfectly to poorly drained, coarse almost bleached sands with poor natural fertility associated with moderately deep to deep, well drained red, yellowish red or orange sands and loamy sands with weak structure and low natural fertility and inclusions of (a) deep, imperfectly to poorly drained, non-calcareous grey or brown sandy loams to sandy clays with strongly mottled and compact subsoils having moderate natural fertility, (b) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil and shallow, imperfectly drained, dark grey or brown sands to sandy clays with hard pan within 50 cm from the soil surface, often calcareous and sodic in the subsoil, having moderate natural fertility
PSa	Dominant soil is shallow, imperfectly drained, dark grey or brown sands to sandy clays with hard pan within 50 cm from the soil surface, often calcareous and sodic in the subsoil, having moderate natural fertility with inclusions of (a) deep, moderately well to imperfectly drained brown, pale yellow,light grey or white, mottled sands and loamy sands with poor structure and very low natural fertility and (b) moderately deep, moderately well to imperfectly drained black, dark grey or brown, usually calcareous clays with ephemeral structure and good natural fertility but high ESP in the subsoil
RT	Undifferentiated rocky terrain (rocky hills, escarpments, slopes, canyons).

Source: De Pauw (1984)

2.5 Hydrology

Mbulu

Mbulu District covers parts of four major catchments. The main watershed is the south-north oriented line from Nou Forest via Tlawi-Silaloda to Aitcho (Marang Forest), further north following approximately the Mbulu-Karatu road, and from Karatu up to the Northern Highlands Forest Reserve. Streams flowing east from this divide drain to Lake Manyara (e.g. Magara, Endabash, Marera and Mto wa Simba Rivers), those flowing west drain into the Yaeda basin (e.g. Yaeda and Budahaya) and Eyasi basin (Laja and Barai Rivers).

The divide between the Yaeda and the Eyasi catchment areas follows the line from Aitcho to Masieda and then bends southwest to the Kidero Highlands. South of this line drainage is into Yaeda valley, north of it streams drain into Lake Eyasi directly or through the Barai.

In the south the line Nou-Muslur-Endalat-Harar forms the watershed. North of this line the area drains into Yaeda valley, south of it drainage is to the southwest through, in part, Dongobesh and Haidom Rivers. This southern part has few clear water courses and is characterized by extensive bottomlands (mbuga).

All perennial rivers in the district originate in the highland forests. The major ones are the Endabash, Yaeda, Magara and Dongobesh. Other important perennial rivers are the Mto wa Simba, Mbulumbulu and the Mamahau in the north, and some streams near Daudi, Mbulu and Kainam-Datlaa. Most other rivers are seasonal or ephemeral. The largest ones are the Barai, the Budahaya, the Endadubu, the Laja and the Marera. Perennial fresh water springs of importance are found at Quang'dend in the Mang'ola area; they feed Mang'ola River. A spring line along the north-east shore of Lake Eyasi yields water of variable salinity, but it is generally potable for livestock.

Lake Eyasi is a shallow saline (soda) lake that may dry up almost completely in the dry season; the area is then covered with a salt crust.

The lowest part of Yaeda Basin is largely waterlogged in the rainy season and for a considerable time thereafter. Apart from some permanent swampy areas it dries up during the dry season.

Kondoa

All rivers in the Kondoa district flow only during and immediately after the rainy season. During this time large amounts of sediments are transported and are successively deposited in the stream channels and frequently fill them up completely or spread into adjoining lands as fan-shaped accumulations. These vast sand rivers are typical in semi-arid areas suffering from soil erosion. There are two major rivers in the districts. The Bubu river drains the north-west part of the district discharging into the Bahi depression, an internal drainage basin. The Bubu flows in its northern course through the Mbulu plateau for much of the year but only small pools survive through the dry season in its southern course.

The Kinyasungwe river, having long sections forming more-or-less broad mbuga areas, is a seasonal river draining the north-eastern part of the district. It has been reported that with the effects of soil conservation measures being undertaken in the Kondoa Eroded Area (KEA) its sediment load is decreasing and the sand rivers are being stabilized. Lack of permanent water sources restricts the availability of large areas on the plains to farming activities and settlement.

Singida

There are no permanent rivers in Singida district. The main river ways, which contain water during parts of the rainy season only, are the Mponde and Bubu which flow into the Bahi swamp to the south in Dodoma region. However the district has a significant resource in terms of dams. According to the study by Snowy Mountains Engineering Corporation (1978) there are 16 springs and nine natural dams.

The major catchments in the study districts are shown in Figure 5.

Figure 4: Generalized soil map of Mbulu, Kondoa and Singida districts (after De Pauw, 1984)

2.6 Vegetation

The distribution of vegetation in the three districts reflects the wide range in climatic and soil conditions. The influence of climate on the vegetation is attributed to the effects of temperature, rainfall, and evaporation. The relation between soil conditions and the vegetation is governed by soil physical and/or soil chemical characteristics. Locally vegetation is strongly edaphologically determined, i.e. linked to the soil characteristics at the site and the topographical position, and thus often directly related to the availability of water.

Sites with shallow soils (< 50 cm deep) over indurated material usually support a dwarf shrub bushland or bushed grassland vegetation. Steeply sloping areas with stony soils and on many escarpments support a thick bushland vegetation.The steepest stony slopes have specifically xeromorphic plant species and a very sparse grass cover.

In this paper, the vegetation is described in Table 4 in relation to the identified agroecological zones (see also Table 5 and Figure 6).

2.7 Agro-ecological zoning

Agro-ecological zoning has been undertaken by Samki and Dewan (1984) and De Pauw (1984). De Pauw's agro-ecological zoning is the more detailed of the two. According to De Pauw, the three districts fall in agro-ecological zones E2, N1, N3, P1, P2, P9, P10 and P11 (Figure 6). The description of these agro-ecological zones is given in Tables 4 and 5.

Figure 5: Major watersheds in Mbulu, Kondoa and Singida districts (from Atlas of Tanzania*)*

Table 4 *General description and distribution of vegetation types in Mbulu, Kondoa and Singida districts*

AGRO-ECOLOGICAL ZONE	VEGETATION
N1	With annual rainfall between 600 - 1,000 mm, the vegetation comprises mainly *Combretum* bushland and (wooded) grassland with some thornbush. In the *Combretum* bushland (or wooded grassland) the trees are low (often less than 5 m) and have an open stand.
N3	This zone, characterized by sodic and saline flats, has predominantly *Sporobolus* grasslands associated with *Cyperus*, *Odyssea spp.*, *Suaeda monoica* and *Salvatore persica*. In places, on sand and sandy loams with shallow, mobile groundwater, *Borassus aethiopum* palm grassland *Acacia Xanthophloea* occurs together with Borassus palms. The grasses are mainly *Hyparrhenia spp*.
E2	The main vegetation is grassland. Other types of vegetation include *Acacia-Commiphora* bushland and thornbush and succulents in the driest areas.
P1	Due to human activities, much of the original vegetation in this zone has been reduced to an induced plant community which could be described as open bushland or wooded and bushed grassland, characterized by a mixture of scattered or grouped trees and bushes in a tall growth of grass. Grass fires are frequent so that fire tolerant tress have often replaced previous species. Of the latter, the baobab (*Andansonia digitata*) and the Umbrella Acacia (*Acacia tortilis*) are the most common.
P2	The natural vegetation in this zone is *Miombo* woodland composed of *Isoberlina* and *Brachystegia* species. It is to be found mainly on the summits of the mountains and hills; on the peneplain it remains mainly in forest reserves, indicating that this woodland was probably much more extensive in the past
P10	This zone is dominated by thicket vegetation interspersed with woodland and grassland.
P11	In this zone, which has many periodically waterlogged bottomlands, the vegetation is dominantly thicket and swamp grass vegetation; locally the grassland is bushed or wooded. Common trees are *A. Drepanolobium* (3 - 5 m high), *A. Seyal* (3 - 9 m high), *A. mbulensis* (up to 10 m high) and *A. gerrardii* (15 m). Areas that have permanent ground water support *Cordia-Maerua* groundwater forest or bushland i.e. a dry type of groundwater forest. Common species are *Acacia tortilis* (*umbrella acacia*), *Cordia gharaf, C. ovalis* and *Maerua triphylla*; *Acacia xanthophloea* (yellow fever tree) groundwater forests (or bushland) occur to a limited extent on concave lower slopes with imperfectly drained, mostly calcareous soils

Source: Magoggo *et al* (1994), Agrar-Und-Hydrotechnik (1984), De Pauw (1984)

Table 5 Characteristics of the agro-ecological zones in Mbulu, Kondoa and Singida districts

ZONE	CLIMATE	PHYSIOGRAPHY AND SOILS	VEGETATION / LAND USE
E1	Mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of less than 2 months per year; GP on-set dates: Feb	gently undulating to rolling plains and plateaux at 500 - 1,200 m asl; reddish sandy clay loams and sandy clays of semi-arid regions, developed on gneissic rocks	cultivated area: less than 1%; thicket and/or semi-desert vegetation (79%); wooded grassland (10%), grassland (5%), bushland and/or thicket (5%); estimated livestock carrying capacity: 1 LU/km²
E2	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 2 - 2½ months per year; GP on-set dates: Jan	gently undulating to rolling plains at 500 - 1,200 m asl; reddish sandy clay loams and sandy clays. In depression the dominant soils are the clayey cracking Vertisols.	cultivated area: 46%; wooded grassland (29%), thicket and/or semi-desert vegetation (19%), grassland (5%), woodland (2%); estimated livestock carrying capacity: 4 LU/km²
N1	mean annual temperatures: max 29-31, minimum 19 - 23; one dependable growing period of 3 - 5 months per year; GP on-set dates: Nov to Dec	rolling to hilly dissected plateau at 1,500 - 2,500 m asl; fertile, reddish clay loams and clays, soils developed on volcanic ash, lava and on gneiss	cultivated area: 38%; main vegetation type: wooded grassland (35%), complex of bushland and thicket (18%), forestry (8%); estimated livestock carrying capacity: 9 LU/km²
N3	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one short growing period (less than 3½ months) per year, adverse influenced by salt-affected soils	flat lacustrine plains at 900 - 1,100 m asl; extensive salt or soda flats, often inundated; salt-affected soils with good proportions of dark cracking clays in depressions	cultivated area: 10%; main vegetation types: grassland (50%), complex of thicket and semi-desert vegetation (30%), wooded grassland (10%); estimated livestock carrying capacity: 2 LU/km²
P1	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 2 - 2½ months per year; GP on-set dates: Jan	gently undulating plains at 1,100 - 1,300 m asl; low-fertility sands developed on granites	cultivated area: 24%; main vegetation types: wooded grassland (55%), woodland (14%); estimated livestock carrying capacity: 5 LU/km²

Table 5 (continued)

P2	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 3 - 3½ months per year; GP on-set dates: Dec	gently undulating plains at 1,100 - 1,300 m asl; well drained low-fertility (loamy) sands developed on granites and gneisses	cultivated area: 18%; main vegetation types: complex of bushland and thicket (32%), woodland (30%), complex of woodland and bushland (10%), wooded grassland (9%), estimated livestock carrying capacity: 1 LU/km²
P9	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 3 - 3½ months per year; GP on-set dates: Dec	gently undulating plains at 1,100 - 1,400 m asl; light and medium-textured heterogeneous soils formed in continental deposits overlying granites	cultivated area: 25%; main vegetation types: bushland (50%), wooded grassland (15%), grassland (5%); estimated livestock carrying capacity: 6 LU/km²
P10	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 3 - 3½ months per year; GP on-set dates: Dec	gently undulating plains at 1,100 - 1,400 m asl; light and medium-textured soils formed in continental deposits overlying granites	cultivated area: 2%; main vegetation types: thicket (61%), woodland (20%), wooded grassland (16%); estimated livestock carrying capacity: 2 LU/km²

P11	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; one DGP of 3 - 3½ months per year; GP conditions determined by duration and depth of flooding, water logging, run-off or run-on, presence or absence of salinity; GP on-set dates: Dec	flat plains at about 900 masl; predominantly hard and except in upland areas, alluvium with proportions of affected soils	cultivated area: (52%); main vegetation types: bushland/thicket (25%), swamp vegetation (11%), wooded grassland (8%); estimated livestock carrying capacity: 4 LU/km²
P12	mean annual temperatures: maximum 27 - 30, minimum 15 - 18; for upland areas one DGP of 3 - 3½ months per year. for most of the zone, however, growing period conditions are determined by duration and depth of flooding; GP on-set dates: Dec	flat, seasonally inundated lowland plains developed on young alluvium at 900 - 1,200 m asl; poorly drained dark cracking clays of topographic depressions with high natural fertility and moderate moisture storing properties	cultivated area: (56%); grassland (36%); thicket and/or semi-desert vegetation (8%)

Notes: DGP = Dependable Growing Period; GP = Growing Period; LU = Livestock Units

Source: De Pauw, 1984

Figure 6: Agro-ecological zones in Mbulu, Kondoa and Singida districts (after De Pauw, 1984)

Agro-ecological zone N1 is found in the eastern and the northern parts of Mbulu district, zone N3 occurs in the western part of Mbulu district around Lake Eyasi. The central and southern parts of Mbulu district and most of Singida district fall in agro-ecological zone P2. Zone E2 covers almost the eastern half of Kondoa district. The western part of Kondoa district and a minor part in the east of Singida district fall in agro-ecological zone P1. Agro-ecological zones P9, P10 and P11 cover small parts in the south of Kondoa and Singida districts.

2.8 Population and land use

Mbulu

According to Magoggo *et al* (1994), from the 1988 census Mbulu District had a total population of approximately 268,000 inhabitants. The average annual growth rate reported varies between 2.8 and 3.5%. Population densities are highest and settling is more concentrated in villages in the high-rainfall and high-altitude areas in the northern and central-eastern parts of the district. The inhabitants of these areas are largely agro-pastoralists. The somewhat drier and considerably less densely populated southern part of the district (with a population density of about 46 persons per km²) is inhabited by both agro-pastoralists and purely pastoralist. The very dry zone towards Lake Eyasi, comprising Mang'ola and Yaeda game controlled areas, is largely unpopulated (with an average density of approximately 6 persons per km²) and mainly a grazing ground for cattle and wildlife. There are small population centres near the irrigated Mang'ola and Yaeda Chini areas. A small, isolated group of Wahadzabe hunters-gatherers still persists in the remote Kidero Highlands.

These large differences in population distribution in Mbulu district are a consequence of the high variations in ecological conditions.

The distribution of different types of land use in the district is strongly influenced by climatic, soil and terrain conditions. At the general level areas with deep, relatively fertile, clayey soils and mean annual rainfall above 600 to 700 mm are characterized by permanent cultivation while in other areas shifting cultivation is the more dominant mode of crop production. In all parts of the district, land which is not used for cultivation is generally used for extensive grazing. The semi-arid and arid western half of the district is largely used as rangeland. Most annual crops are grown during the rainy season which starts in November or December.

A wide range of crops is grown in the district. In the north mainly maize, pigeon peas and beans are grown, commonly rotated with wheat or barley. In this part of the district the level of mechanization is relatively high: land preparation is mostly done by tractors or oxen.

In the major part of the district the dominant cropping system is a maize-beans-sorghum intercropping scheme.

Irrigated cultivation is practised to a limited extent (total irrigated area is approximately 3,000 ha). Main irrigated crops are onions and maize; others are beans, garlic, rice, *Citrus spp*., peanuts, vegetables and coffee.

Yields are variable: highest average maize grain yields (4.4 - 5.5 tonnes/ha) have been reported in the volcanic areas in the north while maize grain yields as low as 0.9 to 1.1 tonnes/ha are obtained on the poor granitic soils in the southern part of the district (Magoggo, *et al*).

Responses to applications of manure or chemical fertilizer on maize are reported throughout the district to be high. Manure is used throughout the cultivated areas in varying quantities depending on availability. On average manure is applied to each field once every three years. At present little chemical fertilizer is used in the district, mainly restricted to the northern part.

Livestock is an important aspect of agriculture in the district. Nearly three quarters of the district is almost exclusively used as rangeland. Zero-grazing is practised to a limited extent in the more affluent northern and eastern parts of the district.

In areas that have trees and shrubs of suitable quality charcoal production is an important activity.

Kondoa

Kondoa district has a population of 350,000 people, with an average density of 28 persons per km². The reported annual population growth rate is 2.2 per cent.

The highly populated areas are those with favourable climatic conditions for rainfed agriculture. The most densely populated areas are the undulating dissected plateau and the highlands, the footslopes of the escarpment and the peneplain on the road to Dodoma. Due to the favourable land characteristics and adequate rainfall conditions, the population is very high, so that the majority of the arable land is cultivated at present. The highest population is found in the so called Kondoa Eroded Area (KEA) in the vicinity of Kondoa town and in Bereko division to the north of KEA. The 1988 population census gives a total of 110,000 people within the enclosed area, or 100 person per km². Average family size is 5.2 (HADO, 1995).

The majority of the population in Kondoa are engaged in agriculture. Traditionally sorghum and bulrush millet have been the main staples. Of recent, in relatively high-rainfall areas maize and finger millet are grown. Surpluses, especially of maize and finger millet, are sold or used for local brewery. Major cash crops are maize, finger millet, groundnuts, sunflower and, to a lesser extent, castor seed, sesame and pulses. In some parts of the district activities of arable agriculture are low due to low soil fertility and the marginal rainfall conditions.

Inhabitants of Kondoa district, as is common in Central Tanzania, maintain livestock herds for social, capital and security purposes. Animal husbandry is mainly practised on uncultivated or fallow land and harvested fields, all of which may be grazed by anyone except where the fields are fenced. There is also much seasonal movement, with areas near the homesteads being used in the wet season; in the dry season the animals are taken to the mbuga and valleys, often a great distance from the homesteads, in search of pasture and water. The nomadic Masai herdsmen or the sedentary Rangi peasant mainly use the Masai steppe for unimproved grazing during the dry season. For much of the district grazing is limited due to tsetse infestation and forest reserves.

In areas that have trees and shrubs of suitable quality charcoal production is an important activity. Honey collection using traditional hives is an important activity in some woodland areas.

Singida

Data on land use in Singida district is scanty. However, based on rapid field observations the cropping patterns in the southern parts of Kondoa continue into this district. Smallholder cultivation of maize, sorghum, cassava and groundnuts is practised.

In areas that have trees and shrubs of suitable quality charcoal production is an important activity. Honey collection using traditional hives is an important activity in some woodland areas.

Table 6 summarizes population densities for areas of the districts for which data could be obtained Though the table does not give the complete coverage for the districts under this study, it serves to show the range in population distribution.

The economy of the study area is based on agriculture. In the northern high-altitude parts of Mbulu district on the Ngorongoro mountain slopes, medium to high input, mechanized agriculture is practised with wheat and beans as the main cash crop. In the rest of the districts the main economic activities are based on livestock. Though livestock are kept in large numbers in these districts, their contribution to the family wealth is mainly from the sale of milk. By tradition the mainly agro-pastoral farmers in these districts do not easily dispose of livestock for conversion to other forms of wealth.

The Ministry of Agriculture keeps records of areas under cultivation for the regions of Tanzania. These records give estimates of areas under cultivation for various crops and the yields for the particular crops. These data cannot be taken to be completely accurate on account of the way they are obtained. Moreover, they are compiled on a regional basis and a district breakdown can not be obtained. However, for purposes of indicating trends they can be used to give a general picture. Table 7 gives these statistics for the major crops in the three districts, i.e. maize and sorghum. The table also gives an estimate of livestock numbers according to the same source. Figures 6 is a graphical representation of this table.

Table 6 Population densities in some parts of Mbulu and Kondoa districts

DISTRICT	ZONE	AREA (sq. km.)	POPULATION (total)	DENSITY (pers./km²)
MBULU	Northern zone	102,185	86,878	85
	Eastern-central zone	147,480	97,177	66
	Southern zone	149,385	69,306	46
	Western zone	264,000	14,805	6

KONDOA	Kondoa Eroded Area	1,100	110,000	100

Sources: Magoggo *et al*, (1994), HADO (1995)

Table 7 Trends of areas under cultivation, production and livestock numbers in Arusha, Dodoma and Singida regions for the period 1981/82 to 1992/93 as an indication for Mbulu, Kondoa and Singida districts respectively

REGION	LAND USE	STATISTIC	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
Arusha	MAIZE	area ('000 ha)	115	115	103	101	111	156	156	161	153	128	137	113
(with		total production ('000 tons)	167	167	148	233	368	493	200	378	229	153	161	144
Mbulu)		yield (kg/ha)	1,455	1,455	1,441	2,299	3,330	3,162	1,282	2,357	1,494	1,194	1,177	1,278
	SORGHUM	area ('000 ha)	12	12	11	20	20	21	24	22	13	43	40	22
		total production ('000 tons)	8	8	6	9	9	14	18	18	32	33	37	24
		yield (kg/ha)	670	670	501	457	457	681	746	820	2,508	774	911	1,092
	LIVESTOCK	NUMBERS	2,169,455	2,219,352	2,270,397	1,855,880	1,855,880	1,855,880	1,855,880	1,855,880	1,855,880	1,855,880	1,855,880	1,855,880
Dodoma	MAIZE	area ('000 ha)	32	32	41	19	18	43	43	47	46	58	35	50
(with		total production ('000 tons)	37	37	32	22	25	61	59	61	36	54	21	33
Kondoa)		yield (kg/ha)	1,158	1,158	771	1,156	1,402	1,409	1,396	1,304	788	934	608	655
	SORGHUM	area ('000 ha)	29	29	64	60	46	45	48	49	78	181	144	108
		total production ('000 tons)	20	20	75	111	96	40	26	28	91	122	124	36
		yield (kg/ha)	681	681	1,172	1,865	2,081	880	545	562	1,159	671	861	333
	LIVESTOCK	NUMBERS	1,100,645	1,125,960	1,151,857	1,004,914	1,009,186	1,012,997	1,016,340	1,019,212	1,021,600	1,013,600	1,041,500	
Singida	MAIZE	area ('000 ha)	16	16	16	20	25	47	49	46				
(with		total production ('000 tons)	20	20	20	45	37	68	48	48				
Singida)		yield (kg/ha)	1,219	1,219	1,219	2,308	1,454	1,457	992	1,033				
	SORGHUM	area ('000 ha)	31	31	31	40	37	37	40	42	108	128	106	88
		total production ('000 tons)	27	27	27	52	36	40	34	36	84	120	106	121
		yield (kg/ha)	864	864	864	1309	979	1072	849	859	777	937	1000	1376
	LIVESTOCK	NUMBERS	1,769,708	1,810,411	1,182,050	1,882,081	939,822	939,822	939,822	939,822	939,822	939,822	939,822	939,822

Source: Ministry of Agriculture and Livestock development, BASIC DATA AGRICULTURAL AND LIVESTOCK SECTOR. Planning and Marketing Division. United Republic of Tanzania.

Figure 7: Trends of areas cultivated and production of major food crops in Arusha, Dodoma and Singida regions

Table 7 and Figure 7 show that over the period 1981/82 to 1992/93 areas under cultivation at the regional level have more or less remained constant. Land productivity, however, shows an erratic trend. The lack of a clear trend in productivity as shown in Figure 6 points to the fact that rainfall and its distribution has a dominant effect on land productivity in these areas. It is therefore difficult to make any conclusions about trends of soil productivity on the basis of this information.

3 ASSESSMENT OF LAND DEGRADATION

3.1 Causes of land degradation

Land degradation in Mbulu, Kondoa and Singida district has been triggered by human intervention on the natural setting. Thus the present status and rates of land degradation can be attributed to natural processes inherent in the physical setting of the area and the influence of human actions on them.

Considered on a short geological time scale, land surfaces in central Tanzania, under natural conditions, have reached a tentative equilibrium between formative and destructive forces. In parts where the net balance is in favour of the destructive processes, e.g. in the highlands and mountains, the erosive destruction due to high relief intensities is more than compensated for (in terms important to agricultural production) by higher rates of bio-chemical weathering and decomposition. The natural vegetation in these areas is mainly forest with a rich and permanent undergrowth which is commonly watered by laterally flowing streams. These areas are cooler and receive higher amounts of rainfall compared to the "lowlands". The highlands and mountain regions are either volcanic, e.g. northern Mbulu, or orogenic with metamorphic rocks, e.g. in the highlands of Kondoa district. Both the volcanic and metamorphic rocks weather easily, thus supplying a thick mantle of soil. the soils developed on the volcanic materials (mainly basalt) have high silt content and fragile structure. The metamorphic rocks found in the area are rich in white mica and the resultant soil has fragile structure. These soils are thus easily eroded when exposed to the agents of erosion. Thus the natural stability of the land resources in these highlands depends on the presence of an effective vegetation cover. Remnants of this ecological setting are to be found in protected forest areas of Marang and the extreme northern parts of Mbulu district.

Although the balance on the plains of central Tanzania, with much lower relief intensities, would appear to be in favour of the formative processes, these areas receive less rainfall. The rainy season is short, followed by a long period of dry, windy conditions. The rains fall in heavy torrents erratically spaced in the season. The relatively higher temperatures limit the thickness of the vegetation cover and restrict the type of vegetation to the more hardy species. During the dry season most of the undergrowth dies off and some of the trees shed leaves. At the beginning of the rainy season the undergrowth struggles to re-establish itself. The underlying rocks are the hard-weathering granites which form a rather poor mantle of soil. The soils developed on these rocks are mainly coarse textured, naturally low in nutrients and easily impoverished through leaching.

This is the natural setting of the lands in the three districts. Land degradation begins where human or animal activity disturbs the geological and biological balance between landscape setting, climate and vegetation cover. A change in any one of these three factors disturbs the fragile ecological balance. Since human and animal activities can hardly influence landscape and climatic attributes, the causes of land degradation are related to disturbances on the vegetation cover. The causes of land degradation in the three districts are related to major vegetation clearing events, neglect of the extension services and land use developments.

3.1.1 Natural processes

The natural processes which are responsible for land degradation in the three districts are rainfall intensity and distribution, terrain and intrinsic soil characteristics.

The rainfall distribution in the three districts is such that the rainy season is followed by a virtually uninterrupted dry season. During the dry season, which is typically of about six months, the soil dries out completely and most of the vegetation dies off. The soil surface is thus left unprotected against the erosive action of wind and the torrential rains at the start of the wet season.

The northern part of Mbulu district lies at the lower slopes and feet of the volcanoes of the Crater Highlands. Slopes are generally steep and long. Surface as well as lateral sub-surface water flow across large distances from the piedmonts to the almost flat peneplains is responsible for a major part of the gully erosion found in these areas.

In the hilly parts of the districts terrain is also a major contributing factor to erosion. This is the case in the eastern parts of Mbulu and the northern part of Kondoa district which has come to be known commonly as the Kondoa Eroded Area.

In many parts in the rest of the districts the landscape is characterized by many inselbergs. In

Singida district, for example, these inselbergs are devoid of any vegetation. Thus all the rain that falls on the areas covered by inselbergs runs off to the hill slopes, resulting in high run-off and gully formation.

Most of the soils found in the three districts have high erodibility due to their very nature. Being mostly coarse, loamy sand and sand loamy soils with low in organic matter they are prone to leaching, leading to fertility depletion. The reddish brown clays formed on volcanic material in the northern part of Mbulu district have high silt contents (silt being highly susceptible to transport) and fragile (unstable) structural aggregates (Magoggo, *et al*, 1994). Most of the other clayey soils have low organic matter which gives them weak structural aggregates.

3.1.2 Human intervention

Records show that in all the three districts large areas were partly or completely cleared in the period around 1940 for the purpose of eradicating tsetse and to open the areas for agriculture and settling. According to the Tanganyika tsetse annual reports (Banyikwa, et al., 1979) there had been extensive deforestation for tsetse control since 1927. By 1957, when it is claimed that tsetse flies had been eliminated, large areas had been affected by the deforestation programme in all the three districts. It is reasonable to suggest that land degradation, in terms of soil erosion, above the geological rates was initiated by these early clearing activities. As the population settled in the cleared areas the problems were accentuated.

The 19th century slave caravans, which passed through these semi-arid areas, demanded a lot of grain and fuelwood. This led to emergence of rather intensively cultivated areas and clearing of the natural *Miombo* woodland on marginal and fragile eco-systems without any conservation measures.

The central railway line passing through Dodoma was also responsible for deforestation. The locomotives, generators and wooden sleepers consumed large amount of wood, whereas the line itself attracted a large of population.

Important determinants of good land husbandry are to do with the socio-economic environment. For Tanzania many of these factors have a history which is well known and stems from its attempt at socialism in the early 1970. The socialist model of development as defined for Tanzania included strengthening of the powers of the ruling party to rule over all aspects of development. Since agriculture was defined to be the backbone of development, the party had a lot of influence in issues related to agricultural land use.

Following the repeated food shortages of the early 1970's the country devised a scheme for the improvement of agricultural production through the *Kilimo cha Kufa na Kupona* (Agriculture: a Matter of Life and Death) campaign. Naturally politicians were given the leading role in the whole issue of agricultural production. At some point during this campaign it appeared that all available land had to be cultivated and even people involved in other forms of production or provision of services such as shop owners were forced to go into cultivation. Naturally this meant that for those people who did not consider agriculture as their way of making a living invested only as much input as would save them from the wrath of the state laws. The effect of this was two-pronged: first, those people who were not by inclination farmers had more wealth than the subsistence farmers. Using the influence of their social and economic standing they had access to the best land, which, however, they had no interest in managing well. And for some time there was no stable ownership of land. Secondly, this naturally meant shortage of land for those people who really depended on it for their living. So, for quite a long time people lived in a general state of insecurity in terms of land ownership.

After the Arusha declaration, which set the country on the socialist development path, major changes were introduced. One of these was the infiltration of ruling party authority into all spheres of life. Since agriculture was and still is regarded as the backbone of the country's economy strengthening of the agricultural sector was at the top of the party's political agenda. Whatever the intentions of this dogma, it was construed by party leaders as assuming infallible roles even in specialist fields such as agricultural extension. Cases of conflicting extension messages between the extension technical staff and these party officials were not uncommon. Messages concerning application of fertilizers, for example were used by politicians to achieve fame whereby the tendency was to struggle for the highest rates of fertilizer consumption, regardless of the actual requirements as subscribed by scientific experimentation. Because the party was supreme over all else, this led to total submission on the part of the technocracy, demoralization of the extension staff and eventually contempt of technical advice on the part of political decision makers.

Even after the waning of this dogma, the agricultural extension service has been given only marginal importance by the Ministry. There are arguments in some quarters that the importance accorded to the agricultural sector by the national politics is more lip-service than actuality. Thus, even though the extension officers have to attend to large geographical coverage due to their limited number, they are commonly without means of transport.

The linkage of the extension staff with research is another factor which contributes to delayed or poor transfer of technology from research to farmers.

This problem is exacerbated by the fact that the majority of the people involved in agricultural land use in the three districts (and in the country as a whole) are what would be called "resource-poor" peasants with a very low level of formal education. Their access to both extension messages through the media and agricultural inputs is limited. The low level of resources available to people in rural areas means that most families can hardly produce enough food for their own subsistence. The family labor has to be divided between food and cash crop production, provision of water for the family and livestock, and activities related to the provision of shelter and fuel. Poverty exacerbates itself. Land which is poorly managed deteriorates rapidly, thereby producing even less and after some years its productivity falls far below the needs of the family depending on it and has to be abandoned. Thus until recently the dominant type of arable agriculture in many parts of the districts under study was shifting cultivation. This type of agriculture is still practised in some localities, although it has been replaced by rotational bush-fallowing and, in recent years, by increasing areas of permanent cultivation. This type of agriculture leads to massive deforestation, even in cases where the actual area under cultivation is not increasing. Some crops, particularly tobacco (which is grown in some parts of Singida), use a lot of forest for curing.

The present level of land husbandry in the three districts is greatly responsible for the high rates of land degradation. Chemical and organic fertilizers are either not applied at all or used in insufficient amounts. In many parts of the districts, flat cultivation is practised; where animal drought or tractor power is used this is commonly done down-slope. Both these methods are ineffective against soil erosion and may even accelerate the process. Protection measures, such as contours, terraces, etc are employed to a limited extent only and usually not done correctly. In areas where commercial agriculture is practised (e.g. northern Mbulu), the continuous use of heavy machinery has led to destruction of top-soil structure and formation of a plough pan.

What has been more responsible for land degradation is the effect of the wrongly-planned *Ujamaa* villages established in the mid-1970's (see Box 1). These resulted in high pressure on arable land, rangelands, forests and water resources.

Box 1: Villagization programme

In the early 1970's Tanzania launched an ambitious social and economic development programme which necessitated village re-settlement. This entailed moving people from their traditional settlement and agricultural lands to new areas. The primary objective of the programme was to settle people in villages of manageable size so that the government could easily provide the population with social amenities such as schools, safe water and medical facilities. The programme envisaged to increase agricultural production through collective ownership and management of farm land. This programme was extensive and covered all rural areas of the country except a few densely populated parts in the northern and southern highlands.

The objective of this programme, which came to be known as *villagization*, was social and economic development and its mechanism was totally oblivious of environmental concerns. The new village centres were located arbitrarily, frequently motivated by local politics at the village level. Since provision of social amenities was the primary objective, the villages were mostly located along roads. The result of all this was poor availability of arable land around the village centres. New farm lands were allocated and large areas were cleared both for agriculture and for construction of dwellings.

This programme was not preceded by an appropriate education campaign to introduce the planned new way of life; village plans were not based on scientific environmentally sound advice; it was not introduced in phases to provide an experience base; and there was no adequate impact assessment carried out. There was, expectedly, general resistance to the whole concept and the programme was run more or less by force. Socially the population did not feel they owned the land; issues of inheritance of land were unclear and remained precarious. Consequently the farms, which were collectively owned and managed and came to be viewed as public property, were poorly managed and commonly outright sabotaged.

The areas of the country most adversely affected by the *villagization* programme were the sparsely populated parts of the country and those zones which depended on perennial crops such as cashew and coconut. Mbulu, Kondoa and Singida are sparsely populated and agriculture is based on annual crops. This programme resulted in massive demoralization of the population and possibly set back the development of land husbandry techniques quite a bit. The low propensity of present-day youth to farm-based activities may have some of its roots to this era.

About a decade after the inception of the programme, when it became clear that it was not achieving its intended objectives, people spontaneously drifted back to the ways of cultivation and acquired new land. This also led to further clearing of new areas for cultivation close to the new settlements. In some areas the communal farm lands continued to exist officially, but were poorly managed and therefore prone to degradation.

Source: Kauzeni et al (1983)

As a result of implementation of the policies outlined above, land use technologies have not developed sufficiently to control land degradation. In most cases land use technologies in use are actually responsible for land degradation.

Until recently the dominant type of arable agriculture in many parts of the districts under study was shifting cultivation. This type of agriculture is still practised in some localities, although it has been replaced by rotational bush-fallowing and in recent years, by increasing areas of permanent cultivation. This type of agriculture leads to massive deforestation, even in cases where the actual area under cultivation is not increasing. Some crops, particularly tobacco (which is grown in some parts of Singida), uses a lot of forest for curing.

As a general rule land husbandry practices in the three districts are poor. Chemical and organic fertilizers are either not applied at all or used in insufficient amounts. In many parts of the districts, flat cultivation is practised; where animal drought or tractor power is used this is done down-slope. Both these methods are ineffective against soil erosion and may even accelerate the process. Protection measures, such as contours, terraces, etc are employed to a limited extent only and usually not done correctly. In areas where commercial agriculture is practised (e.g. northern Mbulu), the continuous use of heavy machinery has led to destruction of top-soil structure and formation of plough pans.

Accurate data on the size of the village herds are difficult to obtain. District estimates of livestock populations vary considerably. Based on data of the Livestock Census of 1984 as reported

by Magoggo *et al* (1994), stocking densities are calculated in Table 8. The livestock carrying capacity of Kondoa district is low in general. Similar data for the other two districts can not be obtained but according to the District Agricultural and Livestock Development Officer (DALDO) of Kondoa district (Pers. Comm.), research done so far by HADO has shown that the livestock number in the district is almost four times higher than the recommended carrying capacity. The Mbulu case can be taken as representative of stocking patterns in the three districts. The Mbulu data show considerable exceedance of the land carrying capacity. (Compare these stocking densities with estimated livestock carrying capacities reported in Table 4, pg 24'). These high stocking rates have led to depletion of vegetation especially during the dry season.

The contribution of stock routes to erosion is significant. Many spectacular forms of erosion in the districts are linked to the movement of livestock along specific routes. These routes are established because of the sparse distribution of watering points, a factor which results into heavy traffic of livestock along specific routes. Grazing and trampling destroy the vegetation cover along these routes. Initially narrow paths gradually merge to form broad, bare strips. Since these tracks mostly run along slopes, they readily develop into gullies. In this way stock trails have destroyed considerable areas within the district and have gullied the land to such an extent that alternative routes have to be used, thus extending gully damage into adjacent areas.

Annual uncontrolled bushfires are associated with crop cultivation since they are caused by farmers as part of land preparation, livestock land use where vegetation is burned for the purpose of inducing growth of new grasses and getting rid of ticks. In some cases fires are lit for hunting and honey-collection business.

In addition to the above, other types of use which lead to land degradation include wood cutting for fuelwood, construction and timber. Bad road engineering, mainly construction of roads downslope, has also caused many road side or mitre drains to develop into deep gullies. Land degradation due to urbanization in the districts is as yet not significant. The district headquarter towns and other shopping centres are small and their growth is insignificant.

Policies on tenure and correct use and management of land resources have, until the last few years, been absent or not enforced. For a major part land in Tanzania has been and continues to be freely accessible. lack of these policies contributes to poor resource management and land degradation. Changes in policies such as removal of subsidies on agricultural inputs such as fertilizers, on the other hand, have had a negative effect on agricultural production and land conservation.

Table 8 Average stocking densities in Mbulu district

ZONE	AREA (ha)	NO. OF LIVESTOCK UNITS	LIVESTOCK UNITS PER HA
Northern Mbulu	102,185	67,390	0.7
Central Mbulu	132,480	90,927	0.7
Eastern Mbulu	15,000	6,589	0.4
Southern Mbulu	149,385	100,023	0.7
Western Mbulu	264,000	74,528	0.3

Sources: Magoggo *et al*, 1994

3.2 Types and extent of land degradation

Land degradation is the reduction in the capacity of the land to produce benefits from a particular land use under a specified form of land management. It includes degradation of soil, vegetation and water resources. Land degradation has intricate relationships with the biophysical factors of land capability as well as socio-economic considerations in terms of the way the land is used and the benefits expected from the it.

3.2.1 Soil degradation

Soil degradation can be defined as the decline in the productive capacity of the soil as a result of changes in the hydrological, chemical and physical properties of the soil and associated soil erosion.

3.2.1.1 Soil erosion

The most evident form of land degradation in the three districts is soil erosion as expressed by rills and gullies of varying proportions. Gullies as deep as 3 meters which advance by several meters with each rainfall event have been recorded in all the three districts. Other forms of soil erosion are splash and sheet erosion. Soil erosion is widespread in all the districts. The main cause of erosion is

run-off water; erosion by wind, though present, is of less significance.

The soil survey study of Mbulu district (Magoggo *et al*, 1994) showed that 8.5% of the district was severely eroded, 20.1% moderately eroded, 55.2% slightly eroded and 16.2% was not affected by erosion. Gullies develop readily in the red and black soils of the volcanic area in the north, even on gentle slopes. Serious gullying also occurs on and at the base of denuded hills in the volcanic area. Gullies have also formed on footslopes and river plains below escarpments, on the steep slopes in the eastern high altitude areas where soils have developed on micaceous gneiss and gullies in bottomlands all over the district. Sheet erosion is present throughout the district, although this form of erosion is visually unobtrusive.

In Kondoa district the most severely affected area is the so-called Kondoa Eroded Area (KEA) where severe gully erosion has taken place. This area covers about 10% of the district. However, this is not the only area affected by erosion. Quantitative data on extent of soil erosion in both Kondoa and Singida districts are not available.

3.2.1.2 Physical degradation

The common form of physical soil degradation is destruction of soil structure. This is common in areas where there is continuous cultivation. It is more serious where this is done with tractors, e.g. the northern parts of Mbulu district. Another important cause of breakdown of structure is trampling by animals. Structure deterioration is manifested in these districts by plow pan formation and surface capping. Surface crusts are widely observed in all the three district. They are particularly common in cultivated and overgrazed areas which have sparse vegetation. The proneness of the soils of the districts to crust formation may be due to their low organic matter.

3.2.1.3 Chemical degradation

Chemical soil degradation refer to the change in chemical characteristics of the soil in terms of decreases plant nutrients and/or increased adverse chemical elements and salts. In the districts under this study the significant form of chemical degradation is depletion of plant nutrients.

It is difficult to find data to substantiate land degradation in the form of nutrient depletion. However, in all districts there are widespread reports of declining productivity. A part of this can certainly be blamed on nutrient depletion through mining by crops.

3.2.1.4 Biological degradation

Biological degradation is a decrease in soil biological activities which are essential for maintaining the physical structure of soils and their ability to supply essential chemical elements to plants. Data on soil biological activity are not available. However, bad agricultural practices such as burning and clearing of vegetation lead to further depletion of the intrinsically low organic matter and consequently reduction in biological activity.

3.2.2 Vegetation degradation

The decline in quantity and/or quality of the natural biomass, decrease in the vegetative ground cover and lowered capacity of self-regeneration are what constitute vegetation degradation.

Vegetation degradation is rampant in all three districts. The main causes of vegetation removal is through clearing, burning and by overgrazing. Quantitative data are not available.

3.2.3 Water degradation

Water degradation refers to the decline in quantity and/or quality of surface and ground water resources. This is caused by decreased infiltration of rain and resultant increased surface run-off which lead to increased risks of flooding, lower dry season stream flows and decreased ground water recharge.

Siltation of (both natural and constructed) open water surfaces is a common phenomenon. This problem is felt more in Singida district where these open water bodies are a source of fishing. The water reservoirs of economic importance in the district include the Miyanji, Mugoli and Masogweda fish dams. The Masogweda dam is a natural water body while the other two are constructed dams. Following vegetation degradation in catchment areas over the last years, all of these fishing reservoirs and others are now plagued with siltation problems which have led to some of them drying up completely during the dry season in some years. In Mbulu district spectacular siltation rates have been observed in the Mang'ola basin (Magoggo *et al*, 1994).

Broad sand rivers, which flow only for short periods during the rains, are a feature of the hydrology of the both Kondoa and Singida district and parts of Mbulu. The width of these sand rivers are reported to be increasing except in areas where conservation measures have been implemented.

4 IMPACT OF PAST AND ON-GOING PROGRAMMES FOR CONTROLLING LAND DEGRADATION

4.1 Pre-independence measures

Traditional techniques of soil conservation have been developed based on indigenous experience by land users in various environments in Tanzania (See Box 2). In some parts of the country these techniques and practices are well known and adhered to, indicating that they have been found to be successful by the local populations. This fact notwithstanding, very little research has been directed into these methods. The reason for this can be attributed in part to the training bias of researchers. Most Tanzanian researchers being western trained, tend to place more emphasis on methods developed in the western world. For this reason the spread of these methods has been limited.

Box 2: Traditional soil conservation methods

Traditional soil conservation methods have existed in several parts of the country even before German and British colonialist came to the then Tanganyika. These practices were developed by peasant farmers to prevent soil erosion and in most cases increasing organic matter in the soil. These practices involved various techniques which suited their local environment and farming systems. The most common cited example of indigenous soil conservation technique is the "Matengo pit" developed and practised by Matengo tribe in Ruvuma region, Mbinga district.

The Matengo pit system

The Matengo pit system aims at improving soil fertility by using decaying grass in the bunds. Erosion is controlled by trapping excess water in the pits (Stenhouse, 1944). The Matengo area is a highland with very steep hills and narrow valley bottoms. In this area even the steepest slopes are cultivated. Originally the Wamatengo occupied relatively flat lands. However, constant raiding by the Wangoni and the slave raiders forced them to occupy hilly lands from where they could defend themselves. Out of necessity the Matengo evolved a system of agriculture, including crop rotation, systematic following, and soil conservation measures, which enabled them to keep their restricted lands under constant cultivation, and to preserve their precious soil against erosion on the steepest hillsides. The method is as follows:

The grass is cut and laid in rows forming a grid. One set of rows roughly follows the contour, and the other set is at right-angles to the first set. The rows are 7 to 10 feet apart, depending on the amount of grass to be covered, and on the depth of fertile soil with which to cover it. the soil in the squares is dug out and pulled on top of the rows of grass. Digging continues until the subsoil is exposed in the centre of each square. The pits are 4 to 5 feet across and so are the soil beds. Up to a square yard of subsoil is exposed in the bottom of each pit. Storm drains are not made if a hillside is cultivated by this method right up to the top, but where the hilltop cannot be cultivated, a storm drain is usually made above the highest cultivated field.

Maize is planted in short lines which tend to be radial from the pits. The lines are about one yard apart and with single seeds spaced at about one foot in lines. The maize is nearly always planted as a pure crop. On a second field similarly cultivated, beans and peas are planted as pure crops at a spacing of 4 to 6 inches in each direction. This gives a very dense stand of these crops.

Clean weeding is the rule. Weeds are pulled out and thrown into the pits where they form a valuable compost with accumulating silt. At the end of the season, crop residues are also deposited in the pits, the old soil beds are split and the new beds formed over the old pits. The new pits occupy the place where the old beds intersected.

The rotation adopted is the simple one of alternating a grain crop (maize) with a leguminous crop (beans and peas). This alternation is absolutely regular and is carried on until the soil requires to be fallowed. The pits of the old cultivation remains and continue to function as an effective check to erosion on the followed land. The fallowing is systematic but not regular, because it depends on the relative fertility of the other fields at the disposal of the farmer. Careful farmers keep their land under cultivation for eight to ten years before fallowing is necessary.

dangerous accumulation of water is possible, as any overflow from one pit is trapped by the next. Even heavy downpours are fully trapped and the water gradually sinks into the subsoil, so that even the smaller streams starting high on the hills do not dry up in the dry season. However, the most important advantage of this system is that shifting cultivation is unknown to the old generation of Wamatengo.

Now that there is no shortage of land, younger generation of Wamatengo are moving outwards from the old settlements and adopting lazier methods of cultivation. They are losing their grip on a valuable heritage. The introduction of cash crops is accelerating this deplorable breakdown, to the old system of producing the traditional food crops.

Source: A.S. Sternhouse, 1944.

Box 2 : continued

The rotation of crops, the fallowing, and the returning of all weeds and crop residues to the soil form good agricultural practices. The pit system of cultivation is very effective as a check to erosion. The technique is simple and no instruments are required except for a billhook with which to cut the grass, and an ordinary hoe with which to do the digging. No dangerous accumulation of water is possible, as any overflow from one pit is trapped by the next. Even heavy downpours are fully trapped and the water gradually sinks into the subsoil, so that even the smaller streams starting high on the hills do not dry up in the dry season. However, the most important advantage of this system is that shifting cultivation is unknown to the old generation of Wamatengo.

Now that there is no shortage of land, younger generation of Wamatengo are moving outwards from the old settlements and adopting lazier methods of cultivation. They are losing their grip on a valuable heritage. The introduction of cash crops is accelerating this deplorable breakdown, to the old system of producing the traditional food crops.

Source: A.S. Sternhouse (1944)

Mound Cultivation in Ufipa, Tanganyika

Ufipa district in south-west Tanganyika, consist, for the most part, of a plateau (altitude 5,000-7,000 feet), covered with tall grass and with only scattered trees, apart from a few patches of hill forest. Each dry season the pastoralists burn off this tall grass over nearly all the district, presumably to provide new grass for their cattle and to reduce ticks. Agriculturally the Wafipa are very primitive. They do not put manure on their fields, unless ordered to do so, on the grounds that they have always in the past managed to grow enough food to survive without using manure. The land would become very deficient in humus were it not for the system of mound cultivation practised by the Wafipa. The method of cultivation in the plateau generally follows a rotation starting with mounds, followed by flat cultivation, followed by rough mound, followed again by flat cultivation and then by ridge cultivation.

The rotation begins during February to April when the grass is cut and put in small heaps. The sod is then cut by hoe and piled in neat circular mound of up turned divots over the heaps of grass, each mound being about 3 feet in diameter and 2-2 and half feet high. The distance between one mound and the next is 1-2 feet. the customary crop on the mounds is beans, though sometimes cassava and sweet potatoes and rarely chick-peak and wheat are planted. Beans are harvested in June and July.

Weeding begins in October and the weeds are thrown on the mounds. In late November or in December,when the rains have begun, the mounds are broken down and spread over the field. By this time the grass and turf are rotted down. When the soil is damp enough, the field is planted on the flat with finger millet and sometimes maize. Alternatively, seed may be broadcast and the mounds spread over them. If cassava is planted, it is always put at the base of the mound and left in the field when the mound is broken down, so that it continues to grow among the finger millet and maize.

By June or July, all the millet and maize has been harvested and the fields are left till November when the people make small rough mounds covering heaps of weeds and crop residues. These mounds are left till the following January when they are broken and spread, and fields again planted with finger millet (rarely maize) which is harvested about the following June, and the field is left in its flat condition.

In the following December the field is ridged and planted with maize interplanted with

Source: M. Lunan, 1950.

Box 2 : continued

groundnuts, beans or bambara nuts, or occasionally left and planted with groundnuts alone. This may be repeated for several years until the soil is exhausted and then it reverts to grass and weed fallow.

If bushes or small trees are encountered in the field during the first mound cultivation they are cut down, put in a heap, and surrounded by a ring mound. If there are large trees, the branches are cut, heaped around the trunks and surrounded by a ring mound. The branches in a heap are burned at the end of the dry season and pumpkins customarily planted in the rings. The cultivation rotation then goes on as described above, but there is no methodical spreading of the ashes over the field, and there is no burning of trees outside the cultivated area to collect the ashes.

Source: M. Lunan (1950)

Mound cultivation is a combination of composting in situ and crop rotation, and, although no plant foods are added to the soil from outside the field, wastage of plant residues is avoided. This seems to be a simple and efficient method of conserving the organic matter in the soil, and it must produce a friable and absorbent topsoil. Since the mounds are about three feet in diameter, and only one to two feet apart, the dressing of composted material after breaking down the mounds must be very many tons per acre. the result f this is that the field may be cropped for several years before its productivity drops below an economic level.

It is interesting to note that the Ufipa tribe plant legumes on the mounds while they are decomposing, thereby making use of the soil at a time when plants would be liable to nitrogen starvation because of the demand for nitrogen by the decomposing organic matter. In the later stages of the rotation, too, legumes play an important part in mixed cropping, and it is clear that these people have discovered for themselves the importance of nitrogen in the crop cycle.

One of the difficulties with grass leys and green manuring in the tropics is the fact that the organic matter is frequently ploughed in about the end of the rainy season, and by opening the soil there is a tendency for it to dry out rapidly and to leave insufficient moisture for decomposition of the plant material.

Soil fertility studies in the tropics have tended to be based on the adoption of methods which have been successful in temperate climates, but here we have an opportunity of improving on a native practice by mechanizing it, if that is possible, and by applying fertilizer to the decomposing organic matter.

Source: Duthie (1950)

3.3.1.3 The Erock System of Soil Conservation

The Erok people of Mbulu district inhabit the mountainous country which rises between the Great Rift Valley and the Yaida and Eyasi depressions.

Under pressure from the Masai on the northern flank and with treacherous neighbours in the Tatoga peoples, Erok were, for sometime before the advent of the Europeans, confined to a limited area which they had carved out of the forest clad mountains. Like other tribes in similar circumstances, such as the Wamatengo and Wakara, they evolved a system of soil conservation.

Land for cultivation is whenever possible selected in the steep and narrow valleys. The fields are of small size, generally about one quarter of an acre and are made to occupy a single "terrace". These terraces are in early stages protected by a storm drain above the field and cultivation is designed to work the soil away from the slope until it is level. Owing to the steepness of the slopes and the adjustment of a field to each terrace, the vertical interval between the terrace edges is considerable; for this reason a perfectly level terrace is only seen in favourable situations. The climate provides an all-the-year round growing season and enables the cultivator to protect his terrace edges with grass and crops, as a result the usual deterioration of the terrace edge so commonly seen in drier situations does not occur.

Box 2 : continued

similar circumstances, such as the Wamatengo and Wakara, they evolved a system of soil conservation.

Land for cultivation is whenever possible selected in the steep and narrow valleys. The fields are of small size, generally about one quarter of an acre and are made to occupy a single "terrace". These terraces are in early stages protected by a storm drain above the field and cultivation is designed to work the soil away from the slope until it is level. Owing to the steepness of the slopes and the adjustment of a field to each terrace, the vertical interval between the terrace edges is considerable; for this reason a perfectly level terrace is only seen in favourable situations. The climate provides an all-the-year round growing season and enables the cultivator to protect his terrace edges with grass and crops, as a result the usual deterioration of the terrace edge so commonly seen in drier situations does not occur.

The formation of a terrace is a gradual process. After the construction of a storm drain, followed by pulling down of soil from a face, say three feet deep, and the provision of a Kikuyu grass verge on the edge of the terrace, cultivation will proceed.

Old fallow land or new land is deeply cultivated with a long digging pole which turns over the sod, leaving a very deep broken surface to weather in the cold season. With the advent of the true short rains season and higher temperatures this land will be contour planted between small ridges with say maize, while a strip of pumpkin is established on the lower side of the "terrace" to afford additional protection. At hoeing time the ridges are commonly reinforced according to the season and the amount of rubbish which may have been buried. In some cases the ridges may be split back to earth-up crops, but still naturally retain their soil and water conserving principle.

Important practices affecting the terrace occur when the next planting takes place. Assuming that a short rains crop has been removed in May, the cultivator's next work is to chop out the stover and lay it evenly over the field.

The value of this thatch in conserving moisture is understood by the Erok people who could well do with such stover as forage for cattle from his overstocked grazing. When cultivation takes place this stover is drawn into lines starting at the lower side of the terrace, then ridged over and the seed planted at once between the ridges; in the process of ridging the soil is pulled downhill and gradually season by season the terrace is formed.

To those experienced in the dangers of green manuring under dry conditions it seems remarkable that a heavy stand of dry stover can be so disposed of after the heavy rains without any noticeable effect on the following crop. Too often fresh weed growth is burned or eaten off in the field owing to difficulties of disposal in the soil; this Erok method of sowing a listed crop between the ridges carrying rotting crop residues is a development which would well repay investigation elsewhere under varying conditions of rainfall.

Soil movement within the plot under this system is reduced to a minimum while at the same time loss from the terrace is adequately controlled. Wash from land surrounding the cultivated terrace is, in the old Erok country,of little danger on account of the presence of a fair grass cover, while depth of the soil assists in the formation of the terraces, many of which have faces twelve feet deep.

Source: Hartley (1938)

These few records of traditional soil conservation techniques were written between 1930's and 1950's by the British. These methods, besides being very effective at controlling soil erosion, use what is available on the farm to improve the organic matter of the soil thereby reducing the use of artificial fertilizers. They are not expensive because simple tools are used which are readily available and affordable to the farmers. Intercropping, crop rotations and fallowing future prominently in these traditional methods.

Unfortunately after independence, very few studies have been undertaken to identify other traditional soil conservation techniques. Scientists have completely ignored research on crop rotations, intercropping and fallowing which are the methods commonly used by small scale farmers in the country. In Tanzania today research is largely concentrated on monoculture and on rates and methods of application of artificial fertilizers. This is not only alien to most farmers, but also does not auger well

with the current situation whereby there is withdrawal of subsidies, high prices, poor availability and distribution of fertilizers.

J.R. Soper in 1956 had this to say, "The older men have been working the land for many years and they have acquired valuable experience which is often overlooked. In some parts of East Africa this sort of information has been collected and is written up in district books. Let use it and not leave it to sink into oblivion. Where no records exist, the collection of this data should have a high priority".

In the late 1920's soil erosion became an issue of concern among the colonial administrators. In 1926 a Native Authority ordinance was introduced. The ordinance had granted Native Authorities power to control factors of land degradation. These included protection of cultivated slopes and water courses, the control of burning grass, the introduction of cover crops and the closure of steep slopes to cultivation. In 1929 an advisory committee on soil erosion was set up. It met for the first time in 1931. The committee concluded that in the absence of enough funds one had to rely on persuading people to adapt improved land use methods rather than carry out extensive conservation schemes. This was then the policy and practice of the 1930's and early 1940's (Christianson, 1981).

The anti-erosion programme carried out involved reduction of stock numbers, contour ridging of cultivated land, contour banking of uncultivated land, gully control, reafforestation and in some cases re-settlement. The anti-erosion measure were closely linked to demonstrations on use of farm yard manures and to range control and anti-famine programmes.

In 1940's and early 1950's construction of contour bunds started in wheat schemes in Mbulu district. These soil conservation programmes expanded into the central province (Kondoa and Singida districts were part of the central province) where it was estimated that over 2,000 miles needed banking. Thus, 143 miles of contour banks were constructed in the Central province in 1949,557 miles were added in 1950, and 660 miles were completed in 1953. These banks were constructed by the local population under the supervision of staff of the department of Agriculture (Christianson, 1981). In addition, water supplies were constructed with a view of opening up new pasture areas, controlling stock movements and encouraging people to relocate to relieve overgrazed areas.

Generally, most of measures were not successful. Some of the reasons for the failure of pre-independence conservation measures are:

- The colonial administration did not appreciate the fact that some groups had adopted their own agricultural systems which could control soil erosion. The introduced conservation measures were foreign and difficult to adapt. Some of them were too labour intensive to be easily accepted.

- Orders and rules on soil conservation applied to indigenous people only; so the local people felt they were being discriminated against.

- Depopulation measures meant that arable farmers were forsaking their inherited land rights.

- Sometimes conservation works were carried out as punishment for disobeying local chiefs or poll tax evasion.

- Colonial officers used force or coercion to implement those conservation measures.

4.2 Post-independence measures

The early post-independence period saw a breakdown of soil conservation programme initiated during the colonial era. This breakdown of the soil conservation schemes coupled with the natural increase in human and livestock populations, accelerated soil and other land degradation process in the country. Such measures like prohibition of cultivation on steep slopes, contour farming, control of timber exploitation, control of bush-fires were no longer being strictly observed during the early post-independence period. Some of these conservation measures had become quite unpopular to the local people. Some of the pre-independence politicians capitalized on this unpopularity of the conservation measures and denounced conservation measures on the basis that they were colonial.

Although the three districts have similar land degradation problems, post-independence efforts which have been tried in controlling it are worth looking at separately. Each district has applied its own approach with varying degrees of success and sustainability.

Mbulu district has the advantage of having a set of soil maps for selected villages at appropriate scale and a district soil map at 1:100,000 as well as comprehensive land evaluation reports. These soil survey and land evaluation studies were commissioned following the recognition by the district authorities of the importance of knowledge on land resources in combating land degradation. The district has highly contrasting agro-ecological environments. Of the three districts it is the only one with large, continuous tracts of land which are cultivated with limited and controlled grazing activities.

These are to be found mainly on the footridges in the north and in the other high-altitude areas in the south east. The western part of the district is mainly pastoralist.

Attempts to revive the construction of contour bunds were undertaken mainly by the Regional Integrated Development Programme (RIDEP) in the early 1980s. In the RIDEP programme for erosion control rows of sisal plants and *Euphorbia spp*. were established along the gully-heads especially in the extensively gullied Bashay-Changarawe area. At present land conservation activities are undertaken by the District Council in an integrated manner with staff from agriculture, land use planning, forestry and livestock. Most soil conservation practices have been carried out in relation to arable agriculture and are mainly restricted to the northern part of the district. They chiefly comprise the construction of contour bunds that are left bare or, in few places, are planted with sisal or trees. Strip-cropping is practised on a limited scale on the footridges. On the wheat-growing estates in the north, contour bunds are relatively broad, permanent and mostly grassed. These efforts include village legislation on soil conservation. Common legislation concerns the closure of steep denuded hills for grazing and cultivation in order to restore the vegetation cover. By-laws have been set up in some villages (e.g. Gunyoda and Mbulumbulu) banning grazing and cultivation in other areas that have been affected by serious gully erosion. Locally reafforestation of hill slopes (e.g. in Rhotia, Giekurum/Arusha, Kilima Tembo) is carried out.

Following implementation of the recommendations of the soil survey reports (which mostly focused on improvement and extension of existing measures) successes have been reported by farmers. Most farmers who claim to implement the recommended erosion control measures also assert reduction in soil loss and increases in land productivity over surprisingly short periods.

Kondoa district is renowned for the most drastic soil conservation programme ever undertaken in Tanzania. This programme is being carried out by the "Hifadhi Ardhi Dodoma" - HADO (Dodoma Soil Conservation) project. In 1972 the former President J.K. Nyerere made a visit to the district. After seeing some of the most degraded areas of the district he directed the Ministry of Tourism, Natural Resources and Environment (MTNRE) to prepare a programme for conservation of the whole Dodoma region. The project wad initiated in 1973 after the government had approved a development plan called "Afforestation and Soil Conservation Master Plan - 1972/73-1981/82, Dodoma Region" (Noren, 1995). The project is under the Ministry of Tourism, natural Resources and Environment, being implemented by the Forest and Beekeeping Division (FBD).

Although the project covers the whole region, much of the resources (about 60%) are concentrated to Kondoa district. The project manager is stationed at the project headquarters in Kondoa. Within Kondoa district the project coverage is restricted to the Kondoa-Irangi Highlands popularly referred to as the Kondoa Eroded Area (KEA). The Kondoa Eroded Area covers about 1,256 km² about 10% of the district and has a population of about 110,000 people.

Box 3: The HADO Project

Since its inception HADO has received support from SIDA as part of the Swedish Support to the Forestry sector of Tanzania. SIDA support has covered most of the development costs while the government of Tanzania contributions have covered recurrent costs, mainly salaries of permanently employed staff. The contribution of SIDA to the project from 1973/74-1993/94 is about SEK 20.6 mill. while that of Tanzania is estimated at SEK 0.4 mill. SIDA funding will end in December 1996. Another contribution to HADO project, though not directly connected with HADO expenditure, came through SAREC research funding. SAREC spent a total of SEK 12 mill. on research (Noren, 1995).

The overall goal of HADO was and is still to prevent and arrest the advance of soil erosion and where technically and economically possible to reclaim the depleted land for productive use. The main implementing strategies have been:

- construction of contour bunds to reduce the speed of surface run-off. To protect the bunds from breaching they have been stabilized by means of vegetative techniques;
- in gully-reclamation, earthen and stone check-dams have been constructed to reduced the intensity of discharge, trap sediments, increase percolation and improve soil moisture conditions in order to facilitate establishment of plant cover in the gullies. Planning of grass on the bottom of gullies has also been found to be an efficient means of trapping sediment and reducing water speed;
- in some gullies peripheral live fences of sisal have been planted to check run-off from the sides and to prevent livestock from entering the protected gullies;
- quickly sprouting vegetation has also been used to trap sediments moving across alluvia fans as a result of torrential rains.

To get a clear picture of HADO activities it convenient to break down the period into three phases.

Phase I: Covered the period between 1973/74 and 1978/79. The objectives during this period were:

- to ensure that people in Dodoma region are self sufficient in wood requirements;
- to ensure communal wood growing schemes in the region;
- to promote Ujamaa and communal bee-keeping activities;
- to encourage the establishment of shelter belts/windbreaks, shades and fruit tree growing;
- to conserve soil and water conservation and to reclaim depleted lands.

During this phase the following activities were undertaken:

1. Reclamation of land - under this activity the following steps were taken:

- removing of livestock and people from a non-agriculture land;
- construction of contour bunds, 10-500m long ridges perpendicular to the slopes to catch and infiltrate the water running along the slopes;
- planning of vegetation such as Agave, Eucalyptus, Leucena etc. on top of these contour bunds.

Earlier during the project construction of contour bunds was done using coiler tractors. However, these were later replaced by paid manual labourers.

It is reported that after 6 years of work, 7,300 ha of the 125,600 ha wide of Eroded Area had been bunded and closed to grain (Noren, 1995).

2. Nurseries: Central nurseries had been established to supply seedling for reforestation activities. The

Box 3 : continued

- construction of contour bunds, 10-500 m long ridges perpendicular to the slopes to catch and infiltrate the water running along the slopes;

- planning of vegetation such as Agave, Eucalyptus, Leucaena etc. on top of these contour bunds.

Earlier during the project construction of contour bunds was done using coiler tractors. However, these were later replaced by paid manual labourers.

It is reported that after 6 years of work, 7,300 ha of the 125,600 ha wide of Eroded Area had been bunded and closed to grain (Noren, 1995).

2. Nurseries: Central nurseries had been established to supply seedling for reforestation activities. The types of seedlings raised varied from fruit, ornamental and timber trees. The seedlings were given freely to individuals, schools, villages and some were planted in HADO demonstration woodlot. It is estimated that up to 1978/79 some 3 million seedlings had been raised in Kondoa. HADO also promoted the establishment of nurseries in schools and villages with technical support (advice and training on nursery management) and material assistance (provision of seeds and polythene planting tubes).

3. Demonstration woodlot: The main of these demonstration woodlot was to popularize tree planting. By the end of this phase about 1,000 ha of woodlot were planted in Kondoa district. Over 80% were for fuelwood/poles, 20% for timber. Survival rates has been put at 50-80%.

One of the biggest mistake done during this phase was the failure of HADO to identify and map types, extent and severity of land degradation in the Kondoa Eroded Area. HADO also failed to take into account the land resource base and the socio-economic situation of the area. This led to HADO not being able to prepare action plan of priority areas to be treated. According to Noren, areas where erosion is "acceptable" and where few people live have got the general priority of action. As such badly eroded wastelands were left with no further action.

Phase II: 1979/80-1985/86: It is during this phase that HADO became known and popular nationally and internationally following the complete expulsion of all livestock from the Kondoa Eroded Area. Historical background is necessary to understand reasons for this drastic action.

Prior to the establishment of HADO and in response to the intensification of land degradation in Kondoa district, in 1968 the Kondoa District Council had issued a by-law prohibiting grazing, cultivation and felling of trees without special permission in the Kondoa Eroded Area. After HADO had been established some progress had been achieved, although at a very slow pace. According to HADO reports by June 1979 only 7,307 ha within the KEA had been bunded and effectively closed to grazing. This corresponds to an average rate of rehabilitating 1,200 ha/year. At that rate it would require more than 100 years for HADO to rehabilitate the whole area.
The make matters worse, livestock was eating the vegetation which was coming up and trampling on the structures which had been erected, thereby reducing the small progress which was made. The only solution HADO came up with was total destocking of KEA. The solution was presented to the ruling party, "Chama Cha Mapinduzi" (CCM) in April, 1979. 14th, 1979 the Kondoa District Executive Committee of CCM, chaired by the District Party Chairman and attended by village or branch chairmen and secretaries among others, took the following decision:

"By 31st october 1979 all livestock, i.e. cattle, goats, sheep and donkey/mules should be out of KEA. The party and the government should deliver this massage to the villages and give all livestock owners a six months period of grace to prepare for the move". To prevent any doubts as to the mandate and authensity of the district decision to destock the KEA, both the Dodoma Regional Party Secretary and the then Minister for Natural Resources and Tourism, toured the area addressing meetings in support of the decision.

After 31st October, 1979 the whole area was destocked. The number of animals moved out of KEA included 46,375 cattle, 28,840 goats and 10,666 sheep (Noren, 1995). Oxen, however, were and are, allowed in the closed area during the cultivation period from October to February. People who wish to use oxen for cultivation purposes, are granted permits by HADO (up to 8 animals per household) for the appropriate period. No oxen may be grazed in the closed area before the 1st october and all must

Box 3 : continued

On April 14th, 1979 the Kondoa District Executive Committee of CCM, chaired by the District Party Chairman and attended by village or branch chairmen and secretaries among others, took the following decision:

"By 31st october 1979 all livestock, i.e. cattle, goats, sheep and donkey/mules should be out of KEA. The party and the government should deliver this massage to the villages and give all livestock owners a six months period of grace to prepare for the move". To prevent any doubts as to the mandate and authenticity of the district decision to destock the KEA, both the Dodoma Regional Party Secretary and the then Minister for Natural Resources and Tourism, toured the area addressing meetings in support of the decision.

After 31st October, 1979 the whole area was destocked. The number of animals moved out of KEA included 46,375 cattle, 28,840 goats and 10,666 sheep. Oxen, however, were and are, allowed in the closed area during the cultivation period from October to February. People who wish to use oxen for cultivation purposes, are granted permits by HADO (up to 8 animals per household) for the appropriate period. No oxen may be grazed in the closed area before the 1st october and all must have left by the 28th February.

Phase III: Was supposed to last from 1986/87 to 1993/94.

It was, however, extended to December, 1996. The first five years, i.e. 1986/87-1989/90.

The general aim was:

- to prevent and arrest the advance of soil erosion and reclaim depleted land.

The main objectives were:

- to get self-sustained, integrated land use practices;
- to involve people in planning and self-help;
- to develop water and soil conservation in harmony with traditional systems;
- to integrate relevant discipline;
- to train people, both civil servants and farmers;
- to carry out adaptive trials;
- to have campaign to popularise and make people aware of soil conservation;
- to cooperate with national and international agencies.

For the period 1990/91-1994/95 the main aim is soil conservation through project activities and public participation. The major activities are as follows:

- combating soil erosion through various methods;
- increasing of land productivity through better agricultural practices;
- introducing of improved diary cattle with zero grazing system;
- creating of public awareness of soil conservation;
- environmental protection in all aspects;
- training of project personnel.

The research component:

Box 3 : continued

- introducing of improved diary cattle with zero grazing system;
- creating of public awareness of soil conservation;
- environmental protection in all aspects;
- training of project personnel.

The research component:

1. Environmental and socio-economic research

The research component supported by SAREC is not directly connected to HADO. it has, however, a direct bearing on the future of HADO. This component was started in September 1990 and a joint cooperation programme between the Institute of Resource Assessment (IRA) of the University of Dar es Salaam and the School of Geography of Stockholm University. The programme is called "Mau-land interrelations in semi-arid Tanzania:. There are 17 projects aimed at studying the processes of land degradation and resource conservation both as natural processes of land degradation and resource conservation both as natural processes of land degradation and asocial actions where farmers make decisions that influence these processes. the projects cover Kondoa district and/or adjoining districts of Dodoma, Babati, and Hanang districts. To date some 50 activities and reports have been published.

2. Animal husbandry research

In 1982 Mpwapwa Livestock Production Research Institute (LPRI) of the Research and Training Department, Ministry of Agriculture, Tanzania and the Department of Animal Nutrition and Management (HUV) of the Swedish University of Agricultural Sciences (SUAS) initiated a project called "Feed resources for ruminants in semi-arid areas of central Tanzania" funded by SAREC. The aim of the project was to introduce and train farmers in all aspects of zero grazing. Farmers were provided with loans to buy heifers on fulfilling the following conditions:

- construction of a stall;
- setting aside a minimum of 0.5 ha of growing fodder grass or other plants;
- have a permanent water source available;
- calves from the heifers should be sold back to the project for delivery.

According to reports, by the end of 1990, around 40 farmers had improved cows and 60 with 1-2 pure zebus in 3 villages in KEA. It is reported further that the average yield of milk from improved cows was 9.1 kg/day and for selected pure zebu 4.2 kg/day.

Source: MTNRE (1995)

There are many lessons, both positive and negative, to be learnt from the experiences of HADO as regards conservation and rehabilitation of lands. Positive results of HADO project include:

- Re-establishment of vegetation in areas that were once wasteland. This was achieved by closing large areas of former rangelands to livestock grazing and evicting all animals from the area. Other measures used to protect these areas include patrolling and protection of these areas from grazing, uncontrolled cutting of trees and burning. These measures allowed the restoration of vegetative cover through natural regeneration. It has been reported that by 1987, large areas of KEA had field layer vegetation covers between 30-80% of the ground, frequently to a height of more than half a meter. This is a clear indication that natural vegetation has a capacity to recover once those factors that contribute to the destruction of vegetative cover are arrested.

- There has been an increase in arable agricultural activities in areas that used to be badlands. It has

been reported by HADO that productivity in KEA has increase compared to times before the beginning of the project.

- Sandy rivers have stabilised and as a result agricultural activities have sprang up in areas where it was not possible to grow anything. It has been reported that more and more rivers carry water for longer periods now than at the beginning of the project and springs have more water.

- There has been a notable success in the construction of contour bunds to control run-off in those areas needing remedial treatment. To stabilise these structures various species of trees were planted including: Agave, Euphorbia, Cassia and Leucaena. Success has also been achieved in gully reclamation and stabilization by planting grass in the gully bottoms. In some areas peripheral live fence of sisal has been used to check run-off from the sides and to prevent run-off from entering the protected gullies.

- During implementation of HADO project environmental and socio-economic research and research on animal husbandry were undertaken. Research findings have been published and will probably have a bearing on future activities in the district.

- Services on contour alignment on farmers fields and advice to individual farmers on bund construction for water flow control.

- Short- and long-term staff training on forestry and soil conservation and management subjects.

Notwithstanding these successes, HADO has had a number of defects both during the formulation and implementation of the project. Some of these defects include:

Lack of a target group

Throughout the existence of HADO, the project did not have a clear vision as to who was the target and beneficiary of the project. From project objectives and activities it is evident that land rather than land users was the target. Instead of involving consulting, educating and convincing the land users during the planning and implementing of the project HADO personnel spent a lot of time policing and enforcing laws to close rangelands to livestock grazing. By avoiding involving the local population in its activities, HADO created antagonism between HADO staff and the land users to such an extent that there were confrontations between them, some of these confrontations were fatal. This lack of involvement of the land users led to villagers believing that the project did not belong to them forcing HADO to incur extra costs for maintenance of the infrastructures laid down.

The method used in implementing HADO activities were top-down, and rough. By evicting all cattle from KEA without any consultation with the land users and without any proper planning is reminiscent of the methods used during the colonial period. Some of the politicians in the district used the argument of returning the cattle to the KEA during their election campaigns for parliamentary seats.

Lack of baseline data

Land degradation is a result of physical and socio-economic conditions of the area. Understanding of these factors isa pre-requisite before planning any conservation activities in the area. The basic data needed include soils, landforms, climate, vegetation, hydrology,land use, infrastructure, marketing, population, cultivated acrages, agricultural yields, household incomes, household income or range quality. Other basic information essential, particularly to enable decision and policy makers to establish priorities for action, include causes, types, extent and severity of land degradation. Although in many HADO reports it has been reported that there has been an"unbelievable ecological transformation of the landscape" in the KEA, one preliminary study, however, found out that the rate of recovery of the vegetative cover varied considerably depending on such factors as soil type and degree of past erosion. This baseline data is lacking not only in the district but also for Kondoa Eroded Area. The project should have strived to obtain this data for proper planning of conservation and rehabilitation of the Kondoa Eroded Area. Due to lack of this basic data and the absence of any monitoring system of land degradation and rehabilitation in the area it is not possible today to quantify the degraded area which has now sufficiently recovered, which areas are still undergoing recovery and which areas are still degraded and therefore need urgent attention.

Lack of land use plans

There are no scientifically based land use plans in the district not to say of the Kondoa Eroded Area. HADO, during its period of existence, should have developed flexible land use plans taking into account that people in the area are agro-pastoralist. Areas suitable for crop production, extensive grazing, forestry etc., should have been identified and proper methods of range-management and land husbandry developed. The introduction of zero grazing and eviction of cattle was really trying to avoid the real problem of developing sound and sustainable land use plans. Due to lack of proper land use plans HADO now is proud of the fact that there has been an expansion of cultivated area in the former grazing land. HADO has completely ignored beekeeping as a form of land use despite being repeated several times as one of its core activity. This lack of land use plans has led to:

* Land use conflicts between HADO, pastoralists and agriculturalists.

* over-exploitation of land resources by overstocking or over-exploitation of resources which accelerate land degradation.

* Replacement of traditional crops such as millet and sorghum by maize which is not very draught resistant and a heavy demanding crop.

* Failure to find a solution as to what to do with the rehabilitated land in the Kondoa Eroded Area.

Lack of coordinated sectoral approach

HADO is under the Ministry of Natural Resources and Tourism and is managed by staff from the Forestry and Beekeeping division. All technical staff are trained foresters and have not technical knowledge and extension skills required to work with farmers and promote soil and water conservation activities as an integral part of farming system. They do not have the knowledge on improved agronomic practices and soil management methods required to improve and sustain land productivity, and thereby increase and livestock production.

Although in recent times HADO has embarked on soil conservation at a farm level, this has been limited to laying out contour ridges in farmland, construction of contour bunds and cut off drains and implementing gully plugging measures. HADO has employed physical methods ignoring the biological methods of land conservation.

Unfortunately most environmental conservation campaigns in Tanzania are centred on conservation of forests and tree planting. Very little is said about proper land use and land husbandry practices.

Lack of monitoring and evaluation process

HADO project has had the advantage of having several consultancies on project role and functions. Unfortunately it had only one independent external evaluation which took place between March and April, 1995 at the end of the project. This situation had a negative effect of the project activities. Very often consultants had conflicting views as to the role and function of the project. External evaluation missions would have ironed out the different views of the consultants and helped in reformulation of policy and strategies of the project as circumstances changed.

The role of research

Research activities were started almost fifteen years after the initiation of the HADO project. Since research activities take a long time before getting any meaningful results, it is only now that some of the research findings are being published, when the project is coming to an end. It means the project is not going to benefit from these research findings. However, certain aspects of research which are relevant and very important to the three districts seem to have been ignored. The three districts fall in a semi-arid area where the length of growing periods are short with erratic rainfall during the growing periods. The dry seasons are long. Soils are poor in organic matter, nutrient status and moisture retention properties. Inhabitants of the districts are agro-pastoralists. The following fields should have been considered for research:

* Soil moisture conservation: In most cases crop yield reductions in these areas are a result of soil moist deficit rather than soil loss perse. Research should have been undertaken to develop techniques which have a focus on rain water management (soil moisture conservation) rather than on soil conservation and run-off control.

* Maintaining and raising organic matter content: This is important for raising the topsoil cation-exchange capacity of the soil which is essential for improving the efficiency of fertilizer

application. Organic matter has also the added advantage of improving soil moisture retention of the soil.

* Selection of suitable crops for these areas. Currently, maize is the prevalent crop in these areas although maize is marginally suitable to these areas. There is also a need of developing varieties of the different crops which will be suited to these areas.

* Research on indigenous, traditional land husbandry practices available in the district with a view of improving them if necessary and marrying these techniques with more modern approaches.

* Natural pasture management based on the quality and quantity of pasture, seasonal variation and taking into account of the traditional pasture management.

* Research on other activities such as beekeeping, aquaculture etc., which would be socially and economically accepted to the people. These activities would increase the economic well being of the inhabitants.

Box 4: The Kondoa Integrated Rural Development Project (KIRDEP)

It is a project between the Netherlands government and the government of Tanzania. The executing agencies are the Kondoa District Council for Tanzania and SNV, a Dutch Non-Government Organization for the Netherlands government. The project started in 1993 and the 1st phase of the project will terminate at the end of 1977.
Funding of the project is almost wholly done by the Netherlands government. The government of Tanzania is funding of salaries of local personnel and shared services.

The project covers two divisions of the district, i.e. Bereko and Goima, with an area of 1,321 Km^2 and a human population of 120,000 persons. The main activities in the two divisions are crop production of maize, millet and sorghum, free range livestock keeping, beekeeping and some fishing in Bereko division.

The objectives of the project are:

- to improve socio-economic status of people with particular emphasis on women;
- to improve the productivity and income from economic sectors with special reference to the agricultural, livestock and forestry sectors.

To achieve these objectives the project will use the community oriented approach which follow a process or programmatic approach, with optimal community participation. This approach has the following characteristics:

- open-ended and participatory character;
- starting small, expanding step by step;
- learning by doing;
- quality before quantity.

The soil conservation techniques applied in the area are:

Physical: *Fanya juu* and *fanya chini* terraces;

Biological: *Makarikari* (Swahili), elephant grass strips, *Leucaena* tress along contour terraces.

The project conducts training in soil and water conservation committees, local (civic) and religious leaders. The project also provides financial support to its staff for seminars, workshops and study tours.

Another activity which the project supports is the establishment of group and individual nurseries. The project, however, does not have nurseries of its own. Seedlings are sold at sub-sidized prices and distributed by the project. The staff of the project come from the field of agriculture, livestock, forestry, resource management and lands.

Box 4 : continued

The project is, however, facing some operational difficulties. These difficulties are:

- difficult to achieve reciprocal understanding between extension personnel and farmers;
- inadequate farmer acceptance of extension packages due to low confidence resulting from top-down approach used before by HADO;
- inadequate qualified staff;
- frequent changes within the District Council of key people involved in the project.

Source: MoAC (1995)

Although it is too early to give a conclusion on KIRDEP there are, nevertheless, a few comments which can be made about the overall mode of operations:

* There is no programme of action/activities to achieve the objectives.

* Rather than learning by doing, the project should initiate research programme in agriculture, livestock, forestry, etc. Learning by doing is equivalent to doing things by trial and error.
  Research should be directed to such aspects as identifying suitable crops and varieties, crop rotations, intercropping, tillage methods, use of locally available fertilizer including farm yard manure and rock phosphates. Other important areas of research should include quality and quantity of natural pastures, pasture management, zero grazing, etc. The project should also take into consideration the local traditional/indigenous methods used in the area. These methods should be thorough analyzed preferably through a multi-disciplinary approach. The local traditional methods should be used as the basic entering point for development of sustainable conservation programme.

* A land resources inventory and land evaluation of the district should be undertaken to form the basis for developing flexible and sustainable land use alternatives taking in account the socio-economic conditions of the area. At the moment, budget not permitting, site characterization of the areas in which the project is working, should taken.

* The project should also undertake a land degradation inventory to identify causes, types, extent and severity of land degradation. This information should be used to develop strategies, plans and programme of action for soil and water conservation activities and pinpoint areas which require urgent actions.

* Creating awareness should not be confined to educating the people only. Other means should be explored including starting a local newspaper, using national newspapers, radio and TV programmes and field days, visits by farmers to other projects within and outside the district, training of farmers and extension officers at a training institute for period of ten to fourteen days.

Box 5: Usandawe-Uburunge Beekeeping Project

The project was centred in Kondoa district and was started in 1973. The objective of the project was to resettle the Wasandawe and Waburunge people into villages so that they could be taught modern beekeeping methods and modern crop and animal husbandry. The Wasandawe and Waburunge are by tradition honey hunters. According to 1978 census they numbered 26,000, of whom, 1,000 were engaged in beekeeping using more than 1,300 traditional beehives and 270 modern beehives. It was envisaged that by establishing modern beekeeping facilities in the villages the Wasandawe and Waburunge will be attracted to settle down in the villages and also carry out other development activities together with honey production.

It was planned that from the inception of the project to 1977 4500 modern beehives would be supplied to more than 80 villages in Kondoa district. Towards this end a hive making workshop was built in Kondoa town but was never completed. Only 615 of the targeted modern beehives were distributed to the villages.

At the moment there is very little happening with the project due to the following reasons:

- withdraw of the donor;
- lack of funds from the government;
- lack of technical staff.

Source: RDD (1980)

4.3 Singida district

Following recognition of land degradation which, in the district, was perceived through vegetation depletion and erosion, a soil conservation programme was initiated in the early 1980s in about 10 pilot villages out of the 136 villages in the district. This programme was supported and managed by the Tanzania Christian Refugees Service (TCRS). The Swedish International Development Agency (SIDA) also had a parallel soil conservation project for a period of ten years up to 1993.

The TCRS soil conservation activities include construction of contour bunds (popularly known in Kiswahili as *fanya juu*), grass strips for their stabilization and tree planting. These activities are carried out under the District Environmental Committee with task forces on livestock, natural resources and land planning. The programme started with an awareness raising campaign in three villages, then participatory rural appraisal studies to establish a mechanism for a "bottom-up" approach. The third step was concerned with training and demonstrations. In each of the three villages, a village environmental committee was set up. This village committee has at least 50% women representation. The village environmental committee is responsible for implementation of soil conservation matters as well as legislation and its enforcement.

Soil conservation started in 1991 and showed sufficient success in Msimihi, Ikanoda and Utaho villages to attract the interest other villages. However, in Sekou Toure village the success of the programme was unsatisfactory. Sekou Toure village was one of the pilot villages during the Ujamaa villagization era. During that time a lot of government support was poured in for housing and provision of social services. This created a dependency attitude which is attributed by TCRS to the slow picking up of do-it-yourself activities such as soil conservation.

Authorities in the district concede a certain amount of success from these conservation efforts. They report increases in production and reduced erosion. From field observations in the district, however, it is difficult to see evidence of rehabilitation of vegetation on the hill tops. Most inselbergs in the district are bare. There are, indeed, specific cases of severe gully erosion which have been controlled through tree planting and gully-plugging activities. The case of Utaho Primary School, a village near Singida town, is an example.

The main area of shortcomings reported by both the district authorities and TCRS are insufficient "animation", i.e. raising of awareness. The district authorities also think that the element of water requirements for the trees was not a consideration in the soil conservation activities. TCRS have noticed differences in commitment to soil and water conservation activities between villages with and those without land title deeds. They conclude that this is probably because people in villages without them feel they can easily move elsewhere.

Although not given prominence by the district authorities and technical staff, there was a need to

identify indigenous land husbandry techniques which exist in the district. No documentation on these is available. As such it is difficult to quantify the extent to which they are practised and their degree of effectiveness in controlling land degradation.

5 CONSIDERATIONS FOR CONSERVATION AND REHABILITATION OF LANDS

The problems of environmental degradation and need for conservation and/or rehabilitation have been recognised at global level. In recognition for concerted efforts by nations in combating environmental degradation several policies and guidelines have been issued at the global level. These are meant to guide individual nations in formulating their own strategies relevant to their specific environments. At implementation level, the country has followed up its national policies and strategies with establishment of various executing institutions with mechanisms for linkage and coordination. Any strategies or actions proposed for the conservation and rehabilitation of lands in the three districts under this study must take both national and global guidelines into consideration. This chapter discusses these global and national policies and strategies and national institutions which have been established to implement them.

5.1 Global strategies and policies for environmental conservation

The basic document addressing issues of soil degradation and the rational use of land resources for national development and prosperity is the World Soil Charter. The charter was adopted by the 12th session of the FAO conference in November 1981. The charter aims at creating awareness to the governments, International Organization and land users to the merits of managing land resources for the long-term advantage rather than for short-term gains. The charter has a set of principles, guidelines for action and possibilities for follow-up. It also includes activities which are basic for the promotion of optimal land use including land resources inventories, assessment of degradation hazards, evaluation of production capacity, improvement of soil fertility, combating desertification, land reclamation, integrated land-use planning, training and institution building (FAO, 1982).

To complement the World Soil Charter, FAO and UNEP (1983) prepared Guidelines for control of soil degradation. Although these guidelines were intended to create awareness to policy makers, planners and administrators, they are valid also for technical staff and other people involved in land-use planning and soil and water conservation activities.

The International Scheme "The conservation and rehabilitation of African lands" is a document prepared by FAO (undated) specifically addressing issues of land degradation in Africa. The document advocates the need for long-term programmes backed by sound land-use policies and strategies to catalyse their development. The document emphasized the need to develop and promote sound land-use management which because they produce increased yields and profits within one or two seasons, encourage wide spread participation. The document, further, points out of the need of each country having a national action to identify causes of land mismanagement and suggest solutions based on techniques designed both to raise yields and to prevent degradation (ARC/90/4).

The latest document which forms the basis for a global strategy for rehabilitation and conservation of lands is the 1992 United Nations Conference on Environment and Development (UNCED) which produced a blueprint on how to make development socially, economically and environmentally sustainable. This blueprint came to be known popularly as Agenda 21. Agenda 21 is an elaborate document which covers all aspects of the environment. It draws on the experiences and expertise gained when preparing the above mentioned documents where issues of land degradation and conservation are concerned.

5.2 National strategies and policies for environmental conservation

Several policies have been formulated in Tanzania laying strategies for the conservation of the environment. These include:

. the Agricultural Policy of Tanzania
. the National Conservation Strategy for Sustainable Development of 1994
. the Land Policy

In this section the contents of these policies and guidelines will be summarised before going on to discuss the institutions that have been established to implenent them.

5.2.1 The Agriculture Policy

The Agriculture Policy of Tanzania was first issued in 1983 by the then Ministry of Agriculture. It was issued along with but separately from the Livestock Policy of Tanzania by the Ministry of Livestock Development. The two documents are now being revised as one document under the name

of "The Agricultural Policy of Tanzania and, as of the time of writing this report, is still in a draft form. The revision of these policies has been prompted by the following factors:

- amalgamation of the two policies into one following the merger of the Ministry of Agriculture of livestock into one Ministry - Ministry of Agriculture and Cooperatives (MoAC);
- economic changes that have taken place since their publication;
- the existence of the new national land policy; and
- the importance of proper management and protection of a delicate natural environment (MoAC, 1995).

The Agriculture Policy is divided into four main sections viz. general policy goals, objectives, policy instruments and strategies. Under the general policy goals the document states that "the ultimate goal is the improvement of the well-being of the people whose principal occupation and way of life is based on agriculture". See box 6 for details.

Box 6: The Agriculture policy

(Source: Ministry of Agriculture & Cooperatives, 1995)

The agricultural policy of Tanzania (MoAC, 1995) states nine objectives as outlined below:

(a) To assure basic food security for the nation, and improve national standards of nutrition by increasing output, quality and availability of food commodities;

(b) To improve standards of living in the rural areas through increased income generation from agricultural and livestock production, processing and marketing;

(c) To increase foreign exchange earnings for the nation by encouraging the production and increased exportation of cash crops, livestock products, other agricultural surplus, by-products and residues;

(d) To produce and supply raw materials, including industrial crops, livestock, by-products and residues for local industries, while also expanding the role of the sector as a market for industrial outputs through the application of improved production, marketing and processing technologies;

(e) To develop and introduce new technologies which increase the productivity of labour and land;

(f) To promote integrated and sustainable use and management of natural resources such as land, soil, water and vegetation in order to conserve the environment;

(g) To develop human resources within the sector in order to increase the productivity of labour and to improve ability, awareness and morale;

(h) To provide support services to the agricultural sector which cannot be provided efficiently by the private sector;

(i) To promote specifically the access of women to land, credit, education and information; (MoAC, 1995).

These objectives will be achieved using the following instruments (MoAC, 1995):

(i) Agricultural research, extension and training;

(ii) Monitoring and evaluation of agricultural development and identification of new opportunities (products technologies, markets, etc) and promotion of new production processes;

(iii) Collection and dissemination of market information in order to integrate the domestic markets and make foreign markets accessible;

(iv) Facilitate the provision of a good infrastructure, especially transport and storage;

(v) Control of quality, hygienic and sanitary standards;

(vi) Control of vermin, epidemic pests and diseases;

(vii) Providing an adequate legal and regulatory framework;

(viii) Natural resources management;

(ix) Promotion of institutional structures in the agricultural sector;

(x) Taxes and subsidies.

There several strategies have been proposed for attaining the objectives of the Agricultural Policy. Relevant to conservation and rehabilitation of lands are the following strategies:-

- priority for applied rather than basic research, and for solving immediate problem facing the

5.2.2 The National Conservation Strategy for Sustainable Development

The resolutions of the 1992 United Nations Conference on Environment and Development were followed up in Tanzania through a national workshop which was held in 1993 and identified about half of the issues in Agenda 21 as being of relevance to the country. These were published in the National Conservation Strategy for Sustainable Development (NCSSD) of 1994. The main strategy in the NCSSD document is to integrate environmental issues in the development planning process. The NCSSD recognizes that environmental activities are multi-sectoral and cross-institutional in nature and thus require an elaborate institutional and legal framework to ensure maximum coordination and enforcement among agencies. Because conservation and development issues are strongly linked, the sectoral activities must be mutually supportive and aimed at a common goal (NEMC, 1994). According to NCSSD there is need for a broad concept of sustainable development, which is defined as improving the quality of life within the carrying capacity of the resource base. Permanent benefits are to be gained by uniting conservation and development within one process. See box 7

Box 7: The National Conservation Strategy for Sustainable Development (NCSSD)

The NCSSD document identifies land degradation as the most serious environmental propmen affecting the country. Land degradation affects over 80% of the population which depends on land based activities for their source of income. It also affects the entire population which depends on the food and raw materials produced by the agricultural, livestock and forestry sectors.

The document points out causes of land degradation in Tanzania as being:

(i) Poor crop cultivation practices including up and down methods of cultivation, cultivation on sloping lands, lack of crop rotation, poor vegetative cover, inadequate use of organic fertilizer, lack of sufficient conservation measure, cultivation in marginal areas, and lack of appropriate technology and land husbandry techniques.

(ii) Unsustainable use of forest, grassland and woodland including expanding agriculture, cutting for fuelwood and timber and uncontrolled bushfires.

(iii) Land tenure issues in general with particular emphasis as it affects pastoralists.

(iv) The rapid population growth and

(v) Poverty as a cause and an effect.

To combat and prevent land degradation the document proposes the following action plans:

1. Combating land degradation

1.1 Promote an integrated approach to planning and management of the land resources.

1.2 Review and harmonise legislation with the aim of promoting optimal use and sustainable management of land resources.

1.3 Establish or strengthen institutional mechanisms to facilitate active involvement and participation at the local level on land use issues.

1.4 Evaluate the rationality of existing land use practices in Tanzania with a view towards recommending appropriate uses. This includes mapping areas to identify and evaluate natural resources.

1.5 Monitor the extent of land degradation.

1.6 Monitor the extent to which mining activities contribute to land degradation.

2. Sustainable Agriculture

2.1 Establish or strengthen soil and water conservation activities, including the control of soil erosion, water harvesting and improved irrigation techniques, improving or replenishing soil fertility and promoting physical conservation measures such as terracing, contour ploughing and zero cultivation.

2.2 Promote the expansion of necessary infrastructure (i.e. access to suitable inputs, marketing facilities, transport etc) to promote settled agriculture in areas where shifting cultivation agriculture is practised.

2.3 Assess and promote traditional land and livestock husbandry systems where appropriate.

2.4 Devise and rehabilitate stock routes for the movement of livestock.

2.5 Develop effective and environmentally friendly methods of tsetse fly control.

Box 7 : continued

2.2 Promote the expansion of necessary infrastructure (i.e. access to suitable inputs, marketing facilities, transport etc) to promote settled agriculture in areas where shifting cultivation agriculture is practised.

2.3 Assess and promote traditional land and livestock husbandry systems where appropriate.

2.4 Devise and rehabilitate stock routes for the movement of livestock.

2.5 Develop effective and environmentally friendly methods of tsetse fly control.

2.6 Improve water management in irrigation schemes to make them more effective. Monitor large-scale irrigation schemes for possible environment impact.

2.7 Identify and review methodology by which extension packages (e.g. agriculture forestry, wildlife, education, fisheries, etc.) can convey harmonised environmental message. Improve the understanding of the rural population as to the importance of resource conservation measures.

2.8 Promote the controlled use os fire for range management purposes. Explore the possibility of assigning individual or village level responsibility for controlled fires via a system of permits.

3. Promote the sustainable use of Forest Reserve

3.1 Strengthen afforestation and reforestation activities. Promote agroforestry and the conservation of catchment areas. This includes identifying appropriate species and planting methods.

3.2 Promote the efficient and rational use of forest and woodland resources coordinate agricultural and forestry activities to take into account the importance of maintaining and vegetation cover.

3.3 Promote alternative source of energy. Develop technologies and methods to use forest and agricultural residues for cooking and power production. Promote the use of electricity in urban areas as an alternative to charcoal.

Strategic measures envisaged to tackle environmental degradation include planning, legal (both legislative, enforcement, and institutional), international cooperation and administrative and institutional framework. As regards measures to conserve natural resources the following is proposed:

1. Lands

(a) The government should formulate and adopt a new comprehensive land policy which addresses both rural and urban land use issues, needs and priorities and enables socio-economically optimal land use patterns to be determined. The policy should focus on giving security of tenure to those "holding" land under customary law and strengthening the management capacity for public lands.

Box 7 : continued

giving security of tenure to those "holding" land under customary law and strengthening the management capacity for public lands.

(b) One important management tool is sufficient data. Land capability profiles should be prepared to guide the rational use of land at local and national level. Those making decisions in the field of land use should have access to a natural resource monitoring and information system.

(c) Another underlying cause of mismanagement of public lands is the lack of clearly defined institutional roles and responsibilities between central and local government. Related to this is the need to strengthen capacity to manage public lands.

(d) Legal mechanisms should be established to mediate land use conflicts between competing interests such as agriculture, livestock, mining, conservation, industry and other developers.

(e) Incentives to encourage sustainable land use should be designed. These could consist of penalties for abuse of the land resources, or preferential access/low rents to users who use the resource sustainably. Traditional approaches to land management, especially for common resources, should be studied for their potential contribution to the design of incentives.

2. Agriculture

(a) Measure to conserve and restore (chemical and physical) soil fertility have the highest priority. These include:

- emphasizing biological nitrogen fixation through intercropping and crop rotation with leguminous crops;
- integrating agro-forestry into farming system;
- promoting the application of farm yard manure, compost, green manure and crop residue, (and locally available rock phosphate e.g. Minjingu rock phosphates); and
- promoting mulching and tillage practices to improve soil structure.

These measures have the added benefit of reducing the dependency on inorganic fertilizers.

(b) Promote improvements in land husbandry through the provision of farming equipment and supporting infrastructure for agricultural activities, e.g. markets, storage, better crop practices, credit facilities, efficient cooperatives, communication facilities. This should be done taking adequate account of the socio-economic issues involved such as land tenure, infrastructure, marketing facilities, commodity prices, and producer consumption needs.

(c) Integrated land use plans should be implemented in order to reduce the conflicts with regard to existing land use and land tenure patterns.

(d) Measures should be taken to ensure that irrigation schemes do not withdraw excess water.

(e) Improving land husbandry measures will reduce the need for agro-chemicals and thus reduce soil and water pollution from agricultural run-off. The possibility of increasing the price of agro-chemicals byu reducing subsidies or imposing "environmental" taxes should also be explored.

(f) Attempts should be made to match respective demands/supply of resources.

In the field of agricultural development there is need to use agro-ecological zones as a basis of crop-patterns.

(g) Programme should be implemented to halt erosion and watershed destruction.

(3) Livestock

(a) Provide secure land tenure rights to pastoralists. The current land tenure reforms should clearly define property rights in lands managed by the public sector, protected areas and common property resources.

Box 7 : continued

price of agro-chemicals byu reducing subsidies or imposing "environmental" taxes should also be explored.

(f) Attempts should be made to match respective demands/supply of resources.
In the field of agricultural development there is need to use agro-ecological zones as a basis of crop-patterns.

(g) Programme should be implemented to halt erosion and watershed destruction.

(3) Livestock

(a) Provide secure land tenure rights to pastoralists. The current land tenure reforms should clearly define property rights in lands managed by the public sector, protected areas and common property resources.

(b) Develop and integrated land use planning system that will classify rangelands into simple grazing management categories for wet and dry season use so as to minimise encroachment into grazing lands. Range inventories should be conducted so as to establish the current production potential of grazing in different ecological zones. Ensure the incorporation of the traditional wisdom of pastoral systems into modern rangelands and livestock management systems. Pastoral knowledge of common resource management must be appreciated, documented and utilised for development. Related to this, the government should encourage and empower local community structure to develop and implement systems of natural resources management, using the community as the basic management unit.

(c) Improve the declining productivity of rangelands through a rangelands rehabilitation programme designed to improve low quality roughage in the dry season and which should take into account the role of crop residues and fire in the livestock production systems.

(d) Improve livestock marketing infrastructure and promote an attractive pricing structure to encourage pastoralists to offer their livestock for sale. Similarly, animal health services should be improved.

(e) Develop and disseminate environmentally friendly technologies for village/community level livestock water supply with maximum participation from the pastoralists.

4. Forestry and Beekeeping

(a) Promote and implement the concept of buffer and transition zone management, including community participation in the management of forest reserves.

(b) Promote the multiple roles of trees, forests and woodlands and protect these areas especially in the vicinity of water sources.

(c) Strengthen inter-sectoral coordination and promote holistic approaches to land resources management.

(d) Diversity the forestry industry so that it uses less marketable tree species and no-wood products.

(e) Design incentives such as pricing policy, concession arrangements, revenue collection systems, and property rights to minimize the further depletion of forest resources.

In the document it is pointed out that the report alone will not ensure effective strategy implementation. The major pre-requisites are: commitment, organizational structure, resources (and policies).

Box 7 : continued

(e) Design incentives such as pricing policy, concession arrangements, revenue collection systems, and property rights to minimize the further depletion of forest resources.

In the document it is pointed out that the report alone will not ensure effective strategy implementation. The major pre-requisites are: commitment, organizational structure, resources (and policies).

Source: NEMC (1994)

5.2.3 The National Land Policy

The national land policy basically aims at enhancing land conservation through improved land ownership systems. The policy document thus addresses three basic issues viz. land use planning, land tenure and land administration. It aims at creating awareness of the value of land so that land-based activities should be viewed like any other asset-based enterprises. Box 8 gives details of the contents of the land policy of Tanzania.

Box 8: The National Land Policy

The national land policy looks at three basic issued: land use planning, land tenure and land administration.
Under land use planning the national land policy works village land use planning and land use management.

The following are policy statements for village land use planning:

- Local land use plans will be developed by district councils in collaboration with the village councils.
- Land use planning will be done in a participatory manner to involve beneficiaries. Planning will be preceded by studies to determine existing land tenure, land use patterns and land capability.
- Village land use plans will be used as a tool for implementing policies for better land use and management. Furthermore, village land use plans will provide a basis for guiding extension service packages including techniques in agriculture, livestock, forestry, wildlife, fisheries and environmental conservation.

It is further stated in the policy that "the land use plans consist of rigid land use zoning which is sometimes not suitable for proper management of rural land resources" [MLHUD, 1995].

Land use management cover agricultural land use and rangelands and livestock keeping. Policy statements include:

- Multiple land use techniques will be encouraged in areas of conflicting land use.
- Community involvement in resource management, land use planning and conflict resolution will be necessary.
- Agricultural land will be identified, set aside for agricultural use and protected against encroachment by pastoralists.
- Resource sharing will promoted.
- Security of tenure for pastoralists in pastoral land will be guaranteed by appropriate measures including gazetting to protect grazing land from encroachment.
- Certificate of village land will be issued to protect common property regimes.
- Under utilized or reflected former pasture land will be reclaimed and restored to pastoralists, when not in conflict with national interests.
- When any activity other than pastoralism ceases in rangelands (e.g. abandoned ranch) that land will revert to its original land use.
- Shifting agriculture and nomadism will be prohibited.
- Incentives to proper pastoral land stewardship including provision of infrastructure like water supply and cattle dips should be provided and modern trans haematic pastoralism will be encouraged.
- Cattle movement will be regulated through coordinated planning and the provision of stock routes and other mechanisms.
- Pastoralists and agriculturalists/peasants will be educated on good land management and utilization.

Box 8 : continued

- Cattle movement will be regulated through coordinated planning and the provision of stock routes and other mechanisms.

- Pastoralists and agriculturalists/peasants will be educated on good land management and utilization.

5.3 Sectoral institutions for implementation of environmental conservation and their linkages

In recognition of the fact that issues of land degradation and conservation are cross-sectoral several the national policies are exceuted through a number of sectoral ministries. The executing institutions fall under the following ministries representing the various sectors dealing with the environment:

. Ministry of Agriculture and Cooperatives
. Ministry of Lands, Housing and Urban Development
. Ministry of Natural Resources and Tourism
. Ministry of Water and Energy

The ministries are responsible for the formulation and implementation of policies concerning issues under their mandate to ensure that national development objectives are reached.

All these sectors (ministries) are coordinated by the Vice President's Office, which is also responsible for defining national policy on environmental issues. The Prime Minister's Office, being responsible for planning and development at the regional, district and at village levels, is responsible for coordinating the various sectors at these levels.

Within the ministries, institutes have been established and charged with the implementation of sectoral policies.These institutes have mandates of either research, database administration, information dissemination, training or policy execution. The National Environment Management Council, under the Vice President's office, has been given the mandate of coordinating all issues concerned with the environment. In Box 9 this section gives a brief description of the sectoral institutions established for implementing the national strategies for land conservation.

Box 9: Institutions for implementing the national development policies

1. The Vice-President's Office

The Vice-President's Office is at present charged with defining national policy on environmental issue. This task was formerly under the Ministry of Tourism, Natural Resources and Environment (MTNRE). The main agency charged with this task is the National Environmental Management Council (NEMC). NEMC is an advisory organ to the government on environmental issues. The National Environmental Management Council was established in 1983 to coordinate and harmonise environmental issues. The NEMC's main role and functions are policy formulation, legislation, coordination of environmental issues, review of environment-related policies and environmental education. Major achievements by the NEMC are the preparation of the National Conservation Strategy for Sustainable Development (NCSSD) and the Nation Environment Action Plant (NEAP). The NEMC has yet to prepare a National Environmental Policy.

2. Ministry of Lands, Housing and Urban Development (Ardhi or MLHUD)

The Ministry is responsible for allocation, registration, mapping and land use planning. The Ministry is also responsible for administration of all land on behalf of the President. The Ministry has a number of agencies which are dealing with land planning issues. They include:

(i). The National Land Use Planning Commission (NLUPC). The National Land Use Planning Commission was established in 1984 and is responsible in terms of policy, legislation, coordination, implementation and education. The Commission's roles and functions include (MLHUD, 1984):

- formulate land use planning policy;
- recommend policies and programmes that will achieve more effective protection and enhancement of the quality of the land and encourage better land use planning;
- formulate legislation proposal on land use planning issues;
- coordinate the activities of all bodies concerned with land use planning and be the channel of communication on these matters to the government;
- foster cooperation between the government, local government authorities and other bodies engaged in land use planning programmes;
- establish and maintain liaison with Land Advisory Committee (LAC) in districts and regional on land use planning issues to ensure safeguarding of both national and local interest;
- specify standards, norms and criteria for the protection of beneficial uses and the maintenance of the quality of land;
- prepare regional physical plans and ensure their implementation by the regions - The Nation Land Use Policy;
- be an information centre;
- develop educational programmes on land use planning.

(ii). The Ardhi Institute: A training institute under the Ministry of Lands, Housing and Urban Development. It trains people a technician and professional level in urban and rural planning. The bias of the training is on skills required for urban/town planning. Important aspect of natural resources management such as soil and water studies, forest management, range and wildlife management, environmental impact assessment are not offered. Unfortunately, graduates from this institute are absorbed by the various division of the ministry which is responsible for drawing up rural land use plans. There is, therefore, a need for the Institute to change its curricula to reflect the mandate of the Ministry and of the National Land Use Planning Commission.

Box 9 : continued

various division of the ministry which is responsible for drawing up rural land use plans. There is, therefore, a need for the Institute to change its curricula to reflect the mandate of the Ministry and of the National Land Use Planning Commission.

(iii). The Department of Surveys and mapping: The division is responsible for physically drawing land use plans prepared by the planners. It is also a data source and provides base maps, topographic maps, aerial photographs etc. It has also the responsibility of surveying plot layout in urban areas.

3. Ministry of Agriculture and Cooperatives (MOAC)

This is probably the most important ministry as regards rural land use planning and land degradation. Agriculture plays a key role in both the household and national economy, while at the same time, inappropriate agricultural practices and land tenure are the main causes of land degradation. The Ministry, though not directly dealing with land use planning, provides expertise and data in the fields of agriculture in general and land management and resource assessment in particular.

The main agencies dealing with aspects of land use planning within the Ministry are:

(i) Land Use Planning and Soil Conservation Section: The section is responsible for land use planning and soil conservation activities in the regions, districts and villages. The section links up with Ministry's extension service in the identification and development of appropriate farm-level management practices. It also works with other institutions including the NLUPC and Town Planning division of the Ministry of Lands, Housing and Urban Development, in preparing village and other land use plans.

(ii) The National Soil Service (NSS): The National Soil Service was founded in 1974 as a bilateral cooperation project between the government of Tanzania and FAO/UNDP. The aim of the project was to develop and institution at a national level to meet the needs of the country for soil survey, land evaluation, soil testing, soil fertility and management study and to train national staff to operate the services effectively. the National Soil Service is both a research programme, engaged in studies of the effect of soil characteristics, soil management and fertilizer application on crops and livestock performance and a support programme rendering services in soil mapping, cro suitability assessments, soil, water and plant analyses. In addition, the NSS is responsible for the nation wide coordination of soil research and fertility studies. Most of the support by NSS is provided on requests to private estates, district programmes, cooperatives or independent projects.

The objectives of the National Soil Service have been:

- to characterise, map and evaluate soil at national, regional, district, project and farm level for agricultural development purposes;
- to provide soil testing facilities and services to farmers;
- to provide short training to the agricultural extension services on use of soil information;
- to advise the Tanzanian government at national, regional, district and village levels on matters of soil resources appraisal, soil management, fertilizer-use and soil conservation;
- to compile progressively a soil and land suitability map of Tanzania at a scale of 1:1,000,000;

Box 9 : continued

- to compile progressively a soil and land suitability map of Tanzania at a scale of 1:1,000,000;
- to develop and update national guidelines for soil survey, land evaluation, soil fertility and management research and soil, plant and water laboratory;
- to coordinate all soil studies in the country from national to farm level as a support discipline for efficient land use planning;

Box 9 : continued

(iii) The Range management Section of the Department of Livestock Development: This section is responsible for evaluating rangelands and preparing range management plans aimed at avoiding overgrazing. Range management plans incorporate the development of stock watering facilities, pasture improvement and the separation of grazing land from agricultural land. The section is also responsible for ensuring the availability of grazing during all seasons, the provision of water, and veterinary and marketing services. Comprehensive and systematic range management plans and coordination with other land uses have been prepared for only few parts of the country. The main bottleneck is funding.

(iv) Irrigation Division: The division has the responsibility on all aspects of the development of irrigation schemes, including identification, evaluation, design and construction. The capacity of the division to undertake surveys and evaluate suitability for irrigation is weak. Such work has been largely done by experts from other divisions or ministries using different methodologies and standards. Comprehensive land use plans, that include either actual or potential land use in the irrigable areas, are seldom undertaken.

(v) The Ministry of Agriculture Training Institutes (MATIs): The MATIs provide training to agricultural technicians, who are in most cases posted to rural areas to work as agricultural extension workers. Their curriculum does not include aspects of either rural land use planning or soil and land degradation.

4. The Ministry of Tourism and Natural Resources

This Ministry is important in three aspects. Through its Forest division it is responsible for managing both natural and plantation forest reserves on public land which cover 46% of the country. It undertakes soil conservation measures as a normal part of forest management. Its priority is the layout of infrastructure, conservation in forests and plantations and protection of catchments. These responsibilities havered to its involvement in HADO (Hifadhi Ardhi Dodoma) and HASHI (Hifadhi Ardhi Shinyanga) in Dodoma and Shinyanga respectively.

Through the division of wildlife and other agencies of the Ministry it is responsible for protection, development and management of national parks, conservation areas, game reserves. Wildlife and tourism sectors are major foreign exchange earners of the country. The Fisheries Division deals with fisheries resources management. Increasing concerns about coastal management makes it an important partner for land use planning. Some of the programmes and projects coordinated by the Ministry having a land management component are:

- the country wide tree planting - village afforestation programme;
- the Dodoma Regional soil and water conservation project (HADO)
- the Shinyanga Regional Soil and Water Conservation Project (HASHI);
- the Soil Erosion Control and Agroforestry Programme in Lushoto (SECAP);
- the Tropical Forest Action Plan;
- the Beach Rehabilitation Programme;
- the Tanga Integrated Coastal Zone Management Programme;
- the National Mangrove Management Programme;
- the National Integrated Coastal Zone Management Programme;
- the Lake Victoria Environmental Management Programme.

Box 9 : continued

5. Prime Minister's Office - Regional Administration and Local Governments

The office is the coordinating institution of planning and development activities among line ministries in the regions and districts. It also holds the Ministries of Regional Administration and Local Government, which are important as they include those levels of government (regional, district and village) where land use plans are initiated, discussed, finalized and implemented and have a direct impact.

6. The National Planning Commission

The National Planning Commission under the President's office is responsible for economic planning and coordination of planning activities at the national level. It prepares guidelines for the five-year development plans and annual budgets. It coordinates development projects and assigns priorities for funding and implementation. Under this mandate it is also responsible for the coordination of all programmes and projects dealing with natural resources management and utilization. At the level of the district economic planners operate under the Planning Commission.

7. Other Institutions

The institutions mentioned below fall outside the major ministries involved in land use planning but they are important because they indirectly influence land use planning:

(i) The Institute of Resource Assessment (IRA) : The IRA is an independent institute within the University of Dar-es-Salaam. It concentrates on basic and applied research in the following areas, natural resources and environmental, agricultural systems, water resources, population and human settlements, and remote sensing. Consultancy services in these work areas are provided to the government, parastatal organisations, and international organisations, etc. The remote sensing section uses both satellite and aerial photos, and provides methodological support to the different research areas. Other methods used include participatory rural appraisal and conventional socio-economic surveys.

(ii) Agricultural Research Institutes and Centres : Under the Department of Research and Training there are seven research zones, two sub-zones with 51 research institutions and centres. There are research programmes covering cash and food crops, livestock special programmes (soils, agroforestry engineering) and farming systems. Due to its strongly decentralized set-up and a strong linkage with the extension services in the same ministry, the research system is in a better position to conduct adaptive research that is relevant to local agro-ecological and socio-economic conditions. Particularly research findings on land resources, land evaluation, integrated plant nutrition, soil conservation, water harvesting, adapted cropping systems, land reclamation, irrigation and drainage will form vital components to be incorporated in land use plans at different levels.

(iii) Sokoine University of Agriculture (SUA) : The Agricultural University at Morogoro has a mandate to train agricultural, veterinary and soil scientists at degree levels (B.Sc., M.Sc. and Ph.D. The University also conducts basic and applied research in all fields related to agriculture. It also involved in consultancies in the above fields. Research findings from SUA are also very important for land use plans.

Box 9 : continued

(iv) The Tanzania Forest Research Institute (TAFORI) : TAFORI was established in 1980 to conduct research on all aspects of forest management involving both local as well as exotic species. Its functions include experimentation, research coordination, training and technical advice.

Table 9 List of soil survey coverage in Tanzania

AREA	SCALE	COVERAGE
Kwamtili Cocoa and Coconut estate	1: 5,000	462 ha
Kigombe Sisal estate	1: 30,000	3918 ha
Mwera Sisal estate	1: 20,000	8200 ha
Kwamdulu Sisal estate	1: 20,000	4640 ha
Kwamkoro and Bulwa Tea estates	1: 25,000	1354 ha
Mkongo Rusende Rice farm	1: 50,000	200 ha
Amboni Sisal estate	1: 50,000	5535 ha
Mishamo refugee settlement	1: 5,000	12800 ha
Matipwili village irrigation scheme	1: 10,000	500 ha
Mikere farm		2000 ha
Kilangali village irrigation scheme	1: 10,000	600 ha
Mgongola village irrigation scheme	1: 10,000	500 ha
Ulyankulu refugee settlement	1: 50,000	29000 ha
Mkindo village irrigation scheme	1: 5,000	155 ha
Mvumi village irrigation scheme	1: 10,000	530 ha
Pongwe Sisal estate	1: 20,000	3685 ha
Ngombezi Sisal estates		800 ha
Ndolela farm	1: 50,000	2000 ha
Kikwetu Sisal estate	1: 50,000	5500 ha
U.F.C	1:50,000	550 ha
Umoja and Fil estates	1: 25,000	1500 ha
Dodoma Capital City	1: 50,000	2500 sq km
TARO-Naliendele farm		850 ha
Chrismill-Farm	1: 50,000	625 ha
Laki Laki estate		400 ha
Kitivo village irrigation scheme	1: 10,000	1521 ha
Naberera Seed farms	1: 25,000	4815 ha
Simba Seed farms	1: 25,000	2430 ha
Lolkisale Seed farms	1: 25,000	25500 ha
Southern Highlands (Kidabaga; Usokami;Ihanu)	1: 5,000	34300 ha
Tungi sisal estate	1: 25,000	2181 ha
Namuai Seed farm		810 ha
Visiga Seed farm		20 ha
Njombe Wattle estate	1: 50,000	17000 ha
Dodoma-Bereko division	1: 50,000	
Dodoma-Zoisa division	1: 50,000	
Iringa region	1:100,000	50000 sq km
Tanga region	1:500,000	27000 sq km
Bukoba-Ngono	1:100,000	700 ha
Upenja Sugar Project Zanzibar	1: 10,000	3010 ha
Bombwera Sisal estate	1: 30,000	2320 ha
Lower Rufiji Valley	1:125,000	
Lower Moshi Irrigation scheme	1: 5,000	2885 ha
Kwamgwe Sisal estate	1: 30,000	1480 ha
Kwashemshi Sisal estate	1: 30,000	1500 ha
Kwafungo Sisal estate	1: 30,000	2330 ha
Setchet Wheat Area - Hanang district	1: 50,000	10725 ha
Basuto Wheat farm	1: 50,000	26500 ha
Loliondo Area		52000 ha
Manyuvu and Nkalinzi - Kigoma Area	1:250,000	
Tumbi Research farm	1: 10,000	1800 ha
Selected Areas near Arusha and Monduli	1:250,000	204000 acres
Kilimanjaro region	1:250,000	13260 sq km
Kilosa - selected areas	1:250,000	1500 sq km
Serengeti woodlands	1:125,000	13250 sq km
Machame North Coop.Soc.(LAMBO)	1:9,000	1261 ha
T.P.C.-Moshi	1:50,000	1400 ha
Mbeya Region	1:100,000	60000 sq km
Rukwa Region	1:2,000,000	60000 sq km
Tarime Highland	1:125,000	44756 ha
Arusha foundation Seed farm		485 ha
Basuto and Balangida Lelu area	1: 50,000	154000 ha
Kilombero valley	1:125,000	10350 ha
Tabora Region	1:250,000	73500 sq km

Lower Rufiji	1:125,000	
Geita and Sengerema	1:125,000	9803 ha
Karatu-Oldeani area	1: 50,000	10725 ha
Morogoro district	1:250,000	21000 sq km
Mbulu district a.District survey	1:100,000	7600 sq km
Mbulu district b.10 villages	1: 20,000	50000 ha
Kilombero area	1:125,000	
Pawaga area	1:125,000	
Usangu area	1:125,000	1500 sq km
Mtwara and Lindi regions (Selous excluded)	1:250,000	123400 ha
Kitere Irrigation scheme		1200 ha
Mikindani farm	1: 25,000	5100 ha
Buturage, Kabirizi and Ruhunga villages - Bukoba	1: 25,000	5070 ha
Kiriya Irrigation Scheme	1: 25,000	600 ha
Kigonigoni Irrigation Scheme	1: 25,000	10 ha
Mvureni Irrigation Scheme	1: 25,000	500 ha
Kileo Irrigation Scheme	1: 25,000	315 ha
Maswa district	1:250,000	3200 sq km
Kisangata farm - Kilosa district		5700 ha
Karimi Tea - Amani		880 ha
Mahonda Sugar estate - Zanzibar		2025 ha
East Usambaras (Kwemwewe & Shambagene villages)		
Ukiriguru soils		500 ha
Haidom area, Mbulu district	1: 50,000	39122 ha
Katesh Area, Hanang district	1: 50,000	77000 ha
Dodoma Region	1:250,000	41300 sq km
Selem, Bambi, Kidichi and Kitope Coconut Farms		100 ha
Kimani Irrigation Scheme	1:10,000	7730 ha
Cheju Area, Zanzibar	1:20,000	1200 ha
Ngombezi Sisal Estate	1:20,000	14730 ha
Bukoba district	1:250,000	
Southern and Eastern Slopes of Kilimanjaro	1:100,000	1000 sq km

Source: NSS (1993)

For soil surveys published prior to 1970, see also "A Soils Bibliography of Tanzania" by Cook, 1975

Figure 8: Areas covered by soil surveys in Tanzania

5.4 Shortcomings of existing policy and institutional framework

There is a shortfall in the number of sectoral policies existing in the country. Clear and well defined policies on land use, and land resources management and conservation are missing and where these exist are either absolute or do not adequately address issues of land degradation. Policies which exist now and which are relevant to land management, conservation and rehabilitation are the overall national policy objective and the land and agriculture policies.

In all the three districts under this study, the greater part of rural land degradation was attributed to livestock activities. Apart from grazing there is considerable movement of herds in search of water. In Mbulu district, for example, it is reported that at the worst of times livestock cross from one end of the district to the other in search of water on a daily basis. A water policy does not exist.

A major cause of the degradation of woody vegetation is the need for fuel. A great part of fuel for domestic use is derived from woody products. This applies to rural areas as well as to the urban centres. In the rural areas crop residues frequently supplement fuel wood obtained from natural vegetation. However, around urban centers charcoal is obtained exclusively from natural vegetation. Although there is recognition in political circles of the danger of continued reliance on fuel wood, an energy policy to guide the search for and use of alternative energy sources does not exist. Such a policy would address issues of soil management, soil conservation and watershed management.

The country does not have a policy to guide the crop production sector. Crop production techniques have also been blamed for increased land degradation. In all districts it was noted that cultivation is done in an "incorrect manner". However, there has not been formulated a soil policy.

There are many institutions dealing with land use (see Box 9). These institutions belong to different ministries. Their mandates do not include obligations to incorporate activities of other sectoral institutions nor provide mechanisms for linkage. For example the National Environment Management Council (NEMC) is charged with the overall coordination of environmental issues. The National Land Use Planning Commission (NLUPC) is responsible for coordination of land use planning activities. Environmant and land are terminologies which are very closely linked. The boundary between the environment and land is obscure. In the context of Tanzania the creaton of the two bodies has created more confusion rather than helping solve issues of land degradation. It has led to each institution preparing its own projects which in most cases are either overlapping or a duplication. To make matters worse, the two institutions are under-staffed, under-equipped, under-funded and lack expertise in aspects of land use planning and management. They are therefore too constrained to effectively carry out their coordination roles.

The NEMC can be seen to be a truly cross-sectoral institution since it is under the Vice president's office. However, the NLUPC and other institutions are under parent ministries with activities and scope limited to the particular sector. The effectiveness of these institutions in coordinating others is virtually non-existent. This has led to formulation of strictly sectoral projects and programmes (see Box 3).

6 STRATEGIES FOR IMPLEMENTATION OF CONSERVATION AND REHABILITATION ACTIVITIES

Although many factors can be put forth as being causes of environmental degradation, at the root of it all lies poverty. The rural populations spend a lot of energy on the struggles of survival, i.e. searching for water for domestic use and livestock, searching for fuel wood (under increasingly stringent "conservation" by-laws) and the obtaining of food. There is usually little resources left for conservation activities. As a matter of fact some conservation activities are at loggerheads with the struggle for survival. It is unnatural to expect sustained popular participation in issues of forestry conservation, for example, when the community relies on the same forest for erecting shelters and for fuel. Thus strategies for environmental conservation must aim at raising the population from the present poverty level.

6.1 Priority research programme on soil and water management

There has been very little research on soil and water management in the study area (and in the country in general). It has generally been accepted that the most limiting factor to crop production in Tanzania is water availability. In most areas, particularly in the three districts under this study, water availability could be improved through optimal utilization of rainfall, since possibilities for irrigation are limited. The next most important limitation is related to soil fertility, which is controlled largely by organic matter. Therefore a large proportion of crop production problems could be solved through development of techniques of optimizing moisture from rainfall and increasing levels of organic matter in the soils.

The highest priority for research in the three districts should be given to the following areas:

. research into different soil and water conservation techniques (including tillage practices, mulching)

to identify suitable ones for the different agro-ecological zones
. research on effects of cover crops, mulching and tillage practices
. development of crop varieties and cultivars suitable for the different agro-ecological zones in the three districts
. types of fertilizer, rates, time and methods of application. Research should also focus on locally available fertilizers, including rock phosphates, composts, farm-yard manure and green manuring
. crop rotations, intercropping, alley cropping and fallowing systems
. integration of crop production in livestock keeping
. productive utilization of rangelands by developing technologies which will address judicial use of rangelands during the wet and dry seasons. Alternative livestock management systems, including zero-grazing, should be identified, tested and extended to farmers
. development of agro-forestry techniques which will be suitable to the semi-arid environment of the three districts using tree species, fodder plants and fruit trees which can withstand six months of dry season
. definition of diagnostic criteria for land degradation assessment
. development of indices for sustainable land use systems
. field techniques for quantifying soil site attributes
. quantification of specific crop requirements
. agro-climatic research to determine optimal integration of rainfall characteristics, soil-water relationships and crop and livestock production
. water harvesting techniques
. relationships between land use systems and land degradation

Focus should be directed to on-farm, problem oriented research which addresses existing problems and provide farmers with practical solutions. This will require a two-way flow of communication, i.e. from the farmer to the researcher and vice versa. This requires that farmers be involved in problem identification, planning, and implementing the research projects. For their part the researchers will be responsible for setting up the experiments and analyzing results. Emphasis should be on small scale farmers who are the ones most affected by land degradation and form the majority of land users. Studies and experiments should be conducted on bench-mark soils within the agro-ecological zones. Data obtained should be correlated with meteorological data and soil characteristics.

6.2 Priority areas of action

Strengthening of the institutional framework

To enhance the coordination mechanism, there is a need of establishing one institution which is not sectoral and is very high on the government and political hierarchy. This institution should preferably be placed under the Vice President's office which, in the present government setup, is charged with environment issues. Such an organization should have an executive as well as technical committee. The executive body will be responsible for recommending to government on coordination requirements, priorities and resource allocation. The technical body will be responsible for planning, evaluating, monitoring and advising different sectors on technical issues. It should be composed of members from different sectors and institutions dealing with land use and management.

Alternative energy sources

Research into the use of alternative energy sources such as cow dung and grain husks and appropriate cooker technology should be encouraged. This will greatly reduce the rate of deforestation associated with fuel wood and cut down the amount of human resource input spent on spent on the its search, especially by women. This should go hand in hand with the establishment of wood lots for fuel wood at the household level.

Provision of water for livestock and small scale irrigation

Nation-wide efforts should be initiated immediately to construct low-cost dams in all sub-catchments. Community-level resources should be used in the construction of such dams and appropriate water rights and rules set up at the village level to control pollution and siltation. Since water from such dams is not expected to be safe for drinking, these dams will primarily be used for livestock and small-scale irrigated horticultural produce.

Identification of grazing lands and their carrying capacities

On a catchment basis, grazing lands should be identified, demarkated and their carrying capacities calculated. This can be done as part of the catchment or village land use plan. Although initially it is not expected that the livestock carrying capacities will be honored, subsequent participatory activities should be initiated aimed at reducing livestock populations to appropriate levels in the earmarked areas.

Other areas of action

Since land degradation is a dynamic process a monitoring programme should be initiated. Monitoring activities will pinpoint areas of high propensity and areas where conservation is having an effect. In this connection remote sensing and GIS technologies should be introduced to land use planners at the district level. Environmental impact assessment studies should be made for all new and on-going land use projects.

6.3 Programme for conservation and rehabilitation of lands

This document has attempted to highlight the types, causes and extent of land degradation in Mbulu, Kondoa and Singida district. It has also given the policy contexts within which any conservation and/or rehabilitation strategies can be implemented. Finally we have endeavored to show researchable and other actionable issues related to the conservation and rehabiliation of lands. This section will give a suggested programme for implementation of actions proposed in this document.

. land use plan
. land use policy
. soil policy
. water policy
. construction of dams for collecting rain water
. establishment of wood lots for fuel
.

7 REFERENCES

Agrar-Und HydroTechnik GmbH, 1984. *Dodoma Region Integrated Development Plan: Land Resources Survey*.

De Pauw, E.F., 1984. *Soils, physiography and agro-ecological zones of Tanzania.* Crop Monitoring and Early Warning Systems Project. Ministry of Agriculture, Dar es Salaam and Food and Agriculture Organization of the United Nations, Rome.

Duthin, D.W., 1950 (pers. comm.). *The mound cultivation in Ufipa*. The East African Agricultural Journal, Volume 16.

FAO, 1982. *World Soil Charter*. Food and Agriculture Organization of the United Nations. Rome, Italy.

FAO/UNEP, 1983. *Guidelines for the Control of Soil Degradation*. Food and Agriculture Organization of the United Nations and United Nations Environmental Programme.

FAO, undated. *Conservation and Rehabilitation of African Lands.*Food and Agriculture Organization of the United Nations. Rome, Italy.

HADO, 1995. *Dodoma Region Soil Conservation Project: **Final report by evaluation mission appointed by SIDA and Ministry of Tourism, Natural Resources and Environment**.*

Hartley, B.J., 1938. *The Erok system of soil conservation*. The East African Agricultural Journal, Volume 4.

Kauzeni, A.S., I.S. Kikula, S.A. Mohamed and J.G. Lyimo, 1993. *Land Use Planning and Resource Assessment in Tanzania: A Case Study.* International Institute for Environment and Development and Institute of Resource Assessment, University of Dar es Salaam

Lunan, M., 1950. *The mound cultivation in Ufipa*. The East African Agricultural Journal, Volume 16.

Magoggo, J.P., A.J. Brom, F. van der Wal and J.L. Meliyo, 1994. *Land resources inventory and land suitability assessment of Mbulu district. Volume 1 to 5*. NSS report R5. National Soil Service, ARI Mlingano. Tanga, Tanzania.

Mbegu, A.C., undated. *The HADO project: what, where, why, how*. Forestry and Beekeeping Division, Ministry of Lands, Natural Resources and Tourism. Dar es Salaam, Tanzania.

MLHU, 1995. *The National Land Policy*. Ministry of Lands, Housing and Urban Development. Dar es Salaam, Tanzania.

MTNRE, 1995. *Dodoma Region Conservation Project. Final report by evaluation mission*. Ministry of Tourism, Natural Resources and Environment. Dar es salaam, Tanzania.

MoAC, 1995. *The Agriculture Policy of Tanzania*. Dar es Salaam, Tanzania.

MoAC, 1995. *Project Profile for Soil and Water Conservation Projects*. DRAFT. Ministry of Agriculture and Cooperatives. Dar es Salaam, Tanzania.
NEMC, 1992. *Tanzania Report to the United Nations Conference on Environment and Development*. National Environment Management Council. Dar es Salaam, Tanzania.

NEMC, 1994. *National Conservation Strategy for Sustainable Development*. National Environment Management Council. Dar es Salaam, Tanzania.

NSS, 1993. *Soil survey guidelines of Tanzania. A first draft*. National Soil Service, Agricultural Research Institute Mlingano, Tanga, Tanzania.

RDD, 1980. *Dodoma Interim RIDEP*. Office of the Regional Development Director, Dodoma, Tanzania.

Samki. J.K. and H. Dewan, 1983. *Soils and Agro-ecological zones of Tanzania*. National Soil Service, Agricultural Research Institute Mlingano, Tanga, Tanzania.

Snowy Mountains Engineering Corporation, 1978. *Singida Region water resources survey. **Volume 1: Report on preliminary assessment.*** Ministry of Water, Energy and Minerals. Dar es Salaam, Tanzania.

Soper, J.R.P., 1956. *The African cultivator*. The East African Agricultural Journal, Volume 22.

Sternhouse, A.S., 1944. *Agriculture in the Matengo Highlands*. The East African Agricultural Journal, Volume 10.