Rehabilitation of Degraded Sub-humid Lands in Sub-Saharan Africa: A synthesis.

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Tanzania

2002

Summary

The continued vicious cycle of population-poverty-and-environmental degradation has been acknowledged. The purpose of this paper, therefore, is to draw attention to the serious consequences of land degradation, a national and trans-national socio-economic complex problem, and the need for rehabilitating degraded lands in the sub-humid lands of Sub-Saharan Africa (SSA). The paper gives the role of forests, global extent of forest and land degradation and its implications. It also describes the Sub-humid zone of SSA, outlines in broad terms: (i) the causal factors (i.e. direct and underlying causes) and impact or consequences of sub-humid lands degradation (i.e. economic, social and environmental concerns) and (ii) extent/trend of land degradation in sub-humid areas of SSA. Rehabilitation efforts through: (i) single-and-mixed species plantations, (ii) agroforestry, (iii) catalysing native forest regeneration, and (iv) fire and miombo regeneration are discussed. The paper also analyses case studies on rehabilitation of degraded sub-humid lands from selected countries in SSA, identifies factors for success and failure and draws lessons to be learnt for successful rehabilitation of degraded sub-humid lands in SSA. Finally it draws from the analysis of case studies, researchable constraints to successful rehabilitation of degraded sub-humid lands in SSA, and makes recommendations for policy, management and research and training for their successful rehabilitation.

List of Abbreviations and Symbols

bill	Billion
C	Carbon
CO	Carbon monoxide
CO_2	Carbon dioxide
COLUFIFA	Committee for the End of Hunger
FAO	United Nations Food and Agriculture Organization
GDP	Gross Domestic Product
ha	Hectare
HADO	Hifadhi Ardhi Dodoma (Dodoma Land Rehabilitation Programme)
ITTO	International Tropical Timber Organization
KEFRI	Kenya Forestry Research Institute
K	Potassium
mill	Million
N	Nitrogen
NGO	Non-Governmental Organization
NWFP	Non-Wood Forest Products
OECD	Organization for Economic Co-operation
P	Phosphorus
PACD	Plan of Action to Combat Desertification
SADC	Southern African Development Community
SAP	Structural Adjustment Programme
SSA	Sub Saharan Africa
SOC	Soil Organic Carbon
t	Tonnes
TFAP	Tropical Forest Action Plan
UNCED	United Nations Conference on Environment and Development
UNCOD	United Nations Conference on Desertification
UNEP	United Nations Environmental Programme
URT	United Republic of Tanzania
WRI	World Resources Institute
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
%	Percent
>	Greater than

Chapter one

1. Main Issues

1.1 General Introduction

Forests in Sub-Saharan Africa (SSA) and other tropical areas provide many wood and non-wood forest products (NWFP) and other services of direct benefit to mankind (Struhsaker, 1987; Kaoneka, 1999). The wood products include: fuelwood, charcoal, round wood, sawn wood, wood based panels and pulp and paper while the NWFP consist of game meat, medicinal plants, fodder, latex, beverages, dyes, fibers, gums, resins, oils, beeswax and honey, tannins and toxins. Other benefits which accrue from the forest include: watershed functions, maintenance of soil fertility, conservation of biodiversity, sustaining cultural values, carbon dioxide (CO^2) sequestration, climatic amelioration and eco-tourism (Kaoneka, 1999). Despite all the invaluable goods and services provided by natural forests, however, their destruction is still going on, which contribute significantly to the current environmental or land degradation. Land degradation, being an insidious process characterized by decreased land productivity, loss of biodiversity, loss of CO^2 sink and diminishing returns from forest investments threatens the livelihoods and environments of many of the world's poorest people (Lundgren and Taylor, 1993; Kaoneka, 1999).

There is a growing recognition that land degradation as a result of over-exploitation of the natural resources (i.e. exploitation level exceeding the carrying capacity of the land) or unsustainable forest-range-and cropland management is global in nature and requires international attention. Rehabilitation is, therefore, considered an important remedy.

The rehabilitation of degraded lands is a subject that is receiving attention in many parts of the world, especially in SSA. The reason for such interest include dwindling or disappearance of forest cover, environmental problems, scarcity of forest products, pressures on remnant natural forests, large areas of potentially productive lands languishing in a highly degraded state or decreased production from the land, decreased infiltration and water retention capacity, increased runoff and disrupted hydrological cycles (floods and water shortages), increased sediment transport and water pollution, siltation of dams and destruction of coastal and marine environments, increased inequality of access to resources, poverty, hunger, social unrest and famine (Rocheleau *et al.*, 1988; Lundgren and Taylor, 1993; Rowe *et al.* 1994; Barraclough and Ghimire, 1996; Ayoub, 1998; INFORSE, 1998; Salami, 1998; Montagnini, 2000).

Estimates on forest cover decline or deforestation, soil degradation losses, desertification and greenhouse gases emissions as a result of over-exploitation and poor management of natural resources are variable probably due to differences in concepts and classifications on forest resources, definition of deforestation and inventory techniques (Palo and Mery, 1990; Mgeni, 1991; Soussan and Millington, 1992; Grainger, 1993) and methods used to quantify soil losses and greenhouse gases emissions as well as a variety of physical, cultural and economic environments.

For example, the report by Rowe *et al.*, (1994) indicate that between 1850 and 1980, about 15% of the earth's forests and woodlands disappeared as a result of human activities. FAO (1995), however, estimated that during the 1980s, global forest, woodland and scrub declined by 2% with 11 mill. ha of tropical forest cover being cleared annually. Studies by Rowe *et al.* (1994) estimate deforestation in the tropics at a rate of 17 to 20 mill. ha annually. The authors further point out that in Africa about 20% of productive tropical forests were logged over by 1985, whereas in Asia and Latin America the figures were 19 and 9% respectively. Between 1980 and 1985 the estimated annual rate of tropical deforestation was 0.6% or 11.4 mill. ha (FAO, 1988). In studies by World Bank (1978) and Seiler and Crutzen (1980) however, 12 or 5 - 6 mill. ha were cleared each year respectively. The state of the world's forest report by FAO (1999) gives the annual deforestation rates of 12.6 and 3.7 mill. ha in the tropics and Africa respectively in the period between 1990-1995. Houghton *et al.* in WRI (1987) pointed out that the forests and woodlands of the Middle East and North Africa declined by 60%, those of South Asia, tropical Africa and Latin America by 43, 20 and 19% respectively. According to Evans (1992), the 1990 survey by FAO clearly shows that deforestation in 62 tropical countries amounts to 16.8 mill. ha $year^{-1}$. Between 1865 and 1985, the percentage forest cover in Thailand dropped from 55 to 29% while West Africa, Ivory Coast and Nigeria lost more than 5% of forest each year (Evans, 1992). In Ethiopia, about 19,000 ha of hill and montane forest are deforested annually, which accounts for about half of the total annually deforested area in the country (FAO, 1993). WRI (1996) estimated that between 1960 and 1990, one fifth of all natural tropical forest was lost. FAO (1982) indicated that 70% of the woodland area was converted into agricultural land while 4 to 5 mill. ha of commercially productive closest forests are logged annually. Traditional farming systems (mainly shifting cultivation) in Africa are responsible for the loss of 4 mill. ha of forest (Quinones *et al.*, 1997). Presently, these traditional farming systems are well known not only to accelerate soil degradation and release of greenhouse gases to the atmosphere, but also lead to weed invasions, impoverished post-fire climax vegetative ecosystems, and loss of biodiversity (Borlaug and Dowswell, 1995). The reports by Oldeman *et al.* (1990) suggest that almost 2 bill. ha (Table 1) of land worldwide have been degraded in the past 45 years (1945-1990), equivalent to about 17% of vegetated soils. Further, about 300 mill. ha of this land has suffered strong to extreme degradation such that their original biotic functions are damaged and reclamation may be costly if not impossible. Also, its estimated that two-thirds of the world's degraded lands are found in Asia and Africa.

The continued threat to the world's land resources is exacerbated by the need to reduce poverty and unsustainable farming practices (Buresh *et al.*, 1997). It has been estimated that at least 25 mill. t of soil is lost per year in erosion (Dover and Talbot, 1987). The FAO projected a global loss of productivity of rain fed cropland of 29% for the period 1975-2000 (FAO, 1984). On per capita basis, Brown and Wolf (1984) estimated a global decline of cropland per person of 19% between 1984 and 2000 and a decline in top soil of 32% per person which is a good indication that the process of soil loss would eventually undermine the world economy if not prevented.

Table 1: Extent of human-induced soil degradation since 1945.

Region	Degraded area		Degraded area share of vegetated land	
	Moderate, severe & extreme	Light	Moderate, severe & extreme	Light
	← Mill. Ha →		← Percentage →	
Europe	158	61	16.7	6.4
Africa	321	174	14.4	7.8
Asia	453	295	12.0	7.8
Oceania	6	97	0.8	12.3
North America	79	17	4.4	0.9
Central America & Mexico	61	2	24.1	0.7
South America	139	105	8	6.0
World	***1,215***	***749***	***10.5***	***6.5***

Source: Oldeman *et al.*, (1990).

Tropical deforestation which in most cases leads to land degradation has been put forward as the main biotic cause of the increase in atmospheric carbon (C). At present, the atmosphere annually absorbs 1 – 3 bill. metric t of C from tropical forest burning and 5.6 bill. metric t from the use of fossil fuel, mainly in industrial countries (Woodwell in Rowe *et al.* 1994). In recent years, the share of the buildup of green house gases in the global atmosphere attributable to the burning of tropical forests has been expanding more rapidly than the share of fossil fuel use (Rowe *et al.* 1994).

Land degradation in (semi-) arid regions often referred to, as desertification is also a result of forest clearance. According to INFORSE (1998), desertification is occurring at moderate or high levels in 1.9 mill. ha (18%) of irrigated croplands, 48.86 mill. ha (61%) of rainfed croplands, and 995.08 mill. ha (74%) of African rangelands (INFORSE, 1998). The annual rate of desertification is about 10% in arid lands, 1% in semi-arid lands and 0.1% in dry sub-humid lands leading to an annual increase of lands affected as follows: 156.9 mill. ha in arid areas, 23.03 mill. ha in semi-arid areas and 1.3 mill. ha in dry sub-humid areas, making a total of 181.2 mill. ha increase per year throughout the dry lands of the world. These figures give an average rate of current desertification of 3.5% per year.

Although land degradation occurs throughout the world, it is more acute in Africa, especially SSA which is characterised by decreasing food production per capita, worst levels of poverty and malnutrition. From these observations it is obvious that land degradation has implications not only for the 600 mill. people (13% of the world total) living in SSA (WRI, 1998) but also for all of us and our posterity which may be adversely affected by it.

Increasing evidence exist to show that there has been a great deal of local governmental and international body's efforts directed at rehabilitating degraded lands, and ensuring sustainable exploitation and management of natural resources (Palo and Mery, 1990; Mascarenhas, 1991; Monela, 1994; Misana *et al.*, 1996). In Tanzania for example, following the concern about the progress of deforestation, the

German colonial administration drew up in 1904 a Forest Conservation Ordinance establishing Forest Reserves on Crown Land where settlement, farming, grazing and all other unauthorized activities were prohibited (Mascarenhas, 1991). This tradition of conservation was continued even after independence. Other measures undertaken by or suggested to local government to halt forest destruction include (Mascarenhas, 1991; Leach and Mearns, 1993; Monela, 1994; Misana *et al.*, 1996):

- afforestation and reforestation schemes (at village and commercial level),
- control of population growth (birth control, improved sanitation and health education),
- reforms of public fiscal, monetary and agrarian policies,
- soil conservation measures and agroforestry (i.e. agrisilviculture, silvopasture and acquasilviculture),
- reconciling wood supply and demand through economic use of the available forest products (e.g. use of energy serving cooking stoves, use of alternative energy sources such as oil and solar energy and compressed crop wastes) and sustainable forest management.

At international level (i.e. international context), the creation of a number of international organizations clearly indicates that land degradation is a national and trans-national social-economic complex problem or a global issue, requiring an integrated approach involving international co-operation in terms of technique and finance if its control is to be successful. As exemplified by Nduwamungu (2001), the United Nations Environmental Programme (UNEP) was launched in 1972 and initiated a new era of incorporating environmental considerations in development and forest policies. Since then, the Organization for Economic Co-operation and Development (OECD), the World Bank and FAO have also been gradually embracing this approach.

In the tropics, the United Nations Conference on Trade and Development (UNCTAD) launched in 1964 with the aim of decreasing asymmetrical features in international trade and exchange between developing and developed nations created in the field of forestry, the International Tropical Organization (ITTO) in 1983 (Palo and Mery, 1990). The major objective of ITTO was to encourage the development of national policies aiming at sustainable use and conservation of tropical forests and their genetic resources and at maintaining the ecological balance. In 1985, FAO initiated the Tropical Forestry Action Plan (TFAP) and afterwards three other UN institutions namely The World Bank, The United Nations Development Programme (UNDP) and the World Resources Institute (WRI) formulated their own programmes with similar environmental concerns (Nduwamungu, 2001). This brought about a joint financing plan aiming at conserving and developing tropical forest resources on a long-term sustainable basis, to benefit not only tropical countries, but also *"all people of the world"*. Since then, depending on the availability of funds, a number of national TFAPs have been established with varying duration (Palo and Mery, 1990).

Desertification a worldwide phenomenon is also a subject that is receiving much attention due to its negative impact on human's welfare, especially in Africa. In the 1970's for example, the international community recognized that the desertification is a major economic, social and environmental problem of concern to more that 100 centuries in all regions of the world. In 1977, the United Nations Conference on

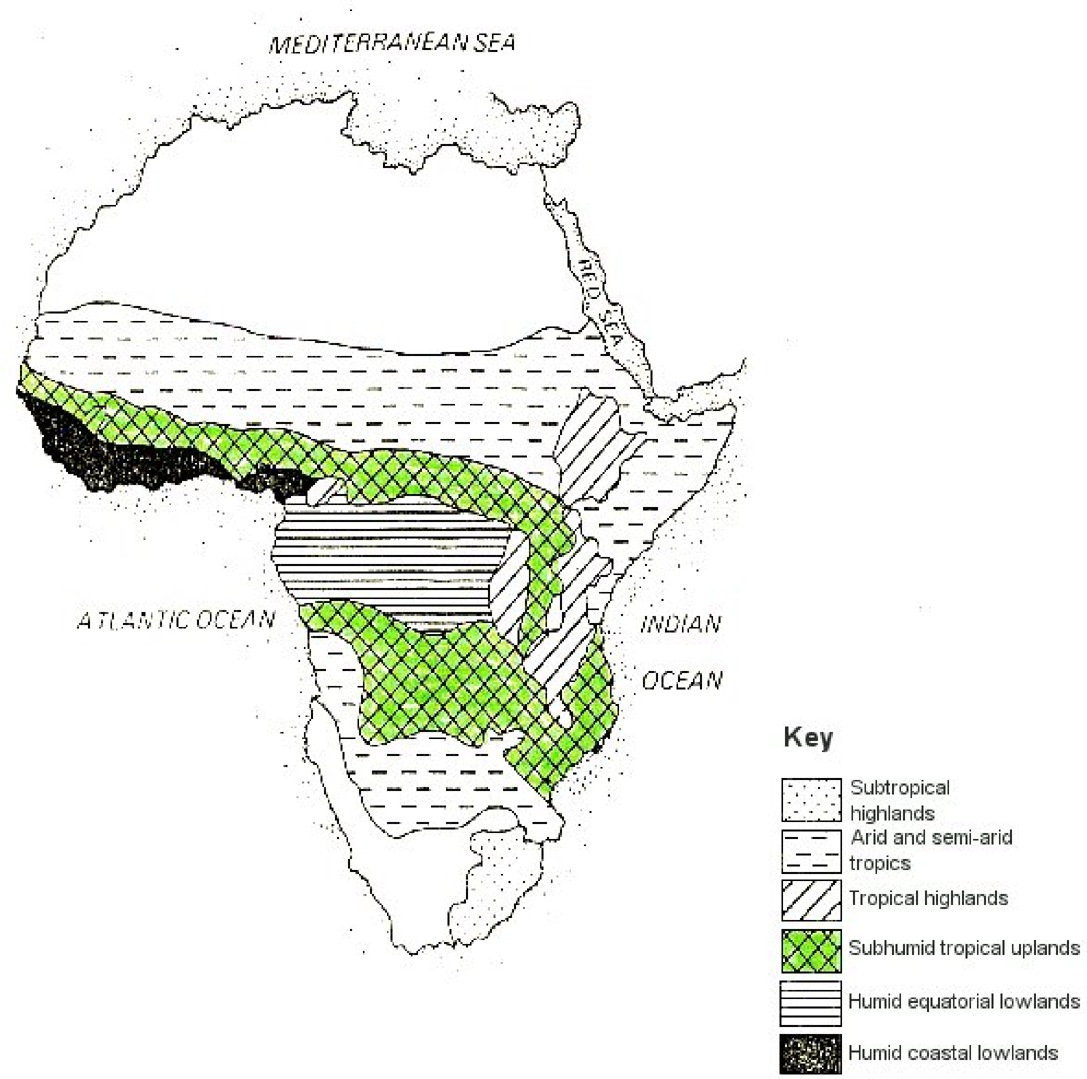
Desertification (UNCOD) adopted a Plan of Action to Combat Desertification (PACD). Unfortunately, despite this and other efforts, the UNEP concluded in 1991 that the problem of land degradation in arid, semi-arid and dry-sub-humid areas had intensified, although there were "local examples of success". As a result, the question of how to tackle desertification was still a major concern for the 1992 United Nations Conference on Environment and Development (UNCED), which was held in Rio de Janeiro, Brazil. The conference supported a new, integrated approach to the problem, emphasizing action to promote sustainable development at the community level. The Convention to Combat Desertification, therefore, strongly emphasizes on a "bottom-up" approach with strong local participation in decision-making. Traditionally, local communities have been relatively passive participants in development projects. Now the Convention puts them on equal footing with other actors in the development process. Communities and their leaders, as well as Non Governmental Organisations (NGOs), are important partners in formulating the action programmes and in carrying out the actions. For this innovative and complicated process to work, awareness campaigns may be needed to inform people about the new opportunities presented by this Convention.

Despite all these efforts/attempts to rehabilitate degraded lands and ensure sustainable exploitation and management of the existing natural resources, however, evidence exist to show that a number of local governments and international bodies/projects have failed to meet their planned objectives mainly because they addressed symptoms rather than causes or used unfavourable approaches to the targeted local communities/end-users of forest products. Also most of the existing land rehabilitation efforts/schemes tend to focus on biological aspects and pay inadequate attention to the socio-economic viability of the system.

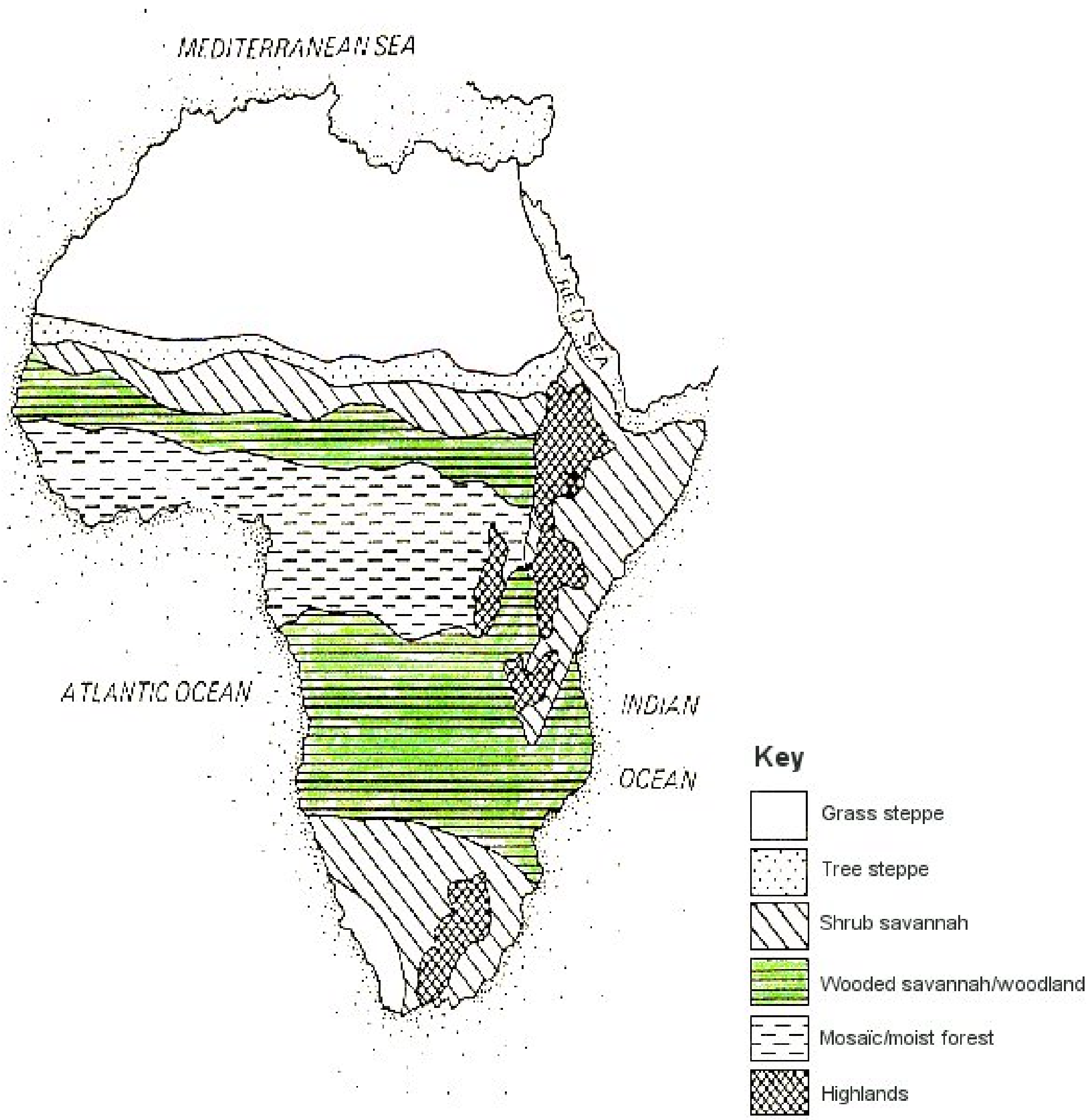
This paper, therefore, describes sub-humid areas of SSA and reviews: (i) causal factors (i.e. direct and underlying causes) and consequences of sub-humid lands degradation, and (ii) extent/trend of land degradation in sub-humid areas of SSA. It also analyses case studies on rehabilitation of degraded sub-humid lands from selected countries in SSA, identifies factors for success and failure and draws lessons to be learnt for successful rehabilitation of degraded sub-humid lands in SSA. Finally the paper draws from the analysis of case studies, researchable constraints to successful rehabilitation of degraded sub-humid lands in SSA, and makes recommendations for policy, management and research and training for their successful rehabilitation. In this review, it is hypothesized that environmental concerns viz. deforestation and land degradation are symptoms and that the real cause lies in policy failures. Often researchers cite population growth as a cause of deforestation. Nevertheless, there is widely held view that population growth is a symptom and that the real cause lies in poverty. People simply respond to socio-economic demands imposed by poverty. In fact the vicious cycle of population-poverty-and-environmental degradation has been acknowledged (Kaoneka, 1999).

1.2 The sub-humid zone of Sub-Saharan Africa

Sub-Saharan Africa is home to 600 million people (WRI, 1998), living in a variety of physical, cultural and economic environments. The sub-humid ecological zone of SSA is depicted in the two maps, showing climate (Map 1) and vegetation zones for the continent (Map 2) (Rocheleau *et al.*, 1988). It is apparent from these maps that the sub-humid zone is characterized with wooded savannah/woodland (e.g. miombo woodlands) or Sudano-Guinean vegetation with an average annual rainfall ranging between 1000 - 1500 mm and mean annual saturation deficit varying from 7 to 12 mm (Rocheleau *et al.*, 1988). Deckers (1993) also defined the sub-humid zone of SSA as a region with a growing period of 180 to 269 days. The predominant soils of this zone are Alfisols, Ultisols and Oxisols with Alfisols being common in the sub-humid tropics (Deckers, 1993). Alfisols are frequently deficient in nitrogen (N) and phosphorus (P), and they tend to acidify under continuous cultivation. They also have a clay accumulation horizon and low capacity to store plant nutrients. Ultisols and Oxisols are well drained, contain little or no weatherable minerals, and have a clay fraction containing kaolinite and oxides and hydroxides of Fe and Al. These soils typically have low cation exchange capacity and low inherent fertility implying that they frequently require balanced fertilization with several nutrients. From these observations, therefore, it is evident that site-species matching is very crucial if rehabilitation of degraded lands in sub-humid areas of SSA is to be successful.



Map 1: Climatic zones in Africa (Rocheleau *et al.*, 1988).



Map 2: Vegetation zones in Africa (Rocheleau *et al.*, 1988)

1.3 The causes, consequences and extent of land degradation in the sub-humid zone of Sub-Saharan Africa

Social, economic and political factors have created incentives for land degradation as a result of inappropriate farming practices and rapid exploitation of forests and intensified pressure on remaining forests and woodlands or deforestation in the sub-humid zone of SSA. Even though it is generally agreed that sub-humid miombo and associated woodlands are increasingly being cleared, the magnitude of such deforestation remains unknown due to lack of reliable data on areas, stocks and yields (Misana *et al.*, 1996). As exemplified in Tanzania, variable estimates of deforestation were recorded. During the 1981-1985 period, the annual deforestation rate was estimated by FAO at 130,000 ha or 0.3% of total forest cover in Tanzania (Sharma, 1992; WRI *et al.*, 1994). While Kaale (1984) and URT (1989) reported an annual deforestation rate of 300,000 – 400,000 ha. Ahlback (1992) on the other hand demonstrated that during the 1990's, the annual deforestation in Tanzania increased to almost 500,000 ha (i.e. 140,000 – 160,000 ha due to agriculture and about 200,000 - 330,000 ha due to fuelwood). Recent estimates by URT (1998), however, clearly show that deforestation rate in Tanzania ranges from 130,000 to 500,000 ha per annum. In the SADC region, Shaba (1993) estimated that about 600,000 ha of indigenous forests are annually cleared for other land uses. This figure, however, appears to be underestimated in comparison with the figures given in Table 2 for seven miombo countries by WRI *et al.*, (1994), FAO (1999) and Nduwamungu (2001). Table 2 illustrates the generally high deforestation rates ranging from 40,000 - 765,000 ha (1980 -1990) and 50,000 - 740,000 ha (1990 - 1995).

Table 2: Forest resources in miombo countries since 1980

Country	Total forest cover (thousand ha)			Annual deforestation rate			
	1980	1990	1995	1980-1990		1990-1995	
				Area (000ha)	%	Area (000 ha)	%
Angola	24812	23385	22200	-143	-0.6	-237	-1.0
D.R. Congo	120597	112946	109245	-765	-0.6	-740	-0.7
Malawi	4011	3612	3339	-40	-1.0	-55	-1.6
Mozambique	18683	17443	16862	-124	-0.7	-116	-0.7
Tanzania	37936	34123	32510	-381	-1.0	-323	-1.0
Zambia	35931	32720	31398	-321	-0.9	-264	-0.8
Zimbabwe	9506	8960	8710	-55	-0.6	-50	-0.6

Source: WRI *et al.* (1994), FAO (1999) and Nduwamungu (2001).

1.3.1 Direct causes

The major direct causes of uncontrolled deforestation and soil degradation in the sub-humid lands of SSA are settlement and agricultural expansion, overgrazing, fuelwood and charcoal production, uncontrolled fires, commercial logging, development of infrastructure/industry and refugees (Kaoneka, 1990, 2000; Evans, 1992; Rowe *et al.*, 1994, FBD, 2001).

a) Agricultural expansion, human settlement and processing

Traditionally, fields under the various shifting cultivation systems were left fallow for at least 10-20 years. In that period, 90% of the wood biomass would regenerate. Over time, the resource/man ratio changed due primarily to relatively rapid increase in population changing the nature of resource utilisation. People cleared the natural forests to form agricultural lands and human settlements and as a consequence, the length of fallow was, in many instances, shortened so that the farming system moved from woodland fallow to bush fallow, and in many cases to grass fallow. This process of intensification has contributed to deforestation and degradation of sub-humid forests of SSA. In fact, the traditional shifting cultivation is the leading cause of deforestation in the sub-humid areas of SSA accounting for 70% of the woodland converted (FAO, 1982). In addition, fires often set by shifting cultivators and other forest dwellers are a major cause of forest degradation and impede regeneration of woody plants (Rowe *et al.,* 1994). This traditional agriculture also results in mining soils of plant nutrients by removing crop residues, leaching, and soil erosion (Smaling *et al.*, 1997).

Tobacco growing is a widespread and a highly economic activity within the small scale farming system in most countries of the sub-humid zone. Tobacco growing however requires substantial quantities of wood for curing and has consequently led to massive clearance, destruction and degradation of sub-humid forests (Temu, 1979, Brigham *et al*., 1996). Woodland losses are amplified by the need for fresh land each year in order to avoid the risk of root-knot nematodes (Misana *et al.,* 1996).

For the sub-humid forests bordering lakes in SSA, wood is cut by the lakeshore communities and commercial fishing industry for fish smoking (Brigham *et al*., 1996). This has contributed to the clearance and degradation of these forests. The burgeoning brick-making industry also takes its toll on the natural forests because of the large amount of fuel consumed during firing (Struhsaker, 1987).

b) Uncontrolled fires

Uncontrolled dry season understory fires are a major cause of sub-humid land degradation. Most of these fires occur in the unreserved forests (public lands or general lands). The fires are caused intentionally or accidentally by people preparing land for cultivation (shifting cultivation), collecting honey, making charcoal, hunting or livestock owners burning to prepare areas to provide green flush for their livestock and to control pests such as ticks (Frost, 1996). Fires tend to be more frequent and intense in areas of low woodland cover and high mean annual rainfall, where grass production is high but grass quality and therefore grazing pressure is low (Frost 1996). The impact of fire on plants depends on the intensity and timing in relation to plant phenology. Late season fires in miombo woodlands are more intense and destructive than fire burning early in the dry season when much of the vegetation is still green and moist (Trapnell, 1959; Frost, 1996). In Zambia, stem mortality of woodland and coppice plots measured after a two-year period was found to vary from 3-4% when early burnt but 18 and 40% respectively when burned late (Chidumayo, 1989 in Frost, 1996). Frequent late season fires in addition to changing species composition also affect vegetation structure transforming woodlands to open, tall grass savanna with only isolated, fire tolerant canopy trees and scattered understory trees and shrubs (Frost, 1996). Other effects of severe fires include: large flux of nutrients leaving the ecosystem through volatilization and rapid mineralization of nutrients and increased microbiological processes (increased decomposition, nitrification and denitrification rates), losses of nutrients through accelerated erosion, and leaching, adverse changes in hydrological functioning (increased runoff, peak flows and sediment delivery to streams), degradation of soil physical properties (breakdown in soil structure, reduced moisture retention and capacity, development of water repellency), losses in microbial populations and associated processes, and decreases in micro- and macrofauna (Neary *et al.*, 1999).

c) Overgrazing

Overgrazing of herbage in the sub-humid forests/woodlands is another important cause of woodland degradation in this ecological zone. Overgrazing in these areas is mainly due to large herds of cattle arising from unwillingness among livestock owners to de-stock and the fact that most of the forests/woodlands are open access (not reserved). The consequences of overgrazing have been land degradation (soil compaction, broken soil crust and erosion) as well as reduced species diversity and density. As most miombo woodland browse species are deciduous, there is nutrient bottleneck during the dry season but overgrazing during the wet season. However, the presence of tsetse fly in some miombo woodlands which transmit trypanosomiasis to cattle has limited the rearing of cattle in these areas.

Studies in Zimbabwe have shown that, heavy browsing significantly reduced the biomass of *Julbernardia globiflora* while in Zambia, heavy browsing within two years led to the death of coppiced stumps of *Brachystegia spiciformis* and *Baphia bequaertii* (Chidumayo *et al.*, 1996). In Malawi, heavy browsing has been found to be detrimental to tree regeneration especially of preferred species (Chidumayo *et al.*, 1996).

Livestock management strategies based on rangeland fencing (e.g. Ngitiris in Tanzania) often conflict with wildlife management by preventing seasonal migration of wild-range animals. In upsetting the ecological balance such enclosures compel both domesticated and wild species to overgraze their respective fodder bases, thereby contributing to further degradation (Rowe *et al.*, 1994).

d) Firewood gathering and charcoal making

In many developing countries, 90% of all wood is used for firewood for cooking and heating and domestic uses such as building poles and fencing materials (Evans 1992). The consumption of firewood ranges between 0.5 and 2.0 m^3 $person^{-1}$ $year^{-1}$ (Evans 1992). Firewood gathering and charcoal making have contributed significantly to forest destruction and land degradation in the sub-humid zone of SSA. Rapid population increase and fast rate of urbanisation have increased the demand for these products while poverty has prevented transition to other sources of energy (Struhsaker, 1987; Monela *et al.*, 1993). Furthermore, wood is inefficiently utilized using unimproved firewood and charcoal stoves. As a consequence, in Africa, firewood use increased from 290 mill. m^3 to 410 mill. m^3 per year between 1970 and 1982 (Evans, 1992). Acute firewood scarcity (i.e. supplies not meeting demand even with over cutting), in 1980 affected 96 mill. people in 23 countries, including those in sub-humid areas of SSA (Evans, 1992). As a consequence, some communities are using cow dung and agricultural residues for cooking instead of leaving both to improve fertility of farm plots.

Charcoal is one of the major products in sub-humid forests and provides an important income for rural dwellers. According to CHAPOSA (1998) charcoal production has become one of the major income sources for rural people in areas where transportation to the big cities is possible. In southern Mozambique for example, 70% of the cash income was from charcoal. In Tanzania, 75% of the farmers in studied areas had charcoal as an important source of income. In Zambia, with the collapse of the agriculture market, charcoal is virtually the only income source in rural areas. Studies in three major cities (Lusaka in Zambia, Dar es Salaam in Tanzania and Maputo in Mozambique) revealed that woodland cover has been reduced during the study period partly due to charcoal production and partly due to increased cultivation. During 1989-1998, forest resources for charcoal production in Lusaka, Dar es Salaam and Maputo areas reduced by 25% (from 32 to 17%), 22% (from 22 to 17% of area covered) and 74% (from 3 to 1%) respectively. Based on projected population growth and wood fuel use trends, the Lusaka supply area would remain with about 80% of current wood resources in the year 2015, the Dar es Salaam area with 20%, and the Maputo area with 15% of current resources. The percentage of closed (natural) forest remaining in the three areas would be 60, 20 and 0% respectively for Lusaka, Dar es Salaam and Maputo. It should be noted that the land coverage of closed forest in the Maputo area was only 1% already in the 1998.

e) Commercial logging

There is some regional variation in the relative contribution of commercial logging to loss of forests and woodlands in the sub-humid lands of SSA. It has been estimated that 20% of productive tropical African forests were logged by 1985 (Rowe *et al.,* 1994). Commercial logging can damage as much as 53% of the remaining smaller trees, destroy as much as 50% of the original forest and disturb 40% of the topsoil (Struhsaker, 1987). Other effects include: suppression of regeneration by weeds or failure to regenerate and damage to the watershed functions of the forests (Kaoneka and Solberg, 1994). Thus ecologically, pitsawing is less damaging than mechanised felling because it results in minimal land degradation as compared with mechanized logging (Struhsaker, 1987; Pocs, 1988; Kaoneka and Solberg, 1994). Pitsawing can, however, cause the following problems when not properly controlled and monitored (Pocs, 1988; Iversen, 1989; Kaoneka and Solberg, 1994):

- altering the under-canopy environmentally opening large gaps inside the forest reserves,
- pitsawing can be wasteful because of poor sawing accuracy due to inadequately skilled cutting crews,
- monitoring of the actual resource inventory in the area subject to pitsawing is difficult. Consequently, far more timber than the official licence allows appears to be taken out illegally from the forest reserve,

- pitsawing disturbs the natural regeneration by taking out trees with good gene pool qualities.

f) Infrastructure and industrial development

Investments in road and railway construction, industries, hydroelectric projects and mineral and oil extraction, necessary to meet development objectives, often entail environmental trade-offs. For example, in order to enhance agricultural development and mining activities, colonial governments constructed roads and railways to access areas with great potential in terms of agriculture and minerals (Misana *et al.*, 1996). In Eastern and Southern Africa, the construction of railways by Germans in Tanzania and British in Zambia in order to promote agricultural development, industries and mining activities resulted into population concentrations, rapid urbanization and high rates of deforestation and land degradation due to domestic woodfuel and industrial wood requirements (Misana *et al.*, 1996, Nduwamungu, 2001). Land degradation also occurs due to mining pits not being rehabilitated. In Tanzania for example, there is a growing number of small-scale miners driven by poverty and the search for alternative income earning opportunities digging thousands of mining pits which are never rehabilitated (Mwero, 2002). When minerals are exhausted, mining sites are abandoned and miners move to more lucrative sites (Mwero, 2002).

g) Refugees

The presence of refugees (with large numbers concentrated in certain locations) in some countries of the sub-humid zone has had severe environmental consequences in terms of rapid depletion of forests and land degradation. In Tanzania there are about 700,000 refugees mostly from Burundi, Democratic Republic of Congo and Rwanda (FBD, 2001). Land clearing for refugee camp sites, construction material, fuelwood and agricultural crop production constitute a major threat to forest resources in refugee populated areas (Babu and Hassan, 1995).

1.3.2 Underlying causes

The above direct causes of uncontrolled deforestation and thus land degradation are driven by market and policy failures, rapid (and uncontrolled) population growth and rural poverty, and the state of economy (Rowe *et al.*, 1994; Kaoneka, 2000). Many of these underlying causes are related and because they are so often embedded in divergent social and economic contexts, their relative importance varies substantially among countries. Solutions to deforestation based on significant policy reforms are more likely to succeed if measures are also taken to control population growth and to alleviate rural poverty.

a) Market and policy failures

Market and public policies are important determinants of how forests are used and managed (Rowe *et al.*, 1994). Market failures refer to the inability of market prices under certain conditions, such as the presence of open access exploitation, externalities, incomplete information and imperfect competition, to reflect accurately the value of marketed and non-marketed or non-tradable environmental services

(Rowe *et al.,* 1994; Wardle and Kaoneka 1999). Such failures also mean that markets are unable to ensure equitable resource and income distribution to promote maximization of collective welfare of the society (Wardle and Kaoneka 1999). Policy failures are consequent upon the following (Rowe *et al.,* 1994; Simula, 1997; Wardle and Kaoneka, 1999; Kaoneka, 2000):

- inability of governments to institute strict centralised management without adequate financial and managerial capacity, the consequence has been inefficient management of forest resources,
- inability of governments to adequately define property rights thereby rendering forests an "open access" resource with consequent risk of over-exploitation and general resource degradation and lack of investment incentives on forest activities,
- inability of governments to charge a sufficiently high forest rent which reflects the real financial cost of managing forests. The low forest rent creates an incentive for inefficient use and over-exploitation of forest resources,
- Implementation of old forest policies which fail to adequately address emerging opportunities and constraints imposed by national aspirations, international agreements and conventions,
- Non-forest incentives (pricing policies, tax incentives and other subsidies) encouraging private investments in leading sectors such as agriculture, energy, mining and transportation, leading to forest conversion to these uses.

Since the mid 1980's, many countries of the sub-humid zone have been implementing the structural adjustment programmes (SAP) aimed at rectifying severe macro-economic problems, including falling export earnings, worsening balance of payments, mounting debts and declining economic growth (Misana *et al.,* 1996). The implementation of SAP has also contributed to unsustainable forest utilisation and land degradation. The SAP package includes: removal of price controls, trade liberalisation, reducing government spending, floating exchange rate of the domestic currency and decentralisation of management roles through privatisation and devolution (Kaoneka, 2000). For the countries that have implemented SAP, a major effect of SAP has been reduced financial capacity of forest departments to manage forest resources effectively. Secondly, peasant farmers who, hitherto, depended on subsidised farm inputs have been compelled to encroach forests in order to expand farmlands to meet the rising demand of food a consequence of family expansion and population growth. This leads to an upsurge in deforestation and degradation (Kaoneka, 2000). On the other hand, higher crop prices may result in increased land clearance as new land is opened up for cultivation (Misana *et al.,* 1996).

Other past and present policies which have contributed to sub-humid forests degradation include (Misana *et al.,* 1996):

- Colonial land alienation policies which led to much of the land especially the more fertile being reserved for European settlers and peasants being concentrated in marginal lands leading to severe deforestation and degradation of forests,
- Colonial policies to encourage cultivation of export crops (like tea, tobacco, coffee and cotton) and mining mainly by settlers, through incentives like technical assistance, financial credit and road and railway construction leading

to accelerated conversation of forests to farms and increased demand for fuel for tobacco curing and urban areas established due to mining activities. These colonial agrarian systems have been reinforced by post-independence agricultural policies,

- Land reclamation policies e.g. in Tanzania where miombo woodlands invaded by tsetse fly were reclaimed by clearing woody biomass,
- Livestock policies e.g. the Tanzanian one which encourages pastoralists to migrate to less populated areas. Thus the problem of land degradation which is characteristic of livestock concentration zones is simply exported to other areas. Bush clearing to control the advance of testse flies is emphasized in the livestock policy and this has hindered re-establishment of woodlands and created impetus for further woodland clearance,
- Resettlement policies e.g. the Tanzania villagisation policy of 1967 which involved establishment of nucleated villages, some in virgin lands which necessitated extensive clearance of woodlands for farmland and settlement expansion. Woodlands became no man’s land open for exploitation by any one,
- Energy policies focussing on the commercial energy sector (electricity), rather than woodfuel used by over 80% of the population in the sub-humid zone. Such inadequancies of the energy policies in addressing woodfuel problems have led to the depletion of forests particularly around major towns/cities,
- Population policies emphasizing on family planning rather than rural-urban migration leading to increased woodfuel demand, usually in form of charcoal and increased deforestation in the vicinity of the urban areas.

b) Population growth and rural poverty

According to Barraclough and Ghimire (1996) many analysts, using national level data, frequently blame deforestation in tropical countries on a country’s population growth and poverty. Detailed local-level case studies in Tanzania, however, reveal that the relationships between population dynamics and environmental degradation are much too complex to support reductionist generalizations about cause and effect (Barraclough and Ghimire, 1996). Barraclough and Ghimire (1996) in a study in Tanzania found out that, in a highland rural area (Lushoto), large population increases led to more cover, while in a lightly populated region (Rufiji), there has been rapid deforestation. In another degraded area, (Kondoa), the authors found for a conservation project (HADO) that, colonial rulers rehabilitated deforested land by excluding local pastoralists and farmers which resulted in social and ecological problems elsewhere. On the other hand, the reports by Palo (1994) and Yirdaw (1996) among others, have shown that there is a significant correlation between population pressure and deforestation, especially when there is a prevailing poverty, an ambiguous land tenure system, lack of agricultural intensification, market failures, and political instability.

In the past, population density in the sub-humid areas of SSA was low and the agricultural systems followed by indigenous farmers did not degrade soil and water resources due to the long fallow period (10 - 20 years) and respect developed by shifting cultivators for the forested areas (i.e. sources of food and medicine) surrounding them. With the coming of outside civilizations, however, indigenous shifting cultivators have been given access to modern life-saving drugs and medicines that have helped prolong their lives. This has resulted in population increases that placed more pressure on the food production systems. Rapid population growth often intensifies pressure to convert forest areas to other uses, as well as exploit forests for short-term benefits (e.g. food and fuelwood supply) (Rowe *et al.,* 1994; Nduwamungu, 2001). As the people interacted with the outside world, educational and economic opportunities began to be available. While such opportunities were noteworthy, they tended to encourage the breakdown in the culture that the early subsistence models used to exploit and manage natural resources sustainably. It has been estimated that between 1997 and 2020, population in SSA will more than double to over 1.1 bill. people (Rosegrant *et al.*, 1995). Investments by national governments and the international community have been insufficient to assure food security, arrest poverty and reduce environmental degradation in this continent, especially in sub-humid areas (Quinones *et al.*, 1997). Indeed, if the present trends continue, food insecurity, malnutrition, and resource degradation will increase, and by 2020, it is conceivable that Africa will need to import between 50 and 70 mill. t per year of food stuffs (mainly cereal grain) to meet the demands of the increased population (Dyson, 1995; GCA, 1996). Almost certainly, Africa will not have the economic resources to produce such huge volumes of food on a commercial basis nor will the international community be willing to provide it as concessional sales or food aid (Quinones *et al.*, 1997).

Poverty is one of the main underlying factors contributing to deforestation and soil fertility depletion (Rowe *et al*. 1994; Quinones *et al.*, 1997). Poverty-led environmental degradation is responsible for much of the degradation of marginal lands, deforestation, overgrazing of fragile rangelands, cultivation of steep slopes, and consequent soil erosion, flooding, and loss of vegetative cover observed in many parts of the developing world, especially in the sub-humid zone of SSA. The majority of rural poor rely heavily on forests and woodlands for income and subsistence. While many traditional rural communities have developed comparatively sustainable forms of resource use, many others are compelled, by circumstances often beyond their control, to exploit forests unsustainably for short-term gain (Rowe *et al.* 1994). Since most of the poor in Africa are rural, and agriculture is their mainstay, therefore, it follows that agricultural development must be the central strategy for economic growth and poverty alleviation (Birdsall, 1995). It is important to stress, however, that hunger, poverty, and environmental degradation in Africa are intimately correlated thus implying that any action to reduce poverty and hunger will assist in minimizing environmental degradation as well (Cleaver and Schreiber, 1994; Quinones *et al.*, 1997).

c) State of the economy

According to Rowe *et al.* (1994) poor economic performance combined with high external debts, pushes countries, especially those of SSA to exploit forest resources quickly for short-term gains. The debt burden provides an inducement to liquidate forest capital. Debt service requirements also provide a justification for expanding export crop production into forest areas. Several countries e.g. Sudan, Liberia, Burundi and Mauritius are heavily dependent on a few commodities for foreign exchange. The pressure to generate foreign exchange earnings, therefore, has led to an emphasis on quick return and unsustainable land-use practices. As a result, most developing countries including those in the sub-humid ecological zone of SSA have adopted policies that led to forest conversion to agriculture and short-term exploitation of forest capital.

1.4 Impact of land degradation

1.4.1 Economic concerns

As experience indicates in many developing countries including those in sub-humid areas of SSA extensive conversion of forests and woodlands causes substantial economic losses at local and national levels (Rowe *et al.,* 1994). Increased sediment deposits resulting from soil runoff from clearings in higher elevation areas may increase annual floods and reduce growing seasons in cultivated flood plains. Deforestation in upland watersheds often causes flooding of lowland settlements, displaces populations, and reduces food production (as in Madagascar) (Rowe *et al.* 1994). In Tanzania, due to deforestation, many parts of the country have been experiencing serious soil erosion problem particularly in the central region, where the widespread sheet and gully erosion have rendered most of the land unproductive (Nduwamungu, 2001). Deforestation has also affected the water catchment areas and the quantity and quality of water they supply. There is also extensive evidence of reduced dry season river flows and drying up of springs and seepage. In West Usambara for example, a total of 400 streams and several springs ceased to exist or become seasonal due to deforestation (Nduwamungu, 2001). According to Struhsaker (1987), removal of forest cover in the southern part of the Rwenzori Mts near Bwera in Uganda, has led to increased flooding and landslides, with loss of life and property. Siltation of major river basins associated with watershed deforestation impedes hydroelectric development and endangers commercial fisheries. This is in conformity with the example from Kenya suggesting that denudation of Mt Kenya's lower slopes has caused massive soil erosion and siltation of major rivers, thus greatly shortening the life of hydroelectric installations (Hughes, 1984), as well as damaging the coral reefs and fisheries on the coast.

The illegal and unsustainable harvesting of the wild coffee *Coffea canephora*, the original wild stock of *Robusta coffee,* typically results in the destruction of more than 80% of the potential crop (i.e. reduced coppicing ability and productivity) suggesting a loss by the Ugandan government of $ 100 000 to 200 000 on the 1985 market (Kingston, 1967; Struhsaker, 1987). For timber, there is increasing evidence that when SSA timber is harvested for export, the revenue that governments collect from logging companies is much lower than what it should be (Rowe *et al.,* 1994; Kaoneka, 1999). Accelerating forest degradation in SSA threatens industrial and fuelwood production as well. The estimated economic cost of tropical forest depletion ranges from 4 to 6% of the gross national product (GNP) in major timber-exporting countries, sufficient to offset the economic gains of forest exploitation (Miller *et al.* 1991; Rowe *et al.,* 1994).

1.4.2 Social concerns

Extensive forest clearing and land degradation in the sub-humid zone of SSA have serious social consequences, especially for indigenous communities and the rural poor (Rowe *et al.,* 1994; Quinones *et al.*, 1997). Over the past several decades, large forested areas in sub-humid areas of SSA (as in Tanzania, Zambia and Mozambique) have been brought under government ownership, overriding traditional rights of forest control in many miombo countries (Rowe *et al.,* 1994; Misana *et al.*, 1996; CHAPOSA, 1998; Kaoneka, 1999). Indigenous communities (including tribal groups) throughout the tropics (Rowe *et al.,* 1994) and sub-humid areas of SSA (Moyo *et al.*, 1993) have been displaced by shifting cultivators, ranchers and commercial loggers. A more serious outside threat (i.e. outside civilization) to the resource poor indigenous communities, however, was their legal status. Even though they and their ancestors may have lived in their current villages for centuries, they had no modern legal evidence that they owned or were free to continue the use of their lands. This meant that not only their way of life but their right to continue to farm was in jeopardy. Their story has human right implications but also suggests the possibility that the world may lose the cultural heritage and knowledge (i.e. traditional knowledge of forest species and genetic resources that have important economic applications) of these indigenous people that is not available outside (Rowe *et al.*, 1994).

In many parts of the world, women being the main producers of food and gatherers of fuelwood and water tend to particularly suffer from environmental degradation. There are indicators that about 100 million people in rural areas and 150 million in urban areas suffered from acute shortage of fuelwood (FAO, 1983). In sub-humid areas of SSA for example, another forceful illustration of deforestation as a result of population pressure combined with agricultural expansion has been the social, economic and environmental costs of fuelwood scarcity to women and their families in terms of increased distance from to fuelwood sources and increased expenditures for the purchase of fuelwood (Barraclough and Ghimire, 1990; Kaoneka and Solberg, 1994; Rowe *et al.,* 1994; Nduwamungu, 2001; Njuki, 2001). As exemplified by Kilahama (1988), until the late 1970s firewood in Tanzania was collected within a radius of one to two kilometres from the village, however, by the 1980s, women in Mwanza, Shinyanga, Mbeya, Mara, and Arusha were walking up to ten or more kilometres looking for firewood. From this example, therefore, it can be noted that fuelwood depletion counters many positive benefits of rural development, as women and children spend more time (daily throughout the year) gathering firewood from more distant sources and less time in other vital activities (e.g. decreased women's farm labour, time spent in cooking) (Rocheleau *et al.* 1988; Rowe *et al.,* 1994). Firewood shortage combined with reduced agricultural income may lead to less firewood for cooking and less frequent or less nutritious meals than people have had (before) in the past (Rocheleau *et al.*, 1988). It may also lead to the increased reductions in time spent by children in schools (Rowe *et al.,* 1994) and the use of animal dung and crop residues for fuel (Rocheleau *et al.,* 1988; Rowe *et al.,* 1994), thus depriving the soil of an important source of nutrients in farming systems where these organic materials would otherwise be applied to the cropland. It has been reported that often 25% of family income is spent on fuelwood due to the increased price of this scarce commodity (Evans, 1992).

Evidence also exist to show that undergoing rapid agricultural settlement and extensive deforestation in many sub-humid areas of SSA has led to the spread of contagious diseases (Rowe *et al.,* 1994). This is in full agreement with studies by NEMC (1995) in Tanzania, also showing that the lack of and poor quality water attributable to the increased sedimentation of rivers and dams and frequency of flash floods reported in several parts of the country have, in many cases, been associated with incidences of many water-borne diseases such as typhoid, diarrhoea and Cholera.

1.4.3 Environmental concerns

Extensive deforestation is associated with a loss of biodiversity, climate change, desertification and degradation of watersheds in the sub-humid zone of SSA (Rowe *et al.,* 1994).

a) Loss of biodiversity

It has been estimated that the total number of plant species around the world range from 5 to 30 mill. (Rowe *et al.,* 1994). The authors further indicate that tropical forests contain about one-half of the 1.4 mill. named species in the entire world biota with 40 - 60% of tropical species being endemic to specific locations in some countries (Gentry in Myers, 1988). This implies, therefore, that the destruction of even small forest areas can eliminate entire species. Wilson (1988) estimated that 10,000 species are extinguished each year because of tropical deforestation. Many of the threatened species, however, have economic value as important sources of food, medicine, genetic material for crop hybridisation, and other marketable products including ornamental plants for export (i.e. ferns, orchids, *Palisota* and *Pollia*) (Struhsaker, 1987; Rowe *et al.,* 1994). The report by Kokwaro (1976) indicates that more than 1300 species of traditional medicinal plants, many of which are found in forests, are used in East Africa. Although people disagree about the degree of reduction and the value of biodiversity, a consensus exists that maintaining biodiversity requires protection of habitats and that, in light of insufficient knowledge, conserving threatened biological resources and habitat is prudent (Rowe *et al.,* 1994). The maintenance of biological diversity is a matter of concern to all humanity as the whole world is benefiting from species that had their origin in tropical forests.

b) Climate change

There is widespread political and scientific concern about the alarming increase in the release to the atmosphere of CO_2 and other so-called greenhouse gases as a result of forest degradation. Forests, as earlier seen, are a storehouse of organic C and help to regulate global atmospheric temperatures and the distribution of moisture. The reduction of sub-humid woodlands, therefore, impairs their important atmospheric functions as C sinks, and the combustion of forest biomass releases into the atmosphere CO_2, contributing significantly to the build up of greenhouse gases and global warming. There are valid concerns about climate change associated with the release of C from both fossil fuels and tropical forests (including woodlands in the sub-humid zone of SSA) (Rowe *et al.,* 1994).

c) Desertification

One of the most pressing problems facing Africa, especially SSA today is desertification, which takes many forms and affects the lives of rural people in immediate, practical ways. The disappearance of forests and topsoils, fauna reduction, erosion of pasture and arable lands, soil erosion by wind and water, soil and water salinization, loss of soil capacity to retain water, and decreasing soil productivity/fertility all these affect the livelihoods of farmers, herders, gatherers, artisans and traders (Rocheleau *et al.*, 1988; Rowe *et al.*, 1994; INFORSE, 1998). Desertification a worldwide phenomenon, but the situation in Africa is among the worst mainly due to poverty leading to heavier reliance on trees for fuel and large-scale migration from poor rural areas to the urban centres of Africa, uncontrolled population growth, inadequate agricultural practices, and increase of livestock beyond the carrying capacity of the land (INFORSE, 1998).

To tackle desertification problem in sub-humid areas of SSA, therefore, there is need to go into the roots of social problems in Africa and elsewhere today as a basis for proposing remedial measures.

d) Watershed degradation

Loss of forests can contribute to the degradation of watersheds with downstream effects. The main effects are disrupted hydrological regimes resulting in reduced discharge and thus water for domestic and industrial consumption as well as soil depletion leading to reduced agricultural productivity (Struhsaker, 1987).

Chapter two

2. Lessons from Case Studies: Factors for Success

2.1 General Aspects: Rehabilitation Techniques

Degraded lands severely impacted by intensive and/or repeated disturbance may still provide a wide range of products (i.e. fuelwood, poles, cattle grazing) and services of value to local community for subsistence and cash income. Caution, therefore, needs to be exercised in the identification of degraded land, its importance to local communities and the need for and methods of rehabilitation and management. Rehabilitation, if required should also seek to identify and enhance the ecological and socio-economic value of such lands to local communities and not deprive them of existing benefits.

In other words, before embarking on a major programme of rehabilitation, the objectives and implications should be carefully examined. According to Vanclay (1994), the objectives may include enhancing timber production, preventing further soil erosion, restoring scenic quality, or restoring a natural ecosystem, and these may be conflicting. For example, in areas with good access, one financially viable option for bringing degraded forest back into timber production is to convert it into industrial plantations, but this introduces two problems: (i) substantial areas of bare soil may be exposed and liable to erosion during plantation establishment, and (i) most industrial plantations are monocultures which provide less diversity, and create a habitat for fewer plants and animal species than does the degraded forest (Vanclay, 1994). Mixed species plantations, community forestry and agroforestry schemes, therefore, may offer greater environmental and economic benefits.

2.1.1 Land rehabilitation through single-and-mixed species plantations

Plantations of fast growing native and exotic trees are assuming an increasingly significant role in landscape management and the rural economy in many tropical regions including the sub-humid zone of SSA (FAO, 1993). Such plantations provide fuel, small dimension timber and NWFP for local communities and are being used increasingly for rehabilitating deforested watersheds and other degraded landscapes particularly in densely populated tropical regions (Barraclough and Ghimire, 1996; Brown *et al.*, 1997). According to the United Nations estimates, tree planting for non-industrial uses (i.e. woodlots for fuel and locally used timber), agroforestry plantings, and plantations established primarily for rehabilitation of deforested watersheds increased dramatically between 1981 and 1990 (Parotta, 1999).

It is increasingly recognized that the traditional rehabilitation method (i.e. monoculture plantations of exotic species) may not be appropriate in all instances or for all purposes (Struhsaker, 1987; Perera, 2000), though silvicultural techniques are better-established and short-term productivity and economic benefits may be high.

The transformation of degraded sub-humid lands of SSA into rehabilitated natural woodlands rather than into monoculture plantations of exotics may be more suitable in the following cases:

- to meet the diverse product (e.g. fuelwood and fodder) needs of the local people,
- to supply valuable indigenous forest species as supplies decline with the depletion of primary woodlands,
- to restore ecological values including biodiversity, watershed functions and soil stabilization,
- the facilitation of natural succession processes can be a relatively cheap method of reforestation and may therefore be particularly suitable for establishment by local resource-poor people.

These driving forces along with increasing local empowerment enhance the interest in and scope for rehabilitating some sub-humid degraded lands to natural woodlands or forests that may be better suited to serving local community and environmental needs, as compared to monoculture plantations of exotics. However, such needs are more often met by establishing plantations of mixed species (both native and exotic as desired), though silvicultural knowledge on mixed species is still limited (Chokkalingam *et al.*, 2001).

There is increasing evidence that mixed-species plantations are more suitable while rehabilitating degraded lands in sub-humid areas of SSA than the single-species plantations due to their high potential for biomass production and attraction to animal seed dispersers as well as increased soil fertility which is in agreement with the reports by Vanclay (1994) and Parotta (1999). The report by Yirdaw (2002) also confirms that mixed plantations furthermore offer such benefits as: (i) diversified wood and non-timber products, (ii) lower the risk of disease and pest outbreak, (iii) protect the soil and improve fertility, (iv) provide shade and protection to valuable understory plants and (v) offer better habitat for wildlife. The inclusion of promising indigenous tree species along with exotic species would further improve the ecological stability and sustainability of forest plantations (Yirdaw, 2002). Mixed forest plantations, therefore, should be given serious consideration in the planning and establishment of forest plantations.

There have been some documented cases of increased productivity or total yields of wood volume in mixed-species plantations as compared to pure plantations in both temperate and tropical regions (FAO, 1992; Yirdaw, 2002). For example, in an experiment in Hawaii a 40:60 *Eucalyptus saligna/Albizia falcataria* mixture resulted in a 140% increase in the total yield of wood over the pure eucalypts at the age of 65 months (Yirdaw, 2002). However, accurate species/site matching and the choice of complementary species is critical to success and the effect of one species on another can change with site and time (Yirdaw, 2002) and gains are also dependent on the timing and scale of forest management interventions (FAO, 1992). This, therefore, is a good indication that appropriate choice of tree/shrub species adapted to the local environmental conditions is very crucial if rehabilitating degraded lands in the sub-humid zone of SSA is to be successful. Although a mixed plantation of eucalypts and nitrogen fixing tree species increases the biodiversity and yield in Ethiopia, the skills required to manage mixed plantations are greater and the initial financial input may be higher than for single species plantations (Yirdaw, 2002). With proper management practices, plantations on degraded lands facilitate natural successional processes and increase biodiversity. Usually, species-rich understories of native trees develop inside plantations, which can be manipulated along with the plantation tree species to develop into a new and diverse forest (Lugo *et al.,* 1993; Yirdaw, 2002). Tree species, which are more effective for erosion control ought to be included in forest plantations and especially in plantations established on steep terrain.

Since tree species differ widely in their nutrient uptake, storage and recycling patterns (Cuevas and Lugo, 1998), the promotion of short-rotation plantations, as a solution to the chronic wood shortages faced by hundreds of millions of people in the sub-humid areas of SSA (i.e. 600 million people in SSA) and other tropical regions (FAO, 1981; WRI, 1998), has raised concerns about their sustainability. Of particular concern is the risk that frequent harvest-related nutrient losses could result in soil fertility and biomass productivity declines over successive rotations, particularly on inherently infertile or otherwise degraded soils where such plantations are often established (Gonçalves *et al.*, 1997). Another set of concerns raised by critics of short-rotation tropical plantations and monospecific rehabilitation programmes revolve around the common use of exotic species and their effects on soil fertility and biodiversity (Vanclay, 1994; Parotta, 1999; Yirdaw, 2002). It is often alleged that exotics, particularly *Eucalyptus* species which is commonly used by reforestation programmes in the sub-humid zone of SSA (as in Ethiopia, Malawi and Uganda), more rapidly deplete soil nutrients and water, and that they inhibit the development of native flora in their understories and accelerate soil erosion because of the necessity of clean weeding at an early stage which expose soil (Struhsaker, 1987; Parotta, 1999; Yirdaw, 2002). In order for these short-rotation plantations to continue to provide social, economic and environmental benefits over successive harvest rotations, a better understanding of tree species' impacts on various aspects of soil fertility, including nutrient cycling processes, is therefore, essential. The report by Parotta (1999) indicates that in the case of plantations established primarily for rehabilitation of severely degraded sites, watershed stabilization, and/or native forest restoration, additional knowledge of how planted trees can facilitate, or inhibit, natural successional processes that lead to the development of structurally diverse and functionally stable forest ecosystem is also needed.

Enrichment planting may also help trees to occupy the site more quickly but the growth of these trees is slow relative to the growth rates of the weed species. Enrichment planting has the following advantages (Malimbwi and Mugasha, 2001):

- partial preservation of internal microclimate and soil protection by the initial growing stock,
- shade demanding species can be regenerated,
- a natural all-aged secondary stand rich in species can be preserved under the upper story formed by the valuable tree species when this or these grow older,
- due to small quantity of plants required, the material and field planting costs are low.

Enrichment planting, however, may not be a feasible technique because there are considerable expenditures due to the indispensable intensive tending of young stands and protection from fire.

2.1.2 Rehabilitation of degraded lands by catalysing native forest regeneration

Restoration of ecosystem health and productivity can cost-effectively be achieved through abandonment of degraded land and subsequent natural forest succession. A study carried out in the forest-savanna edge in Gabon, Central Africa, showed that after three year of protection, vegetation surveys revealed rapid colonization of nascent savannas by 45 species of tree seedlings (King *et al.,* 1997). The study further showed that the soil of the nascent savanna (less degraded) had 5 times more calcium and magnesium and higher organic matter than ancient savannas (highly degraded).

In recent years, there has been consideration of management options to accelerate recovery and restore productivity, biodiversity and other values. There is strong evidence that plantations can facilitate forest succession in their understories through modification of both physical and biological site conditions (Parotta *et al.*, 1997). Changes in light, temperature and moisture at the soil surface enable germination and growth of seeds transported to the site by wildlife and other vectors from adjacent forest remnants (Parotta *et al.*, 1997). Although seed dispersal by animals is the predominant form of dissemination of propagules in many tropical regions including the sub-humid zone of SSA and has the potential to facilitate recolonization of native vegetation degraded sites, the presence in a given site of relevant traits for attracting seed dispersers e.g. the availability of perches, structural complexity of the vegetation and the presence of food resources, especially fruit, as an attractant is very crucial (Wunderle, 1997). Tree plantations with these traits will be particularly attractive to animal seed dispersers and, therefore, will have higher rates of seed rain than plantations lacking these traits.

The efficiency of animal seed dispersal to restoration sites can, however, be limited by the degree of isolation from a seed source, animal seed dispersers in the region and by large seed size (Wunderle, 1997). In highly degraded regions where seed sources may be isolated and animal dispersers rare, restoration will require direct sowing or planting. However, even under the best of conditions with a full complement of animal seed dispersers and nearby seed source, large seeded species, because of their immobility, should be planted if a full return to primary forest is desired (Wunderle, 1997). Forest rehabilitation on degraded lands can, however, be greatly accelerated if fires are efficiently controlled.

2.1.3 Fire and miombo woodland regeneration

Miombo woodland species regenerate largely through coppice regrowth and root suckers rather than through seeds (Robertson 1984 in Campbell, 1996). Chidumayo (1988) observed that stumps of almost all miombo woodland trees have the ability to produce sucker shoots. According to Malimbwi and Mugasha (2001), although seeds of majority of miombo trees and shrubs germinate immediately after dispersal when there is enough moisture, tree density in regrowth miombo woodland decreases with time due to moisture and heat stress. The majority of seedlings of miombo trees experience a prolonged period of successive shoot dieback during their development phase in order to cater for these stresses. Shoot dieback is caused by water stress and/or fire during the dry season. Also with the case of suckers and coppice, fire can either slow or accelerate growth. If a destructive fire occurs before dominant shoots attain a safe height to escape mortality, the process of sucker shoot domination reverts to the initial stage and stumps respond by producing an equal or larger number of replacement shoots (Chidumayo, 1988). However, resistance to these environmental factors varies with species.

Fire was found to be the major ecological factor, which leads to the development of miombo woodland (Lawton, 1978). It is generally agreed that frequent uncontrolled fires are harmful both to vegetation and soil, and that for some purposes controlled burning is beneficial (White, 1993). The impact of fire on miombo depends on time and frequency of burning and on the flammable biomass. Based on burning experiment from 1933 in Ndola (Zambia), Trapnell (1959) reported that repeated late and hot fires may destroy the woodland. About 50% of the trees died after eleven years of late fires. While early burning allowed maintained regeneration, complete protection leads to the development of a more closed, partly evergreen forest. On the other hand, complete protection for a few years leads to an accumulation of fuel which is more detrimental to tree biomass if a fire occurs.

It therefore follows that for the woodland forest to thrive better, fire management regime should be practiced. It is generally agreed that one of the best ways of protecting and managing miombo woodlands is to carry out early burning, that is, to burn patches of grass and undergrowth in the early dry season before the grass gets too dry in order to avoid more intense, more-damaging fires later in the season (Campbell, 1996).

2.1.4 Land rehabilitation using agroforestry

Reclamation agroforestry involves two stages. In the first stage, trees (including at least some nitrogen fixing species) are planted on degraded forest land with the objective of checking further erosion and restoring soil organic matter and fertility status and in the second stage, the cover is selectively removed and agricultural production introduced (Young, 1989, 1995; Kieppe and Rao, 1994; Kessler and Wiersum, 1995). However, time is needed to build-up the enlarged plant-litter-soil nutrient cycle (Kellman, 1979 in Kessler and Wiersum, 1995), a period during which exploitation of the vegetation should be very low with necessary protection from grazing etc. The initial tree removal can be along contour aligned strips, with belts of trees remaining in between, leading by stages towards hedgerow intercropping (Young, 1989, 1995). Other options include fodder incorporation along strips or multi-storey systems (Young, 1989, 1995).

In moist savannas of Benin, studies by Aihou *et al.* (1999) revealed that the alley cropping systems with *Leucaena Leucocephala*, *Gliricidia sepium* (N_2-fixing) and *Senna siamea* restored crop productivity (i.e relative grain yield increase of 107%) on a degraded site characterized by Rhodic Ferralisols and Rhodic Eutrustox soils. Taungya systems (Evans, 1982), which combine agricultural production with tree crops, are commonly used to rehabilitate degraded lands in many tropical countries including SSA. Studies in Tanzania by Kaoneka and Solberg (1994) demonstrate that the *Shambaa* people use their traditional agroforestry and intercropping systems to improve soil productivity and crops yields. This traditional agroforestry system consists of the multi-storey tree garden, which involves the mixing of trees and farm crops in a spatial arrangement. The system includes a spatial mixture of an under-storey of coffee (and fruits), food crops such as maize/beans and a variety of pulses, a middle storey of *Grevillea robusta*, a multipurpose species commonly used for timber, fuelwood and building poles production.

From the farmer's perspective, agroforestry can be a way to reduce deforestation or land clearing and increase crop yields (i.e. food) and the diversity of products grown, but an additional benefit is the creation of a C sink that removes CO_2 from the atmosphere or maintenance of C in existing vegetation and, therefore, has implications for climatic change (Shroeder, 1994). Agroforestry, being one of several approaches for improving land use, is also frequently invoked as an answer to shortages of fuelwood, cash income, animal fodder and building materials in SSA (Rocheleau *et al.*, 1988).

Thus, the provision of adequate soil nutrients by using safe, locally available and low cost organic inputs, and the complementary practices of using improved seeds and proper plant population, weed control, and other cultural practices would ensure increased productivity. The intensification of agriculture was indeed reported to reduce the need to expand cultivation into marginal and ecologically fragile areas (WRI, 1999).

2.2 Case Studies

Today most Africans still live in rural areas, earning a livelihood in small-scale farming, herding and fishing. Their ability to manage the resource base that permits this should not be underestimated. Case studies on successful grassroots development approaches compiled by the WRI and a number of workers testify to the storehouse of knowledge and talent that has for too long gone unnoticed and untapped. This knowledge base can be used not only to protect the natural resource base and livelihoods, but also reverse declines in per capita agricultural production.

Smallholder farmers across the continent, especially those in sub-humid areas of SSA, have taken various measures to safeguard soil and water resources, such as multiple cropping, crop rotations, terracing, agroforestry, check dams, and irrigation canals. Livestock herders have long managed pastures through rotations, restricting land use to safeguard against overgrazing and protecting resources for dry season use. Ngitiri practices in Shinyanga (Tanzania) and community-based management of Duru-Haitemba Forest of Arusha Region and Mgori forest of Singida Region (Tanzania), and other conservation measures in many parts of the sub-humid zone of SSA are among the successful examples of land rehabilitation. Deforestation and desertification in Kondoa, however, is a well-known example of failure by the Tanzanian government, colonial rulers and HADO Project.

2.2.1 *Ngitiri*: a successful traditional method of land rehabilitation in Shinyanga,Tanzania

Background

In the past, Shinyanga region, Tanzania had been extensively forested with woodland and bush land species such as *Acacia, Brachystergia, Albizia, Commiphora* and *Dalbergia* species. However, massive deforestation through shifting cultivation, tsetse flies control campaign in early 1920's and most recently extensive grazing led to soil fertility decline and degradation and the subsequent low crop yields, shortage of dry season fodder, scarcity of fuelwood and construction poles and severe wind and soil erosion (MNTE, 1995). The report by Kamwenda (1999) indicates that between 20 - 30% of the livestock in Tanzania are found in Shinyanga where 18% of the land is utilized for livestock keeping. According to projections by URT (1996), Meatu district in Shinyanga region has the highest number of livestock totalling to 1 404 627. The pressure on grazing land in Shinyanga is quite intense and will continue to become worse due to the high annual growth rates of livestock of 3-5%, short duration of grasses and lack of multiple land use planning (MNTE, 1995). The magnitude of environmental degradation and its subsequent effects due to overgrazing and haphazard exploitation of rangelands forestry resources seem to have overwhelmed the indigenous people who previously used to live harmoniously with these vital environmental resources (Curtis and Ruddy, 1990).

Objective, approach, results and analysis of reasons for ngitiri success

In an attempt to alleviate the dry season fodder supply shortages, conserve and protect soils and reclaim degraded land (Kilahama, 1994a,b; Maro, 1995; Msangi, 1995), the Sukuma agropastoral community use their indigenous silvopasture technology known as *ngitiri*. Studies by Kamwenda (1999) indicate that the ngitiri has the potential of improving the ecology of the site where trees enrich the soil surface through decomposition and mineralization of their litters (i.e. leaves, flowers, twigs and branches). The extensive ground cover of shrubs, grasses, herbs and forbs also help prevent soil erosion and facilitate water infiltration and percolation by reducing surface runoff and increasing soil water storage (Kamwenda, 1999). There is increasing evidence that ngitiri is a widespread and very popular system among the Wasukuma of Shinyanga region comprising six districts since 1920's. Ngitiri regarded, as traditional dry season fodder reserves (Otsyina and Asenga, 1994) are farmer led initiatives that evolved out of the traditional strategies in grazing. It encompasses retaining of an area of standing hay until the rain season ends, the area remains closed to livestock at the onset of rain season and opened up at the peak of the dry season to allow the livestock get dry season fodder (Maro, 1995; Mugasha *et al.*, 1996). Grazing under ngitiri normally starts from July/August of the year after crop residues and forage in fallow areas have been depleted; and animals are removed from ngitiri after all the fodder is exhausted or when fodder becomes available outside the ngitiri (Kilahama, 1994a,b; Otsyina and Asenga, 1994).

There are two types of ngitiri e.g. private ngitiri and communal ngitiri differing in size, location and management. Depending on availability of land the size of private ngitiri varies from 0.2 to 20 ha with an average of 20 ha. Communal ngitiri, on the other hand, are established with mutual consent of village members and, they consist of large areas of 10 to 20 ha with an average of 50 ha. The communal ngitiri established during *Ujamaa* villages only exist in Shinyanga rural and Maswa districts (Otsyina, 1994; Maro, 1995).

Individual or private ngitiri are located around homestead along lowland river ways and on-farm lands away from homestead (Malcom, 1953; Brandstrom, 1985; Maro, 1995; Msangi, 1995). Homestead locations are more preferred for calves, oxen and lactating cows grazing during the wet season (Malcom, 1953; Brandstrom, 1985). Ngitiri on farmland serve several purposes including the provision of fodder during the dry season, soil restoration through fallowing and nutrient cycling and protection of land ownership rights (Otsyina, 1994). Individual ownership pattern of ngitiri proved to have very positive implications in management, improvement and development, as farmers had been more willing to undertake development work on their own land (Msangi, 1995).

Ngitiri are traditionally established on degraded croplands and rangelands, mainly for fodder supply. The sites are demarcated during the wet season, and regularly protected from grazing animals until the most critical fodder shortage period in the dry season (Kilahama, 1994a,b; Otsyina and Asenga, 1994; Maro, 1995). Initial setting of ngitiri area is the responsibility of the family head in the case of private ngitiri whereas a group of elders is involved in the case of communal ngitiri. Site selection is governed by land availability, proximity to homestead, production potentials and ease of protection (Kilahama, 1994a,b; Otsyina, 1994; Maro, 1995; Msangi, 1995). Although ngitiri boundaries are not rigidly demarcated, the ownership right is highly respected and protected by the local community bylaws, which employ local scouts known as *Sungusungu* and impose heavy penalties on offenders.

Ngitiri grazing minimizes weight loss, improves condition of oxen just before the onset of the cultivation season, increases the animal survival and possibly increases milk yield among lactating cows (Otsyina, 1994). Farmers prefer to graze on communal ngitiri or rangelands first and serve private ngitiri for later use when feed sources are exhausted (Otsyina, 1994). To ensure prolonged availability of fodder in ngitiri during dry season and minimize land degradation, the Wasukuma also developed various rotational grazing management strategies (Malcom, 1953). The most common system presently used can be described as progressive deferred grazing which involves demarcation of paddock for specific periods. Upon completion of fodder on particular paddock, animals are moved to a fresh paddock. Duration of grazing on a paddock depends on its size, availability of fodder and the number of animals (Malcom, 1953; Otsyina, 1994; Kamwenda, 1999). In communal ngitiri, paddocks and movements of animals between paddocks is controlled by well informed and experienced elders, who apparently make management decisions on specific indicators such as level of utilization and availability of fodder (Kilahama, 1994a, b). The ngitiri by virtue of their composition mainly trees, shrubs, grasses and their interaction with livestock constitute an ideal agroforestry system capable of eliminating most of the fodder shortage, fuelwood and pole scarcity and soil degradation constraints. The traditional ngitiri system together with the underlying ecological and management concepts, therefore, provide a valuable opportunity and a basis development of sustainable silvopastoral agroforestry systems in Sukuma-land (Mugasha *et al.*, 1996). The extensive farmers and animal keepers' indigenous knowledge about the values of trees and grasses, ecological bases of ngitiri location and management and general acceptance of the system provided potential tools for developing parallel agroforestry technologies such as fodder banks and improved fallow systems (Kilahama, 1994a, b; Maro, 1995). In addition to the development of sustainable silvopastoral systems, it is also possible that the ngitiri system analogy could be valuable for developing other agroforestry technologies on croplands, which could combine fodder production as well as soil fertility restoration in space and time (Mugasha *et al.*, 1996).

Despite the great role played by ngitiri in reclaiming degraded lands this system is presently confronting problems of land scarcity, invaders, encroachment, land insecurity, fire hazards, conflicts, overgrazing, low quality of fodder during the dry season attributable to low availability of quality fodder species and the land restrictions by Government laws (Maro, 1995; Msangi, 1995; Kamwenda, 1999).

Overall assessment of ngitiri success

The success of the traditional ngitiri fodder reserves in Shinyanga region can be attributed to the fact that this system is established traditionally and managed by farmers themselves implying that any land rehabilitation project (e.g. HASHI/ICRAF project) based on this valuable indigenous knowledge is also likely to succeed. This can be testified by the results from Kamwenda's (1999) studies demonstrating that 95% of the respondents (farmers) supported the use of ngitiri to supply dry season fodder and reclaim degraded lands.

Improvements to the ngitiri

Generally, although the agropastoralists of Shinyanga attained the planned objective using their traditional technology, it can be noted that to efficiently conserve land in Shinyanga and increase the availability of high quality dry season fodder and wood based products, however, ngitiri need to be improved and this can be achieved through (Otsyina, 1994):

- introduction of improved fodder grasses,
- planting of fodder trees (MPTs),
- rotational grazing and destocking,
- thinning of the existing trees to encourage grass growth, expansion of ngitiri coverage areas,
- introduction of bylaws protecting these ngitiri and,
- training farmers on how to plant, conserve and manage trees.

Although the Wasukuma have a good knowledge on uses of trees and browse species, studies by Kamwenda (1999) showed a number of technical issues for ngitiri management and improvement including:

- lack of knowledge by farmers about propagation, planting and management of trees,
- absence of tree seedlings,
- lack of proper treatment or care at early stages of tree establishment,
- inadequate knowledge of the site requirements of the tree species (especially MPTs),
- lack of integration of the produce to satisfy various end needs, and
- conflicting primary objectives of land management.

Farmers need to be assisted in some of these aspects in order to improve the ngitiri system.

2.2.2 Successful community-based management of two miombo forests (Duru-Haitemba and Mgori) in northern Tanzania

Objectives and approach

According to Wily (1997), it was for both protection and productive purposes that Duru-Haitemba and Mgori Forests in northern Tanzania were, with others, earmarked for conservation nearly a decade ago. Making the forest pay for itself was by the nineteen eighties a favourite maxim of aid donors in the forestry sector, and with the help of Swedish funds, the typically long and expensive preparatory process of survey demarcation and inventory was launched. In each case the intention was to secure remnant forest against diminishment by future expanding settlement, through the routine deployment of Forest Guards to the new reserves, and especially to secure a source of revenue for the cash-trapped local governments (District Councils), from the issue of licences for timber and pole-wood extraction, and permits for grazing and other forest uses.

Results and analysis of reasons for success or failure

By deploying Guards, villagers felt that the forests were no longer their concern. The fact that Forest Guards could be persuaded to issue permits-legally or illegally- to clear fields in the forests, burn charcoal, fell timber and other activities which elders had not themselves allowed, made their resolve only stronger. In both Duru-Haitemba and Mgori Forests, therefore, large amounts of timber began to be illegally extracted, game hunting multiplied to unsustainable levels, including poaching of elephants for ivory and encroachments by a steady stream of pioneer farmers from neighbouring areas increased. By eliminating the local sense of proprietorship, no matter how weakly this was backed up in statutory law, or implemented on the ground, government also eliminated local guardianship, or recognition in the wider community that the forests were not public property in the "free rider" sense. Indeed, a reversal of local responsibility into a sometimes actively antagonistic mode, both local people and outsiders regarding the forest as there for the taking, and government as "fare game". Even those who were dismayed at the degradation-taking place (and in Duru-Haitemba concerns that forest degradation was already affecting stream flow from the ridges, emerged after a mere two or three years) made no attempt to help government Foresters identify illegal users among themselves or the more commercial offenders from usually more distant areas.

To ensure sustainable exploitation and management of these two forests, villagers offered the way forward. Village leaders (initially the Duru-Haitemba villages) insisted that they, could be active and responsible forest managers and their first claim was to evict encroachers and ban damaging users. With its hands and budget tied, local Government (the Babati District Council) agreed to let them try. The only condition was success; that Duru-Haitemba remains as uncultivated forest and if used, be used in a sustainable, non-damaging ways. Later, in the case of Mgori Forest, which was still seen as having more income-generating potential, an additional caveat was made, indicating that should commercial utilization take place in the future, the Government would receive a share through a simple system of taxation on forest products sold in the official markets.

The Forest Guards were withdrawn, and the village communities provided with facilitatory assistance to decide precisely how they would manage the forests themselves. The main sentiment of villagers at this stage was one of mixed amazement, anxiety and determination, aptly expressed in their fear that "We have a great responsibility. Now we cannot blame Government if our forest disappears. Our children will blame us if we fail". It is of note that without exception each community promptly banned obviously damaging activities, including those which they had so forcefully insisted were "essential forest uses" at the time the forests were to be owned and managed by the government; Government Foresters watched as encroachers were evicted, charcoal production, ring-barking and forest clearing banned, and the mainly non-local loggers "encouraged" to leave the community. An increasingly nuanced range of regulations were devised and implemented through which fuelwood, pole-wood, and other common requirements were able to be sustainably extracted. Most villages zoned their "Village Forest Reserves", closing off the most valuable or most damaged areas to consumptive use, confining permitted uses, including often grazing, to certain areas or months of the year. With their forest springs now protected against livestock, several villages rehabilitated the environs with tree planting. Finally, forest guarding was actively instituted, involving selected young men in the community, thereafter exempt from providing other work inputs in the village, and "rewarded" with a share of the fine payments levied on offenders. It is logical that the prime incentive for these communities to actively manage forests is their sense of "ownership", and control over the use and future of the resource.

In the kind of forest management arrangements that Duru-Haitemba and Mgori represent, all partners may be seen to benefit; Government has lost the burden and costs of fielding Forest Guards and management, and the considerable costs of conflict with local populations.

The villagers themselves gain not only prime rights over the resource but dramatically heightened capacities, again that spills into other spheres of village organization and livelihood. Some villages have used the organization of Village Forest Management to tackle grazing and swamp land management. The forests themselves offer visible evidence of gain; un-regulated in-forest settlement or cultivation, charcoal burning and rampant timber harvesting have all largely disappeared. Boundaries are not only stable but in some cases extended, where a community has added to the area under protection, a trend that stands in stark contrast to the demands for reduction in the size of the proposed Government-owned forest reserves. Damaging forest use of all kinds has dramatically declined to an extent that most villages are looking for additional ways or rewarding their village Forest Guards, than through a share of income generated by fines.

In the more degraded Duru-Haitemba the return of understorey shrubbery and grasses, and the return of bee swarms to the forest, is heralded as a welcome sign of improvement in the forest condition. The return of wildlife in Mgori, is similarly observed. Meanwhile, both Duru-Haitemba and Mgori forests enjoy a level of protective vigilance they have not seen before, either prior to, or during their intended gazettement as forest reserves. For the last 30 months, more than 200 young village men routinely patrol and watch over one or other part of the two forests. This is undertaken at zero cost to Government, and with a level of vested interest in its survival on the one hand, and with a level of local accountability on the other, that no

Government regime could sustainably provoke. Perhaps it is this feature more than any other that signals the advantages of community-based forest management especially cheap-and effective.

2.2.3 Colonial rulers and HADO's failures to rehabilitate degraded lands in Kondoa

Many of the complex interactions between land appropriation, demographic change and colonial and post independence politics are illustrated by Kondoa in Central Tanzania (Mugasha and Nshubemuki, 1988; Barraclough and Ghimire, 1996). The district is frequently cited as a classic example of deforestation and desertification caused by population growth and supposedly careless pastoral and cultivation practices. Over half the district's 1.4 mil ha are badly eroded. The increased caravan trade in Central and Eastern Africa during the eighteenth century induced massive clearing of forested areas (i.e. miombo woodlands) at the supply points for expanded agricultural production and for fuelwood supplies to the iron-smelting kilns.

Colonial rulers' objectives, approach and reasons for failure to reclaim degraded lands in Kondoa.

Towards the end of the 19th century, the rinderpest epidemic decimated the bovine population in East, Central and Southern Africa from Ethiopia and Somaliland to Botswana and the sleeping sickness carried by tsetse fly began to spread southwards into Kondoa-Tanzania. To contain this sleeping sickness affecting the Rangi people, the British colonial administrators of Kondoa embarked on tsetse fly eradication campaigns and mass evacuation of population in danger of sleeping disease and resettled them in concentrated villages in tsetse free areas. Tsetse eradication programmes consisted of clearing woodland and bushes in infected areas of the hills and plains to facilitate resettlement from and destocking in the badly eroded highlands. Colonial rulers also imposed labour-intensive soil conservation practices such as ridge cultivation, contour banking and reforestation. These measures did not take adequate account of the Rangi's customs and livelihood concerns, but the Rangi were too weakened to resist collectively. Some responded to harassments by he colonial officials with apathy, others by migrating to other regions. A net ecological result of the British administration's conservation interventions was to slow land degradation in the highlands but to accelerate it in the lowlands.

Due to the renewed deforestation and erosion as well as food shortages the post-independence government made Dodoma region (of which Kondoa district was a part) the second area of villagization in 1972. The Dodoma Land Rehabilitation Programme (HADO: a swahili acronym for Hifadhi Ardhi Dodoma) was, therefore, established in Kondoa district, Tanzania in 1973, with substantial financial and technical support from Swedish International Development Agency (Sida), to rehabilitate its soils and forest.

Objectives of HADO and Approach

The objectives of HADO as stipulated by the 1973/74-1981/82 Master Plan are as follows (Mbegu and Mlenge, 1983):

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

The programme's approach was in many ways similar to that of the British land rehabilitation effort in the 1930s. It emphasized cattle destocking, soil conservation measures such as contour banking and tree planting for shelterbelts, agroforestry and village woodlots. In severely eroded areas, cattle were excluded, effectively evicting their owners as well. Like the earlier efforts, HADO was a top-down and technocratic project with little real participation by the local people in setting goals or in designing and implementing the project.

Results and analysis of reasons for HADO's failure

The HADO programme did demonstrate that eviction of people and cattle could contribute to the restoration of vegetative cover on some degraded semi-arid lands within a relatively short time but such narrow technocratic approach only exported problems elsewhere.

Chapter three

3. Researchable Constraints, Recommendations for Policy and Management

3.1 Identification of Constraints

Although efforts have and are being made to rehabilitate degraded lands in the sub-humid zone of SSA, a number of constraints inhibit the rehabilitation process to enhance the ecological and socio-economic value of such lands to local communities. These constraints include:

- Government and other stakeholder lack of/limited interest in, policies for, and commitment to rehabilitation of degraded lands,
- Contraction of public sector capacity to control and manage forest resources,
- Lack of/limited community involvement in forest resource management and in rehabilitation of degraded lands with devolution of secure tenure and use rights,
- The lack of other social and economic preconditions (e.g. lack of secure and clear tenure, markets and marketing development for products, and inequitable cost and benefit sharing) play an important role in inhibiting the rehabilitation process. Lack of secure and clear tenure for example results in forest resources being treated as open access resources,
- Poor/limited monitoring of silvicultural, ecological and socio-economic changes of the rehabilitation process,
- Limited silvicultural knowledge on rehabilitation towards natural forest or mixed-species plantations and inadequate species – site matching,
- Poor extension services resulting in limited or lack of adoption of proven technologies (e.g. improved charcoal and wood stoves and agroforestry technologies), as a way of reducing pressure on the forest resources,
- Often the rehabilitation focus is on biological aspects and inadequate attention is paid to the socio-economic viability of the system,
- The species chosen for the facilitation of rehabilitation may have limited value for meeting the subsistence, environmental and market needs of local people.

3.2 Recommendations for Research and Training

From the preceding causal factors and consequences of land degradation, rehabilitation efforts and constraints to successful land rehabilitation process there are research gaps. Research should be undertaken in the following areas:

- The impacts of natural resource policies/legislation, sectoral policies, and macroeconomic policies on sub – humid forests management and utilisation,
- Research is needed on silvicultural management of mixed species stands and species-site matching,
- Nursery studies on methods to raise indigenous trees, especially miombo species need high priority if the indigenous tree species are to be successfully used in rehabilitation,

- Research is needed in finding alternative and more sustainable methods of food production,
- Studies are needed on the valuation of forest resources to estimate the total economic value so as to reflect the value of the forest as a physical asset and indicates the rationale for investing in forests. Valuation is also important in defining property rights as it indicates the actual value of the forest which can be used as a basis for setting proper rents and taxes,
- Training of selected farmers as trainers of fellow farmers should be used as a strategy in the scaling up of sustainable farming systems like agroforestry.

3.3 Recommendations for Policy

Policies are needed which enable local people to adapt and protect themselves in a rapidly changing and usually hostile socio-economic environment. To successfully rehabilitate the sub-humid zone degraded lands, therefore, there is a need for reviewing relevant policies with the objective of improving sub – humid forests management and utilisation. The following are the policy recommendations:

- Governments must have rehabilitation policies and be committed to their implementation,
- Forestry and other natural resources policies should be reviewed to enable involvement of communities and other stakeholders in management and utilisation of general/public lands forests/forest reserves,
- There is need for natural resource policy reviews so that non – gazetted forests/woodlands are not treated as “open access” resources,
- Land policies should be reviewed so as to enable communities and villagers to have secure and clear tenure rights.
- Policies that have impact of woodlands/forests should be reviewed to address issues of incompatibility.

3.4. Recommendations for Management

The following management recommendations are proposed:

- Forests have to be managed in terms of socio-economic, ecological and cultural sustainability or, in other words, in accordance with principles of multi-functionality and equitable benefits/responsibility sharing. Communities should be involved in joint forest management (JFM) of adjacent forest reserves or in community based management (CBM) of unreserved forests (i.e. public/general lands) bordering villages,
- Continued agricultural intensification is essential to achieve the triple goal of (i) assuring production of sufficient food for future generations at reasonable prices, (ii) protecting natural resources from exploitation and (iii) alleviating poverty, hunger, food insecurity and malnutrition ,
- Adoption of agroforestry, a sustainable production system affordable by resource poor farmers so as to ensure food security and wood availability and thus reduce pressure on forest resources. Establishment of woodlots should also be encouraged,

- To reclaim degraded lands through increased sustainable food crop production and reduced rural poverty it is suggested that national and global societies invest in actions that increase the soil's nutrient capital in the long-term,
- Wide adoption of improved charcoal and wood stoves as a way of reducing wood and charcoal consumption due to current use of inefficient stoves,
- To avoid further degradation and improve sustained multiple use of land-based resources there is a need for developing land use plans, appropriate and organized expansion systems and sustainable agricultural practices.

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