RECENT LAND COVER AND USE CHANGES IN MIOMBO WOODLANDS OF EASTERN TANZANIA.

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ABSTRACT

Forest and woodland ecosystems in Tanzania occupy more than 45% of the land area, more than two thirds of which made up of the Miombo woodland. The main form of land use in the Miombo region has long been shifting and small-scale sedentary cultivation. The lack of infrastructure and prevalence of deadly diseases such as malaria and trypanosiomiasis have long limited extensive clearance for cultivation, livestock farming and settlements. However, due to positives changes in the socio-economical, political and technological setup in miombo region, the types and intensity of land use are now changing. This paper discusses preliminary results from a study conducted with the aim of contributing to the understanding of dynamics of land cover and use changes in miombo woodlands of eastern Tanzania. The study area comprises four villages around the "Kitulangalo Forest Reserve", 140 km west of Dar es Salaam on either side of the Morogoro-Dar es Salaam highway. Landsat MSS satellite images of July 1975, Landsat TM satellite images of July 2000 were used to assess land cover changes between 1975 and 2000. Participatory Rural Appraisal (PRA), questionnaire survey and checklists for key informants were the major methods used for collecting socio-economic data. The land cover/use class of woodland with scattered cultivation has recorded the highest percentage of change between July 1975 and July 2000. While all other classes have registered positive changes, only the closed woodland class has had negative change meaning that this class has been decreasing in favour of other land cover/use classes. Recent land cover and use changes are drastic in the study area. These changes have been triggered largely by varied factors including mainly increased population density and subsequent economic activities. Economic activities including charcoal business, shifting cultivation, opening up of improved highway and pastoralism in the study area have greatly contributed to deforestation and woodland degradation. In light of these findings, there is need for:

(1) Adequate land use planning and survey of village lands so as to avoid exacerbation of land use conflict and environmental degradation in the study area.
(2) Agrarian reforms to eliminate open access regimes to natural resources.
(3) Enforcement of fiscal policies related to the extraction of natural resource products such as timber and charcoal so as to reduce pressure on woodlands.

1. INTRODUCTION

Miombo woodlands cover about 2.7 million km² which is about 70% of the Zambezian phytoregion (Millington *et al.,* 1986; White, 1983) extending from Tanzania and the Southern Democratic Republic of Congo in the North to Zimbabwe in the South, and across the continent from Angola in the West to Mozambique in the East. Miombo vegetation is characterised by the dominance of *Brachystegia* species either alone or in association with *Julbernardia* species and *Isoberlinia* species. Forest and woodland ecosystems in Tanzania occupy more than 45% of the land area (URT, 1989) and more than two thirds of this percentage is up made up of the Miombo woodland (Temu, 1979). Miombo woodland is the dominant vegetation type in the Zambezian floristic region (White, 1983). Miombo woodlands provide resources that are vital to the livelihood of millions of rural and urban people living in and around them in central, eastern and southern Africa. In fact, people obtain from these woodlands a multitude of products including food, energy, shelter, medicines and a number of invaluable environmental and spiritual services (Campbell *et al*.,1996).

The Miombo ecosystem has been occupied and utilised by both animal and human beings for centuries. It is believed that miombo woodlands have developed from a combined effect of climate, herbivory and both natural and man-made fires (Frost, 1996). Early interpretations of the dynamics of Miombo woodland development were based essentially on a single-state equilibrium model of a regional climax vegetation. Miombo forests were considered sub-climax to evergreen or semi-evergreen forest, maintained as such by fire, man and large herbivore disturbances (Freson *et al*., 1974; Strang 1974; Lawton, 1978). More recently however, multi-state models have been suggested, arguing that there are multiple quasi-stable states in miombo vegetation structure and composition. Each state has its own characteristics, dynamics and a threshold beyond which a shift occurs to a different state. The shifts are driven by a variety of disturbances (Stromgaard, 1986; Westoby *et al*., 1989; Starfield *et al*., 1993). With repeated disturbances, closed-canopy miombo forests may degrade to open woodland and secondary grasslands, but the process may be reversible if fire is excluded and other disturbances are minimised (Freson *et al*., 1974; Lawton, 1978; Stromgaard, 1988). However, these dynamic processes are still not clearly established.

The main form of land use in the miombo region has long been shifting and small-scale sedentary cultivation. The lack of infrastructure and prevalence of deadly diseases such as malaria and trypanosiomiasis have long limited extensive clearance for cultivation, livestock farming and settlements (Scholes *et al*., 1996). However, currently the types and intensity of land use are changing due to changes in the socio-economic, political and technological development in the region (Nduwamungu, 2001). In fact, the emergence and growth of urban markets for forest products has led to unprecedented clearing or degradation of woodlands for firewood, charcoal, timber and industrial cultivation of tobacco (World Bank, 1990; Misana *et al*., 1996). In the 1990s, it was estimated that about 6000 km² of miombo woodlands were cleared annually (Shaba, 1993). In a recent study, it was reported that about 93% of open woodland were clearcut for commercial charcoal production in eastern Tanzania (Coast, Dar-es-Salaam and Lindi Regions) between 1991 and 2000 (INCO_DEV., 2002). The objectives of this study were:

(1) to assess land cover and land use changes on a local scale in the miombo woodlands since the 1970s,

(2) to identify the socio-economic drivers for the observed changes, and

(3) to discuss management strategies for the sustainable use of the miombo natural resources.

2. METHODOLOGY

2.1 Study area

The study was confined in villages around the “Kitulangalo Forest Reserve”, about 50 km from Morogoro Town and about 140 km from Dar es Salaam (Fig. 1). The socio-economic survey was conducted in Lubungo, Maseyu, Gwata and Kinonko villages. Lubungo and Gwata are traditional villages where most people from scattered settlements were regrouped during the villagisation programme in 1974/75. The villagisation programme consisted in regrouping scattered households in large and easily accessible villages to facilitate provision of development facilities such as water, electricity, social and health centers. Maseyu village was created during villigisation. Kinonko was a traditional village but was depopulated after expropriation by the army in 1969 for the establishment of a military camp in the area, but recently people have started coming back.

The average annual rainfall is 900 mm which is seasonally distributed, providing a wet season from November to May and a dry season from June to October. The annual mean

temperature is 24.8°C while the mean annual minimum and maximum temperatures are 18.6°C and 28.8°C, respectively. This climate supports regular rain fed agriculture. The main crops are maize, millet, peas and simsim. The farms are reported to have low crop yield as a result of infertile soils, lack of adequate soil moisture and poor agricultural implements (Shayo-Ngowi *et al*., 1995).

The main vegetation type is open dry miombo woodland (White, 1983) dominated by *Julbernardia globiflora, Brachystegia boehmii* and *Pterocarpus rotundifolius* having a canopy height of up to 20m The heterogeneous understorey includes as most common woody plants *Combretum* species, *Diplorynchus condylocarpon* and *Dichrostachys cinerea* (Nduwamungu & Malimbwi, 1997). The grass layer is mainly made up of tall *Hyperrenia* grasses up to 1.5m high.

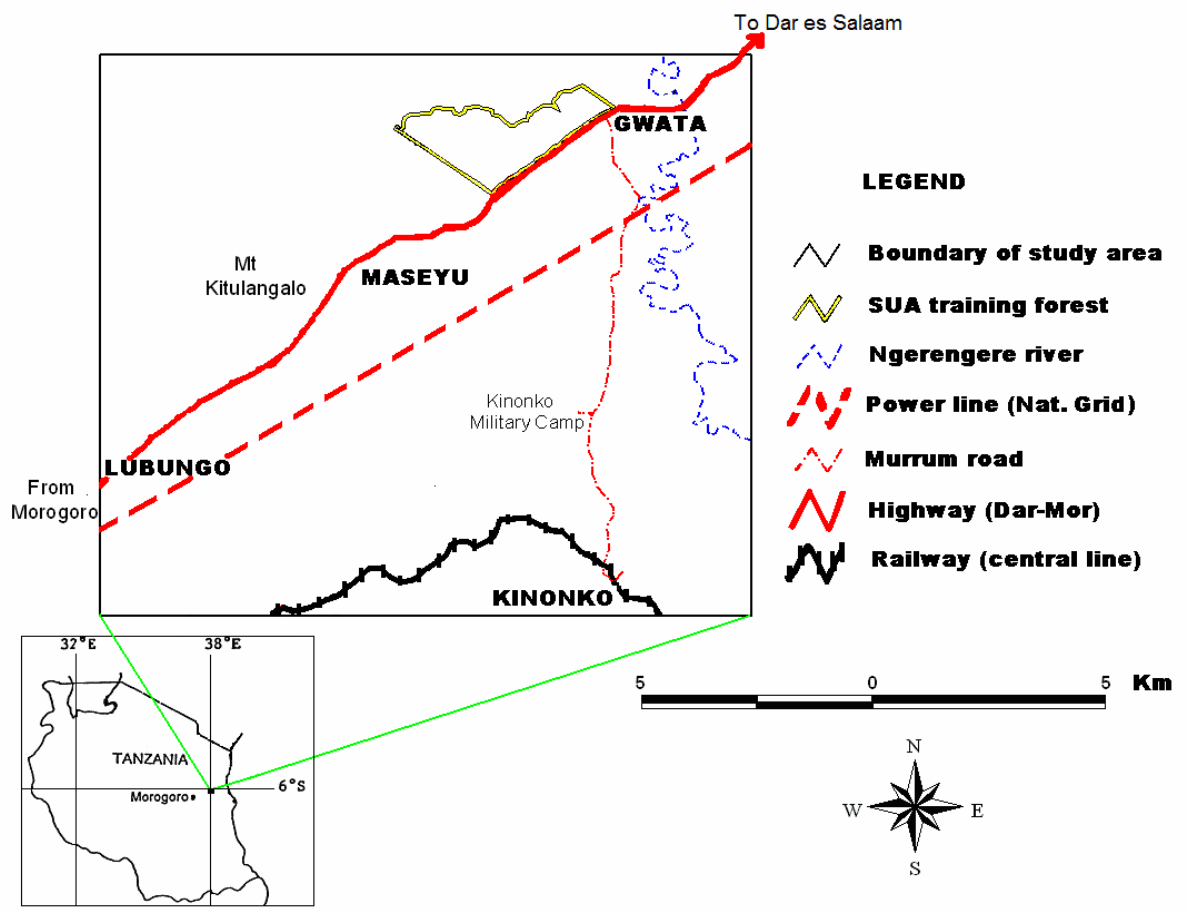

Figure 1: Sketch of the study area and its geographical location

2.2 Materials

The materials used for assessing vegetation cover and land use changes included Landsat MSS satellite images of July 1975, Landsat TM satellite images of July 2000 and toposheets 1/50,000 (Ubenazomozi sheet 181/1 & Mkonowamara sheet 183/2). The instruments used to collect socio-economic data included semi-structured questionnaires and checklists for key informants.

2.3 Data collection and analysis

The interpretation and classification of satellite images involved subsetting and other pre-processing steps including georeferencing or image registration, colour composite and unsupervised classification; ground truthing, screen digitization of some features,,supervised classification and change detection (Lillesand, 2000). Subsetting consisted mainly in selecting and extracting the study area from the full scene images. The images were georeferenced to the UTM map coordinate system so as to be able to use the toposheets for ground truthing . Colour composite and unsupervised classification enabled us to establish major land cover classes before ground truthing to match the reality in the field with the classified image. After ground truthing, the supervised classification enabled to proceed on land cover map composition for each image. The classification of the vegetation types used the following key:

- *Closed Woodland (>20% cover)*: bright red smooth or lightly speckled.
- *Open woodland (10-20% cover)*: blue-green + few bright red or pink speckles.
- *Cultivation& settlements*: pale, pinkish to cream.
- *Woodland with scattered cultivation*: bright red or pink with pale blue speckles.
- *Bareland* (area apparently with no vegetation cover): greyish to white.

Change detection allowed determining changes that have occurred between 1975 and 2000 and their direction. The software used are Erdas Imagine 8.3.1 and ArcView GIS 3.2.

Socio-economic data were gathered through Participatory Rural Appraisal (PRA), questionnaire survey and checklists for key informants. While PRA was held only at Maseyu (non-traditional village) and Gwata (traditional village), the questionnaire survey took place in all the four villages and involved ten respondents randomly selected in each village. PRA participants included representatives from the Village government, the eldery people, the youth and the women. Key informants consisted of local authorities (chairman

and executive secretary), agricultural officers in the studied villages and one or two elderly people in each village. The major issues discussed during PRA, socio-economic survey and checklists for key informants, included the settlement history of the village, major socio-economic activities practiced in the area and their impact on land cover and uses.

3. RESULTS AND DISCUSSION

3.1 Land cover and use changes July 1975-July 2000

The interpretation and classification of the satellite images for the study area have led to the composition of the two historical land cover maps of the study area (Fig. 2 & 3). The results from the analysis of vegetation and land use changes between July 1975 and July 2000 are compiled in Table 1.

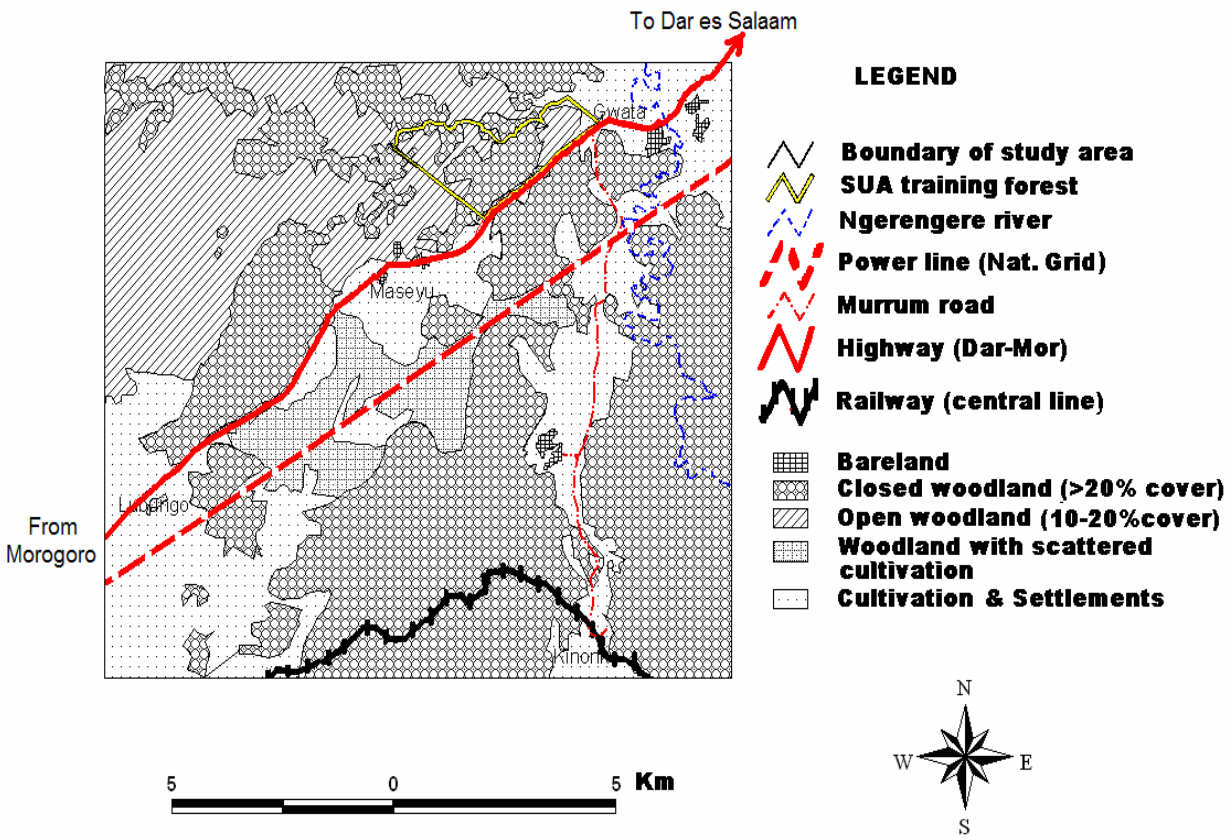

Figure 2: Land cover map for the study area in July 1975

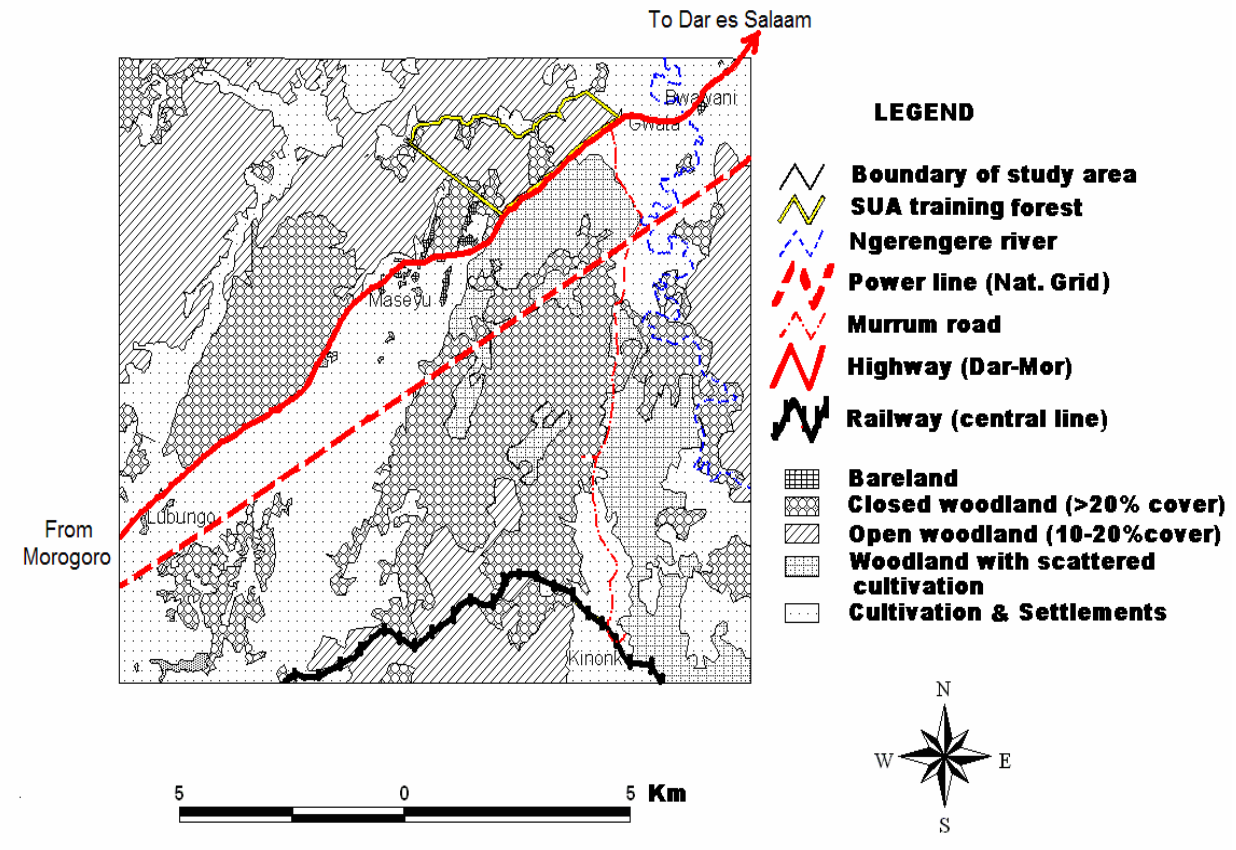

Figure 3: Land cover map for the study area in July 2000

Table 1: Land cover/uses changes between July 1975 and July 2000

Land cover/uses types	Area (ha)			
	July 1975	July 2000	Change (1975-2000)	% Change (1975-2000)
Closed woodland	8289	4599	- 3690	- 45%
Open woodland	3096	4400	+ 1304	+ 42%
Cultivation and settlements	4409	6073	+ 1664	+ 38%
Woodland with scattered cultivation	1001	1699	+ 698	+ 70%
Bareland	186	208	+ 22	+ 12%

The closed woodland class has shown a drastic decrease between 1975 and 2000 while all other vegetation types have largely increased (Table 1). This implies that the class has been decreasing in favour of other land cover/use classes, that is, open woodland, cultivation and settlements, woodland with scattered cultivation and bareland. By observing Fig. 2 and 3, it can be noted that some closed woodlands have degraded into open woodland or were converted into cultivation and settlements. A close look on Fig. 2 and 3, reveals further

that, higher changes occurred close to the road. In fact, a great portion of woodland with scattered cultivation in the vicinity of the Morogoro-Dar es Salaam highway has now become cultivation and settlements. On the other hand, key informants observed that due to discontinued cultivation of sisal in the area since the 1970s, some areas that were under sisal plantation have now regenerated into woodland in areas controlled by the military camp of Kinonko while those falling under public domain are largely under food crop cultivation.

3.2 Major characteristics of the study villages

The study villages, at the exception of Lubungo village, were originally inhabited by people from Kwele tribe. Nevertheless, during the villigisation programme and afterwards other tribes came in particularly neighbouring tribes including the Luguru, Zigua and Kami (Table 2). The tribes from far away include Ha and Mang'ati/Masai which are the most dominant. The Ha people came to work in Sisal plantations at Kinonko while the Mang'ati/Masai people are pastoralists with large herds of cattle who migrated to this area in search of grazing areas. In general, in all the four villages, the number of females is slightly higher than that of males.

Table 2: Major characteristics of the study villages (July 2005)

Features	**Lubungo**	**Maseyu**	**Gwata**	**Kinonko**
Year of registration	1974	1976	1974	-
Origins	Traditional village	Villagisation	Traditional village	Traditional / new village
Number of subvillages	6	5	5	2
Number of households	562	495	368	319
Population	2800	1328	2840	830
Males	1350	640	1308	395
Females	1450	688	1532	435
Active population	800	497	600	250
Major tribes (percents in brackets are only estimates)	Luguru (80%), Kwele, Kami, Zigua, Chagga	Kwele (60%), Zigua (30%), Luguru, Chagga, Mang'ati/Masai	Zigua (60%), Kwele, Kami, Luguru, Ha, Hehe, Masai	Kwele (60%), Zigua (20%), Luguru, Ha

3.3 Major reasons behind land cover and use changes

3.3.1 Economic hardships and uncontrolled immigration

Even though immigration throughout the country increased during periods after independence in 1962 particularly during the resettlement programme (villagisation) of the 1970s, the rate of immigration of people culminated in the 1980s, a period characterized by Structural Adjustment Programme policies. Apart from pastoralist tribes, the majority of immigrants of the 1980s were from towns where they had failed to make a living due to retrenchment and unemployment (INCO_DEV., 2002). These people were compelled to immigrate to the rural areas where they engage mainly in crop farming, extraction and trade of forest products such as charcoal production, timber extraction and casual employment in road works.

The uncontrolled immigration has introduced in the study area new tribes with different land use habits than those of the indigenous tribes. In fact, while the indigenous tribes were mainly practising shifting cultivation, most of these tribes are practising intensive cultivation, charcoal burning and pastoralism. This is maybe why the area covered by cultivation and settlements, scattered cultivation and open woodland has highly increased between 1975 and 2000 (Fig. 2 & 3, Table 1). In fact, during the last twenty years the population has excessively increased in the four study villages. Maseyu village, created during villagisation programme, has registered the highest population increment since 1985. Figure 4 shows the population growth during the last twenty years in the study area.

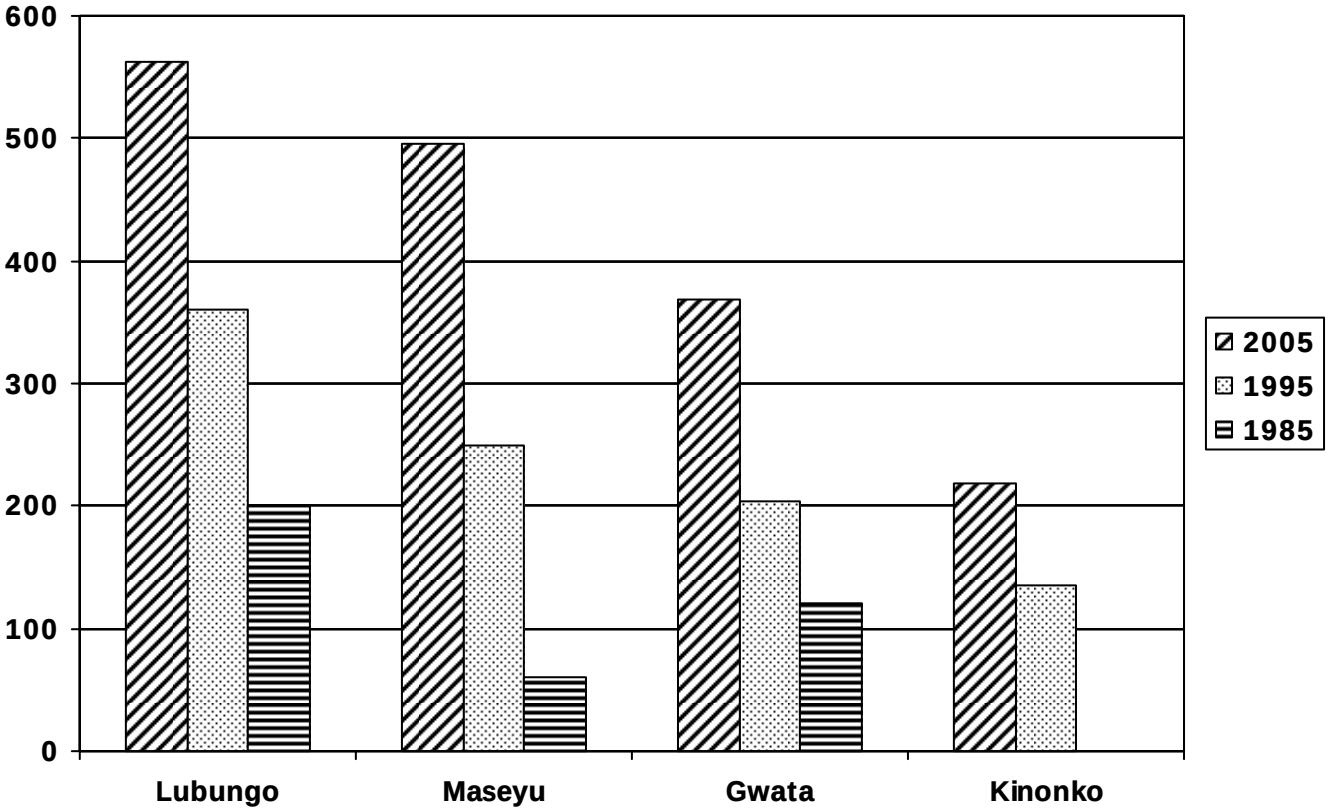

Figure 4: Household number growth from 1985 to 2005.

As mentioned above, one of the land uses that are currently impacting on the environment and livelihood of people in the study area is pastoralism. Although the area was void of livestock prior to 1980s due to the presence of tsetse fly causing the sleeping sickness, now pastoralist tribes such as Mang'ati or Masai (particularly in the Maseyu village) have invaded the area and grazing is common in woodlands of the study area. The coming of pastoralists has added to the problem of woodland degradation (through overgrazing), land use conflicts with indigenous tribes which are essentially subsistence crop farmers. In fact, during PRA meetings, crop farmers complained of the destruction of their crops by passing pastoralists.

3.3.2 Expansion of economic activities

The major economic activities in the study area were reported to include: crop farming, charcoal production, livestock keeping, petty business and casual employment especially in road construction and maintenance works. As in other regions of the country, crop farming came out as the major economic activity in the study area (Table 3). Food crops grown in

the study area include: maize, millet, cassava, irish potatoes, rice and vegetables including pigeon peas, cow peas, tomatoes and onions. Cash crops are mainly simsim and millet. There used to be also sisal plantations but they have now given way to food crops. However, it is not clear whether types of preferred crops cultivated have changed with the coming of new tribes in the area.

The estimated percentage of households involved in the major economic activities as their principal source of income in the study area are shown in Table 3. It should be noted however that the percentages shown do not get income only from the mentioned economic activity. Most families get income from several economic activities and the percentages shown in Table 3 express the major income for the households. For example, most charcoal producers or traders also practice crop farming, while others also do petty businesses and occasionally may become casual labourers.

Table 3: Involvement of local people in economic activities (major income for livelihood)

Economic activities	Percentage of households (%)
1. Crop farming	80
2. Charcoal production	10
3. Livestock keeping	5
4. Others (petty business & casual employment)	5

As discussed above, these economic activities have influenced the changes observed in land cover and uses in the study area. According to Desanker *et al*. (1997), human activities are central to the current dynamics of miombo ecosystems. In fact, interviewed people in the study area argued that some closed woodlands have degraded into open woodlands or cultivation and settlements probably due to shifting cultivation, overgrazing, or charcoal production. The areas under woodland with scattered cultivations are probably those areas affected by extensive charcoal production and subsequent shifting cultivation (INCO_DEV., 2002). In fact during PRA meetings, it was reported that in sites where woodlands are cleared for charcoal production, shifting cultivation is practiced in the more fertile patches. These patches can be cultivated for about five to six years and then left fallow for about four to five years.

Charcoal production is a highly lucrative activity for the local people particularly during recent years after the rise in the price of energy such as petroleum, electricity and gas. INCO_DEV. (2002) reported that 23% of people in woodland areas in the vicinity of Dar es Salaam were solely surviving upon charcoal business. In July 2005, one bag of charcoal was sold at 1500 Tshs (1.5 USD) at production site, 3500 Tshs (3.5 USD) at roadside and 8000 Tshs (8 USD) in Dar es Salaam

Meanwhile, the use of woodlands for charcoal production has several ecological implications. At first, there is a depletion of mature woodlands and trees favoured for charcoal production. As the favoured species grow scarce, the less favoured mature trees are also used. When no mature trees remain, then charcoal production can no more be sustained in the area. The fate of the area at that time will depend on external factors such as population pressure and resulting land uses. In the case of shifting cultivation, usually the land is abandoned after a period, and left to regenerate as open woodland. In the case of permanent cultivation and settlement, stumps are cleared and the land remain cleared indefinitely (INCO_DEV., 2002). Heavy grazing also results in a similar outcome. However, in this case only species unsuitable for forage proliferate (Desanker *et al.*, 1997).

The opening of the Morogoro - Dar es Salaam highway has also contributed to land cover and use changes due to highway users often being implicated in starting fires through careless disposal of campfires and cigarette butts. The improved accessibility has also increased charcoal production and timber extraction due increased commercialisation outlets. This was also noted by Desanker *et al*. (1997) that in addition to population dynamics, infrastructure improvement has been an important determinant of general trends in deforestation and degradation of miombo woodlands over decades. However, Desanker *et al.* (1997) argued that inter-annual variability is not tightly linked to such parameters and believed that econometric variables are probably better predictors of deforestation and degradation of miombo woodlands.

4. CONCLUSION AND RECOMMENDATIONS

Recent land cover and use changes are remarkable in the study area. These changes have been triggered largely by varied factors including mainly increased population density and

subsequent economic activities. In fact, the growth rate of the population in the study area is very high largely as a result of uncontrolled immigration since the villagisation programme. Economic activities including charcoal business, shifting cultivation, opening up of improved highway and pastoralism in the study area have greatly contributed to deforestation and woodland degradation.

In light of findings from this study, there is need for adequate land use planning and survey of village lands so as to avoid exacerbation of land use conflict, environmental degradation and inappropriate land uses in the study area. Moreover, investing in agricultural intensification through provision of adequate inputs (such as fertilisers and improved seeds) and modern agricultural implements and technologies would reduce the need for clearing more land for increasing crop production to satisfy local community needs. Lastly, there is need for enforcing fiscal policies related to the extraction of natural resource products such as timber and charcoal so as to reduce pressure on woodlands and for prohibiting open access regimes to natural resources. This would be partly achieved through local community involvement in the management of natural resources by joint forest management or community based management practices.

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