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Population Dynamics and the Contraction of the Miombo Woodland Ecozone: A Case Study of Sikonge District, Tabora Region, Tanzania

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ABSTRACT
A study was conducted in a cereal-tobacco farming system in Sikonge District, Tabora Region. The objective of the study was to determine the implications of forest resource demand by the ever growing population. A social survey was conducted in the period 2011-2012. Randomized stratified multistage sampling using proportionate population sizes was employed to select 365 households and six institutions in the study area. Assessment of vegetation cover change was based on time-series satellite images and repeated aerial photographs. Data processing and analysis was accomplished by the use of ERDAS Imagine Version 8.7 and Statistical Package for Social Sciences (SPSS). The results revealed that depletion of closed woodland between 1984 and 2012 was 46.7 hectares per year on average. Likewise, cultivated land increased by an average of 265 (0.8%) hectares annually within this time period. The expansion of cultivated land was at the expense of the Miombo woodlands fueled by internal and external socio-economic drivers led by population growth, agricultural expansion, domestic fuel wood and charcoal and increased demand for tobacco curing.
Key words: Population growth; Miombo woodland; socio-economic drivers; land use/land cover changes.

INTRODUCTION
Several studies have shown that, miombo woodlands are no longer supporting human activities due to significant reduction in size and increased demand (Prins and Kikula 1996; Ngulumbe et al 1997; Chidumayo and Kwibisa 2003; Walker and Desanker 2004). FAO (1982) estimated that tropical forests were vanishing at a rate of 7.3 million ha per annum. According to Burgess (1993) the extent of tropical deforestation reached 16.9 million ha per annum, at an annual deforestation rate of 0.9% throughout the 1980s. Projections by FAO (1982) indicated that 150 million ha or 12% of the remaining closed tropical forests and roughly 76 million ha of open tropical woodlands would be deforested within 20 years. In Tanzania, miombo woodland is disappearing at a high rate. A study conducted in Tanzania showed that, about 91,200 ha of forest is cleared each year through tobacco curing, field expansion, fuel wood, construction, bush fire and lumbering (MTRE 1989; Ramadhan 2002).

As regards small scale tobacco curing, Temu (1979, 1980) reported that $20m^3$ of miombo wood is used to cure 1 ha of tobacco, while (Wahid 1984; Siddiqui 2001; Schwartz et al 2002) revealed that $15m^3$ is used to cure 500 kg. On average, of recent, tobacco farmers use $1m^3$ firewood to cure 57 kg of tobacco (Abdallah and Sauer 2005, 2007). However, the actual amount of firewood used varies with the design of the barn.

As the area under forestry in the world is decreasing, the population is increasing at an alarming rate. Every year approximately 100 million people are added to the globe. This rate will lead to a population of 8.5 billion people by the year 2025 (Turner 1996). The increased population means increased land and food which depends on the expansion of cropping land for food production (Chidumayo and Kwibisa 2003; Walker and Desanker 2004). This will further deplete miombo ecozones in tropical Africa and hence the concern on the miombo ecozones sustainability. Miombo forest plays an important role in the world. It is the source of energy for majority of people, medicinal plants, food, animal feed and acts as a cushion for global warming. In Tanzania it provides areas for crop production, source of timber, food and shelter for wildlife (Misana 1999; Monela et al. 2000; Schwartz et al. 2002).

There is evidence showing that during recent years, there has been extensive deforestation throughout Tanzania. This land degradation process, during the last two decades or so, has been caused by, among many other factors, land clearing for both small and large scale farming; procurement of biomass energy for processing agricultural products (e.g. tea and tobacco), and for domestic and industrial consumption and procurement of building materials. These factors have, to a large extent, been influenced by the high rate of population growth during the last two decades.

Vegetation in Tabora region and Sikonge District in particular is primarily miombo woodlands with pockets of bushland thicket, grassland (higher elevations) and wetland vegetation consisting of wooded grasslands and swamps in lower elevations. The miombo woodland in Sikonge district is under threat due primarily to increasing population. Available statistics point out that in the 1988 national population census, Sikonge District had 78,633 inhabitants. The 2002 population census had 123,733 inhabitants. Population projections which were made up to 2008 showed 145,011 people, at a growth rate of 4.83 per annum. Demand for wood products, mainly fuel wood is increasing due to increased population. It is estimated that about 70% of the demand for wood originate from urban and rural households (10% and 60% respectively) and from tobacco (30%). Land clearing for agriculture further accelerates deforestation. Agriculture is the most important economic sector in Sikonge District. A statistical breakdown of the local economy shows Agriculture (78%), Business Operations (7%), Elementary Occupations (4%), and Office Work (3%) (Sikonge District Council Profile 2010).

Rapid urbanization taking place in Tanzania is due to rural-urban migration and natural causes such as births and a decreased child mortality rate in towns (Elgizouli 1990; Karekezi and Majoro 1999; Sauer 2007). Most of those arriving from the countryside to settle in towns fall in the low income group who predominantly depend on traditional biomass for their energy requirements. This high rate of urbanization, too, has had extensive impacts on the peri-urban environments. Sikonge urban centre is one such fast growing urban ecosystem with an estimated population of 174,472 (Sikonge District Council Profile, 2010).

The growing rural population in Sikonge District on the other hand is also increasing the demand for energy disproportionately as observed trends in land use/land cover changes indicate that deforestation and the encroachment of cultivation in woodland areas is alarming. Cultivated land particularly for cereal and tobacco growing is increasing annually. This expansion of the cultivated land seems to be at the expense of the Miombo woodlands. Unless urgent action is taken to satisfactorily mitigate this energy demand, Sikonge and Tanzania in general risks economic stagnation and escalating poverty levels which will sustain over-reliance on traditional biomass energy and consequently exacerbate deforestation.

Theoretical Perspectives on land use responses to Population Change

One of the first comprehensive theories of population-land use relationships was developed by Thomas Malthus. Malthus posited that population growth would lead to famine and an eventual population crash due to the fact that human populations grow geometrically while food production increases arithmetically (Malthus, 1873). Additionally, Malthus stated that since the most productive land tends to be used first, as rural population increases, the average quality of new agricultural land brought into production declines. In response to technological advances unimaginable to Malthus, Boserup presented the notion that population growth should encourage technological changes to increase food output per unit of land (Boserup, 1965). Given our understanding of the theoretical linkage between population and agricultural land use in developing regions, it is expected that a negative relationship between population density and forest clearing per unit rural inhabitant will surface and that Tanzania will experience a similar scenario over time.

The general objective of this study was to assess the impact of cereal-tobacco farming and other anthropogenic activities on miombo ecosystem in Sikonge district while the specific objectives were to; (i) quantify the spatial-temporal land cover dynamics from 1984 to 2011 in the Sikonge District miombo woodland; (ii) determine the trend, nature, and magnitude of land use land cover change; (iii) evaluate the socio–economic implications of traditional biomass energy production on the environment and; (iv) forecast the future pattern of land use land cover in the area.

MATERIALS AND METHODS

Study Area

The location of the study was Sikonge District which is one of the 6 districts of Tabora Region.

Fig 1. Study area map showing location of study sites
Source: Sikonge District Council 2012

The district has geographical coordinates of 5° 38' 0" South, 32° 46' 0". It is bordered to the north by the Uyui District, to the south by the Mbeya Region, to the northwest by the Urambo District and to the east by the Singida Region. Sikonge District covering an area of approximately 21000 km^2 is administratively divided into 11 wards: Chabutwa, Igigwa, Ipole, Kiloleli, Kiloli, Kipanga, Kipili, Kitunda, Pangale, Sikonge and Tutuo.

Population and Sampling

Sikonge District had a total population of 133,388 (0.34 percent of total for Tanzania) with a growth rate of 4.83 per cent per annum and the urban centre had a population of 27,113(NBS 2002). Total number of households in a district was 22, 249 while 6.3 was the average household size. Assuming a projected annual growth rate of 4.83 per cent, the population of Sikonge District was estimated to be 174,472 (Sikonge District Council Profile, 2010).

The study population consisted of residents of Sikonge urban centre and all farmers dealing with tobacco production in Sikonge District. The sampling frames were the residential areas and institutions within Sikonge District, while the units of analysis (study objects) were the households and different institutions (schools, college, restaurants/hotels, and hospitals). For households, stratified multi-stage random sampling was applied and the various strata were: the low, middle and high income households. Stratification was important because unlike in the rural set up, income level is a factor that governs the pattern of energy consumption in urban areas. Stratification was based on the type of dwelling unit which to a large extent represented the income level of the residents. The types of houses in the residential areas were used as a guide to the level of income, thus; Sikonge urban centre with a higher concentration of mansions was purposely chosen to represent the high income households. Tutuo with a predominance of one to three permanent houses represented the middle income ones, while Igigwa, Kitunda and Kipanga areas with a proliferation of semi permanent houses and shanties represented the low income households.

For the institutions, lists of schools, hotels/restaurants, hospitals, and college were obtained from the Sikonge District Council. Through the assistance of random table numbers, these lists were used to select the required number of institutions. In all instances, slightly more than the actual number of households/institutions to be surveyed was chosen. This was purposely done to compensate for any defaulters. As a result of this sampling procedure a total 365 households and 6 institutions were sampled for the study.

This study relied on a social survey. Qualitative data was derived from cereal-tobacco farming and energy use experiences of households and institutions within Sikonge District. Through analytical research, available aerial photographs and satellite images, coupled with ground reconnaissance and personal interviews in cereal farming, tobacco curing, fuel wood and charcoal production areas, the relationship between these activities and environmental effects was determined.

Tools and Techniques for Gathering Survey Data

The study used the following tools in the order presented: Questionnaires were administered to households and institutions to obtain information on personal details, settlement, and tobacco curing and domestic energy use. Charcoal/fuel wood transporters were personally interviewed to establish the sources and destination of their products. Focus group Discussions with charcoal producers and in-depth individual interviews to opinion leaders namely: *Vitongoji* chairpersons (Kitongoji is a local name given to the lowest administrative unit in the rural local government system in Tanzania), Forest Officers and Agricultural Officers in tree felling and energy production areas were conducted. This highlighted the extent of deforestation in these areas, which was related to the quantities of charcoal used in the urban centre as well as the quantities of fuel wood used in cereal-tobacco farming villages.

Quantification of Charcoal and Fuel wood Consumption by Households and Institutions

Spring balances were used to weigh biomass energy (charcoal and fuel wood) consumed by households and institutions. Weights were taken for 15 days: five days in January 2011, and the rest were spread up to November 2011. This was done to take into consideration the little variations which may have occurred in energy use across months. Every day in each of the households, the research assistants who were chosen from within the study areas weighed and recorded the fuel wood and /or charcoal to be used. Where there was bulk storage of charcoal, the whole sack of this energy source was weighed then the following day at the same time of the previous weighing, the next weight was taken and the difference noted. This established the quantity of charcoal used on that day.

As for fuel wood, where households and institutions kept large stacks of wood, a request was made to the owners to set aside quantities that would satisfy about three days' use. This smaller stack was weighed and subsequent weights taken in the following days, the difference was recorded as the quantity of fuel wood used on a given day. As the stack subsided, more wood was added from the larger one and the new weight noted. In the poor households of Igigwa, Kitunda and Kipanga, it was evident that most families could not afford to buy and store charcoal or fuel wood for future use. In this case they indicated the amounts and were weighed to determine their daily consumption. Hotels/restaurants, schools, hospitals and college which used a lot of charcoal had their daily consumption weighed in terms of sacks.

Quantification of Tree Cover in the Biomass Energy Production Areas

To establish the trend in tree cover in these areas, aerial photographs were acquired and used to compute respective tree covers in the following years: 1984, 1997 and 2011. Sample vertical aerial photographs acquired from the Institute of Resource Assessment, University of Dar es Salaam were used to determine the percentage cover and area (hectares) under different vegetation types in each ward. A 35mm camera using a 20mm wide angle lens mounted under an aircraft carriage from Surveys and Mapping Division, Ministry of Lands, Housing and Urban Development had been used to take photographs along transects spaced 5km wide at 2.5 km intervals along each transect at a height of about 500 metres above the ground level in the year 1984. This gave an average scale of approximately 1:30,000 covering 45 – 50 ha on the ground per photograph.

To estimate area, the colour photograph transparencies taken in the field were projected onto a grid screen. The grid comprises of 100 dots systematically arranged on the screen (29.5 cm × 21 cm). Hits on different vegetation classes were identified and recorded for each slide photograph in the ward. Tree cover was estimated by expressing the number of dots hitting the different vegetation types as a percentage of the total number of dots. All types of forests, bushes, wood lots and hedges were considered as they constituted the major sources of wood fuel. The actual area under different vegetation classes in each ward was then calculated by applying the percentage value to the actual sampled area (stratum). The following formula sourced from the Institute of Resource Assessment, (2010) was used:

$$A = d / 100 \times c$$

Where A = area under vegetation

d = ward stratum area in (ha)

c = average to cover under each vegetation type in the ward

Land cover classification

The first step in the assessment process involved the use of five topographic map sheets (code Y742 Edition 1 – TSD Sheets 137/2 for Sikonge; 118/3 for Igigwa; 174/3 for Kitunda; 136/3 for Tutuo and 138/2 for Kipanga) with a scale of 1:50,000 from the Surveys and Mapping Division, Ministry of Lands, Housing and Urban Development, Dar es Salaam. They were first projected to a local coordinate system (UTM-zone 36 M, datum-Arc 1964) and then used as a master map in geo-referencing the acquired satellite images. Satellite images (LandSat 4 MSS for 1984, LandSat 5 TM for 1997 and LandSat 7 ETM+ for 2012) acquired from the Institute of Resource Assessment, were interpreted in the laboratory into various polygons reflecting different land cover/use types. Tonal signature (colour, texture and shape) was the basis for classification of the different cover/use types. Fieldwork was conducted to ascertain representative features registered on satellite images. Computation was done through the use of Geographical Information System (GIS) to establish the extent of the different cover types in the different years. ERDAS Imagine Version 8.7 spatial modeller software was used for processing and displaying the data. Cultivated areas and those covered by natural vegetation were mapped out. The maps were then used to assess the woody biomass in the areas covered by the District.

A classification (maximum likelihood classifier of ERDAS Imagine Version 8.7) approach was employed to generate land use/cover maps with five classes; Farm land, Forest land, Grassland, Cleared land and water. Post-classification comparison was used as a detection technique to reveal different trends in land use/cover changes over the periods (1984 to 2012).

RESULTS AND DISCUSSION

Characteristics of Respondents

Most of the respondents interviewed were men (59.2 %) and only 40.8% were women. This was a result of interviewing heads of households who were men. The small percent of women heads representation occurred as a result of their husbands (heads) being absent from home and these *de-facto* heads would constantly remind the interviewer that they were representing their husbands who were away at the time of the interview.

Table 1. Gender and Age of Respondents

	Sex of Respondent		Total Respondents	Percent Respondents
Age of Respondent	Male	Female		
< 30 years	28 (13%)	78 (52.3%)	106	29.0%
31 – 45 years	150 (69.4%)	55 (37.0%)	205	56.2%
46 – 55 years	22 (10.2%)	16 (10.7%)	38	10.4%
>55 years	16 (7.4%)	-	16	4.4%
Total (n = 365)	216 (59.2%)	149 (40.8)	365	100.0%

Source: Sikonge Population/ Land cover survey, 2012

Most men interviewed were aged between 31-45 years (69.4%), below 30 years (13%) and 10.2% of men aged between 46-55 years while a small percent of (7.4%) were above 55 years of age. Most women were aged below 30 years (52.3%), followed by those aged 31-45 (37.0%) and 10.7% for those aged 46-55 years. The most interesting aspect noted was that a large number of the respondents were within the reproductive age. Table 2 shows that (50.8%) of the respondents belonged to households with 6 – 10 members followed by 28.8% respondents with 11- 15 members and 10.2% in each category, that of 1-5 persons per household and the one with 16-20 persons per household. The average household size in Sikonge is 6.3 persons per household.

Table 2. Distribution of Respondents by Household Size (n=365)

Household size	Frequency	Percentage (%)
1 – 5	96	26.3
6 – 10	187	51.2
11 – 15	61	16.7
16 – 20	21	5.8
Total	365	100

Source: Sikonge Population/ Land cover survey, 2012

The number of people per household in Sikonge District may be either due to higher birth rates or due to the increased tendency of tobacco farmers to hire labourers from other places in and outside the district. The reasons why people prefer many children is possibly the fact that in small holder farms, the family is the main source of labour for agricultural production. As regards literacy, many respondents (74.4%) reached primary school level of education, followed by 17.8% who have no formal education, 6.7% secondary school level of education and about 1.1% college level of education. Seventy two percent of the respondents depend on growing crops (cereals and tobacco) for their livelihood needs (Figure 2). Other sources of income in descending order were livestock keeping, lumbering, honey harvesting, and kiosk business. Although results showed 72% of income as coming from crop farming (cereal/tobacco), the direct effect is on the forest as farmers grow tobacco which is the number one crop source of income and the first source of forest destruction in the district.

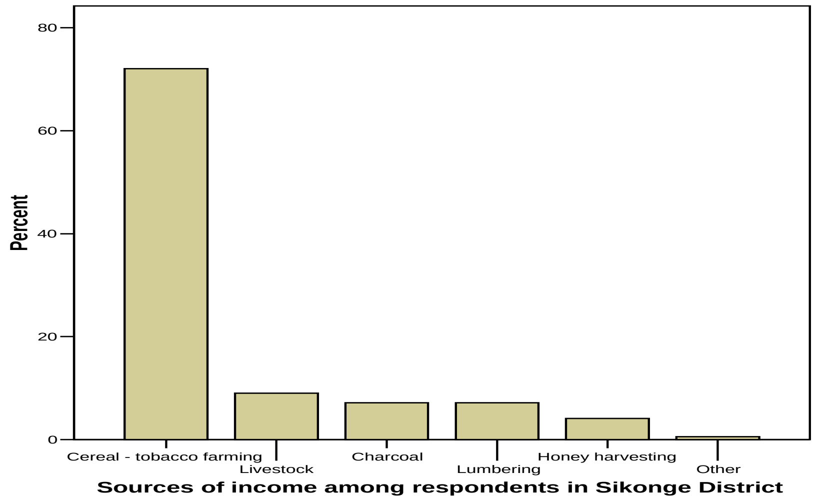

Fig 2. Sources of income among respondents in Sikonge District
Source: Sikonge Population /Land cover survey, 2012

Cultivation has been a major source of woodland change and deforestation in Sikonge District, followed by charcoal production and lumbering between 1984 and 2012.

Fig 3. Cultivation amidst Miombo woodland in Mitowo, Tutuo area (March, 2012)
Source: Sikonge Population /Land cover survey, 2012

Fig 4. Charcoal preparation amidst Miombo woodland in Mitowo, Tutuo area (March, 2012)
Source: Sikonge Population/Land cover survey, 2012

These results were confirmed by 71% of the respondents in Tutuo, Igigwa, Kipanga and Kitunda areas during the survey (Table 3).

Table 3. Observed Activities Contributing to Woodland Degradation in the Study Area

activity	percentage
Tobacco curing	71
Agricultural expansion	13
Charcoal making	8
Timber	6
Others	2
Total	**100**

Source: Sikonge Population /Land cover survey, 2012

Almost all the respondents in the studied areas said tree cover is thinner today than 10 years ago due to tobacco curing and charcoal making activities in the area.

Fig 5. Tobacco growing in Kipanga, Sikonge District. (March, 2012)
Source: Sikonge Population/ Land cover survey, 2012

Fig 6. Tobacco Barn in Kipanga, Sikonge District. (March, 2012)
Source: Sikonge Population /Land cover survey, 2012

Sixty seven percent of respondents in Tutuo, Igigwa, Kipanga and Kitunda areas also believed that charcoal is hauled from very far distances and is scarce today than ten years ago as a result of depletion.

Quantities of Traditional Biomass Energy used by Households and Institutions in Sikonge Urban Centre

From the results presented in Figure 7, it is clear that wood fuel resources are an important energy source for the residents of Sikonge Urban Centre. At 81% (charcoal and fuel wood), it slightly surpasses the national figure of more than 70% (The National Energy Policy of Tanzania, 2003) in total. Sikonge Urban centre required some 2,892,256 kg of charcoal in the year 2012. Since 8 kg of wood yield 1 kg of charcoal (World Bank, UNDP, 1990), this quantity of charcoal would need 361,532 kg (2,892,256 ÷ 8) of wood for its production. The households also consumed 143,811 kg of fuel wood. Together with wood for charcoal, a total of 505,343 kg (361,532 + 143,811) of wood was used for cooking energy.

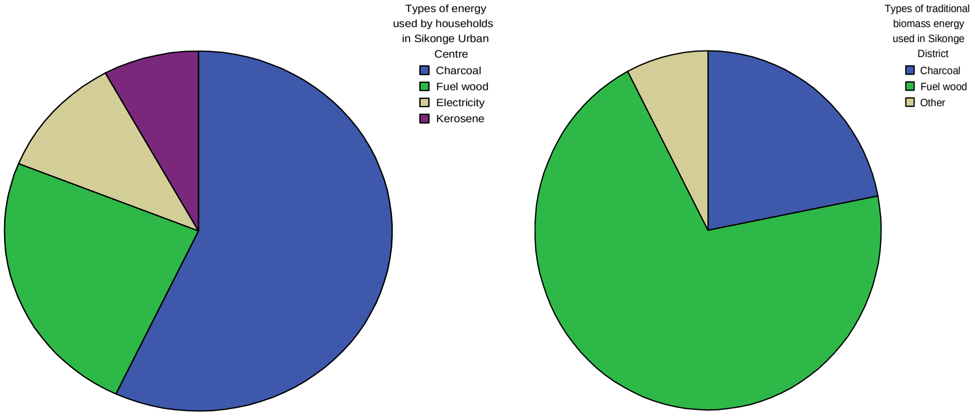

Fig 7. Types of energy used by households in Sikonge Urban Centre and Fig 8. Types of traditional biomass energy used by institutions in Sikonge Urban Centre
Source: Sikonge Population/ Land cover survey, 2012

Annual per capita use of charcoal and fuel wood by households were 150 kg and 574 kg respectively. These were higher than the national averages of 141kg and 563 kg (Ministry of Energy and Minerals, 2003) respectively. Since over 81% of the households were found to use traditional biomass energy as their main cooking fuel, the higher per capita charcoal and fuel wood use suggests that a significant number of Sikonge Urban Centre households are cooking meals that require more heat energy. Some 399,217 kg of wood was used up in 2012.

As for institutions in Sikonge urban centre in the year 2012 some 106,126 kg of wood was required for cooking energy. This represented 72% of their energy needs (Figure 8). Fuel wood and charcoal in that order were the main types of energy used for cooking. Like in the case of households in the urban centre, traditional biomass was the most important cooking energy source for institutions in Sikonge urban centre.

Households in sampled rural Sikonge used 102,623 kg of charcoal equivalent to 820,984 kg of wood and 2,362,269 kg of fuel wood for tobacco curing. Households of urban Sikonge, institutions and sampled rural areas altogether used 3,688,596 kg (3,688.6 tons) of wood for energy. On average 1m^3 of wood = 667 kg of wood (Hall and Mao, 1994). Therefore, 3,688,596 kg is equivalent to 5,529.3 m^3 wood. This quantity of wood required a tree plantation of 186.8 hectares equivalent to 46.7 hectares on average. This result corresponds to the quantifications of biomass in the sampled rural wards done using the procedure for assessing aerial photographs as explained earlier. Figure 9 presents the results.

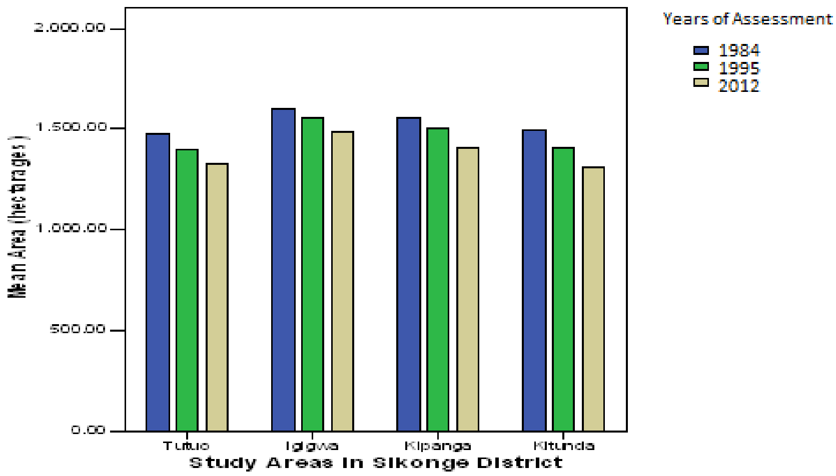

Fig 9. Trends in vegetation cover in the sampled traditional biomass energy production areas in Sikonge District
Source: Sikonge Population /Land cover survey, 2012

Spatial – temporal land cover changes

The land cover in the district of Sikonge was determined from satellite images of 1984, 1997 and 2012. Table 4 presents the main characteristics of satellite imagery used.

Table 4. Characteristics of the Satellite Imagery used in Land Cover Classification

Acquisition date	Sensor	Cloud cover (%)	Path/Row	Resolution
December 30,1984	Landsat 4 MSS	0.00	168/065	57×57
January 31, 1997	Landsat 5 TM	0.00	168/065	30×30
March 21, 2012	Landsat 7 ETM+	0.00	168/065	28.5×28.5

Source: Institute of Resource Assessment, University of Dar es Salaam 2012

An overall image classification accuracy of 63.2% was obtained. Thematic maps derived from satellite images of 1984, 1997 and 2012 were prepared and their area coverage is displayed in Table 5.

Interpretations of satellite imagery (1984, 1997 and 2012) support the cereal - tobacco production trends and the associated land cleared for cereal - tobacco growing and curing. An initial comparison among the decadal maps shows a decrease in forest area throughout the time scale analyzed. Again, the forest area in 1984 had clear outline which indicated a thick forest with little deforestation. In 1997, some forest had been cleared and clear patches/portions were visible. Land-cover area statistics in the district (Table 5) show that, cleared land increased by about 120 ha (5.5%) from 1984 to 1997, and later increased by about 700 ha between 1997 and 2012 (30.2%). The overall increase between 1984 and 2012 was 820 ha (37.3%).

Table 5. Land Use and Land Cover Distribution Sikonge District: 1984, 1997 and 2012

LANDUSE/ LANDCOVER CHANGES	1984	1997	1984-1997	2012	1997-2012	ANNUAL RATE OF CHANGE
	AREA (Ha)	AREA (Ha)	PERCENTAGE CHANGE	AREA (Ha)	PERCENTAGE CHANGE	1997-2012
Farmland	269,879	284,773	(+14894) 5.5	317,312	(+ 32539) 11.4	0.8
Grassland	153,886	149,544	(- 4342) - 2.8	140,181	(- 9363) - 6.3	- 0.5
Cleared land	2197	2,317	(+ 120) 5.5	3,017	(+ 700) 30.2	2.2
Forest land	1,468,306.7	1,433,893.3	(- 34413.4) -2.3	1,367708.3	(- 66185) - 4.6	- 0.3
Water body	5,578	5,578	0	5,582	(+4) 0.7	0.1

Source: Sikonge Population/Land cover survey, 2012

Grasslands decreased by about 4,342 ha (-2.8%) in the period 1984 to 1997 and further decreased by 9,363 ha (-6.3%) from 1997 to 2012. Between 1984 and 2012 grasslands decreased by approximately 13,705 ha (-8.9%) This coincides with the practice of small-scale farmers, who cleared the forest for tobacco agriculture and left it fallow after some years to use it for cereal production and grazing. The area transformed from natural vegetation to cultivated land between 1984 and 1997 was 5.5% compared to 11.4% that was transformed between 1997 and 2012. This implies that changes in land cover type from natural vegetation to cultivation that took place between 1997 and 2012 are about twice the changes between 1984 and 1997 (Table 5). There is an annual increase rate of 0.8% in farmland between this time period (equivalent to 265 ha annually) which is evident in the reduction of grassland and 4.6% reduction of forest land. This may be a result of unprecedented population growth accompanied by the shift towards tobacco and cereal farming which has attracted many people into farming as a way of earning their livelihood. Areas that are not available for agricultural expansion are forest and game reserves.

Nature and Location of Change in Land Use and Land Cover

An important aspect of change detection is to determine what is actually changing to what i.e. which land use class is changing to the other. This information reveals both the desirable and undesirable changes and classes that are "relatively" stable overtime. This information also serves as a vital tool in management decisions. This process involved a pixel to pixel comparison of the images through overlay.

Areas with no change and instability i.e. loss or gain by each class between 1984 and 1997 particularly in the change in hectares as observable in table 5, stability seems to be a relative term as no class is actually stable during this period except when observed from the percentage change.

Transition Probability Matrix and Projection for 2025

The transition probability matrix records the probability that each land cover category changes to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix by the number of cells of corresponding land use in the later image.

For the 5 by 5 matrix table presented below (Table 6), the rows represent the older land cover categories and the column represents the newer categories. Although this matrix was used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land use/ land cover of 2025.

Table 6. Transitional Probability Table Derived from Land use/Land cover Maps of 1997 and 2012

Classes	**Farm land**	**Cleared land**	**Grassland land**	**Forest land**	**Water body**
Farmland	0.5553	0.1495	0.0885	0.1969	0.0097
Cleared land	0.1385	0.5132	0.1735	0.1692	0.0057
Grassland	0.0471	0.3902	0.0432	0.0507	0.0090
Forest land	0.2163	0.4050	0.0501	0.3203	0.0083
Water body	0.1682	0.0378	0.0633	0.3174	0.0133

Source: Sikonge Population/Land cover survey, 2012

Row categories represent land use and land cover classes in 2012 whilst column categories represent 2025 classes. As seen from the table, farmland has a 0.5553 probability of remaining farmland and 0.1495 of changing to cleared land in 2025. This therefore shows a positive change (expansion), with a probability of change which is much higher than stability. Cleared land during this period will likely maintain its position as the highest class with 0.5132 probability of remaining cleared land in 2025. Grassland has a probability as low as 0.0432 to remain as grassland in 2025 which signifies instability as much of it is turned into farmland. On the other hand, the 0.4050 probability of change from forest land to cleared land shows that there might likely be a high level of instability in forest land during this period. Water body which is the last class has a 0.0133 probability of remaining as water body.

Implications of Traditional Biomass Energy Production on the Environment

Woody biomass energy particularly charcoal requires large quantities of trees to support its production in order to meet the energy demand of medium sized towns like Sikonge and its rural area. The study has also revealed that tobacco leaf curing accounted for 71% of the forest destruction followed by field expansion (11.4%). Tobacco curing has been reported by other researchers as one of the factors leading to deforestation (Siddiqui, 2001). Ramadhani et al., 2002 found to have accounted for about 60 %. Sauer and Abdallah (2007) reported that, to cure 57 kg of tobacco, a farmer requires 1m^3 firewood which mostly comes from natural forest. On the other hand deforestation through field expansion and shifting cultivation pose another threat to the Miombo ecozone. With population increase and diminishing public forest land (land that is not protected by law), fallow period is being reduced, thus not allowing full regeneration.

CONCLUSION AND RECOMMENDATIONS

The increasing population pressure has been identified to be the major contributing factor to the observed changes in the Miombo ecozone. The demand for wood products will continue to rise every year as the population increases and particularly so as long as clearing of woodland for cereal - tobacco production and cutting of wood for curing tobacco as well as need for new settlements continues. Although the district has been undertaking afforestation efforts with the main aim of trying to narrow the gap between adverse supply and demand situations of fuel, there is need to intensify farmers' education aimed at encouraging the regeneration of woodlands by leaving their farms fallow for a sufficient period of time. It is true that in the absence of any further disturbance after tree cutting, the areas may progressively revert to woodland. Over and above, alarming population growth rate should be addressed and this should go hand in hand with inadequate agrarian policies which have not addressed properly the practice of shifting agriculture in these cereal-tobacco farming areas.

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