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ENVIRONMENTAL IMPACT OF CEREAL-TOBACCO FARMING SYSTEM IN MIOMBO WOODLANDS: A CASE STUDY OF UYUI DISTRICT, TABORA REGION, TANZANIA

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ABSTRACT

A study was conducted in the cereal-tobacco farming system in Uyui District, Tabora region. The results revealed that depletion of closed woodland between 1970 and 1980 was 380 hectares per year and between 1980 and 1997 was 40 hectares per year. The results also showed that cultivated land increased by 225 and 240 hectares annually between 1970 - 1980 and between 1980 – 1997, respectively. The expansion of the cultivated land was at the expense of the Miombo woodlands. Key socio-economic factors identified by the study as drivers for the observed degradation of Miombo woodland include population growth, agricultural expansion and increased demand for fuelwood for tobacco curing.

Keywords: Cereal-tobacco farming, Miombo woodland, Shifting cultivation, Deforestation, Tabora

INTRODUCTION

Tobacco is the world's leading non-food crop. According to Geist (1997), 75% of all tobacco produced in Africa comes from Zimbabwe, Malawi and Tanzania. About 90 % of tobacco produced in Africa comes from countries covered by miombo woodland.

Tanzania produces about 2 percent of world tobacco. Tobacco is among the major traditional export crops in the country. It is the 4th largest crop after coffee, cotton and cashew nut and its production has been steadily increasing. According to Geist (1997), between 1984 and 1992 the area under tobacco increased by 66%. The tobacco industry employs more than 196,000 families which is about 3.6% of Tanzania population (TORITA, 2001). In year 2000 a study done by Tanzania Tobacco Board (TTB) revealed that earnings from tobacco export account for 9.7% of all traditional agriculture crops.

Tobacco production is however dependent on clearing of new land and supply of accessible fuelwood for tobacco curing and consequently degrading woodlands. According to Otsyina *et al*., (1997), to cure 1 ha of tobacco requires about 2 ha of miombo woodland. As a result, fuelwood requirements for tobacco curing and expansion of agricultural land for tobacco production have led to massive clearing and destruction of the Miombo woodlands. In addition, the massive woodland clearance leads to increased distance to sources of fuelwood as well as production costs of tobacco.

However, reliable data and information on the extent and rate of degradation of the Miombo woodlands is lacking. Most of the available estimates rely on subjective assessments with limited measurements which lead to variations in the estimates. This publication is therefore aiming to contribute towards improving the availability and accuracy of the data through use of remote Sensing and Geographical Information System (GIS) techniques.

Remote sensing technology is capable of acquiring information about the landscape regularly and over large areas, it can therefore be used to assess the spatial and temporal extent woodland degradation. GIS can provide a capability for integration and evaluation of different spatial and temporal data sets.

The general objective of the study was to carry out spatial and temporal assessment of the impacts of cereal-tobacco farming system on the Miombo woodland in Uyui District, Tabora region. The specific objectives were: (i) to map the current cereal-tobacco farming systems, (ii) to assess land use/land cover changes as the result of cereal-tobacco farming systems over a period of 27 years (1970-1997), and (iii) to identify socio-economic factors influencing land use changes in the cereal-tobacco farming system.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Igoko and Isikizya villages, Uyui District, Tabora region. Uyui District is located in the Miombo ecozone, where flue-cured tobacco is the main cash crop. Isikizya and Igoko villages are among of the villages found in the cereal-tobacco farming system, and started in 1964 and 1967 as Tanzania Tobacco Settlement Schemes. Uyui District receives unimodal rainfall at annual average of 880 mm. The rain falls from October to April with peaks in December and February. The temperatures range from a mean minimum of 14.9^{o}C in June to a mean maximum of 32.5^{o}C in October. The altitude is between 1000 metres and 1300 metres. The soil texture is predominantly sandy loam, sand clay loam and sand clay. Soils are *ferric acrisols* low in organic carbon, phosphorus, total nitrogen, and cation exchange capacity (CEC) and are typically acid with pH 4 to 6 (Chidumayo, 1993b, FAO, 1994, Otsyina *et al.,* 1996).

The natural vegetation consists of Miombo woodland which is dominated by species of the genera *Brachystegia*, *Julbernardia* or *Isoberlinia* of the legume sub-family of *Caesalpinioideae* (Lind and Morrison, 1974). The word Miombo comes from the Nyamwezi (a tribe of Tabora) name of the tree *Brachystegia boehmii* "Miyombo". The miombo woodland contains the valuable hardwood species such as *Plerocarpus angolensis* (Mninga), *Dalbergia melanozilon* (Mpingo), *Afzelia quanzensi* (Mkola), and *Brachystegia speciformis* (Mtundu). These woodlands cover about 69% of the total area of Tabora region.

Major economic activities in the District include farming, mainly through shifting cultivation using hand tools and ox-plough. Maize, rice, cassava, sweet potatoes, beans and vegetables are the main food crops. Cash crops include tobacco, groundnuts and sunflower and vegetables (onions tomatoes). Livestock keeping is limited to about 5% of the farmers and herd size ranges from 2 to 100 (Otsyina *et al.*, 1997).

Assessment of spatial and temporal distribution of land use/cover

Interpretation of Aerial Photographs

Aerial photographs from 1997, 1980 (1:25,000) and 1970 (1:50,000) were interpreted using mirror stereoscope. Photo elements, such as shape, pattern, tone, texture, shadows and associations were used to distinguish different land use/cover classes as described in Dent and Young (1981) and Lillesand and Kiefer (1994). The classes were: closed forest, open forest1 (less open, 50–70% crown cover), open forest2 (more open, 10–50% crown cover), cultivated areas, bushland, grassland, water reservoir and settlements. The interpretation was then digitised and georeferenced to the Universal Transverse Mercator (UTM) co-ordinates, Zone 36 using ArcInfo and ArcView software. Maps showing the extent of coverage for each land use/cover in 1970, 1980 and 1997 were then produced.

Change Detection Analysis

Change detection analysis entails finding the type, amount and location of land use changes that are taking place. Various algorithms are available for change detection analysis. In this study, post-classification comparison change detection was used. The three generated land use/cover maps were overlaid to produce two thematic layers containing classes for every coincidence of classes in two land use/cover layers, i.e. 1970-1980 and 1980-1997. The use of a change detection matrix provided details on the nature of change.

In the end, the rate of deforestation was computed the following formula

$(\%\ Y{-}1) = \{[(F1 - F2)/F1]\ /N\} * 100$

Where:

F_1 = Forest area at the beginning of reference period

F_2 = Forest area at the end of reference period

N = Number of years in reference period

Y =Year

In this study, deforestation refers to both permanent and temporary removal of trees in Miombo woodlands followed by alternative land use/cover.

Assessment of socio-economic factors influencing land use changes

The selection of households was performed through a stratified, multistage sampling process. In each District one ward was selected and from the ward two villages were selected. The selected villages were within the Tanzania Tobacco Settlement Schemes. Ten percent of the households in each village were sampled for interviews, making a total of 59 respondents. Participatory rural appraisal (PRA) was conducted in these two villages. In collaboration with the farmers, time series technique was used to identify the local, national and international events which the community considers to have important historical impact on land resources issues in the past. Trend line helped to get the views of the community on the changes of resources over time.

Formal interviews of household heads using a structured questionnaire were conducted to obtain land use changes consequences on social interaction and household economy.

Data Analysis

The data obtained was organised into manageable units. Relevant coded information was then subjected to content analysis using the Statistical Package for Social Sciences (SPSS). Frequencies,

multiple responses and cross-tabulation data analysis were used to assess socio-economic activities.

RESULTS AND DISCUSSION

Change Detection Analysis

Figure 1 depicts the results from change detection analysis between the two temporal periods, i.e. 1970 to 1980 and 1980 to 1997. The results showed that both temporal periods, 1970-1980 and 1980-1997, had experienced considerable land use transformation. In the two periods, closed forest has continuously decreased, while cultivated land has continuously increased. The coverage of closed forest area has decreased from 4523.3ha in 1970 to 680ha in 1980 and 51.6ha in 1997, while cultivated land has increased from 5070.9ha in 1970 to 7325.8ha in 1980 and 11474.8ha in 1997. This is an indication of an encroachment of Miombo woodlands as a result of lateral expansion of agricultural activities.

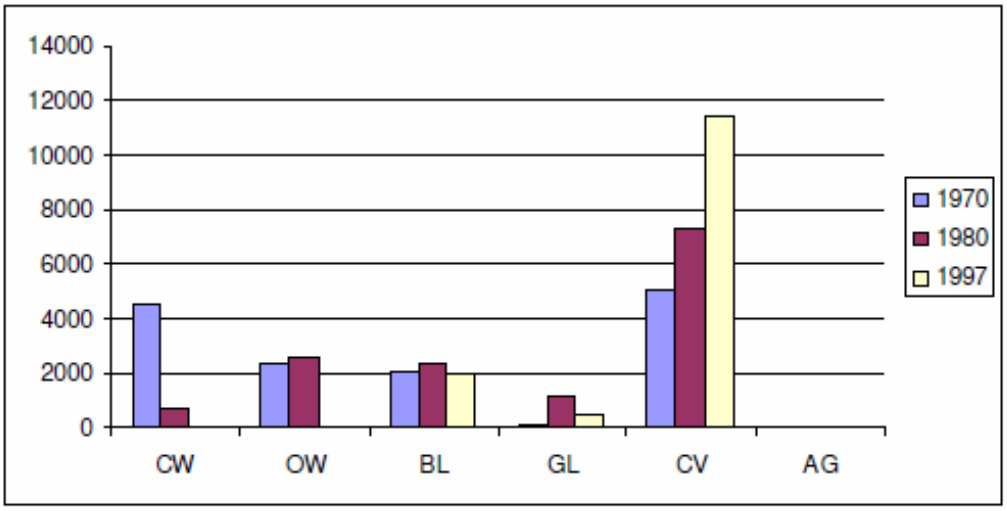

Figure 1: Coverage (ha) of land use/cover classes in 1970, 1980 and 1997

Key: CW = Closed Woodland; OW = Open Woodland; BL = Bushland; CV = Tobacco-Cereal farming; AG = Agroforestry

Change detection matrix, Table 1 and 2, where generated to provide information on the nature of change. As indicated by Table 1, between 1970 and 1980, only 493.6 ha (10.9%) of closed woodland did not undergo any change 1625.6 ha (35.8%) and 1369.0 ha (30.2%) were changed to open woodland and cultivated land respectively. Furthermore, the table reveals that out of 5069.6 ha of cultivated land, 4088.3 ha (80.6%) remained unchanged, 570.7 ha (11.3%) changed to bushland, while 63.5 ha and 347.1 ha were converted to grassland and open woodland respectively. This indicates existence of fallowing, shifting cultivation or abandoning of agricultural fields. Generally, the table reveals a trend of conversion of land covers from higher grades to lower grades. Table 2 indicates the change of land use between 1980 and 1997. Out of the remaining 687.7 ha of

closed woodland, only 7.1% remain unchanged and 516.7ha (75.1%) changed to cultivated land, while 114 ha, 2.7 ha and 5.5 ha changed to bushland, grassland and open woodland, respectively. This could be due to encroachment of woodland through shifting cultivation and farm expansion.

Table 1**:** Change detection matrix between 1970 and 1980 (in ha)

	CW	OW	BL	GL	CV	Total
CW	493.6	1625.6	326.1	722.0	1369.0	4536.3
OW	0	182.2	800.0	17.1	1324.6	2323.9
BL	141.0	336.3	646.3	232.5	703.3	2059.4
GL	0	0	0	116.4	0	116.4
CV	0	347.1	570.7	63.5	4088.3	5069.6
Total	634.6	2491.2	2343.1	1151.5	7485.2	14102.1

Key: CW = Closed Woodland; OW = Open Woodland; BL = Bushland; CV = Tobacco-Cereal farming

Table 2 Change detection matrix between 1980 and 1997 (in Ha)

	CW	OW	BL	GL	AG	CV	Total
CW	49	5.5	114	3	0	517	688
OW	2	0	315	0	5.6	2280	2602
BL	0	0	875	26	0	1428	2328
GL	0	0	108	467	0	584	1159
CV	0	33	590	8	32	6661	7324
Total	51	39	2002	504	37	11469	14102

Key: CW = Closed Woodland; OW = Open Woodland; BL = Bushland; CV = Tobacco-Cereal farming

Table 3 shows that between 1970 and 1980 closed forest was decreasing at a rate of 384.3 ha per year or (8.5% per year), and continued to decrease at a rate of 5.4% per year between 1980 and 1997. The decrease in closed forest is partly due to the increased agricultural activities. Cultivated land increased rapidly at a rate of 4.4% per year between 1970 and 1980 and 3.3% per year between 1980 and 1997. This could be attributed to the expansion of farm size due to the increased population, as well as ambition to get more yields of tobacco and food crops. Bushland has increased at a rate of 1.4% per year between 1970 and 1980, and for the period of 1980 to 1997 decreased at a rate of 0.9% per year. This might be due to clearance of bushes for cultivation of crops such as rice, sweet potatoes and onions and reduction in fallow period. Agroforestry was new land use/cover in 1997. The cover was introduced as part of the government's tree planting campaign.

Table 3: Rate of change for different land use/covers between 1970 – 1980 and 1980 – 1997

Land use/ cover	Coverage			1970-80 (10 years)			1980-97 (17 years)		
				Change in Ha	Rate of change (%/year)	Rate of change (Ha/year)	Change in Ha	Rate of change (%/year)	Rate of change (Ha/year)
	1970	1980	1997						
CW	4523.3	680	51.6	-3843.3	-8.5	-384.3	-628.4	-5.4	-37
OW	2328.6	2602	38.5	+273.4	+1.2	27.3	-2563.5	-5.8	-150.8
BL	2048.2	2330	1984.6	+281.8	+1.4	28.2	-345.4	-0.9	-20.3
GL	116.4	1151	498.6	+1034.6	+88.9	103.5	-652.4	-3.3	-38.4
CV	5070.9	7325.8	11474.8	+2254.9	+4.4	225.5	+4149	+3.3	+244
AG	0	0	37.3	0	0	0	+37.3	+5.9	+2.2

Key: CW = Closed Woodland; OW = Open Woodland; BL = Bush land; CV = Tobacco-Cereal farming; AG = Agroforestry

Scio-economic factors influencing land use/land cover changes in the cereal-tobacco

Population dynamics

A comparison between 1978 and 1988 population census reveals an increased population from 10,827 to 13,421 people with annual growth rate of 3.4%. From 1988 to 2002, the population increased from 13421 to 25936 people with an annual growth rate of 3.6%. The average household size for the entire sample households was found to be 10.7 people. This is above the national average of 4.9. This has increased pressure on limited land resources including fuelwood for tobacco curing and household use, charcoal, timber, agricultural land. All leads to massive clearing and destruction of the Miombo woodlands.

Land and land tenure

The result showed a general reduction of field sizes as a result of fragmentation. About 44% of the respondent households has land size between 6 to 10ha, 35.6% of the respondent households has 1 to 5ha and 20.3% has more than 11ha. This might be due to factors such as population growth and villagesation programme. The villagesation programme resulted in demarcation of plots into two or more. The results also revealed that an average land allocated to food crops (maize, cassava, sorghum, groundnuts, sweet potato, beans, rice) was the largest 3.9ha per year per family followed by fallow land 3.8ha. Land allocated to tobacco was 1.6ha per year per family. The average of land allocated to forest was 0.54ha per family, which is very small compared to mode of farming

Farming practices

About 88% of farmers practise shifting cultivation/crop rotation. This is due to conventional wisdom among farmers that crop rotations reduce the incidence of insects, plant pathogens, nematodes (in tobacco crop) and weeds. But this has negative impacts on Miombo woodland because in most cases new land is opened at the expense of the woodlands. On many small-scale farms in the study areas tobacco is rotated with cereals, which are rotated with pulses, root crops and fallow grass. Out of 59 households, 48 households (81.4%) are fallowing the land.

Traditionally, farmers used shifting cultivation farming practice with long fallow periods of 10 to 20 years as remedial measure to reduced soil fertility and low crop yields (Otsyina *et al.,* 1996). However, with the increasing population, most farmers cannot practice sufficiently long natural fallow periods to permit complete regeneration of soil fertility. Due to high costs of fertilizers and inaccessibility to credit facilities, farmers cannot expand their production by intensification but only by clearing more land and encroachment of forest/woodland.

CONCLUSION

The study has revealed the usefulness of remote sensing and GIS in quantifying and locating the changes in land use/covers. The impacts of human actions on the resources become clearer, and hence appropriate intervention strategies can be designed. The change detection analysis has revealed a substantial decrease in forest/woodland between 1970 and 1997, opening up of land for cultivation and tree cutting for tobacco curing being the major causes.

The study has shown that since 1970s there has been considerable land use transformation. Closed forest has continuously decreased and changed to open woodland and cultivated land. Most of the cultivated land continued to be planted with crops while a small part changed to changed to bushland, grassland and open woodlands. This indicates existence of fallowing, shifting cultivation or abandoning of agricultural fields.

The land use change partly resulted from population growth which increased pressure on limited land resources. Expansion of agriculture, harvesting of fuel wood for tobacco curing, cooking, charcoal and timber production contributed significantly to land use changes and degradation.

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