Ecological impact of tobacco farming in miombo woodlands of Urambo District, Tanzania

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Abstract

This paper examines the ecological threat of tobacco farming in Urambo District, the leading producer of flue-cured tobacco in Tanzania with other major producers being Tabora, Iringa and Chunya Districts. Structured interviews were conducted in four villages while 39 Modified-Whittacker plots were laid in tobacco fallow lands for inventory of woody species to ascertain ecological performance and the impact of tobacco on species diversity, richness and standing stock functions. There was higher than expected species richness with a total of 115 tree and shrub species identified. Tobacco farming showed no significant negative effect on the floristic composition and stem density. However, the significantly reduced biomass and change in vegetation structure illustrate the potential loss in ecological function of the woodlands. Land clearing for tobacco planting account to an annual deforestation of 3.5% while on average a farmer requires 23 m^3 of stacked wood only for curing per season which adds another 3% of deforestation. Shifting cultivation is no longer sustainable given the shortened fallow periods of 4 years. Improved barn structures, alternative sources of fuel like coal, tree planting, mixed cropping and cash crops that are environment friendly are recommended for ecological restoration.

Key words: deforestation, richness, species composition, tobacco

Résumé

Ce papier traite de la menace écologique de la culture de tabac dans le quartier d'Urambo – le plus grand producteur de tabac séché au four de la Tanzanie. Les quartiers de Tabora, Iringa et Chunya sont aussi des producteurs majeurs. Des entrevues structurées furent menées dans quatre villages pendant que 39 terrains < Modified-Whittaker> furent préparés dans les champs de tabac en jachère afin de recenser les espèces boisées et déterminer la performance écologique et l'impact du tabac sur la diversité et richesse d'espèces, et le nombre d'espèces par échantillon. Nous avons constaté un taux de richesse d'espèces plus élevé que l'on attendait, avec un total de 115 espèces d'arbres et buissons identifiées. La culture de tabac n'a montrée aucun effet négatif significatif sur la composition floristique et la densité de queues. Cependant, la biomasse fortement réduite, et le changement dans la structure végétale, montrent la perte potentielle dans la fonction écologique des bois. Le défrichage du bois pour faciliter la plantation de tabac constitue un taux de déforestation annuel de 3,5%, tandis que chaque agriculteur a besoin en moyenne de 23m^3 de bois empilé par saison pour le séchage au four – qui rajoute encore 3% de déforestation. La culture itinérante n'est plus viable étant donné les périodes de jachère raccourcies de 4 ans. Les structures de grange améliorées, des sources de combustibles alternatives comme le charbon, la plantation d'arbres, l'emblavage mixte, et les cultures de rente qui sont écologiques sont préconisés pour le rétablissement d'un équilibre écologique.

Introduction

Despite the worldwide criticism on the tobacco industry arising mainly from environmental and health concerns (Geist, 1999b), tobacco is still one of the major agricultural cash crops in Tanzania. It is grown mostly on small- and medium-scale subsistence farms and has since independence become a useful crop in the miombo woodland regions of Tanzania (Lind & Morrison, 1974).

Today, the growth of tobacco is leading to new and severe threats to the woodlands. Ecological functions of the

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woodlands are particularly threatened by the production of flue-cured tobacco which accounts for 70–80% of the crop's total production in Tanzania. The threat comes from the large quantities of wood drawn from the natural miombo woodlands for curing the crop. Tobacco production also requires extensive virgin land to support shifting cultivation and therefore the availability of sufficient forest areas to supply the needed fuel wood, fresh land and still fulfil other forest functions, is an issue of considerable ecological importance. This high demand of woodland has been considered an accelerator for localized deforestation.

Previous assessments on the tobacco-related environmental threat have mostly been on global, regional and very little on national scales (Brylinsky, 1996; Geist, 1999a), levels at which deforestation associated with tobacco is considered not a significant negative externality. In Tanzania for example, deforestation caused by tobacco farming is considered high but not serious on a national scale considering the share of forest on total land (35%) (Ministry of Natural Resources and Tourism, 1998) which is far above the forest cover required to ensure adequate supply of fuel wood (8.4%) (Geist, 1999b). Furthermore, the share of the land under tobacco (about 1%) is far below that of available arable land (Geist, 1999b). The ecological impact of tobacco farming is therefore felt more on a local or district level.

This study explored on the ecological threat of tobacco farming in the miombo woodlands of the Urambo District, which is the leading producer of flue-cured tobacco in Tanzania with other major producers being Tabora, Iringa and Chunya Districts.

Material and methods

The study area

Urambo District is within the Tabora region, which is located in the mid-western part of Tanzania on the central plateau, covering an area of 21,299 km^2 with an elevation varying from 1000 to 1500 m. The District Council's estimates of 2001 indicated the population of 258,130 people, with a density of 12 people per km^2. The climate is warm with daily mean temperature of 23°C and over 1000 mm of rain annually. Soils are of medium fertility when first cleared of woodland, but both structure and fertility declines under successive cropping. There are four forest reserves covering a total area of 994,000 ha dominated by the species *Brachystegia speciformis* Benth., *B. boehmii* Taub. and *Julbernardia globiflora* (Benth.) Troupin and about 291,144 ha of general arable land, but United Republic of Tanzania (1998) reported that forests are rapidly being converted into cultivated land to give way for the expanding tobacco farming following market liberalization.

Inventory of woody species

Thirty-nine Modified-Whittacker plots (Stohlgren, Falkner & Schell, 1995) (Fig. 1) were laid in the tobacco fallow lands for woody species structure, composition, richness and stocking to reveal the impact of tobacco farming on species diversity, richness and standing stock functions. The fallow lands were categorized into three: fallow lands of 1–5 years, 6–10 years and those of over 10 years, where nineteen, twelve, and eight plots were laid in each category respectively, considering the density and variation among and within stand stock. The density and variation increased with increasing fallow age. In each 1000 m^2 of the plot all trees and shrubs with diameter at breast height (d.b.h.) ≥ 4 cm were identified and measured for d.b.h. This lower d.b.h. limit of 4 cm roughly corresponds to the minimum d.b.h. needed by miombo trees to survive grassfires (Kielland-Lund 1982). All trees and shrubs in the ten 1 m^2 subplots, two 10 m^2 nonoverlapping subplots and 100 m^2 central subplot were identified to species level and enumerated with any additional species listed from the remaining area of the 1000 m^2 plot. Within each plot, total height of a dominant tree was measured and recorded and a regression analysis was performed to develop an equation for height estimation of other trees.

Wood stocking parameters namely, number of stems per hectare (N), basal area per hectare (G) and wood volume

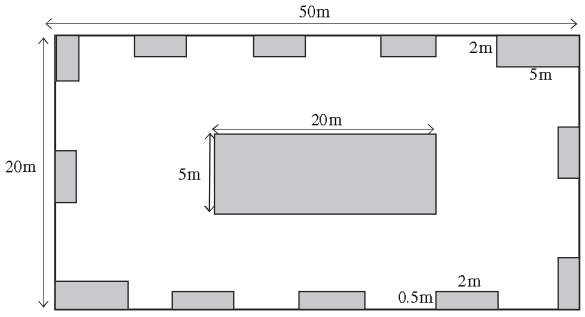

Fig 1 A sketch of the Modified-Whittacker sampling plot design used for inventory of woody species in tobacco fallow lands

per hectare (V) were calculated for each species as described by Philip (1994). For individual trees, volume was calculated using the equation by Malimbwi, Solberg & Luoga (1994):

$$V_i = 0.0001 d_i^{2.032} h_i^{0.66},$$

where V_i = volume of tree i (m^3), d_i = diameter at breast height (1.3 m) of tree i (cm), h_i = the total height of tree i (m).

Household survey

A total of 61 heads of household from four randomly selected villages of Motomoto, Imalamakoye, Kasungu and Mtakuja were interviewed using a structured questionnaire. This survey revealed socio-economic aspects related to tobacco farming such as potential of tobacco as an economic activity (source of income and employment), number of tobacco farmers, amount of land under tobacco farming, quantity of wood required for tobacco curing, level and power of woodland clearing, shifting cultivation and consequent length of fallow periods and resultant deforestation.

Results

Tree and shrub species structure, composition and richness

A total of 1732 individual trees and shrubs with d.b.h. ≥4 cm distributed as 79.7% trees and 20.3% shrubs were counted. Categorically, the total of individual trees and shrubs counted in fallow lands were distributed as 159, 837 and 736 for fallows of 1–5, 6–10 years and those of over 10 years respectively. In fallows of 1–5 years, 20 species were identified all of which were trees while in fallows of 6–10 years, 52 tree and nine shrub species were found and in those fallows of over 10 years, 43 species were trees and fourteen species were shrubs. The shrub component was however rich in terms of number of species in proportion to the number of individuals recorded compared with the tree component. The proportions were at the ratio of about 1 : 5 and 1 : 9 for the shrub component higher than that of 1 : 15 and 1 : 13 for the tree component in fallow lands of 6–10 years and in fallows of over 10 years respectively. The most important tree species found were *Terminalia sericea* Burch. ex DC., *Combretum zeyheri* Sond., *C. collinum* Fresen. *B. spiciformis* and *J. globiflora* whereas the shrub species were *Strychnos pungens* Solered, *S. innocua* Del., *Dichrostachys cinerea* Miq. and *Catunaregam spinosa* (Thunb.).

In total, 111 tree and shrub species were identified within sample plots and four more species which either did not meet the lower d.b.h. limit of 4 cm or fell outside the plots were also identified, adding to 115 species. Average number of species found in each subplot dimension for the three categories of tobacco fallow lands and their corresponding species–area curves are shown in Table 1, where for the equations, S represents the species richness (number) and A is subplot area. There was a noticeable increase in number of species as the fallow period increased and based on that trend, three species–area curves were developed as in Fig. 2.

The higher coefficients of determination ($r^2 = 0.93$; 0.96; 0.99) indicated strong relationship of species richness to subplot area. Negative regression constants of species richness in the fallow lands of 1–5 and 6–10 years indicated that there was a decreasing rate of increase in number of encountered new species while in fallow lands of over 10 years, a fairly increasing rate in the number of species encountered for each unit area increase of the woodlands was depicted. Close similarities in curve slopes indicated similar rates of encountering new species. Furthermore, considering the 100 m^2 subplots, a one-way ANOVA test indicated that there were no significant differences ($F_{2,36} = 1.533$, $P < 0.05$) among the three categories of fallow lands in terms of number of species.

Table 1 Average number of species found in each subplot scale for each category of fallow lands and their corresponding species–area curve equations

	Subplot dimension (m^2)				
Categories of tobacco fallow lands	1	10	100	1000	Species–area curve equations
1–5 years	1	5	16	22	$S = -0.1667 + 7.5 \log A$ ($r^2 = 0.93$)
6–10 years	1	7	20	28	$S = -0.1667 + 9.5 \log A$ ($r^2 = 0.96$)
Over 10 years	1	9	20	29	$S = 0.5 + 9.5 \log A$ ($r^2 = 0.99$)

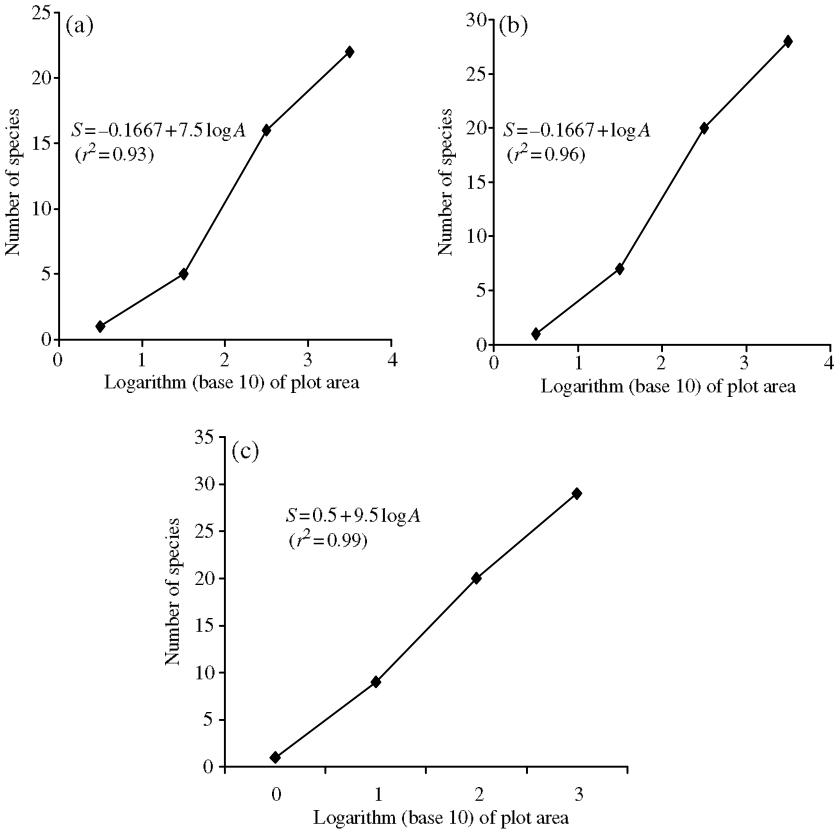

Fig 2 Woody species–area curves for tobacco fallow lands categorized into (a) 1–5 years, (b) 6–10 years and (c) over 10 years

Stocking of woody species

The overall mean stem density for individuals with 4 cm d.b.h. or above was 567 stems ha^{-1} while the average total stem density in each of the three categories of fallow lands was 84 stems ha^{-1} in fallow lands of 1–5 years, 698 stems ha^{-1} in fallow lands of 6–10 years and 920 stems ha^{-1} in those of over 10 years (Fig. 3). The increasing trend in number of stems per hectare as the fallow period increases suggests good recovery in the tobacco fallow lands. The basal areas representing the cross-section

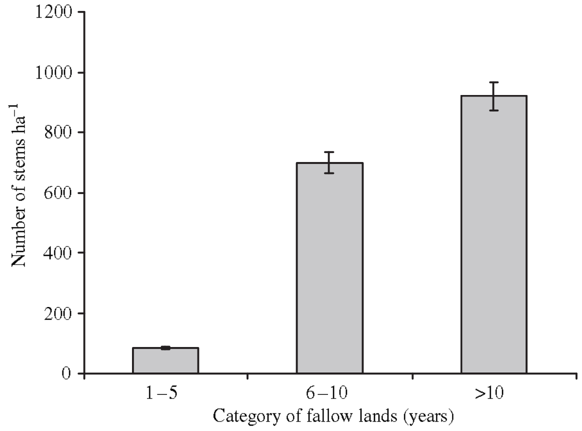

Fig 3 Number of stems per hectare by category of fallow lands

Fig 4 Basal area (m^2) per hectare by category of fallow lands

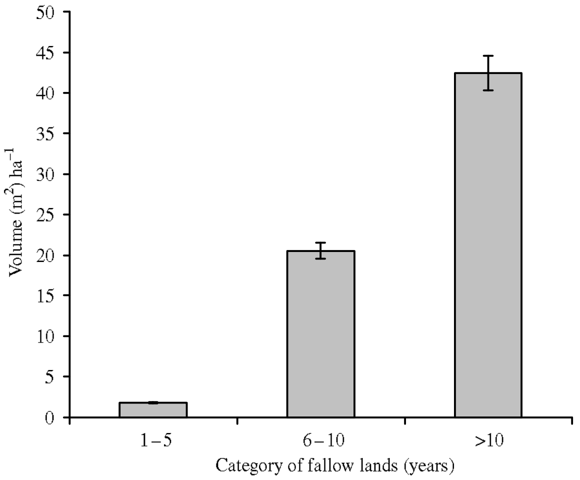

Fig 5 Wood volume (m^3) per hectare by category of fallow lands

area at 1.3 m height were 0.37, 3.48 and 6.14 m^2 ha^{-1} for 1–5, 6–10 and over 10 years fallows respectively. Tobacco fallow lands of 1–5 years had an estimated wood volume of 1.8 m^3 ha^{-1}, whereas those of 6–10 years had 20.6 m^3 ha^{-1} and for those of over 10 years, estimated wood volume was 42.4 m^3 ha^{-1} (Figs 4 and 5).

Potential of tobacco farming, shifting cultivation and deforestation

Of about 43,800 households in the district, 90% depend on crop production for their income. Tobacco farming is the major economic activity, with 75% of farmers being regular tobacco growers. The district had an estimated 14.7% (42738 ha) of arable land cleared each year to care for tobacco farming only (land for cultivation), which accounts for 3.5% of annual deforestation of the whole of forested land in Urambo District. On average a household was found to cultivate about 1.3 ha of tobacco in a season and about 23 m^3 of stacked wood is required to cure tobacco produced from that same piece of land. After curing, the same piece of land produces on average 1.2 tonnes of tobacco. This is based on Wahid (1984), who reported that 2000 kg of green leaf tobacco produce 340 kg of cured tobacco. This amount suggests that 1 ha of fallow land of 6–10 years produces less volume of wood than the average quantity of wood required by an average tobacco farmer in a season. Considering only those fallows of over 10 years therefore, more than 32,800 ha of woodlands would again be cleared annually only for curing tobacco. Such clearing represents another 11% of deforestation occurring in the general lands which is 3% more to the annual cover loss of the whole forested land in the district.

Shifting cultivation remains the major farming system in Urambo District not only for tobacco but also for other subsistence crops like maize, beans and groundnuts. Tobacco is never mixed with any other crop. A more virgin land is preferred because of fear of soil-borne diseases, and the farmer would wish to clear another virgin land to reap a bumper harvest in each season. About 69% of tobacco farmers reported to clear a new area of woodlands for tobacco cultivation in every new season because they cannot afford the cost of heavy chemical pesticide application. The results showed only 25% of tobacco farmers grow tobacco on the same piece of land for two consecutive seasons and as little as 6% cultivate tobacco on the same land for more than two consecutive seasons. Fallow periods have consequently been shortening over time to as short as 4 years. In some cases a farmer would bring back tobacco on the land just after a rotation of the same 4 years with other cereal crops and therefore completely breaking away the shifting cultivation system with intensive systems that rely on heavy applications of chemical fertilizers. Fuel wood for curing tobacco harvested from this sort of land has to however, be ceded by cutting down new woodlands from village forests and in extreme cases forest reserves.

Discussion

Ecological integrity

The absence or little presence of the shrub canopy layer in the studied tobacco fallow lands is largely attributed to the lower d.b.h. limit of 4 cm which limited the chance of smaller individuals which are mostly shrubs to be recorded. Frequent annual grassfires which are characteristic in the miombo woodlands (Frost, 1996) and the slush and burn also contributed to the elimination and/or scattering of the shrub species especially in those fallow lands of <5 years where most regenerating trees and shrubs were below the lower d.b.h. limit of 4 cm to survive grassfires (Kielland-Lund, 1982). However, high species proportion of the shrub compared with tree component is linked to the pioneering of the shrub species once the land is left to natural fallow after tobacco cultivation. Shrub species also sprout from stumps and root suckers faster than the tree component. Furthermore, the shrubs especially those of the family Euphorbiaceae and Loganiaceae are suggestively more resistant to disturbances and survive most of the annual grassfires. The shrub species are however later suppressed but not eliminated as the tree layer grows up and merges into new micro-habitats as a result of successional events.

In comparison (Luoga, 2000), tobacco fallow lands that were studied are still rich in terms of number of species. This higher than expected number of species in tobacco fallow lands is due to the observed behavioural land preparation technique by small-scale tobacco farmers who rarely involve uprooting of stumps from the cut trees and shrubs. Most of the regeneration is therefore from the sprouting stumps and root suckers, adaptations which make most miombo trees and shrubs regenerate and survive extinction from disturbance which increases resilience. Coppicing properties, which depend on terminal, lateral or basal propagules and profuse seed germination, are adaptive features developed by plants in disturbed environments. The number of species appears to be positively affected by human disturbances possibly because of opening up which provide better chances of regeneration even from seeds. It is therefore ecologically likely to have recorded more species in the disturbed general lands compared with forest reserves (Zahabu, 2001).

Similarities of species–area curves observed in tobacco fallow lands and to those in forest reserves (Luoga, 2000) indicate that clearing in miombo woodlands for tobacco farming has no significant effect on their floristic composition and sometimes subtle human-induced changes increase local species richness. This is also an indication of homogeneity in species structure and composition (Nduwamungu, 2001) despite their site differences. Furthermore, the observed strong species–area relationship and their r^2 values allow for better estimation of local species richness from a series of plots in the disturbed but recovering miombo woodlands. Most of the species could be recorded in the 100 m^2 subplots and therefore these subplot dimensions may favourably be used locally to estimate species richness in disturbed woodlands.

Recovery and the biomass

The observed resemblance of stem density to those reported by Malaisse (1978) and Nduwamungu (2001) is an indication that tobacco fallow lands still follow a normal vegetation pattern expected in the miombo woodlands despite their heavy disturbance. This may also suggest that clearing for tobacco farming and other subsistence crops by small-scale farmers does not necessarily alter the miombo ecosystems in terms of stem abundance as long as enough fallow periods are maintained. As pointed out earlier, small-scale tobacco farmers in Urambo District rarely uproot stumps during cultivation, the practice that relatively maintains the number of stems per unit area after regeneration. Cleared areas also make regeneration by seed much easier as the ground litter is reduced and thus contact with the soil is not obstructed.

Contrary, the observed smaller basal areas and volumes than those earlier reported from other miombo woodland sites by Strang (1974) and Nduwamungu (2001) represent an obvious fact that they are still in their early stages of recovering from the disturbances, though the increasing trend in basal areas and volumes as the fallow periods are lengthened suggests good recovery despite the continued cutting for various domestic uses and even tobacco curing from the fallow lands. In general, the distribution of both basal area and wood volume followed the common J-shaped trend expected in natural forests because of presumable influence of large trees on basal areas and wood volumes as the fallow periods are extended.

Deforestation

The observed rate of woodland depletion is a significant threat to the future of the studied miombo woodlands and conforms to reports at national level (Brylinsky, 1996). Complexities in tobacco farming make it however difficult to have reliable and consistent estimations on the rate of depletion of woodlands because of some tricky stages a farmer undergoes in expanding land for tobacco cultivation. In a given tobacco-growing season for example, it was noted that an individual farmer would clear 1 ha of woodland to grow tobacco and the cleared debris is used for domestic fuel wood over the season. When the planted tobacco becomes ready for curing, the farmer would clear one more hectare to get fuel wood for curing the harvest. So this farmer would have cleared 2 ha of woodlands in one particular season. The 2 ha may however be cleared at once when the farmer deems it necessary and because of expected difficulties, tobacco harvesting and consequent curing usually starts in the mid of the rain season.

Increased human pressures to as high as 12 persons km^{-2}, increased power of farmers to expand their tobacco fields due to tobacco market liberalization in early 1990s and most apparently that virgin woodlands have become scarce are supposedly driving factors for the breaking away of the shifting cultivation cycle. Chidumayo

(1987) reported that for the shifting cultivation system to remain sustainable the estimated carrying capacity in miombo woodlands is 3–4 persons km^{-2}. At this carrying capacity the fallow periods would be long enough (at least 20 years) for woodlands natural fertility to be restored (Luoga, 2000). With this exceeded carrying capacity and significantly shortened fallows, recovery of woodlands is highly threatened and a change of land cover from woodlands to bushlands (Luoga, 2000) or even permanent deforestation (Chidumayo, 1999) may soon or later take its course. Shifting cultivation practice in Urambo District is therefore no longer sustainable although it has shown to maintain woody species richness in the fallow lands but this is likely to be a short-term impact and the consequences of permanent cultivation may soon be apparent.

Conclusions

The significantly reduced biomass and change in vegetation structure in the fallow lands illustrate the long-run potential loss in ecological function of the woodlands in return of the short-term economic benefits. Flue-cured tobacco therefore, maintains its threat to ecological functions of the studied woodlands. It should be born in mind however that this ecological degradation has been an inevitable consequence of use for survival and thus effective resource conservation requires developing an integrated approach that incorporates both socio-economic development and ecological resilience. It is recommended that improved barn structures that maximise the heat they produce and exploring and bringing into use alternative sources of fuel like coal and tree planting for household and communal woodlots should be promoted. Mixed cropping and cash crops that are environment friendly are also essential for ecological restoration.

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