

# Assessment of the Merchantable Timber Volume of the Savannah Woodlands on the Communal Lands in Northeastern Côte d'Ivoire

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**Abstract:** Disfiguration of the original woodland savannah by agricultural activities has led to the existence of forest fragments across northeastern Côte d'Ivoire. These fragments of forest or savannah-forests act like wildlife habitat, source of timber resources or barriers to wildfires. However, they are under threat by subsistence farming activities. Previous classification results of Landsat images indicate that they account for between 5 and 10 percent of the land cover types. The objective of the present study is to evaluate their merchantable timber content. Our results show a low diversity in timber species with only two species (*Khaya senegalensis* and *Azelia africana*) found exclusively in savannah-forests. Moreover, current farming practices subdue the timber resources and measured merchantable timber volume is 1.8 cubic meters per hectare of savannah-forest. Agroforestry is a recommended alternative to actual agricultural system but farmers must be convinced of the economic benefit of on-farm tree farming.

**Keywords:** Côte d'Ivoire, Savannah-forest, timber merchantable volume, tropical forestry

## 1 INTRODUCTION

The northeastern region of Côte d'Ivoire belongs to the Guinean zone, a woodland savannah with scattered trees and shrubs. Agricultural land uses are drastically and steadily shaping up the landscape and the original land cover is turning into a mosaic of cashew nut orchards of different ages, forest galleries, and fragments of forests which are termed hereafter savannah-forests. Similar trends have also been observed across West African savannahs [1]. Since the '90s, cashew farming has gain in importance in local agriculture due to good market prices and crop adaptation to growing conditions [2]. The high rate of conversion of the woodland savannah into cashew orchards has led to further fragmentation of the original woodland savannah cover.

Agricultural activities affect non-timber products [3],[4],[5] as well as on timber resources of the woodland savannah. The non-forest sector has not been inventoried for its timber resources because the resources are meager and the trees are protected. The different responses of the vegetation types to land-use are mainly due to the different degrees of anthropogenic disturbances to habitat characteristics [1]. Hence, the relentless fragmentation of the woodland savannah and its subsequent conversion into cashew orchards is expected to have a long lasting impact on the livelihood of the people who depend on it for their fodder, medicine, fuelwood or timber products. Compared to the Comoe National Park, it is apparent that the woody cover of the communal land is less dense (Fig. 1), which is a result of the negative impacts of land use. However, fully protected national parks do not necessarily conserve the greatest diversity of tree species or unique species [6].

Unlike the forest zone, timber density of the woodland savannah is naturally. Hence, extensive farming activities are expected to have a marked negative impact on timber resources. Timber resources on communal lands are protected

by law. Ironically, while logging activities are illegal, "harmful" agricultural activities are not. The local farming practice based on yam cultivation in association with cashew nut depletes the woody resources except for valued trees such as *Vittelaria paradoxa*.

The forest sector of the south or the region below the eighth parallel fulfils the country's timber needs. However, the high deforestation rates recorded in the forest zone of Côte d'Ivoire are also responsible for the decline of timber resources. Hence, for a continued supply of timber products, the woodland savannah must not be overlooked. Instead, management of its valued timber tree species must be among the top priority of the government's forest policy in light of the increased deforestation observed in the forest sector of the south. For the woodland savannah zone to become a potential source of timber resources particularly for endemic tree species, reliable data and information about the current state of woodland savannahs are needed. Hence, the objective of this present study is to determine the current mean merchantable timber volume of the woodland savannah across northeastern Côte d'Ivoire. The volume of timber readily harvestable (merchantable) is very informative about the natural timber producing capacity of the woodland savannah and the impacts of land use on timber resources. Moreover, it is partly indicative of the effectiveness of the application of the restrictive law forbidding timber logging activity in the region.

Previous results obtained through the analysis of Landsat imagery (unpublished data) show that the fragmentation of the landscape has resulted in the woody layer referred to as savannah-forest which accounts for 5 to 10 percent of the area. We hypothesized in this study that these savannah-forests contain the bulk of the timber resources on the communal land of northeastern Côte d'Ivoire. The results of the inventory are shown below. The impacts of agricultural ac-

tivities on the timber resources are analyzed and plausible suitable forest management initiatives for the woodland savannah of Northeastern Côte d'Ivoire are suggested.

## 2 MATERIALS AND METHODS

The region of interest is the communal lands of northeastern Côte d'Ivoire or the region lying east of the Comoe National Park and extending to the country's border with Ghana. In this vast area, a mosaic of yam farms, cashew orchards, savannah woodland, forest gallery, bare soil, and savannah-forests are the dominant land cover types. For this preliminary study, we only sampled up to 20 km from the eastern border of the park (Fig. 1).

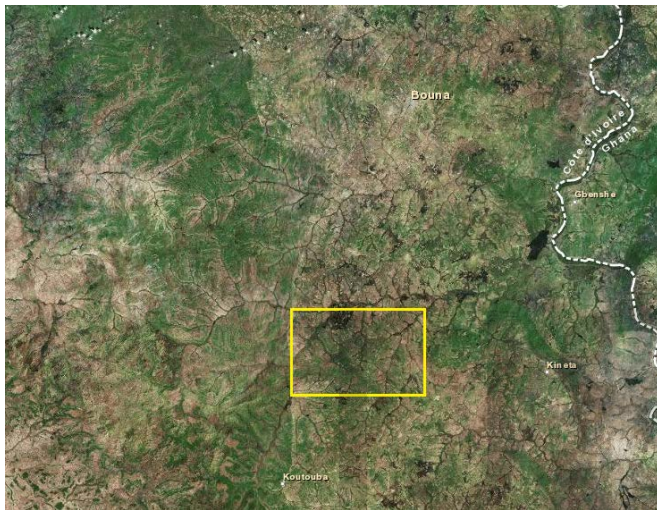


Fig. 1. The communal land (half right) contrasts with the Comoe National Park (half left) and sampled area in yellow rectangle

Three savannah-forest sites were randomly selected from a classified Landsat image (unpublished data): Kokpingue (8°57' 17.3"N; 3°10' 9.10"W), Siraoudi (8°52' 46"N; 3°4' 13.2"W), and Blotti (8°54' 17"N; 3°2' 53.7"W). These sites were further confirmed on a very high resolution image (Quickbird). Ten one-hectare plots from the savannah-forest and 10 other from all the other land cover types were selected to timber sampling purposes. A simple t-test is used to compare the timber data of both two lands cover types.

Timber characteristic recorded were species, diameter at breast height (dbh>20 cm), tree merchantable height (height suitable for sale >4m), and tree location (useful for assessing future impacts of land use on visited sites or for change detection studies). Chosen valued timber trees must have a merchantable height greater than 4 meters and a diameter at breast height of 20 cm or more because timber trees meeting these criteria are the likely candidates for logging. Their volume is valuable information since it shows the potential timber resources available and underlines the necessity to enforce the law against illegal logging in the region. Moreover, it pro-

vides a baseline data for the development of a good forest policy which does not exclude the savannah woodlands.

The merchantable volume of both sawn logs and standing timber trees in a plot was computed using Smalian's formula knowing the end diameters and tree length. The total volume per one-hectare plot is then derived by summing up individual tree volumes for all trees in a plot. This value is a guess of the unknown mean merchantable volume of timber per hectare of a given land cover. Since it is expected to vary widely across locations, its average value over many sites is used.

Tree locations were recorded with a GPS so that future studies can revisit the same trees. A tape is used to measure tree perimeter at breast height or the height of logs. Observed merchantable height of illegally felled trees was less than seven meters and at least four meters. Hence, an eight meter long graduated pole was used for standing trees.

## 3 RESULTS AND DISCUSSION

### 3.1 Characteristics of savannah-forests

The savannah-forest land cover accounts for about seven percent (5 to 10) of the region and include open and closed savannah woodland and forest galleries. It occurs on areas not suitable for cultivation or areas that have been spared or less affected by wildfires. In rare occasions and where the pressure on land resources is not high, they occur on virgin areas or less frequently revisited fallows. Savannah forests vary from one to five hectares or more. The minimum size was set as the threshold for detecting a savannah-forests site on a Landsat image. The sizes of the savannah-forests depend on the intensity of farming activities. The Blotti site is encroached by farming activities (Fig. 2). In the areas cleared for yam cultivation, all valued timber trees are removed.



Fig.2. Farm encroachment at the Blotti savannah-forest site

### 3.2 Timber resources assessment

Only timber trees of length greater than 4 meters and of diameter at breast height greater than 20 cm are inventoried

in this study and the corresponding merchantable timber volume (standing or sawn) is computed. Timber data were analyzed by land cover type: savannah-forest and all other land cover types.

Almost all the timber trees were observed in the savannah-forest. In all the other land cover types, only one tree was recorded on the 10 plots selected. In fact, the savannah-forest land cover type accounts for about 99 percent of the timber resources of the study zone. The yam based farming system which removes trees in farm is very harmful to the establishment of timber trees. On lands that have been cultivated so many times over the last decades, barely any timber tree remains. However, non timber trees such as *vittelaria paradoxa* are present. This discriminatory attitude about tree preservation shows local farmers' unawareness of the economic value of timber species.

Large differences in tree density exist among savannah-forest sites. At the Blotti site, a plot had twelve trees whereas one and no tree was observed at plots at the Siraodi and Kokpingué sites, respectively. The Blotti site was rather prolific in trees. The likely explanation is that the site is distant from the nearest village and farming encroachment must have been recent (Fig.2). Moreover, no logging activities have been observed at this place; this further shows that the site is the least perturbed by farming activities. Even the number of younger trees (not meeting the criteria for merchantable) is high. Logging activities observed the Kokpingué and Siraodi and their proximity to the nearest village explain the low tree density at these sites. At the Kokpingué site, episodes of logging activities exist. Over the last ten years, seven trees have been felled.

Diversity in timber species is low as far as merchantable timber resources are concerned. This may not be true if all timber tree sizes and class ages were considered. We did not inventory younger trees. Two timber tree species clearly stand out: *Khaya senegalensis* and *Azelia africana*. The former is the most prominent, accounting for more than 80 percent of the timber resources of the region. The large difference in the occurrence of the two species may be linked to the fire regime prevailing in the communal land [7]. *Azelia africana* is statistically linked to the fire regime or its establishment is favored by the existence of wildfires which unfortunately are less frequent in the savannah-forests. Other factors may be soil type and fertility, impacts of human land uses but further investigation is needed.

The mean merchantable volume better describes readily available timber resources which can justify any illegal logging activity in the region. Its value when pooled across all the plots is 1.8 cubic meters per hectare of savannah-forest. Assuming a conservative value of five percent (5%) for the relative importance of savannah-forest, the mean merchantable timber volume may also be expressed as 0.09 cubic meter per ha across the whole study region and may reach 0.2 cubic meters for a maximum fraction of the savannah-forest of 10 percent. These values agree with observations made by McComb and Jackson [8] that the species of natural woodland savanna are of poor quality and slow growth.

When expressed per hectare of savannah-forest, the

mean merchantable volume estimate (1.8 cubic meters) is acceptable for a natural woodland savannah and shows the relative importance of the savannah-forests. Although, the value is insignificant compared to those found in plantations, it is encouraging to initiate silvicultural programs in the region since seedlings and seeds are readily available under adult trees. Moreover, plantations of *Khaya senegalensis* have been successfully tried in Australia with recommended density ranging from 400 to 833 stems per hectare [9]. Teak, a multi-purpose tree already planted in the forest sector, can be extensively adopted by farmers if teak farming profitability is proven in the savannah woodland. As noted by Noda and Himmapan [10] in Thailand, most small scale farmers never consider the potential benefits of planting teak on their farms because of their need for short-term economic returns.

The findings in this study can be summarized in two points. Firstly, savannah-forests are the main reservoir of timber resources of the woodland savannah on the communal lands of northeastern Côte d'Ivoire. Hence, it is essential to accurately map this land cover type. The mean merchantable timber volume is 1.8 cubic meters per savannah-forest. Secondly, diversity in merchantable timber trees is very low. The two main timber species are *Khaya senegalensis* and *Azelia africana* with the former accounting for than 80 percent of the timber resources.

#### 4 RECOMMENDATION

Since farming practices in the northeastern Côte d'Ivoire deplete timber trees on communal farm lands, public awareness must be raised about the economical and ecological values for the timber resources. Timber trees should receive as much interest as valued non-timber trees do. Protection actions of selected prolific savannah-forests are welcomed before agricultural activities ultimately wipe out all the timber resources of the region. Finally, since the strict ban on timber logging activity on the communal lands has not been effective at protecting timber resources because of current farming practices, we strongly recommend the introduction of some agroforestry initiatives in the agricultural policy of the region.

#### 5 CONCLUSION

Reliable data are essential for the development of a good forest policy and for making wise decision. Using a combination of ground inventory and remote sensing techniques, the present study gives a glimpse to the conditions of the "forests" of northeastern Côte d'Ivoire. Namely, a state of the timber resources of the region is given but needs further refinement since land uses are continuously modifying the landscape. Preservation of remaining timber resources hinges upon the fate of the savannah-forests and plantation of the species such as teak (*Tectona grandis*) or *Khaya senegalensis*.



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