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Assessing tropical moist forest conditions: the case of Mengo Forests

Gombya-Ssembajjwe, William, S.
Department of Forest Management, Makerere University, PO Box 7062, Kampala, Uganda

Abstract

A total of fourteen forests under government (nature conservation and exploitation), private and communal institutional arrangements used by different local groups living in eight settlements were studied to determine the effect of tree harvesting on the forest conditions. The fieldwork was conducted according to the guidelines of the IFRI research programme. There were significant differences in the occurrence of human consumptive disturbances among forests and institutional arrangements. The distribution of disturbances were also significantly different between two distances (within 30 km and between 30-80 km) from Kampala. However, the regression analysis indicated no significant functional relationship between the distances and the forest variables tested. At both sapling and tree stages, there were significant differences for species richness, the Shannon index, the Simpson index, basal area, and height between forests, as well as institutional arrangements.

Key words: Consumptive disturbances, governance, sustainability

Introduction

Forests in Uganda are an essential foundation for the country's current and future livelihood and growth. Uganda's natural forests are estimated to cover an area of 63,460 km^2 (FAO, 1993), of which 23.2% are gazetted forest reserves and the remaining 76.8% are under either private or communal ownership. These forests are interspersed among agricultural areas and the rate of deforestation is alarming. For example, FAO (1993) estimated deforestation to be at 650 km^2 annually. If this rate continues unabated, it would result in most natural forests disappearing within the coming century. The primary causes of deforestation in Uganda are clearing for agriculture, pitsawing and mechanical logging for timber, charcoal burning, cutting for commercial firewood, road building, and urbanisation.

The incentives for individuals and government to earn income from forest resources and turn forested land into commercial, industrial or residential uses are primarily for short-term gain and highly tangible benefits and are strongest in areas near urban centres.

In Uganda, commercial exploitation of natural forests started at the end of the first world war and has continued up to the present times with great intensity. This is because of the high demand for forest products in Kampala City. The mismanagement of public resources in 1970s and early 1980s led to these forests to be used as open access resources. From mid 1980s up to now some management of these forests especially the reserves is being strengthened in order to reverse the trend.

A study was therefore carried out to generate essential information needed by public officials, researchers and forest users in order to develop policies for sustainable management of forests in Uganda. The specific objective was to determine the health conditions of the forests being used for consumptive purposes, based on the hypothesis that if deforestation processes start with consumptive use of forests, then forests near market centres for forest products are more degraded than those further away.

Methodology

The fieldwork was carried out in Mpigi District, Uganda. Forest data were collected from tropical moist forests (TMFs) of Mengo. They have evergreen closed canopies (Barbour *et al.*, 1987), locally classified as medium-altitude *Piptadeniastrum-Albizia-Celtis*, the three genera being dominant in mature forests (Howard, 1991). The methodology followed was that recommended by the IFRI research programme (Ostrom, 1993). The IFRI definition of a forest as an area of at least 0.5 hectares, containing woody vegetation (trees, bushes, shrubs, etc.) and exploited by at least three households governed by a similar legal structure was adopted. This definition was developed in order to be able to conduct research about landscapes that would be considered as forest in most settings, but

also to include vegetational areas that would not traditionally be considered a forest by foresters.

Forest selection

Forests were selected using a matrix that was designed, taking into account the different institutional arrangements (government, private, and communal), agro-ecological conditions (all forests were from the same agro-ecological zone i.e. the tall grassland), as well as socio-economic factors, like human population density and the market for forest products. All the forests are located in rural areas where the users are heavily dependent on forest resources for cash and domestic needs. This is because the management of forests in these areas has increasingly become difficult due to the increasing demands for the forest products, especially charcoal and firewood. The assumption was that if this study was to contribute knowledge to successful sustainable management of forests in densely populated areas with high demand for forest products, then the same management system was likely to work in a sparsely populated area, probably with minor adjustments.

A total of fourteen forests were selected for this study (Table 1), based on earlier studies by Becker *et al.* (1995) and Gombya-Ssembajjwe (1995). This number was considered sufficient to generate enough data for empirical analysis because all were selected from one agro-ecological zone, the tall grassland. Nature conservation forest reserves are designated for nature conservation, research and teaching, while communal forests are for historical/ cultural uses.

Sample plots

The forest sample plots were randomly selected and their locations were determined by placing a grid over a forest map (in cases where such maps were available), using random numbers to select co-ordinates of a random point in the forest. Where maps were not available (private forests and sacred forests), an effort was made to make sketch maps on scale which were then used to determine the random forest plots. Once the plot centre was located, concentric circles were established. A forest sample plot consisted of three concentric circular areas, one of 1 metre-radius for sampling ground cover and woody seedlings, one of 3 metre-radius for sampling shrubs and saplings, and one of 10 metre-radius for sampling trees. Seedlings are defined as young trees or shrubs, usually less than 1 metre tall and less than 2.5 cm in diameter. Saplings are defined as young trees with a maximum stem diameter less than 10 cm but greater than 2.5 cm. A tree has a diameter measured at breast height (DBH) of greater than or equal to 10 cm.

The number of plots completed in order to obtain a representative sample depended upon the size of the forest and the level of confidence desired about the measurement taken. A sampling area of 0.94 ha in all large forest patches (10 - 2,000) ha was considered adequate to get representative measures of the forests. This figure was obtained by graphically plotting a performance curve of the average value of the number of species per plot as a function of the number of sample plots (Ostrom, 1993). After a sample size of 20 plots, the curve would flatten. The forest size was not considered very important, as measurements were carried in patches used by the communities and the distance users travel into the forest to harvest products was 3 km on average.

Data were collected on tree, shrub and sapling sizes, densities, species types, and general condition of the forests, observing in particular human consumptive disturbances in each plot. The disturbances observed and recorded included pitsawing, charcoal burning, commercial firewood harvesting, agricultural encroachment, and harvesting of building poles.

Analytical framework

Statistical Analysis. A chi-square analysis was carried out on the consumptive disturbances to test for significant differences in frequency distribution among the forests and institutional arrangements. A regression analysis was also carried out to test for the significance of the functional relationships between the distance from Kampala.

Computation of basal area and diversity indices

Basal area is a useful descriptive expression of a forest

Table 1. Government and private forests used in the study

	Institutional arrangements			
	Government		Private	
Distance from Kampala (km)	Nature forests forests	Exploitation forests	Individual forests	Communal sacred
Within 30	Buttobuvuma Mpanga	Lwamunda Mugomba	Mugalu Namungo	Bukasa Semalizi
Between 30- 80		Kizzikibi Kyambogo	Lukambagire Najjakulya	Magezigoomu Mukasa

and, since it is the area on the ground occupied by the tree(s), it is calculated by the function $p[DBH]^2/4$

Diversity indices

Measures of diversity are frequently seen as indicators of the wellbeing of an ecosystem (Magurran, 1988). Diversity is measured by recording the number of species, describing their relative abundances or using a measure which combines the two components. Diversity measures take into account species richness and evenness. Species richness is the numerical count of all species in a sample and, as a measure of diversity, provides an instantly comprehensible expression of diversity (Magurran, 1988).

Indices based on the proportional abundances of species

The Shannon and Simpson indexes were used to determine proportional abundances of species. The Shannon index assumes that individual species are randomly sampled from an infinitely larger population (Pielou, 1975) and that all species are represented in the sample (Magurran, 1988). Shannon (1948) calculated the index using the equation

$H' = -\Sigma p_i \ln p_i$ .....1, where

p_i, is the proportional abundances of the ith species (n_i/ N); n_i is the number of individuals in the ith species and N the total number of individuals. The value of the Shannon index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Margalef, 1972). Simpson (1949) considered not only the number of species and the total number of individuals (N) but also the proportion of the total that occurs in each species. He showed that if two individuals are taken at random from an infinite community, the probability that the two will belong to the same species is:

$D = Sp_i^2$ .....2.

The quantity p_i is the proportion of individual trees in the ith species. He calculated the index using the following formula:

$D = S(n_i(n_i-1))/(N(N-1))$.....3, where n_i is the number of trees in the ith species. As D increases, the diversity decreases.

Results

Human consumptive disturbances

For each plot, the type of disturbance observed was assigned a value of 1, the same applied to plots where no disturbances were observed. The total sum of these two categories of observations was then the same as the total number of sample plots taken in a forest (Table 2). In some plots only a single type of disturbance was observed (e.g. harvesting for commercial firewood). In others (especially in forests within 30 km from Kampala) all or a combination of these disturbances were observed at the same time indicating that consumptive disturbance was a process whereby one disturbance led to others. For example, harvesting for pitsawing as the original disturbance was followed by charcoal burning, and in some plots charcoal burning was followed by agricultural encroachment. However, only the most recent disturbance observed in each plot was recorded.

Tree values

Results of species richness, Shannon and Simpson indices, basal area per plot and mean heights under different institutional arrangements are presented in Table 3.

ANOVA could only be carried out on the number of trees, species richness and the mean height. The forests were grouped according to their ecological settings. The settings included riverine forests Kizzikibi, Kyambogo, Lwamunda, Buttobuvuma, Mpanga, Lukambagire, Mugalu and

TABLE 2. Types of human consumptive disturbances and their occurrence

Institutional Arrangements	Forests	Disturbances and their occurrence						Total Plots
		None	PS	CB	CF	AE	Others	
Government	Mpanga	28	0	0	0	0	2	30
	Buttobuvuma	4	3	10	5	4	4	30
	Mugomba	0	2	7	13	3	5	30
	Lwamunda	15	17	12	4	7	5	60
	Kizzikibi	2	16	2	3	0	7	30
	Kyambogo	4	23	1	0	0	2	30
Private	Mugalu	3	8	9	6	3	1	30
	Namungo	17	3	1	1	7	1	30
	Lukambagire	7	0	4	10	7	2	30
	Najjakulya	17	10	1	0	1	1	30
Communal	Bukasa	3	0	0	0	0	0	3
	Semalizi	5	0	0	0	0	0	5
	Mukasa	8	0	0	0	0	0	8
	Magezigoomu	10	10	3	1	2	4	30
Total		123	92	50	43	34	34	376
Proportional %		33	25	13	11	9	9	100

Namungo); grassland forest pockets (Najjakulya, Bukasa, Magezigoomu, and Semalizi); permanent swampy forests (Mugomba); and lakeshore forests (Mukasa). This reduced the the ecological differences. Given the small population in other ecological setting, the test was carried only on riverine forests to establish that the differences in values for number of trees, species richness and mean height were significant and are due to management regimes. At 5% level with 5 df, p = 0.187 for the number of trees; 0.382 for species richness; and 0.757 for mean height. This indicate that there are significant differences in the values of number of trees, species richness, and mean height for the riverine forests, implying that there are no differences between government exploitation, government nature and private individual management regimes.

Regression analysis

Regression analysis was carried out (Table 4) to test the significance of functional relationships between the variables and the distance from Kampala.

Conclusion

The results of the study show that health conditions of the forests may be similar under different institutional arrangements. The major differences occur between forests within an institutional arrangement. However, on the whole forests for consumptive use had a higher occurrence of human consumptive disturbances than those for non-consumptive one. There was more occurrence of disturbances in forests for consumptive use located within 30km from Kampala than those located between 30-80 km. Again considering basal area per plot, non-consumptive forests under both government and communal arrangements had better performance than consumptive forests. The based general professional observation

Table 3. Forest tree values by forests.

Forest	Trees (No)	Species richness	Shannon index	Simpson index	Basal area (cm^2)per plot	Mean height(m)
Kizzikibi	367	54	3.15	0.07	0.78	12.7
Kyambogo	454	68	3.48	0.04	1.06	12.9
Lwamunda	732	101	3.93	0.02	0.78	14.0
Mugomba	139	37	2.99	0.06	0.33	09.8
Buttobuvuma	314	64	3.57	0.03	0.57	13.4
Mpanga	385	70	3.55	0.04	0.96	15.8
Lukambagire	247	44	3.02	0.08	0.40	10.4
Mugalu	299	50	3.40	0.04	0.81	10.1
Najjakulya	237	43	2.97	0.08	0.32	08 8
Namungo	351	66	3.71	0.03	0.85	17.5
Bukasa	59	7	0.75	0.68	1.27	08.2
Magezigoomu	293	41	3.22	0.04	0.57	10.8
Mukasa	101	24	2.76	0.07	1.11	14.4
Semalizi	86	18	2.18	0.16	1.43	10.8

Table 4. Coefficients of variables from the relationships with distances

Variables	Regression Equation	R -sq (adj) value %	p value
Number of trees	No of Trees = 10.7 + 0.0014 Distance (D)	0.0	0.902
Basal area per tree	Basal area / tree = 0.0739 - 0.000155 D	0.1	0.245
Basal area per plot	Basal area/ plot = 0.781 - 0.00141 D	0.0	0.316
Species richness	Species richness = 7.39 - 0.0118 D	0.5	0.087
Shannon index	Shannon index = 1.69 - 0.00071 D	0.0	0.566
Number of saplings	No of saplings = 3.53 + 0.0293 D	2.8	0.001***
Species richness saplings (SRS)	SRS = 2.21 + 0.0190 D	4.8	0.001***
Shannon index saplings (SIS)	SIS = 0.611 + 0.00610 D	5.2	0.001***

*** significant at the 0.1% level.

forests under the government institutional arrangement was better than those under private institutional arrangement. This suggests that natural forests could be better managed under government institutional arrangements. But with one single study it was difficult to come to a decisive conclusion, therefore I would be able recommend on which the institutional arrangement best governs the natural forests after completing the same study in other areas of the country.

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