ECONOMICS AND SUSTAINABILITY OF COMMERCIAL PRODUCTION OF WOOD FUEL IN MIOMBO WOODLANDS OF EASTERN TANZANIA

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Abstract

Miombo woodlands, which comprise the largest proportion of the savanna regions of southern Africa, are central to the livelihood of both rural and urban households**.** Wood fuel is the main source of energy for the majority of the population, with firewood used in rural areas and charcoal in urban centres. Indigenous commercial production of charcoal, using earth mound kilns, utilises about 42 tree species, a higher number than for any other uses. Over 56% of the trees harvested within communal lands (ranging between 2.4 and 68.6 cm dbh) were felled for charcoal. The apparent profit in charcoal production is attributable to very low capital outlays, "free" own labour, "free raw materials", lack of concern about associated external costs, high demand for charcoal and lack of alternative income-generating activities. Cutting of trees for charcoal implies an opportunity cost as the trees may have been used for other purposes such as timber, construction, medicine, firewood and food.

Miombo woodlands also perform vital ecosystem services such as carbon sequestration, nutrient cycling and watershed protection. The estimated local wood consumption for charcoal of 6.01 m^3 $capita^{-1}$ $year^{-1}$ is very high compared to subsistence firewood consumption of only 1.3 m^3 $capita^{-1}$ $year^{-1}$. The area cleared for charcoal production locally was about 1 671 ha $year^{-1}$ which is about 10% of the accessible area within local communal lands. This shows that although commercialisation of wood resources provides tangible monetary benefits to rural communities, it also contributes to environmental degradation that will ultimately threaten their long-term survival.

1. Introduction

Tanzania uses about 90% of its total energy (biomass, petroleum, electricity and coal) as wood fuel, compared with only 14% in South Africa (SADC, 1993). Most of the wood fuel is supplied from miombo woodlands, which are dry tropical woodlands covering nearly 3 million km^2 in Africa, and inhabited by > 40 million people. Miombo is the source of products that serve the basic needs of rural people plus an additional 15 million urban Africans (Campbell *et al.*, 1996). In Tanzania, firewood is used in rural areas while charcoal is used in urban centres. The demand for charcoal is rising due to the relatively high cost of electricity and petroleum-based fuels (e.g. paraffin), as well as rapid rates of population growth, particularly in urban areas (Deudney & Flavin, 1983).

This study assigns monetary values to the production function of the indigenous charcoal industry and demonstrates its importance to the economies of the local producers through cost-benefit analysis (CBA) and quantifies the local impact of commercial utilisation of charcoal on the environment.

2. Study area

The study was conducted in the villages and woodlands on public (communal) lands surrounding Kitulanghalo Forest Reserve, located about 50 km east of Morogoro Municipality on the road to Dar-es-Salaam, which is about 150 km further east. The area is bisected by the Dar-es-Salaam-Morogoro-Lusaka (Zambia) highway, which is the main transportation route for forest products to urban/commercial centres such as Dar-es-Salaam and Morogoro. The climate of the area is tropical and subhumid (Kielland-Lund, 1990). Mean annual rainfall is about 900 mm, which is seasonally distributed providing a wet season from November to May and a dry season from June to October. The mean annual temperature is 24.3 ^oC while the annual minimum and maximum temperatures are 18.6 ^oC and 28.8 ^oC respectively.

This climate, together with the generally nutrient-poor, well-drained soils, supports miombo woodlands and some patches of semi-evergreen forests (Kielland-Lund, 1990). The farms in the area, which were traditionally cultivated for cash crops, are reported to have low yields because of poor tools, lack of markets, poor inherent soil fertility as well as lack of adequate moisture (Shayo-Ngowi *et al.*, 1995).

2. Methodology

Structured questionnaire interviews were administered to 80 households in two sampled villages, Gwata and Maseyu in November and December 1997. The questions that were asked covered the broader social and economic viewpoint of the households with respect to the use of tree products from the surrounding woodlands. Unstructured and group interviews were used to obtain information from key informants who were

charcoal producers (n=8), charcoal wholesalers (n=3), village headmen (n=3), forest guards (n=3) and the regional forest officer. In the woodlands, ten unburnt charcoal kilns were randomly selected and measured to obtain the stacked and solid volume of wood, which was then converted into charcoal weight equivalents (Ishengoma, 1982; O'Kting'ati, 1984). The data from households and charcoal kilns surveys were used in cost-benefit analysis (CBA) by calculating the net present value (NPV) of future cash flow from charcoal production on both a *per capita* (NPV_c) and a per hectare (NPV_h) basis. Thirty 50 X 20 m plots were surveyed in the woodlands to assess both standing and harvested wood, to identify the species that were harvested (from stumps) and to establish the purpose for which they were removed

3. Results

3.1 Extent of charcoal production

Fifty-four percent of the households were involved in charcoal production, indicating that charcoal burning is one of the main activities in the area, creating employment for both rural and urban people, as the urban end-users buy their charcoal from retail traders, who in turn buy from wholesalers or from producers. The marketing of charcoal therefore forms a complex network creating employment for various people. Ninety-six percent of the respondents in the study area use firewood for domestic fuel, compared with 4% who use charcoal, indicating that charcoal is produced mainly for the market. There are also outsiders from other regions in the country who are involved in charcoal production in the area. The outsiders are more occupied with charcoal production than the local people, and some of them use fire as a means of felling trees, especially the dense-wooded *Acacia nigrescens* Oliver, a practice which is not used by local producers and which sometimes results in "accidental" wildfires. The species of *Julbernardia globiflora* (Benth.) Troupin and *Combretum molle* Engl.& Diels, which are most preferred for charcoal production, were those with the largest volumes of felled individuals in the communal woodlands.

3.2 Cost-benefit analysis (CBA)

When the cost of labour, raw materials and the opportunity costs of other foregone products were not included, using an effective discount rate of 4%, the NPV_c calculated over 15 years was USD 451.45 $capita^{-1}$, and USD 510.60 $hectare^{-1}$, indicating that the charcoal production is profitable from the producers' point of view. But, when the opportunity costs of other products were included in the analysis, the NPV_h calculated over 15 years was negative, suggesting that charcoal production is associated with negative externalities.

3.3 Full cost of charcoal production

The volume of newly felled trees was 6.38" 2.9 (S.E) m^3 ha^{-1}, which exceeded by far the mean annual increment (MAI) of dry miombo woodlands of 2 m^3 ha^{-1} $year^{-1}$ (Chidumayo, 1991), signifying that the harvesting of miombo trees in public lands was not sustainable. Charcoal alone contributed to 56.4% of total tree removal, with minimum size selection relative to other purposes of harvesting trees (Table 1). Some of the trees harvested for charcoal have other uses in construction, medicine, firewood and food (Table 2). Highly preferred species such as *Julbernardia globiflora* and *Combretum molle* appear to be negatively affected by high levels of utilisation as their removal/standing volume ratios were 6.85 and 1.41 respectively (i.e. 28% and 13% of total volume removed).

Overall wood consumption for charcoal production was estimated to be 6.01 m^3 $capita^{-1}$ $year^{-1}$, which is very high compared to firewood consumption of only 1-2 m^3 $capita^{-1}$ $year^{-1}$ (Nkonoki, 1981). The estimated area cleared annually by the studied population of 4 640 people was 1 670.5 ha $year^{-1}$, while the total accessible communal land used by the three villages is estimated to be 16 500 ha, some of which have been converted into farm lands and settlements. Thus nearly 10% of the area was cleared annually.

4. Discussion

The apparent profit from charcoal production, which is the reason why 54% of the households were involved in this activity as the main income-generating activity, is attributable to very low capital outlays, "free" own labour, "free raw materials", lack of concern about associated external costs, high demand for charcoal and lack of alternative income-generating activities. The bio-energy programme of the Tanzania Forestry Action Plan (TFAP, 1989) attempted to rationalise the demand for charcoal by encouraging urban people to use improved clay charcoal cooking stoves which use less fuel, but most people still use conventional metal stoves which are readily available and affordable in the market (Monela *et al.*, 1993).

The negative NPVs obtained when the opportunity costs of charcoal production were included indicate that the actual impact of over-utilisation of environmental resources is underrated because externalities are not charged for. The use of fires as a felling tool by outsiders who are involved in charcoal production in the area suggests that they may have a totally different attitude to sustainability, possibly because they feel no ownership of the resources and are likely to move elsewhere when the resources are depleted. Miombo

woodlands also perform vital ecosystem services such as carbon sequestration, nutrient cycling and watershed protection, thus the estimated local clearing of 1 670.5 ha year^{-1} clearly leads to environmental degradation. Monela *et al.* (1993) estimated a cleared area of 4 354 ha year^{-1} along the Dar- -es-Salaam B Morogoro highway, indicating that commercial wood harvesting in eastern Tanzania is not sustainable.

Table 1. Purposes for tree harvesting, their respective contributions (%) to overall harvesting intensity and diameter at breast height (DBH) of felled trees in relation to various uses in public lands surrounding the Kitulanghalo Forest Reserve, Morogoro, Tanzania

Purposes	Harvesting intensity			Diameter of harvested trees	
	No. of sampled stumps	% of all stumps	Stumps ha^{-1} (mean"S.E)	DBH (cm) (mean"S.E)	Range (cm)
Carving	3	0.5	1"1.0	17.2"0.3	12.2 - 21.0
Charcoal	309	56.4	103"22.9	14.2"0.6	2.4 - 68.6
Fires	16	2.9	5"83.3	4.1"0.1	0.9 - 7.3
Firewood	11	2	4"3.4	9.1"0.2	4.2 - 16.9
Land preparation	99	18.1	33"17.1	10.9"0.3	2.8 - 27.1
Natural mortality	28	5.1	9"4.0	8.2"0.3	1.8 - 24.4
Poles	55	10	18"77.1	9.0"0.4	2.6 - 29.1
Ropes*	9	1.6	3"3.0	.4"0.1	3.6 - 10.5
Timber	2	0.4	1"0.5	6.4"0.5	20.7 - 32.1
Tracks	9	1.6	3"3.0	7.1"0.1	4.2 - 9.5
Unknown	7	1.3	2"0.9	11.1"0.5	2.8 - 29.4

*Trees felled before bark stripping

Table 2. Percentage of tree species that are used to make charcoal in addition to other uses in Kitulanghalo Forest Reserve and surrounding public lands, Morogoro, Tanzania

Uses	Number of species	No. of species also used for charcoal	Percentage
Charcoal	42	-	-
Timber	12	11	92
Firewood	36	32	89
Poles	41	29	71
Medicines	35	18	51
Ropes	4	2	50
Carving	2	1	50
Others	18	6	33
Rituals	9	1	11
Food	13	1	8
Mean " S.E	22.2"5.4	11.2"4.1	50.5 "10.1

5. Conclusion

Although commercialisation of wood resources provides tangible monetary benefits to rural communities, it also contributes to environmental degradation that will ultimately threaten the long-term survival of these communities. Self-employment opportunities in charcoal production indicate that unless exposed to other income-generating activities, people will stay in this business at the expense of the environment and their future security.

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