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Fuelwood availability and consumption in a semi-arid savanna, Zimbabwe

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Abstract

This paper quantifies fuelwood availability and consumption in two villages and assesses the gap between the two variables as well as local strategies used to fill the gap. Traditional fuelwood collection areas were found to be wooded grasslands, hills and riverine woodlands. About 60 percent of the households in Shambamuto and 67 percent in Svova "B" collected fuelwood from non-woodland sources such as cultivated lands, wooden structures, woodlots and other sources. Standing wood stock household^{-1} was estimated at 19.4 tonnes in Shambamuto and 8.4 tonnes in Svova "B". Such stock had a potential of supplying an average household with fuelwood of 2.5 tonnes year^{-1} in Shambamuto and 1.4 tonnes year^{-1} in Svova "B". Fuelwood consumption was estimated at 4.5 tonnes household^{-1} year^{-1} in Shambamuto and 4.1 tonnes household^{-1} year^{-1} in Svova "B". The villages were found to be experiencing a deficit of 2.0 tonnes household^{-1} year^{-1} in Shambamuto and 2.7 tonnes household^{-1} year^{-1} in Svova "B" Fuelwood procurement from non-woodland sources was found to be a key strategy of enhancing supply while fuelwood supplementation with non-traditional fuels such as maize cobs, cattle dung, root and stump wood was a key strategy of mitigating demand.

1 Introduction

In southern Africa, over 70 percent of the household energy demands in both rural and urban areas are met through fuelwood gathered from forests and non-

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forest land. Fuelwood is used for cooking, space heating and rural industries such as brick making, fish drying, pottery and beer brewing. Field evidence from many localities suggests that most of the countries in southern Africa are experiencing growing wood shortages.

The conversion of savannas into fallows or degraded forest has increased considerably in southern Africa during the last decades due to agricultural activities. Chenje and others [1] noted that the rate of deforestation in Zimbabwe is 100 000 ha $year^{-1}$, or 0.6 percent of the total forest area, translating into about 7 million m^3 of woody biomass. According to Lele and Stone [2], in Malawi 24 percent of the total forest area has been converted to arable land. Chidumayo [3] found out that of the estimated 0.9 million ha deforested in 1990 in Zambia, shifting and semi-permanent cultivation were responsible for 66 percent and 29 percent respectively and the remaining 5 percent was attributed to harvesting fuelwood.

Reliable data on woody biomass supplies from the degraded forest and woodland areas are not available for most countries in southern Africa. Past planning approaches for woody energy have been adversely affected by lack of data on natural woodland productivity. Attempts to estimate the balance between wood supply and consumption failed to take into consideration that in rural areas, fuelwood is largely collected within the farming landscape. To further investigate fuelwood availability and consumption as well as local strategies used to fill the gap in areas experiencing deficits, two villages were chosen in the communal areas of Zimbabwe known to have fuelwood scarcity problem.

2 Study areas

The study was conducted in Shambamuto and Svova "B" villages in Buhera district of Manicaland province, about 20 km from Murambinda Growth Point. The study areas lie in agro-ecological region IV that according to the Zimbabwean classification of agro-ecological zones is semi-arid. Nyamwanza and Moyo [4] found that annual rainfall is between 450 and 650 mm. According to Torrance [5], mean annual temperature is within 22 to 25^0C. Most of the soils are derived from granite and are often sandy. These soils are predominantly shallow, moderately leached with low fertility and water-holding capacity. Studies by Thompson and Purves [6] show that they have a low agricultural potential, considering that they occur in a drought prone low rainfall area with a high rate of evapotranspiration). The vegetation in its climax state is mostly dry miombo woodland on granite-derived soils dominated by *Julbernadia globiflora* and *Brachystegia boehmii.*

3 Materials and methods

3.1 Sample plots

To estimate standing wood stock and woodland productivity, four major land cover types were identified in Shambamuto (hills woodland, wooded grassland,

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riverine woodland and cultivated lands) and two in Svova "B" (riverine woodland and cultivated lands) from which villagers collected their fuelwood. For each major land cover type identified, sample plots of variable sizes were delineated as follows; cultivated lands (100 m x 100 m), wooded grassland (50 m x 50 m), riverine woodland (50 x 20 m), and hills woodland (20 m x 20 m). To allow effective enumeration of trees, the size of sample plots were reduced as density of woody species increased. At least six temporary plots and six permanent plots were demarcated in each land cover type.

In order to establish permanent plots, one meter length of metal round bars were pounded into the ground at the corners of each plot leaving approximately 30 cm of round bar above the surface. A total of 332 stems of various species were marked in June/July 1999 at 30 cm above ground level with paint so that subsequent re-measurements take place at exactly the same point. Each marked stem was numbered for purposes of future identification.

3.2 Measurement of tree characteristics

In each sample plot, the height and circumference at 30 cm above ground of all woody species greater than 2.5 m in height and with a circumference of more than 15 cm were recorded. A girth tape was used to measure circumference. Height less than 2 m was measured using a fibreglass tape and heights greater than 2 m but less than 4 m were estimated visually. For heights greater than 4 m, an Abney level was used to determine the angle from the top of the tree taken from a predetermined distance away from the tree. Height was then calculated through trigonometric conversion.

The circumference of both standing live and dead trees was measured in temporary plots while only the circumference and height of live trees was marked in permanent plots. In June/July 1999, basal circumference and height were recorded and in June/July 2000, only basal circumference was recorded as well as the status of each marked stem (e.g., alive, dead, broken, smashed, cut, burnt, lost etc).

3.3 Household sampling

A questionnaire was used to collect household data. It included questions on fuelwood procurement, utilisation, supplementation and substitution. It was filled-in by researchers who moved from one household to another asking questions. This was done to increase the response rate, accommodate illiterate people in the survey and to reduce time for data collection. Sixty three percent of the households in Shambamuto and hundred percent in Svova "B" were sampled. A spring balance, capable of weighing 100 kg was used to measure fuelwood consumption for all the selected households. The measurements were done in two stages. In the first stage, households were requested to set aside the amount of fuelwood they would use for the next 24 hours. The fuelwood was weighed, the tree species used were noted and the number of people at home that day was recorded. In cases where people were not at home the day of measurement, members of each household were requested to record the number of people at home on a piece of paper and then tie it with a string to the bundle of fuelwood they had set aside.

The second stage was aimed to reduce the bias of the individuals who set aside fuelwood. They were requested to use fuelwood they had set aside for the next 24 hours so as to find out if there was any surplus or shortfall. All the fuelwood that remained was set aside for measurement. In cases of shortfalls, members of the household were requested to set aside a bundle of fuelwood similar to the one they had added so that the bundle could be weighed.

3.4 Data analysis

Standing wood stock (live and dead) was calculated for all the enumerated trees. Calculations were done irrespective of plant species because all available woody species were used for fuel. The circumferences of trees were converted to diameters and basal area then calculated from the diameter data. Increase in basal area was converted to biomass using Rutherford's 1979 general allometric equation [7]. Frost's 1989 allometric regression equation was used to calculate standing wood stock of all the enumerated woody species. Grundy and others [8] used the equation in Zimbabwe's Mutanda Resettlement Area. The equation is as follows:

$$\text{Biomass (kg)} = \text{exponent}\ (-8.1163 + 1.0077 * Z)$$
where $Z = \ln\ (\text{diameter (cm)})^2 * \text{height (cm)}$.

Growing wood stock and basal area was calculated on a per hectare basis. Woody productivity was expressed in absolute increments in basal area per hectare (corrected for death). Correction for death was effected by deletion of dead stems from the data. Thus, corrected values reflect the basal area change of living stems only, which may have increased, decreased or remained the same. The differences in fuelwood consumption between the two villages were analysed using analysis of variance (ANOVA). Moisture content of fresh wood was estimated at 16 percent as per Attwell and others' recommendations [9].

4 Results

4.1 Fuelwood availability

Traditional fuelwood collection areas were found to be wooded grasslands, hills and riverine woodlands. About 60 percent of the households in Shambamuto and 67 percent in Svova "B" collected fuelwood from non-woodland sources such as cultivated lands, dilapidated wooden structures, exotic woodlots and other sources within their village boundaries. All surveyed households indicated that they do not purchase fuelwood. The majority of the respondents (76 percent in Shambamuto and 93 percent in Svova "B" indicated that they find it difficult to collect fuelwood. All woody species (live and dead) were used for fuelwood.

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Standing wood stock (live and dead) per household was estimated at 19.4 oven-dried tonnes in Shambamuto and 8.4 oven-dried tonnes in Svova "B". Tables 1 and 2 show that cultivated lands, are an important source of woody biomass in both villages. They account for about 15 percent of the total standing wood stock in Shambamuto and 26 percent in Svova "B". Most of the trees left in the fields were medium to large trees while small trees, were found along contour bunds. Standing wood stock per unit area decreased from the relatively dense hills woodland (4.3 oven-dried tonnes ha^{-1}) to cultivated lands (0.7 oven-dried tonnes ha^{-1}).

Table 1: Total standing wood stock in Shambamuto.

Land cover type	Area covered (ha)	Biomass (oven-dried t ha^{-1})	N	Total biomass (t)
Hills woodland	237.5	4.3	8	1021
Wooded grassland	188.1	3.0	6	564
Riverine woodland	109.0	4.0	6	436
Cultivated lands	430.6	0.8	6	345
Total	965.2			2366

Table 2: Total standing wood stock in Svova "B" village.

Land cover type	Area covered (ha)	Biomass, (oven-dried t ha^{-1})	N	Total biomass (t)
Riverine woodland	34.6	3.4	6	118.0
Cultivated lands	57.3	0.7	6	40.9
Total	91.9			158.9

Between the years 1999 and 2000, mean absolute basal area changed positively in all the land cover types despite the fact that some stems had a mean negative growth (Tables 3 and 4). This is attributed to above average rainfall received between the two periods. Most of the stems that shrunk showed signs of stress from diseases. Woody productivity ranged from 0.06 m^2 ha^{-1} $year^{-1}$ (equivalent to 0.2 oven-dried tonnes ha^{-1} $year^{-1}$) to 0.14 m^2 ha^{-1} $year^{-1}$ (equivalent to 0.5 oven-dried tonnes ha^{-1} $year^{-1}$). Generally, stems with smaller diameters had higher basal area increment. Growing wood stock in the study areas had a potential of supplying an average household with 2.5 oven-dried tonnes $year^{-1}$ in Shambamuto and 1.4 oven-dried tonnes $year^{-1}$ in Svova "B".

Table 3: Wood supply in Shambamuto.

Land cover type	Basal area, m^2 ha^{-1}		Absolute change in basal area*	Biomass production t $year^{-1}$
	1999	2000		
Hills woodland	31.73	31.84	0.11	87.1
Wooded grassland	18.16	18.30	0.14	87.8
Riverine woodland	35.07	35.20	1.13	47.2
Crop fields	3.23	3.29	0.06	86.1
Total				308.2

$^*m^2ha^{-1}$ $year^{-1}$

Table 4: Wood supply in Svova "B".

Land cover type	Basal area, m^2 ha^{-1}		Absolute change in basal area*	Biomass production t $year^{-1}$
	1999	2000		
Riverine woodland	30.38	30.52	0.14	16.1
Crop fields	2.98	3.04	0.06	11.5
Total				27.6

$^*m^2ha^{-1}$ $year^{-1}$

4.2 Fuelwood consumption

Fuelwood consumption is estimated at 4.5 air-dried tonnes $household^{-1}$ $year^{-1}$ in Shambamuto and 4.1 air-dried tonnes $household^{-1}$ $year^{-1}$ in Svova "B" (Table 5). The two villages had the same household size (6 people per fireplace or per kitchen) and consumption rates did not vary significantly ($p>0.05$). Fuelwood is sometimes burnt together with maize cobs, animal dung and inferior wood. Due to fuelwood scarcity problem households adjusted demand by employing a variety of saving methods such as extinguishing fire soon after cooking, switching from more energy-intensive to less energy-intensive foods and lowering of the fire grate. Fuelwood substitution with modern forms of energy such electricity, kerosene, gas and solar was not common in both villages.

4.3 Fuelwood availability/consumption balance

Shambamuto village had a deficit of 2 tonnes $household^{-1}$ $year^{-1}$ and Svova "B" had a deficit of 2.7 tonnes $household^{-1}$ $year^{-1}$. Fuelwood collection from cultivated lands reduces the gap by 26 pecent in Svova "B" and 16 percent in Shambamuto. The gap is reduced further through collection of wood from dilapidated wooden structures, exotic woodlots, tree stumps and roots, twigs, and debris of woody plants deposited along riverbanks during rainy seasons.

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Table 5: Fuelwood consumption for Shambamuto and Svova "B" villages.

	Shambamuto	Svova "B"
Mean household consumption*	4.5	4.1
Standard deviation (SD)	1.87	0.52
Standard error of mean (SE)	0.34	0.12
Coefficient of variation (COV)	41.6	12.7
No. of sampled households (N)	77	19
Household size	6.1	6.1
Consumption per person[1]	0.74	0.67

* air-dried tonnes $year^{-1}$

5 Discussion

Results obtained in this study suggest that productivity of woody species in a semi-arid savanna is generally low. Woody productivity figures reported in this study may be considered minimum for two reasons. Firstly, stems with a height of less than 2.5 m were not included. Although smaller stems demonstrate higher growth rates and were used to start the fire, their contribution to the total basal area is low. Secondly, productivity data is for a single year, which does not reflect seasonal variations over a long period of time. Despite these limitations, data from other vegetation types suggest similar rates of basal area increment. Rutherford estimated that the volume of wood production (limbs and branches) for savannas and woodlands in southern Africa is 0.6 oven-dried tonnes ha^{-1} $year^{-1}$. FAO [10] estimated at 1 m^3 ha^{-1} $year^{-1}$ for wooded savannas and 0.5 m^3 ha^{-1} $year^{-1}$ for savannas with trees.

Fuelwood consumption figures of 4.5 tonnes $household^{-1}$ $year^{-1}$ in Shambamuto and 4.1 tonnes $household^{-1}$ $year^{-1}$ in Svova "B" obtained in this study are within the range reported elsewhere in Zimbabwe and in other southern African countries The values are similar to 1 m^3 $person^{-1}$ $year^{-1}$ (equivalent to 0.75 t $person^{-1}$ $year^{-1}$) often quoted for Zimbabwe. Outside Zimbabwe, Allen and others [11] obtained a similar figure of 0.77 tonnes $person^{-1}$ $year^{-1}$ in Sigombeni in Swaziland.

6 Conclusion

Fuelwood was found to be scarce in both villages. A deficit of 2.0 tonnes $household^{-1}$ $year^{-1}$ in Shambamuto and 2.7 tonnes $household^{-1}$ $year^{-1}$ in Svova "B" was recorded. The sourcing of wood from non-woodland areas and the supplementation of fuelwood with non-traditional fuels appear to be sufficient to fill the gap between supply and demand.

In southern Africa, many rural people cannot afford to maintain consumption rates through the purchase of fuelwood, instead they are forced to reduce demand as fuelwood becomes expensive (in terms of procurement). As forests and

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woodlands are transformed into arable lands, standing wood stock declines but the retention of tree stumps and trees in crop fields provide a good source of fuelwood. Due to the fact that rural people employ various adaptive strategies in order to close the fuelwood gap, deforestation may not necessarily be accompanied by fuelwood crisis as projected by traditional estimates of supply and consumption that gave rise to the concept of the fuelwood gap.

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