Consumption and direct-use values of savanna bio-resources used by rural households in Mametja, a semi-arid area of Limpopo province, South Africa

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Household consumption and direct-use values of a range of savanna bio-resources were quantified for 110 households across three villages in the Mametja Traditional Authority, Limpopo province, South Africa. The relationship between household wealth status and use of natural resources was also assessed. We found that the use of natural resources was extensive, the most common being wooden utensils, grass handbrooms, twig handbrooms, fuelwood, wild herbs, wild fruit and edible insects. Households in the poorest of the three villages consumed the most wooden utensils, wild herbs, wild fruit and thatching grass. Fuelwood was widely used, even though two of the three villages had electricity, and consumption was highest in the largest, most developed village. The mean annual direct-use value of indigenous bio-resources, averaged across all households, was R3959 per household or R564 per person. The value was highest in the poorest of the three villages. Poor households relied most heavily on 'essential' natural resources such as wild foods, whereas comparatively wealthy households used a wider range of resources and utilized greater amounts of 'luxury' items, such as wooden utensils and poles. These findings are discussed in the context of poverty and sustainable rural development, and should be of value to scientists, community developers, and policy-makers.

Introduction

According to a growing body of literature, rural communities across the developing world depend greatly on indigenous natural resources,[1–9] which act as a buffer against poverty.[1,9] These resources are used for domestic purposes and to generate income. Some studies have attempted to value natural resources[10–13] by calculating the total value traded, the worth of standing biomass, or the direct-use value (that is, the financial value of resources used domestically). Most surveys of this kind have been conducted in the tropical forest ecosystems of South America and Asia. Only recently has attention been paid to deriving direct-use values of resources in semi-arid savannas in southern Africa.[2,14–17]

Savanna woodlands, covering more than one-third of South Africa's surface area,[18] are home to 9.2 million rural people.[19] These regions are marginal for agricultural activities, largely because of unpredictable rainfall, and are often remote and poorly serviced. Indigenous natural resources therefore play a vital role in the livelihoods of local communities.[9,20] These resources, however, are coming under increasing pressure for reasons such as poverty, high human population densities, and the weakening of traditional authorities that have historically been responsible for the control of access to natural resources in these parts of the country.

Implementation of informed policies needs to address issues of equitable access and sustainable use of resources in semi-arid rural areas. This is hampered in South Africa, however, because policy-makers do not know the value of natural resources, nor the potential loss of value through unsustainable harvesting. The economic and social worth of land-based strategies (including natural-resource harvesting) with regard to rural livelihoods in South Africa have not been fully appreciated, especially in terms of 'direct provisioning' and as part of the 'rural safety net.'[9]

Our purpose was to ascertain the value of the natural resources harvested by local communities. This study attempted to determine the consumption and direct-use worth of savanna resources used in a typical semi-arid rural area of South Africa, and the relationship between the level of household wealth and the use of these resources.

Method

Study site

The study was conducted in the Mametja Traditional Authority in Limpopo province (24°23'S, 30°33'E). The local inhabitants, the Bakoni ba Mametja, speak a dialect of SePedi in the Sotho language group. Under the apartheid government the area formed part of the black homeland of Lebowa. The six, relatively poor rural villages comprising Mametja are typical in the region.

Three villages were selected for this study: Finale A, Mabins B and The Willows. Referred to in this article as Finale, Mabins and Willows, they represent a range of rural settlements, from a small, remote and poorly serviced example (Finale) to a large, better serviced one on a major secondary route (Willows). Mabins is intermediate between the two. Willows and Mabins were electrified in the mid-1990s. Finale has no electricity.

Mametja, at the base of the Transvaal Drakensberg escarpment, has an undulating topography with rocky outcrops. The underlying geology consists of Harmony granite with largely sandy eutrophic soils, although the bottomlands are characterized by more fertile, clay-rich soils. The climate is semi-arid, with a mean annual rainfall of 488 mm.[21] The vegetation is predominantly Arid Lowveld savanna,[22] characterized by tree species such as *Sclerocarya birrea, Combretum apiculatum* and *Acacia nigrescens.*

Data collection

Data were collected during July 2000 using household interviews, participatory rural appraisals (PRA), and key informant interviews. Household socio-economic information and natural resource use data were collected using an in-depth structured questionnaire after Shackleton *et al.*[14] For the household interviews, 110 households were randomly sampled across the three study villages (38 in Finale, 36 in Willows, and 36 in Mabins), providing a coverage of 5% of all households across the three villages. Each village was divided into four sections in which each of four field workers randomly selected households, ensuring an even spread over their section.

The resource use part of the questionnaire included a checklist of all uses of local indigenous resources utilized by the household, followed by a section for details of each (excluding aquatic

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and abiotic resources). Details of resource use were recorded, including frequency of use (weekly/monthly/annually), the amount of the resource consumed, and its availability. Questions were included relating to the buying and selling of the resource of interest as well as local prices, so that direct-use values could be calculated.

The dimensions of containers used for estimating amounts of fruit, wild herbs, and edible insects consumed were measured and expressed in litres. It was difficult to calculate the amounts of wild fruit consumed annually, because fruit is sometimes eaten straight off the tree and availability varies between years. Nevertheless, households estimated the amount of fruit consumed daily or weekly during the fruiting season by indicating the number and size of containers that would be filled with produce. As this study was conducted in July, insects were not plentiful, so the amount of insects consumed was not easy to measure. Households were therefore asked to estimate the volume of insects eaten daily during the six-month period of availability. The amount of wood used in a day by a household was weighed on a spring-balance.

Data on resource consumption had often to be expressed in dimensions of local units such as 'donkey cart load', '4 kg *atchar* bucket' or 'cups', which were then converted to conventional units of measurement. The volume of a cup was taken to be that of the commonly used enamel mug, which is 0.40 l. A *bakkie*-load of wood was determined to be 532 kg (n = 4), almost the same figure calculated by Shackleton *et al.*[14] The mass of a cart-load was not determined, but was assumed to be the same as that of a *bakkie*-load (donkey carts are often made from the carry bin of a *bakkie,* or pickup). A piece of meat the size of an adult's hand was assumed to weigh 750 g .

In each of the three villages we conducted a three-hour PRA session. Its primary aim was to collect information about the species used in each of the resource categories, the most sought-after species, seasonal availability, perceptions of changes in the availability of resources, and an historical perspective of the village. The numbers of participants varied from 17 to 31, and ages ranged from early teens to late seventies. Groups consisted of roughly equal numbers of males and females. To determine local prices and the most popular species used, key informant interviews were conducted with three wood carvers who made wooden utensils.

Data analysis

Socio-economic data. Household data (such as the total of permanent residents or number of cattle owned) were averaged per village. Analysis of variance (ANOVA) and Bonferroni post hoc tests were used to examine statistically significant differences between means. Household data recorded in binary format (for example, the existence of at least one household member with a job or owning cattle) was expressed as a percentage of households per village.

Resource use data. The household resource use checklist data, recorded in binary format, was employed to calculate the percentage of households in each village using each of the resources. Household consumption of each commodity was averaged over all the households in each village. The analysis excluded the consumption of livestock fodder, medicinal plants, furniture and construction reeds because of small sample size and difficulty in quantifying consumption. It also excluded fish consumption, as this project focused on terrestrial savanna products.

Annual household consumption of each resource was calculated as follows:

- Bushmeat — because availability was assumed to be the same throughout the year, monthly consumption was multiplied by 12. In many cases, households reported consuming bushmeat only a few times a year.
- Edible insects — volumes of grasshoppers, termites and flying ants were calculated separately and then summed. Monthly consumption was multiplied by six for the months of availability. The amount of insects consumed was expressed in litres, as few were available to weigh at that time of year, and no data were found on which to convert volume to mass.
- Fencing and housing-poles — a replacement rate of 5% was assumed[15] and applied to numbers of poles per household.
- Fuelwood — an increase in utilization by 35% during the winter months (91 days) due to the use of wood for heating was assumed, based on findings by another study in the region.[23] Because data were collected in winter, daily fuelwood consumption figures were discounted by 35% for 274 days of the year in calculating annual consumption.
- Grass and twig handbrooms — the number owned was multiplied by life-span (less than a year).
- Reed mats — the number owned was divided by their mean reported life-span (1.7 years). The mean size of a mat was 1.7 m^2.
- Thatching grass — consumption of thatch was expressed in bundles. The roof of a thatched dwelling consisted of a mean of 641 bundles, each with a mean diameter of 15 cm. Annual consumption was discounted over an assumed life-span of 25 years.[15]
- Wild fruit — monthly volume consumed was multiplied by a reported fruiting season of eight months. Volume was converted to mass on the assumption that one litre was equivalent to 625 g.[14]
- Wild herbs — volumes of both fresh and dry herbs consumed per week were calculated for both summer and winter, then converted to mass using the following conversion equations: 1 l fresh herbs = 50 g, 1 l dry herbs = 69 g. These were then summed.
- Wooden utensils — the number owned was divided by the mean reported life-span of each type of utensil or implement (for instance, 2.6 years for a wooden spoon and 50 years for a mortar for grinding maize).

Once annual household consumption had been calculated for each of the above resources, the figures were averaged across all households per village. Analysis of variance and the Bonferroni post hoc tests were used to investigate statistically significant differences between village means for each resource.

Direct-use value. Mean annual direct-use value for each resource was calculated by multiplying mean annual household consumption per village (averaged across all households) by current local price. In the case of wooden utensils, different items had different prices, and the composite value was thus the sum of the mean number of each item multiplied by its mean price. Prices of fresh and dried herbs differed, and these were applied to the mean mass of each, respectively. A single price was applied across species in the cases of insects and bushmeat. Mean direct-use value per resource per household was divided by the mean permanent household size in each village to derive the per capita value. Values were rounded off to the nearest R0.10.

Relationship between household wealth status and resource use. To assess the influence of household wealth on resource use, the 20 'wealthiest' households were compared with the 20 'poorest' households from the total sample. This was done by deriving two different wealth rankings of households: 1) based on

income (calculated by the number of formal jobs and pensions per household), and 2) based on the number of livestock (that is, cattle, goats, donkeys, pigs and sheep) owned by the household. These two different wealth rankings were chosen because of the dichotomy between more 'western' and more 'traditional' household economies in these rural areas.

The 20 lowest ranking (poorest) households and 20 highest ranking (wealthiest) were selected for further analysis from each of the two rankings. None of the poor households in the *income ranking* contained a person with a formal job or pension, and none of the poor households in the *livestock ranking* owned any livestock. Mean permanent, migrant and total household size was calculated for poor and wealthy households in both wealth rankings. Two-sample *t*-tests (for normally distributed data) and two-sample Kalmogorov-Smirnov tests (for non-normal data) were used to test for statistically significant differences between means within wealth rankings.

Resource use was compared among poor and wealthy households within each of the two wealth rankings, focusing on the total number of resources used and the annual consumption of wild herbs, wild fruit, fuelwood, housing poles, fencing poles, and wooden utensils. The first three items were selected because they had the greatest direct-use value. The remaining three were selected because they were tree-derived resources, which were generally regarded as having declined in availability (along with fuelwood). Finally, per capita use and consumption were compared by, first, dividing the household figures by permanent household size, and then averaging these per wealth class within the two rankings. Means for household and per capita figures were compared statistically using two-sample *t*-tests (normal data) and two-sample Kalmogorov-Smirnov tests (non-normal data).

Table 1. Village profiles based on household characteristics.

Household variable	Village			Mean
	Finale	Mabins	Willows	
Permanent residents per household	7.2 ± 2.7[a]	7.2 ± 3.5[a]	6.6[a] ± 2.9[a]	7.0
Migrant residents per household	1.5 ± 2.3[a]	1.1 ± 1.1[a]	1.9[a] ± 2.2[a]	1.5
Formal jobs per household	1.1 ± 0.8[a]	0.5 ± 0.6[b]	0.9 ± 1.0[a]	0.8
Old-age pensions per household	0.5 ± 0.6[a]	0.6 ± 0.7[a]	0.6 ± 0.6[a]	0.6
% of households with no formal income	15.9	33.3	19.4	22.9
% of households owning cattle	40.5	25.0	36.1	33.8
Cattle per household (all)	8.9 ± 32.7[a]	1.8 ± 4.3[a]	4.8 ± 8.6[a]	5.2
% of households owning goats	63.2	55.6	50.0	56.2
Goats per household (all)	5.5 ± 8.4[a]	3.4 ± 5.1[a]	3.7 ± 5.4[a]	4.2
% of households owning donkeys	0	5.6	8.3	4.6
Donkeys per household (all)	0[a]	0.3 ± 1.3[a]	0.5 ± 1.7[a]	0.3
% of households owning chickens	73.7	88.9	69.4	77.3
Chickens per household (all)	5.7 ± 6.2[a]	12.6 ± 11.0[b]	8.1 ± 10.2[a]	8.8

Values in the same row with different superscript letters are statistically significantly different.

Results

Socio-economic context

Table 1 summarizes the socio-economic profiles for the three study villages. The mean permanent household size was seven, with an additional mean of 1.5 migrant members per household. Neither permanent household size nor the number of migrant household members differed significantly among the three villages ($P > 0.05$). Mabins had significantly fewer jobs per household than Finale and Willows ($P < 0.05$). There was no significant difference in the number of pensions per household among villages. Mabins had a considerably higher proportion of households with no formal source of income.

Ownership of cattle was noticeably lower in Mabins and was highest in Finale. Ownership of goats was marginally higher in Finale than in the two other villages. Donkeys were owned by few households in Mabins and Willows, and by none in Finale. Mabins had the greatest number of households owning chickens, and the highest mean number of chickens per household ($P < 0.01$).

Household resource use

Our survey recorded that households in Mametja used a total of seven mammal, 19 insect, and 125 plant species. The last included 24 kinds of edible wild herbs and spinach and 45 types of edible wild fruit. The total plant species list used for medicinal purposes included only the most common ones (18 species). Wooden utensils included spoons, plates, bowls, mortars and pestles, walking sticks, and handles for picks, hoes and axes. Edible insects consisted of grasshoppers/locusts (*ditšie*), termites (*dinhlwa*), and flying ants (*magoro*). Mopane worms (*mašoncha*) were excluded from the analysis, as they did not occur naturally in the area and were purchased from other regions. Sixteen local species or varieties of edible grasshoppers were listed in the PRA sessions, each with a unique Sotho name. Bushmeat included a range of antelope, as well as warthog, hares and birds.

The most commonly used indigenous natural resources and products in all three villages were: wooden utensils, grass handbrooms (*mswelo*), twig handbrooms (*mushasha*), fuelwood, wild herbs, wild fruit, edible insects, fence poles, and reed mats (Table 2). All the 110 households sampled regularly used the first three. Averaged annual household consumption was significantly higher in Mabins than in the other villages for wooden utensils ($P < 0.01$), wild herbs ($P < 0.01$), wild fruit ($P < 0.05$), and thatching grass ($P < 0.05$) (Table 3). Consumption of fuelwood was significantly higher in Willows ($P < 0.05$), while the consumption of wild fruit was both significantly ($P < 0.05$) and considerably lower in this village than in Finale and Mabins. Annual village use of fuelwood, calculated using mean household consumption rates and village population figures for

Table 2. Percentage of households using natural resources.

Resource	Village			Mean
	Finale	Mabins	Willows	
Wooden utensils	100	100	100	100
Grass handbrooms	100	100	100	100
Twig handbrooms	100	100	100	100
Fuelwood	97	100	94	97
Wild herbs	100	94	97	97
Wild fruit	97	92	97	95
Edible insects	95	97	86	93
Fencing poles	92	75	81	83
Weaving reeds	68	86	92	82
Fish	66	58	56	60
Bushmeat	47	53	67	56
Housing poles	63	44	56	54
Medicinal plants	34	72	50	52
Thatching grass	45	53	44	47
Grass for livestock	32	11	44	29
Tree leaves for livestock	29	11	42	27
Wood for furniture	8	6	6	6
Construction reeds	4	0	0	1

1996/97 from the Department of Agriculture, was as follows: Finale (269 households), 976 t; Mabins (538 households), 2399 t; Willows (1109 households), 6044 t.

Most respondents perceived declining availability over the past 5–10 years of fuelwood, wood for poles, wood for utensils, and reeds for weaving mats. This was ascribed primarily to over-harvesting, which had resulted in increased distance travelled and, therefore, additional time spent in obtaining these resources. For example, a head-load of fuelwood (35 kg) that previously took about two hours to collect now has a mean collection time of four hours. This means that a total of 520 hours a year is spent on collecting fuelwood alone (that is, about 130 head-loads). The availability of wild herbs, wild fruit, edible insects, bushmeat, thatching grass, and grass and twigs for handbrooms was generally regarded as adequate, although this varied from year to year, mainly because of rainfall.

Table 3. Mean annual household consumption of natural resources, averaged across all households sampled within the village.

Resource	Village			Mean
	Finale	Mabins	Willows	
Wooden utensils	6.5 ± 3.5[a]	9.9 ± 4.9[b]	7.8 ± 4.5[ab]	8.1
Grass handbrooms	4.1 ± 4.9[a]	2.5 ± 2.5[a]	5.7 ± 13.8[a]	4.1
Twig handbrooms	2.8 ± 3.2[a]	3.9 ± 4.3[a]	4.3 ± 3.2[a]	3.7
Fuelwood (kg)	3630 ± 2250[a]	4460 ± 3400[ab]	5450 ± 3460[b]	4510
Wild herbs (kg)	59.2 ± 43.6[a]	92.2 ± 61.9[b]	55.2 ± 33.3[a]	68.9
Wild fruit (kg)	130.9 ± 103.6[ab]	172.6 ± 151.6[a]	81.1 ± 88.2[b]	128.2
Edible insects (l)	69.9 ± 85.3[a]	93.9 ± 94.9[a]	52.6 ± 71.2[a]	72.2
Reed mats	1.3 ± 3.1[a]	1.8 ± 2.6[a]	1.4 ± 2.4[a]	1.5
Fencing poles	6.9 ± 8.7[a]	9.0 ± 12.0[a]	9.6 ± 32.4[a]	8.5
Bushmeat (kg)	0.9 ± 1.0[a]	2.9 ± 2.9[a]	5.0 ± 6.8[a]	2.9
Housing poles	0.6 ± 0.9[a]	0.3 ± 0.6[a]	0.3 ± 0.6[a]	0.4
Thatching grass (bundles)	4.3 ± 13.6[a]	19.3 ± 27.6[b]	7.6 ± 11.2[a]	10.4

Values in the same row with different superscript letters are statistically significantly different.

Direct-use values

All the resources in Table 3 were traded locally, which enabled us to calculate their direct-use values. The annual total direct-use worth of utilized natural resources, averaged across all households, was R3959 per household or R564 per person (Table 4). The greatest value came from wild herbs, wild fruit, fuelwood and edible insects, with the remaining resources making relatively insignificant contributions. Total annual value per village ranged from R3280 per household (that is, R497 per person) in Willows, to R5019 per household (R697 per person) in Mabins. The values for Finale and Willows were similar, especially when divided by village-specific mean household size to derive the per capita values.

Relationship between household wealth status and resource use

Households classified as wealthy, whether because of income or livestock, had significantly larger permanent and total populations than poor households ($P < 0.01$) (Table 5). Wealthy households, based on income, had significantly more migrant household members ($P < 0.01$).

Mean household consumption of natural resources was higher in income-wealthy than in income-poor households, except for wild herbs (Table 6). Owing to high variability in the data, however, the difference was statistically significant only for the total number of resources used per household ($P < 0.01$) and for fencing poles ($P < 0.05$). Livestock-wealthy households consumed a greater number of resources ($P < 0.01$), and more fuelwood (not statistically significant), housing poles ($P < 0.05$), fencing poles (not statistically significant) and wooden utensils ($P < 0.01$) than livestock-poor households, whereas more wild herbs and wild fruit were consumed in the poor households ($P < 0.05$ for wild fruit only).

Income-wealthy households consumed significantly more natural resources per capita ($P < 0.01$) (Table 7). Mean per capita consumption of both wild herbs and wild fruit was higher in poor households, and significantly so in livestock-poor households ($P < 0.01$) . Mean per capita consumption of fuelwood was higher in both income-wealthy and livestock-wealthy households, although there was no significance at 95% CI due to high standard deviations in the data. Figures were significantly higher for the use of housing poles and wooden utensils in livestock-wealthy households ($P < 0.05$), and for fencing poles in income-wealthy households ($P < 0.05$).

Discussion

Resource use

Natural resources were widely used by the inhabitants of Mametja, but household consumption differed among the three villages, especially for resources such as fuelwood, wild herbs, wild fruit, edible insects, and thatching grass. A comparison of per capita consumption of selected resources with other recent studies from Limpopo province further illustrates the variability

Table 4. Mean direct-use values of natural resources per household. Number in brackets are per capita. Units are South African rands.

Resource	Village			Mean	% of total
	Finale	Mabins	Willows		
Wild herbs	1328 (184.5)	2067 (287)	1238 (188)	1544 (219)	39.0
Wild fruit	1047 (145.4)	1381 (192)	649 (98.30)	1026 (145)	25.9
Fuelwood	472 (65.50)	580 (80.50)	709 (107)	587 (84.50)	14.8
Edible insects	548 (76)	735 (102)	412 (62.40)	565 (80.20)	14.3
Reed mats	60.3 (8.4)	82.70 (11.50)	67.20 (10.20)	70.10 (10.00)	1.8
Fencing poles	38.5 (5.4)	50.20 (7.00)	53.60 (8.10)	47.40 (6.80)	1.2
Bushmeat	10.4 (1.4)	34.60 (4.80)	60.70 (9.20)	35.20 (5.10)	0.9
Wooden utensils	24.6 (3.4)	35.70 (5.00)	27.50 (4.20)	29.30 (4.20)	0.7
Grass brooms	24.5 (3.4)	15.20 (2.10)	34.10 (5.20)	24.60 (3.60)	0.6
Twig brooms	13.5 (1.9)	18.90 (2.60)	21.00 (3.20)	17.80 (2.60)	0.5
Thatching grass	3.6 (0.5)	16.20 (2.30)	6.40 (1.00)	8.70 (1.20)	0.2
Housing poles	5.8 (0.8)	2.90 (0.40)	2.90 (0.40)	3.90 (0.50)	0.1
Total	3576 (497)	5019 (697)	3280 (497)	3959 (564)	100.0

among communities (Table 8). Factors that affect local use may include environmental conditions, resource availability, socio-economic characteristics, and access to alternatives. Site-specific drivers of resource use, therefore, need to be understood when developing or supporting local community based natural resource management initiatives.

Illustrating the importance of socio-economic determinants is Mametja's high consumption of fuelwood as an energy source, despite the fact that two of the three villages in the survey have electricity. This reflects the level of poverty, which renders the cost of electricity and electrical appliances, as well as other energy sources, prohibitively high for most households. Natural resources, therefore, are an important cheap or free alternative to other commercial commodities.

Table 5. Mean household population of poor and wealthy households within two different wealth rankings.

Household population	Income		Livestock	
	Poor	Wealthy	Poor	Wealthy
Permanent residents	5.0 ± 1.5[a]	7.5 ± 2.7[b]	6.3 ± 2.3[a]	8.6 ± 2.8[b]
Migrant residents	0.8 ± 1.0[a]	2.4 ± 1.6[b]	1.4 ± 2.6[a]	1.5 ± 2.2[a]
Total	5.8 ± 1.6[a]	9.9 ± 2.9[b]	7.7 ± 3.3[a]	10.1 ± 3.8[b]

Values in the same row, within a wealth ranking, with different superscript letters are statistically significantly different.

Table 6. Mean household consumption of selected natural resources.

Resource	Income		Livestock	
	Poor	Wealthy	Poor	Wealthy
No. of resources	12.8 ± 2.2[a]	14.8 ± 2.4[b]	12.6 ± 2.3[a]	15.6 ± 1.6[b]
Wild herbs (kg)[1]	58.3 ± 36.0[a]	57.3 ± 34.0[a]	73.4 ± 50.2[a]	52.9 ± 34.2[a]
Wild fruit (kg)[1]	110.8 ± 73.6[a]	149.8 ± 133.7[a]	202.5 ± 201.2[a]	97.0 ± 72.5[b]
Fuelwood (kg)[1]	4260 ± 3130[a]	5490 ± 4190[a]	4440 ± 2520[a]	4970 ± 3850[a]
Housing poles[2]	5.4 ± 7.6[a]	11.5 ± 16.8[a]	6.3 ± 9.9[a]	17.6 ± 21.9[b]
Fencing poles[2]	61.4 ± 120.1[a]	294.5 ± 865.1[b]	125.0 ± 196.4[a]	284.2 ± 867.1[a]
Wooden utensils[2]	7.0 ± 3.3[a]	7.4 ± 4.3[a]	5.8 ± 3.5[a]	10.8 ± 5.2[b]

Values in the same row, within a wealth ranking, with different superscript letters are statistically significantly different.
[1]Consumption over 12 months.
[2]Total number present in the homestead at any given time.

Table 7. Mean per capita consumption of selected natural resources.

Resource	Income		Livestock	
	Poor	Wealthy	Poor	Wealthy
No. of resources	2.1 ± 0.3[a]	2.5 ± 0.4[b]	2.3 ± 1.1[a]	2.0 ± 0.7[a]
Wild herbs (kg)[1]	13.5 ± 10.5[a]	8.4 ± 5.3[a]	13.1 ± 9.8[a]	7.0 ± 5.2[b]
Wild fruit (kg)[1]	22.6 ± 14.8[a]	21.8 ± 17.1[a]	34.0 ± 24.0[a]	13.0 ± 44.5[b]
Fuelwood (kg)[1]	670 ± 530[a]	820 ± 720[a]	670 ± 460[a]	830 ± 640[a]
Housing poles[2]	0.9 ± 1.3[a]	1.9 ± 2.8[a]	1.0 ± 1.6[a]	2.9 ± 3.6[b]
Fencing poles[2]	10.2 ± 20.0[a]	49.1 ± 144.2[b]	20.8 ± 32.7[a]	47.4 ± 144.5[a]
Wooden utensils[2]	1.2 ± 0.6[a]	1.2 ± 0.7[a]	1.0 ± 0.6[a]	1.8 ± 0.9[b]

Values in the same row, within a wealth ranking, with different superscript letters are statistically significantly different.
[1]Consumption over 12 months.
[2]Total number present in the homestead at any given time.

Table 8. Mean per capita consumption within user households of selected natural resources from studies within Limpopo province.

Source	Study site	Fuelwood	Wild fruit	Wild herbs
This study	Finale A	491[1]	17.7[1]	8.2[1]
This study	Mabins A	619[1]	22.0[1]	12.1[1]
This study	The Willows	803[1]	11.9[1]	8.1[1]
Banks *et al.* (1996)[25]	Athol	500[2]	–	–
Banks *et al.* (1996)[25]	Welverdiend	555[2]	–	–
Dovie *et al.* (2002)[16]	Thorndale	692	3.1[3]	25.0
Shackleton et al. (1999)[14]	Ha-Gondo	1038	21.4	4.1
Shackleton et al. (1999)[14]	Mogano	1173	25.1	30.2
Shackleton & Shackleton (2000)[15]	Bushbuckridge	–	46.8	2.9[4]
Mean		734	20.7	12.9

[1]Calculated by multiplying mean village consumption (Table 3) by proportion of households in the village using the resource (Table 2), and then dividing by village mean permanent household size (Table 1).
[2]Per capita consumption multiplied by proportion of households using fuelwood (99%).
[3]Assuming 1 l = 625 g.
[4]Household consumption[15] divided by mean local household size of 6.2 (ref. 26).

Direct-use values

Quantifying the direct-use value of natural resources used in Mametja demonstrates the economic value of these resources to rural households. The total mean value on its own is meaningless, however, and needs to be assessed in relation to other means of livelihood. The first useful comparison is with household income. The state old-age pension of R540 per month (in the year 2000) is a yardstick of basic household income and a vital component of rural household livelihoods across South Africa. In Mametja, households received a mean of 0.6 pensions per month, that is, R324 per month or R3888 per year. This is comparable with the total direct-use value of resources used by the average household in Mametja (R3959 per year).

A second useful comparison is with household expenditure on important goods and services. Maize meal is Mametja's staple diet, as it is across rural South Africa. Most households in the region buy maize meal rather than growing and grinding their own. An 80-kg bag of maize meal cost about R175 in the year 2000, and would last the average household one month. The average Mametja household buying maize meal, therefore, spent R2100 a year on this basic food commodity (that is, 53% of the mean annual direct-use value of natural resources that it used).

School fees are another important household expense. In 2000, annual fees were approximately R35 per primary school student and R75 per secondary school student. Households in Mametja had a mean of 3.5 children as permanent residents and, assuming equal numbers of pre-school, primary and secondary school childern per household, this may be calculated as 1.2 primary and secondary school goers in each household. The average household would thus spend a mean total of R132 each year on school fees, which is 3% of the mean direct-use value of the natural resources it consumes.

In this context, the direct-use value of biological resources used by Mametja households is clearly significant, representing not

Table 9. Mean annual direct-use value, averaged across all households, from similar South African studies.

Source	Study site	Value (R)
This study	Finale A, Limpopo	3576
This study	Mabins A, Limpopo	5019
This study	The Willows, Limpopo	3280
Dovie *et al.* (2002)[16]	Thorndale, Limpopo	3435
Magasela *et al.* (2000)[27]	Hlabisa, KwaZulu-Natal	758
Shackleton *et al.* (1999)[14]	Ha-Gondo, Limpopo	3622
Shackleton *et al.* (1999)[14]	Mogano, Limpopo	7239
Shackleton *et al.* (1999)[14]	KwaJobe, KwaZulu-Natal	3621
Shackleton & Shackleton (2000)[15]	Bushbuckridge, Limpopo	2218
Shackleton *et al.* (2002)[17]	Ntilini, Eastern Cape	1645
Shackleton *et al.* (2002)[17]	Tidbury, Eastern Cape	1607
Shackleton *et al.* (2002)[17]	Fairbairn, Eastern Cape	2526
Mean		3212

so much money spent on these resources but rather their value in monetary terms. In households that harvest these resources instead of buying them, direct-use value represents financial savings that can be spent on other important goods and services, such as food and school fees.

Our estimate of savings is conservative, as it focuses only on the cost of local natural resources, without considering more expensive alternatives, such as electricity to replace fuelwood or corrugated iron to replace thatching. It is also crude, as it does not include labour, time and the lost opportunity costs of harvesting and processing the natural resources consumed.

The mean annual direct-use value of resources at both the household and per capita level was highest in Mabins, the poorest of the three villages in terms of employment rates and ownership of cattle. It suggests that poorer rural communities rely more heavily than richer ones on natural resources, and supports the view that using them is an important buffer against poverty.

Direct-use value was lowest (especially at the household level) in the largest village, Willows, situated on a major dirt road. Finale — the smallest, most remote and most poorly serviced village, with no electricity — recorded an intermediate direct-use value (but closer to that for Willows).

This pattern of relative direct-use value does not follow the appealing conceptual model proposed by Shackleton *et al.*[14] This is interesting, since we used a modified version of the questionnaire developed and used by Shackleton *et al.*[14] They predict that the direct-use values of natural resources would be lower in isolated, less developed rural villages than in richer and more accessible settlements, because natural resources are more easily available, there is less trading, and prices are lower. None of the three Mametja villages in the survey, however, falls within the extremes of their model. Prices for local resources did not differ greatly among the three Mametja villages, and differences in direct-use values were due primarily to differences in consumption rates of the various resources.

The direct-use figures for Mametja are comparable with those elsewhere in South Africa (Table 9). Values for Finale and Willows are close to the mean of the twelve sites listed in Table 9 (R3212), while that for Mabins is well above the average. As with the rates of consumption of natural resources, there is significant variation in direct-use values among communities. These differences are a function both of varying consumption rates and local prices.

Household wealth status and resource use

Both wealthy and poor households used natural resources extensively, challenging the commonly held view that the use of natural resources is the preserve of the poor. This point was made by Letsela *et al.*[24], who found a similar pattern in rural Lesotho. Furthermore, our study showed that wealthier households in fact utilized a greater range of natural resources than poorer ones. This could be because they had greater access to people who can harvest these resources, as the wealthy households were significantly larger than the poorer. Wealthy households may also have had other resources at their disposal, such as trucks or donkey-carts, enabling them to collect and transport resources more efficiently. Another contributing factor could be that more disposable income in wealthy households meant that they would use more natural resources or products. It is logical that certain resources, such as poles for stock pens and leaves for animal fodder, would be used more frequently by households wealthy in livestock.

Poor households relied more heavily than wealthy households on 'essential' indigenous resources, such as wild herbs and wild fruit. Analysis of per capita consumption suggests that individuals in wealthy households supplemented their diet of wild indigenous plants with either cultivated or purchased food products. Conversely, 'luxury' items, such as wooden utensils and poles, were more extensively used by wealthy households. These observations are generally supported by the village-level analysis of household consumption, except for the higher consumption of wooden utensils in Mabins. We noted, too, contrary to expectations, that per capita use of fuelwood was not significantly lower in wealthy households.

The results of these analyses indicate the importance of socio-economic factors as drivers of resource use by household s.

Conclusion

The central role of savanna bio-resources in the lives of rural households in Mametja is unlikely to diminish in the near future. This semi-arid, agriculturally marginalized area is characterized by poverty and has few prospects for significant development. Sustainable use of local natural resources is therefore a central issue that needs to underpin rural development in the region.

The results presented in this paper indicate that unsustainable harvesting has the potential to cause substantial loss of value of natural resources in rural areas. The value of these resources, therefore, needs to be fully appreciated by government policy-makers.

Although our data focus on current value, unsustainable extraction also affects unrealized potential value, compromising the potential for enhancing economic value of some resources as a basis for rural development (such as commercialization of marula fruit products[28]). The development opportunity cost of unsustainable resource use, therefore, needs also to be taken into account in policy and initiatives that aim to achieve sustainable rural development.

Resource depletion makes poor households most vulnerable as they rely so heavily on 'essential' natural resources (such as wild food products) and because they are less able to compensate for fewer natural resources by buying natural products or their substitutes. However, even comparatively wealthy households would be significantly affected because they use savanna resources so extensively. These resources may in fact be regarded as a component of household wealth, as they are used both to generate income and to save money.

The results of our survey suggest that rural poverty is linked to 'environmental impoverishment'. Addressing the problem of unsustainable harvesting of the natural resources on which local communities rely, therefore, is a vital component of tackling rural poverty in South Africa, both in the area of government

policy and in initiatives that offer practical support for community-based natural resource management.

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1. Cunningham A.B, (1985). *The resource value of indigenous plants to rural people in a low agricultural potential area.* Ph.D. thesis, University of Cape Town.
2. Campbell B.M., Luckert M. and Scoones I. (1997). Local-level valuation of savannah resources: a case study from Zimbabwe. *Econ. Bot.* **51**(1), 59–77.
3. Bennett B.C. (1992). Plants and people of the Amazonian rainforests: the role of ethnobotany in sustainable development. *BioScience* **42**(8), 599–607.
4. Stiles D (1994). Tribals and trade: a strategy for cultural and ecological survival. *Ambio* **23**, 106–111.
5. Shackleton S.E. (Ed.) (1995). Adaptive strategies of the poor in arid and semi-arid lands: in search of sustainable livelihoods. A case study of the Bushbuckridge District, Eastern Transvaal, South Africa. Report of the Wits Rural Facility, Klaserie.
6. Farooqauee N.A. and Saxena K.G. (1996). Conservation and utilization of medicinal plants in high hills of the central Himalayas. *Env. Cons.* **23**, 75–80.
7. Caniago I. and Siebert S. (1998). Medicinal plant ecology, knowledge and conservation in Kalimantan, Indonesia. *Econ. Bot.* **52**(3), 229–250.
8. Qureshi M.H. and Kumar S. (1998). Contributions of common lands to household economies in Haryana, India. *Env. Cons.* 25, 342–353.
9. Shackleton C.M., Shackleton S.E. and Cousins B. (2001). The role of land-based strategies in rural livelihoods: the contribution of arable production, animal husbandry and natural resource harvesting in communal areas in South Africa. *Dev. South. Afr.* **5,** 581—604.
10. Balick M.J. and Mendelsohn R. (1992). Assessing the economic value of traditional medicines from tropical rain forests. *Cons. Biol.* **6**, 128–130.
11. Godoy R.A., Lubowski R. and Markandya A. (1993). A method for the economic valuation of non-timber forest products. *Econ. Bot.* **47**, 220–233.
12. Grimes A., Loomis S., Jahnige P., Burnham M., Onthank K., Alarco R., Cuenza W.P., Martinez C.C., Neill D., Balick M., Bennett B. and Mendelsohn R. (1994). Valuing the rain forest: the economic value of nontimber forest products in Ecuador. *Ambio* **23**(7), 405–410.
13. Olsen C.S. (1998). The trade in medicinal and aromatic plants from central Nepal to northern India. *Econ. Bot.* **32**(3), 279–292.
14. Shackleton C.M., Netshiluvhi, T.R., Shackleton S.E., Geach B.S., Balance A. and Fairbanks D.F.K. (1999). Direct Use Values of Woodland Resources From Three Rural Villages. Report compiled by the Division of Water, Environment and Forestry Technology, CSIR, Pretoria.
15. Shackleton C.M. and Shackleton S.E. (2000). Direct use values of secondary resources harvested from communal savannas in the Bushbuckridge lowveld, South Africa. *J. Trop. For. Prod.* **6**(1), 28–47.
16. Dovie D.B.K., Shackleton C.M. and Witkowski E.T.F. (2002). Direct-use values of woodland resources consumed and traded in a South African village. *Int. J. Sust. Dev. Wld Ecol.* **9**, 269–283.
17. Shackleton C.M., Shackleton S.E., Ntshudu M. and Ntzebeza J. (2002). The role and value of savanna non-timber forest products to rural households in the Kat River Valley, South Africa. *J. Trop. For. Prod.* **8**(1), 45–65.
18. Low A.B. and Rebelo A.G. (eds) (1996*). Vegetation of Southern Africa, Lesotho and Swaziland.* Department of Environmental Affairs and Tourism, Pretoria.
19. Shackleton C.M. (2000). Woodlands in South Africa and the National Forests Act. *S Afr. For. J.* **187**, 19–28.
20. Cousins B. (1999). Invisible capital: the contribution of communal rangelands to rural livelihoods in South Africa. *Dev. South. Afr.* **16**, 299–318.
21. Williams J. (ed.) (1999). Maburuburung Eco-Tourism Project: general concept recommendations. Report prepared for the Maburuburung Trust. Department of Agriculture, Pretoria.
22. Acocks J.P.H. (1988). Veld Types of South Africa. *Mem. Bot. Surv. S. Afr.* **57**.
23. Griffin N, Banks D.I., Mavrandonis J., Shackleton C.M. and Shackleton S.E. (1992). *Household Energy and Wood Use in a Peripheral Rural Area of the Eastern Transvaal Lowveld.* National Energy Council, Pretoria.
24. Letsela T., Witkowski E.T.F and Balkwill K. (2002). Direct-use values of communal resources in Bokong and Tsehlanyane in Lesotho: whither the commons? *Int. J. Sust. Dev. Wld Ecol.* **9**, 351–368.
25. Banks B.I., Griffin N., Shackleton C.M., Shackleton S.E. and Mavrandonis J. (1996). Wood supply and demand around two rural settlements in a semi-arid savanna, South Africa. *Biomass & Bioenergy* **11**, 319–331.
26. Tollman S.M., Herbst K. and Garenne M. (1995). The Agincourt demographic and health study: Phase 1. Unpublished monograph, University of the Witwatersrand, Johannesburg.
27. Magasela B.B., Watson H.K., Mhlongo B.J. and Bob U. (2002). Direct-use values of non-timber forest products from the rural area of Hlabisa, KwaZulu-Natal. CSIR report submitted to the Department of Water Affairs and Forestry.
28. Shackleton C.M. (1996). Potential stimulation of local rural economies by harvesting secondary products: a case study of the central Eastern Transvaal lowveld, South Africa. *Ambio* **25**, 33–38.

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