Popul Environ (2013) 35:159–182
DOI 10.1007/s11111-013-0189-5

ORIGINAL PAPER

Contribution of forest provisioning ecosystem services to rural livelihoods in the Miombo woodlands of Zambia

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Published online: 4 August 2013

Abstract This paper examines the contribution of forest provisioning ecosystem services (FPES) to rural households and assesses the contributions of forests to the annual incomes of households in Africa's Miombo woodlands. The study employed focus group meetings, in-depth interviews, and interviews of households, as stratified by wealth class and head of household gender in Copperbelt, Zambia. The results show that FPES are vitally important in providing food, medicine, fodder, and construction materials to rural livelihoods. FPES provided 43.9 % of the average household's income and contributed a 10 % income equalisation effect among households, as revealed by the Gini-coefficient analysis. Poorer households received a lower mean annual income from forests than did their intermediate and wealthy counterparts, but in relative terms, forest income made the greatest contribution to the total household incomes of poor households. When stratified by gender, forests contributed 44.4 and 41.8 % of the income of male- and female-headed households, respectively. The study indicates that wealth, rather than gender, was the key determinant of a household's engagement in the sale of FPES. The inter- and intra-community differentiation in the use and sale of FPES, as revealed in this study, enables more effective targeting of forest management interventions and informs efforts to reconcile the goals of poverty reduction and forest conservation.

Keywords Rural livelihoods · Ecosystem services · Gender · Wealth · Miombo woodlands

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Introduction

Ecosystem services are defined as the benefits that people obtain from ecosystems (MA 2005). Global policy interest in forest ecosystem services has increased due to their role in mitigating climate change and providing services that are important to rural livelihoods in developing countries. The economic use of forest ecosystems has long been recognised (Pearson 1937; Whitford 1923); however, forests around the world are disappearing at alarming rates (FAO 2010). This trend has prompted policymakers, researchers, and development agencies to promote the sustainable management of forests in an attempt to reconcile economic development and biodiversity conservation (Paumgarten and Shackleton 2011). Forests provide a number of products that underpin many rural livelihood strategies (Shackleton and Shackleton 2004). These products are collectively referred to as 'provisioning services', defined as 'services supplying tangible goods, finite though renewable, that can be appropriated by people, quantified and traded' (Maass et al. 2005:7). Because the value of vegetation to rural livelihoods is socially constructed and contested (Kepe 2008), the direct-use value of FPES in households is a key determinant of their value, both in consumption and as a source of income (Mamo et al. 2007; Shackleton and Shackleton 2006; Sunderlin et al. 2005; Tesfaye et al. 2011).

Although the importance of FPES to millions of rural households is increasingly being acknowledged, research regarding the impact of socio-economic factors on forest use shows mixed evidence. Wealthy households have been reported to consume more forest products than poorer households in Zimbabwe (Cavendish 2000) and Nepal (Malla et al. 2003); however, studies in South Africa have reported that wealth does not significantly influence the consumption of forest products (Paumgarten and Shackleton 2009; Shackleton and Shackleton 2006). In terms of household income, middle-class and wealthy households have been reported to earn more income from the sale of FPES in Cameroon (Ambrose-Oji 2003) and the Democratic Republic of Congo (de Merode et al. 2004), while a study in Dixie village in South Africa reported that household wealth did not influence the sale of FPES (Paumgarten and Shackleton 2009). Results of research concerning the influence of head of household gender on the use and sale of FPES are also mixed. Households headed by females have been reported to rely more on forest products in Cameroon (Fonjong 2008) and southern Ethiopia (Yemiru et al. 2010), while in South Africa, studies have indicated a negligible gender effect (Cocks et al. 2008; Paumgarten and Shackleton 2009). It is evident that the use and sale of FPES in relation to household wealth and head of household gender varies across different case studies, and further empirical studies are required to explore these relationships and inform local policies and programmes. A comprehension of how the use and sale of provisioning services differs according to wealth and gender is essential in understanding people's reliance on forest ecosystems and the contributions these ecosystems make to their livelihoods (Heubach et al. 2011; Shackleton et al. 2007). Research on the socio-economic differentiation of FPES use is therefore important in the development of local management interventions to protect rural livelihoods and ensure sustainable forest use (Shackleton and Shackleton 2006).

The present study examines the proportions and types of FPES used in the Miombo woodlands and assesses their relative contributions to local livelihoods and household incomes. Furthermore, we explored how household wealth status and head of household gender affect the use and sale of FPES in the Copperbelt Province of Zambia.

Research design and methods

Study area

The Copperbelt Province is located between latitudes 12°20′ and 13°50′ south and longitudes 26°40′ and 29°15′ east and covers a total surface area of 31,014 km^2 (Fig. 1). The average altitude of the region is 1,200 m above sea level, and its geology is characterised by the granite and granite gneiss, basement schist, and lower Katanga rock systems (Syampungani et al. 2010). The province is a high-rainfall area, receiving an average annual rainfall of 1,200 mm, and lies on the Congo-Zambezi watershed (Chidumayo 1987). The average temperature ranges from 17 °C in the cool-dry season to 37 °C in the hot-dry season. Miombo woodlands represent 90 % of the total vegetation and are dominated by the tree genera *Julbernadia*, *Brachystegia*, and *Isoberlinia* (GRZ 1998). The Copperbelt Province is an area of biological significance due to its plant diversity, some of which is endemic (Chirwa et al. 2008; Rodgers et al. 1996). Additionally, the forests are a source of livelihoods for their inhabitants in a sub-Saharan region characterised by high poverty (73 %) and deforestation levels (PRSP 2002); the area is often referred to as the 'world's most income-poor region' (Fisher et al. 2011:161).

Site selection

Two study sites were purposefully selected on the basis of their ecological settings, evidence of the use of Miombo agroecosystems, similarities in socio-economic activities and livelihood activities, and differences in the legal status of the forests and local institutional contexts (see Table 1). The two areas chosen were the Mwekera Forest Reserve and Katanino Joint Forest Reserve. The villages in the two sites represent the two main rural village types of Zambia's Copperbelt region: rural peri-urban and rural traditional villages. This classification is based on the distance of the village from urban cities, which is over 40 km and within 40 km for rural traditional and urban peri-urban villages, respectively (Blake et al. 1997; Simon et al. 2004). In terms of social characteristics, such as socio-economic and cultural contexts, rural traditional villages are situated within a customary land tenure system, while rural peri-urban villages are located on state land (Phillips et al. 1999).

Katanino is located 75 km from the nearest urban town (Ndola) and lies on the main road connecting Copperbelt Province and Lusaka. The villages are dominated by the people of the Lamba tribe, who are the indigenous inhabitants of the Copperbelt Province (Mitchell and Barnes 1950). In Katanino, the villages are under

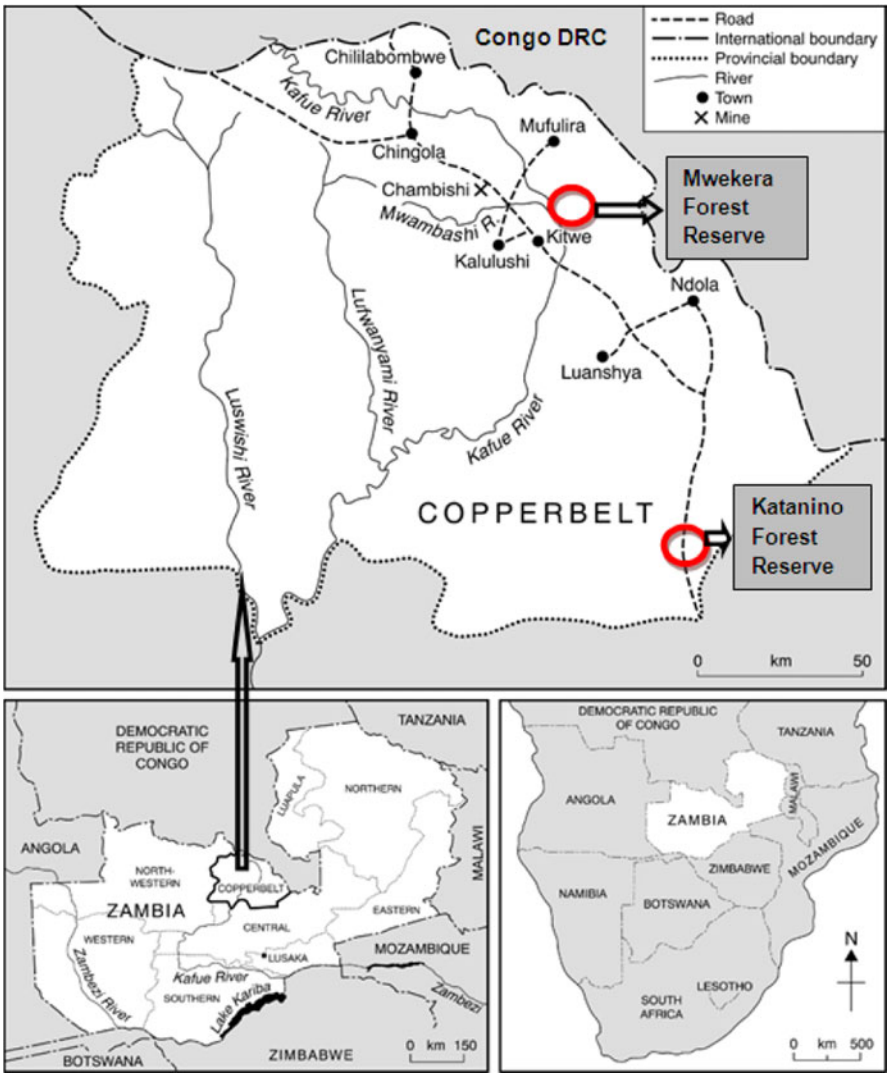

Fig. 1 Location of the two study sites. Modified from von der Heyden and New (2004)

the authority of traditional chiefs, who are responsible for land allocation and general leadership. In these rural villages, the residents are more attached to their traditions and beliefs than those of peri-urban villages (Simon et al. 2004). Mwekera is located approximately 20 km from Kitwe and is comprised of mainly peri-urban villages. In these villages, ethnicities are more diverse due to the mix of tribes in the urban areas which feed these villages. Village leadership is vested in a chairperson, who belongs to the currently ruling political party. These villages were previously held under traditional authority, but urbanisation has undermined the role of traditional chiefs. Table 1 provides a summary profile of the two study sites.

Table 1 Site characteristics

Site characteristics District	Katanino Site Masaiti rural	Mwekera Site Kitwe City
Location of site	13°36′S and 28°42′E; elevation 1,300 m above sea level	12°49′S and 28°22′E; elevation 1,295 m above sea level
Legal status of forest	Joint Forest Management	National Forest Reserve
Local institutional administration	Customary	State
Cultural context	Rural traditional	Rural peri-urban
Average household size	5.3 ± 2.3	6.6 ± 3.7
Head of household gender	Male-headed = 66.1 %, Female-headed = 33.9 %	Male-headed = 78.6 % Female-headed = 21.4 %
Number of households	512	483
Ethnic groups	15 ethnic groups. The *Lamba* are the most dominant ethnic group (61.9 %). Other major groups include the *Bemba* (15.3 %) and the *Lala* (6.8 %), and 16 % of residents belong to 13 other ethnic groups	19 ethnic groups. There is no dominant group. The majority groups are the *Bemba* (22.2 %), *Lunda* (12.9 %), *Lamba* (9.5 %), *Luvale* (8.7 %), and *Ushi* (7.9 %), while 38.8 % of residents belong to 14 other ethnic groups
Distance to the nearest urban markets	75 km	20 km
Vegetation type	Miombo woodlands	Miombo woodlands
Livelihood activities	Farming, charcoal production, livestock	Farming, charcoal production

In these two sites, the villages of Bwengo and Kashitu (Katanino site[1]) and Misaka and Twesheko (Mwekera site) were selected due to their similarities in size and accessibility. These villages are adjacent to the Forest Reserves, and all of their households are within 5 km of the forest edge. The targeting of these two case study sites provided a wide sample of institutional administrations, market accessibility, and socio-economic criteria, allowing for a better determination of the structures and processes that govern access to and use of forest resources and their consequent impacts on the livelihoods of residents.

Data collection

The primary data were collected using structured household questionnaires, focus group meetings, and in-depth interviews. The household questionnaires provided information on the use of FPES in livelihood portfolios. These questionnaires lasted an average of 50 min and were conducted in the local vernaculars (*Lamba* and *Bemba*), in which the researchers were conversant. The questionnaire included several sections covering livelihood activities and the consumption and sale of FPES. Data on the income generated from the sale of FPES were representative of cash

[1] The average distance of the sampled villages to the main road is 11 km.

income from the previous 12 months as reported by the household. In this study, the household income reported for livelihood activities was a self-reported value for net benefits (income minus production costs), with the exemption of own-labour costs, due to the challenge of establishing own-labour costs in rural Africa (Heubach et al. 2011). The reliability of the forest income data was enhanced by the fact that most forest products are sold in the rainy season, when the fieldwork was conducted.

The sampling frame was the list of all of the households in each village. To capture the various categories of households in the household survey, the households were stratified by wealth (Jumbe et al. 2009; Tschakert et al. 2007). In each village, several leaders ($n = 3$–5) were asked to rank the households into wealth categories. Previous studies have indicated that rural people are better able to assess the relative wealth and well-being of their communities than 'outsiders' (Hill 1986). Earlier work has also revealed that rankings are more accurate when three informants (as a team) rank households according to established criteria (Silverman 1966). The criteria for assigning households into wealth categories included livestock ownership, house size and style, including roofing material and the quality of assets owned, and the ability of a household to pay for school fees. A total of 244 households (118 and 126 households in Katanino and Mwekera, respectively) took part in the household questionnaire, representing a 25 % sampling intensity, which is higher than the 20 % recommend by similar studies (Adhikari et al. 2004; Hetherington 1975). The sampled households were stratified by wealth, and the proportions of the wealth categories in the sample therefore reflect the actual wealth status of the households in the sampled villages. The sampling unit in the household survey was the household, while the unit of observation was the head of household. In-depth interviews were conducted with a further 15 key informants to provide information on forest use and changes in use, as well as the local institutions and structures that shaped the use of FPES. The key informants in this study were village leaders and other elderly males and females. These residents were knowledgeable about forest use and were among the oldest living members of their respective villages; they were therefore able to provide information regarding the changes in forest use over time. The average age of the key informants was 68 years. Four focus group discussions were held (one in each village) with 10–15 discussants, which included males, females, and youths belonging to different wealth profiles and involved in different forest uses (such as charcoal production and honey collection). These meetings discussed topics such as local institutions and the use of FPES and the influences of gender and wealth on the use of FPES. The focus group meetings were facilitated by the researchers, and their average duration was 90 min. These focus group discussions were useful for triangulating the household questionnaires and in-depth interviews, and a broader understanding of forest use at the village level was obtained by their use.

The quantitative data were analysed using Statistical Package for the Social Sciences (SPSS) 19. The main statistical analyses conducted were frequency analysis and descriptive statistics. The chi-square test for independence was used to determine the associations between categorical variables, while the *Z*-test was used to compare the significant differences between proportions. The Gini-coefficient was computed to explore the total per capita income and the distribution effects of

forest incomes in reducing income inequality among households (Kamanga et al. 2009; Mamo et al. 2007). Gini-coefficient values range from 0 to 1 (0 indicates an exactly equal income distribution among households, while 1 indicates maximum inequality). The qualitative data were analysed using a grounded theory approach (Strauss and Corbin 1990), in which categories emerged from the interview data.

Results

Composition of households, gender, and wealth differentiation

The average household size was six members. The distribution of head of household gender showed that 72.5 % ($n = 177$) were males and 27.5 % ($n = 67$) were female. The sampled households consisted of 49.2 % poor households, 34 % intermediate households, and 16.8 % wealthy households. No significant association was observed between head of household gender and the wealth status of the household ($\chi^2 = 4.09$; $p > 0.05$).

The use of FPES

A high dependence on provisioning forest ecosystem services was observed across wealth groups and different head of household genders. A range of services were used on a daily basis for home consumption as part of the households' livelihood portfolios. The main categories of resources used were foods, fuelwood, medicines, and construction materials. Overall, 89.8 % of households obtained various foods from the forest ecosystem. After stratifying households by wealth and gender, no relationship was detected between household consumption of forest foods and either household wealth (Table 2) or head of household gender (Table 3). The households used more than one category of food product, with the majority of households engaged in the collection of wild fruits (88.9 %), mushrooms (71.7 %), indigenous vegetables (43.4 %), edible roots (17.2 %), and honey (10.2 %). Other foods collected for household consumption included caterpillars and tubers.

Almost a quarter of the sampled households (24.6 %) used the forest as a source of fodder, primarily for cattle and goats. A significant relationship was observed between the use of fodder and household wealth category (Table 2). A significantly higher proportion of wealthy households used forests for fodder than did poor households at both study sites (i.e. Katanino: $Z = 2.73$; $p < 0.05$ and Mwekera: $Z = 3.47$; $p < 0.05$). Further analysis indicated that a higher proportion of intermediate households in Mwekera used fodder than did poor households ($Z = 3.71$; $p < 0.05$). No significant differences in fodder use were detected between wealthy and intermediate households at both study sites. The tree species that were considered most palatable for cattle were *Baphia bequaertii, Dalbergia nitudula,* and *Parinari curatellifolia*. Other species used for fodder included *Julbernardia paniculata* and *Diplorhynchus condylocarpon*.

The Miombo woodlands are an important source for domestic energy and construction materials. Overall, 90.2 % of households used firewood from the study

Table 2 Proportions of households (%) that use various FPES stratified by wealth of household ($n = 244$)

Forest use	Overall ($n = 244$)	Katanino site					Mwekera site				
		Wealth category			χ^2	Significance	Wealth category			χ^2	Significance
		Poor ($n = 64$)	Intermediate ($n = 39$)	Wealthy ($n = 15$)			Poor ($n = 56$)	Intermediate ($n = 44$)	Wealthy ($n = 26$)		
Food	89.8	95.3	89.7	93.3	0.5	>0.05	85.7	93.7	84.6	1.7	>0.05
Medicine	66.0	76.6	82.1	93.3	2.3	>0.05	55.4	56.8	38.6	2.1	>0.05
Fodder	24.6	18.8	33.3	53.3	7.5	<0.05	5.4	34.1	34.6	15.8	<0.05
Fuelwood	90.2	100.0	97.4	100.0	3.1	>0.05	85.7	79.5	76.9	2.2	>0.05
Construction	87.3	98.4	94.9	100.0	1.6	>0.05	91.1	75.0	50.0	15.4	<0.05

Table 3 Proportions of households (%) that use various FPES stratified by gender of household head ($n = 244$)

Forest use	Overall ($n = 244$)	Katanino site				Mwekera site			
		Head of household gender		χ^2	Significance	Head of household gender		χ^2	Significance
		Males ($n = 78$)	Females ($n = 40$)			Males ($n = 99$)	Females ($n = 27$)		
Food	89.8	92.3	95.0	0.6	>0.05	91.9	74.1	0.3	>0.05
Medicine	66.0	83.3	75.0	1.1	>0.05	55.5	44.4	0.9	>0.05
Fodder	24.6	31.2	22.5	1.1	>0.05	22.2	18.5	0.2	>0.05
Fuelwood	90.2	98.7	100.0	0.0	>0.05	84.8	70.4	0.0	>0.05
Construction	87.3	97.4	97.5	0.0	>0.05	82.8	59.3	6.3	<0.05

area for cooking and heating, while 87.3 % of households used forest provisioning services as sources of construction material (i.e. poles and fibre). The trees that provide building poles for houses and barns are *Pterocarpus angolensis*, *Pericopsis angolensis,* and *Swartzia madagascariensis*, as these species are durable and are not easily attacked by termites, borers, or wood-decaying fungi. Other trees, such as *Anisophyllea boehmii*, *Uapaca kirkiana,* and *P. curatellifolia*, are used for roofing material, as they are also repellent and/or toxic to termites and other wood-eating insects. A relationship between household wealth status and use of construction material was observed in Mwekera (Table 2), where the use of provisioning services for construction was significantly higher in poor households than in their intermediate and wealthy counterparts ($Z = 2.18$; $p < 0.05$ and $Z = 3.99$; $p < 0.05$, respectively). Furthermore, a significant association was also detected between the use of FPES for construction purposes and head of household gender (Table 3). The proportion of households using these construction materials is significantly greater for male-headed households ($Z = 2.47$; $p < 0.05$).

Two-thirds of households reported the use of forests as a source of medicine. Within both study sites, no significant relationship was observed between a household's use of trees for medicinal purposes and either its wealth (Table 2) or the gender of its head (Table 3). A significantly greater proportion of the households in Katanino (80.5 %) used forests as a source of medicine than those in Mwekera (53.2 %) ($Z = 4.63$; $p < 0.05$).

Households use a number of different tree species for the treatment of various ailments. During the in-depth interviews, several respondents mentioned that people belonging to certain religious groups are often not allowed to use traditional medicines and are encouraged to rely on Western medicine. These groups impose religious sanctions (e.g. expulsion from the group) on those who admit to using traditional medicines. The 10 most common tree species used by the households in the study area are summarised in 'Appendix'.

Income portfolios of households and their relative contributions

The economic portfolios of the households in this study are diverse and include crop and livestock production, sale of forest products, remittances, and on/off farm activities (Fig. 2). The pooled results from the two study sites show that forests contribute 43.9 % of average annual household income. Income from crop production was the second most important contributor at 42.0 %. On/off farm activities, remittances, and livestock accounted for 7.6, 3.8, and 2.7 % of annual income, respectively.

The calculated Gini-coefficient was 0.51 for total household income, and the exclusion of forest income increased the Gini-coefficient by 10 % (0.61), indicating that forest income contributes to income equalisation among households.

Contribution of income from FPES to total household incomes

Household incomes from the sale of FPES ranged from KR 10.0 to KR 15000.0 annually, with a mean of KR 1834.0. When analysed by study site, the mean annual

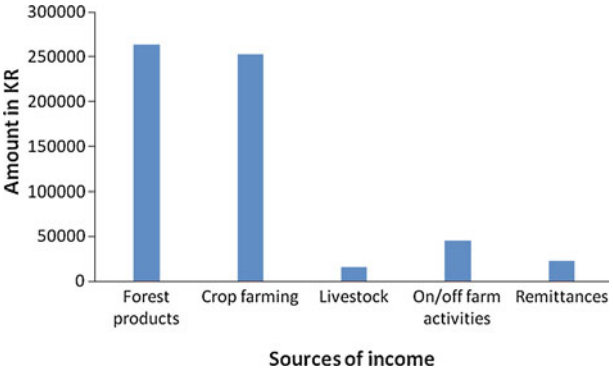

Fig. 2 Sources of annual household income and their contributions in KR. KR (Kwacha rebased) is the local currency in Zambia. The exchange rate with one USD was KR 5.1 during data collection. The Zambian government rebased the currency after the researchers had collected data, and the collected figures were therefore divided by the currency rebasing factor of 1000 prior to data analysis

income from FPES was higher in Mwekera (KR 2140.70) than in Katanino (KR 1512.4). Households sell various provisioning services (half of the sampled households sold more than one product) that contribute to the rural economy, using different FPES to diversify their overall economic portfolios. Among FPES, charcoal constitutes the largest proportion (63.5 %) of forest income, followed by mushrooms (13.6 %). The average contribution of firewood to forest income was 9.9 %, and wild fruits and thatching grass contributed 5.5 and 3.1 % to forest income, respectively. Wild vegetables and honey accounted for 2.0 and 1.5 % of forest income, respectively.

The pooled results show that 69.3 % of all households derive some income from the sale of various FPES. The highest proportion of households engaged in charcoal trading, followed by the sale of mushrooms, wild fruits, and thatching grass (Fig. 3). Relatively fewer households engaged in the sale of handicrafts, reed mats, and a traditional non-alcoholic beverage called *Munkoyo*, which is made from the roots of *Rhynchosia venulosa*.

Charcoal was shown to be the highest contributor to annual income for participating households in both Katanino (KR 1524.8) and Mwekera (KR 1920.4) (Fig. 4).

The charcoal produced in the villages is primarily exported to urban markets (Fig. 5).

Wild mushrooms are a delicacy which are usually sold along the main roads (Fig. 6) or taken to urban markets as far away as Lusaka (approximately 300 km from the study area). A barter system is occasionally observed in which forest products are exchanged for clothes or foodstuffs imported by urban-based middlemen.

Inter-site comparison of households selling FPES

A comparison of the sales of provisioning services between the two study sites revealed that households in Mwekera sold a significantly greater proportion of

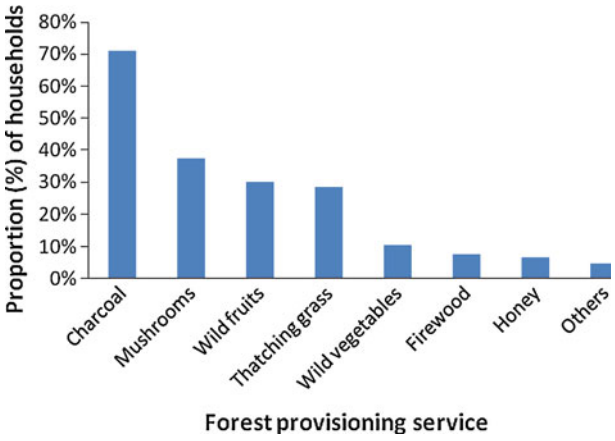

Fig. 3 Proportions of households (%) selling different FPES ($n = 169$)

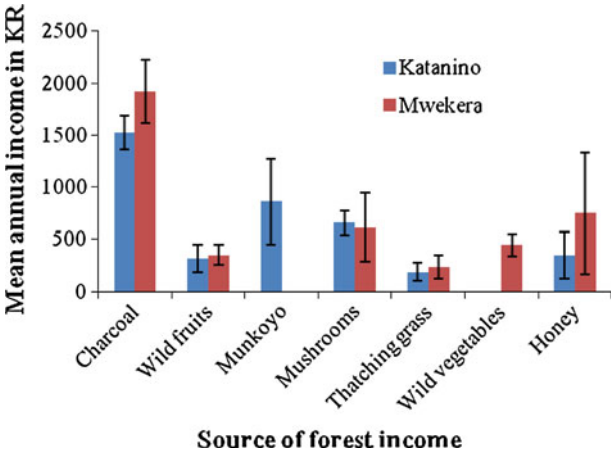

Fig. 4 Mean annual income from different FPES for participating households

mushrooms ($Z = 2.94$; $p < 0.05$) and wild fruits ($Z = 6.51$; $p < 0.05$) than those in Katanino. Differences in the sales of charcoal, honey, thatching grass, and handicrafts were not significant between the two study sites. Furthermore, the sale of firewood and indigenous vegetables was only observed in Mwekera, while the sale of *Munkoyo* was only observed in Katanino (see Table 4).

FPES incomes and wealth status of households

The average incomes derived from the forest by poor, intermediate, and wealthy households were KR 1620.1, 2009.7, and 2340.8, respectively. In relative terms, these amounts represented contributions of 55.5, 48.7, and 19.8 % of total annual household

Fig. 5 Bags of charcoal in Katanino awaiting transportation to Lusaka

Fig. 6 Wild mushrooms (*Termitomyces titanicus*) being sold at a roadside market in Katanino

income, respectively. No significant association was detected between the sale of FPES and household wealth status in Katanino (Table 4). Wealthy, intermediate, and poor households all engaged in the sale of FPES. The results from Mwekera indicated that the wealth status of households had a significant influence on their involvement in mushroom selling (Table 4). A significantly greater proportion of poor households engaged in the mushroom trade than that of wealthy households ($Z = 2.72; p < 0.05$). When asked whether any members of his household sold mushrooms, a wealthy male head of household in Mwekera responded,

> Why should any member of my household wake up early at 4am in the morning to go and collect mushrooms while I have cows in my kraal that need to be milked?

Table 4 Proportion of households (%) selling different FPES stratified by household wealth

Products sold	Overall ($n = 244$)	Katanino site					Mwekera site				
		Wealth category			χ^2	Significance	Wealth category			χ^2	Significance
		Poor ($n = 64$)	Intermediate ($n = 39$)	Wealthy ($n = 15$)			Poor ($n = 56$)	Intermediate ($n = 44$)	Wealthy ($n = 26$)		
Charcoal	45.1	51.6	60.0	33.3	2.9	>0.05	41.1	45.5	19.2	5.1	>0.05
Wild fruits	21.3	6.5	2.6	6.7	1.2	>0.05	48.2	29.5	19.2	7.6	<0.05
Handicrafts	2.4	6.5	0.0	0.0	0.8	>0.05	0.0	0.0	3.8	3.9	>0.05
Wild vegetables	6.5	0.0	0.0	0.0	–	–	5.4	13.6	7.7	2.2	>0.05
Thatching grass	20.5	21.9	17.9	6.7	1.5	>0.05	30.4	22.7	0.0	9.7	<0.05
Mushrooms	27.0	25.0	15.4	6.7	1.7	>0.05	46.4	27.3	15.4	8.6	<0.05
Munkoyo	2.9	7.8	2.6	0.0	0.9	>0.05	0.0	0.0	0.0	–	–
Honey	6.1	4.7	7.7	6.7	4.9	>0.05	3.6	6.8	7.7	0.8	>0.05
Firewood	3.2	0.0	0.0	0.0	–	–	7.1	6.8	3.8	–	–

Mushroom sales were also significantly greater in intermediate households than in wealthy households ($Z = 2.62$; $p < 0.05$), while no difference was observed between poor and intermediate households.

The results further revealed a significant relationship between the wealth status of households and sales of wild fruits and thatching grass (Table 4). A comparison between poor and wealthy households revealed that a significantly greater proportion of poor households sold wild fruits ($Z = 2.50$; $p < 0.05$), while wealthy households did not engage in the sale of thatching grass. There were also differences in the sale of charcoal and the other traded FPES across wealth categories (Table 4).

FPES incomes and gender

The mean FPES income stratified by head of household gender was KR 1970.6 and KR 1452.7 for male- and female-headed households, respectively. FPES income contributed 44.4 and 41.8 % of total annual household income to male- and female-headed households, respectively. The results from Katanino indicate a significant association between head of household gender and involvement in the sale of mushrooms (Table 5), with a significantly greater proportion of female-headed households engaging in the sale of mushrooms ($Z = 2.19$; $p < 0.05$). There were no significant associations between head of household gender and the sale of other FPES, although a relatively higher proportion of female-headed households sold thatching grass and *Munkoyo* while male-headed households were more likely to sell charcoal and honey (Table 5). In Mwekera, no significant relationship was observed between the proportion of households that engage in the sale of FPES and head of household gender, with the exception of charcoal (Table 5), which was sold by a significantly greater proportion of male-headed households ($Z = 3.26$; $p < 0.05$). A relatively higher proportion of female-headed households dominated the sales of mushrooms, wild fruits, and thatching grass, although these differences were not significant. According to all of the focus groups, women and children dominated the collection and sale of mushrooms, vegetables, and fruits within households, while men dominated honey collection and charcoal production.

Discussion

The use of FPES

Miombo woodlands provide an array of benefits to rural livelihoods (Chirwa et al. 2008; Dewees et al. 2010; Kalaba et al. 2009). This study demonstrates the high consumption of FPES for food, medicinal, fodder, and construction purposes in households across both wealth classes and head of household gender. To the local people, 'Miombo woodlands are a pharmacy, a supermarket, a building supply store and a grazing resource' (Dewees et al. 2010:61). Households that employ FPES for direct household consumption save cash resources, which would have otherwise been used to purchase the products (Shackleton and Shackleton 2004). The use of the forest for medicinal purposes was more prominent in Katanino than in Mwekera.

Table 5 Proportion of households (%) selling different FPES stratified by gender

Products sold	Overall ($n = 244$)	Katanino site				Mwekera site			
		Gender of household head		χ^2	Significance	Gender of household head		χ^2	Significance
		Males ($n = 78$)	Females ($n = 40$)			Males ($n = 99$)	Females ($n = 27$)		
Charcoal	45.1	56.4	42.5	2.8	>0.05	45.5	11.1	10.6	<0.05
Wild fruits	21.3	5.1	5.0	0.0	>0.05	34.3	40.7	0.3	>0.05
Handicrafts	2.4	3.8	2.5	0.5	>0.05	1	0.0	–	–
Wild vegetables	6.5	0.0	0.0	–	–	9.1	7.4	0.1	>0.05
Thatching grass	20.5	15.4	25.0	0.9	>0.05	20.2	25.9	0.4	>0.05
Mushrooms	27.0	14.1	30.0	4.7	<0.05	31.3	40.7	0.7	>0.05
Munkoyo	2.9	3.8	7.5	3.1	>0.05	0.0	0.0	–	–
Honey	6.1	7.7	2.5	2.1	>0.05	6.1	3.7	0.2	>0.05
Firewood	3.2	0.0	0.0	–	–	8.1	0.0	–	–

This difference may be caused by Mwekera's greater proximity to Western health facilities, which reduces the village's reliance on trees for the treatment of various ailments. Furthermore, the number of residents using medicinal plants may actually be higher than reported due to the failure of study participants to disclose their use: A number of residents belong to religious groups that forbid the use of traditional medicine because of its perceived association with witchcraft. The imposition of religious sanctions on users of traditional medicines has also been reported in rural communities in the South African savanna (Shackleton et al. 2007).

Household wealth status and consumption of FPES

In terms of wealth differentiation and the household consumption of FPES, the study showed that at both sites, a significantly greater proportion of wealthy households used the forest as a source of fodder. These findings are in agreement with an earlier study in India, which indicated that because the wealth of rural households is largely associated with livestock ownership, wealthy households make considerably more use of the forest as a source of fodder (Davidar et al. 2008). The wealth status of households was also significantly associated with the use of the forest as a source of construction material in Mwekera. This association is likely due to the ability of wealthy households to purchase exotic poles from nearby plantations and sawmills in Kitwe city. In a study of the Dyala district of South Africa, Paumgarten and Shackleton (2009) found that only a small proportion of households used the indigenous forest as a source of construction material due to the ready availability of poles from the surrounding plantations. In the present study, the large proportion of households observed to use FPES in their livelihoods across the wealth strata provided evidence of the importance of FPES to rural livelihoods regardless of the wealth status of households. Although previous research on rural livelihoods has reported the use of forest products as high among wealthy (Cavendish 2000; de Merode et al. 2004), intermediate (Ambrose-Oji 2003), and poor (Twine et al. 2003) households, this study shows that the proportions of households engaging in the collection and use of FPES are comparable across wealth classes. The magnitude of forest product consumption in these households is likely to be influenced by other household factors such as household size and the age distribution of household members.

Gender and consumption of FPES

Clear gender roles in FPES extraction were observed within households. Women dominate the collection of mushrooms, fruits, and thatching grass, while men dominate honey collection, charcoal production, and the felling of trees for firewood, as has been widely reported (Alelign et al. 2011; Chirwa et al. 2008; Kideghesho and Msuya 2010; Kiptot and Franzel 2012; Shackleton and Shackleton 2004). However, the present study indicates no significant difference in the consumption of FPES between different head of household genders, in contrast to the previous findings in other agroecosystems such as the tropical rainforests in the Usambara mountains in Tanzania (Kideghesho and Msuya 2010), the Afromontane forests in north-western Ethiopia (Alelign et al. 2011), and the tropical dry forests of

Nigeria (Gbadegesin 1996). The study findings do, however, coincide with those of Paumgarten and Shackleton (2009), who reported negligible gender effects on forest use in South Africa. Despite the lack of significant differences in the use of FPES between male- and female-headed households, the gender-specific collection and use of provisioning services within households was observed. In male-headed households, women (either wives or adult female household members) engage in female-dominated activities and vice versa for adult men in female-headed households. In most of the previous literature, female-headed households are associated more with female-dominated activities, with little consideration given to households as units composed of different genders (Kideghesho and Msuya 2010; Kiptot and Franzel 2012). Furthermore, the age of household members plays a role in defining the livelihood activities of these members. Labour-demanding activities, such as charcoal production, are more common among young men, and similar observations have been made regarding labour-intensive timber harvesting in Tanzania (Kideghesho and Msuya 2010). These activities are distributed within the household as a unit, whether it is male- or female-headed.

Contribution of FPES to household income

Income from the sale of FPES is an important contributor to overall household income for rural residents (Fisher 2004; Kamanga et al. 2009; Mamo et al. 2007). Households in the study area were shown to combine a number of income streams, using multiple sources of income to diversify their livelihoods, as was consistent with existing literature on rural livelihoods (Belcher et al. 2005; Ellis 2000; Sunderlin et al. 2005). Income from FPES was shown to be the most important source of household income, accounting for a substantial amount (43.9 %) of the annual income of the study area. However, forest incomes have been poorly documented in national poverty and rural development strategies (PRSP 2002; Tesfaye et al. 2011). The contribution of forest income observed in the study area is comparable with that of studies in Ethiopia (Mamo et al. 2007) and Zimbabwe (Cavendish 2000), in which forest income contributed 39 and 35 % to total income, respectively. The extraction of FPES requires minimal skills and technology, making it an attractive income opportunity for rural households (Heubach et al. 2011).

The mean income from FPES was higher in Mwekera than in Katanino, likely because of the former village's greater access to urban markets. In both study sites, charcoal was the main source of forest income. In Zambia, woodfuel (i.e. charcoal and firewood) is the main source of energy for approximately 85 % of urban households (Central Statistics Office 2005), most likely due to its low cost in comparison with that of alternate energy sources, high electricity tariffs, and the unreliability of the electricity supply.

Inter-site comparisons of the households selling FPES indicated that more households in Mwekera were engaged in the sale of mushrooms, wild fruits, and wild vegetables. These fresh products respire and eventually undergo senescence (the breakdown of cells and cell components) after harvest, which reduces their quality and shelf life and leads to post-harvest losses (Pardo et al. 2001). These effects are compounded by poor-storage environments and distance to markets,

which subject the fresh products to further transportation-related mechanical damages. These losses are likely to be reduced with distance to markets, explaining why villages near urban markets are more involved in the sale of fresh products (i.e. mushrooms, wild vegetables, and wild fruits).

FPES income and wealth categories

The results of this study show that FPES contribute a larger proportion of the total annual household income of poor households than that of intermediate and wealthy households. The relative contributions of FPES to household income varied across the wealth strata, with means of KR 2340.3, 2009.7, and 1620.1 for wealthy, intermediate, and poor households, respectively. However, the proportional contribution of FPES income to total household income was highest among poor households (55.5 %). This study indicates that although wealthy households obtain higher mean household incomes from FPES than do their poorer counterparts, poorer households are more dependent on FPES as a source of income, likely due to their overall more limited income streams (Shackleton and Shackleton 2006). In a study in the Shindi ward of Zimbabwe, Cavendish (2000) reported that forest income contributed more to the total income of poor households (40 %) than that of their wealthy counterparts (29 %), while in the Dendi district of Ethiopia, Mamo et al. (2007) reported that forest income represented 59 and 34 % of the total income for poor and wealthy households, respectively. The high contribution of forest income to poor households and the Gini-coefficient observed in this study provide evidence of the importance of FPES to the reduction in income inequality among rural households, a result in agreement with those of previous studies (Kamanga et al. 2009; Mamo et al. 2007). Forest income therefore plays an important role in the amelioration of poverty among rural households (Reddy and Chakravarty 1999). Similar patterns have been confirmed in the Bale highlands of southern Sudan (Yemiru et al. 2010), in Malawi (Fisher 2004), and in northern Ethiopia (Babulo et al. 2008). With respect to the proportions of households engaged in the sale of FPES, a significantly greater proportion of poor households in Mwekera sold wild fruits, mushrooms, and thatching grass. This observation may be attributed to the preference of wealthy households to engage in the sale of more income-rewarding products such as charcoal.

FPES incomes and gender

This study indicated that head of household gender was not a significant determinant of a household's engagement in the sale of FPES. These findings contradict those of other studies (McSweeney 2004; Yemiru et al. 2010), which have reported that female-headed households are more engaged in the sale of forest products than male-headed households. Although females dominated selling as an activity, no differences occurred at household level, as households contain both male and female members who participate in these activities. These findings are in contrast to those of previous research (Babulo et al. 2008; McSweeney 2004), which reported that female-headed households are more engaged in the sale of forest products. The

gender difference observed for charcoal production in this study may be attributable to its physical demands; charcoal production is traditionally practiced by males, and fewer female-headed households participate in the activity as it is dependent on the presence of males in their households. The wealth of households was the main determinant of their engagement in the sale of FPES.

Conclusions

This study has provided insights into the relative importance of FPES to rural livelihoods in Miombo woodlands in different local institutional contexts, as well as the differentiation of the use and sale of forest products in relation to household wealth and head of household gender. FPES contribute substantially to rural livelihood portfolios across household wealth strata and head of household gender. Wealthy households derive the highest mean incomes from the sale of FPES but exhibit the lowest relative contribution of FPES to total household income. FPES income makes the greatest proportional contribution to the income portfolios of poorer households with limited income streams. Furthermore, this study observed a wider variation in the contribution of income from the sale of FPES to total household income due to wealth strata than to head of household gender. The study further indicated that the sale of forest products is determined by contextual factors such as proximity to markets and the nature of the products (e.g. shelf life); apart from charcoal, fewer households sold FPES in Katanino (which was further from urban markets) due to weak demand, especially for products with a short shelf life, such as fresh mushrooms and fruits. The wealth of households significantly influenced the sale of less-income-rewarding forest products such as thatching grass, while no differences among wealth classes were observed in the sale of charcoal. When households were analysed as a unit, there was no difference between male- and female-headed households in the sale of provisioning services, except for the sale of charcoal, which was dominated by male-headed households.

This study contributes to the growing literature on the effects of socio-economic factors on the use and sale of forest products by providing empirical evidence from the Miombo woodlands. The study presents further evidence of the high dependence of rural livelihoods on FPES, highlighting the vulnerability of rural communities to changes in the forest ecosystem. To reconcile forest conservation and livelihood improvement under emerging global strategies such as reduction of emissions from deforestation and forest degradation (REDD+) and climate compatible development (CCD), it is necessary to acknowledge the socio-economic complexities of forest resource management and design effective management interventions. More case studies, such as that of the present paper, should be conducted across various forest ecosystems to understand how local socio-economic factors impact forest use and to inform the development of locally appropriate management practices.

Acknowledgements Sincere thanks to Dr. Monica Di Gregorio and the anonymous reviewers for their comments on earlier drafts of this paper. We are grateful for the funding made available through a Commonwealth Scholarship awarded to Felix Kanungwe Kalaba. Additional fieldwork funding was provided by the Copperbelt University and the University of Leeds (SRI fieldwork bursary). This study was approved by the Ethics Committee of the University of Leeds.

Appendix

See Table 6.

Table 6 Ten most preferred tree species for medicinal purposes ($n = 161$)

Tree species scientific name	Local name	Percentage of households	Tree part(s) used	Ailment(s) treated
Cassia abbeviata	Musokansoka	74.5	Bark/roots	Bilharzia, skin ailments, diarrhoea, cough, malaria
Julbernadia paniculata	Mutondo	24.2	Bark	Diarrhoea, headache
Pseudolachnostylis maprouneifolia	Musalya	18.0	Bark	Diarrhoea
Uapaca kirkiana	Musuku	17.4	Roots/bark	Cough, diarrhoea
Parinari curatellifolia	Mupundu	16.8	Bark/roots	Diarrhoea
Oldfieldia dactylophylla	Lundawampanga	13.7	Bark	Fever, diarrhoea
Syzygium guineense	Musafwa	15.5	Bark	Eye infections, cough, diarrhoea
Diplorhynchus condylocarpon	Mwenge	14.3	Bark/roots	Cough, fever
Zanthoxylum chalybeum	Pupwe	12.4	Root	Cough, diarrhoea
Piliostigma thonningii	Mufumbe	12.4	Leaves	Cough

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