Economic Shocks and *Miombo* Woodland Resource Use: A household level study in Mozambique

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ABSTRACT

Quantitative analysis of household use of miombo resources is limited, and detailed accounts of a full range of environmental resources are scanty. The present manuscript aims to (a) quantify the contribution of miombo woodlands to the household economy; (b) assess the role of miombo woodlands as safety nets in the face of household level economic shocks; and (c) identify the socio-economic determinants of woodland resource use, in the buffer zone of the Gorongosa National Park in Mozambique. Environmental resources from the miombo woodlands make significant contributions to household economies in the study area. Linkages between income levels and miombo resource use are complex. Poorer households tend to use miombo resources for subsistence, while richer households use them for cash income. Our results demonstrate that environmental resources act as a crucial safety net against income shocks, related to health shocks and fire damage. The results highlight the need for incorporating use of miombo woodlands into poverty reduction strategies.

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1 INTRODUCTION

Issues related to environmental degradation, global climate change, and rural poverty have attracted unprecedented attention in recent times. Internationally, there has been an increased resolve to address the links between rural poverty and environmental degradation in the developing world; particular emphasis has been placed on improving the livelihoods of rural poor, which in turn would help conserve the environment. However, the relationship between rural households and environmental change is not clearly understood. A lack of physical and economic accounts is one of the main factors limiting understanding of the relationship between poverty and environment (Duraiappah 1998, Cavendish 2000).

The problem of lack of data is more acute in Africa than in other regions, where reliable data on the use of key environmental resources is either non-existent or inadequate (Cavendish 2000, Fisher 2002). For instance, while there is a wealth of literature on the contribution of tropical forests elsewhere (Peters et al. 1989, Hegde et al. 1996, Godoy et al. 2000a, Hegde and Enters 2000, Pattanayak and Sills 2001), relatively less is known about the *miombo* woodlands in Africa, although there is evidence that rural households in Africa use environmental resources extensively (Sale 1981, Campbell 1996, Campbell and Luckert 2002, Kaimowitz 2002). Quantitative analysis of household use of miombo resources is limited, and detailed accounts of a full range of environmental resources are scanty. Given that an ecosystem represents a basket of highly differentiated goods and services, more empirical evidence examining household dependence on these resources in a robust analytical framework is necessary (Cavendish 2000).

Micro-level quantitative analysis is important from policy, economic and ecological perspectives. Woodlands are vital for welfare of the rural African communities: millions of people depend on woodlands for a host of products; the traditional, swidden agricultural systems depend on the woodlands for nutrients; and woodlands are the source of fodder for livestock (Campbell and Luckert 2002, Kowero et al. 2003). However, there is a lack of appreciation of the economic potential of the woodlands, and as a result, in spite of their importance to households, miombo woodlands are rapidly being lost to make way for other development activities. One of the reasons for the low profile of miombo woodlands is the lack of quantitative micro-level research on woodlands' contribution to household welfare (Cavendish 2000). Micro level analyses provide insights that potentially help devise policy interventions for sustainable use of the miombo woodlands. It is, therefore, imperative to quantify woodland contributions to household welfare and raise the profile of the woodlands in the policy debates, and develop policies that achieve the twin objectives of woodland conservation and local livelihood improvement.

Household level data is comprehensively captured in the Income and Expenditure Surveys (IES) in many parts of the developing world. However, typically, these surveys do not account for environmental resources used by rural households for consumption and cash income generation, which lessens their usefulness for the study of poverty and environment relationships. This necessitates purposeful collection of household accounts of environmental resource use (Cavendish 2000, Cavendish and Campbell 2007; Pattanayak and Sills 2001, Fisher 2002).

The present manuscript aims to (a) quantify the contribution of miombo woodlands to household economy; (b) assess the role of miombo woodlands as safety nets in the face of household level economic shocks; and (c) identify the socio-economic determinants of woodland resource use, in the buffer zone of the Gorongosa National Park in Mozambique. Particularly, it will help answer the following questions. How much do environmental resources contribute to the household economy? Are poor households more dependent on environmental resources than the rich? Do miombo woodlands act as social safety nets when households are faced with income shocks? What socio-economic factors influence environmental resource use?

Mozambique characterizes the problems mentioned above. Mozambique is one of the world's poorest countries. The lengthy civil war lasting 16 years combined with droughts and flood alienated about six million people from their land, and adversely affected agricultural activities of those who were not displaced (Unruh, 1998; Simler et al. 2004). According to the National Household Survey of Living Conditions conducted in 1996-97, about two thirds of the population lived in absolute poverty. While the poverty rates varied from province to province, Sofala province, where the present research was conduced, had the highest poverty rate (88%) (Simler et al. 2004). Recently, however, the country made rapid strides in poverty reduction during a period of high economic growth (World Bank 2004).

Mozambique has an area of 799 390 km^2, with a population of 17.24 million (Government of Mozambique, 2005)[2]. About 71% of the population lives in rural areas, and about 93% of the rural dwellers directly depend on natural resources (Ribeiro 2001**).** In addition, about 41% of the urban labor force is also dependent upon vocations related to agriculture, forestry and fisheries. Agriculture is extensively practiced with a small fraction (14%) of the total cultivable area (36 million ha) actually cultivated and with low use of inputs (Nhantumbo 2000; Ribeiro 2001). However, from statistics compiled from FAO (2005) it is estimated that some 24% of the land area (19 million ha) is subject to shifting cultivation, and about 1 mill on ha is under permanent cultivation.

Mozambique is moderately forested with about 39% (30 million ha) of forest area. The forestry sector plays an important role in the national economy by contributing about 4% of the GDP and about 80% of energy needs (FAO, 2005. Although the current rates of deforestation in the country are relatively small (FAO, 2005), there are significant human pressures on the woodland resources (Ribeiro 2001, Kowero et al. 2003). A range of forest products is extracted from forests, such as construction timber, fuelwood, charcoal, wildlife and so on. In addition to heavy human pressure,

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[2] FAO (2005) provides land use data for the 787,608 km^2 area.

forest fires are a major threat, with about 40% of the country being affected by fire every year. Fire is known to be one of the main tools for land clearing for cultivation, hunting, timber harvest and acquisition of other goods and services including charcoal production and honey collection, and for protecting resources from wild animals. Evidently, while forest resources are critical to development in Mozambique, forests are under heavy pressure.

There is considerable evidence of use of wild resources in the country (Ribeiro 2001, Jindal 2004). However, there is a lack of systematic quantification of resource use at the household level, although certain partial valuations have been attempted. For example there were two socio-economic studies in the very community which is the focus of the present research. A socio-economic assessment of Nhambita community reported that about 69% of the families earned their cash income from sale of natural resources including farm produce. However, the report did not provide estimates of the contribution of forest resources to households (Howell and Convery 1997). Jindal (2004) established a socio-economic baseline of Nhambita community, who observed that annual household cash income fluctuated widely from a meager US$ 9 to US$ 2,850. While it provided some interesting insights into the community and its use of forest resources, it did not provide detailed household environmental resource accounts. As a result, there is a lack of understanding on some basic questions such as what is the total value of environmental resource use and how does the resource use relate to other socio-economic parameters.

Against the above background, the present research aims to develop comprehensive accounts of the household environmental resource use.

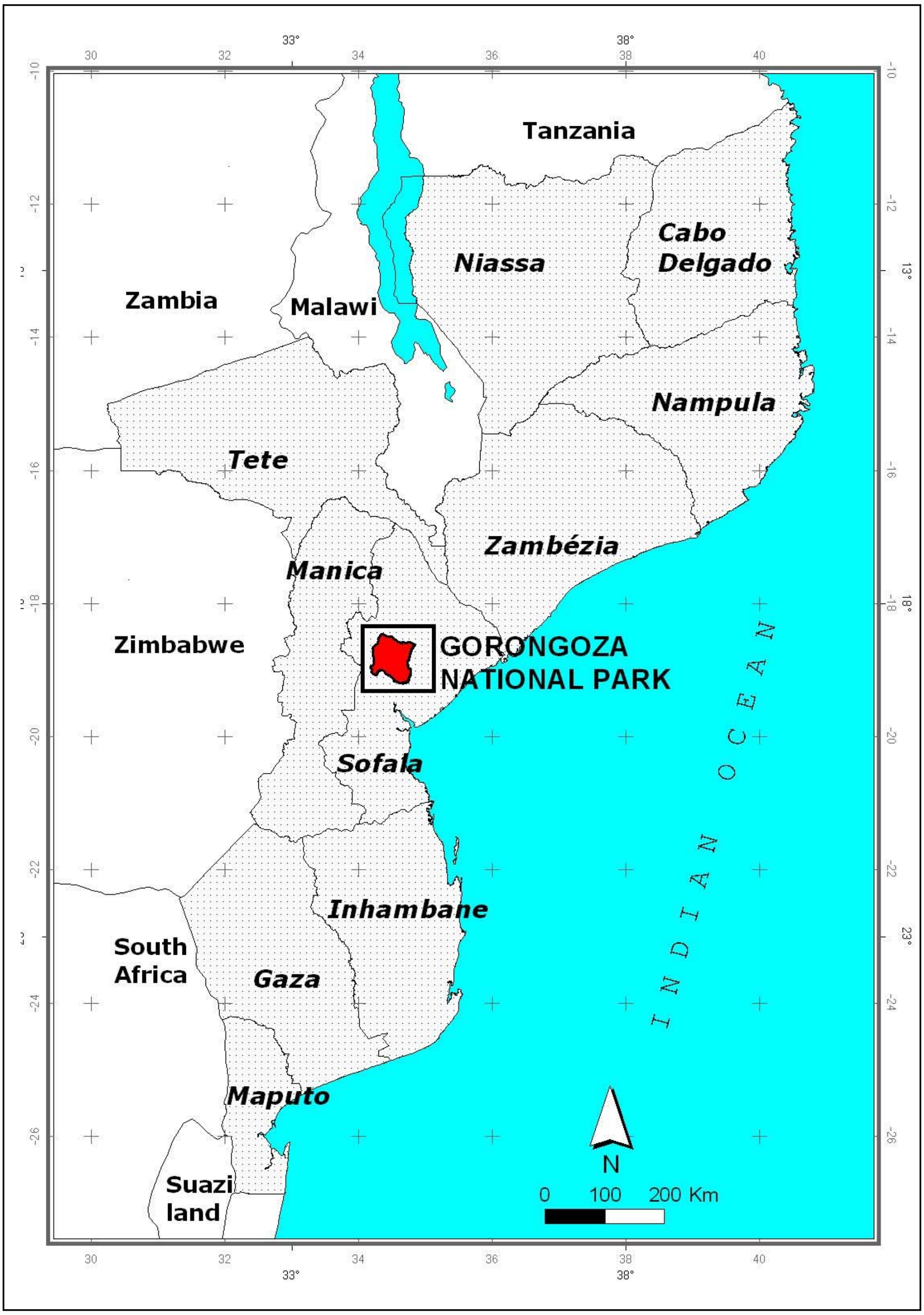
2 METHODS

2.1 *Study area*

The study was undertaken in Chicale *Regulado*[3], located in the buffer zone of the Gorongosa National Park (GNP) in the Sofala Province, Mozambique (Fig. 1). The choice of this area was guided by several factors including past research in and around GNP and continued interest and efforts in Park rehabilitation. Further, there is a small scale agro-forestry based carbon sequestration project, which can be categorized as a payments for environmental services (PES) project, under implementation in Nhambita *Regulado* (Jindal, 2004; Stern Review, 2006; Hegde et al. 2007b). Farmers have signed voluntary contracts with the project implementing agency (EnviroTrade, a UK based company) to plant indigenous and fruit tree plants on their farm (either on the farm boundaries or in mixed rows along with crops) and manage them for 25 years in return for annual cash payments. The objective is to sequester carbon through the plantings and sell carbon credits in international carbon markets. Households which have signed contracts and planted trees (in both the first and second year of the project) are categorized as PES project-participant households.

[3] Traditional authority.

Fig. 1: Map showing the location of Gorongosa National Park, Mozambique



The project also has a menu of other forest based activities for the development of the community, such as carpentry, bee keeping, nursery development, community garden development, etc. and provides full time employment for about 100 people. It also provided limited seasonal employment in forest fire prevention and patrol activities. Besides employment, the project distributed guinea fowls for rearing and red gram seeds for cultivation to community members (see Hegde et al. 2007b for details).

Chicale *Regulado* covers a total of 20 km^2 area, with over 1,100 households spread over five villages, namely Nhambita, Bue Maria, Munhanganha, Pungue and Mbulawa (Table 1). Nhambita village, where the *Regulo* Chicale family resides, is considered as the centre of the study area. Three villages, Nhambita, Bue Maria and Munhanganha, are located close to each other within the buffer zone of the GNP. On the other hand, Mbulawa village is located outside the GNP boundary, and Pungue is situated on the GNP boundary such that a part of the village is inside and a part outside. Key characteristics of the villages are shown in Table 1.

Table 1: Key characteristics of the villages

Characteristics	**Nhambita**	**Bue Maria**	**Munhanganha**	**Mbalawa**	**Pungue**
Location	Within buffer zone	Within buffer zone	Within buffer zone	Outside park	On the park boundary
Distance to tarmac road	9 km	18 km	10 km	1-6 km	1-4 km
Access to markets	Poor	Poor	Poor	Medium	Fair
Main forest products	Own use: wild food, grass, fuel, poles & limited use of clay for pottery & timber	Own use:, wild food, grass, fuel, poles, limited timber & fish	Own use: wild food, grass, fuel, poles & limited use of timber & fish	Own use & sale: wild food, fuel, bamboo, charcoal, poles, timber & gold panning	Own use & sale: wild food, fuel, bamboo, poles, fish & gold panning
Farming	Mainly subsistence;	Subsistence & commercial (cotton; sesame)	Mainly subsistence;	Mainly subsistence;	Both subsistence & commercial (tobacco; vegetables)
Major environmental resource collected	Poles, wild food, clay for pottery	Poles, wild food, fish	Poles, wild food	Poles, wild food, bamboo, charcoal, gold panning	Fish, poles, wild food, gold panning
Number of households	64	42	65	414	441
Households sampled	22	17	19	131	141

The villages also differed in terms of farming systems and environmental resource use patterns. While farming in the first two villages was mainly subsistence; Bue Maria village had a mix of traditional and commercial agriculture (limited area was under vegetable, cotton and sesame cultivation); while Pungue, being located on the bank of the river Pungue, had relatively more commercial farming systems (with tobacco; vegetables). While the first three villages had households gathering more traditional environmental products predominantly for subsistence, households in

Mbalawa and Pungue had a mix of both subsistence and commercial products. Mbalawa had households producing charcoal for sale and undertaking gold panning (for sale), besides gathering subsistence products, while households in Pungue undertook fishing (both subsistence and sale) and gold panning, besides gathering subsistence environmental products. Because of the proximity of the three villages, Nhambita, Bue Maria and Munhanganha, for the purpose of the present research, they are considered as one village henceforth.

Brief historical background

The Nhambita community land was legalized in 2003 after a claim was made under the new Land Act (No. 19/97) which permits communities' ownership of their ancestral land and management of its resources for the benefit of the entire community as per a pre-approved management plan. Part of the community land was taken over by the National Park Authority when the then Hunting Reserve was upgraded to the National Park in 1965. To minimize the poaching pressures inside the GNP during its rehabilitation, a buffer zone strategy was used that envisaged involvement of the local community in the management of the GNP (Zolho 2005).

Climate and geography

The climate is subtropical with alternating cool and dry winters (April-October) and hot wet summers (November-March), with May being the coolest and October being the hottest month. The area lies within the 600 mm and 800 mm per annum rainfall isohyets, and is generally influenced by the Gorongosa Mountain. Most of the rain is received between November to March, with July to September being the driest months (Zolho 2005).

Geographically, land in Gorongosa consists of eroded surfaces of granite and basaltic gneiss complex of Precambrian times, which, after heavy weathering, result in sandy soils that are generally unsuitable for any form of intensive farming (Tinley 1977). The vegetation is dry miombo, interspersed with evergreen thickets on the deeper alluvial sands. There are a few narrow patches of thick riverine forest along the seasonal streams, such as the Lupice, and river Pungue (Zolho 2005).

Land use

Land use in the GNP and surroundings consists of three types: protected area; buffer zone and community land. The protected area is under the State administration. The buffer zone, land immediately adjacent to the GNP boundary, is jointly managed by the government, communities and other stakeholders. While subsistence farming is allowed in the buffer zone, no other commercial activity, including hunting or extraction of forest products for commercial production, is allowed. The community land is managed by the communities under the Land Act. Activities in the community land include subsistence farming, charcoal production, fishing, hunting, etc.

2.2 *Research design*

Questionnaire-based quarterly household surveys, which explicitly integrated quantitative environmental resource use data with household economic data, were the main source of data used in the research. In addition to the four quarterly surveys, two annual household surveys and two village surveys – one each at the beginning of the research and one at the end – were undertaken. Use of surveys in economic research was first suggested by Ciriacy-Wantrup (1947). Household surveys provide a rich source of information at the household level, and its relationship with policy (Deaton 1997). Questionnaires developed by CIFOR-PEN[4] were adapted and expanded to suit the objectives of the research.

Quarterly surveys helped in capturing information at short recall, on the types and quantities of environmental products collected, their consumption and sale, along with prices received and revenue received; household consumption patterns; quantities of farm inputs used and crop yields obtained; off-farm employment and wage income earned. Past research demonstrated that accuracy will increase significantly when recall period is shortened, particularly for irregular income sources such as forests and woodlands (Campbell et al. 2001) and here there are high seasonal variations both in availability of resources as well as in agricultural harvests, which cause sharp seasonal differences in earnings and access to food (Cavendish 2000, Simler et al. 2004). The annual household surveys, conducted at the start and end of the field work, provided information on demography, land use, economic shocks and any changes occurring over the 12-month period.

Village surveys (focus groups) involving key informants, also conducted at the start of the field work, provided a good introduction to community demography, helped finalize household sampling issues in consultation with communities, and provided qualitative information on the influence of geography, climate and other issues affecting livelihoods. A list of all the crops grown and forest products collected in the village, including fish and non-forest environmental products, was prepared, which was used to adapt and augment the questionnaire.

Sampling

Since official household census was not available, we updated the household rosters with village headmen (*Nfumo*'s) by listing all households under their responsibility (Cavendish 2000). These households were then arranged alphabetically, and then a sample was chosen using a random number table. Where the selected household was not available for interviews, either due to multiple-listing[5] or inability to participate due to sickness or old age, the immediate next household on the list was chosen. It is important to have a sample size that is adequate for a statistical analysis. Sample size would depend on population heterogeneity, required level of precision and

[4] Details can be seen at (http://www.cifor.cgiar.org/pen/_ref/home/index.htm).

[5] There were cases where households were listed in more than one village.

availability of resources (Singleton et al. 1993). Considering the heterogeneity in the area, we decided to draw a large sample.

The initial sample was 335 households. Five households migrated in the middle of the research missing at least two rounds of survey, and were excluded from the analysis. Another 24 households were temporarily away during survey months, thereby missing one round of survey. However, these households were included in the analysis, with the missed entries being substituted by the sample averages. Eventually, a sample consisting of 330 households was used for analysis.

Valuation of environmental resources

The environmental resources were valued and aggregated in a consistent manner for households involved in both market and non-market activities to produce household income accounts (Cavendish 2000). Households were asked to report the price of products sold. Where the product was not marketed, households were asked to place a price they would be willing to pay for a product, if they were to buy the same. Since the reported prices differed from household to household, we used quarterly average prices[6] to value products. Since most products were not traded in the market, one would expect households to have considerable uncertainty in valuing their resources, resulting in ambiguous or random responses or missing values. Surprisingly, households were able to place a value on almost all of their products, which were broadly comparable to each other, a finding consistent with Cavendish (2000) and Campbell et al. (2001) in neighbouring Zimbabwe.[7] To assess the plausibility of these values, we compared the reported prices of environmental goods with the local prices of their nearest substitutes wherever possible. For example, value of wild vegetables was compared with cultivated vegetables; value of wild birds captured was compared with chicken; value of game animals captured was compared with that of farm animals; and so on.

The reported quantities of various products were in local measures. We used consistent conversion rates to convert the local measures into standard measures. There were, however, difficulties. For instance, converting *molho* (meaning a bundle or bunch) into standard measures was challenging. For example, fuelwood was always reported in *molho*'s and so were wild vegetables, where the two *molho*'s differed by a large magnitude. The conversion task became even more complex when a catch of rats was also reported in *molho*'s. Direct observation was helpful in devising coarse conversion rules. For instance, one *molho* of fuelwood (weighing approximately 10 kg) was different from a *molho* of wild greens, weighing about a kg; which were different from a *molho* of rats numbering 4 or 5 (medium sized) to 8-10 (small sized).

[6] Prices quoted by households, including the local market prices where appropriate, in the quarterly surveys were averaged after the end of the quarterly surveys, and used in the valuations.

[7] There were some exceptions. For instance, in the case of medicinal herbs, two households came out with figures that were nearly ten times higher than the figures reported by other households.

Quantifying the value of grazing by livestock was difficult. We valued the number of livestock units sold and consumed at home in each of the four quarters.

Income definition

Following Cavendish (2000), we used gross (total) income, as the measure of overall household welfare[8], defined as the sum of cash income, net gifts/transfers, subsistence income (from crops and livestock) and environmental income (value of all environmental products collected for consumption and cash income earning. Incomes were reported in local currency *metical* (plural *meticais*; MTS[9]).

Field work

Field work was undertaken from January to December, 2006. Eight enumerators[10] were recruited and trained, who conducted the interviews in the local language (*Sena*), under the supervision of the researcher. Enumerators went through an intensive 2-week training which included review of the questionnaires, 'in-class' demonstration and mock interviews, which helped address many inconsistencies in phrasing questions and recording responses. Actual interviews were started in a phased manner which helped further refine interview skills of enumerators. Each enumerator was given responsibility of 40 households either in his native village or in the neighboring village. The survey supervisor and the researcher conducting both interviews as well as monitoring remaining interviews (which included both 'surprise' visits to the interviews being done by enumerators, post-interview cross checks with the respondents and regular questionnaire scrutiny). The advantage of placing the enumerator in his own village (or neighboring village) was that it helped build trust with the households which in turn helped obtain information which otherwise would be difficult to collect by an outsider.

The four rounds of quarterly surveys were held in March-April (1st round), June-July (2nd round), September (3rd round) and November-December (final round) of 2006. The two village (community) surveys and annual surveys were held in March (beginning of the survey season) and November (end of the survey season). At the beginning of the field work, discussions were held with key informants and other members in each of the five villages.

[8] Consumption is often preferred to income as a measure of welfare (Deaton, 1980), but in rural Africa consumption and income are not dissimilar (Cavendish 2000). We also measured consumption in this study; it will be examined in subsequent analyses.

[9] All calculations in this study are based on old currency; under the currency reforms, the last three digits in the currency have been removed. The exchange rate fluctuated throughout the study period; however, we use a constant exchange rate of 1US$ = 26,500 MTS.

[10] Enumerators had varying educational qualification, with diploma (highest), certification course and high school (lowest).

3 ANALYSIS AND RESULTS

3.1 *Socio-economic summary of households*

A summary of some socio-economic variables of the sample households in three villages is shown in Table 2.

Table 2: Socio-economic summary of sampled households

Variable	Nhambita	Mbalawa	Pungue	Overall
Sample	58	131	141	330
Size of household	5.28 (2.08)	6.38 (2.82)	5.67 (2.63)	5.75 (2.63)
Number of females	2.9 (1.59)	3.18 (1.89)	2.87 (1.67)	3.00 (1.75)
Number of males	2.31 (1.41)	2.89 (1.77)	2.77 (1.66)	2.73 (1.67)
Number of adults	3.19 (1.25)	3.54 (2.10)	3.33 (1.95)	3.39 (1.91)
Mean education of the household head	3.00 (1.93)	3.42 (2.14)	3.54 (2.08)	3.39 (2.08)
Household literacy (%)	53.22 (50.47)	51.51 (51.00)	64.95 (57.13)	57.56 (53.84)
Total land area (ha)	4.94 (4.81)	3.25 (1.77)	4.40 (3.16)	4.04 (3.16)
Area of agricultural land (ha)	2.42 (1.29)	1.86 (0.98)	2.29 (1.35)	2.14 (1.22)
Length of household formation (years)	20.67 (13.83)	17.06 (12.99)	18.29 (13.50)	18.21 (13.36)
Value of assets (MTN)	579 (1,034)	446 (641)	732 (1,787)	592 (1,313)

Figures in parenthesis are standard deviations

On average, a household consisted of about six members. The average size of household was around 6; average size being largest in Mbalawa (6.38) and smallest in Nhambita (5.28). Literacy rate, which is the ratio of total literate members in the household to total members, was around 58%, which varied from 52% (Mbalawa) to 65% (Pungue). The average size of total land holding was around 4 ha of which 2.14 ha was cultivated. On average, households were formed about 18 years ago. Length of household formation varied from 17 years (Mbalawa) to 21 years (Nhambita). On average, value of assets held by households was about 600 MTN, in the form of bicycle, radio, cash, etc. Owning these assets is considered as status symbol.

3.2 *Type and extent of environmental resource use*

The types of environmental resources collected and extent of household participation are indicated in Table 3. Over three quarters of the sample households participated in collection of animals as food. This category included a range of animals, including rats, cane rats, antelope, etc. Participation was higher in Nhambita (located inside the GNP) and Mbalawa (outside the buffer zone). Collection of birds and insects as food was higher in Mbalawa than the other communities. Two households in Nhambita reported to have sold a part of their animal catch. Participation in medicinal plants collection was highest in Nhambita, where four households reported selling their produce. Over a quarter of the sampled households collected tubers. Participation rate was highest in Mbalawa (31%), followed by Pungue (11%). Mushroom collection was a low level activity in the entire area, with about 8% households involved.

Nearly 60% of the households collected poles, with less than 5% of all households selling poles. Participation in collection was highest in Mbalawa, whereas trading was highest in Nhambita. Collection of bamboo, important for construction, was a major activity with nearly 47% participating. Participation was highest in Mbalawa (56%), followed by Pungue (48%). Nearly 15% of households in Mbalawa and 11% in Pungue reported selling bamboo. On the other hand, collection of timber was not a major activity for the sample households since less than 5% of the households participated in collection, and less than 1% selling timber.

Table 3: Collection of select environmental resources (% of all households)

			% Households participating in			
Category	Product	Indicator	Nhambita	Mbalawa	Pungue	Overall
	N		58	131	141	330
Food	Animals	Collection	81.03	80.92	73.76	77.88
		Sale	3.45	0.76	0.00	0.91
	Birds	Collection	5.17	37.40	13.48	21.52
		Sale	0.00	0.00	0.00	0.00
	Insects	Collection	36.21	70.23	38.30	50.61
		Sale	0.00	0.00	0.00	0.00
	Fruits	Collection	60.34	63.36	50.35	57.27
		Sale	0.00	0.00	0.00	0.00
	Tubers	Collection	2.41	31.30	10.64	26.67
		Sale	0.00	0.00	0.00	0.00
	Mushrooms	Collection	1.72	8.40	10.64	8.18
		Sale	0.00	0.00	0.00	0.00
Medicine	Medicinal herbs	Collection	65.52	54.96	25.53	44.24
		Sale	6.90	0.00	0.00	1.21
Construction	Poles	Collection	58.62	68.70	50.35	59.09
		Sale	10.34	3.05	4.26	4.85
	Timber	Collection	5.17	6.11	4.96	5.45
		Sale	1.72	0.00	0.71	0.61
	Bamboo	Collection	20.69	56.49	48.23	46.67
		Sale	0.00	14.50	10.64	10.30
	Charcoal	Collection	0.00	22.90	0.71	9.39
		Sale	0.00	22.90	0.71	9.39
	Gold panning	Collection	0.00	32.06	13.48	18.48
		Sale	0.00	32.06	13.48	18.48
	Stones	Collection	8.62	3.82	-	3.03
		Sale	8.62	3.82	-	3.03
	Clay	Collection	13.79	16.79	3.55	10.60
		Sale	8.62	11.45	2.13	6.97

Charcoal making was an important activity in Mbalawa where 23% of the households were involved in this activity. Gold panning was a major activity in Mbalawa where about 32% of households were involved. According to the GNP authorities gold panning is a prohibited activity. However, households continue doing it. About 3% of households participated in collection and sale of stones; over 10% participated in collection of clay; and about 7% sold articles made of clay. We have excluded from the table products such as fuelwood, wild vegetables, etc. which were collected by all households.

3.3 Socio-economic differentiation and environmental resource use

Do poor or rich households extract more environmental resources? To answer this question, we classified households according to per capita gross income, and compared the income composition of four income quartiles (a block of 25% of sampled households each) (Tables 4 and 5).

Farming accounted for the largest portion of the gross income (33%) and about 9% of the cash income. Overall, environmental resources accounted for roughly about 40% of the gross income and 25% of the cash income of the households, on average (Tables 4 and 5). Wage income accounted for 11% of the gross income and 32% of the cash income. Livestock sector contributed about 7% of the gross income and 10% of the cash income. In terms of gross income, value of crops used at home declined from the bottom quartile (low income households) to top quartile (high income households). However, share of crop sales increased from first to third income quartiles, which declined in the highest income quartile (Table 4). Similar patterns were observed in the case of cash income (Table 5). Crop sales contributed more to richer sections (third and fourth quartiles) than the poorer sections. On the other hand, livestock sale contributed more to lower income households (first and second income quartiles).

Even more marked patterns were observed in environmental income. Environmental products jointly accounted for a larger share of gross income of high income households than that of the low income households. However, the value of unprocessed forest products consumed at home (consisting mainly of vegetables, roots, insects and animals) was higher for low income households than high income households. Value of environmental products sold for cash income was higher for high income households.

Table 4: Composition of gross income (%)

Variable	Household quartiles				All households
	Lowest 25%	25-50%	50-75%	Top 25%	
Crop used at home	37.03 (14.19)	31.46 (12.04)	27.86 (13.30)	21.83 (14.56)	29.51 (14.58)
Sale of crops	1.86 (4.49)	2.31 (3.45)	4.14 (7.77)	3.27 (5.41)	2.90 (5.57)
Livestock use	1.98 (2.99)	3.77 (5.01)	2.94 (3.96)	1.54 (2.50)	2.55 (3.82)
Livestock sale	3.45 (6.51)	5.29 (7.94)	4.15 (7.97)	2.14 (3.84)	3.75 (6.84)
Use of unprocessed forest products	25.19 (11.29)	23.64 (11.74)	20.86 (10.98)	19.63 (12.03)	22.32 (11.67)
Sale of unprocessed forest products	0.81 (4.10)	0.42 (1.47)	0.87 (2.45)	1.38 (4.17)	0.87 (3.26)
Use of processed forest products	0.72 (1.74)	1.13 (2.44)	1.13 (2.67)	1.96 (7.46)	1.24 (4.22)
Sale of processed forest products	0.82 (3.88)	3.14 (8.00)	5.93 (13.09)	7.53 (18.83)	4.37 (12.54)
Fish use	3.84 (7.29)	4.43 (6.55)	6.09 (9.36)	10.67 (14.23)	6.27 (10.16)
Fish sale	0.71 (2.68)	0.75 (2.34)	1.88 (4.55)	4.12 (7.44)	1.87 (4.90)
Use of mineral products	0.18 (0.99)	0.23 (0.95)	0.34 (2.94)	0.32 (2.25)	0.27 (1.97)
Sale of mineral products	1.87 (6.76)	1.76 (5.72)	3.20 (8.00)	7.45 (12.63)	3.58 (8.97)
Wage	13.88 (14.29)	13.73 (12.19)	10.49 (9.81)	5.00 (4.48)	10.76 (10.88)
Business	0.92 (4.79)	2.89 (8.75)	4.45 (12.23)	9.52 (20.29)	4.46 (13.22)
Others	6.73 (8.84)	5.03 (8.83)	5.67 (10.84)	5.26 (8.95)	5.26 (8.95)
Total	100	100	100	100	100
Gross income (MTN)	10,866 (4,998)	15,507 (4,820)	18,857 (6,409)	31,760 (27,993)	19,284 (16,672)
N	82	82	83	83	330

(Figures in parenthesis are standard deviations)

Composition of environmental income showed some interesting patterns (Table 6). In value terms, fuelwood was the dominant environmental product for the three lowest quartiles, accounting for over 20% of the environmental income. For the top quartile, fish was the dominant product, accounting for roughly a quarter of the environmental income, followed by fuelwood. Share of fuelwood in the environmental income progressively declined from bottom quartiles to the top. On the other hand, contributions of fish, processed forest products and non-forest environmental products increased from bottom to top income quartiles. The share for poles and thatching grass, both used for construction, increased from first to third quartile and dropped in the top quartile. Other products, such as bamboo and animals, did not show a linear pattern of change across income quartiles, and the remaining ones were less significant in terms of their share in the environmental income.

Table 5: Composition of cash income (%)

Variable	Household quartiles				
	Lowest 25%	**25-50%**	**50-75%**	**Top 25%**	**All households**
Sale of crops	6.62 (12.11)	7.33 (10.65)	10.93 (17.88)	10.33 (17.33)	8.82 (14.90)
Sale of livestock	11.54 (20.97)	14.37 (20.25)	10.31 (17.25)	5.06 (8.69)	10.31 (17.71)
Sale of unprocessed forest products	1.97 (8.51)	0.93 (3.48)	2.19 (6.33)	3.91 (12.98)	2.26 (8.60)
Sale of processed forest products	2.94 (13.05)	7.97 (16.30)	5.99 (14.64)	12.01 (26.05)	8.70 (21.66)
Sale of fish	2.98 (11.55)	2.37 (6.99)	11.45 (24.30)	11.90 (21.52)	5.83 (15.10)
Sale of non-forest environmental products	5.06 (16.41)	5.79 (16.88)	7.04 (15.97)	16.23 (26.22)	8.55 (19.79)
Wage	43.99 (33.08)	40.11 (28.90)	30.39 (28.57)	15.13 (17.36)	32.35 (29.63)
Business	2.37 (9.64)	6.33 (17.50)	8.04 (20.22)	14.66 (28.73)	7.87 (20.63)
Other sources	22.53 (25.36)	14.79 (20.54)	13.25 (20.70)	10.76 (18.27)	15.31 (21.72)
Total	100	100	100	100	100
Cash income (MTN)	3,406 (2,494)	5,633 (3,010)	8,062 (4,938)	16,190 (23,773)	8,346 (13,197)
N	82	82	83	83	330

(Figures in parenthesis are standard deviations)

3.4 *Economic shocks and environmental resources use*

Economic contribution of environmental resources is sharply debated in the literature (Perez and Byron 1999, Cavendish 2000, Godoy et al. 2000b, Pattanayak and Sills 2001, Fisher 2002). Many researchers assume that forest products serve as "gap fillers" (i.e. income supplements or safety nets during income shortfalls) rather than engines of development (Godoy et al. 2000b). In the literature, there is often a tendency to combine the different roles of forest products under "livelihood support", ignoring the vary different roles that forest products play. The safety net function of forest products is considered important particularly for the poorest households, and there have been calls to give greater attention in research to this role (Cavendish 2000, Pattanayak and Sills 2001, Fisher 2002). The literature demonstrates the myriad of income shocks that households have in the face of, e.g., crop loss, livestock loss, and health shocks, and shows how households choose to respond to these shocks (Paxson 1992, Rosenzweig and Binswanger 1993, Kochar 1999, Pattanayak and Sills 2001, Rose 2001, Fisher 2002, Cameron and Worswick 2003). Communities in and around GNP regularly witness a variety of shocks, e.g. regular bouts of cerebral malaria, diarrhea and other waterborne illnesses; a variety of accidents (falling from trees, snake bites, etc). The GNP area was the heart of armed conflicts during the civil war, including the laying of anti-personnel mines[11] which continue to present huge

[11] We were warned about ongoing de-mining operation during field work, and were advised not to deviate from the beaten tracks while on foot.

risks. Fire hazards are rampant: a major fire occurred during the study period, sweeping through a part of the area destroying homes, fields and stored grains, resulting in the death of two people (including someone from a sampled households).

Table 6: Composition of environmental income

Variable					
	Lowest 25%	**25-50%**	**50-75%**	**Top 25%**	**All households**
Timber	1.81 (8.94)	1.03 (4.88)	0.74 (3.65)	0.96 (5.38)	1.33 (6.02)
Poles	5.30 (9.37)	5.51 (9.37)	5.61 (7.10)	4.21 (5.46)	5.15 (7.32)
Fuelwood	40.19 (21.72)	29.71 (20.73)	21.58 (15.24)	18.02 (21.04)	27.33 (21.52)
Bark	1.23 (2.64)	0.79 (2.54)	0.54 (1.41)	0.17 (0.59)	0.68 (2.00)
Bamboo	4.56 (9.26)	8.62 (14.19)	5.92 (12.34)	8.82 (16.24)	6.98 (13.33)
Fruits	1.84 (3.32)	1.16 (2.10)	2.15 (2.10)	1.60 (2.79)	1.69 (3.01)
Tubers	0.81 (2.32)	1.05 (2.45)	2.38 (7.17)	1.18 (3.21)	1.36 (4.31)
Vegetables	10.86 (6.71)	6.95 (5.41)	7.45 (7.37)	5.09 (5.77)	7.58 (6.67)
Mushrooms	0.12 (0.57)	0.06 (0.27)	0.33 (2.03)	0.02 (0.08)	0.13 (1.07)
Medicinal herbs	0.45 (1.54)	0.40 (1.52)	0.27 (0.59)	0.25 (0.60)	0.35 (1.15)
Broom-grass	1.24 (1.02)	1.00 (0.76)	0.82 (0.71)	0.66 (0.68)	0.93 (0.83)
Thatching grass	4.28 (8.59)	6.64 (8.87)	7.10 (11.24)	3.16 (4.86)	5.29 (8.81)
Grass	2.49 (8.42)	0.77 (3.02)	0.90 (3.98)	1.03 (3.13)	1.30 (5.15)
Animals	4.78 (5.92)	6.99 (7.02)	5.40 (5.20)	4.43 (4.73)	5.40 (5.83)
Birds	0.39 (1.21)	0.50 (1.44)	0.37 (0.83)	0.48 (1.40)	0.43 (1.24)
Insects	1.46 (3.2)	1.07 (1.75)	1.02 (2.11)	0.74 (1.28)	1.07 (2.20)
Honey	0.18 (0.93)	0.59 (3.66)	1.00 (3.84)	0.53 (2.04)	0.58 (2.88)
Processed forest products	3.29 (9.45)	9.36 (16.42)	11.78 (20.68)	12.77 (25.56)	9.32 (19.27)
Fish	11.23 (10.84)	14.26 (19.57)	18.48 (22.91)	24.45 (29.69)	17.13 (23.50)
Non-forestry products	3.48 (10.84)	3.52 (9.62)	6.16 (14.30)	11.42 (17.54)	6.16 (13.78)
Total	100	100	100	100	100
Gross income (MTN)	3,941 (3,500)	5,682 (3791)	7,708 (5,400)	19,196 (28,454)	9,264 (15,923)
N	82	82	83	83	330

(Figures in parenthesis are standard deviations)

Various shock-related incidents, including crop loss, livestock loss, illness, death of a household member, fire, theft, loss of employment, etc. were examined in this study, along with estimates of monetary loss in terms of actual damage occurred or lost employment income. Household responses to each of these shocks were also examined. However, for the purpose of this analysis, we consider only illness and fire as household specific economic shocks, and examine the safety net role in the context of household use of environmental resources.

Conceptual framework

Empirical literature covers a range of models on diversification and risk coping mechanisms (Paxson 1992, Rosenzweig and Binswanger 1993, Kochar 1999, Pattanayak and Sills 2001, Rose 2001, Fisher 2002, Cameron and Worswick 2003). Following Rose (1999), the theoretical framework underlying the empirical analysis is based on a two period model (which can be extended to multiple periods without the loss of generality) involving household efforts[12] into environmental resource extraction. The 2-period model allows inclusion of ex ante and ex post, and consideration of economic shocks. The first period is the one prior to the occurrence of a shock (such as sickness or fire)[13], and the second period is the period subsequent to the occurrence. The household collects environmental resources in each period.

Let "ξ" be a random variable representing the shock that adversely affects the household income. In period 1, the household does not know the actual occurrence of ξ, but knows its mean value (μ) and variability of intensity (ρ). The household's production and resource extraction efforts in the first period, E_1, depend on μ and ρ, and also factors such as agricultural income, wage income, demography and other variables.

$$E_1 = L_{E1}(\mu, \rho, w, A, \theta) \text{ -------------------------- (1)}$$

Let A be the wealth level (including cash in hand, stored food grains, etc.) in period 1; w be the wage employment; θ be a vector of parameters describing environmental resource extraction. We expect the ρ to affect E_1 in two ways. First, through a "portfolio" effect i.e. given the wage income and wealth level, the household may be assumed to adjust its resources. Second, there may be a "precautionary effect" whereby the household might collect environmental resources either to supplement (or complement) farm harvest. Both of the above will generate positive effects of ρ on environmental resource extraction.

In period 2, the household knows the value of ξ and ρ, and responds to them directly. Therefore, the efforts in period 2, E_2, conditional on decision in the Period 1 is

$$E_2 = E_2(E_1(\cdot), \varepsilon, \mu, A, \theta) \text{ --------------------- (2)}$$

[12] We do not define this in terms of number of labour days spent in actual resource extraction. Instead, we use the environmental income (aggregated values of products used at home and products sold for cash income) per capita.

[13] Rainfall in 2006 was normal, and crop yields were normal in the study area.

where $\varepsilon = \xi - \mu$

We would expect ε to affect environmental extraction through income and substitution effects. When ε is low (high), income shortfalls are low (high) and the household will increase (reduce) environmental resource extraction to smooth income.

Total environmental extraction for the year, E_T is the sum of E_1 and E_2

$$E_T = E_T(\mu, \rho, \varepsilon, w, A, \theta)$$

$$E_T = E_1(\mu, \rho, w, A, \theta) + E_2(E_1(\mu, \rho, w, A, \theta), \varepsilon, \mu, w, A, \theta) \text{ ------------------------- (3)}$$

The presence of ex post responses to shock can be tested from the above equation (3), using the test of: $\partial E_T / \partial \varepsilon \neq 0$ [14].

Empirical strategy

Although data was collected on a quarterly basis, we use annually aggregated data. The safety net role of environmental resources is examined in two ways. First, a household might respond to shocks by increasing own consumption of environment resources (say, wild food) due to paucity of cash income to buy food. We employ a multiple regression to examine the determinants of the total value of environmental resource use.

Second, a household might respond to shocks by extracting and selling environmental resources to tide over the liquidity crisis caused by an economic shock. However, only some households sold environmental resources, which resulted in the remaining households taking zero entries. Therefore, we create a binary variable (yes/no; 0/1) indicating whether a household sold environmental products, and use a logit model for estimating the parameters.

The following estimating equation was used for regression.

$$y_i = \alpha + \beta Xi + \delta Zi + \varepsilon i$$

where *y* represents per capita environmental income; *X* is a vector of socio-economic variables with β beta representing their parameters; *Z* a vector of dummy variables representing shocks; and ε is the error term.

For the logit model, the following specification was used:

$$P^*{}_i = a + bX + cZ + e$$

where *P** is a latent dichotomous variable (1 or 0) with the outcome that whether a household earned a cash income from the sale of environmental resource; *X* is a

[14] However, as Rose (1999) argued, there could be factors other than shocks considered here which bring about uncertainties in resource use. The test mentioned above cannot be considered as the response to risk. If responses are not correlated, then it could be a response; if there is correlation among the risks then the response may be considered as the net response to all sources of risks, which will lead to a potential omitted variable bias that needs to be addressed.

vector of household variables and *Z* a vector of dummy variables representing the shocks; *a*, *b* and *c* are the respective coefficients; and *e* the error term.

Descriptions of the variables used and the expected sign of the coefficients are indicated in Table 7. The models were estimated using Stata (version 8).

Multiple regression

The regression produced consistent estimators with most of the variables taking expected signs (Table 8). We used robust standard errors. There were no missing variables in the model[15], but there was a problem of non-normal errors[16].

Table 7: Description of the explanatory variables

Variable	**Explanation**	**Expected sign**
pcland	Per capita land holding (ha)	-
Lnwage	Natural log of wage income per capita	-
Woman	Dummy variable if the household is headed by woman	+/-
Hhborn	Dummy variable if the household head was born in the village	+
Hhform	Number of years the household was formed	+
Hhform2	Square of the number of years	-
Outpark	Dummy variable if the household was outside the park	+
Pespart	Dummy variable if the household is participating if the PES project	-
Distance	Distance (km) to the forest from the household	-
Sick	Dummy variable if a member of the household fell sick in the year	+/-
Fire	Dummy variable if the household witnessed a fire in the survey year	+/-

The estimation produced some interesting results. We expected per capita land to influence the environmental resource negatively. However, it turned out that there was a positive relationship between land holding and environmental resource use, which was statistically highly significant. It implies that, holding all other factors constant, an additional ha of land is predicted to increase the environmental income by 34%. One plausible explanation could be that environmental products include all wild products from wild and naturally occurring on fallow land and crop lands. Some of the animals were reported to have been captured either in the crop land or fallow land. Because of these reasons, we observe a positive relationship between environmental income and land area. The negative and significant sign on the variable woman (i.e. household headed by a female) is interesting. It implies that female headed households earned 29% less environmental income than male headed households.

[15] Using the Ramsey RESET test, we could not reject the null hypothesis that the model has no missing variables.

[16] The errors turned out to be non-normal. We used log transformation of some of the variables which helped to partially mitigate the problem; yet, the regression failed the skewness-kurtosis test for normality.

Table 8: Regression with robust standard errors

Variable	Coefficient	Robust standard errors	P-value
pcland	0.3400	0.1036	0.001
Lnwage	-0.0570	0.0541	0.258
Woman	-0.2945	0.1369	0.036
Hhborn	0.1667	0.1110	0.133
Hhform	-0.0296	0.0082	0.000
Hhform2	0.0003	0.0001	0.003
Outpark	0. 2111	0.1378	0.124
Pespart	-0.5732	0.1236	0.000
Distance	-0.0500	0.0356	0.160
Sick	0. 4201	0.1932	0.046
Fire	0. 3410	0.1428	0.006
Constant	14.2727	0.7220	0.000

N = 303 F(11, 291) = 8.53 Prob>F = 0.0000 $R^2 = 0.2105$
See Table 7 for variable descriptions

The two variables concerning length of household formation i.e. number of years of household formation and square of the years of household formation, have an interesting interpretation. First year of household formation brought about 3.24% reduction in environmental income, while the second year was estimated to reduce the same by 3.18% (i.e. 0.06% higher than the first year). This implies that households that were formed earlier earned more environmental income than households that were formed recently. Participation in the PES project was estimated to reduce environmental income by 57% compared to non-participant households. Holding all other factors fixed, an extra one km distance between household and forest resource base was estimated to reduce the environmental income by 5%.

The two shock variables had an interesting explanation. Households that reported sickness resulting either in direct monetary expenditure and/or wage loss due to loss of labor days were estimated to extract more environment products and increase their environmental income by 42% which was statistically significant (p value 0.05). Similarly, households which experienced fire increased their environmental income earnings by 34% (p value 0.006).

Logit regression

Results of the logit regression are presented in Table 9. Wage income significantly increased the odds of selling environmental products. The odds of selling were also significantly less for female-headed households compared to male-headed households. Household formation had a diminishing influence on the odds of selling environmental products. PES-participation and distance to forest significantly reduced the odds of environmental product sales. On the other hand, sickness significantly increased the odds of selling environmental products.

Table 9: Logit regression on participation or non-participation in sale of environmental products

Variable	Odds ratio	Std. Error	Z	P-value
pcland	0.9900	0.2267	-0.04	0.965
Lnwage	0.6466	0.0937	-3.01	0.003
Woman	0.2500	0.0864	-4.01	0.000
Hhborn	1.3668	0.3572	1.20	0.232
Hhform	0.9515	0.0213	-2.23	0.026
Hhform2	1.0005	0.0003	1.47	0.142
Outpark	1.0203	0.3811	0.05	0.957
Pespart	0.4269	0.1309	-2.78	0.006
Distance	0.6980	0.0912	-2.75	0.006
Sick	2.0726	0.8380	1.80	0.071
Fire	1.5137	0.6309	0.99	0.320

N = 303 LR chi2 (11) = 61.79 Prob > chi2 = 0.0000
Log likelihood = -178.09453 Pseudo R^2 = 0.1478

4 DISCUSSION

4.1 Household dependency on forest resources

Our results provided an indication of the extent of livelihood diversification by households, which is in line with other studies in Africa (Fisher, 2002; Barrett et al. 2001). Besides farming and livestock, households gathered a variety of environmental products, deriving about 40% of their gross income and 25% of cash income from environmental products. This finding is in line with other studies in southern Africa (Fisher, 2002; Campbell et al., 2002; Cavendish 2000).

Farming was a major activity to households, particularly for poorer households. Poorer households cultivated corn and sorghum and some pulses mainly for their own consumption, which formed the bulk of the farm output value. They seldom sold their food crop output, except when facing severe liquidity problems. On the other hand, richer households earned relatively larger proportion of their income (gross and cash income) from sale of crops, as also demonstrated by Campbell et al. (2001). We have seen that some of the households cultivated tobacco and cotton purely for commercial purposes. It may be recalled that these crops were introduced during the colonial time in Mozambique.

Livestock is considered an important asset in Africa. Farmers usually sell their livestock to meet the liquidity problems. This perhaps explains why low income households derived larger share of income from livestock than richer households. Although all households used unprocessed forest products for consumption, poorer households derived a larger share of their gross income from these products. Rural communities in southern Africa experience severe food shortages during the months (January-March) immediately preceding farm harvest (Fisher, 2002). During interviews, some of the households reported having lived only on wild food during hungry months. Value of the processed forest products used at home was more or less same for all households. However, richer households derived larger shares of their income from processed products and non-forest environmental products. On the whole, our results demonstrate that poverty and environmental resource dependence are closely linked; however, some qualification is necessary. Poorer households use environmental products for own use, while richer households use the environmental resources for cash income. As the income levels rise, the pattern of resource use changes towards more commercial products. This finding is in conformity with other studies (Hegde and Enters, 2000).

4.2 Socio-economic factors and environmental resource use

Empirical evidence on the role of environmental resources as safety nets is limited. Our results of the linear and logit regressions present some interesting insights. Environmental resource use and sale were significantly influenced by gender. Particularly, female-headed households collected significantly less environmental products than the male-headed households, and their probability of participation in the sale of environmental products was also less. This has an important policy implication. A substantial proportion of households are headed by women; some of them are households consisting of single woman. Many male members reportedly perished during the civil war, and the fate of many is still unknown. GNP used to be the capital of the rebel forces during the war, and many households reported losing their male members during the war. Besides the HIV/AIDS pandemic, alcoholism was seen to be a problem, particularly among men. It was reported that consumption of local beer not only drained household budgets but also significantly impacted human health. There were also other factors, such as diseases and accidents which claimed a significant number of lives. As a result of these factors, significant numbers of households are headed by women, and these households tend to be resource poor were more vulnerable to economic shocks.

More established households tend to extract more environmental resources than younger families. Older families tend to have a greater knowledge and familiarity with the geography, seasonality, and quality and quantity of resource availability in their surroundings, and as a result will be in a better position to extract resources. Similarly, the probability of young families participating in the sale of environmental products was also less.

Participation in the PES-scheme was found to significantly reduce environmental resource use and also the probability of participation in sale of environmental products. PES project participants received free seedlings and annual cash payments subject to satisfying minimum conditions. One of the clauses in the contract is that no additional area will be cleared and burnt, after signing the contract. This may have discouraged the PES-participants from burning the forest. About a quarter of the participants were directly employed by the project, in the carpentry unit, forestry and agro-forestry research, community plantations, nursery operations, etc. Some of the participants also received red gram seeds for sowing, and some received jungle guinea fowl for rearing. Some of the PES-participants also got part-time employment in forest fire prevention and control operations which the project undertook. All of the above factors may have acted as an effective alternative to hunting and gathering activity, otherwise undertaken by the households, and resulted in reduced use of environmental resources.

The two shock variables, sickness and fire, were found to significantly increase environmental resource use, and sickness was found to increase the probability of sale. These findings confirm the role of environmental products as safety nets. Besides HIV/AIDS, diseases like malaria, cholera, diarrhea, etc were a common problem in GNP and surroundings. The Government undertakes, from time to time, preventive measures in urban and semi-urban areas, but they rarely reach remote villages like Nhambita. Many of the diseases in the study area are waterborne (diarrhea, cholera), which are preventable provided strict hygiene is observed. Drinking water was a problem, as these villages use stream water for drinking[17] which is more likely to be contaminated. There is a public health post in Pungue which caters for minor ailments. For major health problems, households need to go to the district headquarters at Gorongosa (about 40 km). In the absence of western medicine (which is luxury even in urban and semi-urban places) households tend to use herbal medicine or visit the spiritual leaders and seek spiritual remedies. For these reasons, even a minor ailment can have debilitating effect on lives of the villagers.

Fire is a common tool for cleaning agricultural land after harvest. Use of fire is risky for PES-participants since some of them planted seedlings in mixed rows in the field, and death of seedlings will imply loss of cash payments. Fire is also used in hunting (to smoke animals from their holes and trap them). Households that suffered fire damage significantly increased their use of environmental resources. Although there was a positive relationship between fire and sale of environmental products, it was not significant statistically.

5 CONCLUSIONS

Environmental resources from the *miombo* woodlands make significant contributions to household economies in rural Africa. Our results demonstrate that environmental resources act as a crucial safety net against income shocks, related to health shocks and fire damage. This highlights the need for incorporating the *miombo* woodlands as part of poverty reduction strategies in Africa. Linkages between income levels and *miombo* resource use are complex. Poorer households tend to use *miombo* resources for subsistence, while richer households use them for cash income.

There is a lot of emphasis on female-headed households in rural Africa, in view of their vulnerability to hardships. We had anticipated that, owing to limited resources and alternatives, female-headed households would extract more environmental resources in relative terms than male-headed households, in view of limited requirements of capital and skills for extraction of environmental resources. But, it turned out to be the opposite case in GNP area. It re-emphasizes the vulnerability of female-headed households to hardships given that limited social security measures are

[17] A well was being built in Nhambita with the help of aid agencies including the PES-project.

in existence in the developing world and highlights the need for increased livelihood security to female-headed households.

We observed that PES-participant households extracted less environmental resources compared to participant households. Due to the negative link between PES and environmental resource use, PES-like schemes are likely to be a useful tool to generate greater environmental goods by reducing pressure on the environment, while at the same time improving or maintaining economic wellbeing of households.

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