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Full Length Research Paper

Policy impact on resource use and conservation in Miombo woodland, Pindanganga, Mozambique

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A case study was carried out in Pindanganga to analyse the impact of alternative forest management regimes and sectorial and extra sectorial policies on the well being of stakeholders and conservation of the woodlands using a dynamic game theoretic model, MIOMBOSIM. This study shows that the cooperative management regime is potentially beneficial to local communities if properly implemented and can improve the condition of rural livelihoods and woodland resources. It also shows that regulated forest management regimes, incorporating social concerns or social and environmental concerns, are potentially more beneficial to the household sector that the open access regime, an increase by 100% on sales amount or 100% increase in marketing selling prices of NTFPs can lead to an increase in the per capital benefits of the household sector. An increase by 100% in off-miombo employment opportunities has an insignificant impact on resource use and conservation for the local communities. A combination of these two policy instruments under *ceteris paribus* condition can improve the well being of the rural communities depending on the management regime, but can not lift the household benefits above the poverty line of one US$ per day per person.

Key words: Game theory, forest management regimes, efficiency, non-timber forest products.

INTRODUCTION

Sustainable forest management in Mozambique

The Mozambican government has been effecting institutional changes over the past two decades in the search for adequate policies and strategies for the management of its natural resources. In 1997 the government approved a new land policy, followed by environment law (1997), National Forestry and Wildlife Policy (1999) and the Decree law of administrative decentralisation (Decree Law No. 15/2000), to guide the management of the natural resources (Nhantumbo et al., 2001; Wily and Mbaya, 2001).

The new national forestry and wildlife law (1999) empower local communities to own and participate in the management of natural resources through community-based natural resource management (CBNRM) initiatives. It establishes a process of participatory management of resources in which a management council (*conselho de gestão*) is created, which includes members of the community, local government, private operators and other associations (Article 31, No. 1).

To date the state intends to manage the natural resources as joint ventures with the private sector and the local communities. The national environmental law does not explicitly recognise the contribution of the local communities towards the management of natural resources, but serves as a basis for designing regulations intended to minimise negative environmental impacts resulting from development activities and/or irrational use of natural resources (Nhantumbo et al., 2001).

The first CBNRM project experience in Mozambique was launched in 1994 in the community of Bawa, in Tete Province, located on the border with Zimbabwe and is known as 'Tchuma-Tchato' (Wily and Mbaya, 2001). The relative success of this programme has encouraged the

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rapid spread of new projects over the country. For instance, four years after the establishment of the Tchuma-Tchato project, about 40 projects were being implemented by different government institutions and local and international NGOs through the financial support of international donors (Anstey, 2001; Wily and Mbaya, 2001).

This paper presents the results of the application of the game theoretic model developed by Falcão et al. (2005), this journal issue. The scenarios assessed are related with sectorial and extra sectorial policies on well being of stakeholders, resource use and conservation under alternative management regimes.

OBJECTIVES AND PROBLEM STATEMENT

The general objective of this study is to assess the socio-economic and environmental impacts of the use of miombo woodland resources and to identify the most appropriate management regime in a way that satisfies the achievement of the goals of the stakeholders in Pindanganga. This study has the following specific objectives: (i) to identify the most appropriate management regime and evaluate its socio-economic and environmental impacts; and (ii) to test different policy instruments (sectorial and extra-sectorial policies) to improve the understanding of the interaction between stakeholders and the influence of different factors in management regimes.

To date, it is unknown what will be the socio-economic and environmental impacts if the household benefits from non-timber forest products (NTFPs), human population dynamics, the allowable cut established in the management plans, the effects of transaction costs on the cooperative management regime, charcoal production efficiency variation, greater off-miombo employment opportunities and tree diameter class segregation were taken into consideration, and if either new agricultural incentives are put in place or if the commercial sales or prices of NTFPs were increased.

METHODS

This study demonstrates the use of a dynamic game theoretic model Falcão et al. (2005) in meeting the objectives of the state, the household and private sector as they relate to the miombo woodland resources in Pindanganga.

Study site

The study site was selected to capture the following features: presence of miombo woodlands; the degree of access to transport and markets; presence of commercial logging; and presence of activities of exploitation of forest products (wood and NTFPs) for sale by households. Pindanganga is located in Gondola District, which is one of the major suppliers of timber, construction material (poles and thatching grass) and charcoal within Manica Province to the provincial capital, Chimoio city. Manica province is in the centre of Mozambique, along the Beira Corridor. It is relatively rich in both forest and wildlife natural resources. The forest area covers 36,512 ha of miombo forest at a stocking rate of 37 m^3/ha, under a community based forest management programme. The climate in the study site is characterised as cool and wet. The mean annual temperature is 21.5°C with average maximum of 26.6°C and average minimum of 16°C. The mean annual precipitation is about 1,080 mm, concentrated in January and February. The dry season starts in May and ends in September (MINED, 1986).

In Pindanganga high levels of damage took place in the forest cover because of harvesting wood for fuel, timber, building materials and through forest clearing for agriculture. Since 1994 however, the communities have returned to a more normal lifestyle. The average size of typical household farm is 3.5 ha, the average family size is 6.0 and 2,331 people live in the study site (INE, 2001).

Data collection

The target population was defined as households who use miombo woodlands for agriculture and/or for extraction of wood and non-timber forest products for household consumption and sale. In this study the sample unit was a household. For data collection, the sampling method involved a random selection of households from listings prepared by village leaders in accordance with the definition of the target population. According to FAO (1990), if the total number of households is bigger than 1000, the suggested sample should be at least equal to 50 households. The total sample size for the study is 54 households. They were selected from villages or zones in Pindanganga, out of 1,858 listed households. Since conditions were considered to be more or less uniform, inter-village variation was assumed minimal and hence there was no need for stratified or multi-stage sampling.

To accomplish this research a combination of methods was used to generate the required information. The data were collected from both primary and secondary sources. A structured questionnaire, checklists for formal interviews and informal discussions and participant observations were the methods used to gather information from primary sources. The questionnaire was used to collect data from sampled households in face-to-face interviews. It investigated aspects of household consumption of wood products and NTFPs, activities, labour distribution by sex and age, management of miombo trees, and selling activities. The checklists were used for focused discussion with key stakeholders including relevant district officers and village government leaders and local foresters. The survey was carried out between September-November 2002 and 2003 over a period of 12 weeks in each year.

The data collection was related to crop yields. Wood and NTFP prices were collected at the provincial and district directorate of agriculture and fisheries. An appraisal in various urban markets and rural roadsides gave the latest market prices of construction material (poles, bamboo and grass), fuelwood (charcoal and firewood), logs and honey coming from the study areas. The actual surveyed farms did not collect the information regarding crop yields due to the fact that farmers often had difficulty even recalling within-year information on resource use when the operations have been conducted for several months preceding the date of interview.

In the survey, the transaction cost was determined based on the objectives and working experience of the Pindanganga community based management program. For this program, the information collected related to the composition of local committee members, number of meetings per month/year, the human and financial resources used, number of people involved in patrolling and monitoring the miombo woodlands and in enforcing the transaction.

Charcoal efficiency was measured based on a random sample of 23 earth kilns. To estimate the charcoal yield, the following

measurements were taken: the number of trees harvested the length of the logs and branches prepared to go to the kiln, the diameter at mid point of the length of all logs prepared to go to the kiln, the numbers and weight of the charcoal bags produced.

The subsistence income for the community is estimated based on the total number of households in the community, the typical household size and composition by age and sex, consumption basket of food and non-food items, the minimum per capita caloric requirements established and local markets prices. The calories for the typical household were converted into quantities of products and the monetary values were assigned using local market prices.

Model data inputs

The data inputs for the model are presented in Table 1 (Falcão, 2005). All coefficients used were derived from the survey results. Data on the population, area under forest cover of miombo employment and growth, commercial harvesting costs and discount factors have been obtained from secondary sources. The human population growth in the study sites during the first 20 years of the simulation period is equal to 1.2% for the next 10 years is equal to 1.5% and for the last 10 years is equal to 1.0% (INE, 2001)

Calibration and validation of the model

The data presented in the previous table was feed into the model. The calibration and validation of the model in this research was performed using the harvesting capacity parameter and evaluating the magnitude of benefits, resource use and conservation with the stakeholders. Firstly the harvesting capacity parameter in the basic models was arbitrarily set according to Mlay et al. (2003) and the modelling results were discussed in November and December 2003 with the MOFLOR manager, the harvesting timber association for Manica province and technicians of the provincial directorate of forest and Wildlife at Manica province and local committee members in Pindanganga. Based on the discussions, the parameters were finally set as indicated in Table 1.

RESULTS

Basic simulation results

Data used for the basic simulations were taken directly from the fieldwork report and questionnaires or calculated from there. The impact of management regimes on the stakeholder's benefits is presented in Table 2. The difference in benefits between the two sectors reflects the different market values of the products harvested and harvesting capacity.

The commercial sector derives more of the benefits under the non-cooperative management regime. According to Mlay et al. (2003), for the commercial sector, the non-cooperative management regime is not the best option, but they can get into the cooperative management regime if the total benefits (tangible and intangible benefits) and the penalties for non-cooperation exceed the additional benefits emanating from the non cooperative management regime.

The two first options leading to the highest equivalent annual discounted net benefits from miombo activities to the household sector are the command regime incorporating social concerns and non-cooperative management regime for Pindanganga. The regulated option for environmental reasons leaves all stakeholders with the lowest benefits in both sites. This makes sense because of the emphasis put by the regulator on environmental concerns that is more of the woodland resources are preserved, thereby resulting in lower benefits.

As can be seen in Table 2, the total benefits, if the objective is to maximize stakeholder benefits, that is, the highest equivalent annual net discounted benefits, are achieved under the non-cooperative management regime. Equivalent annual net discounted benefits reduced to US$230 371 per annum, when the objective is resource conservation. Within the regulated management arrangements (command environment, command social and command social and environment), the management with social concerns or with social and environmental concerns are potentially beneficial to local communities.

Table 2 also reports the per capital household benefits from miombo sale of wood products and NTFPs and agriculture. The environmental and social-environmental management regimes are the least attractive. The best management regimes are command regime incorporating social concerns, non-cooperative and cooperative, but under none of the management regimes these benefits are superior to three percent of a US Dollar per day (97% below the poverty line).

The impact of management regimes on forest resource use, number of charcoal bags produced and harvested volumes by sector for commercial purposes are indicated in Table 3. In terms of the impact of different management regimes on forest resources, the best outcome with respect to ecological health of the woodland is achieved under the command environment regime, followed by the command regime incorporating social and environmental benefits. The cooperative management regime is the third best option. The environmental concerns mean that a larger area of forest cover has to be maintained to meet people needs, while protecting the environment. Deforestation is highest under the non-cooperative and social regimes in Pindanganga. As expected, the regulated system incorporating only environmental concern leads to the least deforestation, but it is the option least attractive to the household and commercial sectors in terms of benefits they derive.

Average annual forest area converted to agriculture is lowest under the command regime incorporating environmental benefits. The management options that lead to more conversion of forestland to agriculture are the non-cooperative, cooperative and command with social concerns.

The results on harvested volumes by the two sectors do not include the waste brought about by the harvesting

Table 1. Data inputs for the simulation model in Pindanganga.

Data type	**Units**	**Pindanganga**
Amount of thatching grass sold	Bundles/yr	1000
Average basal area	m^2/ha	6.9
Average farm size	Ha	3.4
Charcoal production efficiency	Percentage	13.7
Chicken price	$/unit	0.55
Chicken quantity sold by the whole community	Unit/year	23 046
Discount factor		[0.909;0.89]
Existing agricultural land	Ha	6 317.2
Forest area	Ha	36 512
Goat price	$/unit	6.1
Goat quantity sold by the whole community	Unit/year	4 754
Harvesting capacity parameter		[0.0003; 0.3]
Harvesting cost by commercial sector	$/$m^3$	2.5
Honey quantity (price)	$/litre	10,000.0 (0.51)
Number of families per site	Persons	1,858.0
Off-miombo labour	Percentage	0.008
Pig price	$/unit	9.2
Pigs quantity sold by the whole community	Unit/year	1,153.0
Price of grass	$/kg	0.01
Price of charcoal	$/$m^3$	1.7
Price of poles	$/$m^3$	2.05
Price of standing miombo	$/$m^3$	11.5
Regeneration (survival rate)		0.012 (0.92)
Agricultural revenue per hectare	$/ha	126.0
Subsistence income for community	$	677 470.14
Transaction cost (fixed cost)	$/ha	2.26
Total man-days/year in the community	Man-days/yr	1 657 283.4
Wage rate	$ per year	405.6

Table 2. Equivalent annual net discounted benefits (EANDB) for private and household sectors from miombo woodland activities in Pindanganga[a]

Forest management regime	**Private sector EANDB ($ per annum)**	**Household sector EANDB ($ per annum)**	**Household EANDB ($ per capita per day)**
Non-cooperative	(1) 443 519	(2) 107 469	0.03
Cooperative	(4) 391 381	(3) 94 252	0.03
Environmental	(5) 230 371	(5) 37 507	0.01
Social	(2) 433 173	(1) 107 761	0.03
Social and environmental	(3) 428 266	(4) 76 086	0.02

[a]The figures in parentheses represent the ranking of the management regime on the basis of EANDB's within each sector.

practice or volume harvested for other basic household needs. The actual volume of miombo removed by the household would include the trees lost by fire (during

charcoal making) and trees felled during land conversion to agriculture but not transformed into commercial products or other wood products harvested for basic household needs.

Regarding the impact on volume of wood products harvested, as expected, the trends correspond to those of benefits derived from these products. In comparison with the non-cooperative model that represents the practice commonly used for a long term in the past, least volume is harvested under the command regime incorporating environmental benefits. For the household sector, the highest volume of wood products is harvested

Table 3. Volumes harvested and amount of charcoal bags produced in Pindanganga[a].

Forest management regime[b]	Converted land (ha)	Standing miombo (ha)	Harvested volume (m^3)		
			Commercial	Household	Charcoal
Non-cooperative	(3) 236	(5) 3 891	6 000	11 666	8 329
Cooperative	(1) 250	(3) 4 118	6 000	11 403	7 825
Environmental	(5) 72	(1) 6 070	3 577	3 577	2 554
Social	(2) 238	(4) 4 031	6 000	11 739	8 381
Social and environmental	(4) 253	(2) 4 331	6 000	10 068	6 361

[a] The figures in parentheses represent the ranking of the management regime.

Table 4. Relative effect (in %) of an increase by 100% in commercial sales of NTFPs (I) and an increase by 100% in market selling prices of NTFPs (II) on discounted net benefits from miombo activities under alternative regimes in Pindanganga[a].

Forest management regime	Commercial annual benefits		Household annual benefits		Total annual benefits		Benefits per capita per day	
	I	II	I	II	I	II	I	II
Non-cooperative	100.0 (0.2)	100.0 (-0.6)	100.0 (-1.0)	100.0 (-0.2)	100.0 (0.0)	100.0 (-0.5)	100.0 (3.6)	100.0 (4.7)
Cooperative	88.0 (-11.8)	0.0 (0.0)	94.0 (-6.9)	109.1 (0.7)	89.2 (-10.8)	89.6 (-10.9)	94.4 (-2.2)	93.5 (5.8)
Environmental	51.8 (-48.1)	52.2 (-0.2)	35.2 (-65.2)	34.9 (-0.2)	48.6 (-51.4)	48.8 (-51.5)	41.3 (-57.2)	40.9 (12.3)
Social	97.4 (-2.4)	98.3 (0.1)	100.7 (-0.4)	99.7 (0.7)	98.0 (-2.0)	98.6 (-1.9)	100.7 (4.3)	99.7 (4.3)
Social and environmental	97.4 (-2.4)	96.8 (-0.4)	96.7 (-4.3)	78.6 (-10.9)	97.2 (-2.8)	93.2 (-7.2)	97.2 (0.7)	80.4 (17.0)

[a]The figures in parentheses represent the percentage of change at the end of simulation compared with the basic scenario.

under the cooperative model.

The household harvesting volumes in the dynamic game theoretic models are restricted according to the allowed cut established by the management plans of the sites. This was done to reflect what is happening in the field. Within the model structure, the harvesting volumes for the commercial sector were limited to a maximum of 6,000 m^3 per year according to the Pindanganga manage-ment plan. For the commercial sector, the average annual harvest under the regulated regime with environmental concerns explicitly incorporated was about 60% of the harvest under open access.

IMPACT OF SECTORAL POLICY ON THE WELL BEING OF STAKEHOLDERS, RESOURCE USE AND CONSERVATION UNDER ALTERNATIVE MANAGEMENT REGIMES

A general increase in the current commercial sales or market prices of NTFPs could be brought about by, for instance, improvement in road infrastructure, new markets closer to the local communities or removal of explicit government taxes on NTFPs. To assess the impact of such an increase, the Pindanganga model was simulated with an arbitrary increase by 100% on the current selling amount of NTFPs (scenario I) and an increase by 100% on the market selling prices of NTFPs (scenario II).

The relative results on the impact of increasing commercial sales amount or prices of NTFPs (honey, chickens, pigs, goat and thatching grass) on annual discounted net benefits from miombo activities are presented in Table 4. These values were obtained by comparisons made in relation to the basic simulation results (values in brackets) and in addition the non cooperative model results are used as reference results for assessing the other management regimes.

An increase in selling market prices of NTFPs did not lead to a change in the ranking of the management

Table 5. Relative effect (in %) of a 100% increase in commercial sales (I) and 100% increase prices of NTFPs (II) on average annual volume of miombo wood products harvested under alternative management options in Pindanganga[a].

Forest management regime	Converted land (ha)		Standing Miombo (ha)		Harvested volume (m^3)					
					Commercial		Household		Charcoal	
	I	II	I	II	I	II	I	II	I	II
Non-cooperative	100.0 (-0.4)	100.0 (-0.4)	100.0 (-0.3)	100.0 (0.7)	100.0 (0.0)	100.0 (0.0)	100.0 (-0.6)	100.0 (0.4)	100.0 (-0.6)	100.0 (0.4)
Cooperative	108.9 (8.5)	108.5 (8.5)	105.3 (4.9)	104.2 (-0.9)	100.0 (0.0)	100.0 (0.0)	100.7 (0.1)	99.7 (2.3)	96.8 (-3.8)	95.9 (2.3)
Environmental	30.6 (-69.5)	30.4 (-69.5)	156.7 (56.1)	155.1 (0.1)	59.6 (-40.5)	59.5 (-0.1)	30.8 (-69.4)	30.5 (-0.1)	30.8 (-69.4)	30.5 (-0.1)
Social	100.9 (0.4)	100.0 (0.4)	104.2 (3.8)	103.0 (0.1)	100.0 (0.0)	100.0 (0.0)	101.1 (0.5)	100.1 (-0.2)	101.1 (0.5)	100.0 (-0.2)
Social and environmental	93.2 (-7.2)	91.1 (-7.2)	108.3 (8.0)	108.4 (-2.0)	100.0 (0.0)	100.0 (0.0)	93.3 (-7.3)	91.2 (6.0)	93.3 (-7.3)	91.2 (19.8)

[a] The figures in parentheses represent the percentage change at the end of simulation compared with the basic scenario.

regimes, while an increase in the commercial sales of NTFPs lead to changes in the ranking within each sector. With regard to discounted net benefits to the commercial sector and compared to the non cooperative regime of the basic run, raising market selling prices by 100% increased the annual discounted net benefits under all management options for Pindanganga. It had a mixed behaviour depending on the management regime. Raising the commercial sales of NTFPs reduced the benefits of this sector under all alternative management regimes (except for non-cooperative). These results conform to *a priori* expectation since selling NTFPs contributes to household economic benefits derived from miombo forest for the household sector. This scenario is in favour of the household sector, meaning that in addition to the restriction on harvesting implied by the environmental concern, the commercial sector is indirectly penalised by the social consideration favouring the household sector.

The household annual discounted net benefits from selling of wood products from miombo activities showed decreased behaviour across cooperative, non-cooperative, environmental and social alternative management regimes. The total per capita per day (selling of wood and non wood products) increased compared with basic runs for all regimes, excluding the environment and the cooperative management regimes. The command regime, accounting only for environmental benefits, was the least beneficial, with discounted net benefits being decreased relative to the base scenario. The net benefits attained their highest value under the social and environmental management option. The observed increase in household benefits per capital per day from miombo activities was caused by an increase in harvesting of NTFPs and less area converted to agriculture.

Using the non-cooperative model from basic runs as a reference, the command model incorporating environmental benefits was the least beneficial, while the command with social and environmental concerns, social concerns and the cooperative models were the most beneficial. The increase of 100% in commercial sales or selling prices of NTFPs could lead to an increase in household per capita benefits, but this was not enough to raise the income of household members above the poverty line of one dollar per day per person, showing that forest policies on NTFPs by themselves in the study sites do not address the poverty problem of the local communities. In terms of per capital benefits, raising market prices of NTFPs had a similar effect as the effect of increasing the amount of NTFPs sold.

The average volume of miombo logs harvested by the commercial sector almost did not change under all management options (Table 5). The largest decline was observed under the command model incorporating environmental benefits. Comparing the alternative management options with current practice (non cooperative model), the largest harvest volume decline was observed under the command model incorporating social and environmental benefits, while the volume harvested was least sensitive to increase selling amount and prices of NTFPs under the command model with social concerns.

The impact of increasing the commercial sales or prices

Table 6. Relative effect (in %) of an increase by 100% in off-miombo employment opportunities on discounted net benefits from miombo activities under alternative regimes in Pindanganga[e].

Forest management Regime	Commercial annual benefits	Household annual benefits	Total annual benefits	Benefits per capita per day
Non-cooperative	100.0 (-0.2)	100.0 (-0.1)	100.0 (-0.2)	100.0 (-0.4)
Cooperative	97.9 (10.7)	101.3 (9.6)	98.6 (10.5)	101.4 (9.3)
Environmental	52.1 (0.0)	34.9 (0.0)	48.7 (0.0)	38.3 (0.0)
Social	98.6 (0.7)	100.2 (-0.1)	98.9 (0.5)	100.4 (0.0)
Social and environmental	97.5 (0.8)	95.5 (34.7)	97.1 (5.9)	95.7 (32.5)

[e]The figures in parentheses represent the percentage change at the end of simulation compared with the basic scenario.

of NTFPs in mitigating deforestation (Table 5) was most pronounced, as expected, under the command model incorporating environmental benefits. This management option showed the highest percentage of the area of standing miombo woodlands at the end of the simulation. The increase in commercial sales and prices are least effective in mitigating deforestation under the non-cooperative model. These results seem to suggest that the most beneficial management options will be those that minimise conflicts (command social and environment and cooperative model) between multiple objectives.

In the study site, within each management regime, an increase in commercial sales or market selling prices of NTFPs leads to decreased deforestation.

THE IMPACT OF EXTRA-SECTORIAL POLICY ON THE WELL BEING OF STAKEHOLDERS, RESOURCE USE AND CONSERVATION UNDER ALTERNATIVE MANAGEMENT REGIMES

The extra-sectorial policy considered in this research is off-miombo employment opportunities due to the pressure on miombo use to sustain the communities (Kaimowitz and Angelsen, 1996). The increases in off-miombo employment opportunities that can come about through increasing investment in the study areas are due to economic growth or improvements in social infrastructure (small scale industry for processing NTFPs, agricultural markets, etc.) and will likely decrease the pressure on woodlands in order to sustain the resources (Bluffstone, 1993).

To assess the impact of such a change in the community's economy, the dynamic game theoretic model for the study sites were simulated with the off-miombo parameter set at 100% higher than the current (0.008% in Pindanganga). The level of increase corresponds to the expectation of the local government in the study areas. Table 6 reports the relative changes compared with the basic runs.

From Table 6, the highest benefits for the commercial sector can be achieved under the non-cooperative management regime followed by cooperative. For the household sector, the cooperative option that is currently in place is the best option in Pindanganga.

Compared with the basic scenario, an increase in off-miombo employment generally there were some mixed impacts observed, depending on the forest management regime. The benefits for non-cooperative, cooperative and command with social concerns have increased. The benefits for command with social and environment concerns have decreased and the standing miombo area has increased. An explanation for the mixed direction of the impacts of such increase may be partly due to the fact that this source of income constitutes only a small part of the total income of the household and benefit very few households in the community.Comparing the results from Tables 2 (basic runs) and Table 7, a greater availability of off-miombo employment generally has induced a slightly lower pressure on forests. The small impact on the site in terms of resource conservation can be explained by the fact that the percentage of people benefiting from such increase is very small.

Table 7. Relative effect (in %) of an increase by 10% on off miombo employment opportunities on charcoal production and volumes harvested by the stakeholders under alternative management options in Pindanganga[a].

Forest management regime	Converted land	Standing miombo	Harvested volume (m^3)		
			Commercial	Household	Charcoal
	100.0	100.0	100.0	100.0	100.0
Non-cooperative	(0.0)	(0.0)	(0.0)	(-0.1)	(-0.1)
	100.4	104.8	100.0	100.5	100.5
Cooperative	(-5.1)	(-0.9)	(0.0)	(2.7)	(6.9)
	30.5	155.9	59.6	30.7	30.7
Environmental	(-0.5)	(0.0)	(43.4)	(0.0)	(0.0)
	100.4	103.5	100.0	100.5	100.5
Social	(-0.2)	(-0.1)	(0.0)	(-0.2)	(-0.2)
	91.9	108.3	100.0	92.1	92.1
Social and environment	(-14.2)	(-2.7)	(0.0)	(6.6)	(20.5)

[a] The figures in parentheses represent the percentage of change at the end of simulation compared with the basic scenario.

DISCUSSION

Basic scenario

Regarding the calibration and validation of the model, all stakeholders within the commercial sector involved on the round table discussions were comfortable with the figures obtained by the basic models after the calibration (Tables 2 and 3) assuming that more than one company will harvest using a simple harvesting license. For the household sector, the results were discussed with the Pindanganga local committee members and they consider the results obtained as acceptable and suggested that they could harvest more if they had better financial means.

The results show that the regulated management regimes incorporating social or social and environmental benefits provide higher benefits to the household sector than the open access regime. This means that we can potentially improve the well-being of the rural communities and encourage woodland conservation if these benefits were felt at the community level. Mlay et al. (2003) got similar results for the Manica and Sofala provinces (centre of Mozambique), while Kachule et al. (2003) found the same for Malawi.

The results seem to suggest that the household sector can get more benefits for centralised management regimes which takes into account social aspects or social and environmental aspects than the non-cooperative management regime. For these centralized management regimes, Mlay et al. (2003) suggested that the benefits have to flow from the regulator to the local communities in order to minimize non compliance to sustainable forest management activities. This can be guaranteed under decentralised management with local community participation but with a clear definition of benefit-sharing arrangements. The cooperative management regime, which already has legal support from property right protection, needs to be promoted in association with policies and regulations which bring incentives to increase the benefits from activities related to NTFPs, such as honey production, keeping domestic animals and the sale of thatching grass.

According to Mlay et al. (2003), the failure of these centralised options has resulted from the lack of flow of such benefits to communities living in the proximities of such resources, in the form of investment in economic and social infrastructure. Therefore, decentralization of forest resource management to local levels with a built-in mechanism on benefit sharing between the regulator and the communities has the potential to improve welfare. The other alternative is a partnership arrangement between the commercial sector and local communities in managing and harnessing forest resources in areas close to these communities. The Mozambican current land law and the forest and wild life management policy, provide a legal basis for putting such arrangements into practice.

The experience is that centrally regulated regimes in Mozambique have not been effective in redressing deforestation, land degradation and conservation. Although the government has the obligation to support society-wide interests, in natural resource conservation and use, experience shows that the policies adopted and instruments used for their implementation have been ineffective. The fact that the social and economic benefits implied by the regulation are not felt at community level, gives an incentive for non compliance which in turn is facilitated by lack of institutional and financial capacity for enforcement (Mlay et al., 2003).

Mlay et al. (2003) found that the cooperative management regime is the second best management option in terms of private benefits and total benefits for the two sectors in the Mozambican provinces of Dondo, Nhamatanda and Gondola-Manica. In this research, the cooperative option is ranked as the fourth option (and therefore less attractive) due to inclusion of

the transaction costs in the analysis.

In the implementation of the cooperative management option (also known in Mozambique as community based natural resource management), the principal aim is biodiversity conservation. The involvement of the community is viewed as strategic to minimise the problem of natural resource degradation, given that the classic and centralised system of natural resource management in Mozambique has shown itself inefficient in promoting and guaranteeing sustainability. The approach works by involving other stakeholders, in particular rural communities.

The results of this research indicate that the levels of deforestation are greater under open access regimes. The factors that have contributed to high rates of deforestation and land degradation in the study areas are incomplete property rights, poor agricultural practices, weak institutional capacity to enforce existing legislation on use of forest resources and policy failure in internalising the externalities arising from exploitation of forest resources. Kaimowitz and Angelsen (1998) got similar results, using analytical models.

The cooperative management regime, taking into account the transaction costs, shows that both the local communities and the commercial sectors can benefit from this arrangement. Although the commercial sector will have to forgone some direct benefits in favour of the household sector, the cost-saving which results from a reduction in conflicts between the two sectors can induce this cooperation in management and utilisation of the woodland resources. The stakeholder benefits found in this study are inferior to the benefits found by Mlay et al. (2003). This can be explained by inclusion of transaction costs, diameter class segregation and population dynamics over the cutting cycle, into this model. In the case of Mozambique, where the forest and wildlife law (GOM, 1999) permits communities to enter into partnership with the private sector in its exploration of natural resources, the results show that such cooperation is potentially beneficial to local communities if properly implemented.

POLICY SCENARIOS

Sectorial policies in the form of commercial sales and prices of NTFPs manifest their impact on the woodland resource mainly through the household sector activities in the form of an increase in household benefits from harvesting wood and non-wood products. The amount of wood products harvested has decreased slightly.

Policy changes in the household or commercial sector are likely to affect the state of affairs in other sectors. While the general direction of policy or institutional change can be predicted, the actual impact will reflect the initial conditions specific to a given site. In addition, the results show that there is no management regime capable of satisfying all goals of the stakeholders, meaning that some trade-off between goals is necessary. This means that a clear definition of priorities is necessary.

In the study site, the deforestation levels are not affected by the increase by 100% on the off-miombo employment. This could be explained by the fact that the percentage of people benefiting from such increased availability of off-miombo employment is very small and the area is relatively rich in forest resources compared with the Savane study area (see Falcão, 2005).

The policy analysis done in this research represents a small contribution to the overall objective of the Mozambican government expressed in the PARPA (Action Plan for the Reduction of Absolute Poverty, 2001 - 2005) and by NEPAD (New Partnership for Africa Development), which states a clear intention to reduce poverty.

The results of this research show that the forest resources in Mozambique cannot be managed under only one management alternative. The choice of the management option depends on site-specific conditions (human population, demand for products, distance from the market, production costs, selling prices, infrastructure, political environment, resource availability, climate, education level of the people, soil fertility). For each alternative, there is a stakeholder trade-off in the use of miombo resources for current economic gains versus conservation of the resource biodiversity.

Not all policy instruments available to understand the behaviour of stakeholders in the study sites were used. Policy instruments such as economic recession, increase in stumpage fees, forest and agricultural price dynamics, risk in agricultural and forestry production, HIV aids could be used.

CONCLUDING REMARKS

Improvements in the well being of rural communities and resource conservation can be achieved with sound forest management practices. There is no management regime capable of fully satisfying all the goals of the stakeholders simultaneously.

The cooperative management regime or Community Based Natural Resource Management (CBNRM) whereby household and commercial sectors cooperate in management and utilisation of woodland resources is a better management regime to advocate.

Sectorial policies targeting NTFPs can lead to an increase in per capita benefits of the household sector by 1 to 5%. Sectorial policies targeting charcoal production efficiency can lead to an increase in per capita benefits of the household sector by 3 to 176%. If these policies are applied in an isolated manner, they will not be enough to take household income above the poverty line of one US$ per capita per day.

The impact of a greater availability of off-miombo employment has shown a reduction in pressure on forests. A ombination of these two policy instruments under *ceteris paribus* condition can improve the well-being of the rural communities by 10 to 25%, but this is not enough to lift the households income above the poverty line of one US$ per capita per day.

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