

Reconciling household goals in southern African woodlands using weighted goal programming

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SUMMARY

Weighted goal programming (WGP) is employed to reconcile the goals of food security, improved incomes and woodland conservation in households from selected sites in Malawi, Mozambique and Zimbabwe. The three goals are attainable simultaneously, albeit with trade-offs useful in guiding development of rural development policies. The WGP model provides a framework for evaluating impact, on the household goals and woodland condition, of some macroeconomic and sectoral policies and demographic changes.

Keywords: goal programming, woodlands, households, simulation, southern Africa.

INTRODUCTION

The aim of this paper is to demonstrate that economic development goals in Southern Africa that seek to increase rural incomes, food security and environmental stability can be reconciled in the context of a set of activities and constraints on land, labour, food production, access to forest and other resources. Households from selected study sites in Malawi, Mozambique, Tanzania and Zimbabwe (CIFOR 2002, 2002) ranked food security as the most important goal, followed by increased incomes. Environment or biodiversity conservation was considered important but inferior as a goal when compared with the other two goals. The study whose results are reported in this paper sought to simultaneously harmonise the achievement of these three goals by rural households that depend on the vast woodlands found in Southern Africa.

The study arose out of the observed increased dependence of rural communities on forest and woodland resources for their livelihood (Monela *et al.* 2000, Campbell *et al.* 2000, Chipeta and Kowero 2004). This is partly due to failure by agriculture to meet many needs of rural households, especially income and food. With declines in cash and export crops in many countries due to various reasons including drought, civil unrests, low market prices and high cost of crop inputs, forest and woodland resources are gradually becoming important sources of rural household incomes that help attain food security, finance health and education. This is in addition to their traditional roles as suppliers of fuelwood, construction material (timber and thatch grass), wild foods,

and environmental services like regulation of climate and water supplies. Further, forests and woodlands are critically important to crop and livestock production and sustaining wildlife.

Many countries in Sub-Saharan Africa are implementing economic reforms to revamp their ailing economies. The specifications of social and environmental impacts resulting from the reforms as well as knowledge on the interplay between policies and ecological systems remain largely unclear (NFP 2001). However, the reforms continue to induce responses by economic agents that have impact on patterns of production and consumption, and on the natural resource base. The inter-relationships between macro-economic policies, agriculture and natural forest resources with people are complex. Exogenous factors, mainly of institutional and political nature, impact on households and in consequence affect the forest condition. These interactions and their complexity make it necessary to study these inter-relationships because of their significance to the whole development process.

This paper contributes to this effort by employing goal programming to reconcile household goals of food security, improved incomes and sustainability of forest resources, in an integrated land use context, in study sites in Malawi, Mozambique and Zimbabwe. This was done by taking into consideration the diversity in household activities and income portfolio associated with the achievement of these goals within the environment created by the economic reforms and other policies implemented in the three countries.

BRIEF OVERVIEW ON MULTIPLE CRITERIA DECISION MAKING IN FORESTRY

Multiple Criteria Decision Models (MCDM) are increasingly been employed in planning given their ability to reconcile multiple goals of decision makers. These multi-objective approaches assign adequate roles for both the analyst and the decision maker (Cohon 1978). The analyst generates alternatives and objective trade-offs between the alternatives. This helps the decision maker evaluate the relative significance of those alternatives and finally selects the most appropriate course of action.

A good annotated bibliography on MCDM in forestry and natural resources management is provided by de Steiguer *et al.* (2003). They disaggregate MCDM into Multi-Objective Decision Models (MODM) and Multi-Attribute Decision Models (MADM).. The MODM are concerned mainly with mathematical optimization approaches that include decision making techniques such as linear, goal and integer programming. Also included are dynamic programming models like those used in hierarchical planning as well as heuristic methods. Applications of MCDM to forestry are many and de Steiguer *et al.* (2003) lists 124 cases. These include:

- decision methods for forest management by Buongiorno and Giles (2003),
- forestry problems in linear, integer, goal and dynamic programming, network analysis and simulation by Niewenhius (1989),
- linear and goal programming approaches to reconcile economic returns and tree diversity by Buongiorno *et al.* (1995),
- regional land use planning using goal programming in Mozambique by Nphantumbo, Dent and Kowero (2001),
- strategic and tactical planning in forestry using a multilevel model by Cea and Alejandro (2000),
- integrating timber harvesting and wildlife habitat goals using a binary integer programming model by Snyder and ReVelle (1997), and
- heuristic techniques that reconcile spatial constraints in harvest scheduling by Weinttaub *et al.* (1995).

MADM are more recent methods that are increasingly becoming popular in quantifying and evaluating public preferences and are reportedly used fairly extensively in the military and medical fields. The MADM support the 'best' decision that arises from using analytical hierarchy process and multi-attribute utility theory. Applications in forestry and land management include those by Hajkowicz, *et al.* (2000), Lahdelma *et al.* (2000) and Martin *et al.* (2000).

Goal programming is one of the MCDM based on the geometric definition of 'best'. It is regarded as a model

that operationalizes the Simonian approach of 'satisfaction' of the decision maker's objectives (Rehman and Romero 1993 quoting Simon 1955, 1957). Goal programming has two variants: Lexicographic Goal Programming (LGP) and Weighted Goal Programming (WGP). LGP is based on pre-emptive ordering of goals and priorities by the decision maker, while WGP is based on a simultaneous consideration of goals and minimisation of the sum of relative weighted undesired deviations from pre-set targets.

A criticism of the limited application of goal programming is the large amount of data required from the decision maker (including objectives, targets, weights and priorities) for estimation of the technical coefficients of the decision variables. This is a particularly important limitation in developing countries where planning in subsistence farming is made difficult due to a lack of data and/or poor record keeping of farm performance and poor co-ordination between agricultural and forestry extension services. These combine to reduce information accuracy, sufficiency and reliability. However, Rehman and Romero (1993) defend the application of goal programming stating that sensitivity analysis can be used to generate information, and in this way reduce the amount of data needed from the decision maker.

METHODOLOGY

Brief description of study sites

In Mozambique the study sites were located in the districts of Dondo, Nhamatanda, and Gondola-Manica in the central provinces of Manica and Sofala. These districts are rich in miombo woodlands¹ that support rural communities and adjacent towns with industrial timber and non-industrial forest products. The rural households had, on the average, six members and were largely involved in subsistence agriculture. Some households were also engaged in livestock rearing and sale of forest products, mainly charcoal.

In Malawi the study was conducted on households bordering three forest reserves namely, Chimaliro, Dzalanyama and Mdeka. The household size averaged five people in the three sites. Like in Mozambique they were largely involved in subsistence agriculture, livestock rearing and trade in firewood and charcoal from the forests.

In Zimbabwe the study sites were in Chivi and Gokwe districts. Gokwe district has better agricultural potential and forest cover. Chivi district receives less rainfall and is therefore a poor area agro-ecologically. The communities in Gokwe border the Mafungautsi State Forest, while those in Chivi rely on the rapidly disappearing woodlands in the district. In both sites the household size was, on the average, seven people. Like in the other two countries, the households were engaged in agriculture and livestock husbandry and less on sale of forest products. Unlike in the other two countries

¹ Miombo woodland is the type of African woodland which is dominated by the legume family Caesalpiniaceae with the most important tree species being those of *Brachystegia*, either alone or with *Julbernardia*, and *Isobertlinia* (Celandier 1983, Lind & Morrison 1974 and White 1983).

there was no sale of charcoal, and households relied more on animal draught power for farm production and transport. We therefore categorized the households into two: those with animal draught power and those without animal draught power.

In all the three countries maize is the staple food. Other crops included beans, sorghum, groundnuts, cassava, sweet potatoes and rice, though not all were cultivated in all sites. Animal products were beef and milk in all sites. Household cropland (in hectares) varied greatly as follows: Dzalanyama (1.44), Mdeka (0.55), Chimaliro (1.25), all in Malawi, Dondo (2.0), Nhamatanda (2.6) and Gondola-Manica (3.5), all in Mozambique, Chivi (2.31 for draught animal owners and 1.92 for non-draught animal owners) and Gokwe (5.11 for draught

animal owners and 3.6 for non-draught animal owners), both in Zimbabwe.

The goal programming modeling approach

The model employed is built following a generalized weighted goal programming methodology developed by Ntantumbo and Kowero (2001) for woodlands in southern Africa and also in Ntantumbo, Mlay and Kowero (2003). In this paper, WGP was chosen so that the goals of the different stakeholders could be considered jointly, thus avoiding giving preference to one goal to the disadvantage of the others. This section briefly outlines the main features of the model. Table 1 presents the general structure of the model.

TABLE1 General planning matrix for the weighted goal programming model

	Agricultural activities					Forestry activities.		Labour			Sign	RHS	
	P	S	B	C	S	P	S	M	F	Ch			
Objective	Minimize positive and negative deviations from the weighted goals												
Land	d											≥	X ha
Labour	d							s	s	s		≤	0
Crop production	s	d	s	D	d							≤	0
Forestry						s	d	d	d	d		≤	0
Consumption	s							d	d	d		≤	0
....													
Food security goal	Normalized supply						Normalized demand				=	100	
Income goal	Normalized supply and demand											=	100

P=production, S=selling, B=buying, C=consumption, M=men, F=women, Ch= children, d=demand, s=supply, RHS=Right hand side

The goals

The typical household in each of the research sites was modeled in terms of major activities performed to meet daily needs. The activities require labour, land and woodland resources, which were identified as the main constraining factors. The household primary goals were found to be self-sufficiency in food (food security) and financial income to meet basic needs such as food, health, and education. The local communities were also found to be aware of the environmental values. However, environmental aspects were found to be largely treated as secondary to food security and income in that order of priority. The objective of the WGP was to minimize the sum of deviations, both positive (P) and negative (N) from the target levels that were set for the income and food security goals.

The household food security goal

According to University of Minnesota (2002), the average minimum daily kilo calorie requirements are 2944 for a man,

2180 for a woman and 2048 for a child. These levels were taken as the minimum daily energy goals for the family. The family should therefore have sufficient food to provide this energy. The food security goal for the typical household therefore seeks to minimize the negative deviations from these minimum amounts of energy required for an active and healthy life for all household members.

The income goal

It was observed that most households in the research sites derived their incomes from a variety of sources. The major ones included the selling of crops, labour, and forest products. The latter includes charcoal, firewood, poles and non-timber forest products (e.g. mushroom and fruits). The objective of the household is therefore to maximize the income realized from these sources. This maximum income is the household's target income, and was determined by running the household model as a simple linear programming model.

The environment protection goal

The attainment of this goal was difficult to assess in the study sites due to lack of information on changes in tree cover or rates of deforestation. In this paper we use the amount of firewood and charcoal as a proxy on the 'disturbance' to the woodlands. These two major products are extracted annually and used for household consumption and for sale. We therefore constrained harvesting of woodland products to the woodland growing stock. In other words we considered an annual allowable cut that is at most equal to the annual growing stock. A better measure of the extent of environmental degradation would have been the rate of woodland depletion or deforestation or change in forest cover.

Activities and constraints

The household activities revolve around farming, collection and selling of forest products, rearing of livestock, off-farm employment, and household chores. With respect to farming and livestock husbandry, the activities were related to production, consumption, selling, buying (to supplement deficits), and storing food from one season to the other. These are decision variables that households have therefore to decide on how much of their labour to allocate.

The main constraints included land for the different crops and cropping systems. The yield for each crop was reconciled with the decision variables for selling and buying. Crop production (in kilograms) was linked to the energy and protein supply by each of the crop types and the total household demand for the same. The dietary mix, as defined by household eating habits, was included in the model so that not only the more nutritious products could be consumed but also the habits defined by the culture and level of well-being could also be reflected in the model. Labor demand for each activity was limited by the maximum labour in the household and capacity to hire any additional labour. The constraints were based on a simple principle: the demand for the resource should not exceed its supply. Table 1 presents the general planning matrix employed.

RESULTS AND DISCUSSION

The WGP model was used to answer a number of questions on the likely effects on the rural communities and the woodlands of changes in the socio-economic environment in these countries. This was done through sensitivity analyses that created scenarios on the potential impacts on rural communities and the natural forest resources of macroeconomic and sectoral policies, technological change in agriculture, prices of agricultural inputs, availability of labour and royalties/fees on forest products. Therefore the yardstick for analysis of the effectiveness of government policy would in this case be poverty reduction through improvement of household incomes, food security and sustainable supply of forest products. Literature, questionnaire interviews, reconnaissance surveys and participatory rural appraisal (PRA) demonstrated that these were relevant issues to the study areas.

Highlights from base line results

The baseline results form the basis for undertaking sensitivity analyses or policy experiments on the influence of the above factors on the livelihoods of the rural communities and the forests they depend on.

Zimbabwe

The results indicated that with the exception of non-draught owners in Gokwe, all other households could potentially achieve fully their food security and income goals and harvest woodland products sustainably, that is the harvest would not exceed the regeneration of the woodland stock. The non-draught owning households would harvest woodlands unsustainably. However, forcing them to harvest woodland products in a sustainable manner could result into more than proportionate loss in achievement of income goals. When non-draught owning households in Gokwe were required to harvest the woodlands sustainably the result was a 32% reduction in harvested area, from 0.71 to 0.40 hectares. This translated into a 61% reduction in household income relative to that in the baseline results.

The results indicated higher levels of woodland use in Gokwe compared to the woodland poor Chivi. For example, draught owning households in Gokwe harvest 0.25 hectares compared to 0.22 hectares harvested by those in Chivi. Also non-draught owning households in Gokwe harvest 0.71 hectares as compared to 0.20 hectares harvested by households in Chivi. Further, the results confirm that draught owning households tend to crop more land compared to non-draught owning households in both sites.

The results appear to support the view that natural resource degradation tends to increase in areas with abundant resources.

Mozambique

While the income goal is achieved in both Dondo and Gondola-Manica, it is slightly underachieved in Nhamatanda. The food security goal is overachieved in all the three sites, which could imply that the households first seek to satisfy their minimum food requirements. However, field observations revealed that this is not always the case since some households preferred to sell their produce for cash or due to lack of good storage facilities, during the harvest (dry) season and purchase food in the wet season. This probably explains the occasional seasonal food shortages experienced in the study sites.

In order to attain these goals households in Dondo would harvest forest products from twice the area of woodlands that their colleagues in Nhamatanda would harvest, and thrice the area households in Gondola-Manica would harvest. The result of such extensive harvests would be the production, in Dondo, of twice the amount of charcoal that would be produced in Nhamatanda and four times that which could be produced in Gondola-Manica. This implies that households in Dondo could become more forest dependent as compared to those in the other two sites. This makes sense due to the fact that cropland is scarcer in Dondo relative to the other two

sites and charcoal production for sale is mainly practiced in Dondo.

Malawi

The results indicated that the food security and income goals were fully achieved. The environmental goal was modeled as the amount of firewood for household consumption. This goal was not achieved in all the three sites, implying that the woodlands would be depleted if they cannot fully satisfy household firewood requirements, if consumption continues at present levels.

Potential impact of changes in technology

Technological changes in agriculture vary. For example, improved seed and efficiency in using other inputs like labour and pesticides could increase crop yields. Also improved crop storage could reduce post harvest losses. The three study countries are mainly agricultural and have, as a strategy, the improvement of both crop production and productivity. This is reflected in the individual country economic development blue print, the Poverty Reduction Strategy Paper (PRSP) (Government of Malawi 2002), the Agricultural Sector Investment Program (PROAGRI) for Mozambique, and the Malawi Agricultural Sector Investment Programme (MASIP) (Government of Malawi 1999).

In this study we simulated improvements in crop yields and their likely effects on the three goals. Generally, changes in crop productivity have been observed to have an indeterminate direction of impact on forest condition. For example, Kaimowitz and Anglesen (1998), Katila (1995) and Angelsen, Shitindi, and Aarrestad (1999) report that crop yield improvements tend to lower crop prices. This would reduce agricultural profitability and therefore promote harvesting of forests in order to maintain or increase household incomes. On the other hand Deininger and Minten (1996) and Panayoutou and Sungsuwan (1994) report that increase in crop yield triggered a reduction in deforestation. Studies by Barbier and Burgess (1996) and Chakraborty (1994) indicated insignificant effects of crop yield changes on deforestation.

Mozambique

In Mozambique, improvements in crop yields simulated at 25% and 50% would produce insignificant impact on

attainment of the three goals in all study sites. The reason for this would appear to be an internal land reallocation that would maintain the base solution. When crop yields were increased by 50% cropland area declined while woodland area cleared increased. For example, in Dondo cropland declined slightly, respectively from 2.0 to 1.9 and 1.59 hectares with the simulated 25% and 50% crop productivity increases.

However, with a modest crop yield decrease of 25%, the impact was significant. The income goal would not be attainable. For example, in Nhamatanda the negative deviation from the goal will be 37%.

The overall implication of the results from these three study sites is that a fairly high increase in crop yields might not appreciably reduce deforestation in areas that are predominantly under subsistence farming and with low crop yields, poor and small local markets, and relatively better prices for forest products,

Zimbabwe

In Zimbabwe, a 25% increase in crop yield was simulated. In the two sites, the food security and income goals were attained. With the exception of non-draught owning households in Gokwe, crop yield increases would reduce cropland area. However, in the woodland scarce Chivi site, draught owning households would allocate more labour to harvesting woodland products while in the woodland rich Gokwe site there would be no change in labour allocation. The non-draught owning households in Chivi would reduce labour for harvesting woodlands while those in Gokwe would allocate more labour to the activity. All these changes would take place if the constraint on woodland conservation were removed (i.e. if we allow an open access situation to the woodlands). However, if we constrain access to the woodlands as a conservation measure, increasing crop yields would result into less labour allocated to harvesting woodlands in the two sites for both the draught and non-draught owning households.

The overall impression is that in the Zimbabwean situation we have an indeterminacy situation on the direction of changes on the woodland condition resulting from improving crop yields.

Malawi

In Malawi, with a simulated increase in crop yield of 25% the cropland area would increase as demonstrated in Table 2.

TABLE 2 Potential impact of a 25% yield increase and decrease (in brackets) on maize and tobacco

Site	Base solution (ha)	Maize area (ha)	% change	Base solution (ha)	Tobacco area (ha)	% change
Dzalanyama	0.91	0.96 (0.84)	5.3 (-7.7)	0.27	0.29 (0.23)	7.4 (-14.8)
Chimaliro	0.76	0.84 (0.65)	10.5 (-14.5)	0.2	0.25 (0.18)	25.0 (-10.0)
Mdeka	0.35	0.42 (0.27)	20.0 (-22.9)	0.09	0.13 (0.04)	44.4 (-55.6)

It would appear that the response to crop yield improvement by households in Mdeka will be very modest in absolute changes in cropland area, even when such improvement is simulated at 75% as in Table 4. However, the response to an equivalent yield decline is generally higher in all sites, in terms

of cropland area reduction, with the decline being higher for the woodland scarce Mdeka site. The compensation for loss in crop income will be made through increased firewood sales as shown in Table 3.

TABLE 3 Potential impact of 25% decrease in yield on firewood sales

	Base solution (m ³ / household)	Sales in dry season (m ³ / household)	% change	Base solution (m ³ / household)	Sales in wet season (m ³ / household)	% change
Dzalanyama	0	1.2	-	0.18	0.52	188.9
Chimaliro	0	1.43	-	1.2	1.8	50.0
Mdeka	0.8	1.1	37.5	0.8	1.4	75.0

The reason for the observed changes in Table 2 is that a yield increase of 25% would stimulate Mdeka households to put all land under crops. However, for households in Dzalanyama and Chimaliro even with a 75% improvement in crop yield

(Table 4) there will still be cropland that is not farmed. In all sites households would not reduce the area under food crops, but expand the area under cash crop (tobacco) since this would increase their incomes.

TABLE 4 Potential impact of a 75% yield increase on maize and tobacco

Site	Base solution (ha)	Maize area (ha)	% change	Base solution (ha)	Tobacco area (ha)	% change
Dzalanyama	0.91	0.98	7.7	0.27	0.31	14.8
Chimaliro	0.76	0.87	14.5	0.2	0.28	40.0
Mdeka	0.35	0.44	25.7	0.09	0.14	55.6

Most probably households in Mdeka would encroach on the woodlands for additional cropland if this were possible in order to take advantage of improvements in crop yields. Households in Dzalanyama and Chimaliro would probably not do the same because they do not appear to have exhausted

their arable land, they are therefore not a threat to the woodlands. The results tend to support this observation. For example, a 75% crop yield improvement would result in a decline in firewood extracted from the forests in both dry and wet seasons as illustrated in Table 5.

TABLE 5 Potential impact of 75% increase in yield on firewood harvested

Site	Base solution (m ³ / household)	Dry season harvest (m ³ / household)	% change	Base solution (m ³ / household)	Wet season harvest (m ³ / household)	% change
Dzalanyama	4.39	3.95	-10.0	3.29	3.04	-7.6
Chimaliro	5.48	4.45	-18.8	3.62	3.14	-13.3
Mdeka	2.8	1.95	-30.4	3.72	3.15	-15.3

As expected the decline is much higher for the woodland scarce Mdeka site as compared to the relatively woodland rich Chimaliro and Dzalanyama. The declines in woodland harvests are higher in the dry season, as expected, because in the wet season fuelwood is used for heating, in addition to cooking.

Overall, in woodland rich sites like Dzalanyama a substantial improvement in crop yield in an environment of

low output crop prices is likely to have a very moderate effect on relieving pressure on the woodlands (Table 5) because the additional benefits to households from crop sales would be small and only trigger modest changes in fuelwood collection. The opposite is the case for the Mdeka woodland scarce site that will most probably relocate labour from fuelwood collection and put it to under all its cropland, most probably to increase incomes from crop sales.

Potential impacts due to increase in input prices

Fertilizers are the main crop inputs, in addition to seeds and pesticides. Reardon and Barrett (2001) report that in order to counter high fertilizer prices farmers tend to invest in organic fertilizers in commercial agriculture. This was, for example, observed in Burkina Faso where farmers are reported to use 13 times more manure on cotton and maize as compared to the subsistence crops of sorghum and millet. Mwanawina and Sankayan (1996) report that increasing crop input prices increased cropland area in Zambia, and probably increased pressure for additional cropland from the woodlands. However, Coxhead and Chivey (1995) report that in the Philippines an increase in crop input prices reduced deforestation. An increase in crop input price appears to have indeterminate effects on condition of forests and woodlands, in that increasing the prices of inputs is likely to lead to two opposing effects. Kaimowitz and Angelsen (1998) make a similar observation.

This phenomenon was explored in the study sites in Malawi and Zimbabwe where use of inorganic fertilizer was reported.

Zimbabwe

An increase in input prices by 25% would not affect the achievement of the income and food security goals for the draught owning households in Gokwe and Chivi. In Chivi the goals would be achieved by changing the crop mix towards higher value crops like ground nuts and cutting down on maize, and without encroaching on the woodlands and reducing total cropland area. However, in the woodland abundant Gokwe site the households would achieve these goals by harvesting more woodland products.

For the non-draught owning households in Chivi the food security goal will be slightly underachieved by 1.5% by harvesting more woodlands and putting more arable land under cash crops. In Gokwe the underachievement will be at 14%, because the insignificant fuelwood market in Gokwe exposes the non-draught owning households to fewer livelihood support options.

Overall, the direction of impact on the woodlands given rises in crop input prices would appear to be largely indeterminate in the Zimbabwean study sites.

Malawi

There was a less than a 25% contraction in cropland when input prices were simulated to increase by 25%. The contraction was more pronounced for tobacco (a cash crop), while there was no change in the cultivation of subsistence crops like maize, groundnuts and beans. Households appear to reduce purchased inputs for tobacco and concentrate on their subsistence crops, a feature of the risk-averse behaviour of smallholder farmers. However, when crop input prices were reduced by 25% there was an increase in the production of all crops, and especially tobacco.

In both instances firewood harvesting levels remained the

same, implying that modest input price changes in Malawi might not affect the woodlands as would be the case in Zimbabwe.

Overall the direction of impact on the woodlands given rises in crop input prices would appear to be largely indeterminate in the Zimbabwean and Malawian study sites.

Potential impacts of changes in prices of and royalty fees for woodland products

One of the measures advocated for reducing deforestation is to discourage harvesting of forest products through high royalties or fees. On the other hand, when the demand for forest products increases the product prices will rise and probably increase deforestation. The study examined the likely implications on the three goals under these two conditions, viz. changes in royalty/fees and increase in product prices. Since trade in the two products examined, firewood and charcoal, is more pronounced in Malawi and Mozambique, Zimbabwe was left out from this analysis.

Potential impact of increasing fees/royalties on woodland products in Mozambique.

The results from the forest rich Dondo site, are used to demonstrate the potential impact of a gradual increase in royalty/fees charged on firewood and charcoal (Table 6). The households do not pay anything at present for harvesting such products, only commercial entities pay.

TABLE 6 *Potential impact of increasing forest fees on the household goals in Dondo*

	*N ₁	P ₁	*N ₂	P ₂
FEES CHARGED FOR COMMERCIAL HARVESTING (CH)	0	10.6	5.2	0
INCREASE 10% ON CH	0	10.6	5.8	0
INCREASE 50% ON CH	0	10.6	5.9	0
INCREASE 100% ON CH	0	10.6	11	0

*1 and 2 denote food security and income goals respectively.

It was also observed that despite the increase in fees the households will continue to harvest the same quantities for own use, and no changes were made to cropping patterns and cropland area. Perhaps this is first due to the very low fees charged on wood for charcoal making (US\$0.192/m³) and secondly due to the very few livelihood support options in the study site. Price sensitivity would appear to be more pronounced when fees are increased by more than 50%, implying that fairly high increases in royalty/fees on woodland products might have very moderate negative effects on household incomes and none on food security. This was

also true of the other two sites, Nhamatanda and Gondola-Manica. However, a 100% increase of royalties will double the penalty on the income goal for Dondo households.

Potential impact of changes in price of firewood in Malawi

In Malawi there is a very pronounced trade in firewood and charcoal. It was observed that harvesting firewood increased gradually with increase in firewood prices. Though the firewood quantities were very low per household they declined progressively from Dzalanyama (woodland rich area) to Mdeka, a woodland scarce site. However, the

responses to increases in firewood prices started to manifest when prices were increased by more than 50%. This implies that the demand for firewood was not very price elastic.

Further, increasing firewood sales prices by over 50% has potential to marginally reduce cropland area as households relocate labour from crops to the more lucrative firewood business. And this impact will be more pronounced on the cash crop, tobacco, and in the land scarce Mdeka that relies more on firewood sales for livelihood support (Table7). However, changes to individual household cropland area were insignificant.

TABLE 7 Potential impact on cropland of a 50% increase in firewood price

Site	Base (ha)	Groundnuts & maize area (ha)	% change	Base (ha)	Tobacco area (ha)	% change
Dzalanyama	0.91	0.9	-1.1	0.27	0.26	-3.7
Chimaliro	0.76	0.76	0.0	0.2	0.19	-5.0
Mdeka	0.35	0.32	-8.6	0.09	0.06	-33.3

When the price of firewood was simulated to decrease by 50% there was minimal change in crop production.

Overall, unless firewood sales prices change significantly there would be minimal changes in the quantities harvested from the woodlands (and possibly minimal effect on deforestation) for sale. Unless there are very significant changes in firewood prices cropping patterns will remain the same and the pressure on the woodlands will continue.

Potential impacts due to changes in labour supply.

Availability of household labour in southern Africa is partly constrained by diseases such as malaria and those related to HIV/AIDS pandemic. Guveya and Sukume (2003), citing UNAIDS (2001), report that in some parts of Zimbabwe agricultural output of small farmers could have declined by as much as 50% because of AIDS. By constraining availability of household labour these diseases reduce rural incomes and increase food insecurity. The household loses productive labour when caring for the sick, someone is sick or dies, and in attending funerals. The households reduce their net incomes through medication of the sick, funeral costs, forgone agricultural production and services not sold. Livestock and other assets are also sold to pay for medication and funerals (FAO 2003, UNDP, FAO 2002).

One could therefore hypothesize that given the potential for labour shortages households would develop coping strategies. Simulations were made on households that lost some of its members or had part of the family member’s labour unavailable due to these diseases.

Malawi

It appeared that the loss of an adult male or female member of the household would not affect the quantity of firewood the household consumes. This is probably due to the ability of

children to collect all household firewood, a role primarily for adult females. Further, the same amount of firewood would be used for cooking in homesteads if one or two members of the household were missing.

However, when an adult male is missing from the household, more firewood would be harvested for sale. This is probably to compensate for loss of income that would result from decline in cash crop production, specifically tobacco, that is male dominated. This would be more pronounced in the wet season with firewood sales potentially increasing by 50%, 17% and 13% in Mdeka, Dzalanyama and Chimaliro respectively. Also households would increase production and sale of food crops.

It was also observed that making available only 30% of adult female labour would create a modest reduction in firewood harvested for domestic consumption. However, a reduction in firewood collection for sale would begin if the adult male labour were to fall below 70% of its current capacity. Firewood for sale is mainly collected by adult males.

Further, when the household had no adults, the solution would be infeasible, indicating the total collapse of household activities as defined in the model. This is the situation facing rural orphans that have no close relatives to support them.

It would therefore appear that loss of one adult member of the family, or reducing the availability of adult labour due to these diseases would not to reduce pressure on the woodlands of Malawi, in some cases the pressure might increase.

TABLE 8 Achievement of goals in Dondo given changes in adult labour supply

	N ₁	P ₁	N ₂	P ₂
No adult male	10	0	91	0
No adult female	10	0	185	0

Zimbabwe

In Zimbabwe, the loss of a child in a Chivi draught owning household was observed not to impair the attainment of both food security and income goals and would not affect the area of woodlands harvested and area under cash and food crops. The food security goal would be underachieved by 74% while that of income would not be attained at all if there is no adult female labour in the Chivi non-draught owning households.

The household would reduce cropland area, stop growing cash crops and devote remaining labour to food crops. However, labour devoted to harvesting woodlands would not change appreciably.

For non-draught owning households in Gokwe, the loss of child labour would result into the underachievement of food security goal by about 15% and the income goal by 10% (Table 9).

TABLE 9 Potential impact of loss of household member in Gokwe

		Draft owners (loss of a man)	Non-draft owners (loss of a child)
		Change	Change
Food security goal	N1	0	15.41
Income goal	P1	0	0.02
	N2	0	9.93
	P2	0	0.00
Area of woodlands harvested (ha)		0.15	-0.38
Area under food crops (ha)		2.63	-0.14
Area under cash crops (ha)		-0.77	0.08
Total cropped land (ha)		1.86	-0.07

For the Gokwe non-draught owning households the loss of a child would result into underachievement of both the food security (by 15%) and income (by 10%) goals. Cropland area would decline slightly as well as harvesting of woodlands. However, the loss of an adult male appears not to jeopardize the attainment of the two goals. There would however be reductions in the area under cash crops, more area put under food crops (with the result that total cropland area increases), and more woodland harvested for sale.

Generally, the direction of change in household activities due to these diseases appears to be indeterminate. However, it would appear that the total absence of any household member in the household, has potential to adversely affect both income and food security by mainly to disrupting agricultural productivity. It could also increase harvesting woodland products for sale since this would remain an important income source in this predicament.

MAIN OBSERVATIONS AND CONCLUSIONS

The results presented in this paper highlight the potential use of WGP at the household level to generate trade-offs among competing rural development goals to inform policy decisions. Three key goals were considered: food security, income and environmental protection. WGP has demonstrated, within the limits inherent in goal programming modelling, how these goals can be attained simultaneously and in ways that harmonise biodiversity conservation with rural community livelihood strategies.

The key highlights from the study are:

1. In all the three case study countries, the results show the trade-offs that exist among the three goals. Specifically, attainment of one or two objectives is at the expense of attaining the other. For example, the Zimbabwe case demonstrates that sustainable harvest of woodlands would translate into a reduction in household income.
2. The results appear to support the view that natural resource degradation tends to increase in areas with abundant resources.
3. The model also demonstrates its ability to simulate the impact of changes in availability of labour on the three goals. This is relevant given the high mortality rates resulting from HIV/AIDS related illnesses, malaria and other diseases. The results indicate that if many poor rural households fail to hire labour when they lose their adult labour the achievement of the income and food security goals would be seriously impaired and this could increase pressure on the woodlands.

Key highlights related to changes in macroeconomic and other sectoral policies include:

4. Technological improvements in agriculture that increase crop productivity might not appreciably reduce deforestation in areas that are predominantly under subsistence farming and with low crop yields, poor and small local markets, and relatively better prices for forest products.

5. Changes in inorganic fertilizer prices appear to produce indeterminate effects on woodland condition in both Malawi and Zimbabwe. In the case of Malawi, farmers' response is much in line with their risk-averse behavior, since they reduce the area under the input intensive (inorganic fertilizer) cash crop and concentrate on the food crops, most of which use little or no fertilizer.
6. Unless firewood sales prices change significantly (i.e., by more than 50%), there would be minimal changes in the quantities harvested from the woodlands and cropping patterns will remain the same. Households will not have a big enough incentive to relocate labour from crops to harvesting woodlands, and especially so when the crop prices are relatively better than those of woodland products.
7. Modest increases in royalty fees appear not to affect the quantities of products households harvest from the woodlands for own use. Royalty fee sensitivity would appear to be more pronounced when fees are increased by more than 50%, implying that significant increases in royalty fees on woodland products might produce very moderate negative effects on household incomes and probably none on food security.
8. The results on effect of changes in input price (specifically inorganic fertilizers), crop productivity and crop sale prices are largely in agreement with observations made in other countries.

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