Agricultural Subsidies and Forest Pressure in Malawi's *Miombo* Woodlands

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Abstract

We examine the impact of an agricultural subsidy program on forest pressure in Malawi. Malawi's Starter Pack Scheme (SPS) aimed to promote agricultural intensification by providing smallholder farm households with free packets of hybrid maize seed and fertilizer (a "starter pack"). Using household survey data collected in southern Malawi, we explore the impact of the program on forest clearing and forest product marketing. Results show households receiving a starter pack had lower levels of commercial forest extraction than non-recipient households. Findings also reveal that starter pack recipients cleared slightly less forest during the survey year. In tandem, the study findings suggest potential modest improvement in forest condition due to the SPS.

Categories: (1) Renewable Resources: Forestry
(2) Poverty and Environmental Degradation

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INTRODUCTION

In Malawi human pressure on forest resources is severe. Although more than one million hectares of the country's total land area of 9.4 million hectares have been set aside in protected areas, these areas remain under threat because Malawi's rural population continues to rely on forest lands for agricultural expansion and resource expropriation (Orr *et al*. 1998). Understandably, with almost two-thirds of its population living in poverty (Poverty Monitoring System 2000), boosting agricultural production is a high priority in the country. As opportunities for land-extensive agricultural growth fade, increased agricultural productivity is needed, made possible with new crop varieties accompanied by increased use of labor and other inputs.

Agricultural intensification has been viewed by many policy makers as a potential forest-saving alternative to extensive forms of agriculture such as shifting cultivation. However, the degree to which agricultural intensification can help to alleviate tropical forest decline remains unclear (Angelsen & Kaimowitz 2001). New agricultural technologies typically render agriculture more profitable, and can thereby increase incentives to clear forests. But market conditions, institutional factors, and technology characteristics also influence outcomes (van Soest *et al.* 2002). In some settings agricultural intensification has been found to decrease forest pressure (Godoy *et al.* 1997; Shively 2001), and in others to increase it (Foster *et al.* 1997).

Agricultural intensification also can impact forests indirectly, in ways other than by changing land uses. In tropical countries, many farm households earn income from selling forest products (Cavendish 2000; Godoy *et al.* 2002), often because farm production is insufficient to provide food self-sufficiency year round (Byron & Arnold 1999). In these settings, agricultural intensification, by making farming more profitable, should increase households' incentives to work on farm and, subsequently, reduce labor allocation to forest product commercialization.

This paper examines how subsidy-supported agricultural intensification has influenced Malawian smallholders' decisions to clear forest and market forest products. The Starter Pack Scheme (SPS) entitled all of Malawi's smallholder households to receive an agricultural assistance package consisting of free seed and fertilizer (a "starter pack"). Previous evaluation studies suggest the program improved national- and household-level food security (Levy *et al.* 2000; Longley *et al.* 1999). We evaluate the SPS from a conservation perspective, asking whether improved access to modern inputs encouraged or discouraged sustainable forest use patterns. Although the SPS was not intended as a forest conservation program, other agricultural intensification programs in Malawi are proposed for such a purpose. Evidence on the forest impacts of the SPS provides useful lessons for conservation-development efforts in Malawi and elsewhere.

STUDY AREA

Background on Malawi's forests

Malawi's forests are dominated by closed, deciduous woodland known colloquially as *miombo*. These woodlands are the most common vegetation type in central, southern, and eastern Africa (Campbell *et al.* 1996). They provide wildlife habitat and a wide range of products and services essential to the well-being of rural people (Cavendish 2000; Dewees 1994; Fisher 2004). Across sub-Saharan Africa the interplay of forest dependence, rapid population growth, poverty, and weak forest management has resulted in highly degraded forest landscapes. In Malawi, for example, over 95 percent of existing woodland cover has been heavily modified by intensive use (Dewees 1994). According to the FAO's 2005 Global

Forest Resources Assessment, Malawi has the fifth highest deforestation rate in the world and lost 14.9 percent of its primary forests during the period 2000-2005.

The key threat to Malawi's forests is clearing for agricultural expansion (GOM 1998a). With limited possibilities to intensify production, farmers often have little option but to clear forest to grow maize and other crops to feed their families. And in many communities, forests are held under state or communal tenure with resources essentially freely available to local populations, due to government failure to enforce property rights or weakened traditional systems of resource regulation (GOM 1998a; Place & Otsuka 1997).[1] Forest conversion is associated with soil erosion, reduced availability of wood, and loss of habitat for plant and animal species (GOM 1998b). Most land-based species, especially large mammal species, have been seriously affected by habitat loss and human activity (Glavovic 2002). In some parts of the country, the impact of forest degradation on wildlife populations has been so severe as to precipitate trans-location of forest species in an attempt to protect remaining populations (Munthali & Mkanda 2002).

Another key factor in the decline of Malawi's forests is intensive wood extraction. About 90 percent of the country's total energy needs is provided by biomass (GOM 1998a). Moreover, the productivity of *miombo* woodlands is generally low. At current levels of demand, wood harvest rates far exceed sustainable yield. Malawi's Forestry Department estimates that the deficit for woodfuels rose from 1.6 to 4.9 million cubic meters between 1983 and 1990 (GOM 1998b). In addition to over-harvesting, destructive harvesting techniques have been reported—trees being felled for firewood and collectors destroying coppices from stumps and saplings, which are required for natural regeneration (Knacck Consultants 1999). More worrisome is charcoal burning, which often involves clear-felling of indigenous trees on customary land.

Recent agricultural developments and the Starter Pack Scheme

Food security in Malawi depends on production of the staple crop – maize. As opportunities for land-extensive agricultural growth fade, use of improved maize technologies has become essential to produce enough maize to feed Malawi's people. In the early 1990s it appeared Malawi would experience a "delayed Green Revolution" as evidenced by increased use of hybrid maize seed and chemical fertilizer among smallholder farmers (Smale 1995; Heisey & Mwangi 1997). Key to diffusion was credit distribution to maize growers at subsidized interest rates, subsidized input prices, and producer price supports for maize (Zeller *et al.* 1999). But these policies contributed to large budget deficits. In response, Malawi implemented agricultural marketing reforms: liberalization of input and output marketing by government parastatals, elimination of input subsidies, currency devaluation, a rescinding of the ban on smallholder burley tobacco production, and liberalization of all agricultural output prices.

An unintended consequence of reforms and other concurrent events, was the creation of incentives for farmers to expand maize cultivation, rather than intensify production. Fertilizer and maize seed prices increased substantially in the 1990s, owing mainly to a series of devaluations. The price of maize also rose so that input-output price ratios were lower in the late 1990s compared with the early 1990s (Agricultural Development Marketing Corporation, personal communication 1998). This relative-price change should have favored increased use of modern inputs. However, for the majority of Malawi's smallholders that are net buyers of maize, higher maize prices translate into an income decrease (Peters 1996) and less cash available for farm input purchases (Blackie *et al.* 1998). At the same time, credit access was reduced with the collapse of the national credit system after massive loan default.

Since the mid 1990s there has been a large decline in smallholder use of chemical fertilizer and hybrid maize seed. This presents a serious problem in Malawi, where infertile soils and degraded seed stocks result in low crop yields in the absence of improved inputs (Whiteside & Carr 1997). By the mid 1990s Malawi faced a food security crisis with a food deficit of several hundred thousand tons a year (Ministry of Agriculture, personal communication 1998).

In this context the Malawi government implemented the Starter Pack Scheme (SPS) during the 1998/99 and 1999/2000 agricultural years. All of Malawi's 2.8 million smallholder households were entitled to receive a starter pack containing hybrid maize seed and chemical fertilizer to plant about 0.1 hectare. The SPS was aimed at promoting food security, increasing maize productivity, and improving soil fertility. SPS evaluations indicate that the net contribution of starter packs at the household level was an estimated 175 kilograms of maize in 1998/99 and 70-120 kilograms of maize in 1999/2000 (Levy & Barahona 2002). Nationally, maize production increased from 1.5 million tons in 1997/98 to 2.1 and 2.2 million tons in 1998/99 and 1999/2000. Recent harvests were good, in part because of favorable weather, but also due to the SPS. Maize surpluses led to a fall in the maize price, resulting in further improvements in food security because of the high share of farm households that are net buyers of maize (Levy & Barahona 2002).

In sum, evidence points to positive short-term impacts of the SPS on national and household food security. Longer-term benefits are possible if the program, by introducing many farmers to modern inputs, stimulated future demand for these inputs (Mann 1998). Below we evaluate the SPS from a conservation standpoint, asking if improved access to seed-fertilizer technology changed smallholders' incentives to exploit forests.

DATA AND METHODS

Data for the study come from a household survey completed in three villages in southern Malawi between June 1999 and August 2000. Research villages were selected to represent the main forest management types in Malawi and provide a spectrum of market access. Village 1 is 10 kilometers from a tarmac road and town and adjacent to the Mulanje Mountain Forest Reserve (MMFR) managed by the Forestry Department. Households in this village have access to relatively abundant forest resources, ranging from *miombo* woodland at the base of Mulanje Mountain to pine and eucalyptus plantations to afro-montane forest near the mountain's summit. Markets for non-timber forest products (NTFPs) and timber are relatively well-developed near Village 1.

In Village 2, *miombo* woodland on customary land is managed as a Village Forest Area (VFA) by the village head and a committee of village leaders. The VFA system, in which communities set aside woodland areas for conservation purposes, was initiated in the 1920s and rekindled recently by the Forestry Department (Place & Otsuka 1997). Located 20 kilometers from a tarmac road and town, Village 2 is remote, but is close to Mozambique (5 kilometers), where agricultural and forest goods can be purchased at prices below those in Malawi.

The little remaining *miombo* woodland on customary land in Village 3 is *de facto* open access due to the breakdown of traditional authority in recent years. A substantial portion of communal woodland has been cleared for agriculture and charcoal burning. Most charcoal sold in Malawi's major cities is produced by local people in surrounding rural areas (Makungwa 1997). Village 3, adjacent to a tarmac road linking it to Blantyre (Malawi's largest city) 40 kilometers away, is well-positioned for charcoal marketing. The entire sample consists of data from 99 randomly-selected farm households, representing 12 percent of the total population in the three villages.

Village differences in forest use are illustrated in Table 1. Although forests are a key potential source of farm land, forest clearing was common only in Village 3. Inter-village differences may reflect existing forest management institutions. The few remaining trees on common land in Village 3 are, in principle, controlled by the village head who is to be consulted when individuals seek to fell trees to open up gardens or to burn charcoal. In practice however, communal land appeared to be treated as open access, largely because the head in Village 3 was viewed by villagers as somewhat weak and ineffectual. By contrast, enforcement of rules prohibiting forest clearing in Villages 1 and 2 seemed relatively effective.

An index was calculated for the quantity of scarce forest resources (wood and bamboo) extracted by sample households for commercial purposes. Mean values are provided in Table 1. There are several plausible explanations for observed differences across villages. First, during the survey year the Village 2 headman appeared more successful at reducing forest access compared with the Forestry Department in Village 1 and the head in Village 3. Second, Village 2 has neither accessible timber, nor access to urban charcoal markets. Finally, only Village 3 households engaged in charcoal burning; this activity is the most degrading of forest resources in the study area (Table 1).

Our statistical analysis involves estimating equations for forest clearing and forest resource extraction. We employ Tobit models because many households in the sample did not clear forest and some did not market forest products. The Tobit technique accounts for censoring in the dependent variables. The regression equations are:

$$Q_F = \beta_0 + \beta_1 Q_{F0} + \beta_2 I + \beta_3 p + \beta_4 H + \beta_5 \theta + \varepsilon \qquad (1)$$

$$\Delta A = \alpha_0 + \alpha_1 I + \alpha_2 p + \alpha_3 H + \alpha_4 \theta + \nu \qquad (2)$$

where Q_F is quantity of wood extracted for commercialization per resident in the agricultural period (when starter packs were received and used) and ΔA is forest area cleared per household resident during the survey year. Our analysis focuses on commercial forest activities rather than subsistence forest use, because the former tend to be more degrading than the latter and are easier to track.

Explanatory variables are defined as follows. In the forest extraction regression, Q_{F0} is the quantity of wood extracted for forest product marketing in the non-agricultural period (prior to starter pack receipt). Binary variable I indicates Village 3 residence, a proxy for absence of forest management institutions, and p is the relative return to labor in forest occupations (compared with maize production).[2] Vector $\boldsymbol{H}$ includes variables that reflect household characteristics (age and education of the household head, share of men among household members, and farm size per household resident). Variable θ denotes the household-specific monetary value of starter pack receipt; it is equal to the value of the starter pack inputs divided by number of household residents for starter pack recipients, and is zero for non-recipients. The estimated market value of starter pack inputs was 450 Malawi Kwacha in 1999/2000 (Levy *et al.* 2000). Table 2 provides descriptive statistics for the explanatory variables.

RESULTS

Statistical results are presented in Table 3. In both regressions we find that several point estimates are individually different from zero at a 90% confidence level. To begin, results from the forest extraction regression suggest a positive association between levels of resource extraction across periods. That is, households have some motivation in the current period to use forests in a manner similar to the previous period, possibly a reflection of physical capital that is specific to forest activities (e.g. forest tools) as well as human capital invested in the forest sector (e.g. charcoal burning expertise).

We control for village effects by including a binary variable for Village 3 residence. Village 3 households accounted for nearly all of the reported forest clearing and the majority of forest resource extraction of the entire sample (Table 1), therefore it is crucial to control for residence in this village. As expected, forest clearing is found to be positively associated with Village 3 residence, all else equal. The Village 3 binary is positive but statistically weak in the forest extraction equation.

Findings indicate that households with higher returns to labor in forest occupations relative to maize production cleared more forest per household resident. This may indicate that forest clearing decisions are driven mainly by potential profits from charcoal marketing, farm land being a joint product of the charcoal burning process.

To assess the extent to which forest use changes over the life cycle of the household head, we include in the model binary variables for householder age. We find little statistical support for a hypothesis that age influences decisions to clear forest or extract forest resources. Consistent with other studies in the tropical deforestation literature, we find that education reduces rates of forest resource extraction (Heltberg *et al.* 2000). Households with a head having some formal education extracted fewer forest resources compared with households with a household head who never attended school.

Adult male labor is crucial for participation in the more degrading forest occupations (charcoal burning and timber extraction), and land clearing is generally a male-specific task in the study area. For this reason we include in the regressions a variable for the proportion of adult males in the household. Findings indicate a positive correlation between forest clearing and adult male household members.

A priori, one might expect farm size per household resident to provide a good indication of a household’s agricultural capacity and degree of food security (Peters 1996). Households with relatively small landholdings per capita should have both the need and the capacity to engage in forest product sale or forest clearing. Parameter estimates for farm size are positive in sign for both models, but the coefficients are not statistically significant at standard test levels.

Turning to our policy variable, we find that, holding other things constant, households that received a starter pack had lower forest resource extraction than households that did not receive a pack. The marginal effect of the starter pack variable computed at the sample mean is –0.679 kilograms per person. Using this information in conjunction with the average value of the starter pack among recipients (126 Malawi Kwacha) and average household size (4.9 people), we determine that starter pack recipient households extracted 420 kilograms less of forest resources compared with households that did not receive a starter pack. This amount of wood is equivalent to about three months of firewood to cook a rural Malawian family's meals.

Results also show a negative correlation between value of the starter pack and forest clearing. Again the marginal effect can be used with information on the average value of the starter pack for recipient households and the average household size to assess the effect on forest clearing of starter pack receipt. Households that did not receive a starter pack cleared an additional 0.03 hectares of forest compared with starter pack recipients. Taken together, these findings suggest the SPS may have had modest favorable consequences for the condition of Malawi's forests. Our results parallel in reverse other research from Africa showing deforestation increased when chemical fertilizer became more costly or scarce (Lee *et al.* 2001).

DISCUSSION

In this section we discuss why starter pack receipt was associated with lower levels of both forest clearing and commercial forest extraction among sample households. We use the conceptual framework provided in Figure 1, which highlights a highly stylized view of the economic forces operating on labor allocation. The net effects of the SPS on forest clearing are analyzed by focusing in turn on substitution, income, and price effects on labor allocation.

Consider first the substitution pathway marked (a) in Figure 1. By providing free inputs to a farm household, farming was made more attractive in the short term. Because the starter pack included fertilizer, labor requirements for a given area of land should have increased to some extent. For a few of farmers that could afford to hire laborers, it is possible that the SPS increased maize production *via* an expansion of cultivated area. But for the majority of smallholders who were seasonally constrained in household labor and lacked resources to hire laborers, use of a starter pack would have necessitated that they reduce the amount of labor allocated to forest clearing, i.e. substitute activities away from forest clearing. We therefore mark the effect of the SPS *via* pathway (a) negative (< 0).

Turning to the income effect on forest clearing, pathway (b), households receiving a starter pack achieved improved food security and higher income. Economic theory posits that as household income rises, the demand for leisure will also rise. But, the influence of income change on household labor allocation is sensitive to several factors including income level (Ashenfelter & Heckman 1974). Most Malawi smallholders have annual incomes that are insufficient to secure their family's basic needs. For this reason starter pack recipients most likely continued to devote labor to productive activities rather than increasing their leisure time. Moreover, the rise in income could have improved work capacity somewhat, possibly leading to an increase in forest clearing. We thus expect that labor allocated to forest clearing due to a starter pack-induced income gain was either unchanged or increased somewhat. We mark pathway (b) as nonnegative (≥ 0).

Finally, the SPS precipitated a change in the implicit price, or value, of forest clearing, which we designate pathway (c) in Figure 1. The logic is as follows. The SPS boosted national production of maize. The large maize harvest in 1998/99, attributed in part to the SPS, depressed maize prices. This price reduction, in turn, reduced incentives to clear forest for farmland in the following production year, 1999/2000. We thus mark pathway (c) as negative (< 0).

Considering paths (a), (b) and (c) together, a possible explanation for our statistical finding of a negative association between starter pack receipt and forest clearing is that negative price and substitution effects outweighed a positive income effect. In sum, it is conceivable that the SPS drew smallholders away from forest clearing activities *via* two key mechanisms. First, cultivation of a starter pack plot very likely necessitated some reduction in the amount of time a family devoted to other activities, including forest clearing. Second, widespread use of the starter pack inputs in the year prior to our survey resulted in a relatively abundant maize harvest which subsequently depressed maize prices. The lower maize prices in turn reduced incentives to clear forest for farmland during the study year.

In the case of forest product commercialization, the substitution effect, designated by pathway (d) in Figure 1, should have been negative. Households receiving a starter pack would have had incentives to allocate more labor to farming and less to other activities such as forest product marketing. In other words, they would have substituted labor away from forest product sale, as the return to labor used in agriculture became higher. As for the income effect, indicated by pathway (e), we expect a nonnegative relationship for the same reasons outlined above for the case of forest clearing. For instance, a rise in income induced by starter pack receipt could have been used, in part, to finance forest enterprises through purchase of forest tools.

The combined effects of (d) and (e) are ambiguous. Our statistical evidence suggests households that received a starter pack had lower levels of forest extraction than did non-recipients. On balance, therefore, it would appear that in the case of forest product extraction, the substitution effect (d) dominated the income effect. In short, when labor became relatively more valuable in farming, households reallocated their effort away from forest degrading activities. This contention is supported by views expressed in conversations with respondents during the survey year. A common sentiment was that given alternative means to earn income, households would reduce their reliance on forests as a source of income.

CONCLUSION

In this paper we examined the environmental impact of Malawi's Starter Pack Scheme (SPS), a free-inputs program aimed at promoting agricultural intensification. Increasingly, agricultural intensification interventions have dual purposes of agricultural development and environmental conservation. Yet theory and evidence of agriculture-environment tradeoffs from low-income areas underscore the challenges to the effective design of these programs and the need for careful research and observation prior to implementation (Lee *et al.* 2001).

Household survey data from southern Malawi were used to evaluate the SPS from the standpoint of forest conservation, asking whether improved access to modern inputs changed incentives for households to exploit forests and, if so, whether this led to an increase or a decrease in forest pressure. Our study focused on two distinct sources of forest degradation: forest clearing for agricultural expansion and forest product extraction for commercialization. Results show that households that received a starter pack had lower levels of forest extraction than households that did not receive a starter pack, all else equal. We also find that receipt of a starter pack was associated with slightly lower levels of forest clearing during the survey year. In tandem, findings suggest that the SPS may have had a small but beneficial impact on forests. Our research results are consistent with a few other studies which show that in certain situations agricultural intensification can reduce forest pressure (Godoy *et al.* 1997; Shively 2001). Alongside evaluation reports that document positive impacts of the SPS on agricultural output and food security (Levy *et al.* 2000; Longley *et al.* 1999), the results of the current study indicate possible agriculture-environment complementarities in Malawi.

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Table 1 Mean values for selected forest use indicators, sample households 1999/2000

Activity	Village 1	Village 2	Village 3	All Villages
Main cooking fuel is wood (%)	100	18	100	69
Purchased wood (%)	18	63	36	39
Cleared forest (%)	3	0	50	12
Area cleared (ha) [a]	0.30	----	0.26	0.26
Quantity of wood extracted for commercial purposes (kg)	1,092	200	11,009	2,953
Drink and food (kg) [b]	136	9	41	66
Bricks and crafts (kg) [c]	40	89	0	50
Firewood and bamboo (kg)	41	102	1,105	301
Timber (kg) [d]	875	0	0	345
Charcoal (kg) [e]	0	0	9,862	2,192
Planted trees in past 5 yrs (%)	31	71	64	54
Number of trees planted	10	9	19	12

a. Mean values are for those households that cleared forest during the survey year.
b. Includes items that use wood as a key input: *masese* traditional beer, *kachasu* dry spirit, *chikondamoyo* maize cakes, etc.
c. Forest-based crafts found at the study sites are: bamboo baskets and mats, grass brooms, wood-fired clay pots, wood crafts.
d. Includes timber sales, and employment as pit sawyers and plank transporters (manual transport from pit sawing sites to the roadside).
e. Includes sales of own-produced charcoal as well as charcoal resale.

Table 2 Descriptive statistics of explanatory variables

Variable	Mean or Frequency	Standard Deviation
Previous period commercial forest extraction (kg/person)	324.40	1,146.60
Village 3 residence	0.22	0.42
Ratio forest returns (MK/kg) to maize returns (MK/ha) [a, b]	0.45	0.54
Household head aged less than 35 years [c]	0.24	0.43
Household head aged 35 – 44 years	0.13	0.34
Share of men in household (number men/household size)	0.17	0.20
Household head had some schooling	0.64	0.48
Farm size (ha/person)	0.33	0.32
Value of starter pack (MK/person) [d]	85.63	98.13

a. Includes imputed values for missing observations for forest and maize returns. Details of the imputation procedure are available upon request.
b. Malawi's currency is the Malawi Kwacha (MK). During the survey year, the exchange rate was about 50 MK = US$1.
c. In the dataset, age is a categorical variable because many respondents were not aware of their age. We estimated age with reference to a list of historical events.
d. Reported mean and standard deviation are for the full sample. Corresponding figures for starter pack recipients only are 126.52 and 95.11.

Table 3 Tobit results for the forest clearing and forest extraction equations

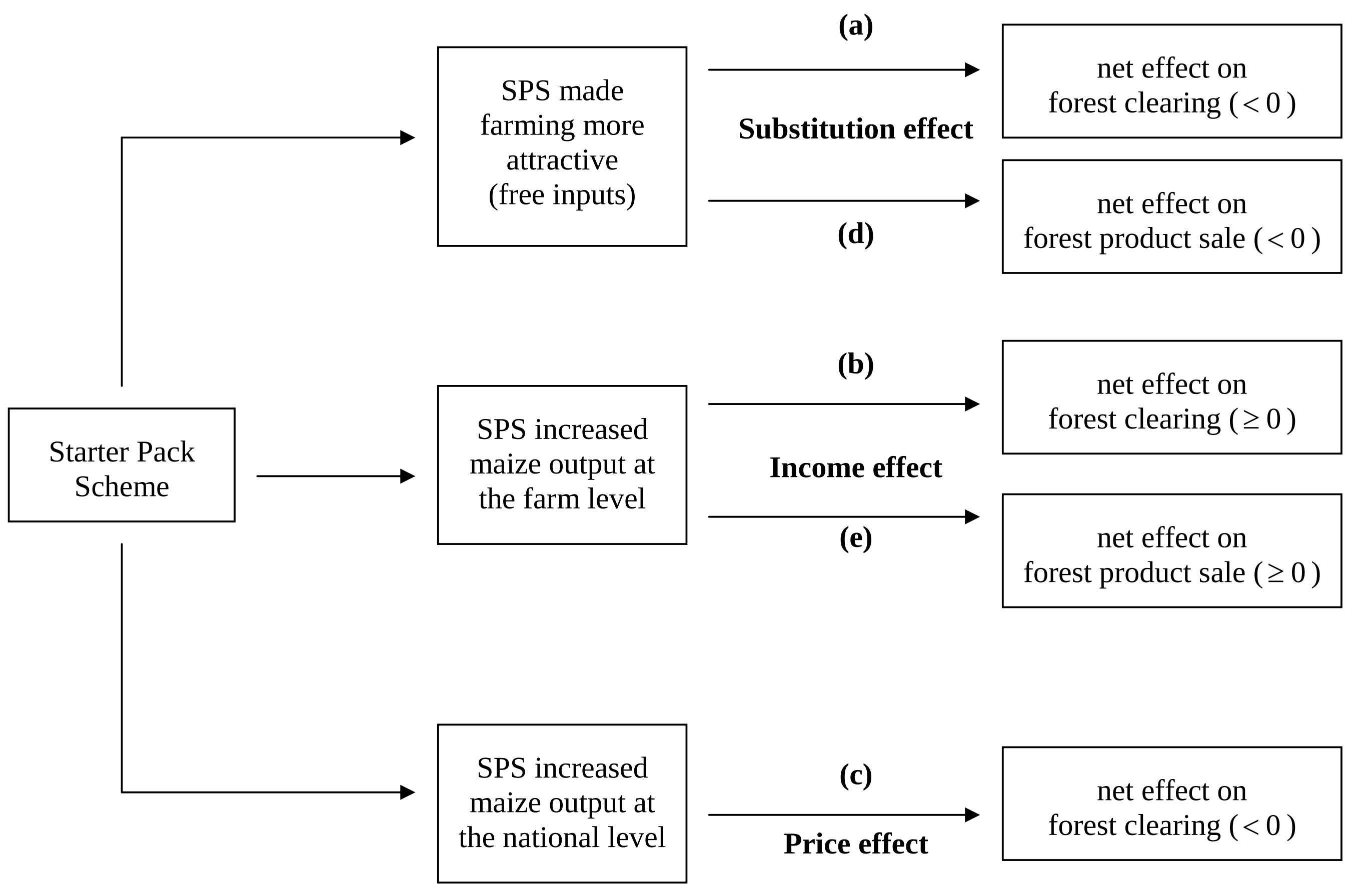
Variable	Forest extraction (kg/person)			Forest clearing (ha/person)		
	Coefficient	Robust Stand. Error [a]	Marginal Effect	Coefficient	Robust Stand. Error [a]	Marginal Effect
Constant	-12.966	99.011		-0.189*	0.048	
Previous period forest extraction	0.785*	0.128	0.291			
Village 3 residence	116.471	124.851	45.098	0.172*	0.033	0.029
Ratio forest returns to maize returns	147.801	162.057	54.781	0.033*	0.019	0.003
Household head aged less than 35 years	-18.409	127.017	-6.780	0.024	0.038	0.003
Household head aged 35 – 44 years	104.852	220.120	40.932	0.044	0.049	0.005
Share of men in household	39.030	259.677	14.466	0.164*	0.081	0.016
Household head had some schooling	-293.046*	117.087	-115.102	-0.058	0.039	-0.006
Farm size	23.900	183.795	8.858	0.090	0.061	0.009
Value of starter pack	-1.831*	0.969	-0.679	-0.0005*	0.0003	-0.00004
Number of observations			99			99
Wald statistic (7) [b]			66.66			60.89

* indicates significance at the 90% confidence level.

a. Standard errors reported in the table use the Huber/White heteroskedasticity-consistent estimator of variance.

b. Wald test for joint significance of all explanatory variables, distributed as a χ^2 with a critical value of 14.07 for 7 degrees of freedom at 0.05 probability.

Figure 1 Substitution, income, and price effects of the SPS on forest clearing and forest product marketing



NOTES

[1] Forest resources are not freely available simply because they are held under communal tenure. In many societies, forests have been sustainably managed by long-standing, community-based management systems in which norms and rules define community members rights to use specific forest resources (Fortmann & Bruce 1988). Such systems can, however, be transformed into *de facto* open access in the face of market, population, and modernization pressures (Blaikie & Brookfield 1987).

[2] The price of maize is observed only in households that sold maize and hourly returns to forest occupations are observed only in households engaging in these activities. We impute missing prices and net hourly returns with sub-sample ordinary least squares (OLS). Details are available upon request.