Tropical and Subtropical Agroecosystems

MODELING LOW-INCOME FARM HOUSEHOLDS FOR ESTIMATING THE EFFICIENCY OF POLICY INSTRUMENTS ON SUSTAINABLE LAND USE IN HAITI: THE CASE FORÊT DES PINS RESERVE

[MODELANDO LAS EXPLOTACIONES AGRICOLAS DE BAJOS-INGRESOS PARA ESTIMAR LA EFICIENCIA DE LOS INSTRUMENTOS DE POLITICA PARA LA UTILIZACION SOSTENIBLE DE LA TIERRA EN HAITI: EL CASO DE LA FORÊT DES PINS RESERVE]

Frito Dolisca[1*], Josh M. McDaniel[1], Lawrence D. Teeter[1]

[1] *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849*
e-mail: fdolisca@hotmail.com
** Corresponding author*

SUMMARY

Deforestation of Forêt des Pins Reserve has been a growing concern to foresters, environmentalists, and local populations in Haiti. A number of approaches, essentially based on "participatory" and "command and control" policies, have been unsuccessfully undertaken to persuade farm households to adopt conservation measures. Negative impacts on the welfare of farmers limit the efficiency of these approaches for forest conservation. This paper investigates alternative solutions to the problem of deforestation of Forêt des Pins Reserve using linear programming models. More specifically, this study evaluates the role of various policy instruments on *low-income farm households*' welfare and forest conservation in Haiti. Data from 243 farmers inside the Reserve are used in the empirical analysis. Results suggest that subsidies tied to environmental benefits seem to be promising for sustainable resource use for *low-income farm households* in Forêt des Pins Reserve.

Keywords: Farm households, deforestation; agricultural subsidies; forest conservation; linear programming.

RESUMEN

La deforestación de la reserve Forêt des Pins es un asunto de creciente preocupación para extranjeros, medioambientalistas y la población local de Haití. Se han probado numerosos enfoques, esencialmente aquellas basadas en políticas "participativas" y de "dirección y control" para convencer a la población local de adoptar medidas de conservación. El impacto negativo en el bienestar de los productores ha limitado la eficiencia de estos enfoques para la conservación del bosque. Este trabajo investiga alternativas de solución al problema de la deforestación de la reserva Forêt des Pins usando modelos de programación lineal. Específicamente este estudio evalua el papel de la aplicación de varias políticas para el bienestar de los productores de bajos ingresos y la conservación del bosque en Haití. Se analizó la información proveniente de 243 productores de la reserva. Los resultados sugieren que los subsidios ligados a los beneficios ambientales parecen ser un recurso promisorio para el uso sostenido de los recursos por productores de bajos ingresos de la reserva haitiana de Forêt des Pins Reserve.

Palabras clave: Deforestación, subsidios agrícolas, conservación forestal, programación lineal.

INTRODUCTION

Agriculture is a key factor in the economic development of Haiti; approximately 70 percent of all Haitians depend on the agricultural sector, which consists mainly of small-scale subsistence farming, and employs about two-thirds of the economically active work force (Haiti-Guide 2003). Cropping activities account for 93 % of current agricultural land use, while pastures occupy less than 5% of available land. Agriculture contributes 23 percent of the gross domestic product (GDP), and accounts for 24 percent of exports in 1998 (International Monetary Funds [IFM] 1998 cited in Bayard 2000). In spite of its fundamental role, the performance of the sector has remained largely behind the satisfactory level.

During the past decades, Haiti has experienced a series of changes in its social, physical, and economic environment. Population increases (2.1 percent per year), and urbanization growth rates have increased the demand for food and fuelwood (Center for International Health Information [CIHI] 1999). Average rainfall has declined one percent per year, growing seasons have become shorter, arable land per capita has fallen, fallows have been shortened and abandoned, and pressure on natural resources has increased (Centre de Formation et d'Encadrement Technique [CFET] 1997).

Population growth and rising food demand led to considerable forest clearing in many parts of Haiti, largely to plant food crops (maize (*Zea mays ssp.*), beans (*Phaseolus vulgaris L*), cassava (*Manihot esculenta*)**,** potatoes (*Solanum tuberosum*), and cabbage (*Brassica oleracea*)) and to establish plantations of crops such as cotton (*Gossypium hirsutum*), sisal (*Agave sisalana*), and sugar (*Saccharum spp.*) (Dolisca 2005). Illegal commercial logging also facilitated the conversion of forests to agriculture, particularly where land use for agriculture conferred property rights over it (Faustin 2003).

Furthermore, the high proportion of subsistence consumption coupled with inadequate credit facilities does not leave the rural farmer with an adequate cash flow to finance the adoption of technological advances (White 1994). The peasants, in need of a product that they could exchange for manufactured goods, have resorted to charcoal and lumber milling; two commodities for which there is ample demand. This *means of exchange* became even more important in the 1970s and 1980s when the Creole pigs were exterminated following the outbreak of the African swine fever epidemic. Also, the disappearance of the indigenous pigs that enhanced the value of the surplus fruit provoked disturbing changes in the Haitian agricultural system: accelerated deforestation and drastic reduction of peasant saving capacity (Dolisca 2001).

Concern over environmental sustainability of agricultural activities has led many governments to attempt to encourage forest conservation in Haiti. Some governments have adopted laws and regulations to prevent farmers from undertaking degrading activities or to force them to adopt conservation practices. However, such measures are not without costs. Regulation options rely on administrative measures which often exceed government's financial and technical resources, and even then are also questionable policies when evaluated in terms of cost-benefit analyses (Palmer et al. 1995). Other measures have concentrated on "negative incentives" such as fines to coerce farmers into compliance with best management practices. Again, Haitian governments and farm households cannot effectively guarantee the use of such tools since enforcement of regulatory mechanisms is often costly and inadequate.

Policy reforms proposed to resolve the problem of regulation in managed forests include measures focusing on improving tenure security and participatory approaches. Although these policy instruments may provide greater justification for observing sustainable management practices, they do not provide positive economic incentives for adopting more costly practices nor do they provide a mechanism of revenue generation for farm households (Gillis 1992). Particular policy measures and institutions that permit a simultaneous improvement of agricultural productivity, alleviation of poverty, and conservation of the natural resource base, are urgently needed in Haiti due to the rapidly declining resource base.

Farm household land-use decisions are generally made based on household specific and exogenous variables taking into account their own objectives. Household specific variables include land, labor, capital, and demographic characteristics of the household. Important exogenous variables to the household include institutional arrangements, access to credit, and soil fertility. These household and exogenous factors influence decision making regarding household factor allocation, including land use and technology investments intended to enhance productivity and sustainability. The heterogeneity of conditions faced by farmers in combination with changes in the state of natural resources make it necessary to use economic models to assess whether changes in policy instruments may induce farm households towards more sustainable land use while maintaining or improving their welfare.

Overall, the purpose of this paper is to investigate alternative solutions to the problem of deforestation of Forêt des Pins Reserve using a mathematical linear programming model. More specifically, the study evaluates the role of various policy instruments on *low-income farm households*' welfare and forest conservation in Haiti. Emphasis is given to incentive agreements such as cross-compliance (subsidies tied to environmental benefits) which are expected to offer positive distributional benefits to farmers. Moreover, the role of land tax and input price policies related to the importance of the crops is also examined.

The rest of the paper is as follows: a conceptual framework; a description of the model used for the empirical analysis; results from the analysis of the impacts of different policy instruments that could enable farmers to reduce forest depletion while improving farm income; and finally conclusions.

CONCEPTUAL FRAMEWORK

This investigation is based on the production function. Theoretically, for any given set of inputs, the maximum output that can be produced is determined by a production function. A farmer may have several options for increasing his resource base. Some of these options involve different technologies, defined in the sense that the assumed input-output relations of the production function for the crop or animal are different for each method. Such choices might involve different crop varieties and animal breeds, or fertilization of crops. Other options in production relate to the amount of a variable input used per hectare or per animal, or to the combination of factors used in producing a unit of a given crop or animal product. Approaches to address the problem of natural resource degradation must deal with the core issue of how to motivate small farmers to respond positively to new policy instruments that can increase net annual income, substitute degrading activities, and reduce the rate of forest depletion in Haiti.

Approaches to forest conservation have changed in recent years. For many years, it was believed that forest depletion could be reduced by the technology for increasing efficiency of existing land uses (improved agricultural seed varieties, improved pasture, and erosion control). While technological options remain an important approach for forest conservation, they have proven difficult to implement in many settings, especially in the developing world (Rao et al. 2003). This approach failed for two main reasons. First, forest degradation is usually only a symptom of other problems (economic, social, political and legal pressures). Secondly, the solutions offered were often unattractive to the farmers and did little to solve their immediate problems of improving yields or increasing their incomes.

Traditional approaches of forest conservation and management, sometimes referred to as "command and control" regulations, are increasingly viewed as having failed in their goals of preserving biological diversity in the tropics. These types of regulations may exceed the financial means and technical expertise available to developing countries (Sharma and Rowe 1992) and are frequently not economically advantageous. Regulations require activities that tend to be costly. Furthermore, because compliance with strict environmental standards is often quite costly, there is no positive incentive to control damaging activities, although there is the negative incentive to avoid penalties. Normally there are no incentives to improve practices above what is required by regulations, and, in addition, incentives to comply with minimum standards may be too weak to overcome the disincentive of bearing the costs (Freeman 1993). A more systematic approach is needed to address the feasibility of environmental regulation as a means of promoting sustainable management of forest resources in the tropics, including appropriate cost-benefit analyses and incentive measures (Palmer et al. 1995).

With the growth in participatory approaches to sustainable development, we have seen increasing emphasis being placed on the involvement of local communities in the entire process of identifying the problems of forest degradation, developing solutions and then implementing forest conservation programs. Chambers (1994) has argued that involvement of a community is vital in making development projects effective through ensuring sustainability and building local capacities. As a complement to this work on participatory development, the literature on communities has recently focused on the social and cultural attributes of local people as assets for sustainable management (Agrawal 1997; Agrawal and Gibson 1999). Promising as this approach may be, participation by itself does not appear to be enough to overcome all the problems of forest degradation. Given the opportunity, land users may well be able to identify the underlying problems and work out possible solutions. However, the solutions may not be within their reach without financial and other forms of assistance. The solutions which are developed may not be sufficiently attractive for them to adopt dramatic social, institutional, or economic changes within their communities.

In contrast to the previous approaches, the economic incentives approach to forest conservation utilizes market-based instruments designed to modify the behavior of the generators of the externality through their effect on the prices of resource inputs used in economic activities. The economic incentives approach may use a combination of policy mechanisms. These include improving security of land tenure, providing price supports and the reduction of export taxes to major cash crops, cost sharing arrangements, subsidies tied to forest conservation (cross-compliance), rewards and prizes, and making inexpensive loans and credit available. Improving land tenure security is a key element in these approaches. When there is poor specification of property rights and tenure insecurity over important assets such as land, farmers are more likely to have short planning horizons so that long-term effects of deforestation on productivity will have less influence on land use decisions (Shiferaw and Holden 2000; 1999; Panayotou 1993). Insecure and ill defined land rights will prevent farmers from obtaining credit because they cannot use insecure land as a guarantee to acquire low interest and long-term institutional credit. As a result, households may not be able to make long-term investments in activities like ecosystem management.

The Model

This section develops a non-separable farm household model based on linear programming (LP) to investigate the role of alternative policy instruments on *low-income farm households*' welfare and forest conservation in the Forêt des Pins Reserve. The LP model has been chosen because the farm income is linear in output prices and quantities (Buongiorno and Gilless 2003). The methodology has been used successfully for many years in operations research for both agricultural and forestry production and conservation (Merry et al. 2002; Bernet et al. 2000; Shiferaw and Holden 2000; Delforce 1994; Jolayemi and Oloami 1995; Nicholson et al. 1994; Howard 1993; Bezuneh et al. 1988**;** Ahn et al. 1981), and in the empirical estimation of deforestation at the household and firm level (Kaimowitz and Angelsen 1998). The LP model is an optimization model that identifies a production plan that maximizes peasant net annual income under various policy instruments.

***The model includes*:**

(1) cropping activities (production, consumption, and selling) based on two different cropping seasons;
(2) labor activities with two types (domestic i.e., supply from one's own family/household (on farm, off-farm, and leisure) and hired and/or sold labor);

(3) livestock activities (production, selling, and consumption); crop storage (a necessity for the households in order to meet the food and seed requirements for the next season); and

(4) any other non-farm activities.

The constraints included limits on:

(1) land (amount of land owned, rented or sharecropped available for each kind of use (agriculture, livestock,));

(2) labor (on-farm, off-farm, and leisure);

(3) cash (seasonal cash needs for fertilizers, pesticides, seed buying, hiring labor, and animal feed requirements); and

(4) food (amount of food for the household and workers outside the household).

The mathematical presentation of the non-separable farm household LP model can be written as follows:

Mathematical presentation and description

$$\textbf{\textit{Max}}\ Z = \sum_{j=1}^{n} - PL_j - Ps_j^i Se_j^i - Pf_j^z Fe_j^z - Pp_j^v Pe_j^v - Pl_j^k Li_j^k + Ps_j^i SCr_j^i + Pl_j^k SLi_j^k + PSFl_j$$

s.t.

$$\sum_{j=1}^{n}\left(\sum_{i=1}^{6} LaCr^i + \sum_{k=1}^{3} LaLi^k\right) \le A$$

$$\sum_{j=1}^{n}\left(\sum_{i=1}^{6} Fl^i + \sum_{k=1}^{3} Fl^k\right) + \sum_{j=1}^{n} SFl \le TFl$$

$$\sum_{j=1}^{n}\left(\sum_{i=1}^{6} PL^i + \sum_{i=1}^{6} Ps^i Se^i + \sum_{z=1}^{4} Pf^z Fe^z + \sum_{v=1}^{2} Pp^v Pe^v + \sum_{k=1}^{3} Pl^k Li_j^k - CaTrj + CaTr_{j+1}\right) \le 0$$

$$\sum_{j=1}^{n}\left(\sum_{i=1}^{6} Tm^i - \sum_{i=1}^{6} Fl^i - \sum_{k=1}^{3} Fl^k - \sum_{i=1}^{6} L^i\right) = 0$$

$$\sum_{j=1}^{n}(Q^i - Se^i) \le 0$$

$$\sum_{j=1}^{n}(Q^v - Pe^v) \le 0$$

$$\sum_{j=1}^{n}(Q^z - Fe^z) \le 0$$

$$\sum_{j=1}^{n}(-Li + SLi) \le 0$$

$$\sum_{j=1}^{n}(-PnCr_j^i + SCr_j^i + SeSt_j^i + CnCr_j^i) \leq 0$$

$$\sum_{j=1}^{n}(-CaTr_j + CaTr_{j+1}) \leq 0$$

$$Fl, L, LaCr, LaLi, Tm, SLi, Li, Se, Fe, Pe, PnCr, SCr, CnCr, SeSt, Q,$$
$$CaTr_j, CaTr_{j+1}, A, TFl \geq 0$$

where:
j is the season identifier beginning at 1,
n is the number of agricultural seasons,
i is the agricultural crop (maize, beans, French beans, onion, cabbage, and potatoes),
k is the livestock (pigs, chicken, and turkey),
z is the fertilizer (12-12-20, 16-10-20, chicken waste, and urea),
v is the pesticide (insecticide, fungicide),
Z is the objective function stated in Haitian Gourdes (1 US $ = 37.5 Haitian Gourdes),
Fl is the family labor stated in man-days,
TFl is the total family labor available,
L is the hired labor stated in man-days,
Tm is the total man-days required to produce one unit of activities,
Q is the quantity of seeds, fertilizer or pesticides required during each season,
A is the amount of land available,
Li is the livestock production (head of animal),
LaCr is the land used for crop,
LaLi is the land used for livestock,
PnCr is the production per crop,
CnCr is the quantity of crop used for consumption,
SLi is the livestock selling,
SFl is the family labor selling,
SCr is the crop selling,
Se is the quantity of seed bought,
Pe is the quantity of pesticide bought,
Fe is the quantity of fertilizer bought,
SeSt is the quantity of seed stocked for next season,
P is the labor price,
Pl is the price of livestock,
Pp is the pesticide price,
Pf is the fertilizer price,
Ps is the seed price,
$CaTr_j$ is the transfer of beginning cash first season to the end cash first season,
$CaTr_{j+1}$ is the transfer of end cash first season to the beginning cash second season,
($Se, Fe, Pe, PnCr, SCr, CnCr, SeSt, Q$ are in kg).

Source of Data

The data for this paper primarily originated from farm surveys conducted in the Forêt des Pins Reserve in summer 2000 and 2003 and from an existing long-term data base of the Centre de Formation et d'Encadrement Technique. Data related to crop yield in the research area also came from the experiments conducted on farmers' fields at Boucan Chat by the Ministry of Agriculture (2000-2001), and at Gros Cheval in 2001. Secondary sources such as: Direction Recherche Agricole (DRA) of the Ministry of Agriculture, Projet d'Assistance Technique pour la Protection des Parks et Forêts monthly reports, and review of literature were used to complement the collected data.

There is a large variation among farmers according to household composition, land holding, wealth, farm equipment, and their risk-bearing capacities. Three major farm household groups have been identified in the area using cluster analysis (Dolisca 2005). This functional classification is summarized as follows: *large-income farms* with at least 2.5 ha of land either in ownership or Haitian state tenant farming and a beginning cash of Gourdes 105,000 (US$ 2800), dependence on hired labor for farming activities and almost daily spending of their time in on and off-farm activities; *middle-income farm households* with at least 1.9 ha of land available either in ownership or Haitian state tenant farming and dependence on remittances from family members; and *low-income farm households* with scarcity of land (less than 0.80 ha) mostly in Haitian state tenant farming, and dependence on selling labor activities as additional source of income. *Low-income farm households* are the focus of this study.

The model was used to simulate the effects of some cross-compliance policy instruments for fertilizers and improved seed inputs on farm household net revenue. It was also used to simulate the effects of land tax and input price policies related to the importance that the crops have in promoting conservation. In the cross-compliance policy, subsidies were linked to conservation (i.e. the peasant is eligible for program benefits if he/she accepts to reduce by 10 percent the amount of his/her agricultural land for reforestation purposes). The willingness of farmers to participate will depend on the effectiveness of economic incentives for forest conservation programs. A policy instrument is considered to be socially efficient when the benefit-cost ratio is greater than one. The benefit cost evaluation was done for 5 years at differing discount rates; subsidized discount rates (i= 0.05, 0.1) and discount rates at the market price (i= 0.2, 0.27).

The farmer is also paid for the reforestation efforts. Under this program, in the first five years of establishment of a tree plantation, the farmer is allowed to combine stands of woody and agricultural species. Seven years after plantation establishment, the farmer is permitted to cut trees under certain stipulations to supply household demand for wood products and for Christmas tree production. An estimated 1600 *widlings* at Gourdes 5 (US$ 0.13) per *widling* is required for 1 ha of reforestation. The amount of cash required for a *low-income farm household* to simultaneously buy seeds, fertilizers, pesticides, and family needs for food and non-food items is Gourdes 17,000 (US$ 453) (Dolisca 2005).

RESULTS AND DISCUSSION

Effects of land tax on agricultural land

The model was run to evaluate the effects of a land tax on agricultural land use (Table 1). In response to the land tax, farm households adjust their land use and cropping patterns. The net annual income based on the base-run simulation of the model is Gourdes 5,552. A land tax will induce conservation by decreasing the amount of land use for agriculture. As a result, the land tax has further diminished possibilities for buying more seeds for agricultural purposes. Net annual income also decreases with the introduction of land taxation. Introduction of a land tax by 35 Gourdes resulted to a land conversion estimate of 19 percent. When the land tax was raised to 100 Gourdes, there was an increase in land conversion of 35 percent. As returns to farm household fall and threaten livelihood, the household also cuts its leisure time and increases on-farm labor supply until the seasonal constraints are binding.

Introduction of a land tax resulted in a decrease of the agricultural land use and income relative to the base-run case. A land tax seems effective in abating forest degradation by reducing the amount of agricultural land use, although the actual mechanism to implement such policies may be difficult. Decreases in net annual income may also reduce the social acceptability of this approach.

Effect of pricing policies

This scenario examines the effect of increasing the input price by 10% of a major cash crop potato (*Solanum tuberosum*) on farm household net revenue and sustainable land use (Table 1). The model predicts that the net annual income increases from Gourdes 5552 (base-run model) to Gourdes 6028 representing an increase of 8%. Potato price forces the households to switch on-farm labor to selling labor until the labor constraint is binding. The area under agronomic crops decreases by 10% compared to the area used in the base run model. Since beans (*Phaseolus vulgaris*) are not a substitute for potatoes (and due to the fall in the budget), the consumption of beans also decreases by up to 2%. The price policy also decreases in marketed supply in potatoes. The decrease in marketed surplus of potatoes may have an eventual effect of increasing potato prices. A 10% increase in input potato price seems to be efficient. An increase in net annual income may increase the social acceptability of this approach.

Effects of cross-compliance policies

The model was run to examine the impact of cross-compliance policies for fertilizers and improved seeds on farm household welfare and forest conservation (Table 2 and 3). This scenario introduces a subsidy on the costs of agricultural crops but, at the same time, reduces by 10% the amount of agricultural land through reforestation.

When reforestation activities reduce agricultural land by 10%, the net income is positive at any level of subsidy for fertilizers and improved seeds. Farm household net income increased relative to the base-run plan by 15% for a 5% fertilizer subsidy. Increasing the level of the subsidy for fertilizers to 50 and 75 percent raises net income by 49 and 58 percent, respectively.

Table 1 Incentive effects of a land tax and a 10% tax on the input price of a cash crop potato (*Solanum tuberosum*) on land use in Forêt des Pins Reserve, Haiti

	Base-Run	Land Tax (Gourdes/ha)						Input Potato Price
		35	40	45	50	75	100	(+10%)
Land conversion (ha)		0.16	0.17	0.18	0.19	0.24	0.30	0.21
Land conversion (%)		18.8	22.1	20.7	22.3	28.2	35.2	24.7
Net income (Gourdes)	5,552	5,065	4,983	4,892	4,793	4,216	3,571	6,028

The benefit-cost ratios for 50-75% fertilizer or improved seed subsidies show that, considering a 5-year cash flow schedule, the policy instrument will increase net social benefits for any social rate of discount less than or equal to 10%. At the rate of discount of $i > 0.1$, the policy instrument is unlikely to be socially profitable. Only a lowering of the social rate of discount could make the instrument a Pareto improvement. It requires 75% of the improved seed subsidy, at $i \leq 0.2$ to induce some conservation behavior. At the rate of discount $i > 0.2$, the policy instrument is socially inefficient for any level of subsidies of seeds and fertilizers. The net annual income increases progressively from Gourdes 5552 without subsidy to Gourdes 8562 with 75% seed subsidy. Since the linked seed subsidy relaxes the credit constraint, the returns to the policy instrument increase with the level of the subsidy.

Effects of a mix of improved seed and fertilizer contracts linked to conservation

Table 4 summarizes the effect of a mix of fertilizer and seed subsidies. When conservation reduces the amount of agricultural land by 10%, a 25% seed subsidy was combined with different levels of fertilizer subsidies. Although the 25% seed subsidy alone brought a positive net annual income, combining it with a fertilizer subsidy of 25%, 50%, and 75% raised the net annual income by 15%, 30%, and 40% respectively. The net annual income increased progressively from 5552 Gourdes without subsidy (Base-run model) to 7972 Gourdes with a combination of 25%-25% seed-fertilizer subsidy representing an increase of 43%. At the rate of discount $i \leq 0.2$, all combinations of seed and fertilizer subsidies are socially efficient. However, at $i > 0.2$, the mix of seed and fertilizer subsidies is socially inefficient.

Table 2. Incentive effects of fertilizer subsidies on forest conservation in Forêt des Pins Reserve, Haiti, assuming a conversion of 10 % of cropland into forest.

	Fertilizers (%)					
	5	**10**	**25**	**35**	**50**	**75**
Income	6376	6564	7162	7590	8282	8784
Present value revenues	98646	99053	100347	101274	102772	103858
Present value costs	73290	72972	71963	71240	70072	69224
Benefit/costs						
i = 0.05	1.35	1.36	1.39	1.42	1.47	1.50
i = 0.1	1.12	1.14	1.21	1.26	1.36	1.43
i = 0.2	0.95	0.94	0.97	0.99	1.03	1.06
I=0.27	0.77	0.77	0.79	0.81	0.84	0.86

$i \leq 0.1$: subsidized discount rate. $i \geq 0.2$ discount rate at the market price.

Table 3. Incentive effects of improved seed subsidies on forest conservation in Forêt des Pins Reserve, Haiti, assuming a conversion of 10 % of cropland into forest.

	Improved Seeds (%)					
	5	**10**	**25**	**35**	**50**	**75**
Net income	6328	6464	6894	7196	7672	8562
Present value revenues	98542	98836	99767	100421	101451	103378
Present value Costs	73306	73012	72081	71427	70397	68470
Benefit/costs						
i = 0.05	1.34	1.35	1.38	1.41	1.44	1.51
i = 0.1	1.12	1.13	1.18	1.22	1.27	1.40
i = 0.2	0.93	0.94	0.96	0.97	1.00	1.04
i=0.27	0.76	0.77	0.78	0.79	0.81	0.85

$i \leq 0.1$: subsidized discount rate. $i \geq 0.2$ discount rate at the market price.

Table 4 Incentive effects of a mix of improved seed and fertilizer agreements linked to a conversion of 10 percent of cropland to forest at Forêt des Pins Reserve, Haiti.

	Improved seed and fertilizer subsidies (%)		
	25-25	**25-50**	**25-75**
Net income	7972	8994	9622
Present value revenues	102101	104313	105672
Present value costs	69747	67535	66176
Benefit/costs			
i = 0.05	1.46	1.54	1.60
i = 0.1	1.31	1.46	1.57
i = 0.2	1.01	1.07	1.10
i=0.27	0.84	0.89	0.92

$i \leq 0.1$: subsidized discount rate. $i \geq 0.2$ discount rate at the market price.

CONCLUSIONS AND POLICY IMPLICATIONS

The simultaneous rate of rapid population growth and stagnation of agriculture yields in large parts of poor countries, particularly in Haiti, have caused a steady decline in food production per capita, and a deterioration of the resource base (Pinstrup-Andersen 1994). The failure of the agricultural sector to keep pace with increased population has provoked disturbing changes in the farm household system: drastic reduction of peasant saving capacity and accelerated forest depletion.

Several past attempts to abate the forest degradation problem through conservation subsidies have often fallen short of expectations (Lutz et al. 1994; Pierre-Louis 1989). Conservation may, for example, create perverse incentives so that to qualify for subsidies, farmers may increase deforestation by cultivating land that may not have been cultivated. Subsidies may also modify land use practices during the duration of the program. Thus, a subsidy proposal needs to be designed carefully and in close cooperation with local people to ensure that they have the motivation and capacity to carry their share of the responsibility. It is at the household level that the final decisions are made about land use, crop and policy choice, production and consumption.

This paper was undertaken with the purpose of evaluating whether changes in policy instruments may induce Forêt des Pins Reserve farm households towards more sustainable land use while improving their welfare. The modeling results indicate that the interlinkage between production subsidies with forest conservation can provide opportunities for facing land degradation-induced productivity declines without adversely impacting the welfare of the people. Such policy instruments, may, therefore, represent improvements in efficiency, equity, and environmental quality. When conservation practices associated with subsidies reduce *low-income farm households'* land, fertilizer and seed subsidies linked to conservation failed to be efficient unless the social rate of discount is less than or equal to 0.1. A mix of seed and fertilizer subsidies were, however, more efficient since they facilitate substantial increases in net annual income. If the social rate of discount is as high as 20%, such economic incentives may become socially inefficient.

When *low-income farm households* anticipate higher or the same returns as a result of switching into a conservation regime, higher yields persuade farm households from investing in forest conservation. It also suggests that policies to enhance forest conservation should look for cost-effective methods which serve dual purposes: forest conservation and higher net annual income. When this is deficient, project manager may have to look for other incentives to persuade land users to install conservation practices. When economic benefits are low, farmers either fail to adopt the recommended practices or abandon them once the subsidized projects are phased out (Lutz et al. 1994; Reddy et al. 2001).

Moreover, the effectiveness of economic incentives for forest conservation depends on the rate of discount and the impact on farmer's livelihood systems of conservation measures. A decrease in discount rates and an increase in the productivity of conservation measures improve the efficiency of policy interventions. Areas for future research include investigating how agroforestry development and/or reforestation may convince farmers' responsiveness to incentive agreements, and how they are likely to achieve long-term sustainable benefits.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support of the Forest Policy Center. The comments of Dr. Curtis Jolly improved the manuscript substantially. Two anonymous referees provided useful comments on earlier version of this paper. Many thanks to all farmers of Forêt des Pins Reserve.

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Submitted February 28, 2006 – Accepted May 25, 2006
Revised received June 07, 2006