Poverty, Resource Scarcity and Incentives for Soil and Water Conservation: Analysis of Interactions with a Bio-economic Model

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Abstract

The paper examines the interlinkages between population pressure and poverty, possible impacts on household welfare and land management, and the consequent pathways of development in a low potential rural economy. A dynamic non-separable bio-economic model, calibrated using data from the Ethiopian highlands, is used to trace key relationships between population pressure, poverty and soil fertility management in smallholder agriculture characterized by high levels of soil degradation. Farm households maximize their discounted utility over the planning horizon. Land, labor and credit markets are imperfect. Hence, production, consumption and investment decisions are jointly determined in each period. The level of soil degradation is endogenous and has feedback effects on the stock and quality of the resource base. This may in turn influence land management choices. Under high population pressure, land becomes dearer relative to labor. This is likely to induce conservation investments, especially when conservation technologies do not take land out of production. When markets are imperfect, poverty in vital assets (e.g., oxen and labor) limits the ability or the willingness to invest in conservation and may lead to a less sustainable pathway. Boserup-type responses are more likely when (privately) profitable technologies exist and market imperfections do not limit farm-households' investment options.

Key words: Bio-economic models, population pressure, poverty, land degradation, incentives for soil conservation.

1. INTRODUCTION

The relationship between population growth or pressure, poverty and environmental degradation has been a subject of debate and controversies over several years with an upswing in the debate over the last 30 years (Malthus 1798; Boserup 1965; Scherr and Templeton 1999). There are contradictory empirical studies in East Africa (Tiffen *et al*. 1994; Turner *et al*. 1993; Lele and Stone 1989; Cleaver and Schreiber 1994; Grepperud 1996). The Machakos study (Tiffen *et al*. 1994), which documents Boserupian adjustments offers hope that suitable policies may lift some of these subsistence-oriented economies out of poverty and also provide sufficient incentives for investment in conservation.

The concern for sustainability of production systems in resource-poor regions and the need to quantify the impact of resource degradation on the future productivity of resources has necessitated an interdisciplinary modeling approach that interlinks biophysical and socio-economic factors. Policy analyses for sustainable soil and water management require functional integration of agro-ecological and socio-economic information. The bio-economic model developed here incorporates important variations in the biophysical system (land and soils) and market characteristics in a rural economy, integrated under the framework of farm-household decision behavior. The choice of crops and livestock, and investments in soil and water conservation technologies is therefore jointly determined by the biophysical system, market characteristics and the scarcity of land, labor and other household resources. Factor market imperfections in the village economy lead to non-separability of production, investment and consumption decisions of farm households. The model is calibrated using household survey data from Andit Tid, central highlands of Ethiopia.

Earlier studies on technology choice among smallholders in the Ethiopian highlands found that low or negative initial returns to conservation technologies might undermine households' incentives to invest in soil and water conservation (Shiferaw and Holden 1998). There was some evidence indicating that population pressure and land scarcity may even encourage removal of conservation structures (that occupy productive lands) introduced in the past through program benefits like food-for-work programs. The objective of this paper is, therefore, to explore the interactions between population pressure, poverty and land management and the consequent development pathways using a multi-period non-separable household model in which changes in the soil quality have feedback effects on the future productivity of land. The paper is organized as follows. Part two offers a descriptive overview of the case study area. The basic structure of the bio-economic model is presented in part three. The simulation results are presented and discussed in part four. In the final part, we conclude by highlighting the major findings and policy implications.

2. THE BIOPHYSICAL AND ECONOMIC SYSTEM

The study site (Andit Tid) is located some 180 km North-East of Addis Ababa in Shewa region. The Soil Conservation Research Project (SCRP) opened a field station at the site in 1982 and gathered extensive biophysical data. The area has a bimodal rainfall pattern averaging 315.4 mm in *Belg* (Jan.-May), and 1056.8 mm in *Meher* (June-Dec.) seasons. Its topography lies between altitudes of 3000 and 3500 m.a.s.l., with over three quarters of the land area having a slope of more than 25%, which makes it highly vulnerable to erosion. The area represents one of the low potential cereal zones in the country facing a serious problem of soil degradation. A variety of crops like barley, wheat, faba beans, field peas, lentils and linseed are grown often without fertilizer use.

There are strong crop-livestock interactions in the system. The common types of livestock in the area include cattle, sheep, goats, donkeys, horses and chicken. Crop residues are typically used as animal fodder. Oxen provide traction power. Animal manure is used for enhancing soil fertility and for fuel. Land may be used for crops, grazing, or tree (mainly eucalyptus) production. High population pressure and scarcity of land seem to increase competition between crop and livestock production, especially for larger stock. Sale of the small stock complements both household consumption and crop production activities.

Andosols and Regosols are the most commonly found soils. Other soils of minor importance include Cambisols and Fluvisols. Andosols, relatively rich in organic matter, are often found at higher altitudes and are mainly used for barley grown during the short rains. Regosols are found at lower altitudes where frost is not a major problem. They are poorer in N but richer in P. The Regosols are the most important and intensively cultivated soils in the area. New land management practices were introduced through program benefits (food-for-work) in 1981 and 1982. With termination of program benefits, structures have been removed from 53% of the plots (Shiferaw and Holden 1998).

Farm-households posses use rights to land. Land has been distributed frequently to peasants, often on the basis of family size and land quality, although recent reform programs (1997) were not explicitly based on these criteria. Surveyed households were classified on the basis of their oxen ownership, a vital means of traction power for smallholders in much of highland Ethiopia. In 1994/95, 26.5%, 15.3%, and 56.5% of the smallholders in the study area owned 0, 1 and 2 oxen, respectively. Households without oxen (the poorest group) obtain a relatively larger share of their income from renting out land and off-farm employment. For simulation of the biophysical system and variations in land quality, we classified land into different soil depth and slope classes. Land 'ownership' by soil type and soil depth classes is presented in Table 1.

Due to its proximity to a major highway, Andit Tid has good access to relatively well-developed output markets in the vicinity. But, there are significant transportation costs to some of the accessible markets in the area. Some labor, land, trees, and livestock and cash (or grains) credit may be obtained within the village. Major transactions often occur in one of the nearby small markets. Short-term informal land rental contracts (share or fixed rent tenancy) may also occur. The rental value of land depends on perceived quality of land, but conservation does not necessarily increase the rental value. Informal credit markets are generally under developed. Formal credit was also largely unavailable. There is seasonality in product prices indicating a high negative covariance between supply and prices. The labor market is largely inactive. The reservation wage may, however, vary seasonally. Labor may be hired in for cash, in fixed share of the crop output or in exchange for traction power.

3. THE BIO-ECONOMIC MODEL

Understanding farm households' incentives and constraints to intensification of land use, technology choice and investment behavior, and analyses of the resulting pathways of development requires integration of biophysical and economic modeling approaches at the household level (Ruben *et al*. 1998). The bio-economic model developed here uses a non-separable farm household model (de Janvry *et al*. 1991) as a basis; production, consumption and investment decisions are jointly determined in each period. The household's choice is constrained by market imperfections emanating from seasonality of prices and transactions costs and asset endowments. The on-site costs of soil erosion and nutrient depletion are endogenous, and their impacts on land productivity in consecutive years influence the household's choice of land management practices.

The farm household maximizes the discounted utility (DU):

$$DU = \sum_{t=1}^{T} U_t \left(1 + r_t\right)^{-(t-1)} \qquad (1)$$

Subject to resource supply, market access and subsistence consumption constraints.[1]

Where:

$$U_t = \frac{1-\mu}{\left(\frac{FY_t}{BN_t}\right)^{\mu-1}} + \mu - 1 \qquad (1.1)$$

The utility function (U_t) has a constant elasticity of marginal utility of income (also called flexibility of money) equal to -μ. The utility function attains a negative value when income is less than subsistence, a zero value when income is just equal to subsistence, and a positive value when income is higher than subsistence consumption. Hence:

$$U_t \begin{cases} > 0 & FY_t > BN_t \\ = 0 & FY_t = BN_t \\ < 0 & FY_t < BN_t \end{cases} \qquad (1.2)$$

FY_t is the full income of the household. BN_t is the subsistence level of full income, dependent on the number of consumers and cultural and religious norms, estimated based on previous studies in the study area.

The rate of discount r is endogenous in the model and is given by:

$$r_t = \frac{FV_{t+1}}{PV_t} - 1 \tag{2}$$

$$PV_t = z + \beta \left\{ \frac{\left(FY_t - \Sigma_s w_{st} h_{st} \right)}{CU_t} \right\} \tag{2.1}$$

Where PV_t is the present value equivalent of the future value (FV_t) the household is willing to accept instead of waiting for one more year. The upper and lower bounds of PV_t are determined based on our household survey in the study area. The PV_t is assumed to be dependent on the level of income per consumer unit in each period (CU_t); the value of β is determined from an econometric model (Holden *et al.* 1998). The value of z is parametrized in the model to derive upper and lower bounds for the household's rate of discount. Household's full income is given by:

$$FY_t = \sum_{g=1}^{G} \sum_{c=1}^{C} A_{cgt} \left\{ \rho_{ct} \, y_{cgt} \left(\boldsymbol{x}_{cgt} \right) - \sum_{i=1}^{I} e_{icgt} \, x_{icgt} \right\} + \sum_{V=1}^{V} L_{vt} \left\{ \rho_{vt} \, y_{vt} \left(\boldsymbol{x}_{vt} \right) - \sum_{i=1}^{I} e_{ivt} \, x_{ivt} \right\}$$

$$+ \sum_{s}^{S} w_{st} \left(h_{st} + ol_{st} \right) \tag{3}$$

A_{cgt} is the area of crop c produced on land type g in year t. L_{vt} is production of units of livestock v in each period. $\boldsymbol{x}_t$ is a vector of inputs $(x_{1t}, \ldots, x_{nt})$ used in production of a unit of crop c in land type g and livestock v in year t. ρ is the per unit price of crops or livestock and e is the per unit input cost. Y_{cgt} and Y_{vt} are the yield functions for the production of crop c or livestock v, respectively. Family labor "consumed" as home time (leisure) in each season (s) is h_{st} while w_{st} is the seasonal reservation wage (after transactions costs). The seasonal off-farm labor supply is ol_{st}.

Crop yield is a non-linear function of the land type, the rooting depth in each period, the cumulative reduction in the plant available nutrient stock, level of fertilizer use and conservation technology choice. Hence, the yield of crop c in each land type (g) is given as:

$$y_{cgt} = f\left(sd_t, N_t, P_t, k_t \right) \tag{4}$$

Where sd_t is the soil depth, k_t is the type of conservation technology used, and N_t and P_t are nitrogen and phosphorus available to plants. The soil depth-yield relationship is econometrically estimated based on the SCRP time-series collected at the site, while responses to N and P are estimated from the FAO fertilizer response studies and the soil productivity calculator (Aune and Lal 1995).

Change in the soil nutrient stock is the cumulative outcome of positive processes (use of fertilizer and animal manure, nitrogen fixation and natural deposition) and negative processes (soil erosion, harvesting of grains and by-products, leaching, and gaseous losses). Soil erosion depletes both rooting depth and soil nutrients. The cumulative change in the available nutrient stock feeds back into the model to influence consecutive crop yields. An enrichment ratio of 2 is used for eroded soil. The change in the N stock is given by:

$$N_{t+1} = N_t - \delta\ (N_t - \eta(se_t)) - \eta(se_t) \quad (5)$$

where *se* is the period *t* rate of soil erosion, δ is the share of soil nitrogen mineralized in each period and η is the N composition of the soil. An enrichment ratio of 2 is used for eroded soil together with an annual mineralization rate of 1% for soil nitrogen. The change in plant available N from period to period (ϕ) due to nutrient depletion is computed as:

$$\phi = \delta(N_t - N_{t+1}) \quad (6)$$

where δ is as defined above. The reduction in plant available N is included into the production function (Equation 4) to influence crop yields in each period. Currently only the effect of depletion of rooting depth and N on crop yields are incorporated into the model. This is because incorporating the effect of P depletion on land productivity requires additional data on P-fixation, conversion of stabile P to labile P, and the total P-stock in the soils. The cumulative loss of N feeds back into the model to influence future crop yields. Based on the agronomist's advice, the model assumes 1% of the soil nitrogen is mineralized every year.

The rate of soil erosion (se_t), and hence the change in soil depth for each land type, in each period depends on the soil type (*st*), the slope (*sl*), rainfall (*rf*), the conservation technology used (*k*) and the type of crop grown (*c*) in year *t*.

$$se_t = \phi\ (st_t, sl, rf_t, k_t, c_t) \quad (7)$$

The parameters of this function were obtained from the SCRP experiments at the site or estimated based on plot-level survey data.

The model uses graded soil-stone bunds (previously introduced into the area) as erosion-control methods. Construction of these structures is estimated to require 100-120 working days per hectare (ha) while maintenance requires 15-20 days/ha/year, depending on the gradient of the land. Removal of conservation practices previously installed on farmland is assumed to require 25% of the construction labor. Conservation structures may occupy productive land and reduce yields in the initial period, especially on steeper slopes. Since this was a strongly expressed concern of farmers in the study area, two versions of the model were solved; (a) the effect of area loss is negligible (Case I), (b) loss of land due to structures may reduce yields by 5-10% depending on the slope of the land (Case II). The first case may result if conservation (in addition to mitigating soil erosion) improves certain soil properties or raises relative returns to intensification (e.g., fertilizer use) and compensates the negative effect of area loss. The second case may result when such positive additional effects of conservation are negligible (or are offset by other negative effects such as increased pest incidence). Both are very likely scenarios. When initial yields with conservation are lower, a long time lag may be involved until conservation provides higher yields.

These two versions of the model (Cases I and II) are solved for the two household types: poor household (no ox), and less poor household (two oxen). The effect of population pressure is incorporated through changing the land-labor ratio of the household at the initial period. Hence, four scenarios are developed in each case: poor land-scarce, poor land-abundant, less poor land-scare, and less poor land-abundant (See Table 2). The model is calibrated to fit the land and household characteristics of the study area in 1998. The model is solved for a planning horizon of 5 years with the endogenous discount factor.[2]

4. SIMULATION RESULTS

4.1 Less poor households vs. population pressure

According to Boserup (Boserup 1965) intensification of land use and investments to enhance its productivity will be limited when land is more abundant relative to labor. This suggests that smaller families with large farms will have lower incentives to increase intensity of labor and other inputs per unit of land to enhance productivity of land. Our simulations also indicate that when land is more abundant relative to labor, the land users lack sufficient incentives to make significant erosion control investments (see Tables 3 and 4). The level of investment in soil fertility management is much larger for land-scarce households than for land-abundant households. The investment gap is even more pronounced if conservation technologies take some land out of production. For the less poor land-abundant household, the cost of soil degradation in terms of future productivity decline is low. The limited effect of degradation on their welfare reduces the incentive to mitigate the externality, especially when the rental value of land does not increase with conservation investments. Shortage of labor relative to land also means that the labor-scarce household may have to hire in labor in order to install labor-intensive soil conservation investments. The cumulative effect of scarcity of labor and land abundance is lower soil conservation effort for the small household. When the area loss due to conservation is marginal (Case I), the land-abundant and labor-scarce households maintain (except those on deep soils or marginal lands converted to grazing) much of the initial conservation previously installed on their lands through program benefits. But, the land-scarce households, dismantle more of the initial conservation, but will still have more erosion control investments on their lands at the terminal period due to new investments made as household welfare improves through accumulation of wealth and reinvestments (Table 3). When conservation takes some land out of production (Case II), both households quickly dismantle the initial conservation, but the land-scarce households re-install them on lands where conservation benefits are large (shallow soils) (See Table 4). The reinvestment on lands with higher investment benefits is likely to increase if a longer planning horizon is assumed as conservation benefits accrue far into the future. Likewise, the effect of the change in the discount rate is likely to be more visible if a longer planning horizon is assumed.

4.2 Poor households vs. population pressure

When the household is poor in both oxen and land, population pressure (increased family size) puts high pressure on the household's ability to meet basic needs. While the lack of traction power forces the household to rent out land, the presence of high transaction costs and imperfect food markets together with the scarcity of land limit the household's ability to rent out land in cash and buy back its own consumption. Hence, the household rents in some traction power to grow some of its subsistence needs and rents out some of the land. But, meeting consumption needs of a large household becomes difficult unless the surplus labor finds employment off-farm. If the labor market is missing, the household is simply unable to meet its basic needs unless external assistance is made available. When sufficient off-farm employment is available, the incentive to implement improved land management practices depends on the profitability of farming relative to off-farm employment. When off-farm employment is limited (as in this case), the household invests surplus labor in soil conservation practices (see Table 5), especially in Case I. But, the level of conservation achieved is less than that of the less poor household (Table 3 and 4) mainly because some of the land is rented out annually without conservation. This is an effect of imperfections in the land market since the value of land does not increase with conservation investments. When the household is poor both in oxen and labor, the relative abundance of land and shortage of labor discourages conservation investments. The household will hire in some traction power and labor depending on the local market to produce part of its subsistence, but rents out the remaining land annually to others without conservation. Again, if the market value of land treated with conservation is higher and labor markets function well, the labor-scarce and poor household is likely to increase conservation investments.

In Case I, poor and labor-scarce households maintain much of the initial conservation compared to the poor land-scarce households but the latter households generally invest more on new land management methods at the terminal period (Table 5). In Case II, both households remove all the initial conservation, but the land-scarce households re-install some of the conservation later when it becomes feasible to meet subsistence needs through storage of some food crops (Table 6). The labor-scarce households remove the initial conservation and fail to reinvest within the planning horizon assumed here since land is not the most limiting factor for their welfare.

5. CONCLUSIONS AND POLICY IMPLICATIONS

In resource-poor regions with high population pressure, sustainable use of land and other resources is becoming an important policy and development problem for farmers, researchers and policy makers. Policy-oriented research into the possible linkages and interactions between land scarcity and poverty and their effects on incentives for land management and household welfare is hence very useful. When the land-to-labor ratio is large, households are unlikely to carry out labor-intensive soil and water conservation investments. A growth in family size and scarcity of land increases the incentive to invest in land, especially when opportunities for off-farm employment are limited. Poverty, in labor and traction power, forces households to rent out land to other relatively better off households. Moreover, under the existing system usufruct rights to land in Ethiopia and the lack of recognition of short-term conservation benefits, the rental value of land does not seem to improve with conservation. Clearly, those renting in land under the informal short-term contracts also lack the incentive to undertake significant land-improving investments as benefits accrue on relatively longer period of time. This is unlikely to change unless farmers' rights are more secure and formal leasing out of land for a relatively longer period of time is made possible.

The incentive to invest in conservation drastically decreases when the new technologies increase scarcity of land and decrease crop yields in the short-term (Case II). This scenario seems to explain extensive removal of conservation methods in the study area in the past. Households seemed to reinvest in soil and water conservation when the subsistence pressure decreases. But, re-investment is likely to be influenced by the magnitude of the immediate negative effect of conservation, like areas loss and pest incidence. We have assumed this initial yield loss to be 5-10% in this study. This indicates the need for additional incentives to compensate farmers for the losses they incur when they choose to invest in soil and water conservation practices. Recently, fertilizer prices have increased substantially with the removal of subsidies and the lifting of pan-territorial pricing system. Without sufficient conservation investments and for poor farmers who cannot afford higher input prices, this is likely to worsen nutrient depletion and degradation of productive lands. Under such conditions, our results seem to support targeted conservation subsidies. The external incentive is also justified when additional external (off-site) effects of soil erosion exist. In sum, the interaction between land scarcity and poverty and the incentives for resource conservation depend on economic and institutional constraints. Poverty, lack of profitable conservation technologies, and insecurity of tenure rights discourage adoption of more sustainable practices. However, population pressure and scarcity of land are more likely to encourage increased land-improving investments when other enabling conditions are fulfilled.

Notes

[1] Lack of space prohibits presentation of model constraints. Only parts that link the household model to the biophysical system are briefly shown here.

[2] A 2.4% annual growth rate of the household is also included. Coupled with depletion of land productivity due to soil degradation, this increases the subsistence requirement overtime.

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Table 1. Land area (in *Timad*) by farm household category, soil type, soil depth and slope classes.

Soil type	Codes	Soil depth class (cm)	Slope Class (%)	Household category		
				No ox	One ox	Two+ oxen
Andosols		All	All	2.03	2.82	4.02
"	AD1S12	0-30	0-20	0.91	1.26	1.8
"	AD2S12	30-60	0-20	0.57	0.78	1.12
"	AD3S34	>60	0-20	0.32	0.44	0.63
"	ADSS34	0-30	>20	0.24	0.33	0.48
Regosols		All	All	3.52	4.88	6.98
"	RD1S12	0-30	0-20	1.62	2.25	3.21
"	RD2S12	30-60	0-20	0.86	1.19	1.69
"	RD3S34	>60	0-20	0.31	0.44	0.62
"	RDSS34	0-30	>20	0.73	1.01	1.44

Timad is approximately 0.25 ha.

Table 2. Household sizes in the selected scenarios at the initial period.

Type	Less poor (pair of oxen)[2]		Poor (zero ox)	
	Large[1]	Small	Large	Small[1]
Family Size	7.2	4.2	7.2	2.8
Worker units	4.0	1.5	4.0	1.5
Consumers units	6.6	3.0	6.6	2.6

[1] These are average values from the study area.
[2] Traditionally, a pair of oxen is need for traction.

Table 3. Percentage of land area treated with conservation practices at the terminal period: Less poor households (2-oxen) when conservation does not take land out of production.

Household Type	Household Welfare	Regosols				Andosols			
		RD1S12	RD2S12	RD3S12	RDSS34	AD1S12	AD2S12	AD3S12	ADSS34
Land-abundant[1]	**4.521**	**32.4**	**26**	**25.8**	**22.2**	**2.6**	**17.9**	**0**	**0**
Land-scarce[1]	2.076	78	97.6	93.5	97.2	0	96.4	57.1	0
Land-abundant[2]	**2.68**	**32.4**	**26.0**	**25.8**	**22.2**	**2.6**	**17.9**	**0**	**0**
Land-scarce[2]	1.208	78.1	97.6	93.5	95.9	0	96.4	57.1	0
Land-abundant[3]	**2.68**	**100**	**100**	**100**	**100**	**1.3**	**100**	**0**	**0**
Land-scarce[3]	1.208	70	57	100	100	0	100	80	0

[1] Lower discount rate (ranges: 0.25 to 0.26 for land-scarce, and 0.21 to 0.22 for labor-scarce households).
[2] Higher discount rate (ranges: 0.57 to 0.58 for land-scarce, and 0.50 to 0.51 for labor-scarce households).
[3] Percentage of the initial conservation kept at the end of the terminal period (high discount rate)

Table 4. Percentage of land area treated with conservation practices at the terminal period: Less poor households when conservation takes 5-10% land out of production.

Household Type	Household Welfare	Regosols				Andosols			
		RD1S12	RD2S12	RD3S12	RDSS34	AD1S12	AD2S12	AD3S12	ADSS34
Land-abundant[1]	**4.511**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Land-scarce[1]	2.03	84.6	0	0	13.2	3.6	0	0	0
Land-abundant[2]	**2.674**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Land-scarce[2]	1.1857	64.5	0	0	13.1	0	0	0	0
Land-abundant[3]	**2.674**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Land-scarce[3]	1.1857	0	0	0	0	0	0	0	0

[1] Lower discount rate, [2] Higher discount rate. The ranges for both the discount rates are similar to Table 3, but only slightly higher). [3] Percentage of the initial conservation kept at the end of the terminal period (high discount rate).

Table 5. Percentage of land area treated with conservation practices at the terminal period: Poor households (zero ox) when conservation does not take land out of production.

Household Type	Household welfare	Regosols				Andosols			
		RD1S12	RD2S12	RD3S12	RDSS34	AD1S12	AD2S12	AD3S12	ADSS34
Land-abundant[1]	3.371	22.2	37.7	13.7	0	35.2	28.7	13.7	0
Land-scarce[1]	**-2.937**	**34.6**	**95.3**	**87.5**	**0**	**39.1**	**62.9**	**87.5**	**0**
Land-abundant[2]	1.901	22.2	37.7	13.7	0	35.2	28.7	13.7	0
Land-scarce[2]	**-1.921**	**22.2**	**95.3**	**87.5**	**0**	**39.1**	**65**	**87.5**	**0**
Land-abundant[3]	1.901	74	100	100	0	100	100	100	0
Land-scarce[3]	**-1.921**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

[1] Lower discount rate (ranges: 0.27 to 0.28 for land-scarce, and 0.22 to 0.25 for labor-scarce households).
[2] Higher discount rate (ranges: 0.60 to 0.61 for land-scarce, and 0.52 to 0.55 for labor-scarce households).
[3] Percentage of the initial conservation kept at the end of the terminal period (high discount rate)

Table 6. Percentage of land area treated with conservation practices at the terminal period: Poor households when conservation takes 5-10% land out of production.

Household Type	Household welfare	Regosols				Andosols			
		RD1S12	RD2S12	RD3S12	RDSS34	AD1S12	AD2S12	AD3S12	ADSS34
Land-abundant[1]	3.364	0	0	0	0	0	0	0	0
Land-scarce[1]	**-3.06**	**22.2**	**0**	**0**	**0**	**39.1**	**0**	**0**	**0**
Land-abundant[2]	1.901	0	0	0	0	0	0	0	0
Land-scarce[2]	**-1.99**	**22.2**	**0**	**0**	**0**	**39.1**	**0**	**0**	**0**
Land-abundant[3]	1.901	0	0	0	0	0	0	0	0
Land-scarce[3]	**-1.99**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

[1] Lower discount rate,
[2] Higher discount rate,
The ranges for both the discount rates are similar to Table 5, but only slightly higher.
[3] Percentage of the initial conservation kept at the end of the terminal period.