Tenure security and soil conservation in an overlapping generation rural economy

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Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28.

Tenure security and soil conservation in an overlapping generation rural economy♣

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Abstract

Tenure security and subsistence needs influence the choice between unexploited topsoil and unspent money (i.e., savings) as the mode of transfer. Using a unique household-level dataset from Bangladesh, which contains data on cropping-intensity and savings spent on education, we detect that rural agricultural households with secured tenure have lower cropping-intensity and higher educational expenditure. Furthermore, tenure security and poverty have opposite, but not offsetting, effects. Households prefer higher educational expenditure to lower cropping-intensity as the mode of transfer. Thus, increased public expenditure may lower the pressure on land and soil resources, by lowering private educational expenditure.

JEL Classifications: *Q24, D13, D64, Q15.*

Keywords: Cropping-intensity; educational expenditure; soil conservation; subsistence needs; tenure security.

1. Introduction

Rural areas of developing countries are highly dependent on agriculture for both income and employment (Malik, 1999). Around 72 percent people from lower-income countries live in rural areas where agriculture is the principal economic activity, contributing around 27 percent of the gross domestic product and employing nearly 80 percent of the workforce (World Bank, 2013). Moreover, low per-capita arable land results in high incidences of poverty in those countries; only 0.18 hectares of land are available per-capita and around 37 percent of people live below the $1.25/day poverty line in lower income countries (World Bank, 2013). Hardcore poverty often forces farmers, especially smallholders, to use their limited land resource intensively to meet even

♣ We thank Ben Gilbert, Thorsten Janus and Ben Rashford for their useful feedback and suggestions.

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the subsistence consumption needs. This high dependence on land-intensive agricultural production results in increased pressures on different attributes of land quality, such as topsoil.

Topsoil, which is an important determinant of agricultural productivity, is often conserved and shared from one generation to the next (Bre´chet and Lambrecht, 2011). Common topsoil conservation practices include stone terracing and tree plantation. However, the benefits of such conservation efforts may take years to be realized (Reardon and Vosti, 1995). The absence of proper land and other important markets in the rural areas of developing countries may limit the eventual financial returns to conservation. Yet, rural agricultural households devote considerable amount of efforts to conserving the topsoil, often as a form of stewardship for future generations (Barbier, 1990; Besley, 1995; Brasselle et al.., 2002; Deninger and Jin, 2006; Ervin and Ervin, 1982; Reardon and Vosti, 1995). Thus, addressing the presence of altruistic behavior within the family (e.g., Becker, 1981), we consider intra-household altruism as the key incentive for conserving the topsoil.

The lack or improper enforcement of land tenure security often contributes to topsoil degradation through reduced incentives for conservation efforts (Fernandez 2006; Gebremedhin and Swinton, 2003; Deininger and Jin, 2006; Kabubo-Mariara, 2007). Thus, tenure security can play a central role in influencing the topsoil conservation decision (IFAD, 2008; UNECA, 2009).[1] Depending on the degree of tenure security, the altruistic current generation may be interested in alternative modes of transfer to the future generation, such as a monetary transfer.

We develop an overlapping generation (OLG) model of a rural economy to explore the linkage between intra-household altruism, tenure security and topsoil conservation. The current generation, which lives two consecutive periods, maximizes an altruism-augmented inter-temporal utility function by making labor allocation, consumption, savings and transfer decisions. In the first period, it allocates the total labor time between agricultural production and topsoil conservation. Income from agricultural production is divided into consumption and savings. At the beginning of the second period, the current generation makes its consumption and transfer decisions. It may transfer a combination of unexploited topsoil and unspent money to the future generation, after meeting its production and consumption needs (e.g., Tomes, 1982).

[1] Land tenure refers to the social relations and institutions that govern access to and control over land and related resources. It determines who can use the land resources, for how long and under what conditions (IFAD, 2008).

Our theoretical analysis focuses on the degree of substitutability between unexploited topsoil and unspent money (i.e. savings) as the method of transfer. Based on the theoretical findings, we hypothesize that households with greater tenure security have lower cropping-intensity, and switch from higher educational expenditure to lower cropping-intensity as the mode of transfer. We use Bangladesh Household Income and Expenditure Survey (HIES) dataset to investigate these hypotheses for the rural agricultural households of Bangladesh.

The impact of tenure security on topsoil and land conservation has been widely researched (Fernandez, 2006; Gebremedhin and Swinton, 2003; Deininger and Jin, 2006; Kabubo-Mariara, 2007). However, this is the first such investigation to consider monetary transfer as an alternative to topsoil. Substitutability between these two modes of transfer may lead to important implications for developing countries. For example, the results of this analysis can possibly bring into question the continual insecurity of land tenure in the Chittagong Hill Tracks and Island areas of Bangladesh.

The content of the remainder of the paper is as follows. Section 2 develops the overlapping generation model of rural agricultural households. Section 3 outlines the optimal solutions. Section 4 analyzes the theoretical findings. Section 5 extends the theoretical discussion in Section 4 by including subsistence needs. Section 6 specifies the empirical strategies and discusses the main empirical results. Section 7 provides additional results and robustness check. Finally, Section 8 summarizes and concludes by discussing the key policy implications of the analysis.

2. An OLG model of rural agricultural households

The OLG model in this paper includes two modes of transfer: unexploited topsoil and unspent money, in the context of a rural developing economy. Our interest is to determine how the choice is made between these alternative modes of transfer and to identify factors critical to this choice.

The rural economy consists of M homogeneous agricultural households, which can be represented by a single household. At any point in time, the representative household consists of two overlapping generations: *young* and *old*. The current generation, denoted by the subscript 1, is born in time t and lives two consecutive periods t (*young* age) and $t + 1$ (*old* age).[2] The current and future generations overlap in time $t + 1$.

[2] Similarly, the future generation, denoted by the subscript 2, is born in time $t + 1$ and lives two consecutive periods $t + 1$ (young age) and $t + 2$ (old age).

The current generation uses its fixed endowments of land and labor for agricultural production. Land is not traded, rather the current generation inherits it with a given topsoil depth and tenure security from the previous generation at the beginning of time t; and on retirement from economic activities at the beginning of time $t+1$, transfers to the future generation with remaining topsoil depth. The altruistic current generation may spend a part of its total labor time in topsoil conservation, which does not directly affect current agricultural production but prevents soil depletion and thus indirectly influences the production of the future generation.

Land tenure security is often missing, or not properly defined and enforced, in the rural areas of developing countries (Ananda and Herath, 2003). We consider an exogenous measure of tenure security, θ, which is continuous within the range $(0,1]$, where higher values of θ indicate greater tenure security, and vice-versa, $\forall\theta \in (0,1]$. Among the extreme cases, $\theta = 1$ implies legally enforced complete tenure security, and $\theta = 0$ implies zero tenure security. We rule out $\theta = 0$ since it prevents any agricultural production. We assume that θ is time-independent, i.e., the degree of tenure security is fixed across generations.

The current generation maximizes a Stone-Geary preference (SGP), which incorporates the subsistence consumption needs present in the rural areas of developing countries. Its inter-temporal SGP consists of the egotistic utility from its consumption above the subsistence level and altruistic utility from the utility of the future generation. Let $c_{1,t}$ *and* $c_{1,t+1}$ denote its consumptions in times t *and* $t+1$, respectively; $\bar{c}$ the subsistence level of consumption; and U_2 the utility of the future generation, which also comprises SGP. The inter-temporal SGP of the current generation is:

$$U_1 = u_{1,t}(c_{1,t} - \bar{c}) + \rho\, u_{1,t+1}(c_{1,t+1} - \bar{c}) + \phi\, U_2, \qquad (1)$$

$$\bar{c} > 0;\ c_{1,t} = \bar{c};\ c_{1,t+1} > \bar{c};\ \phi = \frac{\rho}{1-\rho};\ \rho \in [0,1].$$

All variables are expressed in per-capita terms, and t represents the time index. Both the time and intergenerational preference factors, denoted by ρ *and* ϕ, respectively, are constant over time for all the generations. For simplicity, we assume $c_{1,t} = \bar{c}$ (i.e., the current generation consumes at the subsistence level in time t) and $c_{1,t+1} > \bar{c}$ (i.e., the current generation consumes above the subsistence level in time $t+1$).[3] Thus, utility from consumption in time t, $u_{1,t}(0) = 0$, drops out

[3] This simplification, i.e., $c_{1,t} = \bar{c}$, is common in OLG models (e.g., Babu *et al.*, 1997; Dam, 2011; John and Pecchenino, 1994), and it does not affect the tradeoff between the modes of transfer we investigate. In addition, $c_{1,t+1} > \bar{c}$ necessarily implies that the current generation derives utility from its own consumption in time $t+1$.

of the SGP (1). The egotistic utility function is twice continuously differentiable and strictly concave in its arguments, i.e., $\frac{\partial u_{1,t+1}}{\partial c_{1,t+1}} > 0$; $\frac{\partial^2 u_{1,t+1}}{\partial c_{1,t+1}^2} < 0$.

To derive the indirect utility function of the future generation, we evaluate U_2 at the optimal values of the choice variables of the current generation.[4] The indirect utility, V_2, is the welfare of the future generation taking account of their decisions, which are functions of initial conditions determined by the transfers made to them (e.g., Amacher *et al.*, 2002). Since the current generation transfers either the unspent money (m_{t+1}) or the unexploited topsoil (x_{t+1}), we have:

$$U_2 \equiv V_2(m_{t+1}, x_{t+1}), \tag{2}$$
$$\frac{\partial U_2}{\partial m_{t+1}}, \frac{\partial U_2}{\partial x_{t+1}} > 0; \frac{\partial^2 U_2}{\partial m_{t+1}^2}, \frac{\partial^2 U_2}{\partial x_{t+1}^2} < 0.$$

The current generation cultivates its inherited land (A) with a given topsoil depth (x_t) using on-farm physical labor $(l_{1,t})$ and a vector of all other inputs (B) in time t. Since the rural agricultural households often have limited capital, which is generally fixed and non-accumulating, we normalize $A \equiv 1$ and $B \equiv 1$.[5] The agricultural production function, $q_{1,t}$, is:

$$q_{1,t} = q(l_{1,t}, x_t), \tag{3}$$
$$\frac{\partial q}{\partial l_{1,t}}, \frac{\partial q}{\partial x_t} \geq 0; \frac{\partial^2 q}{\partial l_{1,t}^2}, \frac{\partial^2 q}{\partial x_t^2} \leq 0; \frac{\partial^2 q}{\partial l_{1,t} \partial x_t} = \frac{\partial^2 q}{\partial x_t \partial l_{1,t}} \geq 0.$$

The production function increases at a non-increasing rate with respect to $l_{1,t}$ *and* x_t. An increase in l_{1t} may lead to increased output but at a declining rate. We assume $l_{1,t} > 0$ since agriculture is the only source of income.[6] Topsoil, x_t, also has a beneficial effect on crop production. Inputs are complementary, i.e., $\frac{\partial^2 q}{\partial l_{1,t} \partial x_t} = \frac{\partial^2 q}{\partial x_t \partial l_{1,t}} > 0$, which indicates that additional soil depth improves the crop productivity of the on-farm labor, and vice-versa.[7]

The use of labor for agriculture degrades the topsoil depth at an accelerating rate, which may induce the altruistic current generation to spend a part of its total labor time in topsoil conservation

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[4] By symmetry, the inter-temporal SGP of the future generation is $U_2 = u_{2,t+1}(c_{2,t+1} - \bar{c}) + \rho\, u_{2,t+2}(c_{2,t+2} - \bar{c}) + \phi\, U_3$.

[5] Unlike Bre´chet and Lambrecht (2011) among others, we ignore the physical capital without losing any insight since we focus on the rural developing economies. This simplifying assumption is consistent with a set of forestry literature such as Koskela *et al.* (2002) and Olson and Knapp (1997).

[6] Including separate agricultural and non-agricultural activities simply complicates the model without contributing to our qualitative results. Among the papers making such distinctions include Barbier (2008) and Narain *et al.* (2008). López (1998) separates agricultural production into labor versus land-intensive activities. On the other hand, Barbier (2010) considers only the agricultural labor allocation.

[7] Among others, Barbier (1990), Barbier and Bishop (1995) and Grepperud (1997) use similar production functions.

(e.g., Bulte and van Soest, 2001). Bulte and van Soest (2001) assumes that rural households can enhance regeneration of natural capital (i.e., topsoil in our model) indirectly by allocating their labor time between agricultural production and conservation efforts. Similarly, we consider that the current generation allocates its labor time, $L > 0$, between agricultural production ($l_{1,t}$) and soil conservation effort ($l_{1,t}^{x}$): $L = l_{1,t} + l_{1,t}^{x}, l_{1,t}^{x} \geq 0$.[8] Let $x_t \; and \; x_{t+1}$ denote the topsoil depths in times $t \; and \; t+1$, respectively, which the current and future generations use for crop production. The change in topsoil depth, g, is determined the conservation effort (l_{1t}^{x}) and tenure security: $g = g(l_{1t}^{x}; \theta)$. Thus, topsoil depth at the beginning of time $t+1$ is:

$$x_{t+1} = x_t + g(l_{1t}^{x}; \theta), \tag{4}$$

$$\frac{\partial g(.)}{\partial l_{1t}^{x}} \geq 0, \frac{\partial^2 g(.)}{\partial {l_{1t}^{x}}^2} \leq 0; \; \frac{\partial^2 g(.)}{\partial \theta \partial l_{1t}^{x}} > 0.$$

Conservation efforts l_{1t}^{x} may increase $g(.)$ at a non-increasing rate. Moreover, tenure security θ has a beneficial effect on the marginal effect of l_{1t}^{x} on $g(.)$.

Apart from its exogenous monetary receipts m_t from the past generation, the current generation earns real agricultural income $q_{1,t}$. With zero non-agricultural income, its total income in time t is $(m_t + q_{1,t})$, which it is allocates between consumption ($c_{1,t} = \bar{c} > 0$) and savings ($s_{1,t+1} > 0$). The simplifying assumption $c_{1,t} = \bar{c}$ from (1) allows positive savings: $s_{1,t+1} = q_{1,t} + m_t - \bar{c}$.

The current generation retires from agricultural activities in time $t+1$, and lives on the savings carried out from time t. The budget equation of the current generation in time $t+1$ is:

$$c_{1,t+1} = q_{1,t} + m_t - \bar{c} - m_{t+1}. \tag{5}$$

Since the capital market is imperfect in the rural economy, we assume that the market interest rate is zero (e.g., Fernandez, 2006). The current generation decides on $c_{1,t+1} \; and \; m_{t+1}$ at the beginning of time $t+1$. It may decide to transfer money to the future generation, i.e., $m_{t+1} \geq 0$.

[8] Since $l_{1,t}^{x} = L - l_{1,t}$, this approach resembles the technology choice approach in Barbier (1990). Barbier (1990) considers a conventional vector of input package as well as the choice of adopting an alternative package of appropriate soil conservation method to determine the remaining topsoil depth. Instead, we consider the allocation of labor time between agriculture and conservation efforts.

3. Optimal solutions and substitutability of optimal choices

The current generation maximizes its lifetime utility (1) subject to the constraints (2)–(5) by choosing consumptions ($c_{1,t+1}$), savings ($s_{1,t+1}$), labor ($l_{1,t}$), conservation effort ($l_{1,t}^x$) and monetary transfer (m_{t+1}). After all possible replacements, the maximization problem becomes:

$$\max_{l_{1,t}^x, m_{t+1}} U_1 = \rho\, u_{1,t+1}\big(pq_{1,t}(L - l_{1,t}^x, x_t) + m_t - 2\bar{c} - m_{t+1}\big) + \phi\, V_2\big(m_{t+1}, x_t + g(l_{1t}^x; \theta)\big),$$

$$s.t., \qquad l_{1,t}^x \geq 0, m_{t+1} \geq 0.$$

Optimal values of the choice variables, ${l_{1,t}^x}^*$ and m_{t+1}^*, are implicitly determined by comparing the marginal benefits and marginal costs in (6), which can then be used to derive optimal values of $l_{1,t}^*, x_{t+1}^*, s_{1,t+1}^*$ and $c_{1,t+1}^*$. First-order conditions are summarized as:

$$\phi \frac{\partial V_2}{\partial x_{t+1}} \frac{\partial g}{\partial l_{1,t}^x} \leq \rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})} \frac{\partial q_{1,t}}{\partial l_{1,t}}, \quad \phi \frac{\partial V_2}{\partial m_{t+1}} \leq \rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})}. \tag{6}$$

The household decides on labor-conservation and consumption-transfer tradeoffs at the equality of their corresponding marginal benefits and opportunity costs. First, $\phi \frac{\partial V_2}{\partial x_{t+1}} \frac{\partial g}{\partial l_{1,t}^x} \leq \rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})} \frac{\partial q_{1,t}}{\partial l_{1,t}}$ governs the labor-conservation tradeoff, where ${l_{1,t}^x}^* > 0$ if this expression binds. Marginal benefit of conservation efforts, $\phi \frac{\partial V_2}{\partial x_{t+1}} \frac{\partial g}{\partial l_{1,t}^x}$, is discounted for the intergenerational preference factor ϕ since the conservation efforts in time t affect the consumption in time $t+1$. On the other hand, the opportunity cost of conservation efforts, $\rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})} \frac{\partial q_{1,t}}{\partial l_{1,t}}$, corresponds to the effect of agricultural labor on the consumption above the subsistence level. It is discounted for the time preference factor ρ since agricultural income in time t affects consumptions in times t and $t+1$.

Next, $\phi \frac{\partial V_2}{\partial m_{t+1}} \leq \rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})}$ governs the consumption-transfer tradeoff, where $m_{t+1}^* > 0$ if this expression binds. The marginal benefit of monetary transfer, $\phi \frac{\partial V_2}{\partial m_{t+1}}$, which is adjusted for the intergenerational discount factor ϕ, refers to current generation's perceived marginal utility from transferring money to the future generation. The opportunity cost of monetary transfer, $\rho \frac{\partial u_{1,t+1}}{\partial (c_{1,t+1} - \bar{c})}$, which is adjusted for the time preference factor ρ, refers to the marginal utility of consumption in time $t+1$ by the current generation.

The optimal transfer decision requires simultaneously solving the first-order conditions (6), which yields:

$$\frac{\frac{\partial V_2}{\partial m_{t+1}^*}}{\frac{\partial V_2}{\partial x_{t+1}^*}} \gtreqless \frac{\frac{\partial g}{\partial l_{1,t}^{x}{}^*}}{\frac{\partial q_{1,t}}{\partial l_{1,t}^*}}, \tag{7}$$

where $\frac{\partial V_2}{\partial m_{t+1}^*}$ *and* $\frac{\partial V_2}{\partial x_{t+1}^*}$, respectively, denote the marginal utilities from transferring unspent money and unexploited topsoil, and $\frac{\partial g}{\partial l_{1,t}^{x}{}^*}$ *and* $\frac{\partial q_{1,t}}{\partial l_{1,t}^*}$ denote the shadow prices of unexploited topsoil and unspent money, respectively.

Condition (7) characterizes the choice between the modes of transfer. The left side of (7) defines the marginal rate of substitution between the modes of transfer ($MRS_{x,m}$), whereas the right side defines the corresponding shadow price ratio ($PR_{x,m}$). Ignoring the no transfer case that violates the altruism assumption of the model, we have three potential solutions. First, we have a corner solution if $|MRS_{x,m}| < |PR_{x,m}|$ where the remaining topsoil is a perfect substitute for the unspent money, resulting in the transfer of only the remaining topsoil to the future generation. Next, we have another corner solution if $|MRS_{x,m}| > |PR_{x,m}|$, the current generation transfers only the unspent money to the future generation. Finally, we have an interior solution if $|MRS_{x,m}| = |PR_{x,m}|$ where the remaining topsoil and the unspent money are compatible to each other, and the current generation transfers a combination of them to the future generation.

Although the corner solution $|MRS_{x,m}| < |PR_{x,m}|$ is more appealing for soil conservation, the interior solution is more realistic since the choices of $l_{1,t}^{x}{}^*$ and m_{t+1}^* are inter-temporal. Moreover, conditional on the model parameters, greater substitutability may indicate greater conservation and thus greater transfer of the topsoil by the current generation. We consider the interior solution hereafter so that the modes of transfer, although not perfect, are substitutes.

4. Tenure security and sustainability of topsoil

Topsoil depth is a critical determinant of agricultural production in rural developing economies and should be shared across generations. Conditional on model parameters, such as tenure security and subsistence needs, household's labor allocation decision determines the transfer and intergenerational sustainability of topsoil depth. Intergenerational sustainability is defined as

$x_{t+1} = x_t$, i.e., both the current and future generations have equal endowments of topsoil on their inherited land.

To identify the impacts of the exogenous tenure security θ, we need the corresponding comparative statics for optimal choices of conservation efforts, and monetary and topsoil transfers. Proposition 1 summarizes the comparative statics with respect to tenure security θ.

Proposition 1. *The current generation increases conservation efforts, and, consequently, switches from monetary transfer to topsoil transfer, under greater tenure security. That is,* $\frac{dl_{1,t}^{x}{}^{*}}{d\theta} > 0$; $\frac{dm_{t+1}^{*}}{d\theta} < 0 \; and \; \frac{dx_{t+1}^{*}}{d\theta} > 0$.

Proof. Assume that the second-order conditions are satisfied. Now, since $\frac{\partial^2 U_1}{\partial\theta\partial l_{1,t}^{x}} = \phi \frac{\partial V_2}{\partial x_{t+1}} \frac{\partial^2 g}{\partial\theta\partial l_{1,t}^{x}} > 0 \; and \; \frac{\partial^2 U_1}{\partial\theta\partial m_{t+1}} = 0$, we have $\frac{dl_{1,t}^{x}{}^{*}}{d\theta} > 0 \; and \; \frac{dm_{t+1}^{*}}{d\theta} < 0$. Then, equation (4) implies that $\frac{dx_{t+1}^{*}}{d\theta} = \frac{\partial g}{\partial l_{1,t}^{x}{}^{*}} \frac{dl_{1,t}^{x}{}^{*}}{d\theta} > 0$.

Proposition 1 states that secured tenure ensures better conservation of the topsoil, i.e., $\frac{dx_{t+1}^{*}}{d\theta} > 0$. In addition, since $\frac{\partial m_{t+1}^{*}}{\partial\theta} < 0$, unspent money becomes a weaker substitute for the remaining topsoil under greater tenure security. Together, the altruistic current generation substitutes agricultural labor for conservation efforts in time t under greater tenure security, and, therefore, transfers more topsoil instead of more money to the future generation in time $t + 1$. These results are consistent with a set of literature on land conservation investment in developing countries (e.g., Abdulai *et al.*, 2011; Besley, 1995; Deninger and Jin, 2003; Feneske, 2011), which states a positive effect of tenure security on land conservation.

The inter-temporal nature of the choice between unexploited topsoil and unspent money ensures that the current generation will not fully exploit the topsoil; however, that does not ensure its intergenerational sustainability since the topsoil is conserved for the betterment of the future generation, and not for the sake of topsoil itself. In fact, the presence of unspent money as an alternative mode of transfer allows the altruistic current generation to degrade the topsoil, which might be even accelerated under lower tenure security. Hence, tenure insecurity explains the topsoil degradation in the rural areas of many developing countries. For a formal description, let $\exists\theta^* \in \theta \; such \; that \; x^*_{t+1}(\theta^*) = x_t$ and $m^*_{t+1} > 0$. Thus, since $\frac{dx^*_{t+1}}{d\theta} > 0$, we must have $x^*_{t+1} < x_t \; \forall\theta < \theta^*$ which defines the range of tenure security associated with topsoil degradation.

5. Tenure security, subsistence needs, and sustainability of topsoil

A plethora of literature on the determinants of environmental degradation identify poverty as a contributor to environmental degradation, which includes topsoil degradation (e.g., Barbier, 2010; Duraiappah, 1998). We include subsistence needs, defined as the basic consumption required for survival, as a subjective measure of poverty. In addition to the effect of tenure security, we are also interested in identifying the effect of subsistence needs on current generation's transfer choices. Proposition 2 summarizes the effects of subsistence needs.

Proposition 2. *The current generation lowers conservation efforts and both the modes of transfer, under greater subsistence needs. That is,* $\frac{dl^{x\,*}_{1,t}}{d\bar{c}} < 0$; $\frac{dm^*_{t+1}}{d\bar{c}} < 0$ *and* $\frac{dx^*_{t+1}}{d\bar{c}} < 0$.

Proof. Assume that the second-order conditions are satisfied. Now, from the first-order conditions: $\frac{\partial^2 U_1}{\partial\bar{c}\partial l^x_{1,t}} = \rho\frac{\partial^2 u_{1,t+1}}{\partial(c_{1,t+1}-\bar{c})^2}\frac{\partial q_{1,t}}{\partial l_{1,t}} < 0$ and $\frac{\partial^2 U_1}{\partial\bar{c}\partial m_{t+1}} = \rho\frac{\partial^2 u_{1,t+1}}{\partial(c_{1,t+1}-\bar{c})^2} < 0$. Thus, we have $\frac{dl^{x\,*}_{1,t}}{d\bar{c}} < 0$ *and* $\frac{dm^*_{t+1}}{d\bar{c}} < 0$, which also implies that $\frac{dx^*_{t+1}}{d\bar{c}} < 0$.

Most human-induced land and soil degradations occur because of the interactions between the land and its users (Gerber *et al.*, 2014). However, the relationship between poverty and environmental degradation is ambiguous in literature (e.g., Reardon and Vosti, 1995; Grepperud, 1997; Bulte and van Soest, 2001; Carter and Barrett, 2006; Barbier, 2010). Yet, rural households from developing countries use subsistence environmental products such as food, fuel, fodder, construction materials, medicine, and other products from natural environments to meet subsistence needs and generate cash income (Angelsen *et al.*, 2014; Byron and Arnold, 1999; Sunderlin *et al.*, 2005). Angelsen *et al.* (2014) finds that environmental income accounts for 28% of total household income, whereas the poor households rely more heavily on such environmental income. Thus, the statement in Proposition 2 that subsistence needs decrease conservation efforts is consistent with a set of related literature.

An increase in subsistence needs necessarily affects the savings carried over from time t to time $t+1$, which eventually affects the consumption and monetary transfer decisions in time $t+1$. However, since we assume $c_{1,t+1} > \bar{c}$, and since the current generation increases agricultural labor in response to an increase in subsistence needs, we identify that subsistence needs decrease both the modes of transfer (Proposition 2).

Next, Proposition 3 identifies the effects of simultaneous changes in tenure security and subsistence needs on current generation's transfer choices.

Proposition 3. *Subsistence needs and tenure security have offsetting effects on labor allocation and transfer decisions. That is,* $\frac{d^2 {l^x_{1,t}}^*}{d\bar{c}d\theta} = 0$; $\frac{d^2 m^*_{t+1}}{d\bar{c}d\theta} = 0$ *and* $\frac{d^2 x^*_{t+1}}{d\bar{c}d\theta} = 0$.

Proof. Assume that the second-order conditions are satisfied. Now, from the first-order conditions, $\frac{\partial^3 U_1}{\partial\theta\partial\bar{c}\partial l^x_{1,t}} = 0$ and $\frac{\partial^3 U_1}{\partial\theta\partial\bar{c}\partial m_{t+1}} = 0$ so that $\frac{d^2 {l^x_{1,t}}^*}{d\bar{c}d\theta} = 0$, $\frac{d^2 m^*_{t+1}}{d\bar{c}d\theta} = 0$ *and* $\frac{dx^*_{t+1}}{d\bar{c}d\theta} = 0$.

Proposition 3 is consistent with literature. For example, Barbier (1997) identifies that poverty and insecure land tenure may result against long-term land management strategies such as adopting conservation practices. However, we consider the joint effects of tenure security and subsistent needs in presence of alternative modes of transfer. Proposition (3) suggests offsetting impacts of tenure security and subsistence needs on the alternative uses of labor and alternative modes of transfer, leading to important implications, especially for developing countries where subsistence needs are highly important and tenure security is often uncertain. In Section 6, we develop testable hypotheses based on these theoretical findings and provide empirical evidence in their support.

6. Empirical specifications and results

6.1 Data and Hypotheses

Propositions (1)–(3) indicate that secured tenure results in the current generation substituting agricultural labor for conservation efforts, and, therefore, switching from monetary to topsoil transfer. Based on these theoretical results, our generic hypothesis is that households with greater tenure security will have greater conservation efforts and topsoil transfer to the future generation. For empirical investigation, we use data from the Household Income and Expenditure Survey (HIES), which is the primary source of household-level socio-economic data in Bangladesh.

We chose Bangladesh for two reasons. First, the availability of HIES dataset. We use two recent HIES datasets from survey years 2000 and 2005, with corresponding sample sizes of 7,440 and 10,080. Second, our theoretical model fits perfectly for the case of Bangladesh. Bangladesh is a densely populated country with high dependency on agriculture, especially in its rural areas. In 2009, agriculture employed around 44 percent of the labor force in Bangladesh and contributed around 20 percent of its gross domestic product (BBS, 2010).

Table 1
Summary statistics.

Variable	Mean	Std. Dev.
Cropping-intensity	1.65	0.66
Educational expenditures per child (in taka)	976	1778
Tenure Security	0.63	0.41
Poverty Status	0.66	0.47
Age of the Household Head	44.67	13.29
Household Size	5.23	2.24
Primary Schooling	0.96	0.20
Ownership of tractor/plough-yoke	0.32	0.46
Land quality	0.06	0.24

Notes: We restrict the estimating sample to rural agricultural households to fit the conceptual framework. We define "Rural" as 1 if the household lives in rural areas and 0 if otherwise; "Agricultural Household" as 1 if agriculture is the main source of income and 0 if otherwise. We define "poverty" as 1 if the household spends below the subdivision average level (i.e., poor) and 0 if otherwise (i.e., non-poor), "plough-ownership" as 1 if the household owns a tractor or a plough-yoke and 0 if otherwise, and "land quality" as 1 if the household owns better quality land than the subdivision average and 0 if otherwise. Other variables follow the usual definition.

Due to data limitation and the absence of direct measures, we use alternative measures and definitions for labor allocation, and topsoil and monetary transfers. First, we use cropping-intensity to measure labor allocation. Cropping-intensity (CI) is the number of times a household cultivates a piece of land in a year. Thus, average cropping-intensity for all the pieces of lands, $i = 1,2, \dots, I$ is $CI = \frac{\sum_{i=1}^{I} Cultivated\ Land\ Area}{Total\ Operated\ Land}$. Given the limited labor time, higher cropping-intensity corresponds to higher allocation of agricultural labor and lower conservation efforts, and vice-versa. In practice, Bangladesh has three cropping seasons, which implies that it can have a maximum cropping-intensity of three. Table 1 reports that the average cropping-intensity is 1.65.

Next, we use household's private expenditure on children's education as a measure of monetary transfer to the future generation. Since primary schooling is free and compulsory in Bangladesh, private educational expenditure (EE) is a choice to the household. Moreover, beyond the primary schooling, parents need to allocate a considerable amount of money on their school-going children. HIES contains itemized data on each household's private expenditure for children's schooling. On average, rural agricultural households spend 976 taka per school-going child every year (Table 1).

We empirically define our key parameters of interest, tenure security and subsistence needs, based on the HIES2000 data. First, rural agricultural households usually operate a combination of owned and rented agricultural lands, often without any formal agreement with the owners of rented-in lands. Considering this phenomenon pertinent to many developing countries, we measure tenure security as the proportion of owned land to total operated land: $TS = \frac{Owned\ land}{Operated\ land} \in (0,1]$. According to this definition, the average tenure security among the surveyed rural agricultural households in HIES 2000 is 0.63 (Table 1). That is, they own 63-percent of their total operated lands. Next, since subsistence needs is a subjective measure of poverty, we use household's poverty status (PS) as a measure of subsistence needs. We define poverty status as 1 if the household spends below the subdivision average per-capita expenditure (i.e., poor household), and 0 if otherwise (i.e., non-poor household). Using this definition, 66-percent of the rural agricultural households are poor (Table 1).

Based on the empirical definitions and measurements of key variables from HIES as well as propositions (1)–(3), we identify following specific hypotheses for empirical investigation:

1. Greater tenure security results in lower cropping-intensity and lower educational expenditure, and vice-versa.
2. Poor households have higher cropping-intensity and lower educational expenditure, and vice-versa.
3. Greater tenure security results in a switch from educational expenditure to lower cropping-intensity as the mode of transfer.

In addition to these hypotheses, we investigate whether tenure security and poverty have offsetting effects on cropping-intensity and educational expenditure.

6.2 Empirical Specifications

Consistent with the conceptual model, we test the hypotheses (1)–(3) for rural agricultural households, who are rural households primarily dependent on agriculture for income. We mainly focus on two outcome variables: cropping-intensity (CI) and logged educational expenditures (ln(EE)). The estimating equation for the effects of tenure security (TS) and poverty (PS) on the outcome variables y for household i is

$$y_i = \alpha_0 + \alpha_1 TS_i + \alpha_2 PS_i + \beta X_i + \epsilon_i. \quad (8)$$

Equation (8) addresses the hypotheses (1) and (2). Our parameters of interest are α_1 *and* α_2, representing the effects of tenure security and poverty. We expect $\hat{\alpha}_1 < 0$ *and* $\hat{\alpha}_2 > 0$ for cropping-intensity, and $\hat{\alpha}_1 < 0$ *and* $\hat{\alpha}_2 < 0$ for educational expenditure.

Apart from our main explanatory variables, we include a vector of controls, X. Based on HIES data and the related literature on farm level investment theory (e.g., Feder *et al.*, 1992; Clay *et al.*, 1998; Gebremedhin and Swinton, 2003), X includes variables representing farming capacity (i.e., plough-ownership, land quality and family size) and household's demographic characteristics and socioeconomic status (i.e., gender, age and schooling of the household head). We define plough-ownership as 1 if the household owns a tractor or a plough-yoke and 0 if otherwise, land quality as 1 if the household owns better quality land than the subdivision average and 0 if otherwise, and schooling as 1 if the household head completes at least 5th grade and 0 if otherwise. Other control variables follow the usual definition.

Conditions (6) and (7) suggest that the choice between alternative modes of transfer follow a system of equations. Thus, empirical testing of hypothesis (3) requires the use of IV-2SLS method. We specify the second-stage equation as:

$$CI_i = \gamma_0 + \gamma_1 \ln(EE)_i + \delta X_i + \epsilon_i, \quad (9)$$

whereas (8) endogenously determines ln(EE), and thus specifies the first-stage equation. Our parameter of interest is γ_1, and we expect to get $\hat{\gamma}_1 > 0$ which implies a tradeoff between the modes of transfer.

6.3 Regression Results

Table 2 reports the regression results based on (8) and (9). In addition to the OLS estimates in Columns (1) and (2) for cropping-intensity and logged educational expenditure, we report SUR estimates in Columns (3) and (4) as a robustness check since cropping-intensity and educational expenditure could have simultaneity. Except for household size, all other estimated coefficients are consistent across estimating method. Thus, we use OLS estimates for the following discussion.

We find a consistently negative, but statistically insignificant, relationship between tenure security and cropping-intensity. Results show that a 1-unit increase in tenure security leads to a 0.011-unit reduction in cropping-intensity (Column 1 in Table 2). On the other hand, poverty status and cropping-intensity have positive and significant relationship: poor households have 0.079-units greater cropping-intensity than the non-poor households.

For educational expenditure (Column 2 in Table 2), we find a positive and significant relationship between tenure security and educational expenditure. Results show that a 1-unit increase in tenure security leads to a 26.9-percent increase in educational expenditure. On the other hand, poverty status and educational expenditure have negative and significant relationship: poor households have 79.2-percent lower educational expenditure than the non-poor households.

Table 2
Main regression results – effects of tenure security and poverty status.

	(1)	(2)	(3)	(4)	(5)
	OLS Estimates		SUR Estimates		IV-2SLS
VARIABLES	CI	Log(EE)	CI	Log(EE)	Tradeoff
Tenure Security	-0.011	0.269**	-0.003	0.279**	
	(0.049)	(0.111)	(0.048)	(0.115)	
Poverty Status	0.079**	-0.792***	0.113***	-0.815***	
	(0.037)	(0.095)	(0.040)	(0.096)	
Age	0.000	0.029***	0.003**	0.027***	0.007***
	(0.001)	(0.005)	(0.002)	(0.004)	(0.002)
Household Size	0.003	0.046**	-0.014	0.050**	-0.007
	(0.009)	(0.023)	(0.009)	(0.022)	(0.010)
Plough Ownership	0.122***	0.068	0.137***	0.034	0.141***
	(0.038)	(0.092)	(0.039)	(0.093)	(0.043)
Primary Schooling	0.037	-0.041	0.103	-0.133	0.085
	(0.071)	(0.188)	(0.085)	(0.203)	(0.083)
Land Quality	0.008	0.092	0.047	0.041	0.050
	(0.100)	(0.408)	(0.082)	(0.197)	(0.114)
Log(EE)					-0.124***
					(0.048)
Constant	1.509***	4.677***	1.387***	4.868***	2.016***
	(0.101)	(0.317)	(0.124)	(0.299)	(0.237)
Observations	1,743	1,319	1,204	1,204	1,204
R^2	0.011	0.138	0.019	0.133	0.002

Notes: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. Regressions (1) and (2) correspond to cropping-intensity and (logged) educational expenditures. Regressions (3) and (4) provide results from alternative specification for (1) and (2), respectively. Finally, regression (5) corresponds to the tradeoff between (logged) educational expenditures and cropping-intensity. We restrict the estimating sample to rural agricultural households to fit the conceptual framework.

Together, we estimate $\hat{\alpha}_1 < 0 \; and \; \hat{\alpha}_2 > 0$ for cropping-intensity (Column 1 in Table 2), and $\hat{\alpha}_1 > 0 \; and \; \hat{\alpha}_2 < 0$ for educational expenditure (Column 2 in Table 2). That is, households with greater tenure security have lower cropping-intensity and higher educational expenditure. These findings are robust to alternative estimating methods, and provide partial support to hypothesis (1). We do not identify expected direction of relationship between tenure security and educational expenditure: they are positively related. On the other hand, consistent with hypothesis (2), poor households have greater cropping-intensity and lower educational expenditure.

Ownership of a tractor or a plough-yoke, which represents the entitlement to the means of cultivation, significantly increases cropping-intensity by 0.122-units. However, there are no significant effects of age, household size, schooling and land quality on cropping-intensity.

Age and household size have significant and positive effects on educational expenditure. In particular, a 1-year older household head spends 2.9-percent higher on education, whereas a 1-member larger household spends 4.6-percent higher on education. We perceive that instead of representing farming capacity and socioeconomic status of the household, these control variables may rather represent the demand for educational expenditure. Other controls, plough ownership, schooling and land quality, do not have any significant effects on educational expenditure.

Contrary to our hypothesis (3), OLS estimates suggest that households with secured tenure have greater educational expenditure instead of lower cropping-intensity. We have two interrelated explanations behind this empirical practice. First, potential endogeneity between cropping-intensity and educational expenditure, as condition (7) suggests. We address this issue in (9), and use the IV-2SLS method to estimate the relationship between cropping-intensity and educational expenditure (Column 5 in Table 2). We find a negative and significant relationship between cropping-intensity and educational expenditure, which, together with results in Column (2), opposes hypothesis (3): households with greater tenure security have higher educational expenditure as well as lower cropping-intensity, and vice-versa. As well, poor households have lower educational expenditure as well as higher cropping-intensity, and vice-versa.

However, negative relationship between cropping-intensity and educational expenditure implies poverty status, not tenure security, dominates household's transfer decisions. This leads to our second explanation, dominant effects of poverty status on both cropping-intensity and educational expenditure. Thus, we investigate hypotheses (1) and (2) for poor and non-poor households separately (Table 3).

Regression results vary by poverty status (Table 3). Tenure security and cropping-intensity have negative relationship for poor households (Table 3 Column 1), but positive relationship for non-poor households (Table 3 Column 4). On the other hand, tenure security and educational expenditure have positive relationships for both the poor and non-poor households (Table 3 Columns 2 and 5), whereas the relationship is significant only for non-poor households.

Table 3.
Regression results by poverty status.

	(1)	(2)	(3)	(4)	(5)	(6)
	Poor Households Only			Non-poor Households Only		
VARIABLES	CI	Log(EE)	Tradeoff	CI	Log(EE)	Tradeoff
Tenure Security	-0.027	0.074		0.014	0.732***	
	(0.054)	(0.126)		(0.084)	(0.232)	
Age	0.001	0.026***	0.009	-0.001	0.030***	0.002
	(0.002)	(0.006)	(0.021)	(0.002)	(0.006)	(0.005)
Household Size	-0.007	0.079**	-0.020	0.013	0.013	0.010
	(0.011)	(0.035)	(0.084)	(0.013)	(0.023)	(0.014)
Plough Ownership	-0.092	-0.264	-0.065	0.215**	0.250	0.287**
	(0.089)	(0.213)	(0.351)	(0.102)	(0.289)	(0.127)
Primary Schooling	0.132***	0.109	0.136	0.105*	0.002	0.159**
	(0.046)	(0.112)	(0.083)	(0.057)	(0.154)	(0.064)
Land Quality	-0.078	-0.069	-0.076	0.162	0.368	0.182
	(0.143)	(0.423)	(0.242)	(0.145)	(0.387)	(0.159)
Log(EE)			-0.156			0.002
			(0.871)			(0.134)
Constant	1.729***	4.115***	2.334	1.325***	4.186***	1.128*
	(0.130)	(0.333)	(3.746)	(0.141)	(0.473)	(0.662)
Observations	1,076	807	741	667	512	463
R^2	0.011	0.072		0.017	0.087	0.029

Notes: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. Columns (1)–(3) correspond to cropping-intensity, (logged) educational expenditure and tradeoff for poor households, whereas Columns (4)–(6) report the corresponding results for non-poor households. We restrict the estimating sample to rural agricultural households to fit the conceptual framework.

Secured tenure results in lower cropping-intensity and higher educational expenditure for poor households. However, none of these estimated relationships is statistically significant. Meanwhile, non-poor households with secured tenure have insignificantly higher cropping-intensity and significantly higher educational expenditure. These results suggest that while the poor households are unable to tradeoff between cropping-intensity and educational expenditure, non-poor households can do the tradeoff. Table 3 Columns 3 and 6 confirm these results. However, these results, and their implications, oppose hypotheses (3) since the non-poor households with greater tenure security increases educational expenditure instead of lowering their cropping-intensity.

7. Additional Results and Robustness Check

7.1 Results including "urban" agricultural households

Our conceptual framework necessitates using the sample of rural agricultural households. However, often the identification of a rural household is somewhat vague, requiring a robustness check. The definition of "rural" in HIES is statistical, and often a household from an "urban" area may operate its agricultural lands in an adjacent "rural" area. Table 4 reports the regressions (8) and (9) for both rural and urban agricultural households.

Table 4
Regression results for all agricultural households.

VARIABLES	(1) CI	(2) Log(EE)	(3) Tradeoff
Tenure Security	-0.018	0.254**	
	(0.047)	(0.108)	
Poverty Status	0.058	-0.808***	
	(0.036)	(0.094)	
Age	0.000	0.029***	0.005**
	(0.001)	(0.005)	(0.002)
Household Size	0.001	0.043*	-0.009
	(0.008)	(0.022)	(0.010)
Plough Ownership	0.017	0.001	0.070
	(0.070)	(0.179)	(0.079)
Primary Schooling	0.130***	0.011	0.145***
	(0.037)	(0.087)	(0.040)
Land Quality	-0.104	0.177	-0.099
	(0.086)	(0.287)	(0.094)
Log(EE)			-0.090**
			(0.046)
Constant	1.557***	4.726***	1.905***
	(0.101)	(0.312)	(0.231)
Observations	1,857	1,416	1,294
R^2	0.012	0.138	0.022

Notes: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. Columns (1)–(3) correspond to cropping-intensity, (logged) educational expenditure and tradeoff for agricultural households.

Results are consistent with Table 2. Except for schooling and land quality, all other explanatory variables exhibit similar relationships with the outcome variables. We find that agricultural households with greater tenure security have insignificantly lower cropping-intensity and significantly greater educational expenditure. In addition, poor households have insignificantly greater cropping-intensity and significantly lower educational expenditure.

Moreover, we find a negative and significant relationship between cropping-intensity and educational expenditure, which, consistent with Table 2, opposes hypothesis (3) for agricultural households.

7.2 An indirect measure of land quality transfer

Although HIES data do not have any direct measurement of topsoil and its intergenerational transfer, we use the self-reported data on land quality from the HIES as a measure of topsoil. This assumption is valid since topsoil depth is the principal component of land quality. We group lands according to quality: 0 (worst quality) through 3 (best quality). However, since HIES data are not longitudinal, we calculate the average land quality at the subdivision level for both the survey years. We then consider land quality in 2000 as available for current agricultural production and land quality in 2005 as available for future production.

Table 5 reports regressions (8) and (9) for the rural agricultural households using this indirect measure of land quality transfer. Results in Column 2 exactly match those from Table 2 Column 2. However, Columns 1 and 3 provide robustness checks for Table 2 Columns 1 and 3.

Table 5
Regression results with "land quality transfer"

VARIABLES	(1) Land Quality	(2) Log(EE)	(3) Tradeoff
Tenure Security	-0.073**	0.269**	
	(0.035)	(0.111)	
Poverty Status	0.023	-0.792***	
	(0.028)	(0.095)	
Age	0.001	0.029***	0.002
	(0.001)	(0.005)	(0.002)
Household Size	-0.006	0.046**	-0.006
	(0.007)	(0.023)	(0.008)
Plough Ownership	-0.035	-0.041	-0.046
	(0.057)	(0.188)	(0.066)
Primary Schooling	0.056	0.068	0.043
	(0.043)	(0.092)	(0.043)
Land Quality	-0.100	0.092	-0.116
	(0.153)	(0.408)	(0.150)
Log(EE)			-0.076*
			(0.040)
Constant	2.245***	4.677***	2.652***
	(0.087)	(0.317)	(0.200)
Observations	1,591	1,319	1,086
R^2	0.015	0.138	

Note: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. Columns (1)–(3) correspond to land quality transfer, (logged) educational expenditure and tradeoff. We restrict the estimating sample to rural agricultural households to fit the conceptual framework.

Consistent with Table 2, households with greater tenure security have lower land quality but greater educational expenditures. A 1-unit increase in tenure security significantly decreases land quality by 0.073-units, whereas a 1-unit increase in tenure security significantly increases educational expenditures by 26.9 percent. These results entirely oppose hypothesis (3): households with greater tenure security are less inclined to transfer land quality; rather, they are interested in increasing educational expenditure.

7.3 Substitutability and Switching behavior

So far, empirical results and subsequent discussions imply that tenure security, as empirically defined in this paper, does not result in substitutability among the modes of transfer. Furthermore, rural agricultural households with secured tenure increase their educational expenditure instead of lowering their cropping-intensity.

To check for robustness of this finding, we define household's switching behavior between cropping-intensity and educational expenditure as $SW_i = \frac{CI_i}{EE_i}$, and estimate:

$$SW_i = \delta_0 + \delta_1 TS_i + \delta_2 PS_i + \beta X_i + \epsilon_i. \tag{10}$$

Greater values of SW_i imply that the household prefers lowering cropping-intensity to educational expenditures as the mode of transfer, and vice-versa. Our parameters of interest are $\delta_1 \; and \; \delta_2$, and we expect to get $\hat{\delta}_1 > 0 \; and \; \hat{\delta}_2 < 0$ according to the hypothesis (3). Table 6 reports the regression results.

Table 6
Household's switching behavior.

VARIABLES	(1) Switching Behavior
Tenure Security	-0.015
	(0.014)
Poverty Status	0.057***
	(0.009)
Age	-0.001**
	(0.000)
Household Size	-0.005**
	(0.002)
Plough Ownership	0.011
	(0.021)
Primary Schooling	0.028***
	(0.010)
Land Quality	-0.011
	(0.027)
Constant	0.322***
	(0.031)
Observations	1,176
R^2	0.059

Note: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural agricultural households to fit the conceptual framework.

Results in Table 6 confirm the validity of those from Table 2 Columns 1 and 2. We find that households with tenured secure have insignificantly lower ratio of cropping-intensity to educational expenditure, whereas poor households have significantly higher ratio.

7.4 Offsetting impacts of tenure security and poverty

Proposition 3 implies that tenure security and poverty have offsetting influences on cropping-intensity and educational expenditure. Regression results provide, however limited, supports towards this notion since the directions of relationship are opposite for these two explanatory variables. Statistical significance and relative magnitudes suggest that the effects of poverty status dominate those of tenure security. In addition to separate regressions by poverty status in Table 3, we introduce interaction between tenure security and poverty status in (8) and (9) in Table 7.

Table 7
Offsetting effects of tenure security and poverty.

VARIABLES	(1) CI	(2) Log(EE)	(3) Tradeoff
Tenure Security * Poverty Status	0.044	-0.559***	
	(0.041)	(0.107)	
Age	-0.000	0.035***	0.007**
	(0.001)	(0.005)	(0.003)
Household Size	0.005	0.033	-0.006
	(0.009)	(0.023)	(0.010)
Plough Ownership	0.042	-0.089	0.084
	(0.071)	(0.180)	(0.082)
Primary Schooling	0.118***	0.096	0.141***
	(0.038)	(0.092)	(0.043)
Land Quality	0.015	0.090	0.051
	(0.101)	(0.422)	(0.114)
Log(EE)			-0.134
			(0.083)
Constant	1.545***	4.411***	2.057***
	(0.098)	(0.300)	(0.378)
Observations	1,743	1,319	1,204
R^2	0.008	0.097	

Note: Cluster-robust standard errors in (), with ***,** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. Columns (1)–(3) correspond to cropping-intensity, (logged) educational expenditure and tradeoff. We restrict the estimating sample to rural agricultural households to fit the conceptual framework.

Consistent with results in Tables 2 and 3, we find that poor households with secured tenure have insignificantly greater cropping-intensity and significantly lower educational expenditure. Thus, tenure security and poverty have opposing, but not necessarily offsetting, impacts.

8. Conclusions

We develop an overlapping generation model of rural agricultural households to investigate the tradeoff between alternative modes of transfer, unexploited topsoil and unspent money. Tenure security and subsistence needs have significant influences on the underlying tradeoff, resulting in the current generation substituting agricultural labor for conservation efforts under greater tenure security, and, doing the opposite under greater subsistence needs. Consequently, the current generation switches from monetary transfer to topsoil transfer under greater tenure security or lower subsistence needs, when the modes of transfer are substitutable. Furthermore, tenure security and subsistence needs have offsetting effects on the sustainability of topsoil.

Based on our theoretical findings and data availability, we hypothesize that (1) greater tenure security results in lower cropping-intensity and lower educational expenditure, (2) poor households have higher cropping-intensity and lower educational expenditure, and (3) greater tenure security results in a switch from educational expenditure to lower cropping-intensity as the mode of transfer. We use the Bangladesh Household Income and Expenditure Survey (HIES) dataset, which contains data on cropping-intensity and savings spent on education, to test these hypotheses empirically.

Regression results provide some support to these hypotheses. Households with greater tenure security have lower cropping-intensity and higher educational expenditure. On the other hand, poor households have greater cropping-intensity and lower educational expenditure. While these empirical results partially support hypotheses 1 and 2, they entirely oppose hypothesis 3. In fact, rural agricultural households prefer higher educational expenditure to lower cropping-intensity as their mode of transfer. Furthermore, tenure security and poverty have opposite, but not offsetting, influences on cropping-intensity and educational expenditure. These findings are broadly robust to different estimating method, empirical specification, subsamples, and definitions of transfer.

Altruistic households typically want their children out of subsistence-based agriculture, as evident in our empirical analysis. The direction of tradeoff between cropping-intensity and educational expenditure, i.e., preference towards educational expenditure, implies that increase in educational expenditure requires higher cropping-intensity. This result has an important implication for conservation and development. Increased public expenditure in education may potentially release the rural agricultural households from spending on their children’s schooling, in addition to releasing the children from providing unpaid agricultural and domestic labor (Admassie, 2003; Pallage and Zimmermann, 2007). In addition, it will potentially lower the pressure on land and soil resources to provide income for consumption as well as educational expenditure.

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