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TENURE SECURITY, HUMAN CAPITAL AND SOIL CONSERVATION IN AN OVERLAPPING GENERATION RURAL ECONOMY *

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We develop an overlapping generation model of rural agricultural households to examine whether tenure security and subsistence needs influence the choice between unexploited topsoil and investment in children's human capital as the mode of transfer of wealth. A unique dataset from Bangladesh finds that tenure security is associated with greater topsoil conservation and lower human capital investment. Therefore, there exists a tradeoff between these two modes of transfer. We suggest that increased public expenditure on schooling, which substitutes private expenditure, may lower the pressure on land and soil resources.

Keywords: Human capital; soil conservation; tenure security.

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

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I. INTRODUCTION

Rural areas of developing countries are highly dependent on agriculture for both income and employment (Malik 1999). Around 70 percent people from low-income countries live in rural areas where agriculture is the principal economic activity, contributing around 32 percent of the gross domestic product and employing nearly 80 percent of the workforce (World Bank 2015). Moreover, low per-capita arable land results in high incidences of poverty in those countries; only 0.22 hectares of land are available per-capita and around 47 percent of people live below the $1.90/day poverty line in lower income countries (World Bank 2015).[1] Hardcore poverty often forces farmers, especially smallholders, to use their limited land resources intensively to meet even 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 soil 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); and, often tenure insecurity results in overexploitation of the topsoil to maximize the immediate returns at the cost of future damages (Ray 2005). 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 amounts of time and effort for topsoil conservation, often as a form of stewardship for future generations (Besley 1995; Brasselle, Gaspart, and Platteau 2002; Deninger and Jin 2006; Ervin and Ervin 1982; Reardon and Vosti 1995). This suggests the presence of altruistic behavior within the family (e.g., Becker 1981), and we therefore consider such 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 effort (Deininger, Jin, and Yadav 2013; Deininger and Jin 2006; Gebremedhin and Swinton 2003; Kabubo-Mariara 2007; Ray 2005). Consequently, tenure security can play a central role in influencing the topsoil conservation

[1] In 2012, 47 percent of the population of low-income countries still lived on less than US$1.90 (2011 PPP) a day per capita, and 74 percent lived on less than US$3.10 (2011 PPP) a day per capita (World Bank 2015). Low-income countries are those in which 2014 GNI per capita was $1,045 or less.

decision (IFAD 2008; UNECA 2009). Land tenure, which refers to the social relations and institutions that govern access to and control over land and related resources, determines who can use the land resources, for how long and under what conditions (IFAD 2008). Consistent with this definition, we empirically define tenure security in terms of owned land as proportion of total operated agricultural land by a household. In many developing countries including Bangladesh, agricultural land rental transactions are mostly informal and, therefore, represent a reasonable form of tenure insecurity (e.g., Eskander and Barbier 2016; Ray 2005).[2] 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 investment in human capital of the future generation.

We develop an overlapping generations (OLG) model of a representative rural agricultural household to explore the linkage between intra-household altruism, tenure security and topsoil conservation. The current generation maximizes an altruistic inter-temporal utility function by making labor allocation, consumption and transfer decisions. At the beginning of the second period, the current generation allocates its total labor time between agricultural production and topsoil conservation, and allocates agricultural income between consumption and human capital investment. It transfers the agricultural land with the remaining topsoil to the future generation at the end of the second period. Thus, after meeting its production and consumption needs, the current generation may end up transferring various combination of unexploited topsoil and human capital investment to the future generation (e.g., Tomes 1982).

Our theoretical analysis focuses on substitutability between unexploited topsoil and human capital investment as the method of transfer. Based on the theoretical findings, we hypothesize that households with greater tenure security have greater conservation investment and lower human capital investment. We use the Bangladesh Household Income and Expenditure Survey (HIES) dataset to investigate these hypotheses for the agricultural households of Bangladesh.

The impact of tenure security on topsoil and land conservation has been widely studied in the literature (Place 2009; Gebremedhin and Swinton 2003). Potential sources of tenure insecurity include lack of land titles (Bezabih, Holden, and Mannberg 2012), short-term tenancy contracts (Bandiera 2007; Ray 2005), lack of transferability (Besley 1995), risk of expropriation

[2] Similarly, Ray (2005) considers share tenancy as a measure of tenure security. It identifies that the tenant-farmers might overexploit the land to maximize immediate returns even at the cost of future damages, and under-supply long-run productivity improving investments in land, than the owner-farmers.

(Deininger and Jin 2006) and customary gender-biased inheritance practices (Lovo 2016). However, the empirical relationship is inconclusive, and depends on the specific case under study (Besley and Ghatak 2009). One possible reason is that the alternative modes of wealth transfer by households have not been considered. This is the first investigation to consider how tenure security influences the choice between unexploited topsoil and human capital investment as the mode of intergenerational transfer of wealth.

We find that a unit increase in tenure security has significant associations with a 0.54 percent increase in conservation investment and 0.16 percent decrease in human capital investment. That is, Bangladeshi agricultural households experience a tradeoff between conservation and human capital investments emerging from tenure security: given the level of tenure security, an increase (decrease) in conservation investment must be accompanied by a decrease (increase) in human capital investment, and vice-versa. Substitutability between them may lead to important implications for developing countries in terms of both private educational expenditure and land resource management. Since public and private investments on conservation and human capital investments are complementary, public policies that target the conservation and management of land and soil resources may result in higher private investment on children's human capital development. Similarly, higher public investment in education may increase conservation investment.

The content of the remainder of the article is as follows. Section II develops the OLG model of rural agricultural households and analyzes the effect of tenure security on optimal decisions. Section III specifies the empirical strategy. Section IV provides a brief discussion of data used for empirical analysis. Section V discusses the main empirical results. Finally, Section VI summarizes and concludes by discussing the key policy implications.

II. AN OLG MODEL OF RURAL AGRICULTURAL HOUSEHOLDS

The overlapping generations (OLG) model in this paper includes two modes of transfer: unexploited topsoil and human capital investment (i.e., educational expenditure), 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).[3] It does not earn in time t, rather lives on the contribution from the previous generation. The current and future generations overlap in time $t+1$, when the current generation earns agricultural income, and makes consumption, labor allocation and transfer decisions.

The current generation uses its fixed endowments of land and labor for agricultural production. It inherits a fixed amount of land with a given topsoil depth and tenure security from the previous generation at the end of time t. On retirement from economic activities at the end of time $t+1$, it transfers the land 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 (de Janvry *et al.* 2015). 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 complete tenure security, and $\theta = 0$ implies zero tenure security. We assume that θ is time-independent, i.e., the degree of tenure security is fixed across generations. Empirical analyses, predominantly on sub-Saharan Africa, provide mixed evidence of direction on the relationship between tenure security and soil conservation (Deininger and Jin 2006). While secured tenure can potentially increase soil conservation investment, such investments could also lead to increased tenure security (Besley 1995). However, empirically the direction of relationship depends on the specific type of investment and definition of tenure security (Lovo 2016). As has been outlined in the following sections, we empirically define tenure security in terms of owned land as proportion of operated land and conservation investment in terms of money spent on compost and forest seedlings. While these types of investments are productivity-enhancing, they are not necessarily security-enhancing (e.g., Deininger and Jin 2006). Moreover, because of the absence of a properly functioning land sales market and no apparent governmental policy on the intergenerational transfer of land in Bangladesh, user rights of agricultural land are typically

[3] 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).

transferred through inheritance, making the security-enhancing role of conservation investments less likely at least according to the empirical definitions we use in this paper.

The current generation maximizes a utility function, which incorporates Stone-Geary preferences (SGP) with respect to its subsistence consumption needs as well as altruistic concerns for the future generation. The present generation gains utility from its consumption above the subsistence level and altruistic utility from the welfare of the future generation. Let $c_{1,t+1}$ denote its consumption in time $t+1$, $\bar{c}$ the subsistence level of consumption, and U_2 the utility of the future generation. The inter-temporal utility of the current generation is:

$$(1) \qquad U_1 = u\left(c_{1,t+1} - \bar{c}\right) + \rho U_2,$$

where $\rho > 0$ denotes the weight on the altruistic utility component. 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 $t+1$).[4] Therefore, utility from consumption in time t drops out of the utility function (1) since $u\left(c_{1,t} - \bar{c}\right) = u(0) = 0$. The function $u(\cdot)$ is twice continuously differentiable and strictly concave in its arguments, i.e., $u' > 0; u'' < 0$.

To derive the indirect utility function v of the future generation, we evaluate U_2 at the optimal values of the choice variables of the current generation.[5] v 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 either transfers the unexploited topsoil (x_{t+1}) or invests in human capital (m_{t+1}), we have:[6]

$$(2) \qquad U_2 \equiv v(x_{t+1}, m_{t+1}), \qquad v_i > 0; v_{ii} < 0; i = x_{t+1}, m_{t+1}.$$

The current generation cultivates its inherited land (A) with a given topsoil depth (x_t) using on-farm physical labor $\left(l_{1,t+1}\right)$ and a vector of all other inputs (B) in time $t+1$. Since the rural

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[4] For simplicity, we assume that the consumption of the previous generation in time t incorporates $c_{1,t}$. This simplification, i.e., $c_{1,t} = \bar{c}$, is common in OLG models (e.g., Dam 2011), 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 $t+1$.

[5] By symmetry, the inter-temporal SGP of the future generation is $U_2 = u\left(c_{2,t+2} - \bar{c}\right) + \rho\, U_3$.

[6] These two types of investment become comparable within our utility maximization framework. Benefits coming from these investments must be compared in terms of resulting marginal utility.

agricultural households often have limited capital, which is generally fixed and non-accumulating, we normalize $A \equiv 1$ and $B \equiv 1$.[7] The agricultural production function, $q_{1,t+1}$, is:

$$(3) \qquad q_{1,t+1} = q\left(l_{1,t+1}; x_t\right), \; q' > 0, \; q'' < 0, \frac{\partial q'}{\partial x_t} > 0.$$

The production function increases at a non-increasing rate with respect to $l_{1,t+1}$ and x_t. An increase in l_{1t+1} may lead to increased output but at a declining rate. We assume $l_{1,t+1} > 0$ since agriculture is the only source of income.[8] Topsoil, x_t, complements the crop productivity of labor. That is, additional soil depth improves the marginal productivity of labor, and vice-versa.[9,10]

The use of labor for agriculture degrades the topsoil depth at an accelerating rate, which may induce the altruistic current generation in topsoil conservation. Following Bulte and van Soest (2001), we consider that it allocates the labor time, $L > 0$, between agricultural production ($l_{1,t+1}$) and conservation effort ($l_{1,t+1}^x$): $L = l_{1,t+1} + l_{1,t+1}^x, l_{1,t+1}^x \geq 0$.[11] Let x_t and x_{t+1}, respectively, denote the current and future generation's endowments of topsoil depth. Conservation effort and tenure security determine the change in topsoil depth: $g = g\left(l_{1,t+1}^x; \theta\right)$. Thus, topsoil depth at the end of time $t+1$ is:

$$(4) \qquad x_{t+1} = x_t + g\left(l_{1,t+1}^x; \theta\right), \; g' \geq 0, g'' \leq 0; \; \frac{\partial g'}{\partial \theta} > 0.$$

Conservation effort l_{1t+1}^x may increase $g(.)$ at a non-increasing rate. Moreover, tenure security θ has a beneficial effect on the marginal effect of $l_{1,t+1}^x$ on $g(.)$. This assumption, $\frac{\partial g'}{\partial \theta} > 0$, follows

[7] Consistent with a set of forestry literature (e.g., Koskela, Ollikainen, and Puhakka (2002) and Olson and Knapp (1997)), we do not include the physical capital without losing any insight since we focus on the rural developing economies.

[8] Including separate agricultural and non-agricultural activities simply complicates the model without contributing to our qualitative results. Among the papers making such distinctions include Narain, Gupta, and van' t Veld (2008). On the other hand, Barbier (2010) considers only the agricultural labor allocation.

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

[10] This assumption is realistic especially for the case of Bangladesh, where, albeit very low per-capita farm size, fertile land contributes to higher rice productivity (Rahman 2010).

[11] Bulte and van Soest (2001) assume that rural households can indirectly enhance the regeneration of natural capital (i.e., topsoil in our model) by allocating a part of their labor time for conservation. Again, our approach resembles the technology choice approach in Barbier (1990), who considers a conventional vector of input package as well as the choice of adopting an alternative package of soil conservation method to determine the remaining topsoil depth. Instead, we consider the allocation of labor time between agriculture and conservation effort.

the fact that, since sharecropping is the dominant form of land rental in Bangladesh, and since renters may produce lower crop per unit of land than the owner-operators (e.g., Shaban 1987), agricultural household's incentive to conserve the topsoil may vary depending on tenure security.

The current generation earns real agricultural income $q_{1,t+1}$ in time $t+1$, which it allocates between own consumption ($c_{1,t+1}$), and human capital investment (m_{t+1}).[12] Therefore, the budget equation in time $t+1$ is:

(5) $$c_{1,t+1} = q_{1,t+1} - m_{t+1}.$$

Since the capital market is imperfect in the rural economy, we assume that the market interest rate is zero (e.g., Fernandez 2006). Since the current generation does not live beyond the end of time $t+1$, we assume that it does not save, rather, it may invest in human capital development alongside financing the subsistence consumption of the future generation.[13]

The current generation maximizes its lifetime utility (1) subject to the constraints (2)–(5) and inequality restrictions $l_{1,t+1}^{x} \geq 0$ and $m_{t+1} \geq 0$ by choosing consumption ($c_{1,t+1}$), labor ($l_{1,t+1}$), conservation effort ($l_{1,t+1}^{x}$) and human capital investment (m_{t+1}). After all possible replacements, the maximization problem becomes:

$$\max_{l_{1,t+1}^{x}, m_{t+1}} U_1 = u\left(q\left(L - l_{1,t+1}^{x}; x_t\right) - \bar{c} - m_{t+1}\right) + \rho v\left(m_{t+1}, x_t + g\left(l_{1t+1}^{x}; \theta\right)\right),$$

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

Optimal values of the choice variables, ${l_{1,t+1}^{x}}^{*}$ and m_{t+1}^{*}, are implicitly determined by the first-order conditions, $\rho v_x g' \leq u' q'$ and $v_m \leq u'$. The current generation decides on labor-conservation and consumption-human capital tradeoffs at the equality of their corresponding marginal benefits and opportunity costs. First, $\rho v_x g' \leq u' q'$ governs the labor-conservation tradeoff, where ${l_{1,t+1}^{x}}^{*} > 0$ if this expression binds. Marginal benefit of conservation effort, $\rho v_x g'$, refers to current generation's discounted marginal utility from conservation effort. On the other hand, the opportunity cost of conservation effort, $u' q'$, corresponds to the effect of labor on

[12] For simplicity, we assume that $c_{1,t+1}$ incorporates the consumption of the future generation in time $t+1$.

[13] This assumption implies that the current generation necessarily spends its unspent money from time $t+1$ on human capital investment. Therefore, subsequent analysis still holds even if we assume positive savings. However, it will only complicate the conceptual framework intended to derive testable hypotheses, which can be then empirically tested using the available data from Bangladesh.

the consumption above the subsistence level. Next, $\rho v_m \leq u'$ governs the consumption-human capital tradeoff, where $m^*_{t+1} > 0$ if this expression binds. The marginal benefit, ρv_m, refers to current generation's discounted marginal utility from human capital investment. The opportunity cost, u', refers to the marginal utility of consumption in time $t+1$ by the current generation.

However, the optimal transfer decision requires simultaneously solving the first-order conditions, which yield a system of equations, according to:

$$(6) \qquad v_x g' \gtreqless v_m q',$$

where $\frac{dv^*}{dl^x_{1,t+1}{}^*} \equiv v_x g'$ and $\frac{dv^*}{dl^*_{1,t+1}} \equiv v_m q'$, respectively, denote current generation's marginal utilities from unexploited topsoil and human capital investment. Condition (6) implies that current generation's labor allocation choices, $l^x_{1,t+1}{}^*$ and $l^*_{1,t+1}$, determine its transfer choices, x^*_{t+1} and m^*_{t+1}. Thus, alternative uses of labor work as alternative sources of altruistic utility: conservation effort increases topsoil transfer, and agricultural labor increases human capital investment.

We have four potential solutions to household's transfer decisions:

1. **No altruism case**. This is the case where the current generation does not make any intergenerational transfer. This case violates the altruism assumption of the model.
2. **Conservation investment only**. First corner solution, $\frac{dv^*}{dl^x_{1,t+1}{}^*} > \frac{dv^*}{dl^*_{1,t+1}}$, implies that the current generation substitutes human capital investment perfectly for conservation investment. It invests only in conservation and, therefore, does not experience any tradeoff due to altruism.
3. **Human capital investment only**. Second corner solution, $\frac{dv^*}{dl^x_{1,t+1}{}^*} < \frac{dv^*}{dl^*_{1,t+1}}$, implies that the current generation substitutes conservation investment perfectly for human capital investment. It invests only in human capital development and, therefore, similar to case 2, does not experience any tradeoff due to altruism.
4. **Tradeoff between conservation and human capital investments**. The interior solution, $\frac{dv^*}{dl^x_{1,t+1}{}^*} = \frac{dv^*}{dl^*_{1,t+1}}$, implies that the current generation invests in both conservation and human capital development. That is, it transfers a combination of them to the future

generation and, therefore, a tradeoff arises between these two imperfectly substitute modes of intergenerational transfer.

Most human-induced land and soil degradations occur because of the interactions between the land and its users (Gerber, Nkonya, and von Braun 2014). Thus, characteristics of land users are important in studying the motivation behind soil conservation. In particular, we focus on the effect of tenure security, which has ambiguous relationship with soil conservation. As our introduction discusses, empirical evidence of the relationship between tenure security and soil conservation depends on the specific case under study. Proposition 1 summarizes the effect of tenure security on soil conservation effort in the presence of human capital investment as an alternative mode of transfer.

Proposition 1. *With increased tenure security, the current generation increases conservation effort, and, decreases human capital investment. That is,* $\frac{d{l_{1,t+1}^{x}}^{*}}{d\theta} > 0$ and $\frac{dm_{t+1}^{*}}{d\theta} < 0$.

Proof. Assume that the second-order conditions are satisfied. Since $\frac{\partial^2 U_1}{\partial\theta\partial l_{1,t+1}^{x}} = \rho v_x \frac{\partial g'}{\partial\theta} > 0$ and $\frac{\partial^2 U_1}{\partial\theta\partial m_{t+1}} = 0$, we have $\frac{d{l_{1,t+1}^{x}}^{*}}{d\theta} > 0$ and $\frac{dm_{t+1}^{*}}{d\theta} < 0$.

Proposition 1, which summarizes the effects of tenure security θ on the optimal choices of conservation effort and human capital investment, states that the current generation increases conservation effort under greater tenure security, and, therefore, transfers more topsoil instead of investing more in human capital. As shown in Figure 1, optimal transfer decisions, x_{t+1}^{*} and m_{t+1}^{*}, correspond to $\theta = \theta_0$. Overall, we have $x_{t+1} \gtreqless x_{t+1}^{*}$ and $m_{t+1} \lesseqgtr m_{t+1}^{*} \forall\theta \gtreqless \theta_0$, so that the underlying tradeoff results in a negatively-slopped expansion path in the (x_{t+1}, m_{t+1})-space.

Inclusion of human capital investment as an alternative mode yields a positive relationship between tenure security and soil conservation effort, which is consistent with a set of literature on land conservation investment in developing countries (e.g., Abdulai, Owusu, and Goetz 2011; Besley 1995; Deninger and Jin 2003; Feneske 2011). In fact, it allows the current generation to degrade the topsoil. Especially under insecure tenure, it might be interested in generating altruistic utility from human capital investment through topsoil degradation rather than from topsoil transfer through conservation effort. Hence, the lack of tenure security explains topsoil degradation in the rural areas of many developing countries. Formally, let $\exists\theta^* \in \theta$ such that $x^*_{t+1}(\theta^*) = x_t$ and $m^*_{t+1} > 0$. Thus, since $\frac{dl^{x}_{1,t+1}{}^{*}}{d\theta} > 0$ implies $\frac{dx^*_{t+1}}{d\theta} > 0$, we must have $x^*_{t+1} < x_t\ \forall\theta < \theta^*$ which defines the range of tenure security associated with topsoil degradation.

III. EMPIRICAL STRATEGY

Based on the Proposition (1), we hypothesize that tenure security has a positive association with conservation investment and a negative association with human capital investment. To avoid any potential bias arising from multiple use of a plot of land, we restrict our estimation to agricultural plots only. Panels A and B in Figure 2 reveal that both our outcome variables, i.e., ln(conservation investment) and ln(human capital investment), are left-censored due to farmer's participation decisions: a positive investment is observed only when a farmer decides to invest in either conservation or human capital development. This requires using a variant of type-II tobit model, as suggested in Greene (2012). First, we use a bivariate probit model to simultaneously estimate the inverse mills ratios household's decisions to invest or not. A farmer i invests according to the following bivariate probit model:

$$(7a) \quad D(cons)_i = f(TS_i, z_{1i}, \eta_{1i})$$
$$(7b) \quad D(hcap)_i = f(TS_i, z_{2i}, \eta_{2i})'$$

where $\eta_{1i} \sim (0, \sigma_1^2)$, $\eta_{2i} \sim (0, \sigma_2^2)$ and $cov(\eta_1, \eta_2) = \rho$. Binary outcome variables representing farmer's willingness to invest, $D(cons)_i$ and $D(hcap)_i$, are defined as $D(cons)_i = 1$ if the farmer invests in conservation and 0 if not and $D(hcap)_i = 1$ if the farmer invests in human capital development and 0 if not. TS_i is tenure security, whereas z_{1i} and z_{2i} are the corresponding vectors of controls. We report these results in Appendix Table A1.

The purpose of the bivariate probit model in (7a) and (7b) is to simultaneously estimate the inverse mills ratios IMR_1 and IMR_2. We then include IMR_1 and IMR_2 as additional explanatory variables when estimating the causal relationships between tenure security and investments in conservation and human capital development. However, since this is not a case of sample selection as the distributions are normal for all the nonzero values of the outcome variables (Greene 2012), we do not limit our estimation to any selected sample.

We define tenure security in terms of owned and rented land. Agricultural households usually operate a combination of owned and rented agricultural lands, often without any formal agreement with the owners of rented-in lands. For example, in 2008, 33.8 percent of rural households in Bangladesh rented at least a part of their total operated land, whereas 24.2 percent operated a combination of owned and rented lands and 9.6 percent operated only rented lands (BBS 2014). Considering this phenomenon pertinent to many developing countries, we measure tenure security as the proportion of owned-operated land to total operated land:

$$TS = \frac{a_i^o}{a_i^o + a_i^r} \in [0,1],$$

where a_i^o and a_i^r denote owned-operated and rented-operated land, respectively.

The advantage of this definition of tenure security is that it allows us to overcome the debate on the direction of relationship between tenure security and conservation investment (e.g. Deininger and Jin 2006). This concern over causal relationship arises because certain forms of soil conservation investments, such as planting trees, may also increase perceived tenure security, as farmers with insecure rights to the land might enhance their claims by making such long-term investments (Besley 1995). Our definition of tenure security avoids this possible endogenous relationship between conservation investments and perceived or enhanced tenure security.[14]

However, because tenure security is defined in terms of owned-operated and rented-operated land, it is likely to be endogenous in terms of household characteristics (e.g., gender, age and schooling of the household head and composition of the household), access to agricultural assets (e.g., plough ownership) and dependency on agriculture (e.g., landholding and primary occupation) (Taslim and Ahmed 1992; Rahman 2010; Eskander and Barbier 2016). In other words, the size of owned land may be exogenously determined, but overall operated land will include rented land, the volume of which is likely to be endogenously determined within the system of equations determining the operated land and farming decisions of the household. Overcoming this endogeneity problem requires using a three-stage least squares (3SLS) model, which first applies two-stage least squares (2SLS) on each individual equation, and then uses the covariance matrix of the residuals retrieved from those 2SLS estimators when estimating the complete system of equations using a seemingly-unrelated regression model. The effects of

[14] However, since the level of tenure security might differ across the plots of operated land, our assumption is valid only for household's aggregate operated land, not for individual plots. Due to the lack of plot level data, this paper could not capture this potential source of endogeneity in tenure security.

tenure security on investments in soil conservation and human capital by the household i are therefore analyzed by estimating through 3SLS the following system of equations:

Stages 1 and 2. Compute 2SLS estimates for $ln(cons)_i$, $ln(hcap)_i$ and TS_i by OLS method using the models $ln(cons)_i = f(\widehat{TS}_i, z_{1i}, \varepsilon_{1i})$, $ln(hcap)_i = f(\widehat{TS}_i, z_{2i}, \varepsilon_{2i})$ and $TS_i = TS(z_{1i}, z_{2i}, \varepsilon_{3i})$, respectively. Then, estimate the covariance matrix of the residuals retrieved from these 2SLS estimates.

Stage 3. Together, stages 1 and 2 describe the 2SLS estimation; whereas the stage 3 completes the 3SLS process by applying a seemingly-unrelated regression model for the complete system of equations:

$$(8a) \quad ln(cons)_i = \alpha_1 + \beta_1 \widehat{TS}_i + \gamma_1 z_{1i} + IMR_1 + \epsilon_{1i},$$
$$(8b) \quad ln(hcap)_i = \alpha_2 + \beta_2 \widehat{TS}_i + \gamma_2 z_{2i} + IMR_2 + \epsilon_{2i},$$

where $z_1 \neq z_2$ so that the order condition is satisfied and the system of equations is identified.

Outcome variables, $\ln(cons)_i$ and $\ln(hcap)_i$, are logged conservation investment and logged per-student human capital investment, respectively.[15] Conservation investment includes the money spent on forest seedling and compost fertilizer, both of which are common soil-enriching practices among the farmers in many developing countries including Bangladesh. The use of compost fertilizer and forest seedlings improves soil fertility and plant growth, and, consequently, controls the soil erosion and nutrient runoff (e.g., Bhattarai *et al.* 2011). On the other hand, we use household's expenditure on children's educational activities as the measure of monetary transfer to the future generation. HIES contains itemized data on each household's private expenditure for children's schooling such as money spent on admission, annual/session fees, registration, tuition, books and stationary, uniform and footwear, private tutoring, hostel expenses, transportation and tiffin costs.

Parameters β_1 and β_2 represent the effects of estimated tenure security on conservation and human capital investments, and we expect to get $\hat{\beta}_1 > 0$ and $\hat{\beta}_2 < 0$. The zero-mean error terms are homoscedastic and independent across households: $\epsilon_{ki} \sim (0, \sigma_k^2)\ \forall k = 1,2$. However, errors are correlated across equations for a given household, $cov(\epsilon_k, \epsilon_\kappa) = \sigma_{k\kappa} \neq 0\ \forall k \neq \kappa$. In this case, equation-by-equation ordinary least squares (OLS) estimates are consistent but inefficient,

[15] Results are similar if we use logged per-student conservation investment instead of logged conservation investment.

whereas seemingly-unrelated regression (SUR) estimates obtained from 3SLS model are efficient through the use of feasible generalized least squares (FGLS) method (Cameron and Trivedi 2010; Greene 2012).

Our empirical approach to estimating (8) involves specifying the components of the vectors z_1 and z_2. We identify separate equation-specific controls, which, since $\sigma_{k\kappa} \neq 0$, ensures the efficiency gains from using the simultaneous equations estimates (Cameron and Trivedi 2010; Greene 2012). Based on HIES data and the related literature on farm-level investment theory (e.g., Feder *et al.* 1992; Clay, Reardon, and Kangasniemi 1998; Gebremedhin and Swinton 2003), the vector z_1 explaining conservation investment includes household head's characteristics such as gender (i.e., 1 if male and 0 if female) and age since male-headed households and older farmers might have higher possibility of renting and therefore lower probability of conservation investment (e.g., Shaban 1987; Ray 2005); household characteristics such as number of working members in the household; plough ownership (i.e., 1 if the household owns a tractor or a plough-yoke and 0 if otherwise); and measures of dependency on agriculture such as primary occupation (i.e., 1 if the household head is primarily a farmer and 0 if otherwise) which might increase the amount of rented land,[16] and logged per-capita landholding of the household in order to control for the possibility that larger farmers are more likely to rent less (e.g., Eskander and Barbier 2016; Rahman 2010). On the other hand, the vector z_2 explaining human capital investment includes gender, logged years of schooling and age of the household head, number of school-going girls in the household, logged per-capita landholding of the household, and primary occupation. In both the vectors, we control for districts and survey years to account for any variation specific to regions and survey years.

For identification of the 3SLS model, we exclude "years of schooling" of the household head and "number of school-going girls" from z_1, both having statistically significant correlation with tenure security; whereas "years of schooling" has statistically insignificant correlation with conservation investment, and "number of school-going girls", which is a measure of investment in human capital development of the future generation, may not have a causal relationship with conservation investment. On the other hand, we exclude "number of working members" and

[16] We derive the number of working members as the difference between household size and number of school-going children. This is an upper-bound estimate since very old people and very little children may also be included as working members.

"plough ownership" from z_2, both having statistically significant correlation with tenure security but not necessarily with human capital investment: "number of working members" has statistically insignificant correlation with human capital investment and "plough ownership" may not have a causal relationship with human capital investment.

IV. DATA

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 three recent HIES datasets from survey years 2000, 2005 and 2010 with corresponding sample sizes of 7,440, 10,080 and 10,200. Second, our theoretical model fits perfectly for the case of Bangladesh, which 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). Due to high level of land fragmentation and increasing population, among many other reasons, Bangladesh has one of the lowest average farm sizes in the world, estimated at 0.85 acres per rural household (BBS 2014; Rahman 2010). Farmers often rent lands to increase their operational farm size: in 2008, 33.8 percent of rural households in Bangladesh rent at least a part of their total operated land (BBS 2014).[17] Sustainability of land and soil resources becomes difficult if the farmers do not operate on their own land and therefore do not have sufficient incentive to adopt conservation practices (e.g., Deininger, Jin, and Yadav 2013; Jacoby and Mansuri 2008; Ray 2005). It is most likely that owner-farmers have the best incentive to conserve their soil resources because they have more freedom in their production plans than tenant-farmers.

Table 1 describes the dependent and explanatory variables used in our empirical analysis. Our conceptual framework necessitates using the sample of rural households with agricultural activities, defined as 1 if the household lives in a rural location and 0 if otherwise. Rural households are predominantly agricultural, and lack schooling and ownership to key means to agricultural production. Table 1 reports that 48 percent of these rural households are primarily

[17] Agricultural Census 2008 carried out by the Bangladesh Bureau of Statistics (BBS) found that the 66.2 percent of the rural agricultural households operated owned lands only, whereas 24.2 percent operated a combination of owned and rented lands. In addition, 9.6 percent of them operated only rented lands (BBS 2014).

agricultural households, whereas other also have agricultural activities. Only 49 percent of them own a tractor or a plough-yoke. On average, household heads are 44.24 years old and have only 3 years of schooling. Average household size is 4.92, which consists of 3.91 earning members and 1 student members. On average, each household annually spends Taka 206 on conservation and 2,948 on human capital development. Average landholding is 26.2 decimals and households rent in 11.26 decimals of land on average. The average tenure security is 0.85, i.e., the surveyed agricultural households own 85 percent of their operated lands.

V. RESULTS AND DISCUSSION

As Appendix Table A2 shows, tenure security is significantly determined by the components of vectors z_1 and z_2.[18] Therefore, our choice of 3SLS method is valid since it controls for endogeneity in tenure security when simultaneously determining optimal conservation and human capital investments in the third stage. Table 2 reports the key parameter estimates from the results based on (8). We do not report the survey year and district dummies, but they are available upon request. R^2 values are 0.164 and 0.330, respectively. Following discussion of results focuses only on our testable hypothesis, i.e., effects of tenure security on conservation and human capital investments.

Results in Table 2 support our testable hypothesis. First, we identify a significant and positive association between tenure security and conservation investment, i.e., $\hat{\beta}_1 > 0$. In particular, a unit increase in tenure security is significantly associated with a 0.54 percent increase in conservation investment in the form of money spent on forest seedlings and compost fertilizer (Column 1 in Table 2).[19] Next, tenure security and human capital investment have a significant and negative association, i.e., $\hat{\beta}_2 < 0$. Results show that a unit increase in tenure security is significantly associated with a 0.16 percent decrease in human capital investment in the form of money spent on children's education (Column 2 in Table 2).

[18] As predicted in Section III, we find that age, number of working members, landholding, plough ownership, dependence on agriculture, years of schooling and number of school-going girls all to influence tenure security positively. We also find that male-headed households rent less percentage of their operated lands.

[19] This result is consistent with Grimm and Klasen (2015) who found that the adoption of formal land rights is associated with increased expenditures in conservation such as investments in trees, terraces, ditches, and irrigation systems.

Our findings that $\hat{\beta}_1 > 0$ and $\hat{\beta}_2 < 0$ imply that the effects of tenure security are opposite on conservation and human capital investments. Therefore, there exists a tradeoff between these two forms of intergenerational transfers. Although primary schooling is free and compulsory in Bangladesh, which implies that private educational expenditures are often not necessary rather supplementary at the early levels of schooling, however, beyond primary schooling, parents need to allocate a considerable amount of money on their school-going children, which, according to our results, might not be possible without sacrificing soil conservation investments. In related literature, Larson and Bromley (1990) found that the private property regimes are better for natural resource conservation. The tradeoff we identify implies that this proposition holds even when the farmers have given the option to substitute conservation investment for human capital investment.

Therefore, Bangladeshi agricultural households experience a tradeoff between conservation and human capital investments emerging from tenure insecurity: given the level of tenure insecurity, an increase (decrease) in conservation investment must be accompanied by a decrease (increase) in human capital investment, and vice-versa. Substitutability between these two forms of intergenerational transfer leads to important implications for developing countries in terms of both private educational expenditure and land resource management, especially since public and private investments are complementary. We infer that public policies targeting the conservation and management of land and soil resources, which necessarily releases, at least partly, farmers of their burden of private conservation investment, may result in higher private investment on children's human capital development.

Similarly, higher public investment in education may increase conservation investment. We investigate whether the female secondary school stipend (FSSS) program of the government of Bangladesh reduces the existing tradeoff. FSSS program provides stipend to female students attending grades 6 to 12, and therefore necessarily releases agricultural households from the burden of financing post-primary education of their girls. We follow specification (8); however, we additionally include logged per-student receipt of FSSS and its interaction with tenure security as explanatory variables. Table 3 displays the results, where we only report the coefficient of interest. Note that, because of the absence of girl students attending grades 6 to 12 in most of the agricultural households, we only have 1,442 valid observations for this restricted specification of our regression model. All the coefficients of interest are statistically significant for conservation investment. Although the negative coefficient of the interaction between Tenure security and logged per-student receipt of FSSS implies that at the effect of tenure security on conservation investment diminishes with FSSS, we find at the mean value of logged per-student receipt of FSSS that a unit increase in tenure security is significantly associated with an 8.85 percent increase in conservation investment. On the other hand, all the coefficients of interest are statistically insignificant for human capital investment, although there is a 0.044 percent increase in human capital investment associated with a unit increase in tenure security. Overall, we infer that public policies targeting the improvement and development human capital such as the FSSS program necessarily release the agricultural households of the tradeoff between conservation and human capital investments for a given degree of tenure security, and thereby enable them to increase their conservation investment.

Finally, although usually households spend money on human capital development if they have school-going children, in rural economy, people often transfer resources to their extended family members such as grandchildren and in-laws (Cox and Fafchamps 2007). For example, Duflo (2003) found evidence that South African grandparents finance their grandchildren's consumption of food and nutrients. In addition, Angelucci et al. (2010) identified that in rural Mexico, resource reallocation by extended family members affect children's schooling choices. Consistent with these practices among the extended family members, who do not necessarily dine-in together, often finance the human capital development of the future generation. Therefore, to further validate our findings, we restrict our estimation to the households with school-going children only. 3SLS regression results in Table 4 show that the underlying tradeoff still holds: $\hat{\beta}_1 > 0$ and $\hat{\beta}_2 < 0$ imply that the effects of tenure security are opposite on conservation and human capital investments even after taking off the possibility of investing in the human capital development of the children from extended family.

VI. CONCLUSIONS

We develop an overlapping generation model of rural agricultural households to investigate the tradeoff between alternative modes of transfer, unexploited topsoil and human capital investment. Tenure security influences the underlying tradeoff, resulting in the current generation increasing conservation effort and decreasing human capital investment under greater tenure security. Consequently, the current generation switches from human capital investment to topsoil transfer under greater tenure security, when the modes of transfer are substitutable.

Based on our theoretical findings and data availability, we hypothesize that more secure tenure is associated with higher conservation investment and lower human capital investment. We use the Bangladesh Household Income and Expenditure Survey (HIES) dataset, which contains data on household's expenditure on conservation investment (e.g., spending on forest seedling and compost fertilizer) and human capital investment (e.g., spending on children's educational and recreational activities), to test this hypothesis empirically. Our regression results suggest that this hypothesis cannot be rejected. We find that households with more secure tenure have higher conservation and lower human capital investments. Statistically significant and opposite effects on tenure security on conservation and human capital investments suggest that households may make tradeoffs between these two modes of transfer based on the security of their land tenure. Households with better tenure secure may be choosing increased soil conservation over human capital investment as a means of wealth transfer to the next generation.

Our paper has some limitations, which might open up avenues for future research using either better datasets or different case studies. First, our testable hypothesis can be investigated for different definitions of tenure security and soil conservation measures. As it is evident in literature, results might vary for different definitions; however, since our definitions are valid for many developing countries, our results are important and contribute in literature. Second, based on data availability, a better focus might be given on the indirect effects of public interventions on educational development, such as the FSSS program in our paper, on private investment in soil conservation. We follow specification (8) for our estimations reported in Table 3, although there is a possibility that the sample of FSSS is biased. However, we restrict our estimation to specification (8) due to the unavailability of data on household's social influence, which is the main determinant of the receipts of public funds.

Despite these limitations, we make important contributions in literature by identifying the tradeoff between different modes of intergenerational transfer for a given degree of tenure security, and also by identifying the role of public interventions to overcome that tradeoff. Altruistic households typically want their children to have a better education, presumably to increase their economic opportunities beyond subsistence agriculture, as is evident in our empirical analysis. However, any increase in human capital investment will have to be made at the expense of lower conservation investment. This result has important implications for conservation and development. Increased public expenditure in education may potentially reduce the spending by agricultural households on their children's schooling, as well as possibly releasing children from providing unpaid agricultural and domestic labor (Admassie 2003; Pallage and Zimmermann 2007). In addition, expanding public education might enable households to transfer more funds to soil and land resources conservation from human capital investment, potentially without hurting the human capital development of their children. Finally, households with more secure tenure that are investing in greater soil conservation as a means of transferring wealth could see the efficiency of their investments improve considerably with more public assistance in the form of soil and water conservation demonstration projects, better dissemination of farm-level conservation technologies, improved access to credit to finance such investments, and support from conservation research and extension activities directed at rural smallholders (Barrett and Bevis 2015; Wall 2007).

FIGURES

Figure 1. Tenure security and substitution between the modes of transfer.

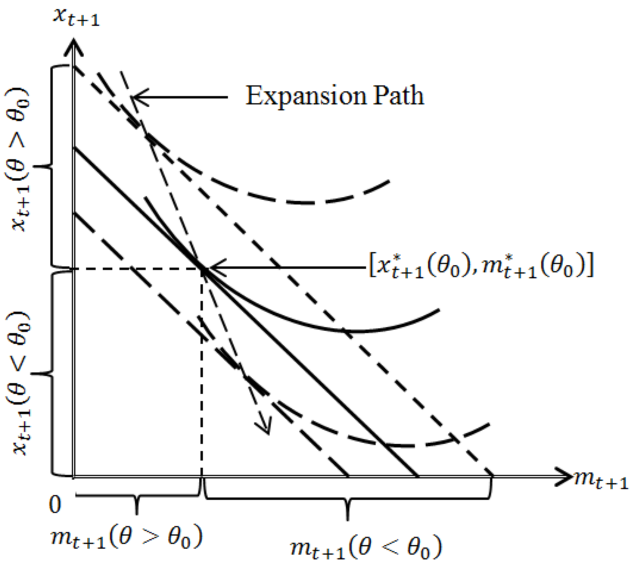
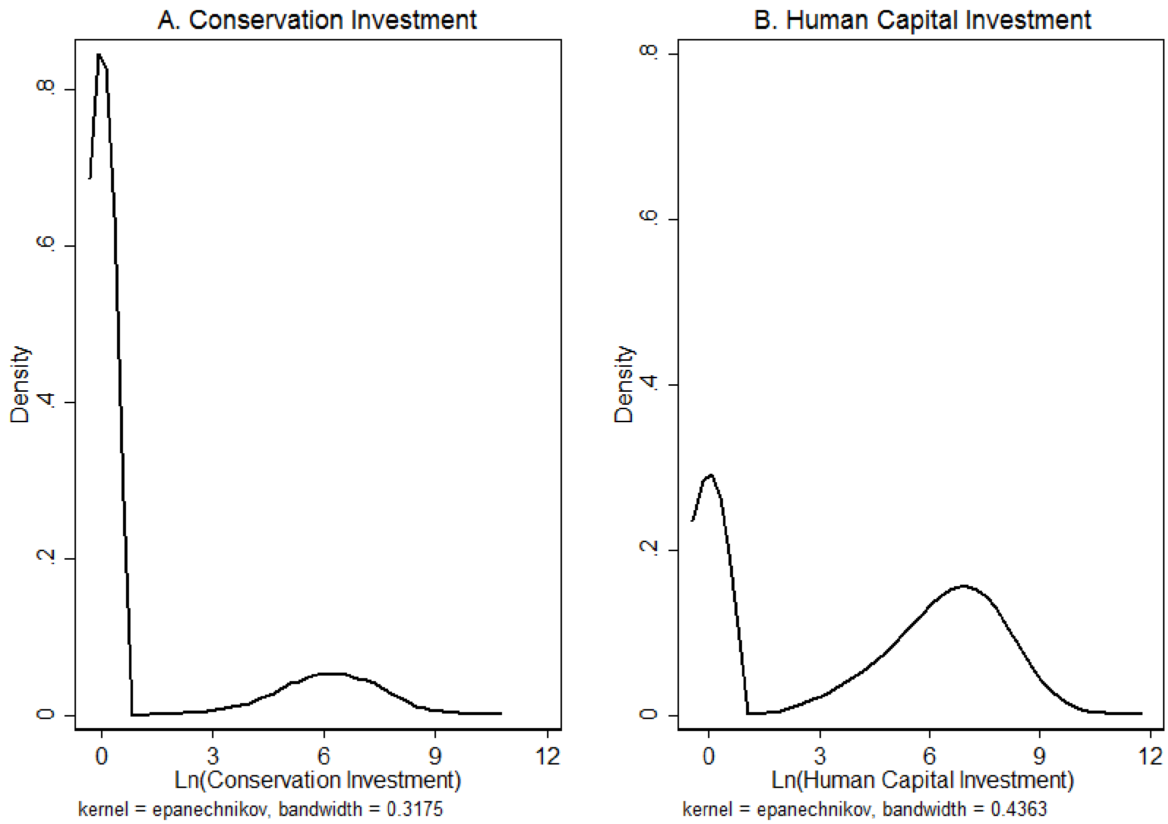


Figure 2. Distributions of outcome variables



TABLES

Table 1 - Description and Summary Statistics

Variables	Description	Mean	Std. Dev.	Minimum	Maximum
Conservation Investment	Total money spent on forest seedling and compost fertilizer	206.10	1059.52	0	34000
Human Capital Investment	Total money spent on children's schooling	2948.33	7897.21	0	243000
Landholding	Amount of agricultural land owned (decimals[¥])	26.20	104.87	0	3200
Rented land	Amount of agricultural rented in (decimals)	11.26	44.07	0	1680
Tenure Security	Tenure security of operated agricultural land	0.85	0.29	0.001	1
Gender	Dummy: 1 if male-headed household, 0 if female-headed household	0.96	0.21	0	1
Age	Age, in completed years, of the household head	44.24	12.67	12	99
Household Size	Number of members in the household	4.92	2.00	1	25
Earning members	Number of working age or income earning members in the household	3.91	1.74	0	20
Student members	Number of school-going members in the household	1.01	1.11	0	10
Years of schooling	Years of schooling of the household head	2.99	4.20	0	16
Plough Ownership	1 if the household owns a tractor or a plough-yoke and 0 if otherwise	0.45	0.50	0	1
Agricultural household	1 if Agriculture is the primary occupation of the household head, 0 if otherwise	0.48	0.50	0	1
Female stipend	Amount of female secondary school stipend (taka)	61.63	280.46	0	11000

Notes: Total sample size is 16,410. All monetary units are expressed in Bangladeshi taka. We restrict the estimating sample to rural households with agricultural activities to fit the conceptual framework in Section II. We define "Rural Household" as 1 if the household lives in rural areas and 0 if otherwise.

[¥] 100 decimals = 1 acre.

Table 2 - 3SLS Regression Results

Variables	(1) Ln(Conservation Investment)	(2) Ln(Human Capital Investment)
Tenure security	0.538***	-0.158*
	(0.205)	(0.085)
Gender	-0.290**	0.212*
	(0.118)	(0.112)
Age	-0.011	0.091***
	(0.010)	(0.020)
$(Age)^2$	0.000	-0.001***
	(0.000)	(0.000)
Working Members	-0.025	
	(0.034)	
$(\text{Working Members})^2$	0.003	
	(0.003)	
Ln(P/C landholding)	-0.098	0.328***
	(0.119)	(0.069)
$(\text{Ln(P/C landholding)})^2$	0.007	-0.044**
	(0.019)	(0.017)
Plough ownership	0.165	
	(0.112)	
Agricultural households	-0.027	-0.072
	(0.053)	(0.047)
Ln(years of schooling)		0.308***
		(0.023)
Number of school-going girls		1.088***
		(0.182)
$(\text{Number of school-going girls})^2$		-0.202***
		(0.049)
Inverse Mills Ratio	-2.095***	-2.629***
	(0.234)	(0.174)
Constant	4.520***	2.319***
	(0.553)	(0.675)
Observations	16,410	16,410
R^2	0.164	0.330
District dummies	YES	YES
HIES dummies	YES	YES

Notes: Standard errors in (), with ***, ** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural households to fit the conceptual framework. Dependent variables are logged expenditures on forest seedling and compost fertilizer (Column 1), and logged expenditures on education (Column 2).

Table 3 - Implications of Public Expenditure on Education

Variables	(1) Ln(Conservation Investment)	(2) Ln(Human Capital Investment)
Tenure security	10.934***	0.058
	(2.936)	(1.640)
Ln(per-student FSSS)	2.054***	0.267
	(0.433)	(0.264)
Tenure security * Ln(per-student FSSS)	-2.078***	-0.014
	(0.485)	(0.295)
Observations	1,442	1,442
R^2	0.236	0.179

Notes: Standard errors in (), with ***, ** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural households who receive female secondary school stipend.

Table 4 - 3SLS Regression Results
(households with school-going children only)

Variables	(1) Ln(Conservation Investment)	(2) Ln(Human Capital Investment)
Tenure security	0.577*	-0.071
	(0.332)	(0.068)
Gender	-0.243	0.013
	(0.178)	(0.106)
Age	-0.001	0.094***
	(0.015)	(0.011)
$(Age)^2$	0.000	-0.001***
	(0.000)	(0.000)
Working Members	-0.023	
	(0.045)	
$(\text{Working Members})^2$	0.003	
	(0.004)	
Ln(P/C landholding)	-0.090	0.247***
	(0.190)	(0.055)
$(\text{Ln(P/C landholding)})^2$	0.007	-0.019
	(0.028)	(0.014)
Plough ownership	0.137	
	(0.164)	
Agricultural households	0.008	-0.072*
	(0.083)	(0.040)
Ln(years of schooling)		0.357***
		(0.019)
Number of school-going girls		-0.028
		(0.058)
$(\text{Number of school-going girls})^2$		0.041**
		(0.020)
Inverse Mills Ratio	-2.229***	-4.928***
	(0.409)	(0.380)
Constant	4.375***	3.264***
	(0.785)	(0.348)
Observations	9,652	9,652
R^2	0.182	0.252
District dummies	YES	YES
HIES dummies	YES	YES

Notes: Standard errors in (), with ***, ** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural households with school-going children. Dependent variables are logged expenditures on forest seedling and compost fertilizer (Column 1), and logged expenditures on education (Column 2).

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APPENDICES

Table A1 - Participation Decisions: Bivariate Probit Regression

Variables	(1) Conservation investment	(2) Human capital investment
Tenure security	-1.019***	-0.220***
	(0.077)	(0.050)
Gender	0.331***	0.383***
	(0.077)	(0.058)
Age	0.022***	0.163***
	(0.006)	(0.007)
$(Age)^2$	-0.000***	-0.002***
	(0.000)	(0.000)
Working Members	0.044*	-0.075***
	(0.023)	(0.027)
$(\text{Working Members})^2$	-0.001	0.009***
	(0.002)	(0.003)
Ln(P/C landholding)	0.524***	0.217***
	(0.054)	(0.041)
$(\text{Ln(P/C landholding)})^2$	-0.067***	-0.046***
	(0.012)	(0.010)
Plough ownership	0.494***	0.138***
	(0.059)	(0.052)
Agricultural households	0.231***	-0.069***
	(0.029)	(0.026)
Ln(years of schooling)	0.089***	0.095***
	(0.013)	(0.012)
Number of school-going girls	0.066	2.459***
	(0.041)	(0.086)
$(\text{Number of school-going girls})^2$	-0.005	-0.496***
	(0.015)	(0.028)
HIES dummies	YES	YES
District dummies	YES	YES
Constant	-1.669***	-4.094***
	(0.281)	(0.235)
Observations	16,410	16,410

Notes: Standard errors clustered at union level are in (), with ***, ** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural households to fit the conceptual framework. Binary dependent variables are conservation investment (i.e., 1 if positive conservation investment and 0 if zero conservation investment) in Column 1, and human capital investment (i.e., 1 if positive human capital investment and 0 if zero human capital investment) in Column 2.

Table A2 – First-stage of the 3SLS Regression Model

Variables	(1) ln(Conservation investment)	(2) ln(Human capital investment)	(3) Tenure security
Gender	-0.159	0.277**	0.330***
	(0.098)	(0.121)	(0.002)
Age	-0.030*	0.100***	0.021***
	(0.017)	(0.021)	(0.000)
$(\text{Age})^2$	0.000*	-0.001***	0.000***
	(0.000)	(0.000)	(0.000)
Working Members	0.001	-0.174***	0.043***
	(0.034)	(0.042)	(0.001)
$(\text{Working Members})^2$	0.002	0.016***	-0.001***
	(0.003)	(0.004)	(0.000)
Ln(P/C landholding)	0.158**	0.251***	0.502***
	(0.063)	(0.078)	(0.001)
$(\text{Ln(P/C landholding)})^2$	-0.022	-0.035**	-0.063***
	(0.014)	(0.018)	(0.000)
Plough ownership	0.390***	-0.046	0.424***
	(0.080)	(0.099)	(0.002)
Agricultural households	0.107**	-0.114**	0.217***
	(0.044)	(0.054)	(0.001)
Inverse Mills Ratio 1	-1.413***	-0.203**	1.190***
	(0.083)	(0.102)	(0.002)
Ln(years of schooling)	0.032	0.294***	0.083***
	(0.019)	(0.024)	(0.000)
Number of school-going girls	-0.276*	1.173***	0.064***
	(0.153)	(0.188)	(0.003)
$(\text{Number of school-going girls})^2$	0.077*	-0.226***	-0.006***
	(0.041)	(0.050)	(0.001)
Inverse Mills Ratio 2	-0.310**	-2.525***	0.001
	(0.147)	(0.181)	(0.003)
Constant	4.162***	2.619***	-2.455***
	(0.577)	(0.711)	(0.011)
R2	0.168	0.331	0.978

Notes: Standard errors in (), with ***, ** and * representing levels of statistical significance of 1%, 5% and 10%, respectively. We restrict the estimating sample to rural households to fit the conceptual framework. Dependent variables are logged expenditures on forest seedling and compost fertilizer (Column 1), logged expenditures on education (Column 2), and tenure security (Column 3).