Reducing Poverty and Natural Resource Degradation Through Human Capital Accumulation

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Abstract

This study examines the role of human capital accumulation in reducing poverty and natural resource degradation by using data of 26 Indian states for the time period 1993 to 2011. For this purpose, we extend the model developed by Ikefuji and Horii (2014) as our analytical framework. Unlike Ikefuji and Horii (2014) who developed an overlapping generations model (OLG) in the context of local pollution, we have adapted it in the context of renewable natural resources. As the main result of our theoretical analysis, we find that an investment in education will increase consumption, income or reduce poverty and natural resource degradation. Based on empirical estimation, we find that natural resource conservation will increase poverty. We also find that increase in education of the individual will reduce natural resource degradation and poverty depending on the indicator used to measure it. The primary classes education will reduce natural resource degradation. Whereas higher level of education as measured by sixth to twelfth classes will reduce poverty. In theory school education makes the students aware of environmental concerns, thereby making them aware of the impact their choices likely to have on environment.

Keywords: Poverty, natural resource degradation, human capital accumulation and GMM

1. Introduction

In 1987, the Brundtland Commission (World Commission on Environment and Development (WCED)) suggested that "poverty is a major cause and effect of world environmental problems". Some areas of the world are caught in a vicious downward spiral: where poor individuals overexploit the natural assets for their survival of the fittest and the degradation of the environment on which they are dependent for their livelihood further deprives them, making their survival indeed more difficult and uncertain. The Handbook produced by the United Nations Development Programme and the United Nations Environment Programme (UNDP-UNEP) (2014), under the rubric of Poverty-Environment Initiative (PEI) reveals that approximately 70 percent of the world's 1.2 billion individuals living beneath the poverty line depend generally on local natural resources for her or his livelihoods.

In order to coordinate the process of environment conservation and poverty alleviation it is imperative to understand that there exists a cause-and-effect relationship between the two processes. They cannot be viewed as two independent phenomena. Considering apart the direction of causality in this poverty-environment nexus poses a serious empirical challenge.

The presence of vicious spiral of poverty and deterioration of environment necessitates directed efforts to alleviate poverty in order to reverse the degradation of environment (Cleaver and Schreiber, 1994; Duraiappah, 1998; Steele, 2007; Scherr, 2000). The poor degrade natural resources because they lack knowledge and they cannot afford sustainable production techniques necessary to improve their livelihood sources. According to United Nations Development Programme (UNDP, 1990) poverty is one of the major threats to the

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environment. It was also argued that in many Asian countries' rapid population growth and environmental degradation are responsible for the acute spread of poverty (Jalal, 1993).

The poor are destined to overexploit the natural resources as they have little access to human and financial capital and they are less likely to migrate somewhere else in pursuit of employment or land in response to limited availability of local livelihood earning opportunities (Bremner et. al., 2010). Forest resource exploitation, fishing, overgrazing, agriculture intensification, and land degradation are major livelihood earning activities of people from low-income group (Narain, 2008). Prevalence of poverty increases the dependence of growing population on scarce local natural resources for survival. Moreover, poor lack resources to invest in sustainable use of natural resources or land management practices (Barbier, 2010; Etongo et al.,2016).

This mutually reinforcing cycle of increasing poverty and deterioration of the environment produces a poverty-environment trap from which the poor find it difficult to break away (Ikefuji and Horii, 2007). In order to escape the poverty-environmental trap, this two-way causal relationship has been extended to include the role of human capital accumulation. There exists a vast amount of literature highlighting the significance of human capital accumulation in a country's economic growth. It is a profound fact that human capital accumulation through higher education makes individuals aware of the importance of protecting the environment and cope better with environmental problems. This paper explores the role of human capital accumulation in escaping the trap of poverty-environment.

For this purpose, we extend the model developed by Ikefuji and Horii (2014) as our analytical framework, which is then tested empirically by utilizing a data for 26 state of India for time period 1993 to 2011, with focus on deforestation and land degradation as an indicator of natural resource degradation. Unlike Ikefuji and Horii (2014) who developed an overlapping generations model (OLG) in the context of local pollution, we have adapted it in the context of renewable natural resources. To do this, we have introduced the production sector that relies on a natural resource intensive technology. This helps us characterize the conditions under which the poor individual will be caught in the poverty-natural resource degradation trap, or alternatively, the conditions that will help escape this trap through human capital accumulation. Specifically, the scope of the study is extended to investigate how accumulation of human capital can help the economy escape from 'poverty-natural resource degradation' trap and its associated effect on evolution of structure of output (namely, composition of output that uses sustainable versus unsustainable technology) in this stylized economy. We develop an economic model to understand the mechanism that led to mutual causality between the poverty-natural resource degradation and, by using it, we examine the desirable policy. We derive the conditions under which individuals will invest in human capital and move on to adopt sustainable technology instead of the natural resource intensive technology.

The present study contributes and provides further insights to the literature with regard to three different aspects. First, unlike other studies to our best knowledge, this is the first study to use state-level panel data to examine poverty- natural resource degradation nexus while dealing with the joint endogeneity between the two. It is our belief that the drivers of natural resource degradation are more clearly observable at aggregate level or state level because natural resource degradation is highly associated with collective poverty and many socio-demographic factors (e.g. population, government expenditure on social sector, infrastructure) have few variations across households. Second, we assess the impact of human capital accumulation on natural resource degradation and poverty. Moreover, we consider the two different indicators of natural resource degradation i.e., deforestation and land degradation. Finally, we employ three different methods to test the relationship between poverty, natural resource degradation and human capital accumulation; feasible generalized

least square (FGLS); instrumental variable two stage least square (IV-2SLS) and System-GMM to account for joint endogeneity between variables.
The rest of the paper is organised as follows. Section 2 discusses literature review, Section 3 discusses the theoretical model, which forms a foundation for our empirical analyses, Section 4 describes the empirical model developed for estimation purpose, variables considered for the study and their data source. Section 5 discusses estimation method used for estimation purpose. Section 6 reports and discusses the main results. Section 7 reports the concluding remarks.

2. Literature Review

Poverty and environment degradation are interlinked as it is believed that they mutually re-enforce each other. Many studies have examined the association between poverty and environment degradation by relying on empirical studies. There are many country specific studies conducted in developing countries to analysed the impact of income levels or poverty levels of rural households on environmental degradation or resource management practices. We now discuss the literature on this subject.
Several studies use country specific especially developing countries data to analyse the dependence on natural resources – especially on open access or common property resources of rural households. The study conducted by Jodha (2000), Rao (1994) and Narain et al. (2008) for India; Escobal and Aldana (2003) for Peru and Cavendish (2000) for Zimbabwe, Bahamondes (2003) for Chile found that rural poor heavily rely on local natural resources for their livelihood. The poor display heavy dependence on common property resources like the water resources, pastures, forests that leads to their overexploitation, a shrinking input base for them when environment is degraded, this, in turn, increases the severity of poverty (Jodha (2000)).
By considering a single measure of environmental degradation, i.e., water pollution, measured by biochemical oxygen demand. The study by Alam (2010) found that alleviation of poverty may decrease environmental degradation if not immediately but in the near future. Instead of considering a single measure of environmental degradation, Aggrey et. al. (2010) has considered five different environmental degradation indicators (namely, wetland conversion, indoor air pollution, water pollution and deforestation). The OLS regression results reveal that wetland degradation and deforestation have positive influence on poverty while the use of charcoal and firewood, access to electricity, clean water and sanitation facilities exhibited no significant linkage with poverty. Similarly, Finco (2009) have characterised poverty in broader terms, to include insufficiency of income, gender discrimination, social exclusion and limited access to the basic needs. The results reveal that this link is complex and remains ambiguous depending on the context-specificity and relationship dynamics among indicators used to measure environmental degradation.
There are many studies that have shown that the poor are not always responsible for natural resource degradation (Cavendish, 2000; Comim et. al., 2009; Broad, 2002; Bucknall et al., 2000; Scherr, 2000). In rural regions, it is non-poor that deplete the natural resources (Ravnborg, 2003). Cavendish (2000) conducted an empirical study in Zimbabwe at the household level, and found that wealthy households were primarily responsible for natural resource degradation. They didn't find any real-life evidence in favour of conventional view that poverty leads to environmental degradation. In fact, they find that environmental degradation hurts the poor more.
None of the aforementioned studies account for the joint endogeneity or two-way relationship that exist between poverty and environmental, which is the most important characteristic to be taken up for examining the poverty-environment nexus hypothesis. The following studies considered the joint endogeneity of the poverty-environment relation. The bi-directional

relationship between environmental change and rural poverty was examined by the Bhattacharya and Innes (2006) suggest that environment degradation stimulates rural poverty and rural poverty spurs environment degradation. Based on their results, they concluded that poverty-environment nexus exists in rural India. Similarly, Dasgupta et al. (2005) investigated the spatial relationship between five environmental problems: deforestation, contaminated water, outdoor air pollution, indoor air pollution and fragile soils and poverty at the district and provincial levels in Cambodia, Vietnam and Lao PDR. The results suggest that the nexus depends on the indicator used to measure environmental degradation and is different in each country.

Based on aforementioned studies, we can conclude that the relationship between poverty and environment depends on the context-specificity, resource-specificity and indicator used to measure the poverty and environmental degradation, since poverty is a multidimensional concept; a single measure cannot capture the diverse aspects of it. Country specific studies shows that while ‘poverty-environment trap’ may exist at the district or household levels, these may not be true at the country level. The country specific studies neither account for the joint endogeneity of poverty and environmental nor highlight the mechanisms through which ‘poverty-environment trap’ surface, which is the most vital for testing the poverty-environment nexus. This paper attempts to fill this gap in the literature by addressing the issue of joint endogeneity of poverty and natural resource degradation. Moreover, in the context of the relationship between poverty and natural resource degradation, only few existing studies have emphasised on the role of human capital accumulation in escaping the poverty-natural resource degradation trap.

In order to analyse the role of human capital accumulation in escaping the poverty-natural resource degradation trap, we need a baseline analytical model that can describe the poverty-natural resource degradation trap itself. For this purpose, we extend the model developed by Ikefuji and Horii (2014) for our analytical framework. This is the only analysis that offers a workable mathematical framework that emphasises on the role of sustainable technology adoption in escaping the poverty-environment trap. They show how a poverty-environment trap can arise for an individual born in developing country, in a situation where agents cannot borrow or lend or credit market is imperfect. In order to explain the mechanism of the poverty-environment trap, they develop a model in the context of local pollution and economic development. They derive the conditions under which the economy could adopt sustainable technology that helps in escaping the ‘poverty-environment trap’.

This research extends beyond Ikefuji and Horii (2014) by assuming that an individual derives utility by making investment in his child’s education apart from utility from consumption when young and adult. Unlike Ikefuji and Horii (2014) who developed an overlapping generations model (OLG) in the context of local pollution, we have adapted it in the context of a renewable natural resource. This resource stock may include fisheries or forests (with well-defined property rights over fishing stocks). Our focus is entirely on the extractive use of resources for production purpose and we neglect amenity services provided by the resources. To do this, we have introduced the production sector that relies on a natural resource intensive technology. In an OLG economy, Gerlagh and Keyzer (2001) have examined the possibility of positive balanced growth path with natural resources, which have amenity value but not used as an essential input into production sector. Unlike Gerlagh and Keyzer (2001), we have incorporated the natural resource as an input in the natural resource-intensive production sector, which is essential for its production. Next, we will discuss our theoretical model.

3. The Model and the Equilibrium Conditions

We consider an overlapping generation model where agents live for two period: t and t+1. The total population is stationery and does not grows. The utility of an individual is represented by the following additively separable utility function:

$$U_t \;= lnC_t^Y + \beta lnC_{t+1}^A + (1-\beta)lnV_{t+1}\,. \qquad (1)$$

Where C_t^Y denotes the consumption of an individual born at time t, C_{t+1}^A, consumption when adult, and V_{t+1} the amount spent or invested in child's education. We, therefore, assume that the parents enjoy giving a transfer to their children for education acquisition as in Glomm and Ravikumar (1992), although this bequest motive is not analysed explicitly by us. Here, $0 < \beta < 1$ is the parameter that measures the weight assigned by young agent to the future level of consumption as opposed to the investment that they make in her/his child's education.
The young agents are endowed with one unit of labor (L_t), which combined with educational expenditure (V_t), which is fully funded by her/his parent's or adult agents of period t, help build their human capital (H_{t+1}), which becomes available to the agent in the period t+1. Similarly, to Ikefuji and Horii (2014), the accumulation of human capital (due to education acquisition) by young agent is defined by

$$H_{t+1} = \psi V_t L_t = \psi V_t l\;. \qquad (2)$$

Where, $\psi > 0$ is the productivity parameter associated with the human capital accumulation.

We assume that at the beginning of the period the adult agents of period t own the stock of natural resources. They sell the stock (including growth) to the firms, which then decide how much of that resource to use as an input in the production of the good. The firm will sell the remaining stock of the resource to the young agent at the end of period t. Further, we assume that individuals cannot borrow or lend as they lack access to well-functioning credit market and they do not work when young. In period t, each young agent receives a transfer of income from his/her parents $(\mathcal{E}Y_t)$ that they utilise for consumption when young (C_t^Y), and to acquire ownership right for natural resources from adult agents $(p_t N_{t+1})$. The budget constraint faced by young agent is given as follows:

$$C_t^Y + p_t N_t = \mathcal{E}Y_t, \qquad (3)$$

where $\mathcal{E}$ is the exogenously assumed fraction of income earned by an adult agents of period t that is transferred to young agents who are born in period t, N_{t+1} is the endowment of the natural resource that young agents purchase from adults of generation t, p_t is the price of the ownership right of one unit of the natural resource in terms of the consumption good.
The adult agent in period t+1 uses her/his total earned wage income (Y_{t+1}) and income received from selling her/his natural resource endowment (N_{t+1}) for consumption (C_t^A), transfer to her/his child $(\mathcal{E}Y_t)$ and to fund expenditure on child's/young agent education (V_{t+1}). Thus, the budget constraint during the second period of individual's life (when adult) can be written as:

$$C_{t+1}^A + V_{t+1} + \mathcal{E}Y_{t+1} = Y_{t+1} + p_{t+1}N_t, \qquad (4)$$

where $\mathcal{E}$ is the fraction of wage income earned by each adult agent in period t+1 that is transferred to her/his young, p_{t+1} is the unit price at which natural resource stock is sold to firms by an adult agent in period t+1.
The total wage income earned by an adult in period t will be as follow:

$$Y_{t+1} = w_{h_{t+1}}H_{t+1} + w_{l_{t+1}}s_{t+1}l + w_{l_{t+1}}(1 - s_{t+1})l = w_{h_{t+1}}H_{t+1} + w_{l_{t+1}}l\,. \tag{5}$$

This can be explained as follows. The adult agent earns income by participating in two types of economic activities: (i) a production activity that depends on human capital intensive technology, for which she/he earns a wage rate for per unit of human capital, $w_{h_{t+1}}$ and wage rate for per unit of unskilled labour, $w_{l_{t+1}}$ and where s_{t+1} is the fraction of unskilled labour devoted to human capital intensive output production, and (ii) another production activity that relies on natural resources for which they earn unskilled labour wage income (of fraction, $(1 - s_{t+1})l$), where $(1 - s_{t+1})$ is the fraction of unskilled labour devoted to natural resource intensive output production. Here l is labour input per unit of output as population of each generations is normalized to one $(L_t = L_{t+1} = l)$.

4. Production structure and firm's behaviour

Human capital-intensive technology

We assume a Cobb-Douglas form production function wherein inputs can be substituted for each other to produce the same output, but cannot be substituted at a constant rate. This type of production function assumes constant returns to scale with respect to all the inputs for a given technology level. The output produced from human capital-intensive technology can be written as:

$$Y^H_{t+1} = A^H(H^{\theta}_{t+1})(s_{t+1}l)^{1-\theta}, \tag{6}$$

where $A^H > 0$ is the constant measuring the productivity level of the human capital-intensive technology.

Natural resource intensive technology

The other available technology of production is natural resource intensive, which uses unskilled labour to produce goods and relies more heavily on extraction of natural resources, X_t. The output produced from natural resource intensive technology is expressed as:

$$Y^R_{t+1} = A^R(1 - s_{t+1})\, lX_{t+1}, \tag{7}$$

where $A^R > 0$ is the constant that measures the productivity or technology level of the natural resource intensive technology, X_{t+1} is the stock of natural resource used for production in this sector. The firm's exploitation of natural resources involves price $p_{t+1,}$ and the utilisation of natural resources as an input into the production depletes the stock of natural resource. Thus, the production technology in this sector is dirty.

Finally, the evolution of natural resource stock is determined by the amount of output produced from natural resource intensive technology. This resource stock has the ability to regenerate or grow over time.
The equation governing the dynamics of natural resource stock is given by

$$N_{t+1} = (1 + \delta)N_t - \eta\, X_{t+1}, \tag{8}$$

Where, $0 < \delta < 1$ is the parameter referring to the natural regeneration capacity of resources and $\eta > 0$ measures the extent of natural resource degradation due to extraction of natural resources.

Solving for the Market Equilibrium

Firm's optimization in the two production sectors

We assume that the human capital-intensive (HCI) sector is the numeraire, such that $p^H = 1$. In a perfectly competitive framework, the profit maximising firm chooses human capital/skilled labour (H_t) and unskilled labour $(s_t l)$, while taking the human capital/skilled labour (H_t) and unskilled labour $(s_t l)$ wage rates, w_{h_t} and w_{l_t} as given, that is,

$$\max_{H_{t+1}, s_{t+1} l} \pi^H = A^H (H_{t+1}^{\theta})(s_{t+1} l)^{1-\theta} - w_{h_{t+1}} H_{t+1} - w_{l_{t+1}} s_{t+1} l.$$

The first order conditions of the representative firm's profit maximization problem are given, in per-worker terms, by:

$$w_{h_{t+1}} = \theta A^H H_{t+1}^{\theta-1} (s_{t+1} l)^{1-\theta}\ ; \tag{9}$$

$$w_{l_{t+1}} = \frac{(1-\theta) A^H H_{t+1}^{\theta}}{(s_{t+1} l)^{\theta}}\ . \tag{10}$$

When output is produced from natural resource intensive (NRI) technology, the representative firm hires unskilled labour $((1 - s_{t+1})l)$ and combines it with extracted natural resources (X_{t+1}) to maximize profit, taking relative prices of natural resource-intensive output (p^R), unskilled labour wage $(w_{l_{t+1}})$, and price of extracted natural resources used in production (p_{t+1}) as given. That is,

$$\max_{X_{t+1}, s_{t+1} l} \pi^R = p^R A^R (1 - s_{t+1}) l X_{t+1} - w_{l_{t+1}} (1 - s_{t+1}) l - p_{t+1} X_{t+1}\ .$$

The first order conditions of the representative firm's profit maximization problem are given, in per-worker terms, by:

$$w_{l_{t+1}} = p^R A^R X_{t+1}\ ; \tag{11}$$

$$p_{t+1} = p^R A^R (1 - s_{t+1}) l. \tag{12}$$

By equating equation (10) with (11), we get that,

$$\Rightarrow s_{t+1} l = \left[\frac{(1-\theta) A^H}{p^R A^R\, X_{t+1}}\right]^{1/\theta} H_{t+1}\ , \tag{13}$$

where $H_{t+1} = \psi V_t l$.

Substituting the value of $s_{t+1} l$ from (13) into (9), we derive that,

$$\Rightarrow w_{h_{t+1}} = \theta (1-\theta)^{(1-\theta)/\theta} \frac{{A^H}^{1/\theta}}{(p^R A^R\, X_{t+1})^{(1-\theta)/\theta}}\ . \tag{14}$$

5. Consumers Optimization

The representative agent born at period t maximizes her/his utility function (1) subject to budget constraints (3) and (4). Given the transfer of income received by each young agent from her/his parents ($\mathcal{E}Y_t$ ($\mathcal{E}$ being exogenous here)) and the expenditure on education (V_t), the agent born in period t chooses the expenditure to be done on her/his child's education (V_{t+1}), the natural resource endowment to buy (N_t). The following first order conditions hold for interior solutions of V_{t+1} and N_t,

$$V_{t+1} = (1-\beta)((1-\mathcal{E})Y_{t+1} + p_{t+1}N_t) \tag{15}$$

$$p_t((1-\mathcal{E})Y_{t+1} + p_{t+1}N_t - V_{t+1}) = \beta p_{t+1}(\mathcal{E}Y_t - p_t N_t) \tag{16}$$

Substituting the value of V_{t+1} from equation (15) into equation (16) yields:

$$\Rightarrow N_t = \frac{1}{2}\left[\frac{\mathcal{E}Y_t}{p_t} - \frac{(1-\mathcal{E})Y_{t+1}}{p_{t+1}}\right] \tag{17}$$

Substituting the value of N_t from (17) into (15), we get V_{t+1} as:

$$V_{t+1} = \frac{(1-\beta)}{2}\left((1-\mathcal{E})Y_{t+1} + \frac{\mathcal{E}p_{t+1}Y_t}{p_t}\right). \tag{18}$$

Further, substituting N_t from equation (17) into (3), we get the consumption of the young agent in period t as follow,

$$C_t^Y = \frac{1}{2}\left[\mathcal{E}Y_t + \frac{p_t}{p_{t+1}}(1-\mathcal{E})Y_{t+1}\right] \tag{19}$$

Further, the consumption of the adult agent is derived by substituting N_t and V_{t+1} from (14) and (18) respectively into (4) as follow:

$$C_{t+1}^A = \frac{\beta}{2}\left[(1-\mathcal{E})Y_{t+1} + \frac{\mathcal{E}p_{t+1}Y_t}{p_t}\right] \tag{20}$$

Further, substituting (13) into (12), we get

$$p_{t+1} = p^R A^R l - \frac{((1-\theta)A^H)^{\frac{1}{\theta}}\ \psi V_t l}{(p^R A^R)^{\frac{1-\theta}{\theta}}\ (X_{t+1})^{\frac{1}{\theta}}}. \tag{21}$$

From equation (21), we can say that

$$p_t = 0,\ \text{ when } X_t = \frac{(1-\theta)A^H(\psi V_t)^\theta}{(p^R A^R)} \equiv \bar{X} \tag{22}$$

where $\bar{X}$ is the threshold level of resource extraction beyond which price of natural resource extraction increases.

Next, substituting the values of w_{h_t+1}, H_{t+1} and $w_{l_{t+1}}$ from equations (14), (2), and (11) respectively into (5), we derive the following expression for aggregate income (Y_{t+1}) as a function of investment in young's education by the parent (V_t) and the extraction of natural resource (X_{t+1}).

$$Y_{t+1} = \begin{cases} p^R A^R X_{t+1}\, l, & V_t = 0; \\ \dfrac{\theta(1-\theta)^{(1-\theta)/\theta} A^{H^{1/\theta}} \psi V_t l + (p^R A^R X_{t+1})^{1/\theta} l}{(p^R A^R X_{t+1})^{(1-\theta)/\theta}}, & V_t > 0. \end{cases} \tag{23}$$

Thus,

Proposition 1: In this overlapping generations (OLG) economy, as the investment in education of the child by the parent increases, the income earned by the adult in the next period also increases (see the case for $V_t > 0$ in equation (29)). If, however there is no investment in child's education by the parent, then in the next period, the adult derives the entire income by working as unskilled labour in the natural resource intensive sector (this follows from equation, when $V_t = 0$).
When $V_t = 0$, $s_{t+1}l = 0$ (from equation (13)) and adult will rely only on NRI technology for earning income (that is $p^R A^R X_{t+1}\, l = w_{l_{t+1}} l$), she/he will earn unskilled wages by working in the NRI sector (see equation (23)). However, when $V_t > 0$, $s_{t+1}l > 0$, in comparison, individual will earn a higher income than the case where $V_t = 0$, which will be through sustainable means of production (again from equation (23)). Thus, we have,

Proposition 2: The diversification of the income earning source of the individual from complete reliance on the NRI sector ($s_{t+1}l = 0$) to partial reliance requires a certain positive amount of investment in the education of the young agent by the parent. From equation (5), it can be seen that when $V_t = 0$, $Y_{t+1} = w_{l_{t+1}} l$, and the adult agent will earn her/his income only from unskilled labour (l). When $V_t > 0$, $s_{t+1}l > 0$ from (13), $Y_{t+1} = w_{h_{t+1}} H_{t+1} + w_{l_t+1} l$, individual will earn income from both skilled labour/human capital and unskilled labour (see equation (5)).

Stationary equilibrium

Steady states are time-invariant sequences defined by $Y_t = Y_{t+1} = \bar{Y}$, $V_t = V_{t+1} = \bar{V}$, $C_t^Y = C_{t+1}^A = \bar{C}$, $N_t = N_{t+1} = \bar{N}$ and $p_t = p_{t+1} = \bar{p}$ in the long run.

Substituting $Y_t = Y_{t+1} = \bar{Y}$ and $p_t = p_{t+1} = \bar{p}$ in equation (18), we will get the steady state value of investment in education as follows. We have,

$$\Rightarrow \bar{V} = \frac{(1-\beta)}{2}\left((1-\mathcal{E})\bar{Y} + \frac{\mathcal{E}\bar{p}\bar{Y}}{\bar{p}}\right) = (1-\beta)\frac{\bar{Y}}{2} \tag{24}$$

Equation (24) says that the steady state value of investment in education of the young agent ($\bar{V}$) depends on the weight put by the adult agent on the investment in child's education $(1-\beta)$ and half of the steady state value of total wage income earned by the adult agent.

Substituting $Y_t = \bar{Y}$, $V_{t-1} = \bar{V}$, $X_t = \bar{X}$ from equation (22), $l = \bar{l}$ in equation (23), we get the steady state value of income earned by the individual to be:

$$\Rightarrow \bar{Y} = \theta A^H (\psi\bar{V})^\theta \bar{l} + (1-\theta) A^H (\psi\bar{V})^\theta \bar{l} = A^H (\psi\bar{V})^\theta \bar{l}\ . \tag{25}$$

Substituting the value of $\bar{Y} = A^H(\psi\bar{V})^{\theta}\bar{l}$ from equation (25) into equation (24), we get

$$\Rightarrow \bar{V} = \frac{(1-\beta)^{\frac{1}{(1-\theta)}}}{2}(A^H\bar{l})^{\frac{1}{(1-\theta)}}(\psi)^{\frac{\theta}{1-\theta}} . \quad (26)$$

Substituting $V_t = \bar{V}$, from (26) and $l = \bar{l}$, in equation (2), we get steady state human capital accumulation to be:

$$\bar{H} = \frac{(1-\beta)^{\frac{1}{(1-\theta)}}}{2}(A^H\bar{l})^{\frac{1}{(1-\theta)}}(\psi)^{\frac{1}{1-\theta}}\ (\bar{l})^{\frac{(2-\theta)}{(1-\theta)}} . \quad (27)$$

From this, the following proposition follows.

Proposition 3: Given $A^H, \bar{L}, \theta/1-\theta$ and ψ, a long run steady state equilibrium level of the human capital accumulation is higher, higher is the weight put by the parent on the child's education (the proof for this result follows from equation (27)).

Substituting the value of $N_t = N_{t+1} = \bar{N}$ and $X_{t+1} = \bar{X}$ from equation (22) and $V_t = \bar{V}$ from equation (26) into equation (5), we get steady state value of natural resource stock

$$\Rightarrow \bar{N} = \frac{\eta}{\delta}\ \frac{(1-\theta)(A^H)^{\frac{1}{(1-\theta)}}\ (\psi)^{\frac{\theta}{1-\theta}}\frac{(1-\beta)^{\frac{\theta}{(1-\theta)}}}{2}\ (\bar{l})^{\frac{\theta}{(1-\theta)}}}{(P^R A^R)} \quad (28)$$

Equation (28) says that the steady state value of natural resource stock is higher, higher is the weight assigned by an adult agent on the investment in her/his child's education$(1-\beta)$, higher is the productivity of human capital-intensive technology (A^H), higher is the share of human capital relative to share of unskilled labour in human capital-intensive output production $(\theta/1-\theta)$, lower is the price of NRI output(P^R) , and lower is the productivity of NRI technology(A^R).

Proposition 4: Given $A^H, \frac{\theta}{1-\theta}, and\ P^R$, the steady state value of natural resource stock is higher, higher is the weight given by adult agent to investment in child's education $(1-\beta)$ (the formal proof follows from equation (28))

Substituting the value of $Y_t = Y_{t+1} = \bar{Y}$ and $p_t = p_{t+1} = \bar{p}$ in equation (19), we get that,

$$C_t^Y = \frac{1}{2}\left(\mathcal{E}\bar{Y} + \frac{\bar{p}}{\bar{p}}(1-\mathcal{E})\bar{Y}\right) = \frac{1}{2}\bar{Y} . \quad (29)$$

Substituting the value of $Y_{t-1} = Y_t = \bar{Y}$ and $p_{t-1} = p_t = \bar{p}$ in equation (20), we get

$$C_{t+1}^A = \frac{\beta}{2}\left((1-\mathcal{E})\bar{Y} + \frac{\mathcal{E}\bar{P}\bar{Y}}{\bar{P}}\right) = \frac{\beta}{2}\bar{Y} \quad (30)$$

$$\Rightarrow \frac{C_{t-1}^{Y} - C_{t}^{A}}{C_{t-1}^{Y}} = \frac{\frac{1}{2}\bar{Y} - \frac{\beta}{2}\bar{Y}}{\frac{1}{2}\bar{Y}} = (1-\beta) \ . \tag{31}$$

Equation (31) indicates that the consumption growth rate is exactly the weight given by adult agent to investment in education $(1-\beta)$.

Proposition 5: In this OLG economy, the sustainable growth in consumption requires that individuals must assign a certain positive weight or importance to human capital accumulation $(1-\beta > 0)$ (the proof follows from equation (31)).

This completes the characterization of our stylized OLG economy.

Utilizing the above theoretical framework, we next carry out our empirical analyses, based on above propositions, one can assert that increase in investment in human capital accumulation will increase income of an individual as well as reduces the natural resource degradation. Also, increase in production of output by natural resource intensive technology vis-à-vis human capital-intensive technology or reduction in natural resources reduces income of an individual and increases natural resource degradation. We propose finding answers to the research questions or test the hypothesis emerging from above analytical results empirically through a state-level analysis for India. We have developed two equations, which are tested for 26 Indian states covering the time period 1993 to 2011.

6. Empirical Model and Variables

Our first equation is the income equation, which assesses the impact of natural resource degradation and human capital accumulation on income level. The explanatory variables are selected based on the theoretical and empirical literature. The benchmark specification follows a panel design and given below:

$$\ln IN_{it} = \delta_0 + \delta_1 \ln NRD_{it} + \delta_2 \ln HC_{it} + \sum_{k=1}^{K} \delta_k \, \text{In} X_{kit} + \varepsilon_{it} \tag{A}$$

Here i denotes the state and t is the year of observation. All the variables considered are in logarithmic. Here IN is the dependent variable that represents income level of a state, NRD is a most prominent regressors of this study i.e., natural resource degradation (NRD), HC is a human capital accumulation. The vector X_k includes host of other influencing variables such as output produced from human capital technology, from natural resource intensive technology etc.

Our second equation pertains to natural resource degradation that aims to estimate the impact of income level (IN) and human capital accumulation (HC) on natural resource degradation (NRD). For this the testable model is specified as follows:

$$\ln NRD_{t} = \beta_0 + \beta_1 \ln IN_{it} + \beta_2 \delta_2 \ln HC_{it} + \sum_{k=1}^{K} \beta_k \, \text{In} X_{kit} + \varepsilon_{it} \tag{B}$$

Here again the vector X_k includes host of other influencing variables that affects natural resource degradation. We will discuss in detail the variables chosen to measure the income level, natural resource degradation, human capital accumulation and host of other influencing variables.

We have measured income level (IN) by poverty level in a state, which, in turn, is proxied by head count ratio. Reduction of poverty is often linked to natural resource base (Adams et al., 2004; MEA, 2005; Sunderlin et al., 2008). This is particularly true for low-income country like India where a large share of working population directly depends on natural resources such as agriculture, forestry and fisheries resources (Sathaye et al., 2006). In order to measure natural resource degradation (NRD), we have considered reduction in forest cover and increase in land degradation (LD) an indicator of it and proxied it by percentage of geographical area as forest cover and percentage of wasteland in a state respectively. We have considered forest cover as a measure of environmental degradation. Forests work as "sinks" that lower the impact of climate change and regulate clean air. Poorer people tend to consume biomass fuels such as straw, firewood etc., which cause deforestation as well as indoor air pollution. Poverty plays a major role in deforestation: it may force adoption of more intensive agriculture by clearing degraded or forest land. This, in turn, causes vegetation cover loss and soil erosion, which could lead to reduction in productivity and aggravated poverty. Hence, there tends to be a cause-effect relationship between poverty and forest degradation. Land degradation is often perceived as an outcome of the failure, to manage resources through necessary institutional arrangement and investment in technological change and to deal with the rising demand for forest products such as firewood, timber, non-timber forest products and fodder for livestock (Mythili and Goedecke, 2016). Moreover, non-farm activities are related with lower soil erosion, higher soil nutrient balances and increase in household income (Nkonya et al, 2008). The increase in poverty increases land degradation because poor household's lack resources necessary to invest in the conservation of natural resource. Land degradation, in turn, leads to an increase in poverty via its contribution to declining and low agriculture productivity (Kirui, 2016).
The main contributor to human capital accumulation is education, for this study we proxy human capital of the country by two different variables i.e. enrolment in primary classes (classes one to fifth) (PCE), and enrolment in classes sixth to twelfth $(SixtwelE)$. Higher education may not only reduce poverty levels through better earnings prospects but could also facilitate adoption of sustainable natural resource management practices by individuals. There exist a clear positive association between education and natural resource conservation, the rise in the education level of an individual favours the adoption of soil conservation practices (Wander et al. (2009). The growth of non-farm income, spread of primary education, more business assets and non-farm employment could lead to reduction in natural resource degradation (Baland et al., 2010). The high illiteracy increases deforestation (Reetz et al., 2012). More educated individuals as opposed to less educated ones have better access to financial capital, physical capital, human capital, and market-based livelihood earning opportunities. Hence, increase in human capital accumulation is expected to reduce poverty and natural resource degradation.

7. Explanatory Variables and Data Sources

Our estimations rely on secondary data sources. We construct a panel data set covering 26 states for the period spanning 1993 to 2011. Most of the data are taken from the State of Forest Report, Government of India, Ministry of Environment, Forest and Climate Change (MoEF&CC); Forest Survey of India (FSI), various issues; Central Statistics Organisation, Ministry of Statistics and Programme Implementation; and Department of Secondary and Higher Education, Ministry of Human Resource Development (MHRD). Table 1., given in Appendix, summarises the definitions of the variables and their data sources.

Estimation methods

Three possible estimation method of the system of equations (A) and (B) given above are following:

Feasible Generalized Least Square (FGLS) estimation method

Our empirical analysis involves panel data regression of 26 state level variables over time period 1993 to 2011. Because our data relates to states observed over time, heterogeneity in these states is bound to exist. The panel data methodology can allow for clear consideration of these heterogeneity One way of capturing each state's heterogeneity is to allow the intercept term to differ for each state, but assume that the slope coefficients are constant for each state. In the literature this is captured by fixed effects (regression) model (FEM). One side effect of the FEM is that it cannot be used to investigate time invariant causes of the dependent variables. One should use random effects model (REM) if one believes that differences across states have some impact on dependent variable. To choose between random or fixed effects, one need to run the Hausman test, under the null hypothesis that the preferred model is REM vs. the FEM (see Green, 2011, chapter 13). It tests whether state specific errors and explanatory variables are correlated with each other. The Hausman test for our model confirms that we should use the FEM, since the state specific error terms are correlated with the regressors.

The states considered for our study are quite heterogeneous. In order to detect heteroscedasticity, the modified Wald-test for group-wise heteroscedasticity in FEM was performed. Further, in order to detect the presence of autocorrelation, the Wooldridge test for autocorrelation for the panel data was conducted. The presence of both autocorrelation and heteroscedasticity was detected. To correct for pair-wise heteroscedasticity and first-order autocorrelation, Feasible Generalized Least Square (FGLS) method was applied to our FEM for the estimation of equations (A) and (B). FGLS is the method that is used for the estimation of coefficients associated with independent variables when the variance co-variance matrix of the residuals is unknown. Hence, the results reported by us are corrected for autocorrelation and heteroscedasticity based on country fixed effect regression model using FGLS.

One limitation of FGLS method is that it does not account for the fact that poverty, natural resource degradation could potentially be an endogenous regressor. To address endogeneity issue, we resort to instrumental variable (IV) method based on fixed effect framework to check for the possibility of endogeneity and obtain consistent estimates

Instrumental variable-two stage least square method

Instrumental variable-two stage least square (IV-2SLS) is a method of estimation that is widely used in many economic applications when the correlation between dependent variable's error terms and the explanatory variables is suspected. In order to deal with it, we can apply IV-2SLS estimation technique to equations (A) and (B) because instrumental variables are used to create a new variable by replacing the endogenous variable. The basic idea is that we can replace the actual realized values of endogenous variables (which are correlated with the error term) by their predicted values that are related to the actual values but uncorrelated with an error term.

We use an instrumental variable IV-2SLS method in a fixed-effects (FE) framework to obtain unbiased estimates of the estimated equations. To check if the instruments are uncorrelated with the error term in the estimated equation, we perform the Sargan- Hansen's test. The Sargan-Hansen's test statistic is implemented under the null hypothesis of no correlation between instruments and the error term of the estimated equation.

Two step Generalized Method of Moments

Many econometric problems could arise with the estimation of equation (A) and (B) such as heteroscedasticity, simultaneity and endogeneity. To resolve all these econometric problems, we resort to generalized method of moments. This is preferred over FGLS estimation technique, which would produce biased estimators. Thus, we resort to estimation based on the generalized method of moment (GMM) system. To remove unobserved time invariant state specific effects the difference GMM takes first differences, and then instrument the right-hand-side variables in the first-differenced equations using levels of the series lagged one period or more. All this is done under the assumption that the time varying disturbances are not serially correlated in the original levels' equations (Bond et al, 2001). In case there are limited number of time-series observations and the autoregressive parameter of the endogenous variable is sufficiently large then difference GMM estimator will be downward bias. To reduce the bias and improve the precision of the estimators System-GMM was formulated by Arellano and Bover (1995) and Blundell and Bond (1998).

The System GMM estimator uses two equations: one differenced and one in levels to obtain a system of two equations. The variables in second equation are instrumented with their own first differences. By adding the second equation additional instruments can be obtained. System-GMM system performs better than first-differenced GMM, the latter being seriously biased in small samples when the instruments are weak (Blundell and Bond, 1998). To increase the efficiency of the estimator, we will use "System GMM" when lagged levels of the regressors are poor instruments for the first-differenced regressors.

To test the validity of lagged variables used as instruments, we use the standard Hansen J statistic, under the null hypothesis that the instruments are orthogonal to the error term. The higher the P-value of the Hansen J statistic the better it is. The higher value imply that the null hypothesis cannot be rejected, it provides evidence in support of exogeneity of instruments. To choose the appropriate lag of the endogenous variables as instruments, we will use Arellano-Bond serial correlation test, which has a null hypothesis that the errors exhibit no second-order serial correlation. The test for AR (1) process in first difference usually rejects the null (P-value < 0.05). In such a case, the second lag is required, because it is not correlated with the error term. The test for AR (2) usually accepts the null of no autocorrelation (P-value > 0.05,) in which case one can experiment with a second or longer lags to find a good instrument.

For each of the two equations (A) and (B), I run a set of FGLS, IV-2SLS and System- GMM models aimed at testing the hypothesis developed based on theoretical and empirical analysis. I run a baseline model in the first place, where main variables alone explain the dependent variable. I then extend this baseline model to include the full set of conditioning variables.

Estimation Results

Table 2 presents the results of estimation of poverty regression equation (A), using the feasible generalized least square (FGLS) estimation method, IV-2SLS and System-GMM. Since, System-GMM unlike FGLS which doesn't account for endogeneity among variables and IV-2SLS whose results depends on the instrument chosen to measure the endogenous variable is unlikely to produce biased results. We will be mainly discussing the estimation results of System GMM.

We find that the coefficient of lagged poverty is positive and significant across all the specifications, which represents that poverty (*POV*) is highly persistent or path dependent. We find that a 1% increase in forest cover will increase poverty by 0.123%. This result arises because most of the forest-based states tend to have high incidence of poverty than the all-India estimates. We find that the increase in primary classes enrolment by 1% will increase poverty by 0.386%. Whereas increase in enrolment in classes sixth to twelfth by 1% will reduce poverty by -1.38e-08%. This is because primary education and literacy programmes are not imparting sustainable literacy, so, children do revert into illiteracy. It is secondary and higher education that accumulate individuals' skills that matches with the requirements of labour market.

We also find that increase in agriculture GSDP will reduce poverty. Whereas coefficients associated with industry GSDP and services GSDP are insignificant. Many empirical findings suggest that agriculture sector growth leads to a higher reduction in poverty than other sectors because many of the rural poor people depend on agriculture for a living. In India, despite the growth of industry and services sectors, the share of these sectors in total employment has stagnated. Hence, their contribution to poverty reduction is not much. The increase in social sector expenditure by 1% will reduce poverty by -0.311%, which highlights the effectiveness of government expenditure on health and education in alleviation of poverty. The increase in infant mortality rate and acute respiratory infection will increase poverty. This increases health risks for children below five years of age and financial burden for the already economically weaker individuals/households. The increase in rural firewood consumption and forestry GSDP by 1% will reduce poverty by -0.458% and -1.91e-07% respectively. This result is supported by many empirical studies which suggest that forest income constitutes a significant portion of poor household's income (Vedeld et al., 2007; World Bank Group, 2016).

We also find that increase in number of bank offices by 1% will reduce poverty by -0.145%. This implies that a state that has a greater access to finance and credit facilities will be able to invest more in human and physical capital which would potentially stimulate growth and development. We also find that increase in urban population by 1% will reduce poverty by -0.088%. A higher share of urban population tends to be associated with steeper rate of overall poverty reduction (Ravallion et al., 2007). The coefficient associated with rate of deforestation and the interaction term between forestry GSDP and rate of deforestation is found to be insignificant.

Table 2: Estimation results of poverty equation based on FGLS, IV-2SLS and System-GMM

Dependent Variable: Log (Poverty)	**Fixed effects with state and year**	**IV-2SLS**	**System-GMM**
Lagged of Log (Poverty)	0.6128*** (0.000)		0.4259*** (0.000)
Log (Forest Cover as percentage of geographical area)	0.0301** (0.063)	-0.9562* (0.086)	0.1227*** (0.000)
Log (Primary classes' enrolment)	0.0888** (0.022)	1.2406* (0.081)	0.3856*** (0.000)
Log (Enrolment in classes sixth to twelfth)	-1.87e-08*** (0.000)	-0.6055*** (0.000)	-1.38e-08* (0.075)
Log (Agriculture GSDP)	-4.28e-08** (0.020)	-0.3077 (0.187)	-2.20e-08** (0.010)
Log (Industry GSDP)	-8.41e-09* (0.070)	-2.06e-07*** (0.000)	2.67e-08 (0.107)

Log (Services GSDP)	0.1001** (0.022)	2.48e-07 *** (0.000)	5.59e-09 (0.467)
Log (Social sector expenditure)		-0.0093*** (0.000)	-0.3109*** (0.000)
Log (Encroachment on forest land)		-0.1254*** (0.005)	
Lagged of Log (Infant mortality rate)			0.1276*** (0.000)
Log (Acute respiratory infection)			7.15e-08** (0.034)
Lagged of Log (rural firewood)			-0.4579*** 0.000
Log (Urban Population)		-1.5842 (0.116)	-0.0883** (0.034)
Log (Number of Bank Offices)			-0.1446*** (0.000)
Forestry GDP		-6.02e-07** (0.029)	-1.91e-07*** (0.000)
Rate of deforestation		0.3289 (0.112)	-0.0162 (0.324)
Deforestation* forestry GSDP		-3.64e-07 (0.246)	
Constant	-1.6440** (0.031)	-6.4260 (0.271)	-0.0829 (0.770)
Number of observations	462	405	
R-Squared	0.9008		
		We instrument forest cover (*FOR*) by using expenditure on forests (*EOF*) and protected forests area (*PF*).	

Note: P-value associated with Z-Statistic is given in parenthesis; ***P<0.01, **P<0.05, *P<0.1

Estimation of forest cover regression equation using FGLS, IV-2SLS and System-GMM Methods

The Table 3 summarises the estimation results of natural resource degradation measured by forest cover as percentage of geographical area (B) by using FGSL, IV-2SLS and System-GMM method, interestingly, the results remain qualitatively the same across all the three methods. The lagged forest cover has a positive impact on forest cover, pointing towards the persistence or path dependency. Based on estimation results, we can say that a 1% increase in poverty will increase the forest cover by 0.378%. The positive coefficient for poverty refutes the prevailing argument that higher poverty leads to reduction in forest cover. All the coefficients have the expected signs except the coefficient associated with poverty. This result is consistent other empirical studies, which find that it is not the poorest households but the wealthy households with medium or high asset holdings were more responsible for clearing forests. Hence, higher income and assets could eliminate the capital constraint which encourages wealthy individuals to clear more forests. Further, we find that increase in enrolment in primary classes (*PCE*) and in sixth to twelfth classes (*SixtwelE*) by 1% will increase forest cover by 0.022% and 0.157% respectively. More educated individuals as opposed to less educated ones have better access to financial capital, physical capital, human capital, and market-based livelihood earning opportunities. We also find that increase in pasture and grazing land and expenditure on forest will increase forest cover by 0.038% and 0.027% respectively. These results are in line with our expectation.

The results suggest that agriculture sector (*AGR*) and industry sector (*IND*) GSDP levels reduce forest cover (*FOR*), which is consistent with our expectation that higher production by natural resource-intensive technology would lead to environmental degradation. Some of the driving factors of deforestation are fuel wood harvesting and agricultural land expansion. Globally, it is estimated that agriculture is the primary cause of about 80 per cent of deforestation. In tropical Asia and Africa, subsistence agriculture and commercial agriculture both account for one-third of deforestation. In Latin America, the foremost driver of deforestation is commercial agriculture which is responsible for around two-thirds of all cut forests (Kissinger et al., 2012). The divergence or clearing of forest land for establishing industry has also led to extensive deforestation. The growth industries based on forests, such as pulp and paper, timber and logging are important causes of deforestation. The increase in demand for timber and agriculture products is critical drivers of deforestation. According to our estimates, the services sector (*SER*) GSDP is found to increase forest cover. This result is in line with the findings of Nkonya (2008), who find that non-farm activities are associated with higher soil nutrient balances, lower soil erosion and increase in household income. Also, in India, services sector, namely, communication, banking and insurance services etc. are the fastest growing areas of economy. In the recent years IT based services, such as business process outsourcing (BPO) have also grown considerably. Hence, services sector production depends more on human capital-intensive technology than the natural resource-intensive technology and it tends to be more environmentally sustainable.

The increase in density of population (*DOP*) is found to reduce forest cover (*FOR*). These results are consistent with the prevailing view that as the population of the country increases it leads to a decrease in the forest cover, since forests need to be cleared to meet the food needs of ever-growing population. Accordingly, forests are converted to permanent settlements that reduce the possibility of regeneration. In India a considerable amount of land area under forest has been cleared for setting up of industries, for agriculture land, and for expansion of infrastructure, housing and other uses.

An increase in forestry sector GSDP (*FORGSDP*), cropping intensity, rural firewood consumption and density of population reduces forest cover (*FOR*) is quite obvious. Furthermore, the interaction term between poverty (*POV*) and forestry sector GSDP (*FORGSDP*) is negative, implying that higher poverty reduces forest cover via increase in forestry sector GSDP, which conforms to our expectation.

Table 3: Forest equation regression estimation using FGLS, IV-2SLS and System-GMM

Log (per cent of geographical area as forest cover)	Fixed effects with state and year	IV-2SLS	System GMM
Lag of Log (per cent of geographical area as forest cover)			0.7582*** (0.000)
Log (Poverty)	0.1287** (0.011)	0.1934 (0.103)	0.3783*** (0.005)
Log (Encroachment on Forest Land)	-6.45e-07*** (0.000)		
Log (Primary classes' enrolment)	0.1222* (0.081)	0.7971** (0.012)	0.0223** (0.029)
Log (sixth to twelfth classes' enrolment)	0.0485** (0.044)	0.7629*** (0.003)	0.1575*** (0.001)
Log (Pasture and grazing land)	0.0386** (0.015)	0.1477*** (0.000)	0.0378*** (0.000)
Log (Expenditure on Forest)	0.0105*** (0.003)	0.0163*** (0.006)	0.0271*** (0.000)
Forestry GSDP	-2.34e-07*** (0.000)		-1.41e-08** (0.037)
Log (Poverty)*Log (Forestry GSDP)	-0.0408* (0.054)		-0.0288*** (0.004)
Log (Cropping intensity)	-0.3698*** (0.000)		
Log (Density of population)	-0.8920*** (0.000)	-0.5250 (0.652)	-0.0817 (0.198)
Log (Agriculture)	-0.3134*** (0.000)	-6.88e-08 (0.120)	-1.21e-07*** (0.000)
Log (Industry)	-7.76e-08*** (0.000)	-0.0348*** (0.007)	-0.1673*** (0.000)
Log (Services)	4.84e-08*** (0.000)	5.86e-10 (0.931)	3.32e-08*** (0.000)
Log (Rural firewood consumption)	-0.0005*** (0.000)		
Constant	9.3740*** (0.000)	3.0832 (0.277)	0.1876 (0.657)
		We instrument poverty by using expenditure on social sector (*SSE*)	

Note: P-value associated with Z-Statistic is given in parenthesis; ***P<0.01, **P<0.05, *P<0.1

Table 4 presents the results from our estimation of the poverty regression equation (A) when percentage of wasteland as geographical area is taken as an indicator of land degradation or natural resource degradation. As can be seen, lagged poverty levels have a positive and significant impact on poverty levels, thus contributing further to poverty levels in the state. We find that as percentage of wasteland increases by 1% poverty reduces by 0.001%. This stems from the fact that the increase in the income of poor requires the intensification of agriculture production, which contributed to land degradation. We also find that primary classes' enrolment increases poverty while enrolment in sixth to twelfth classes reduces poverty. These results are consistent with those obtained when deforestation is taken as an indicator of natural resource degradation. The impact of agriculture GSDP, industry GSDP and services GSDP on poverty remains uncertain as its coefficient sign and significance keeps on changing across different estimation methods. The coefficient sign associated with an interaction term on percentage of wasteland and urban population has a positive sign implying that the increase in urban population reduces poverty via increase in percentage of wasteland. The increase in social sector expenditure and urban population reduces poverty whereas infant mortality rate increases poverty, which is consistent with our expectation.

Table 4: Poverty Regression Equations based on FGLS, IV-2SLS and System-GMM

Note: P-value associated with Z-Statistic is given in parenthesis; ***P<0.01, **P<0.05, *P<0.1

Log (Poverty)	**Fixed Effects with state and year**	**IV-2SLS**	**System GMM**
Lagged of Log (Poverty)			0.8876*** (0.000)
Log (Per Wasteland)	-0.1973* (0.094)	-3.0976** (0.016)	-0.0012** (0.049)
Primary classes' enrolment	0.1048* (0.061)	0.6749*** (0.000)	0.1119*** (0.006)
Log (classes 6th to 12th enrolment)	-2.56e-08*** (0.001)	-0.3256** (0.034)	-2.18e-08* (0.097)
Log (Social sector expenditure)	-0.1553*** (0.000)	-0.3733*** (0.001)	-0.0664** (0.031)
Log (Agriculture)	-0.0441 (0.297)	-0.3103** (0.049)	0.0045 (0.924)
Log (Industry)	-0.0157 (0.276)	-0.0325 (0.232)	3.66e-08* (0.072)
Log (Services)	-0.2237*** (0.001)	0.5164*** (0.002)	-2.15e-08*** (0.008)
Log (Infant mortality rate)	0.1169*** (0.000)	0.1130 (0.155)	
Log (UrPop)	-0.3365*** (0.000)	-2.852*** (0.005)	-0.110 (0.534)
Log (Per Wasteland) *Log (pop)	0.0302 (0.419)	0.6458** (0.029)	
Constant	6.6645*** (0.000)	5.8645 (0.165)	-0.8374*** (0.004)
No. of Observations	491	483	458
		We instrument the percentage of wasteland (*Per Wasteland*) by using funds received for IWDP ($Funds\ received\ IWDP$)	

Table 5 contains the results obtained for the natural resource degradation regression equation (B), when land degradation measured by percentage of wasteland as geographical area is used. The results reveal that the increase in poverty increases the land degradation. A 1% increase in poverty increases the land degradation by 0.102%. This result is in line with many other studies that found that poverty leads to land degradation (Kirui, 2016; Bhattacharya and Innes, 2013; Heger, 2018). We also find that the increases in percentage of irrigated area reduces the land degradation. The higher land-man ratio lowers the land degradation. This means that higher population pressure is causing land degradation on cultivated land.

The increase in funds received for integrated wasteland development programme (IWDP) reduces land degradation. Higher average size of operational holdings also reduces land degradation, which is consistent with our expectation. Farmers' accessibility to larger sized land allows them to produce at maximum capacity and apply newer technology. The increase in length of roads and length of highways has a positive impact on land degradation, but length of roads has an insignificant impact. This result is consistent with our expectation which implies that more infrastructure development causing greater access to otherwise inaccessible land tracts, higher human disturbance, and land use changes resulting from it would exert greater adverse impact on land degradation. The increase in pesticide consumption and agriculture GSDP reduces the land degradation. The increase in industry GSDP and services GSDP has an ambiguous impact on land degradation as the coefficient associated with it changes its sign and significance across different estimation methods. The increase in the density of population reduces land degradation, which implies that increased population pressure on land does not lead to land degradation. This finding somehow contradicts our expectation. Similar result was found by Mythili and Geodecke (2016), who found that increase in population density reduces land degradation.

Table 5: Land Degradation regression equations based on cross section for year 2011, FGLS, IV-2SLS and System-GMM

Log (Per Wasteland)	Fixed Effects with state and year effect	IV-2SLS	System GMM
Lagged of Log (Per Wasteland)			1.3713*** (0.000)
Log (Poverty)	0.0006 (0.575)	0.9768*** (0.000)	0.10217* (0.069)
Log (per Irrigated area)	0.00003** (0.014)	0.0003*** (0.000)	-0.00004* (0.098)
Land-man ratio	-0.00024*** (0.004)	-0.0026*** (0.000)	0.0003** (0.029)
Natural disaster	0.0168* (0.091)		
Fund received for IWDP	-0.00001* (0.051)	-0.00005*** (0.004)	-0.000016 (0.272)
Avg size of operational holdings	-0.0437*** (0.001)		-0.0058 (0.706)
Length of roads	-2.08e-07 (0.109)		3.73e-07 (0.394)
Length of highways	-0.00004*** (0.002)		-0.0001** (0.033)
Log (Productivity of Total Food grains)	-0.000035** (0.015)		
Log (Pesticides Consumption)	8.13e-06** (0.044)	0.08109*** (0.002)	
Log (Primary classes' enrolment)	-1.28e-08** (0.014)	-0.4271*** (0.018)	-0.3933*** (0.002)
Log (classes sixth to twelfth enrolment)	-7.62e-09 (0.203)	0.4435** (0.024)	0.2048* (0.059)
Log (Agriculture)	0.0640** (0.041)	1.45e-07* (0.058)	3.08e-08** (0.015)
Log (Industry)	-0.0079018 (0.194)	7.52e-08* (0.062)	2.34e-08 (0.301)
Log (Services)	-0.0762**	-4.99e-08***	-1.62e-08

	(0.030)	(0.009)	(0.201)
Log (Cropping intensity)		-0.0275 (0.908)	
Log (density of Population)	-0.0008*** (0.000)		
Constant	2.0473*** (0.000)	-2.5815 (0.268)	1.5573* (0.051)
No. of Observations	463	480	447
		We instrument poverty by expenditure on social sector	

Note: P-value associated with Z-Statistic is given in parenthesis; ***P<0.01, **P<0.05, *P<0.1

8. Conclusion

This paper examines the role of human capital accumulation in reducing poverty and natural resource degradation. For this purpose, we extend the model developed by Ikefuji and Horii (2014) as our analytical framework, which is then tested empirically by utilizing a large panel dataset at the state level for India, with focus on deforestation and land degradation. Unlike Ikefuji and Horii (2014) who developed an overlapping generations model (OLG) in the context of local pollution, we have adapted it in the context of renewable natural resources. To do this, we have introduced the production sector that relies on a natural resource intensive technology This helps us characterize the conditions under which individuals will invest in human capital and move on to adopt sustainable technology instead of the natural resource intensive technology.

As the main result of our theoretical analysis, we find that a more educated individual is less dependent on the natural resource for earning her/his income. If the investment in education is zero then the individual has no option but to rely entirely on the natural resource intensive technology for earning her/his livelihood. We also find that as the investment in education increases the output produced from sustainable technology rises and the output produced from natural resource intensive technology falls. We also find that the sustainable growth in consumption requires that individuals must assign certain positive weight to investment in her/his child's education. A long run steady state equilibrium level of the human capital accumulation is higher, higher is the weight assigned by the parents to the child's education.

In this overlapping generations economy, a sustainable growth in consumption requires that individuals must assign certain weight or give some importance to human capital accumulation. This follows from the fact that long-run steady state value of the income earned by individual depends positively on the expenditure on education.

Based on the analytical results, we have tested the following research hypotheses. A country with higher natural resource degradation and lower human capital accumulation experiences higher levels of poverty. A country with higher poverty levels and lower human capital stock experiences higher natural resource degradation. A country that produces a higher share of output with the sustainable technology visa viz the natural resource intensive technology experiences lower level of poverty and lower level of natural resource degradation. These research questions are then tested for 26 Indian states covering time period 1993 to 2011, using three different method namely FGLS, IV-2SLS and System-GMM. We have considered the head count ratio as a proxy to measure poverty, deforestation and land degradation measured by forest cover as percentage of geographical and wasteland as percentage of geographical area as an indicator of natural resource degradation.

Based on empirical estimation, we find that increase in forest cover increases poverty level. whereas increase in land degradation reduces poverty. The conclusion that can be drawn from these findings is that the natural resource conservation will increase poverty. This is due to the fact that income from natural resource constitutes a significant portion of the poor household income. Hence, natural resource conservation will derive poor people of their access to forestry and land resources, which, in turn, will exacerbate poverty. We also find that as poverty increases, forest cover and land degradation tend to increase in the state. It is because in India highly forested area is associated with higher poverty rates. In India most of the forest area is protected; while this can reduce deforestation, it would tend to have a negative impact on people's livelihood by restricting their access to forest use for hunting, logging, and farming. Also, most of the poverty prone states engaged in intensive agriculture activities, which in increases land degradation. This emphasizes the importance of alleviating poverty among rural households that rely on land resources for their livelihoods to mitigate land degradation.

It is found that agriculture sector reduces forest cover and increases land degradation, which is consistent with our expectation that higher production by natural resource-intensive technology would lead to natural resource degradation. Some of the driving factors of deforestation are fuel wood harvesting and agricultural land expansion. We also find that increase in primary classes enrolment will increase forest cover and reduces land degradation in a state. In theory school education makes the students aware of environmental concerns, thereby making them aware of the impact their choices likely to have on environment. Whereas increase in sixth to twelfth classes enrolment will reduce poverty. Therefore, policies aimed at providing market-based employment opportunities to poor people will lead to natural resource conservation. The formulation of policies aimed at providing higher education to the poor people are recommended. because more educated individuals are able to fetch higher paid jobs than the less educated ones.

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Appendix

Table 1: Proxy variables and associated data sources

Variable	Definition	Source
Poverty	Head count index measured by percentage of population below poverty line	Report of the Expert Group to Review the Methodology for Measurement of Poverty, Planning Commission, Government of India, 2014."
Forest cover as percentage of geographical area	Forest cover includes all lands which have a tree canopy density of 10 per cent and above with area of 1 hectare or more (area in sq. km)	State of Forest Report, Government of India, Ministry of Environment and Forest (MOEF), Forest Survey of India (FSI), various issues.
Agriculture	Agriculture GSDP (at 2011-12 constant prices)	Central Statistics Organisation, Ministry of Statistics and Programme Implementation, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Industry	Industry GSDP (at 2011-12 constant prices)	Central Statistics Organisation, Ministry of Statistics and Programme Implementation, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Services	Services GSDP (at 2011-12 constant prices)	Central Statistical Organisation, Ministry of Statistics and Programme Implementation, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Expenditure on social sector	Social sector expenditure includes expenditure on social services, rural development and food storage and warehousing.	Handbook of Statistics on State Government Finances-2010, and various issues of State Finances: A Study of Budgets, Reserve Bank of India.
Encroachment on forest lands	Forest Area under Encroachment (in hectare)	Indian Council of Forestry Research and Education, and Ministry of Statistics and Programme Implementation, Government of India.
Protected forests	Protected Forest is also notified under India Forest Act or the State Forest Acts but has only a limited degree of protection	The State of Forest Report, Government of India, Ministry of Environment and Forest (MOEF), Forest Survey of India (FSI), various issues.
Rate of deforestation	Calculated from the formula specified by FAO (1995) based on data on forest cover	State of Forest Report, Government of India, Ministry of Environment and Forest (MOEF), Forest Survey of India (FSI), various issues.
Percentage of urban population	Total urban Population divided by total population of the state	Office of the Registrar General and Census Commissioner, India, Ministry of Home Affairs, Government of India, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Density of population	Total population divided by total geographical area of the state (per sq. km)	Office of the Registrar General and Census Commissioner, India, Ministry of Home Affairs, Government of India, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Primary classes' enrolment	Total persons' enrolment in primary classes (classes one to five)	Ministry of Human Resource Development (MHRD), Government of India.
Sixth to twelfth classes' enrolment	Total persons' Enrolment in classes sixth to twelfth	Department of Secondary and Higher Education, Ministry of Human Resource Development, Government of India.
Infant mortality rate	Infant mortality rate is defined as "the number of children dying under one year of age, divided by the number of live births during the year, multiplied by 1,000"	Sample Registration System (SRS) Bulletin, various issues, Office of the Registrar General and Census Commissioner.
Forestry and logging GDP	Forestry and logging GSDP (at 2011-12 constant prices)	Central Statistics Organisation, Ministry of Statistics and Programme Implementation, accessed from Handbook of Statistics on Indian states, Reserve Bank of India, 2015-16.
Pasture and grazing land	Permanent Lands, Pastures and Other Grazing Land (in thousand hectare)	Agricultural Statistics at a Glance, 2016, Ministry of Agriculture, Government of India, various issues.
Expenditure on forest	Actual expenditure on forestry	Indian Council of Forestry Research and Education, and Ministry of Statistics and Programme Implementation, Government of India.
Cropping intensity	Ratio of net sown area to total cropped area	Ministry of Agriculture and Farmers Welfare, Government of India, accessed from Handbook of Statistics on Indian States, Reserve Bank of India, 2015-16.
Acute respiratory infection	Number of Cases and Deaths due to acute respiratory infection (ARI)	Compiled from the Statistics released by: Ministry of Health and Family Welfare, Government of India.
Rural firewood consumption	Number of households using firewood for cooking per 1000 households in rural areas	Ministry of Statistics and Programme Implementation, accessed from https://www.indiastat.com/housing-data/17/households-by-type-of-fuel-used-for-cooking.
Percentage of	Wasteland as percentage of total	Data for 1993 are taken from Draft Report on Status of Land

wasteland	geographical area in a state.	Degradation in India, Department of Agriculture and Co-operation, Government of India
Land-man ratio	Defined as rural population per hectare of the net sown area	Rural Population data are taken from Office of the Registrar General and Census Commissioner, India. Net sown area data are taken from the Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture, Government of India
Percentage of irrigated area	Calculated by dividing the net irrigated area by the net sown area	Ministry of Agriculture and Farmers' Welfare, Government of India
Average size of operational holdings	Calculated by dividing the area by the number of operational holdings by major size groups (in hectare)	Agriculture Statistics at a Glance, 2004, Ministry of Agriculture, Government of India website http://agricoop.nic.in/statatglance2004/atglance.pdf
Funds released under Integrated Wastelands Development Programme (IWDP)	State-wise Number of funds released under IWDP in India (Rs. in crore)	Compiled from the statistics released by: Ministry of Rural Development, Government of India
Pesticide consumption	Consumption of Pesticides (Technical Grade) (in thousand tonnes)	Agricultural Statistics at a Glance 2014, Department of Agriculture and Cooperation, Ministry of Agriculture
Productivity of total food grain production	State/Season-wise Productivity of Total Food grains in India (in kg/hectare)	Ministry of Agriculture and Farmers welfare, Government of India
Length of Highways	State-wise Length of National Highways by Type of Surface in India (in km)	Basic Road Transport Statistics of India, Ministry of Transport and Highways, Government of India
Length of Roads	State-wise total and surfaced Length of Roads in India (in km)	Compiled from the statistics released by the Ministry of Road Transport and Highways, Government of India
Natural Disaster dummy	Year of major natural disasters in state = 1 Otherwise = 0	State of the Environment Report 2001 and State Forest Report, 2001; Ministry of Statistics and Programme Implementation, Government of India (ON1368) and past issues