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Land degradation and poverty trap in rural agrarian communities

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Abstract

We investigate how the differences in ancestral generations' sustainable agricultural practices influence the productivity of soil assets bequeaths that generate convexities in welfare benefits for current generations in rural agrarian households in Nigeria. Using a 2-overlapping intergenerational framework, we formalise how benefits from unsustainable practices are limited to the preceding (ancestral) generation and cause a significant welfare loss for current and future generations. In the second part, we propose an empirical framwework to address how the disparity in endogenous soil stock bequeaths create heterogeneities in the current generations' income and agricultural yield by accommodating for the spatial dimensions of soil management practices.

Keywords: Land conservation, Land reform and use, Intergenerational income distribution

JEL-Codes: E21, E24, Q15, Q18

1. Introduction

The economic rationale for formalising the land degradation-induced poverty trap within an intergenerational framework stems from some stylised facts. First, eroding ecosystem services drive involuntary migration and yields, and future generation of households that depend on biophysical assets for livelihoods are trapped in poverty when the feedbacks from its productivity fail to support livelihood (Figure 1) (Scherr 2000, Barrett 2008, Barrett et al. 2011, Barbier and Hochard 2016). Second, rural households' in developing countries depend

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primarily on agriculture for livelihoods, and agriculture is also heavily dependent on soil quality, which makes a decline in soil productivity bequeath lead to a loss in inter-generational welfare (Nakhumwa and Hassan 2012). Third, agriculture has important inter-linkages with different off-farm income and livelihood activities which further add to the complexity of rural welfare and poverty challenges.

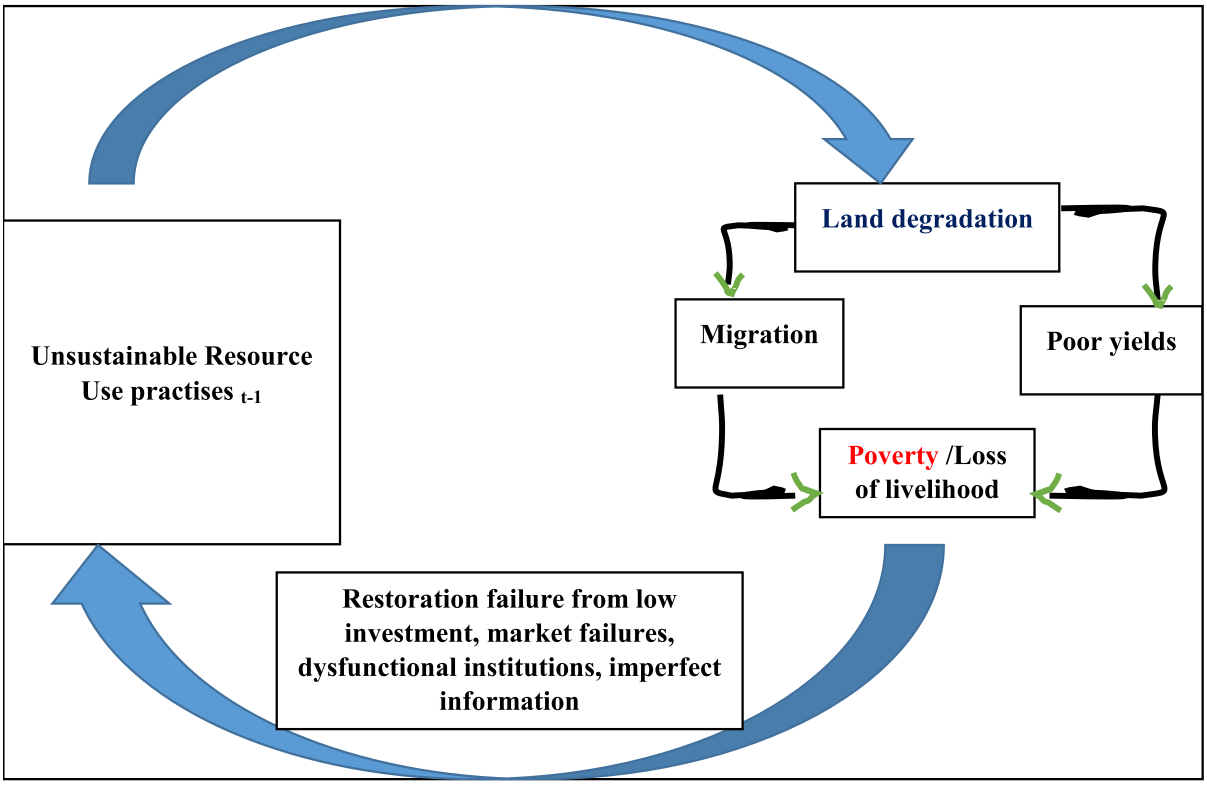

Figure 1: Poverty and unsustainable resource use dynamics

In this study, we seek to understand how land degradation perpetuates poverty within an intergenerational framework. Because households adapt behaviours in response to changes in environmental management which often generating unintended consequences, we explore the link between poverty and land degradation and how this is indirectly caused by a poor bequeath of soil productivity. We explain how this is further accentuated by the inherent vulnerabilities that characterise rural agricultural households e.g. market imperfections that generate inefficiencies and retard assest accumulation, imperfect learning and bounded rationality e.g imperfect information and externalities, coordination failures and weak socio-political and economic institutions (Barrett 2008). In the second part, we propose how to design an empirical framework that will verify the conceptual model by examining how endogenous soil asset productivity bequeath complicates the current poverty status of rural farmers in the north (poor soil bequeath) relative to the rural farming households' in the south (good soil bequeath).

Results are useful in the context of policy formulation that encourages interventions and social protection program for reducing poverty and environmental degradation, and the design of adequate incentives for adoption of sustainable practices. Specifically, the overall findings would significantly help to ascertain the type of intervention necessary for land management and/or for the wellbeing of the human population that depend on the land to get them out of poverty. If people are to get out of poverty, it is crucial to understand how the dynamics of natural resources use translates into dynamics of well-being. Also, it adds to the body of theoretical (Barrett et al. 2011) and empirical evidence on persistence of poverty and biodiversity loss[2]. Relative to other models of the persistence of poverty, the land degradation and poverty nexus appears underexplored, particularly in Africa where it is greatly debated (Sanchez 2002, Sanchez and Swaminathan 2005, Barett 2008, Tully et al. 2015).

We relate our study to previous studies that have examined how endowment passed on to future generations can perpetuate or reduce poverty. Foremost among these studies is Moav (2002). At the risk of oversimplification, Moav (2002) suggests that in an open economy model, the evolution of income within each dynasty generates poverty trap equilibrium along with a high-income equilibrium. We argue that soil stock possesses specific attribute like spontaneous occurrence and non-renewability that makes it markedly different from other conventional income generating activities. Studies which fail to account for these peculiarities could lead to bias in findings on convexities in rural household incomes and welfare. Consequently, we extend Moav (2002) and conceptualise a dynamic model that shows the convex mechanism between intertemporal labour allocations for current harvest or future (conservation) benefits.

In the first part, we developed a conceptual model where ancestral decision makers (households) are characterised as located either in the North (poor soil bequeath) or the South (good soil bequeath) and differentiate the two regions based on the allocation of labour in $time_{t-1}$ for harvest and conservation practices. We argue that the problem for decision-makers in the two regions is similar; to ensure that utility from soil harvest is maximised. Based on this, we

[2] Examples of previous studies include: Dagsupta 1993, Carpenter and Brock 2008, Milner-Gulland 2011

show how the intertemporal/ancestral allocation of labour influences soil depletion and generating convexities in the long-term benefits from harvests, forcing households with poor soil bequeaths to migrate and to generate additional costs to welfare. Additional findings establish how higher benefits from unsustainable ancestral practices are not passed on to the current generation and, therefore, do not necessarily imply higher income for the current generation. This is partly because of market imperfections, imperfect learning and bounded rationality, coordination failures and weak socio-political and economic institutions. More importantly, soil stock and labour are fixed in time *t-1*. The soil is non-renewable and diverting labour away from conservation practices implies declining soil productivity for future use. Equally, rural households are inherently resource-poor; making it difficult to save bumper harvest and invest gains in other productive endeavours.

In the second part we propose to empirically verify our conceptual model by exploring how endogenous soil stock endowment generates convexities in current generation welfare benefits. The endogeneity arises partly from the bi-directional causality between current agricultural income and productivity of soil stock; households that face capital constraints (low income and yield) might be unable to afford conservation practices that improve soil productivity. Subsequently, we account for the spatial land management practice with ancestral land property rights and propose a 2-stage Instrumental variable (IV) estimator to test the study's hypothesis and account for how improved soil productivity contributes to income in rural agricultural households.

The outline is as follows; following this introduction, we present and discuss the conceptual model and methodology in Section 2. Section 3 discusses the methdolgy and Section 4 concludes.

2. The conceptual model

We consider two small, open overlapping-generations, agriculture-based economies, one located in the north and other in the south. Economic activity consists primarily of agriculture, and it extends over an infinite discrete time in a competitive environment. Households in both regions are rational and are endowed with fixed soil resources (*Kt*) and labour (Lt). They allocate labour to undertake a series of soil conservation practises (L_C) and for agricultural production (L_H) in time *t* such that for each allocation ratio ($\phi = L_C/L_H$), there is ϕ (lower bound value), $\bar{\phi}$ (upper bound value) and ϕ^*(threshold value needed to generate sustainable welfare across generations(z*). Labour is mobile and could migrate from a region of lower to higher soil productivity.

In the north, unsustainable practices ensure that the allocation ratio (ϕ^N) is less and below the threshold and range from $\phi < \phi^N < \phi^*$ and in the south, allocation (ϕ^S) range from $\phi^* < \phi^S < \bar{\phi}$. Allocation ratio ($\phi$) in time *t* determines soil productivity in time *t+n* (Ω_{t+n}). For agricultural to be sustainable, we assume a productivity threshold value (Ω^*), given that $\phi^t \geq \phi^{t*}$ for z*. Apart from this, they are identical within as well as across generations for poor technology, and financial capital and savings culture, labour and human capital formation. For simplicity, we ignore the possibility of the farmer considering future selling off the land after losing value.

Effectively, we show that the objective of the farmers in both regions is similar: to maximise the sum of discounted benefits from soil stock for current and future generations. Accordingly, the dynamic optimisation decision problem is specified using a Hamiltonian expression in equation 1.

$$Hc^i = Ht(1-\phi) + \Omega(\phi) + \beta\left[K_t - Ht\right] \qquad 1$$

The farmer is constrained by total soil resources (kt) and labour allocation (ϕ)

$$K_t = St^{t+n} + Ht(1-\phi) \qquad 2$$

$$\phi = \frac{L^C}{L^H} = 1 \qquad 3$$

Preferences are defined in Equation (1) as choosing between the amount of labour for agricultural harvest (Ht) and for maintaining soil productivity(Ω) in time *t,* and the quality of soil bequeath (St^{t+n}) for offsprings in time *t+n*.

The constraint is given by the total soil stock available (*Kt*) which is non-renewable. The second constraint is labour which can be allocated either for conservation or harvest. Based on these, households in time *t* can decide to:

1. Achieve $\underline{\phi}$ (lower bound value) by reducing labour spent on conservation effort (L^C) thereby, harvesting more today, reducing Ω (soil productivity) and a declining St^{t+n}or
2. Maintain labour allocation by at least ϕ* thus ensuring Ω* a higher S_{t+n}

2.1 Conservation Practices and Soil Productivity Bequeath Differential

In the first case, we consider substituting for the value of ϕ in equation 1 and show how the allocation of labour could generate heterogeneities in soil quality bequeath (Ω) in time *t*+*n* such that:

$$S_{t+n} = 0 \qquad if \;\; \phi t \leq \; 0 \qquad 4$$

$$S_{t+n} = \Omega N \qquad if \;\; 0 \leq \; \phi t \leq \; \phi * \qquad 5$$

$$S_{t+n} = \Omega S \qquad if \;\; \phi * \leq \phi t \leq 1 \qquad 6$$

$$S_{t+n} = 1 \qquad if \;\; \phi t = 1 \qquad 7$$

Equation 5 is interesting because it shows that at a very low allocation of labour for conservation practices, soil bequest to future generation in the north would be less than what is required to sustain z*. In the south (equation 6), however, a larger allocation for ϕ^S implies a lower harvest but sufficient to meet with z* and a larger S_{t+n}.

To formalise, we consider equations 4 ($\phi t = 0$) and 7($\phi t = 1$) and derive the FOC of equation (1) to determine how intertemporal labour allocation for conservation practices influence static benefits in time *t* such that benefits from harvest is larger in the north and less in the south.

$$\frac{\partial Hc}{\partial \phi t} = 0 = \frac{\partial (Ht(.)+0)}{\partial \phi} = \beta North \; (marginal \; benefits \; from \; harvest, when \; \phi t = 0) \qquad 8$$

$$\frac{\partial Hc}{\partial \phi t} = 0 = \frac{\partial (0+\Omega(.))}{\partial \phi} = \beta South \; (marginal \; benefits \; for \; south, when \; \phi t = 1) \qquad 9$$

Then we consider how this translates into dynamic benefits. First, I assume world capital rate of return R, then as such,

$$-\frac{\partial Hc}{\partial St} = \beta * t - R\beta t \qquad 10$$

$$R = \partial \beta * t/\partial t \div \beta t$$

Where $\beta * t$ is the future marginal benefit from S_{t+n}

Subsequently,

$$R = I^{N}{}_{t+n} = \frac{\partial[Kt - Ht(.)]\partial t}{\beta t^{NORTH}} \; when \; (0 \leq \phi t \leq \phi *) \qquad 11$$

$$R = I^{s}{}_{t+n} = \frac{\partial[Kt - Ht(.)]\partial t}{\beta t^{SOUTH}} \; when \; (\phi * \leq \phi t \leq 1) \qquad 12$$

Because $\beta North > \beta South, then$ future benefits from soil harvest from the south ($I^{s}{}_{t+n}$) would be greater than the north($I^{N}{}_{t+n}$).

2.2 Evolution of Income from Productivity Differential Bequeath

In this part, we show how the productivity differential of soil bequeaths complicate offsprings' income inequality given the inherent vulnerabilities of the rural households. First, we consider the North. Declining soil productivity implies less harvest that could sustain welfare, and this could generate some push factors encouraging households to relocate to regions with better soil productivity. Additionally, households with better soil could have a marginal increase in welfare by utilising labour (or rents paid by) of members with poor soil bequests. Thus, labour availability in the south increases labour allocation leading to more benefits for southern farmers.

Because households in the North have a less St^{t+n} eqns (5 and 11), offspring can respond in three ways, by:

1. staying back in the north and harvesting less,
2. migrating to the south and rent south land after paying rent of (π) which is a fraction of $I^{s}{}_{t+n}$, or
3. migrating to the south and offer to work for farmers in the south and get paid wage (w").

The second option comes with an additional utility (μ) from being self-employed rather than working for a wage and, an additional probability of risk (δ) from crop failure, relocation and adjustment costs. Accordingly, these possibilities create different income scenarios that fall below z*:

$$I^{N}{}_{t+n} = \frac{\partial[Kt - Ht(.)]\partial t}{\beta t^{NORTH}} \; when \; (0 \leq \phi t \leq \phi *) \quad \text{Stays back} \qquad 13$$

$$I^{N}{}_{t+n} = \frac{\partial[Kt - Ht(.)]\partial t}{\beta t^{SOUTH}} + ((\mu - \delta) - \pi) \quad \text{If migrates and rents} \qquad 14$$

$$I^{N}{}_{t+n} = w'' = \frac{\partial[Kt-Ht(.)]\partial t}{\beta t^{SOUTH}} - \mathrm{w} \quad \text{If migrates and earns wages} \quad 15$$

Equation 13 suggests the benefits if farmers decide to stay back and enjoy the productivity from the north. Equation 14 implies the future benefits if farmers relocate to the south. She benefits from the south's St^{t+n} less the fraction she pays as rents (π) and the differences between the probability of additional risk and utility $(\mu - \delta)$. Equation 15 suggests what the farmer is paid if he decides to work on the farm of a southern farmer. This is less the net benefits for the southern farmers (w).

In the south, three possibilities also exist. Households can decide to:

1. maintain the status quo,
2. decides to lease the farm and earns a fraction as rents (π) and a risk probability (∂),
3. decide to hire labour from North and pay *w"* less gross earnings w.

These imply:

$$I^{s}{}_{t+n} = \frac{\partial[Kt-Ht(.)]\partial t}{\beta t^{SOUTH}} \; when \; (\phi * = \phi \mathrm{t}) \; if \quad \text{Farmer maintains the status quo} \quad 16$$

$$I^{S}{}_{t+n} = \frac{\partial[Kt-Ht(.)]\partial t}{\beta t^{SOUTH}} + (\pi - \partial) \quad \text{if she receives rents} \quad 17$$

$$I^{S}{}_{t+n} = \frac{\partial[Kt-Ht(.)]\partial t}{\beta t^{SOUTH}} + \; w - w'' \quad \text{if she hires North labour} \quad 18$$

Equation 16 shows that the benefit is constant over time if farmers maintain $\phi * = \phi \mathrm{t}$. Equation 17, on the other hand, explains that farmers in the south can also earn a rent (π) if she decides to lease part of her land for northern farmers. This, however, comes with a risk (∂) which captures the probability that Northern farmers deplete soil voraciously. Equation 18 shows farmers in the south can also earn additional returns by employing Northern farmers who are paid w" out of their net benefits w.

The current income scenarios in the South converge into the high-income equilibrium above the threshold. In the north, dwindling soil productivity and additional cost ensure that the North converges below the threshold.

Figure 2 summarises our conceptual expectations.

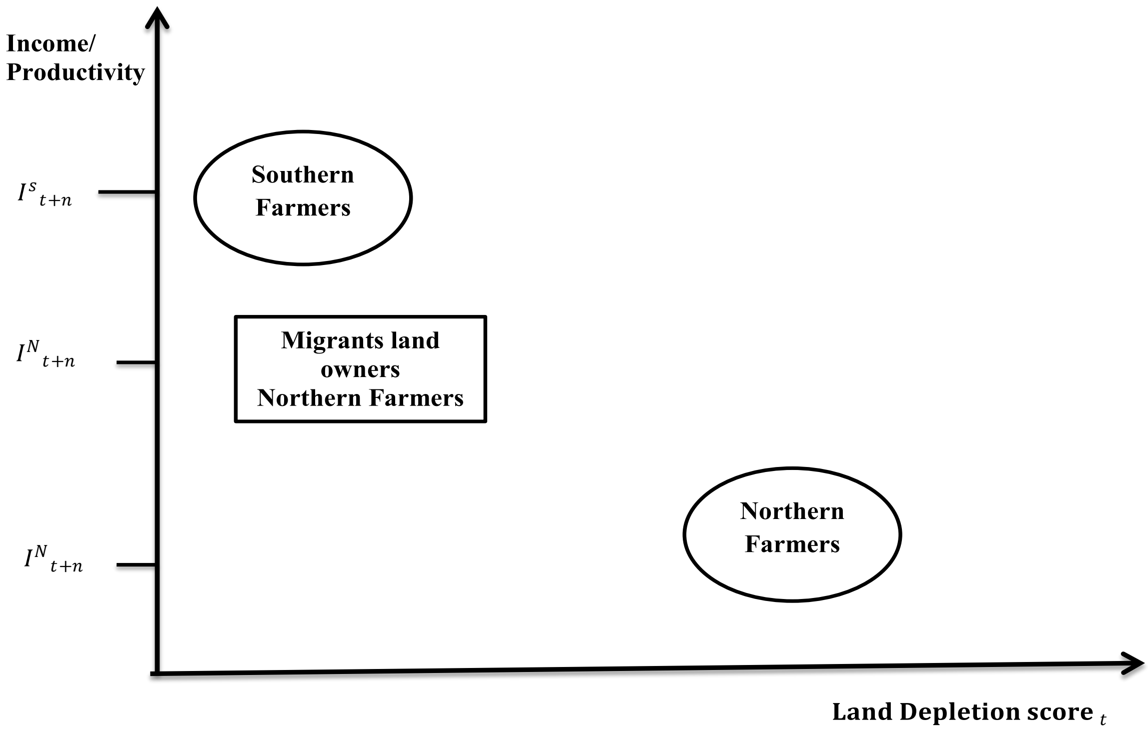

Figure 2: Income evolution and conservation practises (Soil productivity)

3. Methodology

3.1 Study area and Sampling Population

We propose an empirical strategy using data from rural agrarian households in the northern part of Nigeria. Nigeria's far north is arid and semi-arid, and in the last six decades, the region has witnessed over 350,000 sq km of the already arid region turned to desert or desert-like conditions. Also, the region is characterised by a long dry season spell that usually lasts for about eight months (from October to May). According to the National Meteorological Agency, the annual rainy season dropped from an average of 150 to 120 days over the preceding 30 years.

These environmental changes and low wages for labour due to infertile land have a significant impact on farmers in the region whose sole livelihood depends on agriculture, thereby, forcing millions of the farmers to migrate to rural-south, in search of productive land and more fertile farmlands (Grant 1998). Rural-rural migration of crop farmers in Nigeria though varied, nevertheless include of two dimensions. First, there is the migration which involves rural agricultural labourers moving to more fertile areas in search of job opportunities, and there is the movement of farmers due to a shortage of productive land, poor soil or poor economic conditions and settle in other rural communities. Rural-rural migration of farmers in search of productive lands during the farming season can also be easily distinguishable from that in which the migrant stays for many years before returning to his village (Udo 1964, Iwuchukwu et al. 2008). In the case of the former, the farmer could only be interested in being engaged in agricultural work-related activities and usually returns to his family after the end of the harvesting season. In the case of the latter, migration involves spending a longer period and is usually accompanied by the renting of farmland for cropping in the south (Udo 1964).

In this study, we propose to identify migrant farmers originating from a state in the Northcentral (Benue State) to states further to the south (Kwara State). Benue state is a strategic choice because, first, the vegetation of the State is under rapid decline and the conversion of forest regions to grasslands as experienced in Benue State and Nigeria at large (Nyagba 1995, Hula, 2010). In addition, the more predominant conflict over agricultural land between the pastoralist and the crop farmers make the crop farmers in Benue State more disposed to southward migration in search of more fertile agricultural land. We purposively sample Kwara-State as receiving host state due to the proximity and on oral evidence of more displaced farmers from the middle belt region in the area.

To verify our hypothesis, the study proposes to randomly sample four categories of farmers.

1. Resident/host farmers in the south ($South_i$)
2. Migrant farmers from the North with access to land (tenant) in the south ($North_{iMig}$)
3. Migrant agricultural labourers from the North in the South ($North_{iLab}$)
4. Non-migrant farmers in the North ($North_i$).

We propose to sample 500 farming households across a wide range of agro-ecological regions, and with a set of research questionnaire, use the disparity in ancestral land property rights and human capital endowment (education) to identify the impact of soil degradation on agricultural yield and income.

3.2 Model specification

We motivate our thesis of the effect of land asset depletion on agricultural income and yield in equation 19.

$$Log\ Y_{i,t} = \alpha + \lambda Deplete_{i,t} + \partial_1(South_i) + \partial_2(South_i \times NorthMig_i) + \phi \Sigma X'_{i,t} + \mu_i \quad 19$$

$Log\ Y_{i,t}$ is the log of farm income and agricultural yield of the *ith* household in time t. $Deplete$ is the Land depletion score. This is estimated using two indicators as discussed by Okafor (1987). We propose to use the farm size per capita and land fallow index (Okafor 1987) to measure land depletion. The farm size per capita is obtained by computing the area of the cultivable land available to each household in the sample and dividing by the number of persons in the farm household. The major strength of this index is that relating household size to the available agricultural land and it gives a fair measure of the pressure on the usable land. The second index, the fallow index, is the calculated period a unit of land has been left uncultivated to allow regaining fertility. This index is considered important because it measures the degree of degradation on the available agricultural land by indicating reduction in the period of fallow of farm units.

Following Okafor (1987),

$$Fallow\ Index\ (FI) = A_{10}\ (P - B) \quad 20$$

Where $A_{10}$the fallow period 10 years ago, P is a non-zero constant value of fallow reduction and B is the fallow reduction value in the past ten years. For instance, if the length of fallow was zero in 2008 and has remained zero in 2018, then, the fallow index is zero. So the index has a range from zero upwards with lower value indicating less fallow and less degradation.

$\partial_1\ (South_i)$ is a dummy variable which takes value of one if the household is a land owner in the south and zero, if otherwise. The estimate is the marginal effect of having a better soil endowment associated with the south on the farm income and agricultural yield in contrast to other categories of farmers in the north. ∂_2 captures the effect of located in the south as a southern farmer and a migrant north farmer who pays rents or collects wages in the south. The estimates $(\partial_1 + \partial_2)$ capture the main and spill over effect of benefits from the south on income.

3.3. Spatial dimension to land degradation and poverty nexus

Longitudinal studies with long-term data are crucial for evaluating soil degradation impact on poverty as a one-time snapshot can be misleading (Tully et al. 2015). Land degradation fluctuates over time, and farmers' management practices which play a large role in soil degradation vary between seasons and across years (Zingore et al. 2007). Unfortunately, longitudinal studies require continuity of access to study respondents, and the attrition of sample respondents (migrating farmers) might be a limiting factor. The problem of attrition might be especially true in this case because migrants farmers are not permanently placed in a particular locality but are selectively assigned based on suitable climatic conditions like rainfall stability, onset and duration and the presence of local markets.

However, testing the spatial dimension of unsustainable agricultural practices could be done by accounting for historical and ancestral land management practice in preceding generation $(t-1)$ using the disparity in ancestral land property rights and human capital endowment (education). Specifically, we account for how land property right and ownership, and ancestors' $(t-1)$ number of years of formal education indirectly influences agricultural yield and income inequality via the extent of the degradation of the soil bequeath.

In addition to accounting for ancestral generation land practices, this approach also helps to correct for the endogeneity bias in equation (19). The estimates in equation (19) are likely to be biased because of the bi-directional causality between current agricultural income and land conservation practises. Households with capital constraints might have lower yield and reduced income and therefore, unable to afford conservation practices that improves soil productivity. Also, the endogeneity could arise from the third-cause fallacy, that is, the ancestral generation land management practices cause both current generations' soil productivity and income. We propose that a 2-stage Instrumental variable (IV) estimator will be useful to test the study's hypothesis and account for how improved soil productivity contributes to income in rural agricultural households.

Subsequently, land depletion is presented in a first-stage reduced form that accounts for ancestors' tenure practises and human capital in equation (21) and used in the second estimation of equation (19).

$$X_i = \alpha + \gamma_1 Tenure_i + \gamma_2 Ancestor\ Edu + \mu_i \qquad 21$$

X_i is the endogenous regressors, accounting for land degradation ($Land\ Depletion$). $Tenure$ is a dummy variable which measures whether the preceding generation had complete access to land ownership or not. If the preceding ancestors had no formal ownership of land, they might be less willing to implement conservation practices which would affect the extent of allocation of labour for harvest in time $t-1$ generation. A migrant with a short stay on the land will be unwilling to invest capital and labour in practices of which the effects can only be realized after a long period of time (Njeru 2013, Ngrsquo et al., 2013). $Ancestor\ Edu$ measures the years of formal education of the most educated ancestors in the preceding generation of the household lineage. An extensive literature demonstrates a link between adoption of conservation practises and education (Kessler 2006, Asfaw and Neka 2017). We hypothesises that these variables have no direct channel to current income except through the impact on rate of soil asset depletion which is inherited by current generation. We propose to control for other household level socio and economic variables that could possibly influence household income and agricultural yield.

4. Conclusion

We conceptualised and proposed a land-degradation induced poverty trap hypothesis using a North-South dichotomy in the ancestral generations' soil conservation practice. Assuming that ancestral labour allocation for sustainable practices is less in the north, we show how this heterogeneity creates multiple equilibria for future income, such that future members from the north converge to a low-income trap, and the south, to a higher income above the threshold. We propose an empirical verification of the conceptual model that accounts for the endogenous soil stock bequeath using the spatial dimension to land degradation.

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