

**Rural Poverty, Household Responses to Shocks,
and Agricultural Land Use: Panel Results for El Salvador**

Jorge Rodríguez-Meza,
Douglas Southgate, and
Claudio González-Vega*

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* Post-Doctoral Research Associate, Professor, and Professor
Department of Agricultural, Environmental, and Development Economics
The Ohio State University
2120 Fyffe Road, Columbus, Ohio 43210

Corresponding author: Douglas Southgate at 614-292-2432 and southgate.1@osu.edu.

Abstract

This paper addresses factors influencing agricultural land use in rural households in El Salvador, with particular attention paid to the effects of income. Two linkages between the area a household farms and income per capita are critical. First, there is a precautionary demand for land that can be used for subsistence agriculture and this demand declines as income rises. Second, the area a household is able to farm goes up as income increases. Together, these two linkages imply that the relationship between agricultural land use and per-capita income takes the shape of an Environmental Kuznets Curve (EKC).

Using panel data collected since 1995 in four biennial surveys of a nationally representative sample of rural households, we have analyzed agricultural land use at the household level. Evidence of an EKC relating farmed area to per capita income has been obtained. In addition, other factors influencing a household's use of natural resources have been examined.

1. Introduction

Linkages between rural poverty and environmental deterioration in the developing world have long been the subject of debate and concern. For some, the relationship could hardly be more direct. Fifteen years ago, the Brundtland Commission argued that low living standards in the countryside contribute to increased pressure on natural resources, which in turn aggravates poverty (WCED, 1987). Contrasting with the idea of a downward spiral is the conviction shared by many that environmental damage always mounts as people put poverty behind them and grow more affluent.

One way to reconcile these two perspectives is to posit an Environmental Kuznets Curve, (EKC). Accepting that economic growth is initially detrimental for natural resources but eventually becomes environmentally beneficial, economists have investigated the specific dimensions of EKCs corresponding to various kinds of resource degradation in different parts of the world (Dasgupta *et al.*, 2002). Cropper and Griffiths (1994), for example, find that the threshold at which the relationship between income and forest conservation becomes positive is well above GDP per capita in the vast majority of the African and Latin American countries with extensive tracts of tree-covered land. This finding implies that, all else remaining the same, development in those two continents is likely to coincide with widespread loss of natural habitats for some time to come.

Barbier (2001) points out that attempts to estimate a general EKC for agricultural land clearing, one that could be applied throughout Africa, Asia, and Latin America, have met with little success. This is in keeping with much of the economics literature addressing tropical deforestation. In a comprehensive review of 150 empirical studies, Kaimowitz and Angelsen (1998) conclude that exceptions are frequent to general claims

about the forces driving the loss of tree-covered habitats in the tropics. These authors concede that increases in non-agricultural employment in the countryside, which enhance living standards, usually ease pressure on forests. However, improvements in agricultural technology, which are generally reckoned to diminish the clearing of natural habitats, do not always have this effect.

One reason why the driving forces of deforestation are still hard to pin down is that much of the empirical literature consists of cross-country studies. A comparison of average incomes, rates of land-use change, and other national aggregates does not allow for a very nuanced view of why individual households in rural areas happen to be poor or the success or failure of policies for alleviating their plight. Neither do studies that make use of national-level data comprise a good basis for understanding strategies employed by the rural poor to cope with poverty and with short-term adverse shocks to their incomes as well as the part that converting forests into agricultural land plays in these strategies.

In contrast, linkages between poverty, income shocks, and agricultural land clearing can be analyzed using data collected in household surveys. Earlier applications of this approach have yielded important insights. For example, 419 households were surveyed during the early 1990s in the Amazonian lowlands of northeastern Ecuador (Pichón, 1997; Pichón *et al.*, 2001). In addition to information on economic activities and educational attainment, the investigators gathered data needed to study farmers' choices among production systems. They found little evidence of a "peasant pioneer cycle," in which everyone follows the same sequence of land clearing and agricultural activities after initially occupying a forested parcel. Instead, a wide array of farming practices, ranging from intensive use of a limited area to extensive systems associated

with rapid encroachment on forests, was observed. Individual choices among these practices were found to be influenced by a diverse set of factors, including soil quality, tenure security, market access, and educational attainment.

Shively and Martinez (2001) used panel data to analyze land use changes at the household level, in a study undertaken in southwestern Palawan, Philippines. Part of the sample interviewed in 1995, 1997, 1999, and 2001 comprised 56 farm households in a lowland area. Another 42 farm households were interviewed in a nearby upland region that is experiencing active deforestation. Irrigation was developed in the lowland area in 1997. The resulting increase in the derived demand for labor was sufficient to drive up the opportunity cost of human resources at higher elevations, which encouraged a switch to farming systems that save labor, are more capital-intensive, and involve less agricultural land clearing (Shively, 2001). This finding is consistent with the argument that improved opportunities for non-agricultural employment in the countryside tend to reduce the rate at which natural habitats are converted into farmland, presumably because such an improvement raises the opportunity cost of labor required for deforestation (Southgate, 1990). Among others, Bluffstone (1993), Holden (1993), Ozório de Almeida and Campari (1995), and Pichón (1997) offer empirical evidence of this linkage.

One expects that different degrees of access to labor markets would explain the different rates at which various types of rural households clear land. These non-uniform opportunities for non-agricultural employment also ought to explain the different role, for various types of households, of the cultivation of additional land as a risk-coping strategy in the presence of adverse shocks. These distinctions raise the possibility that some

people will experience market conditions that induce them to ease off on land clearing exactly while others are facing precisely the opposite incentives.

The study described in this paper focuses on household-level decisions about agricultural land use in El Salvador. This is a country where recent economic growth has mainly benefited a non-poor minority of the rural population and where many of the rural poor have cleared land for subsistence farming, in an effort to forestall declines in consumption in the presence of adverse income shocks. This behavior matters, because most of the land that the rural poor have cleared for farming has been in the upper watersheds, the deterioration of which represents a long-term threat to water supplies and socioeconomic progress in the country (Panayotou, Faris, and Restrepo, 1997).

The paper begins with a brief discussion of the conceptual foundations for the existence of an EKC relating farmed area to living standards as well as a depiction of the Salvadoran countryside. Next, we describe the longitudinal survey of rural households that is the source of the panel data used in this study. After that, the results of regression analysis are presented, including those indicating an EKC for agricultural land use.

2. Environmental Kuznets Curve

The area farmed by an individual household is driven by multiple factors. The *abilities* of different households to get hold of agricultural land vary, especially because the institutional infrastructure needed for efficient real estate markets is missing in El Salvador. Motivations for holding land also differ among households. For example, an *investment* motive underlies an expansion in farmed area if opportunities exist to exploit untapped profits in agriculture. Another motive is *precautionary*, which relates to a family's desire to possess a site for subsistence farming.

Opportunities to capture additional profits by increasing farmed area are rare in the Salvadoran countryside, where crop production suffers from unfavorable terms of trade, an overvalued domestic currency, and other sector shortcomings. Thus, increases in farmed area do not represent a sound commercial investment. In contrast, the precautionary motive for agricultural land use is important for a large number of rural families, which depend on subsistence farming to cushion consumption in the face of adverse shocks in earnings. In light of these realities, this paper focuses mainly on the precautionary motive.

Although it is influenced by many variables, the demand for farmland as a site for subsistence farming declines as income per capita rises. Households that are better off are less exposed to shocks because of income diversification, which is facilitated by greater access to peri-urban labor markets and by migration abroad. The precautionary demand for land also declines with income because other tools for consumption smoothing, such as the use of accumulated savings and access to loans become available. Also, food consumption by better-off households is above subsistence levels. Accordingly, they may be willing to accept small reductions in consumption rather than devote much labor to low-yielding agriculture.

A household's ability to expand agricultural land use is also influenced by income. Regardless of how it is accomplished – through purchases, renting, or colonization – acquiring land is costly. Moreover, given asymmetric information and incompatible incentives in credit markets, loans for land purchases are available only to households with incomes above certain thresholds. Thus, living standards and the ability to increase farmed area are positively correlated.

Given these two conflicting effects of income on agricultural land use, the applicability of the EKC to settings like rural El Salvador becomes clear. At the poorest extreme of the rural population are those households whose demand for land as a site for subsistence farming is very strong. Given their very limited means, however, they have little or no chance of getting any land. As a household's purchasing power increases and its access to land markets improves, the constraint on the household's ability to satisfy its precautionary demand for farmland is relaxed. Therefore, the relationship between income and agricultural land use is positive.

At the other end of the EKC are households with ready access to real estate but little or no desire to engage in subsistence farming. Land acquisition is not constrained by income. Instead, income growth, which opens up additional opportunities for income and consumption smoothing, causes the precautionary demand for land to fall. Thus, the relationship between income and agricultural land use is downward sloping. Beyond the EKC are the best-off rural households, which have remunerative non-agricultural jobs and no longer cultivate land at all.

Between the two extremes of the EKC are rural households with substantial precautionary demand as well as access to land. Around the peak of the curve are households that farm much more land than the very poor or the relatively affluent.

3. Rural El Salvador

The most densely populated country on the American mainland, El Salvador turns out to be an excellent setting for the analysis of linkages among development, poverty, adverse shocks, and the environment in rural areas.

One reason for this is the duress that the country's farmers have experienced in recent years – duress not unlike what farmers elsewhere in the tropics have suffered. Some of the stress has been environmental. Drought struck in 1997, when the last *El Niño* was at its peak. In early 1999, Hurricane Mitch unleashed torrential rains, which caused flooding and destroyed roads and bridges. Dry conditions returned in 2001, which began with a pair of earthquakes. Even more devastating than these environmental shocks has been the steep decline in the price of coffee – the traditional mainstay of Salvadoran agriculture. After peaking at \$2.00/pound in late 1997, the international price fell to \$1.00 in 1999 and then halved again during the next two years. A pound of coffee has since been changing hands in international markets for \$0.50 to \$0.65.

By and large, the non-poor in rural areas have been able to withstand droughts, storms, and declining prices for commodities. Possessing human capital as well as good access to markets and jobs, they have succeeded in diversifying their incomes. For example, increases in non-agricultural earnings resulting from the recent expansion of *maquilas* – factories where domestic laborers make clothing and assemble other goods for international markets out of imported materials – have more than compensated for whatever farming losses people above the poverty line have suffered (Beneke de Sanfeliú, 2000). Accordingly, their incomes have risen in spite of the environmental and market shocks that have depressed agriculture.

It is the poor who have shouldered the burden of farming's decline, which explains why rural poverty has proved to be stubbornly persistent. Because of limited education, high transactions costs resulting from inadequate physical and institutional infrastructure, and policy-induced inefficiencies in markets for labor, land, and financial

services, households below the poverty line have found it difficult to compete for non-agricultural work in rural areas (Lardé de Palomo and Argüello de Morera, 2000). In addition, the rural poor, who earn much of their meager incomes as wage laborers on other people's farms, have suffered as agricultural employment has contracted. With coffee priced at \$0.65/pound, for example, Central American growers can barely cover variable costs. They therefore have scaled back or abandoned operations. This has cost thousands of unskilled farmhands their jobs (Fritsch, 2002).

With little chance of encountering alternative employment, many of the rural poor have responded to the loss of agricultural wages by dedicating more labor and land to subsistence production of corn, beans, and other basic grains. This response is observed even though newly cleared fields are typically in places where risks of erosion and other forms of land degradation are acute. This explains why El Salvador, where deforestation reached an advanced cumulative stage long ago, has experienced an increase in agricultural land use at the expense of tree-covered habitats in recent years (WRI, 1998). Highly segmented land markets have precluded a more efficient reallocation of resources. This is reflected by the fact that, in 2001, only 3 percent of the agricultural plots used had been purchased or sold during that year.

4. The Longitudinal Survey of Rural Households

Testing hypotheses about the relationship between income per capita and farmed area at the household level is possible in El Salvador thanks to longitudinal surveying dating back to the middle 1990s. Data collection began during the preparation of a rural sector strategy for the country (World Bank and FUSADES, 1997). The U.S. Agency for

International Development (USAID) contributed to the strategy by funding a survey, which was conducted in early 1996 by the Fundación Salvadoreña para el Desarrollo Económico y Social (FUSADES). The next two surveys, which occurred in early 1998 and early 2000, were also funded by USAID as part of the Collaborative Research Support Program on Broadening Access and Strengthening Input Market Systems (BASIS CRSP), which involved Ohio State University as well as FUSADES. The fourth survey, completed in early 2002, was financed by FUSADES (BASIS CRSP, 2001).

Carefully selected to be nationally representative, the sample of rural households that participated in the first survey was proportionately stratified by department and occupational status: self-employed land cultivators, agricultural wage earners, and non-agricultural wage earners. Interviews were conducted with a questionnaire adapted from the World Bank's Living Standards Measurement Survey, and data were collected about sources of household income, employment, land use, market participation, and related subjects during the preceding calendar year (López, 1997).

The rural households that have participated in all four biennial surveys number 427, from a set of 628 households in the original sample interviewed in 1996. Most of this attrition, which amounts to 32 percent of the original sample, occurred between the first and second interviews (i.e., between 1996 and 1998), in part because the original intention of FUSADES and the World Bank was not to undertake longitudinal surveying to create a panel data set. One source of attrition that has been contained relates to households that have moved from one part of El Salvador to another. Considerable effort has been devoted to keeping track of these households. Most attrition, then, has been a consequence of international migration, which has reached high levels in El Salvador.

The period covered by the longitudinal survey turns out to have been very eventful. The initial year, 1995, was characterized by normal prices and good growing conditions. In contrast, 1997 was dry, due to *El Niño*, although this was also the year when international coffee prices peaked. In 1999, there was flooding. In 2001, earthquakes struck and dry conditions returned; also the market value of coffee was a mere 25 percent of what it had been four years earlier. Suffice it to say that longitudinal surveying of a nationally representative sample of rural households in El Salvador has coincided with a series of pronounced environmental and market shocks, which have created enormous income variability throughout this period for the country's rural population. As a result, a unique opportunity has arisen to examine household decisions about agricultural land use and the range of factors, including income per capita, influencing these decisions.

5. Regression Model

Despite the complexity of circumstances that have shaped the behavior of different types of rural households since the middle 1990s in El Salvador, some fundamental relationships can be identified. We are particularly interested in testing the hypothesis that the relationship between income per capita and agricultural land use in El Salvador is characterized by an EKC. For this purpose, we use the following stylized model and estimate it with panel data obtained from the household surveys:

$$l_{it} = c + \beta_1 \hat{y}_{it} + \beta_2 \hat{y}_{it}^2 + \alpha x_{it} + v_i + \mu_{it} \quad (1)$$

where:

l_{it} = area of cultivated land, measured in hectares;

c = constant term;

\hat{y}_{it} = estimate of permanent income per capita;

x_{it} = a vector of time-varying household characteristics;

v_i = a vector of time-invariant, household-specific unobserved characteristics; and

μ_{it} = error term.

Equation (1) explains the area of land that a household cultivated each year as a quadratic function of permanent income per capita and of a set of observable and unobservable household characteristics. Given the underlying EKC hypothesis, it is expected that the coefficients β_1 and β_2 should be positive and negative, respectively.

The vector x_{it} includes the coefficients for observable household characteristics that shift the EKC. The set of unobservable characteristics v_i are household-specific attributes that also influence the amounts of land cultivated by individual households. It is assumed that these characteristics, which include farming abilities, technology used, types of soil, and the degree of the household's risk aversion, have not changed during the period under study.

The approach followed here is to treat unobserved heterogeneity as a set of random variables, which are assumed to be uncorrelated to the time-varying explanatory variables. This assumption provides the basis for using a **random-effects** estimator (Wooldridge, 2000). A **Tobit** estimator is needed because the dependent variable is censored at 0 for all those households that did not cultivate land in a given year.

In equation (1), permanent income per capita is not directly observed. Instead, this variable is treated as the *predicted* income obtained by estimating another equation:

$$y_{it} = c + \delta z_{it} + v_i + \varepsilon_{it} \quad (2)$$

where:

y_{it} = current income per capita net of remittances and subsidies;

c = overall constant term;

z_{it} = a vector of exogenous time-varying explanatory variables;

v_i = a vector of time-invariant, exogenous, household-specific unobserved characteristics; and

ε_{it} = error term

According to this specification, $\hat{y}_{it} = E[y_{it}/z_{it}]$. That is, permanent income per capita is the predicted value obtained from equation (2) for each household, in each period. The fixed-effects estimator is used for Equation (2), since this estimator does not require the assumption that the unobserved effects are uncorrelated to the observed explanatory variables and since the model does not include any time-invariant regressor of interest (Hsiao, 1986).

6. Estimation Results

A balanced data panel containing information about rural households in El Salvador was used to estimate the regression model. As indicated above, the panel contains observations on 427 households, which are representative of the rural population. In spite of the attrition reported, the original sampling proportions for each stratum have basically remained unaltered. The largest total variation has been less than 3 percentage points for a given stratum. Table 1 describes the main differences between

households in the panel and those lost to attrition. The latter are wealthier, with fewer members, and less linked to the agricultural sector.

Table 1. Sample Description

Variable	Mean for households no longer in the panel	Mean for households still in the panel	p-value
Income per capita net of remittances (Cs.)	4,691	3,598	0.03
Household size (number)	5.5	6.0	0.005
Cultivated land (ha.)	0.36	0.47	0.099
Household members employed on own farm (number)	0.84	1.02	0.05
Household members employed outside the farm (number)	1.57	1.58	0.56

Source: Household surveys.

Two separate equations were estimated. Equation (3), below, which corresponds to equation (2), is used to generate a predicted value of per capita income for each household in each year. The deterministic portion of observed income, according to this forecast, is then used as permanent income in equation (4). In turn, equation (4), which corresponds to theoretical equation (1), relates the area of cultivated land to this estimate of permanent income and to other explanatory variables.

$$y_{it} = c + \delta_1 \text{eductotal} + \delta_2 \text{assets} + \delta_3 \text{road} + \delta_4 \text{nmicro} + \delta_5 \text{nout} + \delta_6 \text{animalv} + \delta_7 \text{ninag} + \delta_8 \text{crowding} + \delta_9 \text{assist} + \delta_{10} \text{y97} + \delta_{11} \text{y99} + \delta_{12} \text{y01} + v_i + \varepsilon_{it} \quad (3)$$

$$l_{it} = c + \beta_1 \hat{y}_{it} + \beta_2 \hat{y}_{it}^2 + \alpha_1 \text{ninag} + \alpha_2 \text{nout} + \alpha_3 \text{animalv} + \alpha_4 \text{ext_noag} + \alpha_5 \text{chem} + \alpha_6 \text{exper} + \alpha_7 \text{y97} + \alpha_8 \text{y99} + \alpha_9 \text{y01} + v_i + \mu_{it} \quad (4)$$

The dependent variable in equation (3) is the observed annual income per capita of the household (measured in Salvadoran colones), net of remittances and subsidies. The questionnaire used for the survey was specifically designed to measure this variable, with account taken for the seasonality of the activities of rural households (Deaton, 1997). Cash and in-kind wage earnings were reported for every permanent or temporary job held by any household member during the year. For each on-farm and off-farm production activity of the household, net income was computed from a detailed account of revenues and expenses. The household's consumption of its own production was carefully imputed for agricultural and non-agricultural activities. Income from livestock activities was computed as the gain in the value of the stock of animals during the calendar year. Earnings from renting land and other assets were also included.

Equation (3) explains income per capita as a function of the asset holdings, activity diversification, and market participation of the household.

- *eductotal* expresses the human capital of the household's active labor force. It is measured as the overall sum of years of schooling for all members of the household who participated in income-generating activities. Minimum human capital credentials are needed to engage in better-paid occupations.
- *assets* is an index of ownership of 19 durable household assets, ranging from radios and televisions to vehicles and water pumps. It is a proxy for the household's wealth. Each asset is assigned a weight based on its likely replacement value.
- *road* measures the distance, in minutes, to the nearest paved road; this serves as a proxy for the household's access to urban markets and jobs.

- *nmicro* is the number of microenterprises operated by the household, which is a mechanism to achieve earnings diversification.
- *nout* is the number of members of the household who are employed outside the household's farm and microenterprises; this is another measure of earnings diversification.
- *animalv* is the value of the stock of animals at the end of the year, which indicates the extent to which crop farming is complemented by livestock production by the household.
- *ninag* is the number of members of the household participating in agricultural production activities within the household.
- *crowding* is an index of the number of people per room in the home; this serves as a proxy for living conditions, including a healthy environment.
- *assist* is a dummy variable for the use of agricultural technical assistance services.

An important diversification option for the household is farming. Insofar as this option is reflected by the variables *ninag* and *assist*, no direct measure of the farming variable was included as a regressor in the model, to avoid collinearity.

Table 2 presents selected statistics for all the variables included in the model as well as the number of households who cultivated land in each year. With the exception of the first year of the survey, more than half the households actually cultivated land. The statistics on cultivated and unused land must be interpreted carefully as they were computed only for households that actually used land during the survey-year. Consequently, average unused land only represents the extra land holdings available to the households who engaged in agriculture that year. A full account of the total used and

unused land for the rural households in the sample, considering the cases with zero land cultivated and their corresponding extension of unused land, is better achieved in the econometric analysis.

Table 2. Selected Statistics for Model Variables

Variable		1995	1997	1999	2001
# of households who cultivated land		140	220	265	267
Income per capita net of remittances (Cs 1999)	mean	3,598	3,766	5,040	5,478
	median	2,498	2,406	3,237	3,438
Predicted income per capita (Cs 1999)	mean	3,613	3,778	5,043	5,481
	median	3,214	3,354	4,543	4,926
Cultivated land for hh who cultivate land (sq.m)	mean	14,467	14,411	11,336	9,836
	median	10,416	10,416	6,944	6,944
Unused land for hh who cultivate land (sq.m)	mean	11,522	12,957	9,372	10,177
	median	0	0	434	145
Total years of schooling of labor force	mean	9	10.2	12.5	12.8
	median	6	7	9	11
# of household members in off-farm employment	mean	1.6	1.4	1.6	1.7
	median	1	1	1	1
# of household members in own agricultural production	mean	1.0	1.6	1.8	2.0
	median	0	1	1	2
# of household members per bedroom	Mean	4.3	4.0	4.2	3.9
	median	4.0	3.5	3.5	3.0
Distance to paved road (mins.)	Mean	36.6	36.7	33.0	25.4
	median	25	25	20	20
Years of experience in agriculture	Mean	3.9	6.4	11.6	7.6
	median	0	0	8	3
# of microenterprises in the household	Mean	0.1	0.2	0.3	0.4
	median	0	0	0	0
Index of household assets ownership	Mean	5.9	6.9	8.4	9.8
	median	3.0	4.0	5.5	6.0
Value of stock of animals at the end of the year	Mean	4,883	4,000	3,863	4,928
	median	0	0	0	132

Source: Household Surveys

Table 3 presents the results of the estimation of equation (3) using the fixed-effects estimator. The overall predictive power of the equation, which is used to forecast permanent income per capita, and the significance of each of its coefficients provide a

good foundation for this forecast. Correlation coefficients among the regressors are very low, most being under 0.01, which indicates low levels of collinearity among the regressors.

Table 3. Estimation of the Income Equation Using Fixed-Effects

Variable	Coef.	St.Error	p-value	95%conf.interval	
eductotal	62.82	22.99	0.006	17.7	107.9
assets	47.4	24.1	0.049	0.13	94.7
road	4.03	6.21	0.516	-8.14	16.22
nmicro	1780.7	329.5	0.000	1134	2427
nout	315.7	144.6	0.029	32.0	299.3
animalv	0.09	0.015	0.000	0.061	0.118
ninag	-372.4	129.1	0.004	-625.8	-119.0
crowding	-205.3	76.2	0.007	-354.7	-55.8
asist	1217.1	603.4	0.044	33.2	2401.0
y97	-78.5	361.5	0.828	-787.8	630.7
y99	994.9	370.6	0.007	268	1722
y01	1093.0	393.9	0.006	320	1866
constant	2729.1	534.3	0.000	1680	3777
Overall R-square:			0.2338		
p-value F(13,1246):			0.0000		
Number of observations:			1686		

All but one of the coefficients in the estimated equation (3) exhibit the expected signs. The exception is the coefficient of *road*, which is not significant. Higher levels of human capital and of physical wealth are associated with higher incomes. The less healthy a household's environment is (as indicated by greater crowding), the lower its income is. A greater number of microenterprises, out-of-household jobs, and livestock activities result in higher incomes. Households that depend more on crop production have less capacity to generate income than those engaged off-farm employment. This shows the contrast between subsistence farming and labor market participation. Year-

specific dummy variables that capture other effects not included in the regressors are significant for the year 1999 and 2001.

To estimate equation (4), which explains the area of land cultivated by a household, several variables that address income diversification options were included, along with the permanent income regressors generated by equation (3). Additionally, dummy variables for each year were included, to capture year-specific effects. Also included was the total extent of land in pastures, forests or unused status (*ext_noag*), in order to reflect ready access to land for subsistence farming as a cushion for consumption-smoothing purposes. Two other regressors were the household's experience in farming (*exper*) and the use of chemical inputs (*chem*), which served as a proxy for the technology employed. The land area variables are measured in square meters. Table 4 presents the results of estimating equation (4) using the Tobit random-effects estimator, after several alternative specifications were tested.

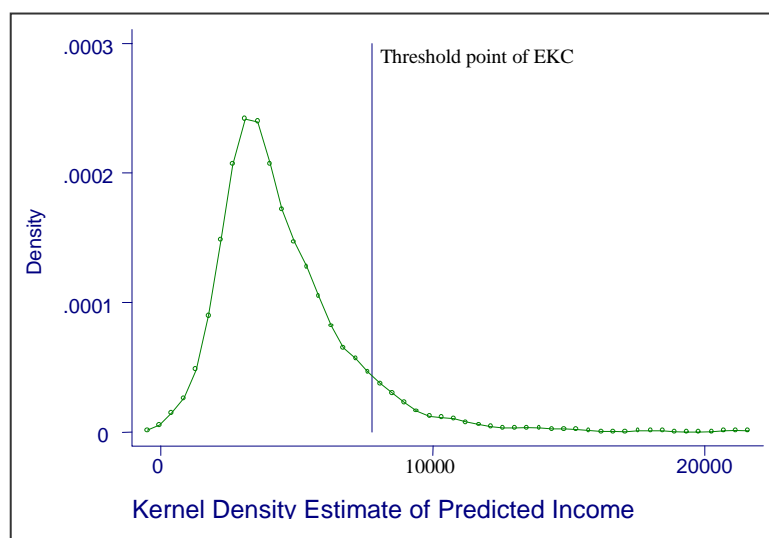
Table 4. Estimation of Agricultural Land Use Using Tobit Random-Effects

Variable	Coef.	St.Error	p-value	95% conf.interval	
p-inc	3.41	0.50	0.000	2.43	4.39
p-inc ²	-0.0002	0.00004	0.000	-0.0003	-0.0001
ninag	2173.5	325.7	0.000	1435.2	2711.8
nout	-1226.8	358.0	0.001	-1928	-525
animalv	0.21	0.050	0.000	0.112	0.307
ext_noag	0.015	0.015	0.310	-0.014	0.045
chem.	23807	1306.2	0.000	21246	26367
exper	201.6	40.8	0.000	121.7	281.5
y97	539.6	1184.3	0.649	-1781.7	2860.9
y99	-219.0	1374.9	0.873	-2913.7	2475.7
y01	-3000.4	1314.8	0.022	-5577.3	-423.5
constant	-28066.4	1966.1	0.000	-31919.8	-24212.9
p-value chi2:	0.0000				
Number of observ:	1478				

The coefficients for the permanent income variable and its squared value have the signs expected for an EKC. A positive relationship between the area of land cultivated and permanent income is confirmed at low levels of income. However, this relationship weakens as income grows and the peak in the EKC is approached. The p-value of the hypothesis test of the two coefficients of income per capita being jointly zero is 0.0000, which shows that there is highly significant evidence to support an EKC relationship in El Salvador.

For the values of the coefficients of the estimated model, the peak of the EKC occurs at 7,763 colones of income per capita, equal to approximately US\$ 1,000. Represented by the vertical line in Figure 1, this level of income per capita is well above the earnings of most of the households in the sample. To be specific, it falls in the tenth decile of the predicted income per capita distribution, which is defined by the cut-off income of 7,456 colones.

Figure 1



Along with estimating coefficients of permanent income and its square, other factors that shift the EKC up or down have been investigated. The coefficient for the dummy variable for the year 1997, although not significant, indicates a positive impact compared to 1995 on farmed area, all else being equal. As explained above, 1997 was a year with adverse climate, which means that many subsistence households would have used more land for subsistence farming in order to smooth their consumption. The dummy variables for the other two years show a negative sign, but only the variable corresponding to 2001 was significant. By that time, rural households apparently had found alternative strategies to cope with the accumulated impacts of the adverse shocks (largely through remittances from relatives who migrated abroad) or had exhausted their potential access to additional land for cultivation at reasonable costs.

The coefficient for the number of members of the household working outside the farm is negative, which indicates a weaker relationship between income and cultivated land for households with greater participation in labor markets. This is particularly true of households with non-agricultural jobs, which offer better opportunities for diversification.

The dependence of the household on its own labor force for agricultural activities, *ninag*, exhibits a positive relationship with the amount of cultivated land. This indicates that employment of household members in agriculture leads to a stronger relationship between income and cultivated land. The positive coefficient for *animalv* is not surprising, given that most households that raise animals also engage in crop production and that livestock activities tend to be land-extensive. Unused land did not turn out to be a significant variable, at least in part because this land is very scarce in El Salvador. If

households use chemical inputs to boost agricultural production (*chem*) and have more years of experience in this sector (*exp*), the EKC relationship between income and area of cultivated land is shifted upwards.

7. Summary and Conclusions

There have been numerous attempts to estimate an EKC for tropical deforestation. Part of this research has focused on a specific region or a particular group of countries. In other studies, the sample has consisted of all countries located on or near the equator. Sometimes, these efforts have met with success. But sometimes not, particularly when the data being used have consisted of national aggregates for a diverse set of places. Furthermore, the conceptual foundations for EKC estimation have not always been apparent, regardless of statistical evidence for the curve's existence.

This study is based on simple, fundamental reasons for an EKC curve for agricultural land clearing. In addition, the relationship between income and land use we have estimated, using a panel of data collected in a longitudinal survey of a nationally representative sample in rural El Salvador, addresses choices made at the household level. We find that the functional relationship between living standards and deforestation indeed seems to be shaped like an inverted *U*.

Any piece of empirical microeconomic research has its limitations. For example, this study does not directly address the possibility that, as migration occurs and labor is reallocated among agriculture and other sector of the economy, land previously farmed by one household may be cultivated by another. Thus, variations in farmed area at the household level, which are the exclusive focus of this study, may or may not add up to an

increase or decrease in overall agricultural land use. While it would be interesting to trace the history of holdings cultivated by our sample of households, it bears mentioning that the legal framework required for real estate markets has severe deficiencies in the Salvadoran countryside. Consequently, transactions between households making a full or partial exit from farming (subsistence and otherwise) and those interested in using more land are impeded.

Something else to acknowledge is that, like all other empirical studies of its sort, our analysis of the microeconomics of agricultural land use are not universally applicable. For example, the spread of commercial soybean production in the interior of Brazil has little in common with Salvadoran farmers' acting on their precautionary demand for farmland. However, the deforestation El Salvador is experiencing has much in common with what is taking place in Java, Madagascar, and many other places, where the rural poor respond to market and environmental shocks by occupying more land for subsistence crop production.

Finally, the purpose of this research, which will continue as more longitudinal surveying is carried out in El Salvador, has not been merely to plot out an EKC for the country. Of comparable importance are our findings about factors that shift such a curve. It is significant, for example, that off-farm employment, which diversifies sources of income, diminishes a household's inclination to clear land, presumably for the sake of subsistence farming. Likewise, additional research can be expected to yield sharper insights into the effects on farmed area at the household level of improved mechanisms for smoothing consumption and of mounting land scarcity. Findings and insights of the

sort our research yields help in the fashioning of a strategy aimed at economic development that is environmentally as well as socially sustainable.

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