Rural Poverty, Income Shocks, and Land Management:

An Analysis of the Linkages in El Salvador

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Among those involved in watershed management and soil conservation projects in the developing world, there is considerable discussion of the relationship between rural poverty, on the one hand, and land degradation, on the other. This concern is appropriate for two reasons. First, poverty is especially acute in the African, Asian, and Latin American countryside (IFAD, 2001). Second, the rural poor tend to concentrate in fragile environments, in part because of policy-induced distortions that cause more affluent people to enjoy numerous advantages in the competition over prime farmland (Heath and Binswanger, 1996).

Systematic investigation of the linkages between rural poverty and environmental deterioration remains at an incipient stage, with a lot of the existing literature being qualitative, anecdotal, or both. As a result, much of what is written applies only to specific settings or even appears contradictory. One investigator claims that poor people in one place are being driven to exhaust every resource in sight. Someone else points out that commercial farmers elsewhere have grown wealthy by depleting renewable resources. What general lessons, if any, can be drawn from observations like these?

This paper addresses major elements of the relationship between rural poverty and land degradation. In particular, we focus on a key facet of poverty emphasized in the recent literature, which is the high susceptibility of poor households to changes in income (Ravallion, 1994), and examine the implications of this susceptibility for natural resource use at the household level.

The empirical research on which this paper is based was carried out in El Salvador, where most of the rural population is poor and where deforestation and other forms of environmental deterioration have reached an advanced cumulative stage. Moreover, the country suffered from climatic disruptions in the late 1990s, associated with the *El Niño* phenomenon. Since there was some foreknowledge of this shock, an unusual opportunity was created to examine *ex ante* decisions made by rural households, including some key environmental consequences of these decisions.

To set the stage for statistical analysis, this paper begins with a description of *El Niño*'s impacts on El Salvador and the country's agriculture. Next, the model developed to analyze poverty-environment linkages and the results of statistical analysis are presented. The paper concludes with a discussion of policy implications as well as suggestions for additional investigation.

El Niño and El Salvador's Farmers

At least as much as in other parts of the world, weather risk is a constant problem for Central American agriculture. The region is devastated periodically by hurricanes sweeping in from the Caribbean. In addition, an upwelling of warm water in the eastern Pacific, which occurs every few years, causes *El Niño* to appear.

Events in 1997 and 1998 were characteristic of the latter phenomenon. Along with a general rise in temperatures, rainfall increased along much of Central America's Caribbean coast. Meanwhile, droughts were experienced along the Pacific coast, where El Salvador is located. Even within the country, *El Niño*'s effects varied. While precipitation was close to normal in the central provinces, the wet season started late and rainfall was below normal in other parts of the country. The drought was particularly severe in eastern El Salvador.

Yield impacts varied from crop to crop. While per-hectare production of beans only declined 3 percent, yields of sugar, coffee, and rice fell 9, 10, and 17 percent, respectively. Especially hard-hit was white corn, which is the main product of small farms, both for market and home consumption. Since the wet season did not begin on time in many parts of El Salvador, planting was delayed. In addition, diminished precipitation hampered crop growth. As a result, yields declined by one-fourth, which was devastating for the many *campesinos* who, for reasons explained below, had planted more land to white corn.

The varied impacts of climatic disturbance on household income have been investigated by Conning, Olinto, and Trigueros (2000), who used the same data set employed in this study. Among their findings is that more prosperous rural dwellers, apparently responding to predictions of *El Niño*, devoted more time to non-agricultural work and cut back on their farming operations. In turn, this latter response reduced opportunities for agricultural employment, on which the rural poor depend (López, 1998). The living standards of the poorest of the poor, who generally lack land, were dealt a severe blow since they rely more on agricultural wages than other segments of the rural population do. Small farmers, who also supply labor to others' holdings, responded to the decline in agricultural labor demand by cultivating more land, either not knowing about impending changes in the weather or not sensing that there was any alternative (Conning, Olinto, and Trigueros, 2000).

Analysis of data collected from rural households by the Fundación Salvadoreña para el Desarrollo Económico y Social (FUSADES) sheds light on the farm-level environmental impacts of these adjustments. Especially interesting are the changes that farmers, small and large, made in land use and labor intensity between 1995, when climatic conditions were normal, and 1997, when *El Niño* struck. This comparison is possible since FUSADES surveyed a sample of 489 rural landowners on two occasions, once in early 1996 and again in early 1998. At each time, interviewees were questioned about their activities during the previous calendar year.

Though modest in terms of total agricultural area, farm-level changes in land use were consistent with preceding observations about how different sorts of rural households responded to *El Niño* and ensuing economic adjustments. Between 1995 and 1997, the area planted to crops on large holdings declined. The owners of these holdings tend to be more prosperous than the rest of the rural population. Since these people also were more likely to learn of impending climatic disturbance by early 1997 and had better access to non-agricultural employment and business opportunities, they rearranged productive activities in ways that de-emphasized farming. Meanwhile, there was an increase in agricultural land use on small farms. The owners of these farms were finding less work on larger holdings and many of them did not receive advanced warning of *El Niño*.

Changes in land use are a valid indicator of different degrees of farm-level pressure on the environment. If a wealthier farmer decided to use less land in 1997 than he had done in 1995, the area taken out of production was likely to be inferior – in terms of yield, degradation risks, or both – than the area still farmed in 1997. Similarly, the additional land used by small farmers in 1997 tended to be less productive and/or more fragile than what they had been using already.

Labor intensity, measured here as person-days devoted to farming divided by farmed area, is also a good measure of human pressure on the environment since the time spent plowing, weeding, and so forth tends to raise erosion risks. [Additional time spent on conservation practices would, of course, be beneficial; however, there was no evidence of this behavior in the data.] As is the case with changes in farm-level land use, differences between 1995 and 1997 in farm-level labor intensities are consistent with preceding observations about *El Niño*'s impacts. To be specific, labor intensity declined on large farms, which is consistent with more prosperous households devoting more effort to non-agricultural work. Labor intensity rose on small holdings, attributed smallholders experiencing a decline in off-farm employment options as well as their imperfect information regarding impending adverse weather patterns.

Regression Model and Results

The data collected in FUSADES's 1996 and 1998 surveys have been used in a multiple regression analysis of households' susceptibility to income shocks and the impact of this susceptibility on natural resource management at the farm level.

The structure of the regression model is recursive. The first equation relates changes in household income, either positive or negative, to a number of variables, most of which have been included in the empirical study by Conning, Olinto, and Trigueros (2000). The model's second equation focuses on environmental impacts, as measured either by changes in land use or changes in labor intensity. Right-hand side variables include the predicted value of the first equation's dependent variable as well as various factors found to influence soil conservation in previous research (Hopkins, Southgate, and González-Vega, 1999).

Panel regression techniques were employed to take advantage of the cross-sectional and time-series components of our data, because repeated observations were available for most of the households in the sample. We estimated a model of the form

$$(1) \quad y_{it} = \alpha + x_{it}\beta + \upsilon_i + \varepsilon_{it}$$

where looking for estimates of the vector of coefficients β or variables x that influence the dependent variable y. The final two terms of the model are random unobservable or omitted variables that determine the dependent variable. The first part of this residual to estimation, υ, is the household-specific residual while ε_{t} is the usual residual with the standard properties (mean 0, uncorrelated with itself or υ and homoskedastic). In the Salvadoran dataset, we have two time periods, 1995 and 1997, so (1) is transformed by taking differences and we use the "within" or fixed-effects estimator for β, β_w,resulting in

$$(2) \quad y_{i,1997} - y_{i,1995} = (x_{i,1997} - x_{i,1995})\,\beta_w + \varepsilon_{i,1997} - \varepsilon_{i,1995}\ .$$

Note that by taking the differences of the two years we have eliminated the time-invariant household-specific residual and therefore have eliminated any correlation between the explanatory variables that we include in the model and household-level fixed effects, allowing for straightforward OLS estimation (Deaton, 1997). Additional information can be introduced through the use of a random effects model, which includes (2) as well as a special case of (1), where observations take their mean values over all time periods and we can use a "between" estimator for β, β_b, resulting in

$$(1') \quad \bar{y}_i = \alpha + \bar{x}_i \beta_b + \upsilon_i + \bar{\varepsilon}_i$$

The random effects ordinary least squares estimator is a matrix weighted average of within- and between-household estimators. Since the random effects model includes additional information, it can be considered more efficient. However, its small-sample properties are unknown and the potential for omitted-variable bias in estimation is present because the random effects model is based on the assumption that household-level fixed effects are uncorrelated with the regressors (Deaton, 1997). Estimation of a random effects model is still in progress. Accordingly, we present the results of the fixed-effects model in this paper.

Table 1 provides descriptive statistics for the variables used in the study. Table 2 shows the results for the per-capita income equation. In this model, income from all sources was regressed against household-level variables that varied over the two time periods. The variables in the model explained about 14 percent of the overall variation in the dataset. Since we took the logarithm of the dependent variable before estimation, each coefficient estimate should be interpreted as the percentage change in per-capita income resulting from a unitary change in the corresponding dependent variable.

Model results indicate that having an additional family member with paid employment increased income by 28 percent. The relationship between income and cultivated land area was positive over much of the sample considered in this study. However, this relationship became negative after farmed land exceeded 22 *manzanas* (the standard measure of area in El Salvador, a *manzana* is equal to 0.7 hectares), a very large landholding for the farms surveyed. Land ownership negatively affected total ousehold incomes, changes in the value of this dummy variable between 1995 and 1997 perhaps indicating that households that sold real estate realized capital gains in the survey year and therefore had higher incomes. However, the negative coefficient also reflects the low returns to agricultural production for much of the sample; farm households often have low incomes but high levels of wealth compared to their non-farm neighbors.

Also statistically significant is the negative effect of the value of livestock holdings at the end of each calendar year. This is plausible because large herds indicate that not much livestock was sold in order to maintain consumption in the face of economic difficulty. Two other variables were found to have no effect on per-capita income: the number of people in the household below the age of 16 and the number of people in the household who contributed unpaid labor, either in farm or non-farm related enterprises. Taken jointly, all coefficients on variables were significantly different from zero according to an F-test.

The second part of our econometric model is an auxiliary regression for estimating the labor intensity of agricultural production per *manzana*, which as mentioned already is a farm-level indicator of land degradation. Labor intensity changed drastically between the two periods for all households, and we hypothesize that this development was due to diminished employment opportunities off the farm. Our model explained 16 percent of the variability in labor hours per *manzana*, initial results indicating that lower household incomes were indeed associated with higher labor inputs per unit of land (Table 3). For example, for a one percent change in incomes, labor intensity per *manzana* increased by almost 10 hours (.01*961.64). Since the dependent variable in this equation is not in logarithmic form, this marginal effect is constant across the range of values taken for labor intensity. Note that the effect of conservation practices and technical assistance from the government or some other outside resource had no effect on effect on labor intensity. Apparently, even when labor was available for on-farm work it was not devoted either to working with extension or other personnel to improve crop management, or to the construction or maintenance of conservation structures.

Conclusions and Directions for Future Work

Our econometric analysis of linkages between rural households' susceptibility to income shocks and their use of natural resources is still at an early stage. Among other tasks that must still be completed is to consult the available literature on farmers' soil management decisions in El Salvador and neighboring countries so that the second part of the model, which addresses land degradation at the farm level, can be refined. Also, the option of estimating a random (rather than fixed) effects model remains a primary goal. In addition, data collected in the third FUSADES survey or rural households, which was carried out in early 2000, will soon be incorporated into the analysis, thereby yielding a richer and more robust data set.

Although this study is still in process, results obtained to date are of substantial interest. Confirming the findings of Conning, Olinto, and Trigueros (2000), our analysis suggests that, due to lack of non-agricultural employment off the farm among other reasons, poor households in the countryside are particularly susceptible to adverse income shocks resulting from climatic disturbance and other events. Moreover, one can argue that these households are apt to respond, both *ex ante* and *ex post*, to income shocks by using land in a more depletive fashion. This response almost certainly outweighs the effects of measures, such as extension initiatives, aimed specifically at promoting soil conservation.

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Table 1: Descriptive Statistics, 1996 and 1998 Salvador Data Set

Variable	Definition	Obs	Mean	Std.
ln_pcinc	logged per capita income	1367	7.50	1.51
income	Income, all sources	1367	18117	21780
under16	Number of household members under 16	1367	2.50	2.06
personas	Number of household members	1367	5.99	2.62
endvalue	Ending value of animal stocks	1367	333933	12200000
invchange	Change in value of animal stocks	1367	-75.67	5499
domwork	Workers employed on farm and in other home activities	1367	3.27	1.95
landcult	Land farmed	1367	0.95	1.81
landown	Land owner dummy	1367	0.34	0.47
totagaway	Wage labor hours outside home	1365	989	1785
totaghome	Family and hired farm labor hours	1365	1488	2139
totag	Total agricultural labor work hours	1365	2478	2550
techassist	Agricultural technical assistance	1367	0.06	0.23
con	Conservation practice dummy	1367	0.25	0.43
labint	Labor intensity per manzana on home production	660	1790	2069

Table 2: Dependent Variable: Logarithm of per-capita household income

Independent Variable	Coefficient	Std. Error	t	P > $\|t\|$
personas	-0.11	0.06	-1.87	0.062
landcult	0.31	0.07	4.24	0
landcult squared	-0.01	0.00	-2.66	0.008
landown	-1.47	0.29	-5.13	0
endvalue	-1.1E-08	0.00	-2.77	0.006
under16	0.04	0.08	0.52	0.605
domwork	-0.03	0.04	-0.87	0.384
paidwork	0.28	0.06	4.81	0
constant	8.00	0.25	32.01	0
R-sq:	0.1401			

Table 3: Dependent variable: Labor intensity per manzana

Independent Variable	Coefficient	Std. Error	t	P> $\|t\|$
Estimated per capita income	-961.643	211.6163	-4.54	0
domwork	391.9577	89.6431	4.37	0
con	-92.1033	208.2367	-0.44	0.659
techassist	-71.6286	437.6781	-0.16	0.87
constant	7190.52	1589.286	4.52	0
R-sq:	0.1647			