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Annex 7: LAND DEGRADATION PROBLEMS IN EL SALVADOR[103]

Introduction

Land degradation is thought to be the most important natural resource management problem in El Salvador. It is commonly thought that '75% of the country's surface is degraded.' Land degradation is thought to lead to reduced agricultural productivity and sedimentation of reservoirs. If land degradation problems are as severe as is thought, they are likely to have a significant impact on agricultural growth and growth potential and on the welfare of a significant proportion of the population—about half the population of 5.6 million lives in rural areas and a third is employed in agriculture. Although there is a perception that land degradation problems in El Salvador are well understood, however, this understanding is in fact very superficial. The commonly-quoted figure of 75% of the country's surface being degraded, for example—in addition to being almost certainly exaggerated—provides no indications of the severity of degradation, of its effects, of the areas in which it is most severe, or of its causes.

This chapter reviews existing data on natural resource problems in El Salvador's rural sector and combines it with new data from a household survey in a strong analytical framework. To the extent possible, it attempts to identify areas (both geographic and thematic) where interventions are both important and feasible. The analysis focuses on effects of degradation on farm productivity rather than on downstream effects such as sedimentation of reservoirs, since this is the critical aspect from the viewpoint of agricultural sector growth.

Because of the limitations of the available data, it is difficult to arrive at definitive answers to the problems of land degradation in El Salvador's agriculture. Nevertheless, several themes emerge from the available information:

- Land degradation problems in El Salvador, while significant, are much less severe and widespread than is commonly perceived.
- Farmers' responses to land degradation problems, while far from universal, are more substantial and widespread than is commonly perceived; where responses are lacking, there appear to be good reasons.

These results, although they contradict much of the conventional wisdom about the situation in El Salvador, are consistent with those of broader recent analyses of land degradation problems in Central America (Lutz, Pagiola, and Reiche, 1994).

Evidence on Land Degradation

This section reviews the available data for clues on the extent and severity of land degradation problems in El Salvador. Much of it is based on the results of a survey of 302 farm households carried out by FUSADES, a Salvadoran NGO, in 1996 (Box 1). Although this survey has limitations for the analysis of land degradation problems, it represents an important and rich new source of information on conditions in rural El Salvador.

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[103] This annex was prepared by Stefano Pagiola and John Dixon. The authors would like to thank Carlos Restrepo, Jaime Acosta, and Margarita de Sanfeliu of FUSADES and Claudia Ocaña of the University of Maryland for their assistance in preparing this report.

Box 1: The FUSADES Survey

This study draws heavily on data from a household survey carried out by FUSADES, a Salvadoran NGO, with World Bank assistance, in early 1996. The survey included a main sample of 630 rural households randomly selected from all regions of El Salvador. This sample was designed to be representative of the rural population, based on information from a labor force survey carried out in 1992. 192 of the households in this sample were farm households, defined as rural households that farmed more than 0.5 *manzanas* (0.35ha) of land. In addition, a complementary sample of 110 farm household was also collected, for a total of 302 farm households. Each of these households farms between 1 and 3 fields, for a total of 472 fields. For each field, a wide range of data were collected, including field characteristics, ownership, crops produced, conservation practices, and other improvements. The data collected on these 472 fields form the main source of information for this study. Detailed information on yields and input use was also collected for each household's main field (that is, for a total of 302 fields). These data are used in the productivity analysis.

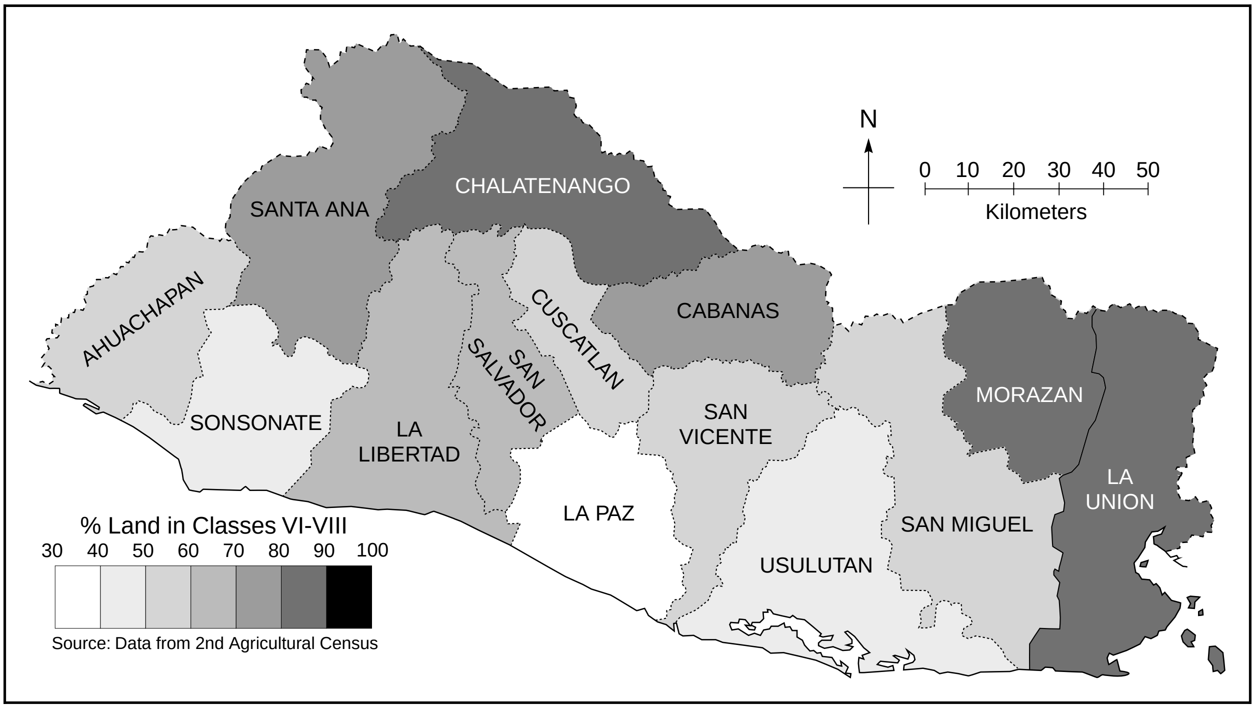
While these data provide a very rich source of information on many aspects of land use in El Salvador, several caveats should be borne in mind. First and foremost, the sample frame is based on population rather than land. One cannot, therefore, use these data to determine the proportion of land under different uses that experiences a particular problem, or on which particular practices are used. Land owned and operated by non-rural residents, for example, would not be captured at all. The majority of land degradation problems in El Salvador, however, are generally ascribed to small farmers. Large commercial units generally occupy the better, flatter land. Moreover, the crops often grown on large holdings, including coffee and sugarcane, tend to provide considerable protection to soils. The sample, therefore, should tend to over-represent fields likely to have land degradation problems. It should also be noted that in the case of some departments the estimates are based on a small number of observations.

Department	Number of Households	Number of Fields	Total Field Area (ha)	Mean Number of Fields	Mean Field Size (ha)
Ahuachapàn	22	31	52.7	1.4	1.7
Santa Ana	25	30	66.5	1.2	2.2
Sonsonate	15	27	21.0	1.8	0.8
Chalatenango	17	26	126.9	1.5	4.9
La Libertad	20	30	48.8	1.5	1.6
San Salvador	14	19	27.3	1.4	1.4
Cuscatlàn	15	26	32.8	1.7	1.3
La Paz	16	26	59.0	1.6	2.3
Cabañas	17	26	47.9	1.5	1.8
San Vicente	13	20	25.1	1.5	1.3
Usulutàn	29	47	64.6	1.6	1.4
San Miguel	36	62	144.7	1.7	2.3
Morazàn	23	38	87.9	1.7	2.3
La Union	40	64	116.0	1.6	1.8
Total	**302**	**472**	**921.3**	**1.6**	**2.0**

Source: FUSADES Survey

Risk Factors. El Salvador is thought to be particularly vulnerable to land degradation. Much of the terrain is mountainous, and the soils are easily erodible. Rainfall is distributed in two rainy seasons divided by distinct dry seasons, so that rainfall is often heavy when ground cover is poor. Map 1 shows the proportion of land in USDA capability classes VI to VIII, which are generally considered unsuitable for cultivation. About 65% of the country falls within these land capability classes. The proportion of such land is particularly high in the northern and eastern parts of the country.

Map 1: Proportion of Land Classified as Unsuitable for Cultivation



Because of population pressure, inequalities in access to land, and the effects of the civil war in the 1980s, substantial portions of land classified as unsuitable have been cultivated, usually by small farmers. Much of it has been planted to various combinations of maize, beans, and sorghum (collectively known as *granos basicos*, basic grains). Common cultivation patterns of these crops often leave the soil bare at the beginning of the rainy seasons.

Erosion. Considering the long-standing concern over soil erosion in El Salvador, there have been surprisingly few efforts to measure it. Measurements of erosion rates and yield were carried out on run-off plots at Metapán, in Santa Ana, over the period 1975-1980 by Flores Zelaya (1976-1981). The treatments studied include a traditional practice and two different conservation measures: live barriers and bench terraces. Table 1 presents mean soil loss and crop yields measured under each of the practices. Unfortunately, no clear link between practices, erosion rates, and yields can be drawn from these data. Although the experiment measured soil loss and yields over 5 years, it only included a few replications of each practice, a problem that was exacerbated when measurement problems led to data from one of the blocks having to be discarded. Moreover, there was significant variation in weather conditions during the study period, as well as exogenous factors such as pest attacks on the beans crops.

One aspect of these data which is worth mentioning is that the most-quoted part is the first-year erosion rate under the traditional practice: 137 metric tonnes per hectare (for example, in World Bank, 1994). Clearly, this single observation is not representative of the observed erosion rates under that practice. Indeed, the similarly high rates observed under all practices in the first year of the experiment suggests this may be an effect of plot establishment. This type of misquoting or misinterpretation of experimental results is one of the reasons the conventional wisdom on land degradation problems in El Salvador is so badly wrong.

Table 1: Erosion Rates and Basic Grains Yields under Alternative Management Practices at Metapán, Department of Santa Ana, 1975-80

		Traditional Practice			Live Barriers			Terraces		
		Soil	Yield		Soil	Yield		Soil	Yield	
Year	Rainfall (mm)	Loss (mt/ha)	Maize (mt/ha)	Beans (mt/ha)	Loss (mt/ha)	Maize (mt/ha)	Beans (mt/ha)	Loss (mt/ha)	Maize (mt/ha)	Beans (mt/ha)
1975	1,895	137.01	1.88	1.15	129.04	2.65	1.35	58.11	2.62	0.71
1976	1,397	72.17	1.50	1.20	5.10	2.45	0.89	5.95	1.88	0.40
1977	1,192	12.68	3.40	1.33	..	4.37	1.50	..	2.62	0.92
1978	1,928	4.50	2.12	1.20	6.89	4.51	0.60	3.25	2.81	0.23
1979	1,716	18.51	2.62	1.33	19.95	3.10	1.51	6.89	2.01	0.07
1980			2.11	0.48		3.15	0.45		1.91	0.17

Notes: Soils at the site are latosols, reddish-clayey, yellowish-red, and gray forest podzol; average slope is 30%
Treatments were replicated 3 times on 1,200 square meter plots; Block III plots omitted due to measurement problems
1978 and 1980 beans yields were affected by severe attacks from slugs (Vaginulus sp.)
.. indicates soil loss was too small to measure

Source: Fifth and Sixth Reports on Research and Runoff Plots at Metapán

Table 2 shows the distribution of fields reported as experiencing erosion by farmers in the FUSADES survey. As might be expected, the reported incidence of erosion increases with slope. Only 22% of surveyed fields with mild slopes experience erosion, in contrast to 83% of fields on steep slopes. Map 2 shows the incidence of reported erosion in the different regions of El Salvador. As expected, a relatively high proportion of fields in northern and western departments experience erosion. More unexpected is the high proportion of fields on which erosion is reported in La Libertad. This reflects the high proportion of fields on moderate and steep slopes found in that department.

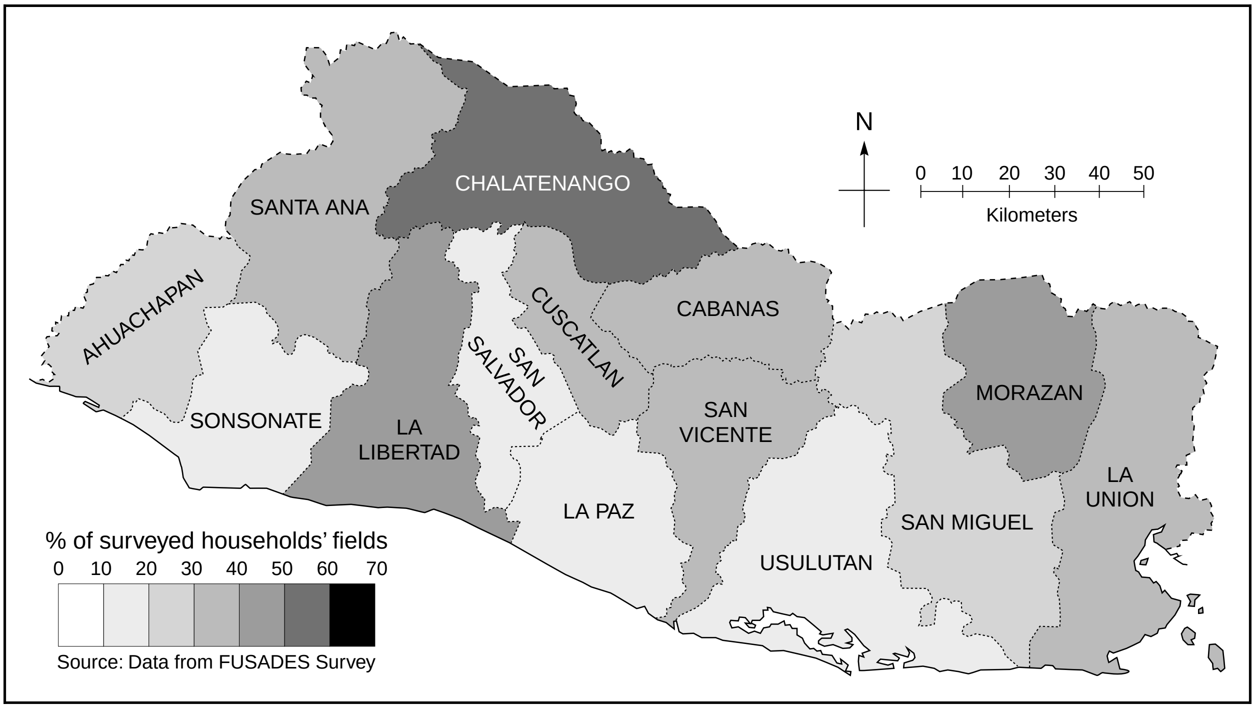
Table 2: Incidence and Effects of Erosion Problems on Fields on Undulating and Sloping Land

	Mild Slope		Moderate Slope		Steep Slope	
	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)
No erosion problems	78	59	46	48	17	28
Experience erosion	22	41	54	52	83	72
Effects of erosion on fields affected:						
No significant problems	64	29	30	24	18	19
Future production will decline:						
Severe decline	0	0	5	5	16	16
Moderate decline	14	4	14	7	11	16
Minor decline	0	0	2	0	5	2
Will need more fertilizer to compensate	0	0	3	1	5	5
Total	**14**	**4**	**25**	**13**	**37**	**39**
Production was reduced in 1995	7	3	17	21	16	9
Fertilizer is washed away	14	4	32	36	32	43
Need to use more fertilizer to compensate	0	0	8	7	11	15

Notes: Percentages for effects of erosion do not add to 100 because of multiple responses

Source: FUSADES survey

Map 2: Proportion of Fields Reported as Having Erosion Problems



Productivity Problems: Evidence from Experimental Measurements. Experimental measurements of the productivity effects of land degradation are even scarcer than measurements of erosion rates. Table 1 provides some information, but it is mostly inconclusive. Beans yields were lower under the bench terracing practice than under either of the other two practices, while corn yields were lower than under the live barriers practice. This is most likely due to the reduction in area cultivated that results from terracing. Corn yields under live barriers appear to be higher than under the other practices, but the results with respect to beans yields are erratic.

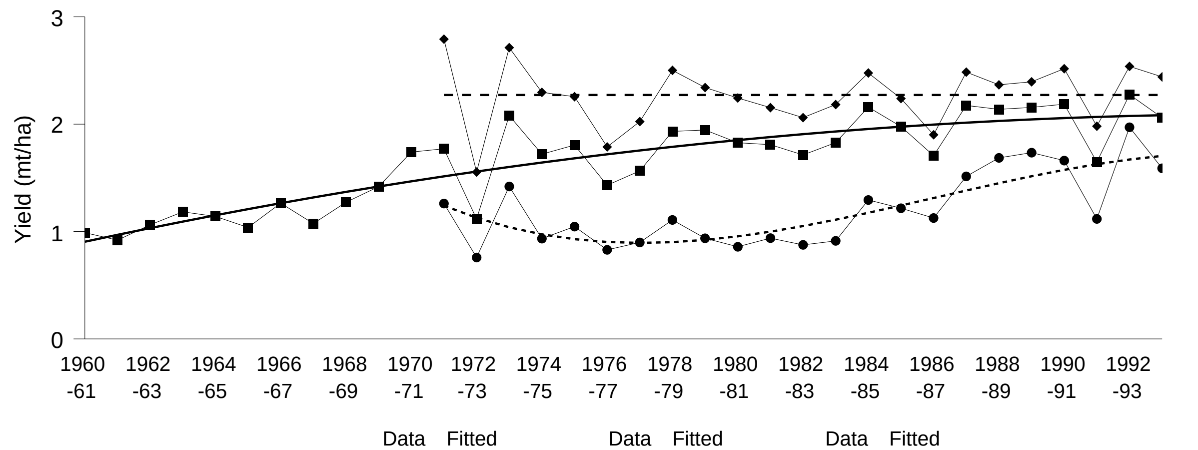
Productivity Problems: Evidence from National Statistics. This section examines the available evidence on agricultural productivity using MAG national statistics. MAG yield data are based on a survey in which 553 sample points throughout the country are monitored, with 20% of sample points being changed every year. The current sample frame is based on 1976 land use map; a stratified sampling procedure is used, based on 11 land use types. The observations are then expanded to obtain regional-level and national-level estimates. The current sample design was not designed to obtain department-level estimates.[104] Although some areas could not be visited during the war and were omitted from the estimates, MAG believes the data should not have been affected since the areas concerned have relatively little agricultural production.

Figure 1 shows maize yield trends over the last 30 years.[105] Although high-yielding hybrid varieties were introduced in the early 1960s (Walker, 1980), agricultural statistics only began distinguishing between hybrid

[104] A new land use map is under preparation. Once it is complete, a new sample frame will be developed. The number of sample points will be increased to 850. The new design will allow statistically valid estimates to be made at the department level. Even this, however, will fall far short of the degree of detail required for analysis of land degradation problems, as discussed below.

[105] Data shown are for the first maize harvest, which typically accounts for over 90% of production.

Figure 1: Maize Yield Trends in El Salvador, 1960-61 to 1993-94



Source: Data from MAG

and local varieties in the 1971-72 crop year. As can be seen, average maize yields have increased substantially, more than doubling in the last 30 years. The early part of this increase reflects the switch to hybrid varieties. Interestingly, while hybrid varieties do not show any significant trend in the last 20 years, local maize varieties show strong and sustained yield increases in the last decade. This probably reflects spill-over effects of improved management and inputs resulting from modern variety use.

Figure 1 does not suggest that degradation is causing widespread productivity declines. National averages, however, can mask local declines. Figure 2 shows maize yield trends at the highest available level of disaggregation: the regional level. These data show similar trends: little or no yield change among modern varieties and relatively strong and sustained yield increases among local varieties. Unfortunately, this disaggregation is not a very useful one, since each region includes sections of all major agro-ecological zones, from the mountainous north to the coastal plains. This is a common problem with data collected according to administrative boundaries. Similar time trends are observed for beans and sorghum, the other main subsistence food crops.

Interpretation of these results is difficult. Certainly they do not provide unambiguous evidence that productivity is declining. The observed pattern of stable or rising yields does not necessarily imply that degradation-induced productivity changes aren't occurring, however. Yields could be rising, for example, because increases in fertilizer use have been sufficient to offset the damage caused by degradation (Figure 3).[106] In this case, degradation would be reflected in rising costs and falling returns rather than in declining yields. The only firm conclusion that can be reached at this point is that if degradation is in fact occurring, it has not been sufficiently important that it could not be offset by increasing input use.

[106] Unfortunately, disaggregated data on fertilizer use on food crops over time are not available, so a full productivity analysis is not possible.

Figure 2: Maize Yield Trends in El Salvador by Region, 1972-73 to 1993-94

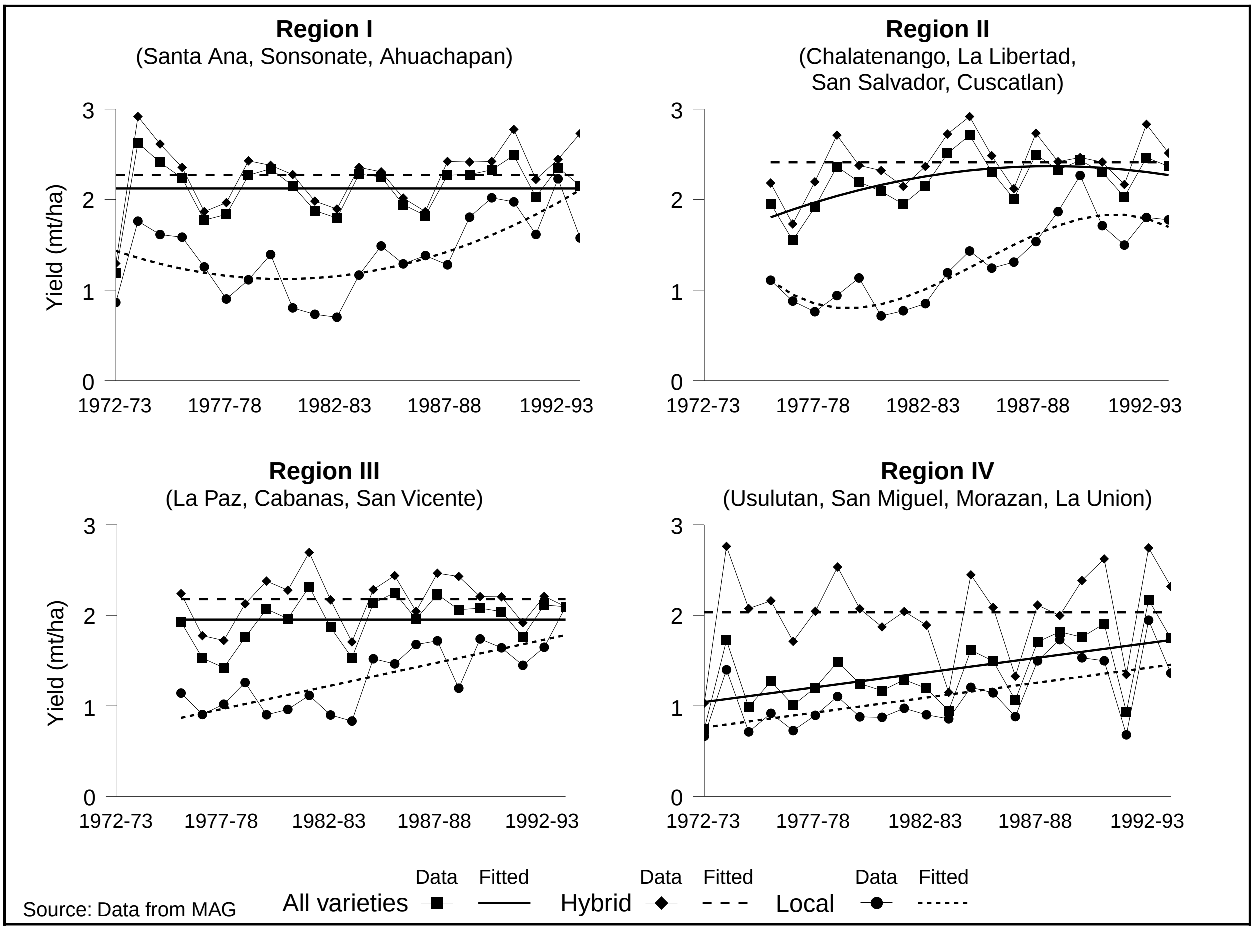
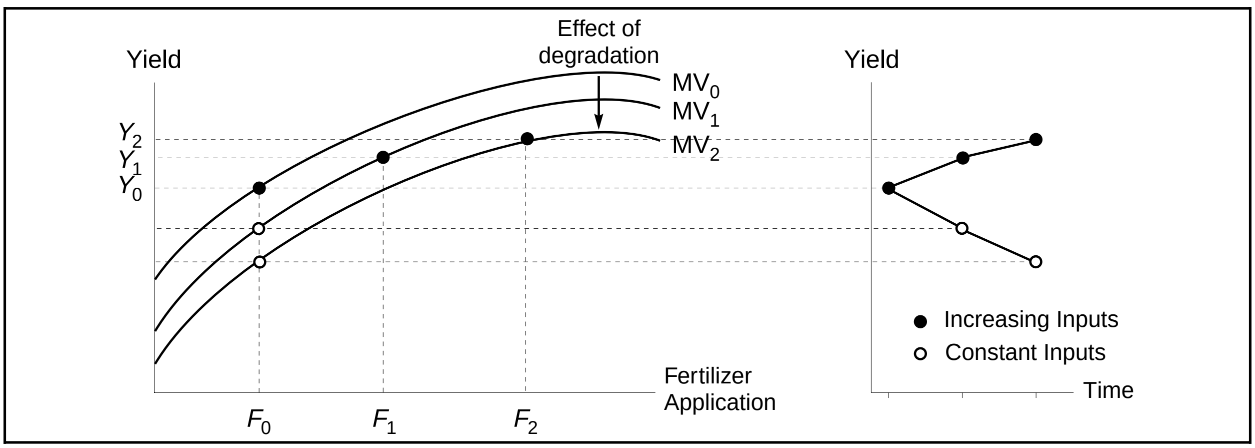
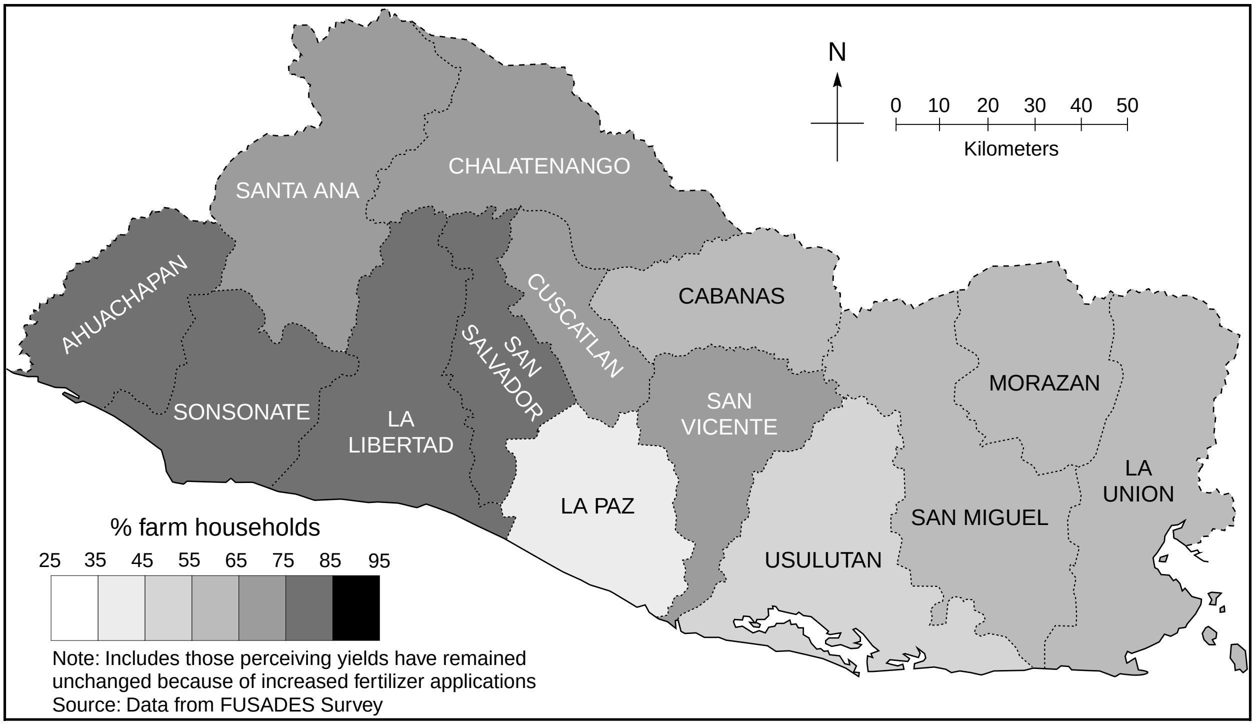


Figure 3: Rising Fertilizer Use Can Offset the Effects of Degradation



Map 3: Proportion of Farm Households Perceiving Yields in Their Areas as Having Declined in the Last 10 Years



Productivity Problems: Evidence from Farmer Perceptions. The FUSADES survey asked farm households what changes they thought yields in their area had experienced in the last 10 years. As can be seen from Map 3, there is a widespread perception that yields have declined (or that declines have only been averted by increasing fertilizer use). Overall, only about 34% of households perceive yields as having either increased or remained the same. The regional distribution of these perceptions is surprising, however, especially the high values for perceptions of yield decline in Ahuachapán, Sonsonate, La Libertad, and San Salvador.

Table 2 above shows the nature and severity of problems that farmers expect to experience on fields on undulating and sloping land affected by erosion. As might be expected, the severity of erosion problems increases with slope. On 64% of the fields with mild slopes which experience erosion, it does not lead to significant problems. In contrast, most fields on steep slopes which experience erosion have problems as a result. Future productivity declines are expected on 37% of fields on steep slopes; almost half of these will experience severe productivity declines. The incidence of current problems (loss of fertilizer and of current production) is also higher on moderate and steep slopes. Fields on steep slopes are also more likely to require additional fertilizer to compensate for previous erosion. Fertilizer use has had to be increased to compensate for the effect of past erosion on 11% of fields on steep slopes, and 8% of fields on moderate slopes.[107] Map 4 shows the regional distribution of fields on which farmers perceive erosion as causing productivity

[107] These fields account for only 2% of surveyed fields (no fields on mild slopes are reported as requiring higher fertilizer use). In contrast, 10% of households perceive that yields in their area have only been maintained because of higher fertilizer use.

Map 4: Proportion of Fields on Which Erosion is Reported as Causing Productivity Problems

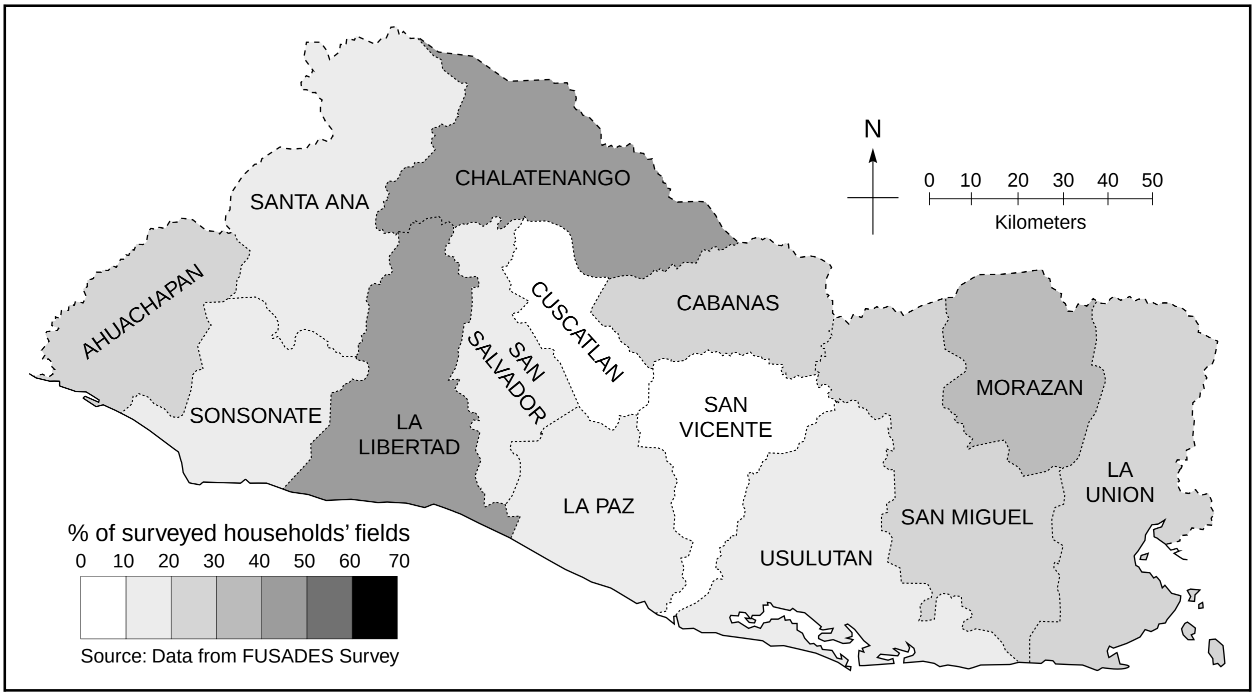


Table 3: Regional Distribution of Problems Caused by Erosion on Fields Affected

Department	Does not Cause Serious Problems (% fields)	Does not Cause Serious Problems (% area)	Future Production Will Decline (% fields)	Future Production Will Decline (% area)	Production Fell in 1995 (% fields)	Production Fell in 1995 (% area)	Fertilizer is Washed Away (% fields)	Fertilizer is Washed Away (% area)	Need to Increase Fertilizer Use to Maintain Production (% fields)	Need to Increase Fertilizer Use to Maintain Production (% area)
Ahuachapán	22.2	22.0	22.2	7.8	22.2	39.0	55.6	70.2	11.1	15.6
Santa Ana	22.2	22.9	55.6	48.6	0.0	0.0	22.2	22.9	0.0	0.0
Sonsonate	40.0	29.6	0.0	0.0	40.0	26.0	40.0	26.0	40.0	59.2
Chalatenango	15.4	5.5	61.5	28.1	15.4	22.6	23.1	33.6	0.0	0.0
La Libertad	53.8	64.1	7.7	3.3	15.4	17.1	15.4	8.8	0.0	0.0
San Salvador	33.3	27.5	0.0	0.0	33.3	13.9	33.3	58.6	0.0	0.0
Cuscatlán	87.5	95.4	12.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0
La Paz	20.0	26.1	20.0	10.9	20.0	4.3	20.0	43.5	20.0	15.2
Cabañas	12.5	7.7	12.5	7.7	12.5	15.4	25.0	46.2	0.0	0.0
San Vicente	85.7	95.2	14.3	4.9	0.0	0.0	0.0	0.0	0.0	0.0
Usulután	25.0	46.4	25.0	14.3	25.0	17.9	12.5	5.4	12.5	14.3
San Miguel	0.0	0.0	29.4	8.9	0.0	0.0	52.9	29.0	17.6	17.6
Morazán	23.5	27.0	41.2	33.3	29.4	42.9	52.9	39.7	5.9	3.2
La Unión	29.2	21.8	20.8	17.6	25.0	16.3	33.3	55.3	4.2	9.1
Total	**30.1**	**23.3**	**26.7**	**17.3**	**16.4**	**16.2**	**30.8**	**33.2**	**6.8**	**7.4**

Notes: Percentages for each department do not sum to 100 because of multiple responses
Source: FUSADES survey

problems caused by erosion on fields; Table 3 provides additional detail on the nature of the reported problems in each department. Overall, farmers do not expect erosion to cause serious problems on almost one third of affected fields. The proportion is particularly high in San Vicente and Cuscatlán. In contrast, about one quarter of fields affected by erosion are expected to experience lower yields in the future. The proportion is particularly high in Chalatenango and Santa Ana and to a lesser degree in Morazán. About one in six fields affected by erosion report that production in the current year was lower because of it, and twice that many report fertilizer being washed away (which would affect current costs but have no long-term effects).

Productivity Problems: Evidence from Input and Output Data. The FUSADES survey collected detailed information on yields and input use for each household's main field (that is, for a total of 302 fields). Efforts were made to carry out a cross-sectional productivity analysis using these data. The results were very poor, however, and are not reported here. This partly reflects the difficulty of carrying out cross-sectional analysis in an area with as much diversity of conditions as El Salvador. It also reflects the fact that for many of the independent variables, the only available measures were subjective qualitative ones. If the analysis is restricted to subsets of the data originating in relatively similar areas, so as to avoid some of these problems, too few observations are available.

Adoption of Conservation Practices. Conservation practices have been promoted by a long succession of projects in recent decades (Box 2). Despite these efforts, the conventional wisdom is that adoption of conservation practices in El Salvador is extremely low.

Table 4 shows the extent of use of different conservation measures on fields in the FUSADES survey. Although only a little more than a third of the surveyed fields have some form of conservation, on moderate and steep slopes the proportion increases to over half. The most commonly-used conservation measures are cultural ones, especially minimum tillage and the use of crop residues for soil cover. Use of these measures peaks on moderate slopes and then falls. Among the structural measures, stone walls are most frequently encountered. Use of stone walls increases with slope, with as many as 20% percent of fields on steep slopes being so protected. Map 5 shows the regional distribution of use of conservation measures. Comparison with Maps 2 and 4 indicates a close correspondence between departments in which erosion and erosion-induced productivity problems are common and use of conservation measures.

It should also be mentioned that some conservation measures also have other purposes. Some cultural conservation practices, for example, also affect current yields. Stone walls may be built primarily because of the need to use stones removed from fields. Although such measures also have conservation effects, this may not be the primary motivation for constructing them.

Summary. Despite the availability of the data from the FUSADES survey, it remains difficult to ascertain the extent and severity of land degradation problems in El Salvador. Nevertheless, it seems clear that catastrophic statements such as '75% of the country's surface is degraded' are substantially exaggerated.

- *Extent of degradation.* A more plausible order of magnitude is that about 50% of fields on moderate slopes and 80% of fields on steep slopes experience erosion, and that about one-third of fields on moderate slopes and two-thirds of fields on steep slopes experience productivity problems. Since fields on moderate and steep slopes account for about 30% and 10% of surveyed fields, respectively, the total area affected is much smaller than 75% of the country's surface.[108] This is all the more true when it is recalled that the sample is likely to over-represent fields on steep

[108] Because the FUSADES sample is based on household sample frame rather than a land sample frame, however, no direct estimate of the proportion of the country's surface affected by these problems is possible (see Box 1).

Box 2: Soil Conservation Projects in El Salvador

Since 1955, the government, through the Ministry of Agriculture and Livestock (MAG), has undertaken a variety of conservation projects (Hernández Navas and others, 1994; Perdomo Lino, 1990):

- META (Improvement of Agricultural Lands) 1962-71. First government program to train soil conservation technicians. Technical assistance to conservation was provided on 47,000 ha.
- FAO Project ELS/71/506. Integrated development project on 2,000 ha in Metapán, Santa Ana. Introduced the concept of watershed conservation. Gabions and reforestation were used to reduce the threat of downstream flooding.
- FAO Project ELS/73/004. Integrated development project on 25,000 ha in the Rio Tamulasco watershed, Chalatenango. First project which combined work on conservation with efforts to increase productivity.
- FAO Project ELS/78/004 (Conservation and Improvement of Renewable Natural Resources in the Northern Watershed of the Cerrón Grande Reservoir), 1980-84, extended by Project ELS/84/006 (Development of Rural Communities and Watershed Planning), 1985-86. Worked in a 124,000 ha area in Chalatenango. Its major objective was to protect the Cerrón Grande reservoir from siltation. Initially, simple conservation measures such as contour plowing were promoted; more complex and effective conservation measures were introduced later, including stone and vegetative barriers, bench terraces and individual terraces, diversion ditches (bench-type and trenches), earth ridges, drainage canals, and ditches. Farmers adopting conservation measures were provided with a package of incentives, including agricultural inputs (seeds, plants, fertilizer, and insecticides), tools, materials for constructing soil conservation works. and technical assistance. About 4,000 ha were conserved.
- FAO Project ELS/86/005 (Agroforestry Assistance to Rural Communities with Scarce Resources), 1987-92. Initially implemented in Cabañas, then extended to Usulután and Morazán in 1989. The conservation practices promoted in this project were similar to those used in the Cerrón Grande project. Stone barriers were the most commonly used measure, followed by diversion ditches, individual terraces, and alley cropping. Madrecacao, eucalyptus, and fruit tree orchards were also established. A similar set of incentives to those used in the Cerrón Grande project was offered to participating farmers. Credit on generous terms was also provided, and has proven very popular among farmers. About 1,200 ha were conserved. Some measurements of yields on conserved plots were made at Guacotecti, in Cabañas, but the sample was small and there were neither control plots nor baseline measurements, so their usefulness is extremely limited.
- WFP "Food for Work" Program, 1972 to date. The Food for Work program has often sponsored conservation work, but the quality of work has been poor.
- Minimum-Tillage Project, 1970 to date. The extension service in Guaymango, Ahuachapán, has advocated minimum tillage since the 1970s. A package of productivity-improving measures (use of hybrid maize and improved sorghum, use of N and P fertilizers, increased plant density, and application of herbicides and insecticides) and soil conservation measures (use of crop residues as mulch, living and dead barriers, and planting on the contour) was promoted. 2,450 ha are considered as being conserved.

MAG estimates 100,605 ha were conserved under these projects, but the true area is probably much smaller, either because conservation measures were destroyed or have decayed after the projects ended, or because they were never built in the first place (Perdomo Lino, 1990).

slopes and less favorable soils. Another way to express this result is that about a quarter of farm households farm fields affected by erosion, and about a fifth farm fields affected by productivity problems.

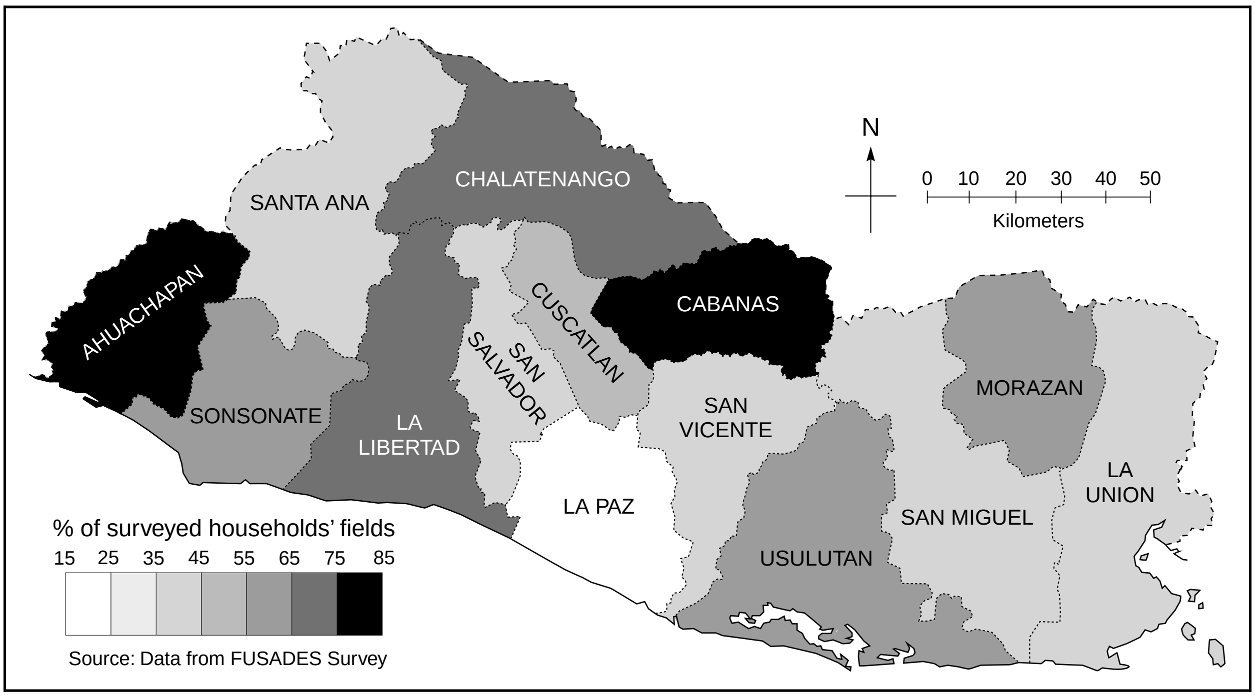
- *Severity of degradation*. Unfortunately, the available data are insufficient to arrive at even order-of-magnitude estimates of the severity of degradation, except to note that, to date, it seems to have been possible to overcome its effects by increases in input use.

Table 4: Use of Conservation Measures

	Flat		Mild Slope		Moderate Slope		Steep Slope		Total	
	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields	(% ha)
Cultural practices										
Crop rotation	2	5	2	1	4	2	4	3	3	3
Minimum tillage	7	11	11	6	20	25	17	13	13	18
Use of crop residue as mulch	10	13	9	5	23	22	11	9	15	16
Cover crops	1	1	6	6	7	4	4	3	4	3
Total	16	25	23	14	39	42	30	25	27	32
Hedges	0	0	3	2	6	4	0	0	3	2
Stone walls	2	2	6	10	11	17	20	31	7	14
Ditches	0	0	2	1	2	2	2	1	2	3
Terraces	3	8	3	3	2	1	2	2	1	1
Gully control	0	0	0	0	5	3	2	1	2	2
Any measure	20	33	36	29	54	58	52	57	38	48
More than one measure	6	7	8	4	21	19	13	13	12	13

Source: FUSADES Survey

Map 5: Proportion of Fields on Moderate and Steep Slopes with Some Form of Conservation



Regionally, the areas most affected appear to include those in the northern and eastern part of the country (the 'usual suspects') but also sections of the western part of the country.

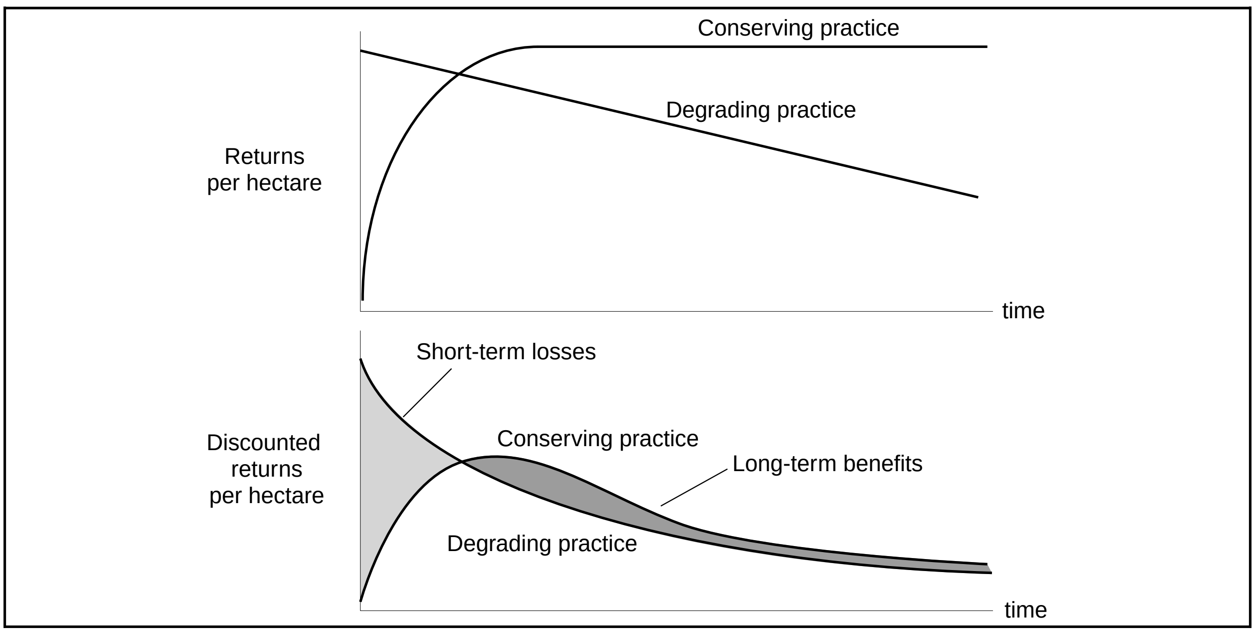
Causes of Land Degradation

To the extent that land degradation occurs, it does so as a result of land use decisions. These decisions are unlikely to be irrational. There is a need to understand why particular land use decisions are made. Without a better understanding of the causes of problems, appropriate policy prescriptions cannot be made. Many explanations have been proposed for the use of degrading practices, including farmer ignorance, insecure tenure, lack of credit, and poverty. We will attempt to examine each of these possibilities to the extent that available data allows.

If we assume farmers are rational, then their land use decisions depend on a comparison of the returns they can obtain under each practice available to them. While many cultivation can degrade the soil, action to slow or arrest degradation through changes in crop and management practices or through the adoption of conservation techniques is likely to be costly, either directly in terms of investment requirements or indirectly in terms of foregone production. The critical question is: do the long-term benefits of reduced degradation make these costs worth bearing?

The diagram in Figure 4 depicts a stylized choice between two land use practices: a degrading practice and a conserving one. The top panel shows the flow of returns under each practice. Under the degrading practice, yields and hence returns gradually fall. Under the conserving practice, stable yields can be achieved after an initial investment.[109] The bottom panel shows the discounted returns to each practice.[110] In this panel,

Figure 4: Incentives to Adopt Conservation Practices: Conceptual Framework



[109] In practice, conservation measures might only slow, rather than arrest, degradation. Conversely, some practices might not only stop degradation but result in improvements in land conditions, thus leading to increasing returns over time. The same reasoning would apply to these cases.

[110] Since the choice of which practice to use is made by farmers in light of their own objectives and constraints, the appropriate discount rate to use is the farmers' own subjective rate of time preference.

the short-term costs and long-term benefits of adopting the conservation practice can be compared directly. If the long-term benefits exceed the short-term losses, we expect the practice to be adopted unless a constraint prevents it. Note that off-site effects such as downstream sedimentation, are not included in this analysis. From the farmers' perspective, this is an externality which they have no incentive to take into account.

Table 5 shows that farmers in the FUSADES survey undertake a variety of improvements to their fields. This suggests that farmers do undertake improvements which they perceive to be beneficial. Any theory which attempts to explain why conservation measures are adopted must also explain why these other investments are made.

Table 5: Improvements to Farmers' Fields

	Number of Fields		Total Area		Proportion Undertaken by Farmers	
Improvement	**(n)**	**(%)**	**(ha)**	**(%)**	**(n)**	**(%)**
Wells	41	8.7	138.8	15.1	28	68.3
Fences	282	59.7	738.6	80.2	116	41.1
Fruit trees	138	29.2	336.3	36.5	56	40.6
Timber trees	103	21.8	366.0	39.7	31	30.1
Coffee trees	53	11.2	99.1	10.8	15	28.3
Other trees	53	11.2	180.5	19.6	13	24.5

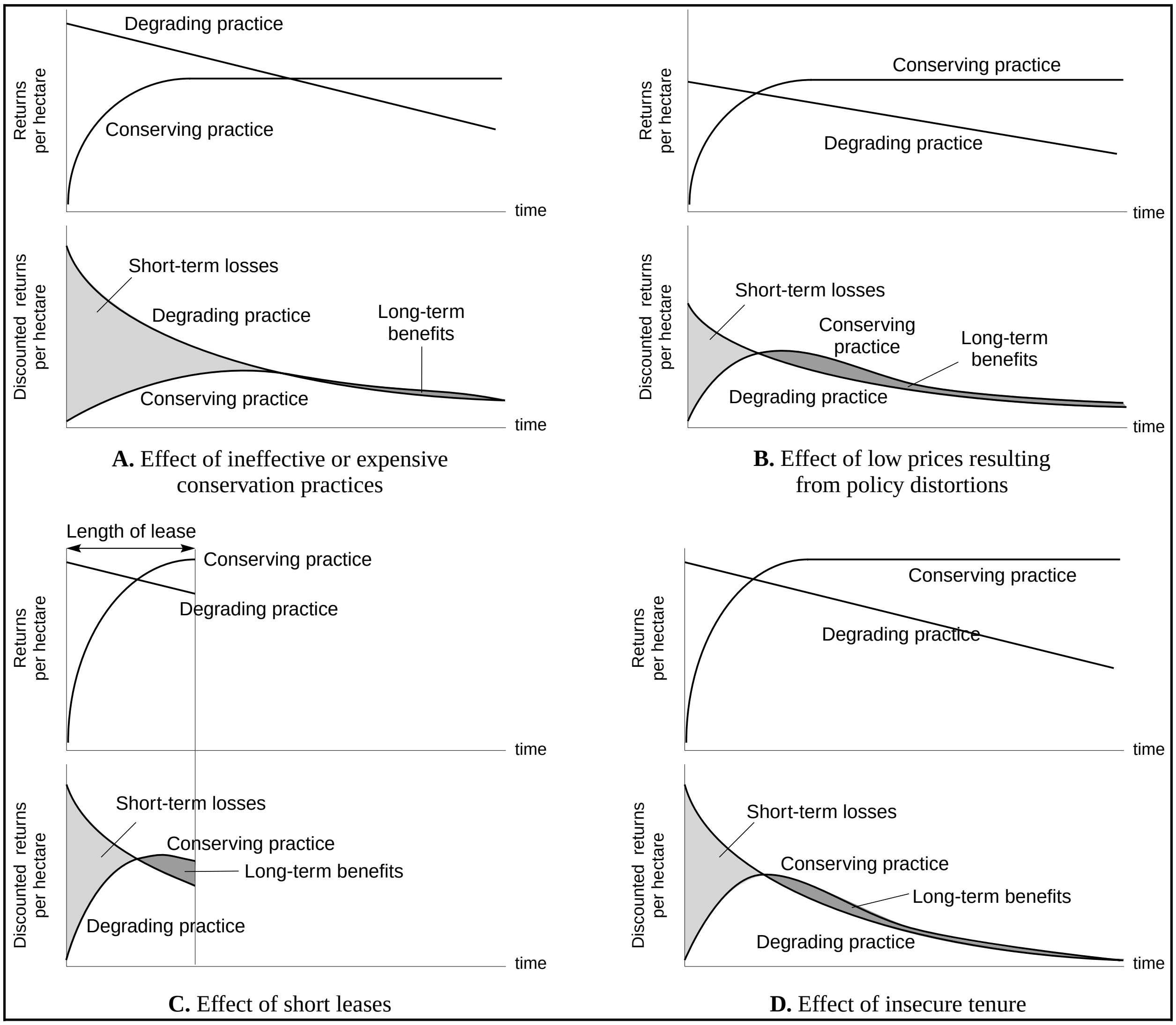
Source: FUSADES Survey

An important factor to bear in mind when considering the causes of land degradation is that the analysis of the previous section suggests that not all farmers are in fact affected by land degradation. The conditions facing these farmers would be represented, in a diagram such as Figure 4, by essentially constant returns over time under their current practices. Under these conditions, they would have no incentive to adopt conservation measures. Thus, we should not expect universal adoption of conservation measures.

Farmer Ignorance. Farmer ignorance, either of the problem or of possible solutions, is often blamed for the use of degrading practices or the failure to adopt conservation measures. This explanation seems unlikely, since it flies in the face of evidence worldwide on farmer rationality. Certainly the extension services available to Salvadoran farmers, and particularly to poor subsistence farmers, have been far from optimal. Nevertheless, management practices aimed at increasing crop productivity (including use of hybrid seed and agrochemical inputs) diffused widely in El Salvador during the 1970s and 1980s (Walker, 1980). In any case, given the numerous projects which have promoted conservation measures throughout the country in the last decades (Box 2), and the evidence from the FUSADES survey that a wide variety of conservation measures are in fact used, farmers seem unlikely to be, at this point, unaware of the options available to them.

Inadequate Conservation Alternatives. If the available conservation practices are not very effective, as illustrated in Figure 5A, or are very costly, the short-term losses to adopting them will exceed the long-term benefits. Information on the effectiveness of different measures does not exist, despite the numerous projects which have, and continue to, promote them. Even information on their costs is difficult to obtain. Research on soil conservation practices in Central America suggests that, except under very particular circumstances, expensive conservation measures such as terraces are unlikely to be cost-effective (Lutz, Pagiola, and Reiche, 1994).

Figure 5: Effects of Different Factors on Farmers' Incentives to Adopt Conservation Practices



Although the data in Table 1 are not conclusive, for example, they do suggest that bench terracing is unlikely to be a cost-effective conservation measure. Beans yields were lower under this practice than under either of the other two practices, while corn yields were lower than under the live barriers practice. This is most likely due to the reduction in area cultivated that results from terracing (a cost which is often forgotten). The reduction of soil loss also does not appear to be significantly higher than with live barriers. When combined with the substantially higher cost of terracing, this makes this conservation practice likely to be unattractive under the conditions found in Metapán. The results with live barriers, which consisted of rows of perennial and densely growing plants planted along the contour, appear to be more promising, at least with regard to corn yields, which are higher than under the other practices. The results with respect to beans yields, however, are erratic. More research is clearly needed to establish the productivity effects of different conservation practices.

The case of Guaymango, in which widespread adoption of conservation tillage has been achieved, has been widely cited as a success story for soil conservation in El Salvador. In this area of Ahuachapán and Sonsonate departments, a long-standing effort which began in the early 1970s, finally resulted in practically complete adoption of the recommended package of productivity-increasing and conservation measures by the mid-1980s. A recent review of this case, however, shows that the conservation measures included in the Guaymango package *reduced* returns from what they would have been had a similar package of productivity-increasing measures been adopted alone (Sain and Barreto, 1996). That the conservation measures were adopted anyway appears to result from their being presented together with the productivity-improving measures (so that their separate effect was not apparent), from making adoption a precondition to the access to credit, and to the fact that while inclusion of conservation measures lowered returns, they remained positive overall. Perhaps agriculture is indeed more sustainable with these conservation measures than without. But is it really desirable to fool (by hiding conservation measures in a broader package) and force (by tying adoption to credit access) poor farmers into adopting conservation measures that reduce their already-low returns from what they might have been?

Macro Policy Framework. Macro policy distortions can affect the relative returns to conservation and can, at times, discourage its adoption. No simple relationship exists between the effects of policy distortions on incentives to conserve. In the example in Figure 5B, distortions that lower output prices reduce the incentive to adopt the conservation practice. This is not a general result, however: policy distortions can also encourage conservation (Pagiola, 1996).

The extent of policy distortions related to trade pricing and marketing of agricultural products has been reduced by the economic liberalization efforts of the 1990s. Although the real prices of several agricultural products have been declining in recent years, this does not appear to be a direct consequence of policy interventions.

Tenure Problems. Tenure problems are a popular explanation for land degradation problems in El Salvador. In principle, tenure can affect conservation decisions in two main ways:

- Leases may be too short for farmers to gain the long-term benefits of adopting conservation practices (Figure 5C).
- If tenure is insecure, farmers are not sure they will be able to gain the long-term benefits of adopting conservation practices. The possibility that they will be evicted acts in the same way as a discount rate, and reduces the perceived long-term benefits of adopting conservation practices (Figure 5D).

A first cut at determining the likely impact of tenure on land degradation can be made by examining the prevalence of different forms of tenure. In the past, such information was scarce, especially in light of the sensitivity of the problem. Table 6 shows the prevalence of the different forms of tenure found in the FUSADES survey. Despite the conventional wisdom, the vast majority (76%) of fields operated by farm households are in fact privately owned.[111] Maps 6 and 7 show the proportion of fields owned and rented in different departments. The proportion of fields owned by their operators tends to decrease, and the proportion rented or share-cropped to increase, from west to east. Share-cropping is only significant in Cabañas and Cuscatlán. As can be seen from Table 6, rented fields tend to be smaller than owned fields. Rented fields are

[111] While it is likely that some categories of tenure (especially squatting and invasion) are under-reported, these seem unlikely to change the proportion of owned fields significantly.

Table 6: Prevalence of Different Forms of Tenure

Tenure	Flat		Mild Slope		Moderate Slope		Steep Slope		Total		Mean Size (ha)
	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	
Owned	81	81	69	82	76	91	70	87	76	87	2.2
Rented	10	13	27	16	18	7	26	11	17	10	1.2
Sharecropped	2	1	0	0	1	0	2	1	1	1	1.2
Rent-free loan	2	0	2	1	2	0	2	1	2	0	0.5
Squatting	5	3	2	1	2	0	0	0	3	1	0.8
Invasion	1	0	0	0	1	1	0	0	1	0	0.9
No answer	1	0	2	1	1	0	0	0	1	0	0.8
Total	100	100	100	100	100	100	100	100	100	100	2.0

Note: Squatting and invasion are similar in that farmers are farmers are occupying land that is not theirs, but squatting does not necessarily imply conflict with the owner.
Source: FUSADES Survey

slightly more likely to be on moderate or steep slopes than owned fields (54% of surveyed fields vs 45%), but the difference is not huge.

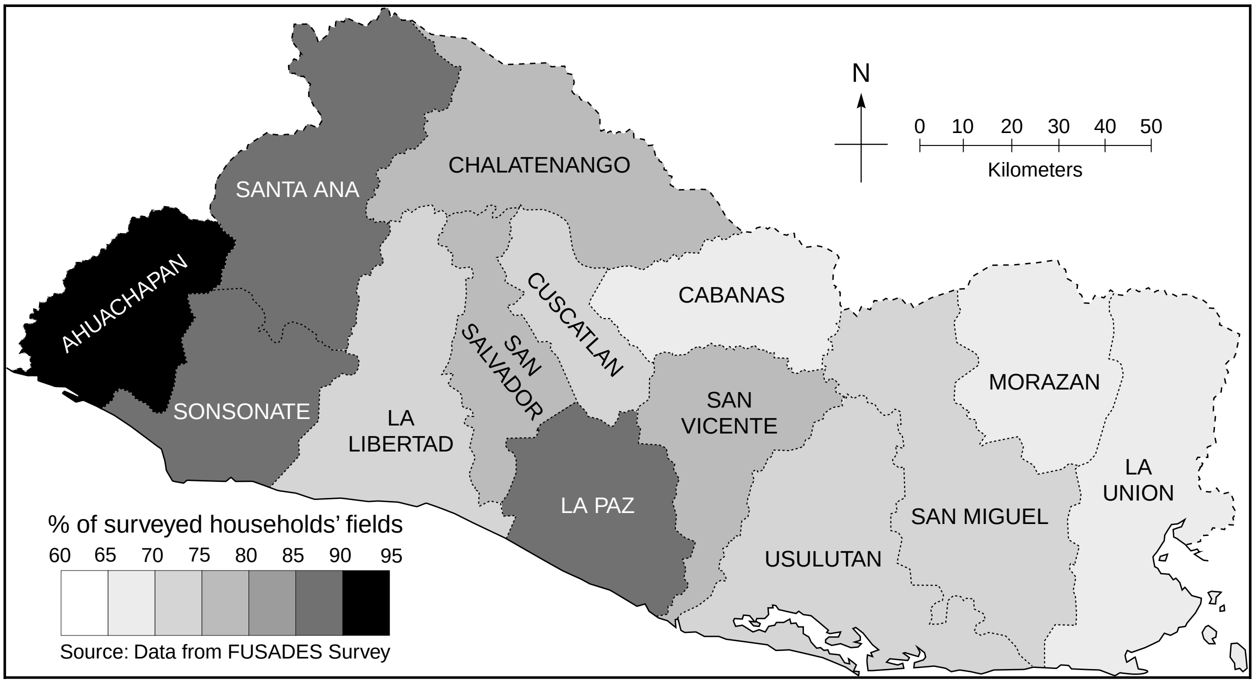
Table 7 shows the relationship between tenure and use of conservation measures. As might be expected most conservation measures are found on owned lands. Surprisingly, however, some rented lands also have conservation measures. This is a result that had already been found by McReynolds and others (1994) using data from the late 1980s. Upon reflection, however, this is less surprising than it might seem. Conserved land, being more productive, is likely to command higher rental rates than unconserved, degraded land. If conservation is profitable, therefore, it is in the landlord's interest to carry out. Landlords also have an incentive to require that conservation practices be undertaken, since any degradation occurring during rental will reduce the landlord's future income from renting out a field. However, this does not seem to happen. While 59% of rented fields report restrictions on what crop can be grown, only 9% report other kinds of restrictions. The survey did confirm that most leases are relatively short-term and insecure. Only 37% of rented fields had been rented for more than 3 years. Conversely, only 7% of farmers expected to continue

Table 7: Effect of Tenure on Use of Conservation Measures

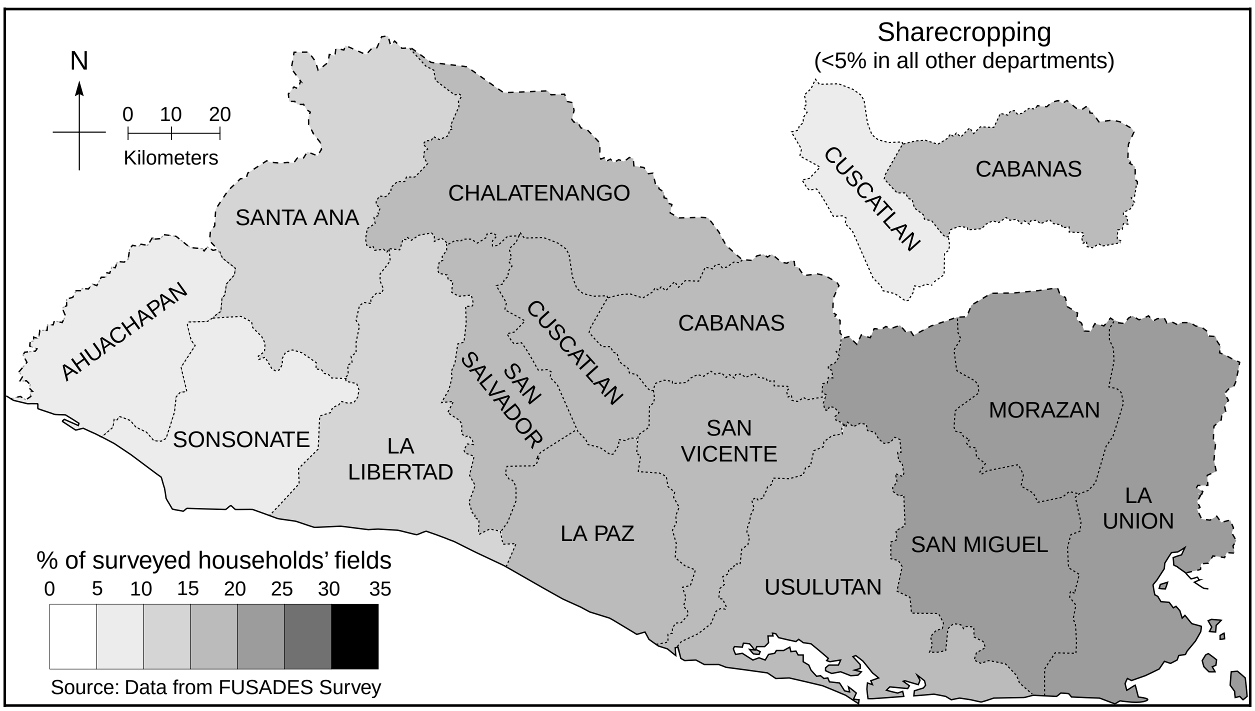
Tenure	Number of Fields		Cultural Practices		Hedges		Walls		Terraces		Ditches		Total	
	(n)	(ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)	(% fields)	(% ha)
Owned	356	795	23	30	3	3	8	15	1	1	3	3	35	48
Rented	78	94	40	41			9	6			1	1	47	46
Sharecropped	9	9	56	52			11	16					67	68
Rent-free loan	8	4	13	8									13	8
Squatting	14	14	29	39							7	15	36	55
Invasion	3	3	33	53									33	53
No answer	4	3	75	78									75	78
Total	**472**	**921**	**27**	**32**	**3**	**2**	**7**	**14**	**1**	**1**	**2**	**3**	**38**	**48**

Source: FUSADES Survey

Map 6: Proportion of Owned Fields



Map 7: Proportion of Rented Fields



renting the same field for more than 2 additional years, while 81% did not know how much longer they would rent the same field.

Credit Availability. Both the availability of credit and its lack have, at various times, been blamed for causing degradation. Salinas and others (1993), for example, argue that formal credit encourages degradation because (i) it finances production in fragile areas; (ii) it does not finance conservation; and (iii) it encourages the use of agrochemicals. On the other hand, Van Doorn (1992) notes that access to subsidized credit was an important factor motivating farmers to participate in the FAO's soil conservation project.

According to the FUSADES survey, none of the farmers have asked for credit for the purpose of financing conservation measures. The most important purpose for seeking credit was to finance production (75%), with land acquisition a distant second (13%). (It is interesting to note that land was used as collateral for 34% of loans.) Given this lack of demand, it seems difficult to blame lack of credit of farmers' failure to conserve. On the contrary, available evidence from the many conservation projects carried out in the country seems to indicate that farmers may be willing to adopt conservation measures *for the purpose of obtaining credit*. Rather than a benefit of credit, conservation seems to be, for many farmers, a cost of obtaining it.

Poverty. There has been relatively little analysis of the causal links between poverty and land degradation. In principle, poverty can affect conservation decisions in two main ways:

- Subsistence needs cannot be met while adopting the conserving practice.
- Poor farmers have higher discount rates and so value long-term benefits less.

Pagiola (1995) suggests that, since poor farmers tend to be heavily dependent on agricultural production for their livelihood and have few alternative income sources, it is very much in their interest to conserve their soil resources, given the extremely high long-term costs of failing to do so. If the subsistence requirements are sufficiently high relative to what their production technology can provide, however, it is possible that no sustainable practices exist that would allow a household to meet its subsistence requirements. In this case, the household would have no choice but to adopt unsustainable land use practices.

Summary. Many farmers do employ a range of conservation practices. But many do not. The available data does not allow definitive answers to the reasons for some farmers' failure to adopt conservation measures. It does seem clear that many of the conservation measures which have been promoted, and particularly the more expensive structural measures, may not be cost-effective for farmers. Conversely, on steep slopes cultural measures, though cheap, may not be sufficiently effective. There may, therefore, be a need for additional research on cost-effective conservation techniques, particularly for farmers on steep slopes. That many conservation measures are not cost-effective from the farmers' perspective has been established in many instances throughout the world (in Central America, for example, by Lutz, Pagiola, and Reiche, 1994). Available data do not allow estimates of how many farmers do have adequate measures available to them and yet fail to adopt them. To the extent that such farmers exist, neither ignorance nor lack of credit seem likely to play important roles in their failure to adopt conservation measures. Rental regimes may well provide low incentives to conserve, but they only affect a relatively small proportion of all fields. Whether, and in what way, poverty affects conservation decisions remains to be established.

Even though conservation measures are relatively widely adopted, interventions to increase adoption might be justified if constraints or market failures mean farmers under-invest in soil conservation. In El

Salvador the main constraints to farmer adoption of soil conservation are usually identified as farmer ignorance, insecure tenure, lack of credit, and poverty.

- *Ignorance*. Ignorance is unlikely to be a constraint. Many farmers do use various forms of conservation, showing that they are widely known.
- *Tenure*. Farm households own three quarters of the fields and almost 90% of the land they operate, so the impact of any tenure problems is likely to be limited. Although there are reasons to expect rental practices to result in under-investment in conservation, primarily because of the short length of most leases, the survey reveals that conservation measures are in fact used on rented lands; indeed, a greater proportion of rented fields than of owned fields have cultural conservation measures (Table 2).
- *Credit*. None of the farmers in the survey had asked for credit to finance conservation measures, although many sought credit for other purposes, so credit is unlikely to be an important constraint.
- *Poverty*. Available data are insufficient to determine whether poverty is an important constraint to investments in conservation.

The available evidence, although insufficient to allow a full cost-benefit analysis of the profitability of conservation measures under different conditions, does suggest that farmers make appropriate conservation decisions given the severity of the threats they face and the cost and effectiveness of different conservation measures.

Conclusions and Recommendations

Given the many weaknesses of the available data, even after the quantum improvement provided by the data from the FUSADES survey, general conclusions must be drawn with caution. With this caveat, available data suggest that:

- The extent and severity of land degradation problems in El Salvador is substantially lower than is commonly perceived, affecting between 50% and 80% of fields on moderate and steep slopes and about 20-25% of farm households. Even with these revised estimates, however, land degradation remains an important national problem.
- Many farmers do invest in conservation measures. Many that do not are likely to fail to do so because of the inadequacy, from a cost-benefit perspective, of available measures. Of the commonly-advanced reasons for farmers' failure to adopt conservation measures, neither ignorance nor lack of credit appear to play important roles. Rental regimes may discourage conservation on rented lands, but this only affects a small proportion of all fields. The effect of poverty remains to be established.

The more nuanced picture of conditions that emerges from the analysis in this paper requires a more targeted approach to interventions designed to address land degradation. Unfortunately, however, available data make it difficult to do so. In particular, collection of data along departmental lines or—even worse—regional lines makes it very difficult to identify hot spots.

Targeted Policies. The available evidence does not indicate a need for new broad, national-level policies. Nevertheless, there is likely to be a need for targeted interventions to address problems experienced in specific areas. The nature of these interventions will vary according to the specific problems encountered. To identify the necessary interventions, improved data will be required.

Data Collection. Despite decades of concern over land degradation and a multitude of projects, data that would allow identification of the extent and severity of land degradation problems remain extremely limited. MAG, for example, collects yield data according to administrative boundaries. Because of the very wide diversity of agro-ecological conditions in each department, such data provide very little information on land degradation problems and offer little guidance in the development of appropriate policy responses. A new sample frame is currently being developed for MAG's production data collection. This frame should be designed to collect data based on agro-ecological conditions rather than administrative boundaries. The need to collect data according to agro-ecological conditions is also a key emerging conclusion of the Land Quality Indicator program being jointly implemented by the World Bank, FAO, UNDP, UNEP, and the CGIAR. On-going national data collection must also be supplemented by targeted research efforts aimed at measuring the linkages between different land use practices and long-term productivity.

Farmers are the ultimate decision-makers when it comes to land resource management. The available evidence suggests that they are responding rationally to land degradation problems, in light of their incentives and constraints. Land degradation problems are also highly site-specific, and differ substantially from place to place. Under these conditions, national-level policies are blunt instruments which are unlikely to be cost-effective and may well have perverse effects. Effective policy responses need to be carefully targeted at a sub-national level.

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