Rural Development Policies and Sustainable Land Use in the Hillside Areas of Honduras

A Quantitative Livelihoods Approach

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Foreword

Promising ways of promoting sustainable development in less-favored areas have long been a focus of the International Food Policy Research Institute (IFPRI). Hillside areas are an important facet of less-favored areas because they often have limited biophysical potential and attract limited public investment. As a result, poverty, low agricultural productivity, and natural resource degradation tend to be interrelated problems in such areas. In Honduras, poverty is deep and widespread, and this is especially the case in the hillside areas—home to one-third of the country's population. The majority of these people earn their living through agriculture, as either smallholders or farm laborers. Rural poverty in the hillsides results primarily from unequal asset distribution, low factor productivity, insufficient public investments in infrastructure and services, and vulnerability to natural and economic shocks.

In this research report, authors Hans Jansen, John Pender, Amy Damon, and Rob Schipper generate important information for use by decisionmakers in assessing policy and public investment options targeted toward increasing agricultural productivity and household income in hillside areas, at the same time stimulating natural resource conservation. Based on detailed household- and plot-level survey data, they develop a quantitative livelihood approach and use it to assess the determinants and effects of household livelihood strategies and land management decisions in an integrated econometric framework. The authors also demonstrate how this framework can be used as a policy targeting tool, thus integrating the livelihood strategies literature with the policy targeting literature.

Even though the results indicate that solutions to poverty in the rural hillside areas of Honduras are neither easy nor straightforward, the study confirms that agriculture should form an integral component of rural development strategies in these areas, where the assets held by many households are limited to unskilled labor and small tracts of owned or rented land. The results indicate that, in order to raise household incomes, public investment and policy programs addressing the hillside areas should focus on improved road infrastructure, broader land access, policies to reduce household size and dependency ratios, and the adoption of land management technologies—for example, through agricultural extension programs and land redistribution—to restore soil fertility. While investments in physical assets should be directed toward households that incorporate off-farm employment or coffee production into their livelihood strategies, agricultural training programs should target livestock producers.

Joachim von Braun
Director General, IFPRI

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Summary

The government of Honduras is becoming increasingly concerned about slow progress in combating rural poverty, which is especially stark in the hillside areas. While both policymakers and donors are under strong pressure to provide adequate interventions, the government and its development partners have insufficient understanding about what drives sustainable rural productivity growth; they therefore have little guidance on how to prioritize expenditures and develop strategic directions for the rural sector.

This report provides policymakers and stakeholders in Honduras with empirical information about livelihood strategies employed in the country's hillside areas, existing poverty-alleviation opportunities, and potential policy and investments priorities, based on extensive survey data for 376 farm households, 1,066 parcels, and 2,143 individual plots located in 95 rural hillside villages in Honduras.

Households in the rural hillsides of Honduras have widely differing asset endowments and livelihood strategies. Households that rely on basic grain farming are the poorest because they are often located in isolated areas with relatively poor agroecological and socioeconomic conditions. Opportunities for off-farm work tend to be limited in these areas, and household strategies that combine on-farm work with off-farm work earn higher incomes.

Soil fertility has a strong, direct, and positive impact on income, while agroclimatic conditions such as higher rainfall and altitude have an indirect positive income effect because they stimulate more remunerative livelihood strategies. Land is not the key constraint limiting the potential for higher incomes in the study regions; more land per se does not lead to higher income per capita, and households with less land are able to compensate by obtaining higher productivity or by pursuing off-farm activities. Land tenure also has no impact on crop productivity and household income, but adoption of sustainable land use practices is higher on owner-operated plots than on leased ones.

Ownership of machinery and equipment enables households to raise labor and land productivity and is especially helpful for households with relatively high opportunity costs for labor, such as those pursuing off-farm employment or coffee production. Livestock ownership, on the other hand, has no significant direct impact on crop productivity and per capita income.

Human capital variables have mixed impacts. Households whose members have more formal schooling have higher perennial crop productivity, but education has no statistically significant impact on per capita income. Households with higher dependency ratios follow less remunerative livelihood strategies and have lower per capita income. After controlling for other factors, the sex of the household head has no significant effect on crop productivity or per capita income, but it does influence some land-management and input-use decisions. Hillside households do not generally receive significant amounts of remittances, so migration has no significant impact on per capita household income.

With the notable exception of agricultural training programs, household participation in other training programs and organizations was found to have only limited effects on crop productivity and income. However, several of these programs are important for the sustainability of agricultural production: agricultural extension in particular plays a key role in promoting

the adoption of sustainable production practices. Geographic determinants also have fairly limited impacts, even though they do influence land-management practices, external inputs, and labor use. Road density has no statistically significant direct effect on per capita household income, despite its positive effect on the productivity of perennial crops, although it may indirectly help to generate higher incomes by promoting livelihood strategies other than the production of basic grains. Better market access is weakly associated with higher value of production of perennial crops but not with higher income. Population density also has limited direct impact on crop productivity and per capita income, though it may have indirect effects via farm size and livelihood strategies.

These findings suggest there are no easy and straightforward ways to combat poverty in the rural hillside areas of Honduras. Many households have few assets other than (unskilled) family labor and some land. This leads to a strong food-security focus, whereby most land and labor resources are allocated to the production of maize, beans, and sorghum using traditional, low-productivity technologies. Many households seem to be locked in a vicious poverty cycle that prevents a transition to other income-earning strategies that could be more profitable.

Though agriculture can potentially help break this cycle as an integral part of the rural growth strategy in hillside areas, it alone cannot solve the rural poverty problem; those remaining in the sector need to be more efficient, productive, and competitive. In particular, public investment programs may want to focus on broadening the physical asset base of poor households and extending the coverage of agricultural training. Investments in physical assets should primarily target crop producers and perhaps also households that have relatively high opportunity costs for labor. Agricultural training activities can focus profitably on development of livestock production.

Public investments may yield a significant positive impact on income, poverty reduction, and the productivity and sustainability of agricultural production in a number of other areas. Improving road infrastructure is likely to stimulate livelihood strategies that emphasize off-farm work, yielding higher returns to smallholders than working on their own farms. Family-planning programs that succeed in lowering both household size and dependency ratios may also help in raising per capita incomes.

Agricultural extension programs and conservation-oriented training programs that make a significant contribution to maintaining and improving soil fertility can help improve household incomes as well. Though this will increase yields in the long term, land-saving production technologies are needed to raise the productivity of annual crops (particularly basic grains) in the short to medium term. Given Honduras' current limited capacity for agricultural technology research in this area, the government may try to find ways to introduce and disseminate appropriate agricultural technologies that have proven successful elsewhere under similar conditions; hence, adequate consideration of local conditions is critical.

Improving access to land (not land titling per se) can also have an indirect positive impact on income by enabling households to pursue more remunerative livelihood strategies such as livestock production. Given the inverse farm size–productivity relationship in the hillside areas, improved land access in the form of land rental markets could also increase total crop production by enabling more productive smallholders to expand their production. Land redistribution programs seeking to increase smallholder land ownership may also be justified on the basis of sustainability considerations, since the adoption of certain soil conservation practices is larger on owned land than on rented land.

Finally, in order to capitalize on the rapidly increasing importance of the migration phenomenon, the government should consider providing basic training to assist prospective migrants, supporting community-based initiatives aimed at investing remittances in a productive way, and improving financial systems to lower the transaction costs and risks associated with remittances.

CHAPTER 1

Background and Justification for the Study

Honduras is one of the poorest countries in the Western Hemisphere. Even though increasing rural to urban migration has occurred in recent decades, poverty remains most severe and widespread in rural areas. The landscape of Honduras is dominated by hills and valleys. The most fertile agricultural land is generally found in the valleys. The hillside areas (Box 1.1; see also Díaz Arrivillaga 1996; UNDP 1998), which account for 80 percent of the land area in Honduras, are generally considered to have lower agricultural potential. Historically, land ownership patterns throughout Honduras have meant that large landowners own the majority of the most productive land in the valleys while smaller, poorer agricultural producers work the hillside land. For this reason, rural poverty is concentrated in the hillside areas throughout the country, where problems of low agricultural productivity and land degradation appear to be getting worse.

Adding to the inherent challenges that farmers working on hillside land encounter, such as increased erosion risk and lower soil fertility, poor farmers in these areas have faced a number of economic and natural shocks in the past several years. The decline in international commodity prices for major export crops such as coffee and bananas has severely impacted resource-poor farmers and agricultural laborers. The global economic slowdown has exacerbated problems of unemployment. Negative economic impacts have resulted from natural shocks including Hurricane Mitch,[1] destructive and erratic rainfall,[2] and recurrent droughts. Unequal distribution of assets and inadequate public policies prevent significant increases in land and labor productivity in these areas. During the past decade, income distribution in rural areas has worsened (Figure 1.1), with increasing numbers of people at both tails of a distribution that exhibits a virtually stagnant mean. Compounding these problems, most hillside communities perceive declining crop yields, decreasing food security, and increasing problems of land degradation (Jansen et al. 2003, 2006).

Low land productivity and rural poverty are closely associated with insufficient protection of the natural resource base and resulting degradation of soil and water resources. Hillsides often consist of steep fragile lands where soil erosion can reach 300 tons of soil loss per year (Tracy 1988; Thurow et al. 2002). Many hillside areas also have an important water storage function. Soils are a critical part of natural capital and play a vital role in providing farm income through agricultural production. Declines in agricultural productivity caused by soil erosion

[1]Hurricane Mitch hit the country from October 25 to November 1, 1998, causing 5,600 deaths and about $4 to $5 billion in damage. Impacts on infrastructure, the destruction of vast agricultural areas, and estimated crop losses of $1 billion affected as much as 35 percent of the rural population (Meltzer 2001).

[2]For example, tropical storm Michelle affected Honduras in the fall of 2001.

Box 1.1 Defining "Hillsides," "Hillside Areas," and "Valleys"

Hillsides are defined as areas with slopes of more than 12 percent (PRONADERS 2000). Hillside areas include not only hillsides but also flat-floored valleys, 300 to 900 meters in elevation, which are scattered throughout the interior hillsides. "Valleys" refer mainly to the lowland areas in the north and northwest of the country, which are generally considered as high-potential areas for agriculture. In Honduras, hillside areas account for roughly 80 percent of the total land area where the major economic activity consists of smallholder farming focusing on production of basic grains, coffee, and livestock. Agricultural potential in hillside areas varies with agroecological factors such as elevation, rainfall, and soil characteristics. However, compared to areas with lower slope and elevation, agricultural options in hillside areas are constrained. Rather than profit maximization, food security is the most important objective of most smallholder households living in hillside areas. Many hillside areas also have less access to transport infrastructure and services.

not only adversely impact farmers' incomes but also have negative off-farm consequences such as silting of rivers, resulting in flooding, reduced water quality, and diminished reservoir capacity.

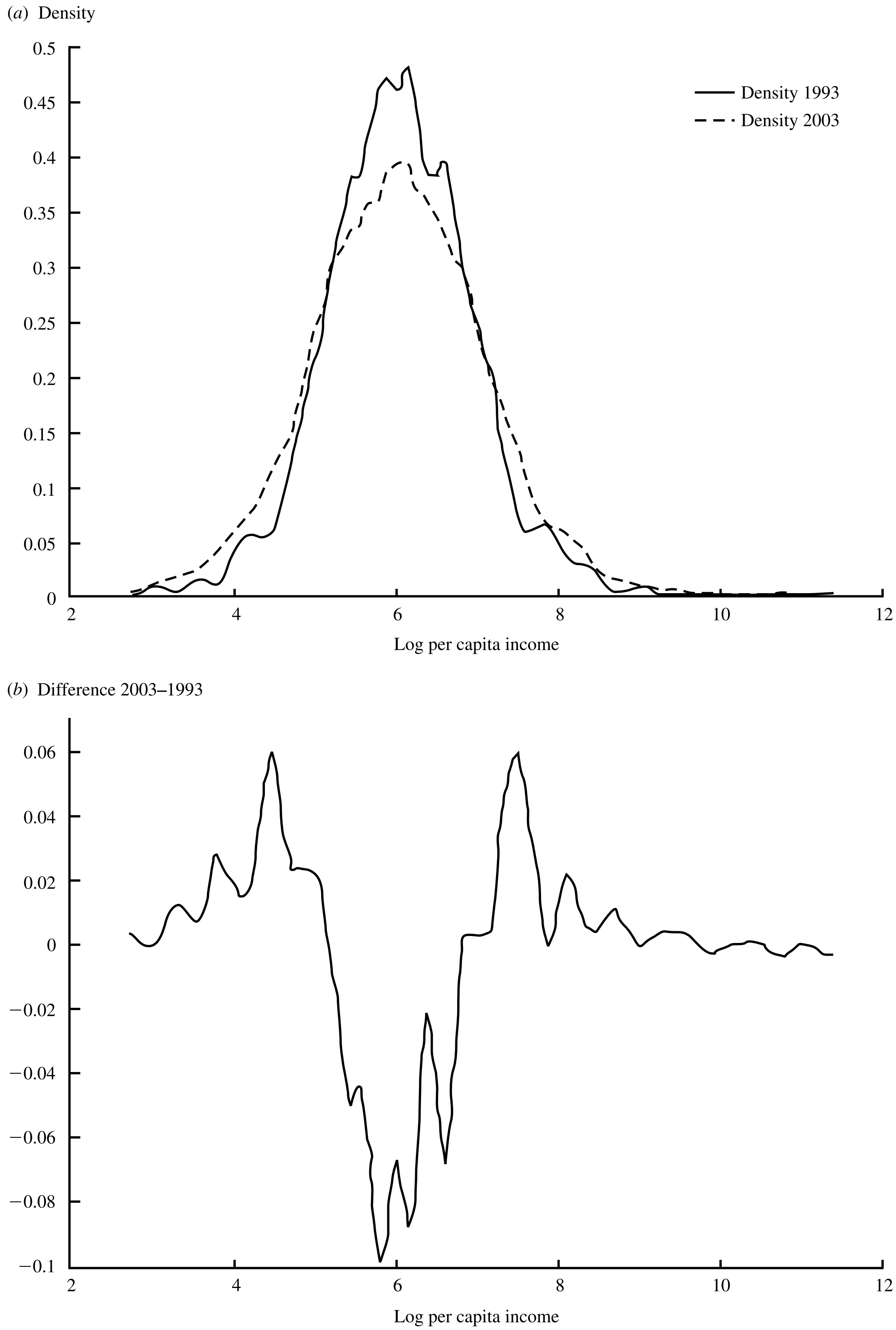
It is not always clear what interventions are needed to foster sustainable land use and land management practices in the hillside areas or what interventions will have the greatest impact on poverty reduction. The main factors that drive the adoption of soil conservation measures in the hillside areas in Honduras, and how the provision of training affects returns to land and income, have yet to be clearly and conclusively identified. Despite a few localized success stories,[3] the rate of adoption of soil conservation measures in the hillside areas is generally low, and identifying the technical, institutional, environmental, and socioeconomic factors that condition farmers' adoption behavior is important for designing promising policies that could stimulate such practices. Understanding the complex relationships among growth, poverty, and sustainable resource use (Vosti and Reardon 1997) is crucial to identifying effective strategies and policies to improve the livelihoods of the inhabitants of the rural hillside areas in Honduras. This report seeks to improve that understanding.

Background

Honduras has a total population of 6.8 million people and a relatively high population growth rate of 2.6 percent per year. Per capita income is US$920 per year (data refer to 2002; see World Bank 2004b). Social indicators such as child malnutrition rate (17 percent), life expectancy at birth (66 years), child mortality rate (32 per 1000 births), and literacy rate (less than three quarters of the population) are among the poorest in the Latin America and Caribbean region. Honduras has acquired Highly Indebted Poor Country (HIPC) status and prepared a Poverty Reduction Strategy Paper (PRSP) in 2001. Honduras reached the so-called completion point in April 2005, which qualifies the country for major debt relief and

[3]See, for example, Deugd (2000) for a description of an agroforestry-based system in the province of Lempira that combines productivity-improving and soil conservation components. See also Cárcamo, Alwang, and Norton (1994) for descriptions of some successes of the former USAID-supported Land Use and Production Enhancement (LUPE) project in the steep hillsides near Tegucigalpa.

Figure 1.1 Changes in rural income distribution, 1993–2003



Source: Based on data from the Permanent Household Surveys 1993 and 2003, National Statistics Institute (INE), Honduras.

will allow Honduras to use its savings on debt servicing to improve essential public services.

About 60 percent (about 4 million people) of the total population of Honduras is considered rural, and an estimated 80 percent of rural people live in the hillside areas. The majority of these people earn their living in the agricultural sector, which remains an important part of the Honduran economy. According to the World Bank,[4] agriculture accounted for 13.5 percent of gross domestic product (GDP) in 2003, down from 21.2 percent 20 years earlier. However, the Inter-american Development Bank (IADB 1999) estimates that the food and agricultural sector (including not only primary production of crops, animals, fish and seafood products, and forest products, but also post-harvest activities such as transport and processing activities) is responsible for much larger shares of total GDP, commodity export earnings, and employment, possibly up to 50 percent.

Poverty in Honduras is highly correlated with living in a rural area: most of the poor are found in rural areas and much of the rural population is poor. Nationally, 59 percent of all poor households and 65 percent of the extremely poor live in rural areas. Three quarters of all rural households live below the poverty line (US$1.50/day per capita) and 80 percent of these households live in extreme poverty (US$1.00/day per capita; data refer to 1999; see Government of Honduras 2001). According to our own survey data (see Chapter 4), nearly 93 percent of the hillside population in the areas studied lives below the poverty line, and 92 percent live below the extreme poverty line. A slowly declining poverty rate masks increases in the absolute number of poor as a result of increasing population; it is estimated that during 1992–2002, the number of poor in Honduras increased by about 1 million (Government of Honduras 2003).

The macroeconomic situation in Honduras gives little reason for optimism. The country has been in an economic crisis since the second half of the 1990s. Growth of GDP is characterized by high interyear fluctuations (Figure 1.2), and consequently, given the very slow decrease in population growth, per capita GDP growth is also highly variable (Cuesta and Sánchez Cantillo 2004). The economic crisis is occurring at a time when adjustments are expected in comparative advantage of agricultural and other enterprises, as Honduras has committed itself to a continuation of the process of market liberalization as a part of the Central American Free Trade Agreement (CAFTA).[5] Sensitive commodity imports include food staples (including so-called basic grains[6]—primarily maize, beans, and rice—but also dairy products and sugar) that are important for the typical Honduran diet. Free trade of these staples could bring positive welfare effects for the poor because the majority are net purchasers of such goods (Jaramillo and Lederman 2005) and create opportunities for growth. But for others who are net producers, accelerating the long time trend of deteriorating terms of trade for agriculture[7] will critically affect the cash value of the production surplus. Without an

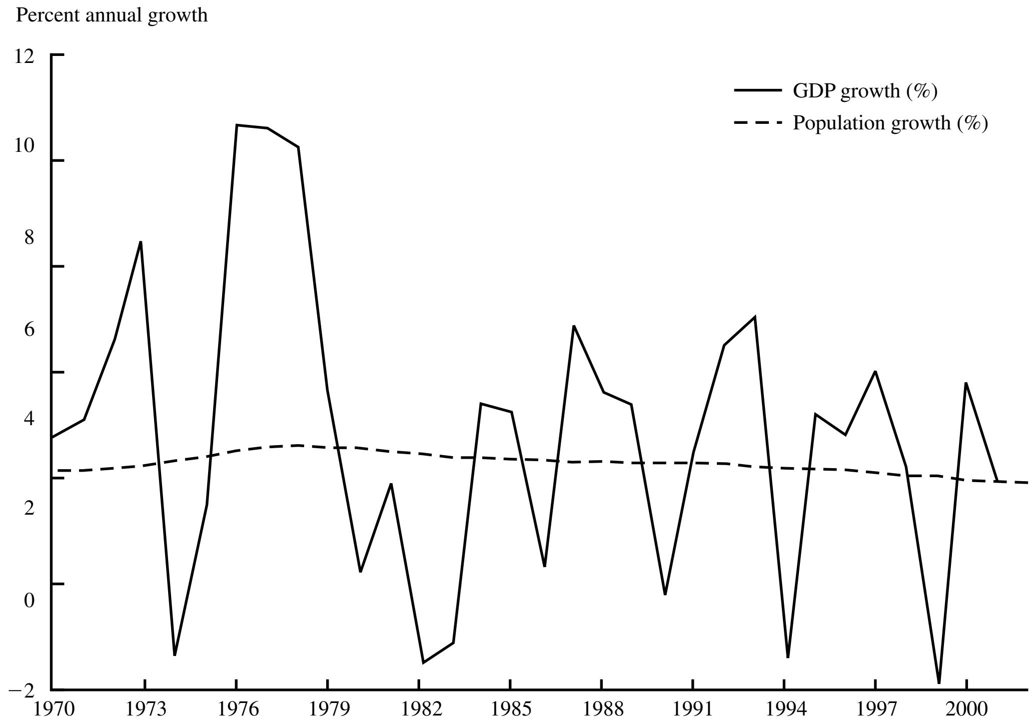
[4]See www.worldbank.org/data/countrydata/aag/hnd_aag.pdf.

[5]Honduras started negotiations for the Central America Free Trade Agreement (CAFTA) in January 2003 and reached an agreement in December 2003. The country signed the CAFTA agreement on May 28, 2004, and its Congress ratified it on March 3, 2005. On July 27, 2005, CAFTA passed in the U.S. Congress. In Honduras, CAFTA took effect on April 1, 2006.

[6]Throughout Central America, the term “basic grains” (*granos básicos*) refers mainly to maize and beans but also includes sorghum and rice.

[7]For details see Chapter 2.

Figure 1.2 Growth of GDP and population in Honduras, 1970–2002



Source: Based on data in World Bank (2004b).

appropriate public investment program, CAFTA could potentially have undesirable social repercussions.

Justification and Contribution

Several observers in recent years have argued that the key to development of sustainable rural livelihoods is investment in an appropriate and socially profitable mix of physical, human, natural, financial, and social capital, taking into account the diversity of contexts in developing countries (Carney 1998; Scoones 1998). But quantitative work regarding the appropriate portfolio of investments for such different contexts, and the implications of different investment strategies and livelihood strategies for natural resource management, agricultural productivity, and human welfare, even though slowly emerging, are still in their infancy.[8]

[8]A large literature exists on determinants of adoption of agricultural technologies (e.g., Feder, Just, and Zilberman 1985; Feder and Umali 1993) and there is a rapidly growing literature on determinants of adoption of natural resource management practices (e.g., Lee and Barrett 2001; Barrett, Place, and Aboud 2002). However, most of this literature does not link natural resource management decisions to the livelihood strategies of households or communities and focuses mostly on household-level assets, with little information on impacts of community and higher-level factors (Place et al. 2002). There is a well developed literature on the impacts of property rights and land tenure on technology adoption and natural resource management and implications for agricultural production (e.g., Feder et al. 1988; Place and Hazell 1993; Otsuka and Place 2001; Meinzen-Dick et al. 2002). While mostly focusing on Africa and Asia, there is much less literature on impacts of other policy relevant factors, such as access to roads, markets, and participation in community-based organizations, and little exploration of the relationship of these issues to livelihood strategies. The work of Fan and colleagues (e.g., Fan, Hazell, and Thorat

In addition to providing empirical information useful to policymakers and other stakeholders in Honduras, this study makes a methodological contribution to the largely qualitative livelihood strategies literature by developing a quantitative application of the livelihoods approach (Ashley and Carney 1999; DFID 1999). While assessing causes and effects of household livelihood strategies and land management decisions in an integrated framework, it shows how this framework can be used as a policy targeting tool, thus integrating the livelihood strategies literature and the policy targeting literature (see, e.g., de Janvry and Sadoulet 2000; Elbers et al. 2004). The marriage of these two literatures offers not only methodological and empirical advances in the livelihoods strategies framework, but also a practical policy development and evaluation tool for policymakers.

In the case of Honduras, the government's current strategy for reducing poverty, as laid out in the Poverty Reduction Strategy (Government of Honduras 2001), has six pillars, many of which address rural development issues: accelerating equitable and sustainable growth, reducing rural poverty, reducing urban poverty, enhancing investment in human capital, strengthening social protection for vulnerable groups, and ensuring sustainability through governance/institutional reforms and enhanced environmental sustainability. The government's policy vision regarding rural development as described in its Rural Development Strategy (RDS; see SAG 2004) makes a clear distinction between households located in the lowlands and households located in the hillside areas. For the former, the focus is on development of their productive capacity, improving market links and competitiveness. For the latter, the focus is on diversification of the local economy, household food security, and community agroforestry options. But because rural populations are highly heterogeneous, efficiency considerations call for the design of policy interventions to be differentiated according to this heterogeneity. Even though the RDS recognizes that survival of small family farms in the hillside areas is essential for rural poverty reduction, it provides no guidance regarding how to address the diversity within this group.

Previous studies[9] in Honduras have offered hints about investment priorities for pro-poor rural growth. While many of these studies provide an amalgam of recommendations on agricultural technology and extension, land, rural finance, nonfarm rural income, human and social capital, and market infrastructure, they generally do not offer recommendations regarding the combinations of assets to invest in for maximum poverty impact or which population groups should be targeted with which type of investment. This study, while implementing and quantifying the livelihood strategies framework, provides a characterization of the heterogeneity within the hillside group of farmers, and by analyzing the specific attributes and asset combinations of different livelihood strategies, offers a policy analysis that is better targeted to subgroups of hillside farmers.

There is a rapidly growing body of theoretical and empirical work that draws on

1999) investigates the impacts of various public investments on agricultural production and poverty. But their work does not analyze the impacts of such investments on households' livelihood strategies or land management conditions. Finally, there is also a rapidly growing literature on rural nonfarm income and livelihood diversification in developing countries (e.g., Ellis 2000; Barrett, Reardon, and Webb 2001; Reardon, Berdegue, and Escobar 2001), but little of this investigates the implications of livelihood diversification for natural resource management.

[9]See, e.g., Pino, Jiménez, and Thorpe (1994); Díaz Arrivillaga (1996); Scherr and Neidecker-Gonzalez (1997); IADB (1999); Barham, Carter, and Deininger (2000b); PEP (2000); Ruben and van den Berg (2001); Barham, Boucher, and Useche (2002); Boucher, Barham, and Carter (2002); Walker and Pino (2002); and Varangis et al. (2003).

the sustainable livelihoods framework (e.g., Rakodi 1999; Ellis 2000; Adato and Meinzen-Dick 2003; Ellis and Bahiigwa 2003; Ellis and Mdoe 2003; Ellis, Kutengule, and Nyasulu 2003; Reddy and Soussan 2003). However, solid empirical characterizations of livelihoods and the impact of changing livelihood strategies on households and communities are relatively scarce. One notable exception is Pender (2004), who used data on primary and secondary occupation and land-use changes over time in central Honduras, the northern Ethiopian highlands, and most of Uganda to determine community development pathways, defined as common patterns of change in livelihood strategies. Common pathways were then grouped and used as units of analysis to explore conservation and cropping practices. Jansen et al. (2003, 2006) used a similar approach but relied primarily on qualitative information and expert knowledge to group rural hillside communities in Honduras according to income-earning strategy.

Several recent studies have recognized potential complementarities between the livelihood strategy approach and policy targeting. Ruben and Pender (2004) address these in a largely theoretical context, discussing the key components for the design and implementation of appropriate policies in areas with high levels of rural heterogeneity. They conclude that given strong rural heterogeneity, community-driven programs are required to guarantee targeting efficiency. Coomes, Barham, and Takasaki (2004) also link the livelihood strategy framework with policy intervention but in an empirical context, to examine the effectiveness of different environmental conservation programs in Peru. They use both income sources and landholdings to characterize different livelihood strategies and discuss the importance of these strategies for resource use and depletion and the economic reliance of households on natural resources. However, there has yet to be a comprehensive study that uses the asset-based approach as the basis for a quantitative identification of livelihoods as part of an integrated econometric modeling framework that empirically examines the impacts of different policies on livelihood strategies, household income, and land management decisions. This study aims to fill that gap by implementing a rigorous empirical specification of rural livelihoods based on labor allocation and agricultural land use, and then uses this specification to identify which policies will affect which types of households, and how. We investigate not only the factors determining livelihood strategy decisions and adoption of land management practices, but also the implications of these decisions for crop productivity. We explicitly address problems of possible endogeneity of explanatory variables and other econometric issues affecting our inferences.

This report seeks to help generate critical knowledge about livelihood strategies employed in Honduras' hillside areas, opportunities that exist and potential priorities for public investment. The work presented here is based on research conducted under the project "Rural Development Policies and Sustainable Land Use in the Hillside Areas of Honduras" of IFPRI, in cooperation with Wageningen University and Research Center (WUR) of the Netherlands and PRONADERS. The research was carried out at three levels: the village or community level, the farm household level, and the individual plot level.[10]

The analysis in the remainder of the report is mainly based on primary survey data at the individual household and plot levels. Our analysis spans descriptive statistics to identify patterns of asset ownership and its relation to poverty, factor and cluster analysis to identify livelihood strategies, and

[10] This report is concerned with the farm household and plot levels only; for results of the community-level work carried out in the same project, see Jansen et al. (2003, 2006).

econometric analysis to investigate determinants and impacts. In addition, we also make use of available secondary data to analyze the context in which livelihood strategies take place and as explanatory variables in the regression analyses.

Organization of the Report

The remainder of the report is organized as follows: Chapter 2 provides an historical overview of macroeconomic and sector policies in Honduras and describes how these have affected economic growth and poverty. Chapter 3 is mainly devoted to conceptual issues and methodology and also includes a presentation of our main research questions and hypotheses. It describes our analytical framework based on a quantification of the livelihoods concept using factor analysis and cluster analysis techniques, and describes the empirical model and approach used in econometric analysis of determinants and impacts of different livelihood strategies, household income, land management practices, input use, and output value. Chapter 3 also includes a presentation of the study's geographical coverage and the sampling frame used for data collection. Chapters 4 and 5 form the core of this report and contain the main results of the study. In Chapter 4 we first present the main characteristics of households in terms of their asset bases to help the interpretation of the results of the empirical model estimations in Chapter 5. We then identify the main livelihood strategies in the hillside areas of Honduras and provide a brief description of each. The empirical model results based on our econometric analysis are discussed in Chapter 5, which also presents the simulation results regarding the effects of a number of alternative policy options regarding investments in certain specific types of assets, in terms of their effects on agricultural productivity, rural poverty, and adoption of soil conservation measures. Finally, in Chapter 6, we return to our research questions, discuss our major findings and conclusions, and derive implications for public policy and investment strategies.

CHAPTER 2

Macroeconomic Policies and Rural Development in Honduras

In the previous chapter we argued that fostering sustainable rural development and making a significant dent in rural poverty in Honduras require increased attention to the hillside areas, a clear prioritization of the rural investment portfolio and available resources, and improved policy targeting. However, the past performance, current situation, and future prospects of the rural sector cannot be analyzed in isolation from the past and current macroeconomic policy environment and sector policies. Therefore, to better understand the main limitations and challenges to increasing the pace of rural development in Honduras, this chapter contains a brief history of past macroeconomic policies and reforms, analyzes past reforms in the agricultural sector, and links these to the performance of the agricultural sector.

Macroeconomic Policies and Reforms

Honduras experienced relatively steady economic growth in the 1960s and 1970s (per capita income grew by 1.8 percent per year on average during this period), but during the 1980s per capita GDP decreased by an average of 0.5 percent per year, resulting from an average annual rate of GDP growth of only 2.7 percent and an average annual population growth of 3.2 percent (World Bank 2004b). Like most other Central American countries, Honduras reacted by adopting a range of structural adjustment and macroeconomic stabilization programs that still continue today. Beginning in the early 1990s, the country gradually replaced the traditional import substitution model by a model led by export growth that focused on trade and market liberalization. Major elements of the reform process included reduction of trade barriers and protection of domestic manufacturers, more flexible exchange rate arrangements, financial market liberalization, adjustments of public utility tariffs, and the development of a legal framework to strengthen property rights (Pino, Jiménez, and Thorpe 1994; ASIES 1996; Thorpe et al. 1995; UNDP 1998; Walker and Medina Oviedo 2000).

The structural adjustment measures resulted in a slight increase in economic growth (to an average of 1 percent per capita per year during 1994–99) and a concomitant decrease in the poverty rate.[11] However, recovery suffered a serious setback as a result of Hurricane Mitch in

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[11]Based on the traditional measure of the proportion of people below a certain minimum income level, official estimates indicate a reduction in overall poverty levels between 1991 and 1998, from 75 to 63 percent of all households (Government of Honduras 2001). However, besides the income-based poverty measure, there exist a number of other indicators that are closely associated with poverty (Narayan et al. 2000; Sauma 2002). An indicator used frequently by nutritionists is height-for-age, that is, the proportion of school-aged children whose

1998 and the coffee crisis that set in nearly immediately afterwards. Per capita GDP in 2002 was 6 percent below its 1979 level (US$712 vs. US$754 in constant 1995 US dollars).

The macroeconomic situation in Honduras after Mitch remains highly problematic, with the country experiencing a serious economic crisis. In per capita terms, GDP growth virtually stalled (but picked up somewhat after 2003) and unemployment remains very high.[12] Even though inflation has decreased somewhat, it is still relatively high at between 7 and 9 percent per year. Finally, the fiscal deficit is stubbornly high (around 7 percent of GDP in both 1990 and 2001) while the external deficit is also relatively high at over 5 percent of GDP, and mostly financed by remittances and foreign aid (Serna Hidalgo 2003).

The main reasons for the macroeconomic crisis include external as well as internal factors (Pino 2003). As far as the former are concerned, Honduras faces a continuously decreasing external terms of trade, an increasing external deficit, high external debt (until recently standing at nearly US$6 billion but currently about US$1 billion less after a significant write-off by a number of multilateral lenders in June 2005), increasing internal debt (exerting upward pressure on interest rates, thus stifling private investment), in addition to the worldwide economic slowdown. Internal factors that are not helpful for achieving sustained economic growth include a shortage of well-founded sector policies, relatively weak institutions and high levels of corruption, low levels of both public and private investment, and a very unequal asset distribution. At the same time, access to additional external resources to finance badly needed investments[13] in infrastructure, health, education, and social organization is conditional on achieving a three-year agreement with the IMF, which after more than two years of negotiation, materialized in 2004.[14] The agreement is considered a cornerstone for financing Honduras' Poverty Reduction Strategy and for a leading role of the state in restoring economic growth in the country.

While a number of economic sectors in Honduras have shown clear indications of comparative advantage as reflected in appreciable growth rates (e.g., the *maquila* sector, particularly in textiles; tourism; agro-

height is below a certain standard considered as normal for their age. This indicator increased by nearly 20 percent between 1993 and 1999, from 40.6 to 47.6 percent (PRAF 1998).

[12]According to the Central American Bank for Economic Integration (BCIE 2003), open (or registered) unemployment is just above 4 percent, but total unemployment is more like 35 percent (28 percent according to the Economist Intelligence Unit) and particularly severe among the youth and women. While this situation has obvious consequences in terms of social equity, it also has led to increasing violence (as witnessed by a homicide rate of about 10 each day) and desperation among large groups of society.

[13]Currently, less than one quarter of total government expenditure is directed toward economic and social infrastructure such as roads, health clinics, schools, and so forth. This problem is exacerbated by the fact that public investment expenditure is much below its budgeted value, thus further limiting the prospects for economic growth. A study by the former PEP-USAID project (PEP 2000) as well as the Honduras Development Policy Review prepared with help of the World Bank (World Bank 2004a), suggest that significant poverty reduction requires an annual GDP growth of 6 to 7 percent, which in turn implies the need for public investments (especially in education and infrastructure) that substantially exceed current levels. Similar conclusions are reported by Morley and Hazell (2003).

[14]The success of the agreement, which calls for tough fiscal measures, can be achieved only through close collaboration with civil society. The agreement has opened the door for increased financing of public investments by multilateral and bilateral sources on more favorable terms, and has also led to bilateral and multilateral debt relief by respectively the Paris Club and the HIPC Initiative. However, the lack of involvement and agreement by civil society regarding the spread and depth of the necessary measures represents a serious governance problem and possibly points to difficult times ahead.

industry; forestry) these sectors are unlikely to be able to absorb the vast and rapidly increasing masses of un- and underemployed people. As a consequence, what is needed is a comprehensive plan that results in a recuperation of economic growth through stimulating the development of medium and small enterprises as well as small-scale commercial farming in rural areas. The implementation of such a plan would require associated policies that guarantee a favorable climate for private investments combined with a prudent fiscal policy that leaves enough room for public investment. Unfortunately, this is not what we have seen happening in recent years. During the period 1998–2002, there has been a continuous reduction in public savings (from 4 percent of GDP in 1998 to 0.2 percent in 2002) and a persistent increase in the net fiscal deficit (from 1.1 percent of GDP to 4.8 percent). Rather than increasing, tax receipts have decreased from 16.7 percent of GDP in 1998 to 15.9 percent in 2002. Moreover, the current tax system in Honduras is highly regressive, with 86 percent of total tax receipts from indirect taxes (which are a disproportionate burden on the poor) and a very low proportion of people who pay income tax.[15]

Agricultural Policy Reforms

Besides macroeconomic reform, the early 1990s also marked the beginning of a process of agricultural sector policy reforms that are expected to continue in the context of CAFTA. The role of the government in the agricultural sector has been much reduced, and reforms included drastic reductions in public sector institutions such as state extension services.[16] The changes in the agricultural sector's institutions and policies had their legal base in the Law for Modernization and Development of the Agricultural Sector, which became operational in 1993 and replaced the 1975 Agrarian Reform Law. One of the major goals of the Modernization Law is to increase tenure security (Thorpe 2000).[17] After more than three decades of heavy government intervention in support of land distribution and rural credit provision (Salgado et al. 1994), a number of land market liberalization initiatives were introduced (see Box 2.1 on land issues in Honduras). In addition, rural interest rates were liberalized in an effort to stimulate commercial bank lending. Also, direct support measures such as consumer subsidies on staple foods (which had a regressive effect because they mostly benefited already better-off urban dwellers) and guaranteed producer prices were gradually abolished, culminating in the elimination of the former Institute of Agricultural Marketing. For a short period of time, agricultural credit was subsidized, but classic problems such as poor targeting, high default rates, and the lack of a sustainable institutional framework led to the abolishment of these

[15] Even direct taxes are mostly paid by middle-income groups, with the highest income groups hardly paying any tax at all or even being net recipients of government funds in the form of export bonuses and other subsidies.

[16] The government extension system, which never reached more than 10 percent of all farmers (Díaz and Cruz 1993), was privatized in 1992 when DICTA (Science and Technology Directorate for the Agricultural Sector) was created. The Fund for Technical Assistance to Hillside Farmers (*Fondo para Productores de Ladera*), established by the World Bank in the year 2000, is the only current source of technical assistance for hillside farmers, but coverage is limited to about 6,000 households in the provinces of Yoro, Olancho, and Francisco Morazán (Hanson, Just, and Lainez 2003).

[17] Increased tenure security was to be achieved through strengthening individual property rights to land, extending titling efforts including the privatization of cooperative lands, activating land rental markets and private credit markets, and removing government from all direct land redistribution efforts that did not involve market mechanisms. Inequality of land ownership as well as of land operated in Honduras increased between 1994 and 2001 (Barham, Boucher, and Useche 2002), though not necessarily as a result of the Agricultural Modernization Law.

Box 2.1 Land Issues in Honduras

In Honduras, lack of access to land (which affects as many as 250,000 rural households) and insecurity of land tenure are widely regarded as critical constraints to asset creation and poverty reduction, as well as a major source of social instability (Government of Honduras 2001). Despite past attempts to transfer significant areas of underutilized private and public land with agricultural potential to *minifundistas* (households with less than 1 hectare of land) and rural landless households, Honduras continues to have a highly skewed land distribution. About 70 percent of landholdings account for about 10 percent of land in farms; and a little over 1 percent of farmers own 25 percent of the land. Of the 465,000 households registered in the 1993 Agricultural Census, 97 percent held less than 50 hectares of land, 80 percent of them held less than 5 hectares of land, and 27 percent held no land at all (Barham, Boucher, and Useche 2002). Tenure security is closely related to landholding size and insecurity of land tenure affects especially smallholders: whereas only 42 percent of all farms below 5 hectares have secure tenure, this percentage is 76 percent for farms > 50 ha (SAG 2002). In addition, there is evidence that the necessary complementary reforms in the credit and other input markets are not forthcoming to a sufficient degree, thus preventing the poor from taking advantage of land market reforms (Barham, Boucher, and Useche 2002).

programs. Distortions in the markets for traditional export commodities (e.g., taxes on coffee and banana exports) were (partially) corrected, while the focus on agricultural policies shifted from a focus on food security (i.e., basic grains crops) and traditional exports to the production of high-value nontraditional export crops.

Along with the above macroeconomic and sector reforms, a process of decentralization began in the early 1990s. The decentralization process not only transferred significant budgetary authority to municipal governments, but also shifted some responsibility for forest areas owned by the government and protection of natural resources in general to municipalities.[18] The government also gave up its monopoly in timber exports. However, the implementation of the decentralization process has been slow and reforms in the forestry sectors are far from being completed.

The remaining forest areas of Honduras are estimated at almost 6 million ha, or about half of the total size of the country. According to SAG (2004) about 100,000 ha of broadleaf forest are converted each year into new agricultural land (mostly in the province of Colón), and conversion of pine forest is continuing as well (deforestation in the western and southern regions of Honduras has long taken place; now it is occurring mostly in the province of Olancho). Addressing deforestation and encouraging sustainable development in the forestry sector are identified as priority areas in the PRSP, particularly after Hurricane Mitch showed that deforestation and lack of appropriate soil conservation practices increase vulnerability to environmental damage from major storms. Efforts to promote agroforestry, improved soil conservation, and specialized forestry operations have been hampered by the conflictive situation around

[18] The Government of Honduras has allowed counties (*municipios*) to regain control over about 30 percent of the country's forests, which belonged to them but had been managed by the central government.

Table 2.1 Shares in GDP and growth rate by economic sector, 1983–2003

	GDP shares (%)			Annual growth rates (%)	
	1983	1993	2003	1983–93	1993–2003
Agriculture	21.2	20.6	13.5	3.8	2.2
Industry	25.3	30.1	30.7	3.9	3.2
Services	53.5	49.3	55.8	3.4	3.6

Source: www.worldbank.org/data/countrydata/aag/hnd_aag.pdf.

forest land tenure and usufruct in the public forest lands, an obsolete centralized institutional framework, a legal framework that is both dispersed and contradictory, and a lack of policies and instruments to increase private and community investment in sustainable forestry activities. Efforts to address these weaknesses via a new forestry law have been impeded by strong and competing political, economic, and social interests.

Trends in the Agricultural Sector

It was expected that macroeconomic reforms, especially those addressing protection of the manufacturing sector and an overvalued exchange rate, would increase competitiveness of the agricultural sector vis-à-vis the nonagricultural sectors and result in higher incomes and lower rural poverty. Unfortunately, this has not been the case. Growth in the agricultural sector lagged behind other sectors throughout the 1990s (see Table 2.1), and prices for most agricultural products declined, along with agricultural incomes and wages. Between 1995 and 2000, value-added in the crop sector grew at an average annual rate of only 0.3 percent (0.6 percent for the agricultural sector as a whole), with large differences in individual crop performance (Table 2.2).

Tables 2.3 and 2.4 present data on crop productivity and cultivated area, respectively, based on information from the various agricultural censuses held in 1952, 1974, and

Table 2.2 Annual percentage growth in real value-added of production, 1980–2002

Category	1980–85	1985–90	1990–95	1995–2000	2000–02
Crop sector	1.3	3.8	3.2	0.3	–0.3
Maize	5.0	5.7	3.8	–5.4	–0.5
Beans	1.8	4.0	1.4	1.3	–6.5
Sorghum	–6.2	13.4	–1.4	–1.5	–8.0
Rice	3.1	4.0	–2.5	–27.5	0.0
Coffee	1.3	3.8	3.2	0.3	–2.5
Banana	–0.4	–1.8	–5.6	–9.9	6.1
Sugarcane	0.5	–0.5	1.0	3.7	0.8
Cotton	–22.9	–7.8	n.a.	n.a.	n.a.
Oil palm	30.8	1.7	7.0	9.5	7.5
Forestry	–0.2	0.9	1.8	0.2	3.5
Livestock	3.6	1.4	3.3	–1.8	2.1
Aquaculture	5.7	9.4	7.7	0.9	n.a.
Total agriculture sector	**1.9**	**3.5**	**3.7**	**0.6**	**2.6**

Source: Based on data in Cotty et al. (2001) and ECLAC (2004).
Note: n.a. indicates not available.

Table 2.3 Yield of principal crops

Category	1952[a]	1974[a]	1993[a]	2000[b]	2002[c]	1952–74	1974–93
			Yield (t/ha)			Growth rate (%/yr)	
Basic grains	0.8	1.0	1.2	1.0	1.0	1.2	0.8
Coffee	0.2	0.4	0.7	0.8	1.0	3.2	3.0
Banana	15.3	43.3	43.4	8.0[d]	16.9	4.8	0.0
Sugarcane		33.7	67.6	72.4[e]	72.1		3.7
Pineapple		9.7	36.3	25.9[e]	32.3		7.2
Plantain		6.8	11.8	13.3[e]			2.9

[a]Source: Data from agricultural censuses as reported in Walker and Pino (2002).
[b]Source: Cotty et al. (2001).
[c]Estimates from ECLAC (2004).
[d]Based on sown area as reported in Cotty et al. (2001); harvested area is much less (effect of Hurricane Mitch) though unknown.
[e]Source: based on 1998–99 data in SAG (2002).

1993 as well as some recent data from ECLAC. In contrast to low productivity growth in basic grains, there have been increases in productivity of some export commodity crops (see Table 2.3). Total cropped area expanded by an average of about 1 percent per year during the past 40 years. The largest expansion of land area was for coffee, increasing from 68,000 ha in 1952 to 211,000 ha in 2000 (Table 2.4). Much of the expansion in coffee production was by small producers in hillside areas responding to favorable prices, the lack of profitable alternatives, and government support. After 2000, coffee area started declining in response to the coffee crisis.[19] During the 1990s, production of cotton virtually disappeared but production of sugar and oil palm increased considerably.

Another way of analyzing structural change in the agricultural sector is by looking at changes in the composition of value added (Table 2.5). Crop production has dominated the agricultural sector since the 1980s, accounting for about two thirds of gross value-added. The shares of forestry and livestock have decreased over time but poultry and fishery products both gained importance.

Agricultural exports account for a major share of total exports, although this share declined from about 75 percent during the 1980s to less than 50 percent since the mid-1990s (Table 2.6). Coffee exports alone have historically accounted for more than 25 percent of total exports (Varangis et al. 2003).

A major factor influencing the growth prospects of Honduras's agricultural sector is its terms of trade. Since the 1980s, the terms of trade for most agricultural products have declined with respect to other countries and other sectors within Honduras (Table 2.7). The export potential of Honduras' agricultural sector depends on the competitiveness of the main agricultural export commodities, which can be measured by the ratio of their foreign to domestic prices (Table 2.8). This ratio shows a declining trend for several of Honduras' major agricultural export commodities (including

[19]After 2000, the declining trend in the world market price of coffee has continued with lows of US$45 per bag (100 pounds) in 2001–02. In 2000–01 Honduras earned US$345 million from coffee but this figure had dropped to US$167 million a year later. Despite expectations to the contrary (IADB, USAID, and World Bank 2002), the coffee price bounced back and reached a level of more than US$100 per bag in 2004.

Table 2.4 Area of principal crops, 1952–2002

Category	1952[a]	1974[a]	1993[a]	2000[b]	2002[c]	1952–74	1974–93
			Area ('000 ha)			Growth rate (%/yr)	
Basic grains	343	387	456	492	573	0.6	0.9
Maize	219	258	292	345	369	0.7	0.6
Beans	50	62	85	76	140	1.0	1.7
Others	73	66	78	71	64	–0.4	0.9
Permanent crops	99	158	226			2.1	1.9
Coffee	68	102	151	251	179	1.8	2.1
Banana	24	19	23	26	27	–1.1	1.1
Sugarcane	0	26	33	56	68		1.2

[a]Harvested area according to information from the various agricultural censuses as reported in Walker and Pino (2002).
[b]Based on ECLAC (2004).
[c]Estimates from ECLAC (2004).

banana, coffee, sugar, and beef), demonstrating that Honduras finds it difficult to remain competitive in these commodities.

The importance of nontraditional agricultural exports increased dramatically during the past decade. Despite their increase from US$87 million in 1990 to US$248 million in 2000, nontraditional export crops have not been able to compensate for large losses in revenues caused by the declines

Table 2.5 Percentage composition of gross value-added in the agricultural sector

Category	1980	1985	1990	1995	2000	2002
Crop sector	65	66	66	65	66	63
Agricultural services	2	2	3	3	3	3
Forestry	13	11	9	8	8	8
Livestock	13	13	13	13	10	10
Poultry	3	3	4	6	8	9
Fisheries	3	4	4	4	5	7
Total	100	100	100	100	100	100

Source: Own calculations based on SAG (2002) for 1980 and 1985, and ECLAC (2004).

Table 2.6 Agricultural share of exports and agricultural balance of trade

	1979–81	1989–91	1998	1999	2000	2001
Total exports (10^6 US$)	789	831	1,533	1,164	1,370	1,311
Agricultural exports (10^6 US$)	588	627	742	440	379	645
Share of agricultural exports in total exports (%)	75	75	48	38	28	49
Agricultural imports (10^6 US$)	146	111	314	431	400	413
Balance of agricultural trade (10^6 US$)	442	516	428	9	–21	232

Source: FAOSTAT database.

Table 2.7 Intersectoral terms of trade of principal crops (1978 = 100)

Category	1980	1985	1990	1995	2000
Crop sector	83	77	70	75	50
Coffee	64	65	30	73	34
Banana	98	84	135	93	109
Maize	81	75	90	85	57
Sugarcane	114	106	73	83	102
Oil palm	102	70	55	92	62
Beans	91	82	134	48	47
Plantain	98	115	104	125	176
Sorghum	90	72	60	51	39
Cotton	90	38	98	n.a.	53
Rice	89	78	106	31	18
Other crops	79	68	54	46	48

Source: Data from the Central Bank of Honduras reported in Walker and Pino (2002).

in coffee and banana exports (Figure 2.1). The most important nontraditional export products include palm oil, melon, pineapple, vegetables, and fishery products. It is estimated that the nontraditional agricultural sector generates at least 100,000 jobs (RUTA 1998).

In contrast to the slow growth of agriculture and its declining share of GDP and exports, major increases have taken place in the economic importance of *maquilas* and remittances. Remittances from abroad during 2002–04 averaged about US$800 million, or more than 10 percent of total GDP (Cáceres 2003; IADB 2003; World Bank 2003). Remittances continue to show strong increases and are now the largest source of foreign exchange. Revenues generated by *maquilas* are about US$600 million per year but may well decrease in the future when the worldwide multilateral textile agreement will expire and China is widely expected to take some of Honduras' export markets.

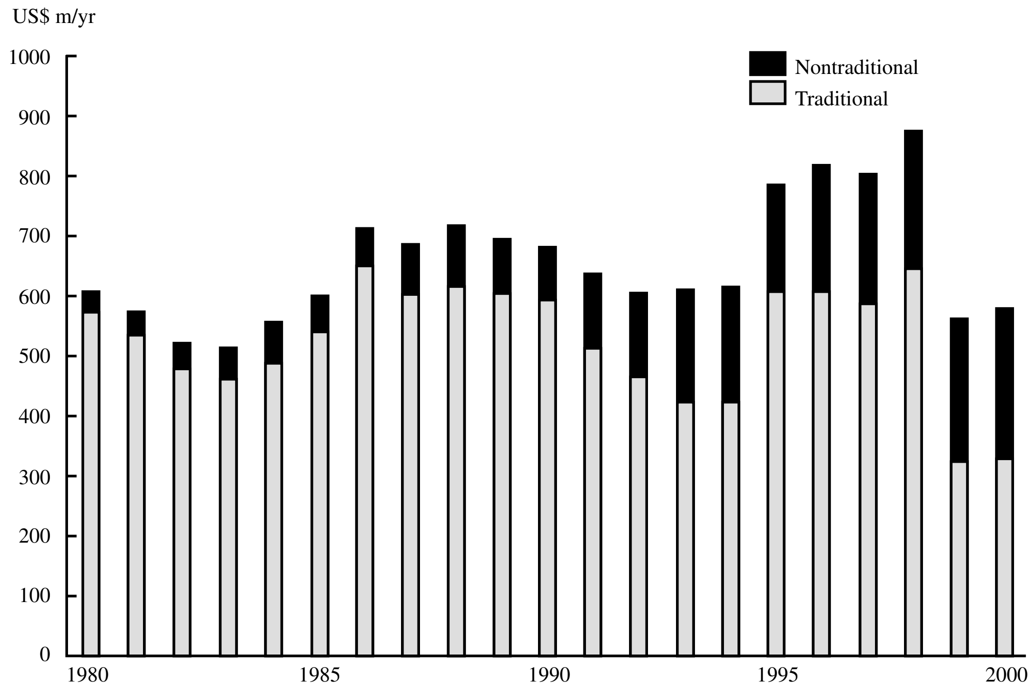
The structural changes in the agricultural sector described in the preceding text, together with low prices of coffee and basic grains, appreciation of the real exchange rate, and the lowering of import duties, have had

Table 2.8 Changes in the ratio of foreign and domestic prices for major agricultural export commodities between 1990 and 1999 (1990 = 100)

Product	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sugar	88.4	86.2	97.3	114.8	101.9	97.7	90.1	80.0	79.1
Banana	93.9	69.8	73.0	72.2	67.6	78.2	64.0	56.4	48.0
Coffee	93.7	68.2	69.7	118.0	162.6	119.1	153.7	135.7	90.0
Wood	107.8	98.7	135.6	158.5	137.8	150.0	146.1	116.8	119.3
Melon	170.8	133.2	169.6	180.2	200.0	210.3	198.7	180.4	179.9
Pineapple	86.0	136.3	143.6	152.6	136.1	142.6	134.7	122.1	118.6
Tobacco	83.2	98.5	106.6	114.8	102.1	101.4	121.7	117.0	98.5
Shrimp	102.5	96.5	125.8	157.7	141.9	140.7	139.7	118.9	115.5
Beef	97.2	95.7	105.7	114.7	90.6	77.6	76.9	76.7	63.3

Source: PEP (2000).

Figure 2.1 Level and composition of agricultural exports, 1980–2000



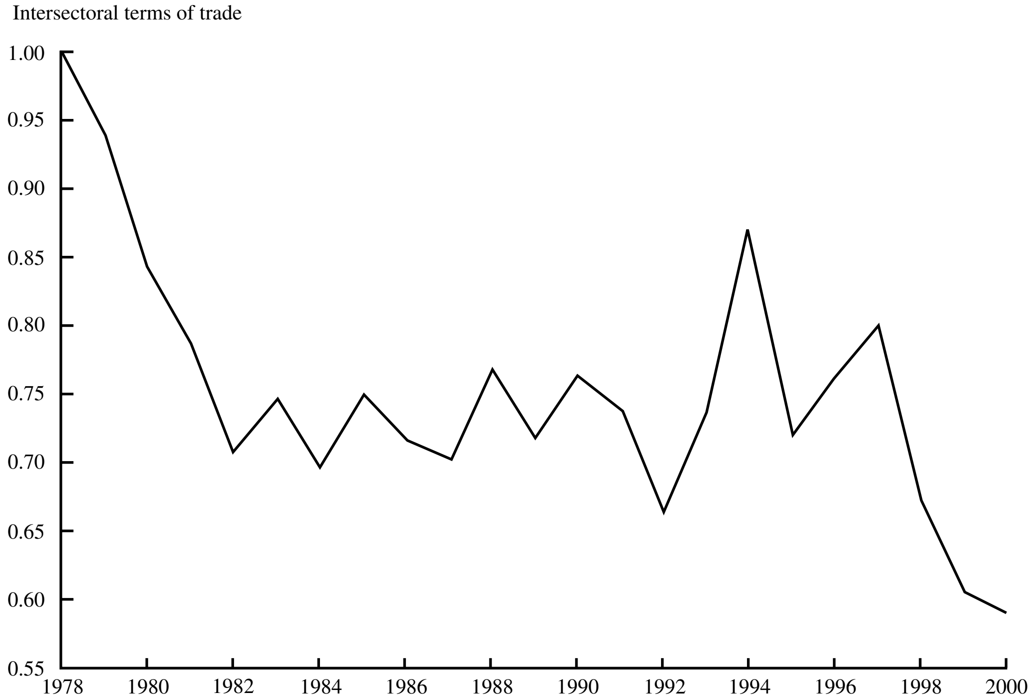
Source: Data in Table E7 in Cotty et al. (2001).

a clear negative impact on the profitability of agriculture. This is reflected in a strong decrease in the intersectoral terms of trade of the agricultural sector relative to the nonagricultural sectors (Figure 2.2). The negative pressure on the profitability of the sector began as far back as the early 1980s but became particularly severe after 1995. Appreciation of the exchange rate[20] was caused mainly by the surge in *maquila* operations, increasing remittances from abroad, and large inflows of aid capital after Hurricane Mitch. The restructuring of the agricultural sector has thus failed to prevent a decrease of nearly 50 percent in its intersectoral terms of trade over the past two decades. Within the agricultural sector all subsectors (with the exceptions of sugarcane and oil palm) have lost a substantial part of their purchasing power (see Table 2.9). Small farmers, whose often already poor livelihoods rely to a substantial extent on basic grains production, lost about one third of their purchasing power over the past 20-some years (Jansen et al. 2002). Nevertheless and in spite of low market values for basic grains, many small farmers' primary goal is still to produce food.

The decreasing terms of trade for the agricultural sector as a whole and the loss in purchasing power of virtually all subsectors have had a strong negative impact on the welfare of the rural population in general and most likely led to an increase in the absolute number of rural poor. Figure 2.3 shows the time trends regarding real purchasing power of the rural population, in Lempiras (Lps) per person per year using the consumer price index as the deflator.

[20] Real exchange rate appreciation was about 50 percent between 1990 and 2001 (28 percent between 1997 and 2001 alone) after which a slight depreciation set in of about 8 percent in total until 2004.

Figure 2.2 Terms of trade of the agricultural sector, 1978–2000



Source: Based on data in Table A11 in Cotty et al. (2001).

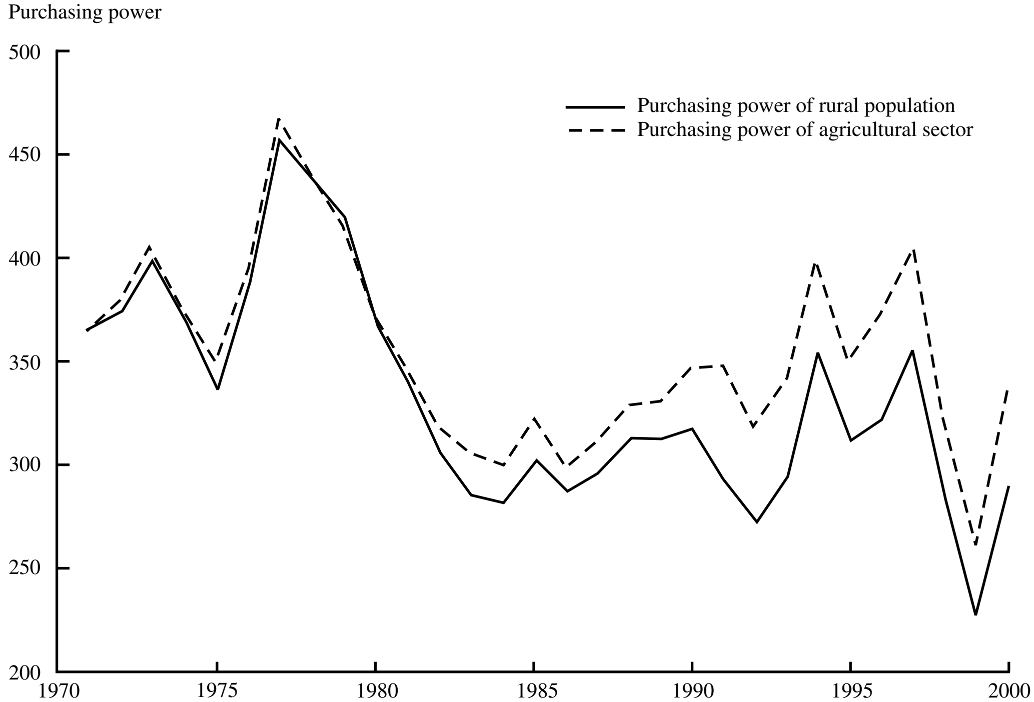
Figure 2.3 also displays the trend in purchasing power of the agricultural sector, again in Lps per person per year but this time using the price index for nonagricultural goods as the deflator. Both trends closely follow each other, showing a rise in the mid-1970s, a collapse in the late 1970s, and early 1980s, slow recovery during the late 1980s and early 1990s, and another collapse in the late 1990s. It thus seems that the following

Table 2.9 Change in purchasing power by agricultural subsector, 1978–2000

Category (1)	Crop production ('000 mt) 1978 (2)	2000 (3)	Percentage change in production, 1978–2000 (4)	Intersectoral terms of trade, 2000 (1978 = 100) (5)	Percentage change in purchasing power, 1978–2000[a] (6)
Coffee	66.7	163.2	+145	34	–17
Banana	950.0	180.2	–81	109	–79
Maize	378.3	445.0	+18	57	–33
Sugarcane	2,101.5	3,888.2	+85	102	+89
Oil palm	61.9	783.6	+1,166	62	+685
Beans	34.2	56.2	+64	47	–23
Plantain	91.8	46.3	–50	176	–12
Sorghum	39.5	57.9	+ 47	39	–43
Cotton	21.1	1.2	–94	53	–97
Rice	29.6	6.7	–77	18	–96

Sources: (2) and (3): Cotty et al. (2001); (5): Walker and Pino (2002); (4) and (6): own calculations.
[a](6) = [((4) + 100) × (5)/100] – 100.

Figure 2.3 Purchasing power of the rural population and the agricultural sector, 1971–2000 (Lps of 1978 per capita per year)



Source: Based on data in Table A15 in Cotty et al. (2001).

conclusion of Barham, Carter, and Deininger (2002) is indeed confirmed: "the liberalized agrarian economy of Honduras shows little sign of operating in the pro-poor fashion that some have hypothesized."

Finally, the CAFTA agreements will undoubtedly have an impact on agricultural production patterns and trade. While there seems to exist a general consensus that CAFTA represents an opportunity and may have a positive influence on overall economic growth, capitalizing on this opportunity in terms of achieving equitable growth will require significant economic, political, institutional, and social reform. CAFTA is likely to lead to increased direct foreign investment and better export performance of certain sectors, but agricultural production for the domestic market could suffer as a result of increased competition from the United States, with possible negative consequences for income and employment opportunities of the rural poor. In this light, the onset of CAFTA in April 2006 for Honduras makes even more urgent the transformation and economic diversification of the rural areas in the country.

This chapter has shown that past macro and sector policies have failed to bring sustainable economic growth to the rural areas of Honduras where particularly the hillside areas continue to suffer from deep and widespread poverty and degradation of the natural resource base. Improved policies and more effective investment programs require a better understanding regarding the main factors that drive poverty alleviation, economic growth, and sustainable land use. These relationships appear to be complex, and addressing them is a major methodological challenge that we will take up in the next chapter.

CHAPTER 3

Methods and Models

In this chapter we first present our main research questions and hypotheses. This is followed by an explanation of our conceptual framework and methods for determining livelihood strategies. We proceed with the development of our empirical model and hypotheses regarding the relationships between livelihood strategy choice, income generation, adoption of land management technologies, and crop productivity. The chapter concludes with a brief description of our sampling frame and survey methods.

Research Questions and Hypotheses

The main research questions addressed in this report are the following:

1. What are the dominant livelihood strategies in the rural hillside areas of Honduras?
2. Which types of assets are critical for which livelihood strategies?
3. How do livelihood strategies and asset endowments influence household income, land management practices, labor use, external input use, and crop productivity?
4. How can government policies influence the adoption of sustainable land management practices?
5. On what types of assets should public investments concentrate, and to which types of households should they be targeted, in order to have maximum impact on income (poverty reduction)?

Following these research questions, we define a number of premises, for which we develop an analytical framework based on a quantification of the livelihoods concept. The first major general premise of this report is that besides by low potential, low productivity in hillside areas is caused by poor policies and inadequate public investment, leaving their inhabitants with insufficient access to key markets and assets such as land, financial services, support services, basic infrastructure, and social services (particularly health and education). Our second premise is that significant increases in public investment allocation to increase the asset base of people living in the hillside areas is a necessary means to mitigate rural poverty in these areas. Further, investment strategies must be appropriately targeted to maximize both their efficiency and impact. Based on these premises we formulate the following specific hypotheses:

1. Rural households can be classified into clusters that represent different livelihood strategies based on the use of their two primary assets—labor and land. In particular, households can be usefully grouped on the basis of (a) their time allocation to different activities such as annual crops, permanent crops, livestock, and off-farm work and (b) households' land-use patterns.
2. The household's livelihood strategy choice can be adequately explained by its endowments of natural and human capital (or assets), and geographic determinants of compar-

ative advantage. Natural capital defines agricultural potential as influenced by local climate, soil quality, and topography, which together determine absolute advantage. Land is also considered part of the household's natural capital. Human capital (which includes size and composition of the household and education of its members) and certain geographic determinants that might be considered as part of the household's vulnerability context further determine comparative advantage.

3. Besides the criterion of type of livelihood strategy, household income is further determined by its asset base in a broad sense, including not only natural and human capital but also physical assets, geographic determinants of comparative advantage, and social capital (measured by the household's participation in programs and organizations).
4. The use of inputs and conservation practices in agricultural production is influenced by the same set of factors that determine household income plus parcel-specific characteristics.
5. Total output value of the farm is determined by the use of inputs and conservation practices plus the factors that determine both of the latter.

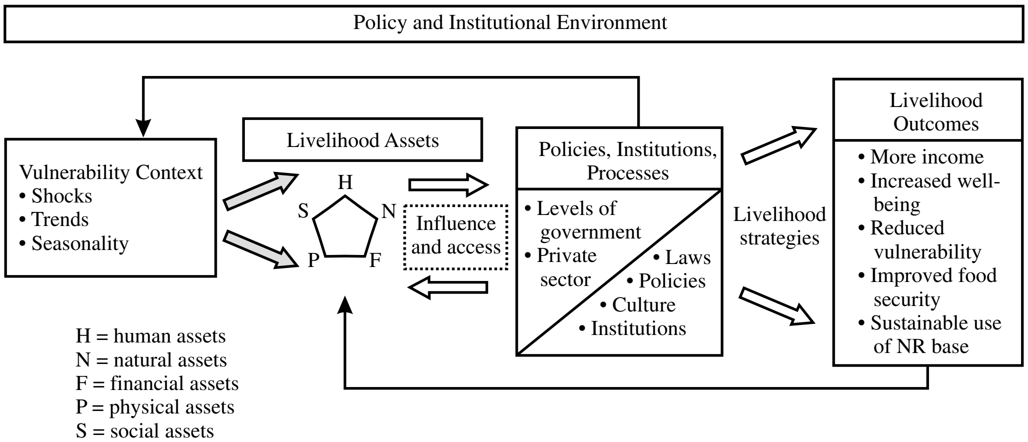
Definition of Livelihood Strategies

Based on the sustainable livelihoods framework discussed by Chambers and Conway (1992), Ellis (1998), Carney et al. (1999), and Adato and Meinzen-Dick (2002), we define livelihood strategies as the choices that people make in pursuit of income, security, well-being, and other productive and reproductive goals.[21] These choices are reflected in the way that people use their assets and as such are an important part of household behavior, while determining well-being. The concept of livelihood strategies has developed through many years of thought and study on how rural households construct their lives and income earning activities, the importance of the institutional structures that surround these households, and their resulting poverty levels. The limitations of traditional poverty indicators such as expenditures, caloric intake, and so forth have become increasingly apparent. Therefore, more attention is being paid, by policymakers, researchers, and other development practitioners, to the diverse portfolio of activities that poor households engage in, as a means to develop and engage in creative poverty reduction strategies that recognize the diversity of these activities. By recognizing this portfolio of activities and assets, policymakers can better target points of vulnerability in poor households and understand how policy and institutional interventions can effectively reduce poverty at the household level.

Clustering households into a limited number of categories that pursue similar livelihood strategies may thus be useful to policymakers by enabling them to target their policies better toward households with certain common characteristics, in this way increasing the efficiency of policy measures and other incentive structures (de Janvry and Sadoulet 2000). In addition, a clear delineation of dominant rural livelihood strategies would help in directing technology transfer programs toward their intended beneficiaries. The alternative to clustering is using

[21]Given the cross-sectional nature of our database, our definition of "sustainable" livelihood strategies (which in our case are largely agriculture based) are those that generate agricultural output with no or minimal degradation of the natural resources base, that is, using so-called sustainable production technologies. A wider definition of sustainable livelihood strategies would include those that provide a sufficiently high and stable income stream allowing for investing in/building up the household's asset base. However, operationalization of such a wider strategy would require a combination of cross-sectional and time-series data.

Figure 3.1 Sustainable livelihoods framework



Source: Adapted from DFID (1999) and Adato and Meinzen-Dick (2002).

continuous measures of asset types, but this does not allow an improvement in the effectiveness of policies through better targeting.

Conceptual Framework for Livelihood Strategies

Implementing the livelihood strategy framework requires an interdisciplinary approach to poverty research that combines both quantitative and qualitative methods. The sustainable livelihoods conceptual framework, represented in Figure 3.1, is a dynamic tool that aims to combine and capture interactions between households, assets, and their surrounding institutional environment.

The asset portfolio, represented by the pentagon in Figure 3.1, is a key component to understanding a household's livelihood strategy. Our initial focus is on the conceptualization and quantification of the household's asset portfolio as an input into the explanation of a household's livelihood strategy. The focus on assets is appropriate given the historically stark inequalities in asset distribution in Honduras (see also the first section in Chapter 4). However, rather than following the sustainable livelihoods framework religiously, we interpret and extend the framework in a number of ways in order to serve the purposes of our analysis. We extend the traditional five asset categories by adding a sixth category that we label "geographic determinants of comparative advantage." This new asset category reflects the household's economic environment, largely in terms of access to markets and public services but also in terms of its vulnerability context.[22] Geographic determinants of comparative advantage play a major role in defining transaction costs faced by the household and influence economic opportunities for both agricultural commodities and off-farm work. They therefore are hypothesized to play an important role in the household's livelihood choice. Together these six asset categories form the household's asset portfolio and define some of its vulnerability context as well.

The sustainable livelihoods framework uses rather broad definitions of each of its five different types of assets (or capital).

[22]Geographic determinants of comparative advantage assume particular relevance in rural Honduras, as besides the capital of Tegucigalpa and the industrial center of San Pedro Sula, Honduras has only four other population centers with more than 100,000 inhabitants. As a result, access to urban markets and services is limited for most of the interior hillside areas.

Natural capital reflects the household's endowment of natural resources and includes land, water, forests, marine resources, air quality, erosion protection, and biodiversity. Human capital reflects the stock of human skills and knowledge in the household and includes education, skills, knowledge, health, nutrition, and labor power. Physical capital includes transportation, buildings, shelter, water supply and sanitation, energy, technology, and communications. Roads are also often included but because they are hardly influenced by household decisionmaking, we treat roads as one element of our geographic determinants of comparative advantage. On the other hand, we include livestock as part of physical capital, the main justification being that a household's ownership of livestock is likely to influence the productivity of both its land and labor resources, just as machinery, equipment, and transportation do.[23] Financial capital includes savings, credit, and transfers and remittances. Finally, social capital is embodied in human relationships and includes any networks that increase trust, ability for cooperation, access to opportunities, informal safety nets, and membership in organizations.

Given the available information in our household data set and secondary data sources, we necessarily adapt and narrow these broad asset definitions and use the following working definitions of each type of asset (or capital):

- *Natural capital* is represented by the amount of land (farm size), climate as defined by rainfall and temperature (approximated by altitude), soil water deficits, quality of the land (as defined by soil fertility and slope), land tenure, and conservation investments.
- *Human capital* is represented by the size and composition of the household, with the latter determining the dependency ratio and, together with farm size, the land/labor ratio; level of formal education of its members, age and sex of the household head, percentage of female adults, migrated household members, and ethnicity. We did not collect data on human health.
- *Physical capital* includes non-land physical assets including machinery, equipment, and transportation assets and livestock.
- *Financial capital* includes transfers (remittances and other cash transfers), credit, and savings.
- *Social capital* includes membership in various types of organizations and programs including training and extension programs, producer organizations,

[23] In DFID's sustainable livelihoods guidance sheets (www.livelihoods.org/info/guidance_sheets_pdfs/), livestock is not mentioned under any of the types of capital, possibly reflecting some uncertainty as to how to classify livestock. According to the Oxford Advanced Learner's Dictionary of Current English (Hornby 1974), capital is "wealth/money/property that may be used for the production of more wealth." Livestock clearly fit this definition because they are durable assets used as a store of wealth and to generate income and capital gains. The concept of livestock as a stock of capital is distinct from the flow of goods and services that can be provided by livestock, such as draught power, manure, milk, eggs, meat, hides, and so forth, and should not be confused with production or sales of livestock products and services (just as the goods and services produced by equipment are distinct from the equipment itself). Although some authors see livestock as part of natural capital (e.g., Quisumbing and Meinzen-Dick 2001), we do not see any compelling reasons for this classification. Livestock are living beings, but this does not seem to justify classifying them as natural capital (human beings are also living beings, but they and their capabilities are classified under human capital). Livestock seem more appropriately classified as physical capital, which is capital produced and reproduced by people for productive purposes. Although natural capital such as land also has productive purposes, for the most part it is not produced and does not exist mainly for the purpose of contributing to agricultural income (with some exceptions), as do livestock and farm equipment. Livestock also commonly serve a role as a form of savings, so one could also argue that they should be classified as financial capital. These issues point out some of the lack of clarity in the definitions of the concepts used in the traditional sustainable livelihoods framework.

financial organizations, and nongovernmental organization (NGO) projects.
- *Geographic determinants of comparative advantage* include population density, road density, distance to markets, and access to public services.

Our ability to quantify the livelihoods framework faces limitations. Given our available cross-sectional data sets, we are unable to address fully the effects of institutional and policy processes, which are dynamic in nature and a critical part of the livelihoods framework. We are also limited in our ability to address issues related to social capital (assets embodied in social relationships), although we address aspects of this by considering households' participation in programs and organizations. Despite these shortcomings, we believe that our effort to quantify some of the relationships in the livelihoods framework is an important contribution to the literature, and can help to guide policy decisions concerning where and how to target programs and public investments to promote more sustainable and productive land management and poverty reduction.

The literature contains a number of attempts aimed at categorizing households into different groups that represent livelihood strategies. Birch-Thomsen, Frederiksen, and Sano (2001) used indices to weigh the importance of different sources of household income. Different types of income were allocated points based on their source, such as income from natural resources, business, rents, and so on. Groups were then formed based on the frequency distribution of income sources. Lambin (2003), in a study on land cover changes in a protected area in Kenya, used clustering techniques to group farmers on the basis of their physical capital as expressed in their land use. Adato and Meinzen-Dick (2002) implemented the livelihoods framework in five case studies using qualitative methods to assess the impact of agricultural technology and research on people's lives. Barrett, Reardon, and Webb (2001) maintain that studies focused on livelihoods should use a diversity of indicators to assess sources of income and income-earning strategies and argue that assets, activities, or income all have limitations and therefore should be used in combination. Rakodi (1999) favors a conceptualization of household strategies as managing portfolios of different types of assets for the identification of relevant policy recommendations.

Given the debate in the literature regarding appropriate methods to implement the livelihood strategy framework, we considered several methods for clustering households based on previous work done in this area, and the information available from our survey and secondary data. Use of income shares (as in Birch-Thomsen, Frederiksen, and Sano 2001) was considered as a means to conceptualize livelihood strategies. However, unless income composition is available over time, using income shares from survey data presents several specific problems when attempting to define a farm household's livelihood strategy. Not only is a household's income for a single year an outcome of a household's use of assets, but it may also be influenced by random events such as weather conditions, which often are particularly variable in hillside areas. For example, a household may have a low share of income from cereal production in a particular year, not because cereal production is unimportant to the household's livelihood strategy but because of a drought, pest damage, price decline, or some other adverse external event. Further, a household's income in a particular year may in part reflect its short-term coping mechanism rather than a long-term livelihood strategy.

In view of the above, we decided to base our definition of livelihood strategy on household decisions concerning allocation of productive endowments (labor and land) rather than outcomes. That is, we used the time allocation of a household on different types of productive activities, and the household's land-use pattern for defining a household's livelihood strategy. Time allocation and land use largely reflect the way in which the household puts its main assets (labor and land) to use. Farm households with similar time allocation and land-use patterns were grouped together using factor analysis and cluster analysis methods explained in the next section. Once we obtained the household groups, each of which represents a distinct livelihood strategy, we named each of the clusters through a careful analysis of average time allocation, land-use patterns, and income shares of households in each of these clusters.

Methods for Determining Livelihood Strategies

To lay the foundations for the factor analysis, we captured each household's (1) pattern of time allocation in terms of the proportion of time spent by its members on agricultural work on the own farm, off-farm agricultural work (working on other people's farms), and off-farm nonagricultural work; (2) proportion of total agricultural work spent on the following six categories: basic grains, other annual crops (e.g., vegetables), coffee, other permanent crops (e.g., plantain, fruit trees), livestock activities, and off-farm agricultural work; and (3) land-use patterns in terms of the proportions of the farm used for basic grains, other annual crops, coffee, other permanent crops, pastures, and forest plus fallow. Factor analysis is a data reduction method that looks for linear combinations within the correlation matrix for the labor- and land-related variables specified previously that we hypothesize are closely linked to households' livelihood strategies. Basically it tries to represent these variables with a smaller set of "derived" variables, or "common factors." We used the principal factor (pf) method in STATA to analyze the correlation matrix of the variables. The common factors are computed using the squared multiple correlations as estimates of communality.

The rotated factor loadings from the factor analysis served as input into a cluster analysis. Cluster analysis categorizes and assigns each household to previously undefined groups or clusters. Cluster analysis is a technique used to identify meaningful, mutually exclusive subgroups of observations from a larger aggregate group of observations (Hair et al. 1998). A cluster analysis preceded by factor analysis usually results in a much more clear-cut delineation of clusters than a stand-alone cluster analysis and is less subject to arbitrary scale effects that influence cluster analysis on directly measured variables. Based on the results of the factor analysis, the cluster analysis methodology explained below was used to determine both the number and composition of the clusters present in the sample.

The first step in the cluster analysis process is an agglomerative hierarchical clustering to inspect the number of natural groups or clusters that exist in the data.[24] A dendogram, based on the hierarchical clustering procedure, was drawn to visually inspect groups within the data. The dendogram indicated the presence of seven primary groups or clusters.[25]

Using results from the hierarchical cluster analysis, *k*-means cluster analysis, a nonhierarchical clustering method, was implemented. Agglomerative hierarchical cluster analysis, used in the first step, efficiently groups households together and helps to

[24] ClustanGraphics, computer software specifically designed for cluster analysis, was used to implement all cluster analysis procedures (ClustanGraphics 2002).

[25] Increase in sum of squares was used in the hierarchical cluster procedure. Increase in sum of squares assumes that cases can be represented by points in Euclidean space and uses a proximity matrix of squared Euclidean distances to determine the similarity between two observations or two clusters. For more technical details, see Wishart (1999).

decide the number of clusters to consider. However, hierarchical clustering can give rise to misclassification of observations at the boundaries between clusters (Wishart 1999). Using *k*-means analysis corrects for this problem. The *k*-means cluster analysis is an iterative process that allows for starting points and their means to be set at the beginning of the process. We used the number of clusters and the means of each factor in these clusters as starting centers for the *k*-means analysis. Observations were then assigned to groups that they are "closest" to. Based on the addition of each subsequent observation, cluster centers were recalculated and progressively calibrated through successive iterations. This process was repeated until all observations were assigned across groups.

Empirical Model

Rural people and policymakers are most interested in what drives outcome variables such as agricultural production, household income, and resource conditions. Once we have clustered the household sample into livelihood strategy groups, the household's livelihood choice can be explained based on a set of predetermined asset-based variables that include natural and human capital and geographic determinants of comparative advantage. Livelihood strategies are an important part of a wider set of explanatory asset-based variables that determines household income and besides exogenous asset-based variables also include physical, financial, and social capital. In this way a household's asset holdings has both a direct and indirect (via their impact on the livelihood strategy choice) influence on income. Of the wider set of asset-based variables, we consider social capital assets (measured by the household's participation in programs and organizations) as endogenous and influenced by the same factors determining the household's livelihood strategy. Resource conditions are linked to land management decisions which are influenced by the same set of variables as household income plus other variables that reflect field-specific characteristics. Finally, agricultural production can be explained by the same set of variables as land management decisions, the use of labor and external inputs, and land management decisions themselves. Labor and external input use, in turn, are determined by a set of factors similar to that for land management decisions.

Based on the preceding discussion, the variables of interest for our econometric model are agricultural production; use of labor, external inputs, and land management practices; choice of livelihood strategy and participation in programs and organizations; and household income per capita. In the following subsections we summarize the empirical model for each of these variables.

Value of Crop Production

For agricultural production, we focus on the value of crop production, in order to avoid estimation of large numbers of individual production functions for single crops in different seasons. We assume that the value of production of crop type i (i indexes annuals or perennials) by household h on plot p in season t (y^i_{hpt}) is determined by the labor inputs applied to the plot (family labor, hired wage labor, piece labor) (L_{hpt}); the land management practices used (no burning, minimum or zero tillage, incorporation of crop residues, use of mulch, use of manure) (LM_{hpt}); the external inputs applied to the plot (inorganic fertilizer, herbicide, insecticide, other purchased inputs) (IN_{hpt}); the "natural capital" of the plot (NC_{hpt}) (biophysical characteristics such as size, altitude, slope, position on the slope, and inherent soil fertility, and presence of land investments such as stone walls, live barriers, and planted trees at the beginning of the period);[26] the

[26]NC_{hpt} includes rainfall since we used a GIS to "assign" rainfall data to each plot.

household's endowments of physical capital affecting agricultural productivity (e.g., land, livestock and equipment owned) (PC_{ht}); the household's endowment of human capital (education, farming experience [proxied by the age of the household head], labor endowment, dependency ratio, gender of the household head, gender mix of adults in the household) (HC_{ht}); the livelihood strategy of the household, which also reflects the household's farming and marketing experience (LS_{ht}); the household's participation in programs and organizations affecting agricultural productivity (e.g., agricultural training and extension programs, farm organizations, NGO programs) (P_{ht}); village-level factors that determine market access and factor scarcity (labeled "geographic determinants of comparative advantage") including, for example, travel time to the nearest market, road density, and population density (X_{vt}); the weather and other characteristics of the season in question (t), and random idiosyncratic factors (u_{yhpt}):

$$y^i_{hpt} = y^i(L_{hpt}, LM_{hpt}, IN_{hpt}, NC_{hpt}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, t, u_{yhpt}) \quad (1)$$

We assume that the preexisting investments on the plot and the biophysical characteristics of the plot (NC_{hpt}), the physical and human capital endowments of the household (PC_{ht}, HC_{ht}), and village-level factors (X_{vt}) are predetermined and hence exogenous to current agricultural production on the plot. Labor use (L_{hpt}), land management practices (LM_{hpt}), and external inputs (IN_{hpt}) are endogenous variables that may be affected by weather conditions or other unobserved factors also affecting production on the plot in the current season (hence possibly correlated with u_{yhpt}). Our estimation strategy (discussed later) addresses this endogeneity issue, using instrumental variable (IV) estimation. The household's livelihood strategy (LS_{ht}) and participation in programs (P_{ht}) are also endogenous household decisions, though we expect that these may be exogenous with respect to management of particular plots. We tested and found empirical support for this assumption (see discussion later).

Labor Use, External Input Use, and Land Management Practices

In equation (1), labor use, external input use, and land management practices are all choices in the current season, determined by the natural capital of the plot; the tenure status (how acquired and property rights status) and accessibility (distance to the residence and to the nearest road) (T_{hpt}) of the plot; the land use on the plot prior to the current year (LU_{hpt0});[27] the household's endowments of physical and human capital; the household's livelihood strategy; participation in programs and organizations affecting agricultural production; village-level factors determining comparative advantages, and season-specific and idiosyncratic factors:

$$L_{hpt} = L(NC_{hpt}, T_{hpt}, LU_{hpt0}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, t, u_{lhpt}) \quad (2)$$

$$IN_{hpt} = IN(NC_{hpt}, T_{hpt}, LU_{hpt0}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, t, u_{ihpt}) \quad (3)$$

$$LM_{hpt} = LM(NC_{hpt}, T_{hpt}, LU_{hpt0}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, t, u_{lmhpt}) \quad (4)$$

As in the value of production equation, the livelihood strategy and participation in programs and organizations may be endogenous in equations (2)–(4), although we expect that such household-level decisions are likely to be exogenous to plot-level management decisions. We also tested this assumption and found empirical support for it.

[27]Since equation (1) [and (5)] has separate versions for annual and perennial plots (for different values of the index i), land use is not included as an explanatory factor in either equation, as in equations (2)–(4).

The reduced form version of equation (1) is obtained by substituting equations (2)–(4) into equation (1):

$$y^i_{hpt} = y^i_{rf}(NC_{hpt}, T_{hpt}, LU_{hpt0}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, t, u_{rfhpt})$$

Livelihood Strategies

We assume that households' livelihood strategies are fairly slow to change, and are thus determined by fixed or slowly changing factors, including village-level factors affecting local comparative advantages (access to markets and roads, population density) (X_{vt}), the land owned by the household, the share titled (based on household aggregation of T_{hpt}), climate and average land quality (based on household aggregation of NC_{hpt}), and the household's human capital endowments (HC_{ht}):

$$LS_{ht} = LS(NC_{ht}, T_{ht}, HC_{ht}, X_{vt}, u_{lsht}) \quad (6)$$

We do not consider other types of capital, including physical, financial, or social capital as determinants of livelihood strategies, because these may be jointly determined with, or even determined by, the livelihood strategy. For example, households that choose livestock production as their livelihood strategy will acquire livestock as part of this strategy; thus it would not be appropriate to consider the household's livestock as a determinant of its livelihood strategy. Similarly, households may choose to participate in particular organizations or acquire particular financial assets or liabilities as a result of their livelihood strategy. Although a similar argument could be made concerning the household's endowments of natural and human capital (and geographic determinants of comparative advantage as well), these types of capital are more slowly changing than the other types, and thus more likely to be a determinant of current livelihood strategy decisions than determined by such decisions.

Participation in Programs and Organizations

We hypothesize that participation in programs and organizations is influenced by the same factors determining the household's livelihood strategy. In addition, we assume that past (prior to the beginning of 2000) participation in training programs (P_{ht0}) and the presence of programs and organizations within the village (P_{vt}) are also key determinants of current participation:

$$P_{ht} = P(NC_{ht}, T_{ht}, HC_{ht}, X_{vt}, P_{ht0}, P_{vt}, u_{pht}) \quad (7)$$

Household Income Per Capita

We assume that income per capita is determined by the same village and household-level factors influencing crop production, labor use, external input use, and land management practices:

$$I_{ht} = I(NC_{ht}, T_{ht}, PC_{ht}, HC_{ht}, LS_{ht}, P_{ht}, X_{vt}, u_{iht}) \quad (8)$$

As in equations (6) and (7), natural capital and land tenure are household-level aggregate variables. Equations (1)–(8) form the basis of the econometric estimation.

Definition and Measurement of Dependent Variables

The measures of the dependent variables in the econometric models include the logarithm of the value of crop production [in Lps/manzana (mz)][28] at the plot level (y_{hpt}); the amount of family labor used on the plot (in person-days/mz), the amount of hired wage labor used on the plot (in person-days/mz), and the value of hired piece labor used on the plot (in Lps/mz) (L_{hpt}); whether

[28]During the survey period, US$1 averaged 16 Lps. One manzana = 0.7 ha.

different types of external inputs were used on the plot (inorganic fertilizer, herbicides, insecticides, and other external inputs) (IN_{hpt}); whether different land management practices were used on the plot (no burning, zero/minimum tillage, incorporation of crop residues, use of mulch, use of manure) (LM_{hpt}); the livelihood strategy of the household (LS_{ht}); whether the household participated in different types of programs and organizations (agricultural training programs, conservation training programs, agricultural extension programs, conservation extension programs, producer or *campesino* organizations, rural banks or *cajas rurales,* and NGOs) (P_{ht}); and the annual income per capita of the household (in Lps/person) (I_{ht}).[29]

The nature of these different dependent variables implies that the econometric models cannot be estimated as a linear system, as some of these are discrete binary response variables (IN_{hpt}, LM_{hpt}, and P_{ht}), some are multiple valued categorical variables (LS_{ht}) and some are censored (nonnegative) variables (L_{hpt}). We discuss the econometric models used below.

Definition and Measurement of Explanatory Variables

Table 3.1 provides an overview of the variables used in the analysis. The plot-level variables indicating natural capital (NC_{hpt}) in the econometric analysis include the size of the plot (in manzanas), the predicted maize yield based on analysis of soil samples, assuming no moisture limitations (a measure of inherent soil fertility; see also footnote 34), the altitude and slope (flat, moderate slope, steep slope) of the plot, the location of the plot on the slope (top, hillside, or bottom), and the presence of prior investments on the plot (stone walls, live barriers or live fences, and trees planted on the plot, other than coffee). Factors reflecting agroclimatic potential, measured by the level of rainfall during the main rainy (*primera*) season (in mm) and the estimated rainfall deficit for maize production during the small rainy season (*postrera*) (in mm) are also included (see also footnotes 26 and 33). In the household-level equations, we use an average of the plot-level indicators of soil fertility, altitude, and rainfall as indicators of household natural capital (NC_{ht}). The total amount of land owned by the household is also included as part of its natural capital.

The plot-level variables indicating land tenure (T_{hpt}) include how the plot was acquired (whether owned, rented/sharecropped, borrowed, or simply occupied) and the land rights status of the plot, if owned—full title (*dominio pleno*) or usufruct rights (*dominio util*). Accessibility of the plot is indicated by the distance of the plot to the household residence and distance to the nearest road. At the household level, the share of land that is owned under full title is also included, as this may affect the household's access to credit, independently of the influence of land tenure on land management incentives at the plot level.

The physical capital of the household (PC_{ht}) is measured by the value of livestock owned (in Lps) and the value of equipment and machinery owned (in Lps). Human capital is measured by the median number

[29]In Chapter 5, we do not report the results of regressions for determinants of hired piece rate labor, other external inputs, and use of mulch or manure because the number of positive observations of these variables was small, limiting the robustness of conclusions concerning explanatory factors. Nevertheless, these regressions were used to predict the levels of these response variables, and these predicted values were used as instrumental variables in an instrumental variables estimation of equation (1), as explained below. Similarly, predicted values from regressions predicting participation in various types of programs and organizations were used as instrumental variables, but these regressions are also not reported in Chapter 5. These additional regressions are available from the authors on request.

Table 3.1 Variables included in the analysis

Variables	Definition	Measurement
Dependent variables		
Livelihood strategy (LS_{ht})	Livelihood strategy pursued by household (livestock, coffee, basic grains only, basic grains/farm worker, basic grains/livestock/farm worker)	Factor and cluster analysis of labor and land allocation decisions
Land management (LM_{hpt})	Use of land management practices on the plot (no burning, zero/minimum tillage, incorporation of crop residues, mulch, manure)	Dummy variables for whether practices used (0 = no, 1 = yes)
Labor use (L_{hpt})	Pre-harvest amounts of labor per manzana of different types (family labor, hired wage labor, hired piece labor) used on the plot	Person-days/manzana (1 manzana = 0.7 hectares)
External input use (IN_{hpt})	Use of external inputs on the plot (inorganic fertilizer, herbicides, insecticides, other external inputs)	Dummy variables
Crop production (y_{hpt})	Seasonal value of crop production on the plot per manzana	Lps/manzana, using local prices
Income per capita (I_{ht})	Annual household net income per capita (subtracting costs of production and livestock losses)	Lps/person
Explanatory variables		
Natural capital (NC_{hpt})		
Plot size	Area of the plot	Manzanas
Altitude	Altitude of the plot	Feet above sea level
Summer rainfall	Average rainfall during the summer rainy season	mm
Soil moisture deficit in secondary season	Estimated soil moisture deficit for maize production in secondary season, based on a model of moisture required for maize and data on rainfall, evapotranspiration, temperature, and soil characteristics (Wielemaker 2002)	mm
Soil fertility	Potential maize yield under nutrient limited but not water limited conditions, using the QUEFTS model (Wielemaker 2002)	kg/manzana
Owned land	Area of land owned by the household, either under freehold (*dominio pleno*) or usufruct (*dominio util*) tenure	Manzanas
Physical capital (PC_{ht})		
Value of machinery and equipment	Estimated value of capital equipment owned by the household at the beginning of the survey year, such as plows, ox carts, sprayers, coffee dehuskers, bicycles, etc.	Lps
Value of livestock	Estimated value of all livestock owned by the household at the beginning of the survey year	Lps
Human capital (HC_{ht})		
Median years of schooling	Median years of schooling completed by household members older than 7 years old	Number of years
Household size	Number of household members	Number
Dependency ratio	Ratio of the number of dependent household members younger than 12 years or older than 70 years old, divided by the number between 12 and 70	Ratio
Female household head	Whether the head of the household is female	Dummy variable (=1 if yes)
Percentage of female adults	Number of females greater than 12 years old as a percentage of total household size	Percentage
Age of household head	Age of the household head	Years
Migration index	Ratio of total number of months lived outside the household by adult household members, divided by total number of adult household members times 12	Index
Geographic determinants of comparative advantage (X_{vt})		
Market access	Index of travel time from the center of the community to the nearest market outlet, using the most common form of transportation. Index was estimated by CIAT and is based on geographical distance, road quality, and slope. A higher value implies poorer access.	Index

Table 3.1—Continued

Variables	Definition	Measurement
Road density	Length of road in the community divided by its area, based on data from CIAT (2001)	km/km^2
Population density	Number of persons in the community divided by its area, based on the 2001 population census (INE 2002)	$Persons/km^2$
Participation in programs and organizations (SC_{ht})		
Conservation training	Whether any household member participated in a training program focused on natural resource management (NRM)/conservation during the survey year	Dummy variable
Agricultural training	Whether any household member participated in an agricultural training program during the survey (other than conservation training)	Dummy variable
Conservation extension	Whether any household member participated in an extension program focused on NRM/conservation during the survey year	Dummy variable
Agricultural extension	Whether any household member participated in an agricultural extension program during the survey (other than conservation training)	Dummy variable
Producers'/*campesino* organization	Whether any household member participated in a producers' or *campesino* organization during the survey year	Dummy variable
Rural bank/*caja rural*	Whether any household member participated in a rural bank or *caja rural* during the survey year	Dummy variable
NGO program	Whether any household member participated in any programs of nongovernmental organizations	Dummy variable
Parcel/plot characteristics (NC_{hpt})		
Area of parcel or plot	Area of parcel or plot	Manzanas
Travel time from parcel to residence	Travel time from parcel to residence	Minutes
Travel time from parcel to road	Travel time from parcel to road	Minutes
Position on hill	Whether plot is at the bottom, top, or side of a hill	Dummy variables
Slope	Slope category of the plot (flat, moderate, steep)	Dummy variables
Land tenure (T_{ht} and T_{hpt})		
Percentage of owned land with freehold title (household level)	Household-level variable for share of owned land with title	Percentage
Parcel and plot tenure		
Usufruct ownership (*dominio util*)	Whether parcel/plot is owned with usufruct tenure rights only	Dummy variable
Freehold title (*dominio pleno*)	Whether parcel/plot is owned with full freehold tenure	Dummy variable
Occupied communal land	Whether parcel/plot is occupied communal land without formal rights	Dummy variable
Borrowed	Whether parcel/plot was acquired by borrowing	Dummy variable
Rented or sharecropped	Whether parcel/plot was acquired by cash rental or sharecropping	Dummy variable
Prior investments on parcel (part of NC_{hpt})	Whether investments existed on the parcel at the beginning of the survey year	Dummy variables
Stone wall		
Live barrier or fence		
Trees planted		
Land use in 1999 (LU_{hpt})	Proportion of parcel under various land uses in 1999	Proportion
Basic grains		
Other annual crops		
Coffee		
Other perennial crops		
Unimproved pasture		
Improved pasture		
Fallow		
Forest		

of years of formal schooling of household members older than 7 years,[30] the total number of household members, the share of dependents in the household (members younger than 12 years or older than 70 years are considered dependents), the age and gender of the household head, the share of female adults in the household, and an index of the share of household labor time involved in migration.

Participation in programs and organizations (P_{ht}) is measured by whether anyone in the household participated during the year of the survey in conservation training programs (e.g., formal training related to soil and water conservation measures such as use of compost, mulching, and minimum or zero tillage), conservation extension programs (receiving shorter-term and more informal extension advice on such conservation practices), other agricultural training and extension programs (receiving training or extension on crop or livestock production practices other than conservation practices), membership in a producers' association or *campesino* organization, membership in a rural bank or *caja rural,* and participation in activities of nongovernmental organizations.[31] Prior participation in training programs (P_{ht0}) is measured by whether the household had participated in conservation or agricultural training programs prior to the survey year.[32] The presence of organizations within the village is measured by whether there are any producer or *campesino* organizations, rural banks or *cajas rurales,* or NGO programs within the village.

The village-level factors influencing comparative advantages (X_{vt}) included access to markets and roads, measured by an ordinal index of travel time to the nearest large urban market (index is developed by the International Centre for Tropical Agriculture [CIAT] using a GIS and based on geographical distance, road quality, slope, and natural barriers); the density of roads in the village (km/km^2); and the population density of the village in 2001 (persons/km^2).

Key Relationships

The key relationships investigated include the impacts of population pressure, access to markets and roads, participation in technical assistance programs and organizations, education, natural capital, physical capital, and land tenure on land management, agricultural production, and income. In the context of imperfect markets, most of these factors have ambiguous potential impacts on these responses and outcomes, depending on the market context. For example, while better market access may promote production of higher-value crops and raise the value of crop production, the latter may be reduced by lower labor use resulting from higher opportunity cost of labor. Population pressure may increase the pressure on fragile lands and increase land degradation but may also stimulate investments in land improvements. While education can be expected to have a

[30]Our use of the median number of years of formal schooling, rather than the more commonly used measure of schooling of the head of household, was motivated by a study by Joliffe (1997), who found using a living standards survey from Ghana that the average or median level of education in the household was a better predictor of farm and off-farm income than the education of the household head. We chose to use the median rather than mean level of schooling because the mean estimator is more sensitive to outliers and missing data problems.

[31]Participation decisions in these types of programs and organizations are not mutually exclusive; for example, a household may participate in more than one type of program. Also, the definitions of some of these variables involve some overlap; for example, households may participate in an NGO program providing agricultural or conservation training or extension. Nevertheless, these variables are reflecting different things—the variable for participation in an NGO program reflects the impact of the type of program (whether by the government or NGO), controlling for the program emphasis (whether conservation, more general agriculture, or something else).

[32]The questionnaire did not collect information on prior participation in extension programs or other organizations.

Figure 3.2 Location of the 9 provinces and 19 counties included in the sample

positive effect on household income, its net impacts on land management and crop production are ambiguous. Better educated households may be more aware of the benefits of conservation practices but also face higher opportunity costs of labor which discourage labor-intensive practices. While households with more education may have better access to credit which may stimulate high-value crop and livestock production and raise output value, they may also opt to work more outside the own farm. For a more detailed discussion of hypotheses about impacts of these and other factors in the context of imperfect markets, see Pender (2001), Nkonya et al. (2004), and Pender and Gebremedhin (2004).

Data

The preceding model is estimated using econometric analysis of survey data collected from 376 households in 95 villages during late 2001 and early 2002, supplemented by information on climate, market access, and population density provided by CIAT.

Our research covers 9 provinces (*departamentos*) and 19 counties (*municipios*) (Figure 3.2). These were selected purposively based on several criteria including representation of agroecological conditions, dominant land use, population density, market access, and the presence of projects and programs. In addition, the importance of a number of counties in the northeast of the country as recipient areas of migrants (extending the agricultural frontier) warranted their inclusion in the study. The remainder of the sampling process was done in a fully randomized manner. In each county, five communities (*aldeas,* more or less equivalent to villages) were randomly selected, on the basis of a list of communities obtained from the 2000–01 population census (INE 2002). Subsequently for the household survey, two hamlets (*caserios*) were selected in each community, again randomly and on the basis of the latest population census. Finally, two households (*hogares*) were randomly selected in each hamlet on the basis of an inventory of households made in the field for each hamlet. The survey sample contains a total of 376 households, 1,066 parcels (defined as a contiguous piece of land based on tenure status), and 2,143 plots (subparcels defined on the basis of land use).

Key socioeconomic elements of the survey at the household level included household composition, education, asset ownership, labor use, sources of income, sales of crop and livestock products, participation in credit markets, membership of organizations, participation in training and extension programs, and collective action. Information collected at the parcel and plot levels included land tenure, cropping patterns, crop production, land management technologies including use of labor and other inputs, and conservation practices and investments.

To be better able to analyze the adoption of conservation practices and suggest policies for sustainable land use, the survey collected detailed biophysical data for a (randomly drawn) sample of two plots on each farm. These included landscape attributes, plot size, type of soil parent material, erosion status, and presence of physical conservation structures. Soil samples were also taken and analyzed in a local soil laboratory and resulted in data regarding pH, nutrient content, organic matter content, and texture. These data were used mainly for the calculation of soil moisture availability,[33] soil fertility,[34] and erosion risk. Soil fertility and erosion risk served as a basis for the construction of a soil quality variable (Wielemaker 2002). Finally, the survey data were supplemented by adding secondary information regarding rainfall, population density, market access, and road density. Most of these data were obtained from CIAT.

Econometric Analysis

Ideally, we would like to estimate the system represented by equations (1)–(4) and (6)–(8) using a systems approach such as three-stage least squares or full information maximum likelihood to deal with endogenous explanatory variables and account for correlation of error terms across the different equations. However, three-stage least squares estimation is not appropriate because there are many limited dependent variables in this system, and joint maximum likelihood is not feasible due to the large number of dependent variables and error terms. Instead, we use single-equation estimators appropriate to the nature of each dependent variable. L_{hpt} are left-censored continuous variables (censored below at 0); hence we use a Tobit estimator to estimate equation (2). IN_{hpt}, LM_{hpt}, and P_{ht} are dichotomous choice variables; we use probit models to estimate equations (3), (4), and (7). LS_{ht} is a polychotomous choice variable; we use a multinomial logit model to estimate equation (6). y_{hpt} and I_{ht} are continuous uncensored variables; thus least squares regression is feasible and used for equations (1), (5), and (8).

[33] Besides rainfall, moisture availability in the soil is critical for crop growth and as such constitutes another indicator of agricultural potential. Moisture availability is soil specific and takes into account not only rainfall but also evapotranspiration, temperature, and soil characteristics. We used the data from our soil samples and operationalized moisture availability as crop water deficits for annual crops (for maize in the main and secondary growing seasons) and permanent crops (coffee). Water deficits were calculated on the basis of data for monthly temperature, effective rainfall (taking runoff into account as determined mainly by slope, slope direction, contour curvature, profile curvature, and position on slope), evapotranspiration, and soil characteristics including depth, texture, and organic matter content. Only moisture availability for the second season was considered because the data indicated very few cases of main season water deficits. Moreover, moisture availability for coffee is highly correlated with moisture deficit for maize in the secondary growing season. For more details, see Wielemaker (2002).

[34] Soil fertility is yet another indicator of agricultural potential. We approximated soil fertility by potential maize yield (nutrient-limited but not water-limited) using the QUEFTS (QUantitative Evaluation of soil Fertility and response To Fertilizers) model (Janssen 1990). For a given plot this model calculates potential yield on the basis of the soil's nitrogen content, pH, and available potassium and phosphorus. We had data for each of these variables from the analyses done in the soil laboratory of the FHIA (Honduras Foundation for Agricultural Research), a private agricultural research institute.

Inclusion of endogenous explanatory variables in equations (1)–(5) and (8) could result in biased estimates. We use instrumental variables (IV) estimation to address the endogeneity problem in equations (1), (5), and (8). Because the dependent variables in equations (2)–(4) are limited dependent variables [censored in equation (2) and binary in equations (3) and (4)], it is not technically appropriate to use IV estimation for these equations. However, we tested linear OLS versus IV versions of these models using a Hausman (1978) exogeneity test, to test whether endogeneity of the livelihood strategies (LS_{ht}) and participation in programs and organizations (P_{ht}) could be biasing our results. For equations (3) and (4), this amounts to assuming a linear probability model rather than a nonlinear probit model (only for the purposes of the exogeneity test). For equation (2), we tested for exogeneity using a truncated version of the regression for family labor, dropping the observations with zero family labor used on the plot. We did this only for the family labor regression, since there were few censored observations for family labor input (only 35 out of 1635 observations), implying that the truncation should have little effect on the validity of the results (there were many censored observations for the other types of labor input). We also tested for exogeneity of these variables (i.e., LS_{ht} and P_{ht}) in equations (5) and (8) using a Hausman test. In no case did we reject exogeneity of the livelihood strategies and participation variables at the 10 percent level. In all cases, the instrumental variables used were found to be highly significant predictors of the endogenous explanatory variables (hence the instrumental variables are "relevant") and the validity of the exclusion restrictions was accepted using Hansen's *J* test (Davidson and MacKinnon 2004) (the results of these tests are reported in the discussion of the econometric results in Chapter 5). These results give us confidence that our results in estimating equations (2)–(5) and (8) are not biased by endogeneity of the livelihood strategies and participation variables.

Based on these results, we treat livelihood strategies and participation in programs and organizations as exogenous variables in estimating equation (1). We estimate equation (1) several ways. First we estimate the full model using ordinary least squares (OLS) and IV estimation, including all of the variables specified. In the full IV model, predicted values of L_{hpt}, and predicted probabilities of LM_{hpt} and IN_{hpt} from estimation of equations (2)–(4) are used as instrumental variables.[35] To identify additional instrumental variables and improve the performance of the models, we tested the joint significance of subsets of the village-, household-, and parcel-level variables using Wald tests in both the full OLS and IV models, and then estimated reduced OLS and IV models that excluded variables that were highly statistically insignificant (p-values at least 0.20) in both of the full models. In the reduced IV model, we tested the relevance of the excluded instrumental variables using joint significance tests for the first-stage regressions, and the validity of the exclusion restrictions using Hansen's *J* test (see Davidson and MacKinnon 2004 for a description of these tests). The excluded instrumental variables were highly significant predictors of all of the endogenous right-hand side variables in the annual crops regression, and for most of the endogenous variables in the perennial crops regression. In both regressions, Hansen's *J* test failed to reject the exclusion restrictions. Thus we have confidence that the reduced models are valid. Hausman tests comparing the reduced versions of the OLS and IV models were conducted, and failed to reject the OLS model in both the annuals and perennials regressions. Thus, the OLS model is preferred as the more efficient model in both cases,

[35]The full IV model is identified by the nonlinearities in equations (2)–(4).

although we report the results of both the OLS and IV models to investigate the robustness of the findings. We also estimate the model in reduced form [RF—equation (5)] and report the results.

For equations (1) and (5), we transformed the dependent variable and the continuous uncensored explanatory variables using logarithms, to reduce problems with nonlinearity and outliers, improving the robustness of the regression results (Mukherjee, White, and Wuyts 1998). We were unable to use such a logarithmic transformation for per capita income in equation (8), owing to negative values of net income for some households.[36] To investigate the robustness of the estimates for equation (8) to problems of outliers in estimated income per capita, we estimated the model using median regression (using bootstrapping to compute standard errors) in addition to using OLS and IV estimation as described previously.

We estimated two alternative specifications of equation (8), with and without interaction terms. The model with interaction terms investigates interactions between the livelihood cluster variables and the most significant policy-relevant variables in the model without interactions, thus providing valuable information as to which types of households certain types of programs and policies should be primarily directed toward for maximum impact.

In all models we tested for multicollinearity, and found it not to be a serious problem (variance inflation factors < 10, and almost all < 5) in all regressions except for the model with interaction terms used to estimate equation (8). In that model, the maximum variance inflation factor was 10.3.

Because stratified random sampling was used, all parameters were corrected for sampling stratification and sample weights. Estimated standard errors are robust to hetereoskedasticity and clustering (nonindependence) of observations from different plots for the same household.

[36]Household income is net of production costs, transfers out of the household, and livestock gains and losses, and can therefore be negative.

CHAPTER 4

Asset Distribution and Livelihood Strategies in the Hillsides of Honduras

This chapter first provides a characterization of sample households according to their asset endowments. We then discuss the main features of the livelihood strategies present in the sample.

Distribution of Assets among Households

We started out by using the household survey data to generate descriptive statistics that characterize each asset category. Throughout this section we employ an income classification that places households in one of three income categories: non-extremely poor households (per capita income > US$1.00), extremely poor households (income between US$0.50 and US$1.00), and desperately poor households (per capita income < US$0.50).[37]

Natural Capital

Average size of landholding of the households in the survey sample is about 14 manzanas (mz), but the distribution of land is highly unequal (Table 4.1). More than 70 percent of all households work less than 10 mz. While the severity of poverty is associated with size of landholding, the relationship is not smooth and continuous: poverty rates are lower among households that farm between 2 and 5 mz than among households that farm between 5 and 20 mz. Even half of the households that farm more than 20 mz are desperately poor. Thus more land, by itself, is no guarantee of prosperity. Land tenure security among hillside households is limited; only 35 percent of households have any land with legal title, but this percentage decreases with level of poverty (51, 35, and 32 percent for non-extremely poor households, extremely poor households, and desperately poor households, respectively). In addition, less-poor households have better soils. They also tend to be located in areas with somewhat higher rainfall and lower altitudes (Table 4.1).

Human Capital

On average, households consist of just over six persons, with no clear relationship between poverty and household size. However, the average dependency ratio of households that earn

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[37] The Honduran National Statistical Institute (*Instituto Nacional de Estadística, INE*) uses income-based definitions of poverty and extreme poverty of respectively < US$1.50/day per person and < US$1.00/day per person. But because only 17 households in our survey sample (4.5 percent) attained incomes greater than US$1.50/day/person, we introduce the term “desperately poor households” to designate households with a per capita income of below US$0.50/day. The latter group consists of 291 households (or 77 percent of the total sample).

Table 4.1 Natural capital

Landholding size (manzanas)	Land distribution: Percentage of all sample households	Percentage of land size distribution for households that earn > US$1.00/ person per day	Percentage of land size distribution for households that earn between US$0.50 and US$1.00/person per day	Percentage of land size distribution for households that earn < US$0.50/ person per day
< 2 mz	21.2	6.4	13.4	24.2
2–5 mz	29.5	36.7	33.9	31.9
5–10 mz	19.0	11.1	16.0	20.5
10–20 mz	11.4	2.9	8.3	12.9
20–50 mz	8.7	30.7	6.3	6.4
> 50 mz	7.0	12.2	22.1	4.1
Column category as percentage of total sample	100	10.9	12.8	76.3

	Climate and land quality: Sample average	Average for households that earn > US$1.00/ person per day	Average for households that earn between US$0.50 and US$1.00/ person per day	Average for households heads that earn < US$0.50/ person per day
Annual rainfall (mm)	1,645	1,765	1,619	1,634
Soil fertility[a]	2,846	3,136	2,980	2,790
Altitude (feet)	2,231	1,686	2,394	2,274

[a]Soil fertility was approximated by potential maize yields (see footnote 34 in Chapter 3 for details).

> US$1.00/person/day is less than half of that of desperately poor households (0.45 vs. 1.0).

Education levels are very low: on average household members have less than three years of formal schooling (Table 4.2). In Honduras, although school enrollment keeps on increasing, dropout rates remain stubbornly high (World Bank 2000). With limited educational progress over time (younger household members tend to have a little more schooling than their parents), the human asset base in rural Honduras has stayed virtually stagnant between 1993 and 2003 (World Bank 2004a).

Even though all poor households reported having members living outside the household, richer households have more members who migrated than poorer households (Table 4.3).

Finally, ethnic minorities (i.e., non-*mestizos*) account for about 15 percent of the total population in Honduras, and our sample is representative in that respect (Table 4.4). With the notable exception of the *Garifunas* (fishing communities on the northern Atlantic coast), our data are consistent with other studies that show that people belonging to ethnic minorities tend to have lower incomes.

Physical Assets

Physical assets include fixed agricultural assets such as machinery and equipment, livestock, vehicles, and housing. On average, households own about US$2,500 in physical assets. There exists a clear negative relationship between the value of total physical assets and depth of poverty: non-extremely poor households, extremely

Table 4.2 Education

Education level:	Percentage of all sample households	Percentage educational distribution for households that earn > US$1.00/ person per day	Percentage educational distribution for households that earn between US$0.50 and US$1.00/person per day	Percentage educational distribution for households that earn < US$0.50/ person per day
Household head:				
< 4 years	72.3	52.6	74.9	74.3
Primary, 4–6 years	26.6	46.4	22.3	24.8
Secondary, 7–11 years	4.2	1.0	1.7	0.9
Postsecondary, > 11 years	0.1	0.0	1.1	0.0
Average years of schooling	2.9	3.6	3.3	2.7
Household members older than 7 years:				
< 4 years	20.5	10.3	14.2	23.0
Primary, 4–6 years	75.5	83.5	78.8	73.8
Secondary, 7–11 years	4.0	6.2	6.9	3.2
Postsecondary, > 11 years	0	0	0.1	0
Average years of schooling	2.8	3.6	3.3	2.7

Table 4.3 Migration

	All sample households	Households that earn > US$1.00/ person per day	Households that earn between US$0.50 and US$1.00/person per day	Households that earn < US$0.50/ person per day
Percentage of households that report members living outside	98.1	80.4	100	100
Number of household members who lived in the household for less than 12 months	0.4	1.2	0.4	0.3
Total number of months lived outside the household by household members in 2000–01	2.8	7.4	3.7	2.0

Table 4.4 Ethnicity

Ethnic group	Percentage of sample households	Mean total income per household per year (Lps)	Percentage ethnic distribution for household that earn > US$1.00/ person per day	Percentage ethnic distribution for households that earn between US$0.50 and US$1.00/person per day	Percentage of households that earn < US$0.50/ person per day
Lencas	10.1	15,412	7.9	7.8	8.6
Garifunas	2.1	19,120	4.4	0.1	0.8
Tulopanes	2.1	7013	0.0	0.0	2.3
Mestizos	85.3	12,078	87.7	92.1	88.3
Column category as percentage of total sample	100		10.9	12.8	76.3

Box 4.1 Remittances

Remittances account for only 3 percent of average household income in the hillsides. But for the 17 percent of sample households that actually receive remittances, this source of income accounts on average for one third of their total income, and for households located near Tegucigalpa this share can be as high as 40 percent. Average annual remittances of recipient households are US$202. Poor basic grains farmers receive fewer remittances than livestock and coffee farmers.

The vast majority of households that receive remittances use these funds mainly for food purchases. Remittances are also used to cover health care expenses and schooling costs, even though to a much lesser extent. Only 20 percent of households in our survey reported *wanting* to spend this income on food, others would have liked to invest this money in buying cattle, fixing up the house, starting a business, buying clothing, or saving. However, many recipient households reported that funds were either insufficient or necessary to buy food, and that these investments could therefore not be realized.

poor households, and desperately poor households own respectively US$4,600, US$3,600, and US$2,100 in physical assets.

Financial Assets

Financial assets include savings, credit, and transfers. Transfers mainly are in the form of remittances, but also include other cash transfers, such as pensions and conditional payments from the *Programa de Asignación Familiar* (PRAF), a conditional transfer program (Morley and Coady 2003). In 2003, Honduras received an estimated US$850 million in remittances from abroad, or more than US$100 per person. Remittances are sometimes considered as a solution to rural poverty but our data seem to suggest otherwise. Only 17 percent of all sample households receive remittances, on average US$202 per household per year or less than US$35 per capita (Box 4.1). Remittances are an important source of income for recipient households but not an exit from poverty for the vast majority of extremely poor households (Table 4.5).

Nearly 70 percent of all rural households do not receive any form of credit (formal or informal; see Table 4.5). Many surveyed farmers claimed that credit is too expensive and also risky, thus preventing them from accessing financial resources for investing in productive activities or as a potential safety net for coping with unexpected disasters. Credit from regulated institutions (mostly banks) is hardly relevant in the hillside areas. Access to formal credit from nonregulated institutions (e.g., producers' cooperatives, communal banks, NGOs, etc.) seems somewhat easier: about 10 percent of rural households reported using it. Informal credit is by far the most common form of credit used by rural households, reported by nearly one quarter of all sample households. Poorer households rely more on informal credit.

Geographic Determinants of Comparative Advantage

Geographic location influences the availability and accessibility of goods and services, and therefore transaction costs. Access to public services varies substantially among hillside communities (Jansen et al. 2003). Fewer than 20 percent of the sample communities have electricity (against 36 percent national rural coverage), and only 13 percent have a public telephone. Fewer than one third of the communities have a health clinic and about one third have access to public transportation. Although 80 percent of the communities have a source of potable water, in general, this service is

Table 4.5 Financial assets

	All households	Households that earn > US$1.00/ person per day	Households that earn between US$0.50 and US$1.00/ person per day	Households that earn < US$0.50/ person per day	Of all households	Of households that earn > US$1.00/ person per day	Of households that earn between US$0.50 and US$1.00/ person per day	Of households that earn < US$0.50/ person per day
Transfers	**Average amount (Lps) per year, receiving households**				**Percentage of households that received transfers**			
Remittances	1,987	5,245	3,513	1,044	17.0	32.5	25.0	13.6
Pension	20,689	28,954		631	1.6	5.0	2.1	1.1
School support	460	311	483	472	25.0	25.0	18.8	26.1
Child support	633	Not applicable	747	586	4.3	0.0	6.3	4.5
Nutritional support	601	No data	801	589	13.0	2.5	8.3	15.3
Old age support	433	No data	744	203	3.7	2.5	4.2	3.8
Scholarships	812	799		823	3.5	12.5	0.0	2.8
Other transfers	498	1,076	885	459	7.9	5.0	8.3	8.4
Total transfers	1,599	5,504	3,468	911	57.6	61.0	58.3	56.4
Credit	**Average amount (Lps), borrowing households**				**Percentage of households that received credit**			
Formal credit from regulated institutions	9,013	2,104	0	20,084	2.1	2.0	0	1.2
Formal credit from nonregulated formal institutions	1429	0	630	1,665	9.6	0	2.7	10.3
Informal credit	2,917	337	1,454	2,460	23.4	16.9	23.2	33.1
Total credit	3,600	523	2,106	3,322	30.9	18.9	25.9	40.6
Savings					**Percentage of households that reported savings**			
					16.9	21.8	16.9	16.3

Table 4.6 Access to public infrastructure and services

Variables (all distance variables are travel time in minutes)	Average value for all households	Average value for households that earn > US$1.00/ person per day	Average value for households that earn between US$0.50 and US$1.00/ person per day	Average value for households that earn < US$0.50/ person per day
Population density	71.9	54.7	60.2	75.7
Road density	4.1	3.3	3.9	4.3
Distance to paved road	74.2	68.7	92.8	72.2
Distance to nonpaved road	34.5	40.2	36.7	33.3
Distance to school	15.1	12.5	10.8	16.1
Distance to health center	66.5	72.3	74.7	64.6
Distance to farmers' market	73.1	72.1	93.0	70.2
Distance to fuel wood source	43.8	40.2	66.7	40.8

limited to main settlement centers of the community. The household data provide evidence of generally difficult access to markets and public services, but they do not show a clear-cut correlation with income level (Table 4.6).

Factor Analysis and Cluster Analysis

The results of the factor analysis on the household allocation of land and labor resources identified six main common factors. The subsequent hierarchical cluster analysis identified seven clear-cut and robust clusters. Of the total of 376 observations (households), *k*-means analysis regrouped 116. We also tried a straight cluster analysis without the preceding factor analysis, but this led to clusters that were both less clear and less stable.

The seven clusters represent the following livelihood strategies:

1. Livestock producers (59 households)
2. Coffee producers (28 households)
3. Basic grains farmers (68 households)
4. Basic grains farmers/farmworkers (85 households)
5. Mixed basic grains/livestock/ farmworkers (116 households)
6. Permanent crops producers (12 households)
7. Annual crops/intensive livestock producers (8 households)

Table 4.7 summarizes the means and standard errors for the variables that were used in the factor analysis. It also reports the results of the pairwise comparison for each variable between every combination of clusters. There is a satisfactory amount of between-cluster variation, even though often it is just one cluster that is very different for each variable. But that may be a result of the factoring. For example, cluster 1 basically consists of livestock producers, and the pairwise analysis shows cluster 1 to be significantly different from the other clusters in pasture area. Similarly for cluster 2 (coffee producers) which is statistically different from all other clusters in coffee area, and so forth.

Livelihood strategies in hillside areas mostly revolve around agricultural and small-livestock activities, with relatively few households engaging in higher-return activities such as production of vegetables or nonfarm activities. In Honduras the latter account for only 22 percent of total rural income on average, compared to 60 percent in Costa Rica, 42 percent in Nicaragua, and 38 percent in El Salvador (data refer to 1997; see Reardon, Berdegué, and Escobar 2001). More than one half of households pursue a livelihood strategy that centers on basic grains production (livelihood clusters 3, 4, and 5), but households in other livelihoods groups also tend to produce basic grains. Livestock is also an important livelihood

Table 4.7 Final clusters and summary statistics[a] of factor analysis variables

Variable	Full sample		Cluster 1 Livestock producers		Cluster 2 Coffee producers		Cluster 3 Basic grains farmers	
	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
Crop mix (share of area)								
Basic grains	.420	0.029	.132[b–d]	0.021	.343[a,c–e]	0.043	.720[a,b,e–g]	0.061
Annual crops	.021	0.013	.009[g]	0.005	.000[g]	0.000	.000[g]	0.000
Permanent crops	.030	0.006	.010[f,g]	0.003	.006[f,g]	0.006	.028[f,g]	0.014
Coffee	.050	0.009	.024[b]	0.012	.410[a,c–g]	0.035	.005[b]	0.004
Pasture	.148	0.023	.646[b–g]	0.031	.051[a]	0.036	.046[a]	0.023
Fallow/forest	.332	0.027	.180[e]	0.033	.189[e]	0.050	.201[e]	0.048
Family labor (activity time/ total family labor)								
On-farm work	.360	0.015	.471[d–f]	0.037	.338	0.060	.432[d]	0.040
Off-farm agricultural work	.086	0.012	.032[d,e]	0.013	.051[d]	0.029	.014[d,e]	0.004
Off-farm nonagricultural work	.034	0.008	.062[f]	0.035	.068	0.034	.049	0.019
Agricultural labor (agricultural activity/total agricultural labor including hired labor)								
Basic grains	.349	0.026	.249[c]	0.042	.267[c]	0.053	.732[a,b,d–g]	0.039
Annual crops	.012	0.004	.023[g]	0.010	.000[g]	0.000	.001[g]	0.001
Coffee	.046	0.010	.029[b]	0.013	.376[a,c–g]	0.087	.000[b]	0.000
Permanent crops	.032	0.007	.018[f]	0.007	.052[f]	0.034	.034[f]	0.014
Livestock	.208	0.028	.544[g]	0.055	.035[g]	0.018	.127[g]	0.040
Off-farm agricultural work	.354	0.035	.138[d,e]	0.054	.270[d]	0.106	.106[d,e]	0.028

Variable	Cluster 4 Basic grains farmers/ farmworkers		Cluster 5 Mixed basic grains/ livestock/ farmworkers		Cluster 6 Permanent crops producers		Cluster 7 Annual crops/ intensive livestock producers	
	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
Crop mix (share of area)								
Basic grains	.751[a,b,e–g]	0.059	.230[b–d]	0.026	.238[c,d]	0.056	.178[c,d]	0.024
Annual crops	.004[g]	0.003	.006[g]	0.003	.003[g]	0.003	.590[a–f]	0.048
Permanent crops	.013[f,g]	0.006	.018[f,g]	0.005	.534[a–e,g]	0.085	.063[a–f]	0.025
Coffee	.020	0.007	.025	0.011	.001[b]	0.001	.000[g]	0.000
Pasture	.019[a]	0.010	.062[a]	0.018	.000[a]	0.000	.099[a]	0.028
Fallow/forest	.193[e]	0.059	.658[a–d,f,g]	0.025	.224[e]	0.077	.070[e]	0.084
Family labor (activity time/ total family labor)								
On-farm work	.255[a,c,e]	0.037	.343[a,d]	0.019	.247[a]	0.030	.317	0.027
Off-farm agricultural work	.246[a–c,e–g]	0.028	.066[a,c,d,f,g]	0.012	.143[d]	0.075	.009[d]	0.009
Off-farm nonagricultural work	.013[f]	0.007	.012[f]	0.004	.068[a,d,e]	0.027	.032	0.033
Agricultural labor (agricultural activity/total agricultural labor including hired labor)								
Basic grains	.155[c,e]	0.016	.342[c,d]	0.046	.246[c]	0.092	.176[c]	0.036
Annual crops	.001[g]	0.001	.012[g]	0.007	.003[g]	0.003	.123[a–f]	0.128
Coffee	.006[b]	0.004	.032	0.008	.005[b]	0.005	.000[b]	0.000
Permanent crops	.002[f]	0.001	.034[f]	0.017	.271[a–e,g]	0.115	.037[f]	0.036
Livestock	.047[g]	0.019	.199[g]	0.042	.039[g]	0.029	.614[a–f]	0.173
Off-farm agricultural work	.788[a–c,e–g]	0.022	.385[a,c,d]	0.051	.436[d]	0.187	.050[d]	0.052

Note: Means and standard errors are adjusted for sampling weights.

[a]Statistically significant difference between cluster 1 and the column cluster at 5% level.

[b]Statistically significant difference between cluster 2 and the column cluster at 5% level.

[c]Statistically significant difference between cluster 3 and the column cluster at 5% level.

[d]Statistically significant difference between cluster 4 and the column cluster at 5% level.

[e]Statistically significant difference between cluster 5 and the column cluster at 5% level.

[f]Statistically significant difference between cluster 6 and the column cluster at 5% level.

[g]Statistically significant difference between cluster 7 and the column cluster at 5% level.

strategy (clusters 1 and 5), and to a lesser degree coffee production (and as coffee laborers).

Brief Description of Livelihood Strategies

This section describes how each cluster employs its land and labor resources, which formed the basis for the cluster analysis.

The livelihood of households in cluster 1 (16 percent of the sample) is based on extensive livestock farming, as indicated by the fact that this cluster has the largest share of pastures (65 percent of operated area on average) and the smallest share of basic grains in their use of land (13 percent; see Table 4.7). These farmers also spend the highest proportion of their total family labor on their own farms, with most of their time devoted to livestock. However, even these farmers put a high value on food security and devote an average of 4 ha to basic grains production.

Cluster 2 (7 percent of the sample) consists of coffee producers who on average devote 40 percent of their farm area and 34 percent of their family labor to coffee. However, these farmers still rely on basic grains for their subsistence needs: they use about one third of their farm area and more than one quarter of their family time to grow basic grains.

Cluster 3 (18 percent of the sample) represents subsistence farmers. Table 4.7 shows that these households devote most of their farmland and family labor to the cultivation of basic grains (mostly maize and beans). These households work relatively little outside their own farm. Households in cluster 4, representing nearly one quarter of the total sample, are similar to those in cluster 3 in the sense that they devote most of their farm area to basic grains. However, rather than working exclusively on their own farms (where the land is often not suitable for second season cultivation), they spend about equal proportions of their time working on their own farms and off-farm (mostly on other people's farms).

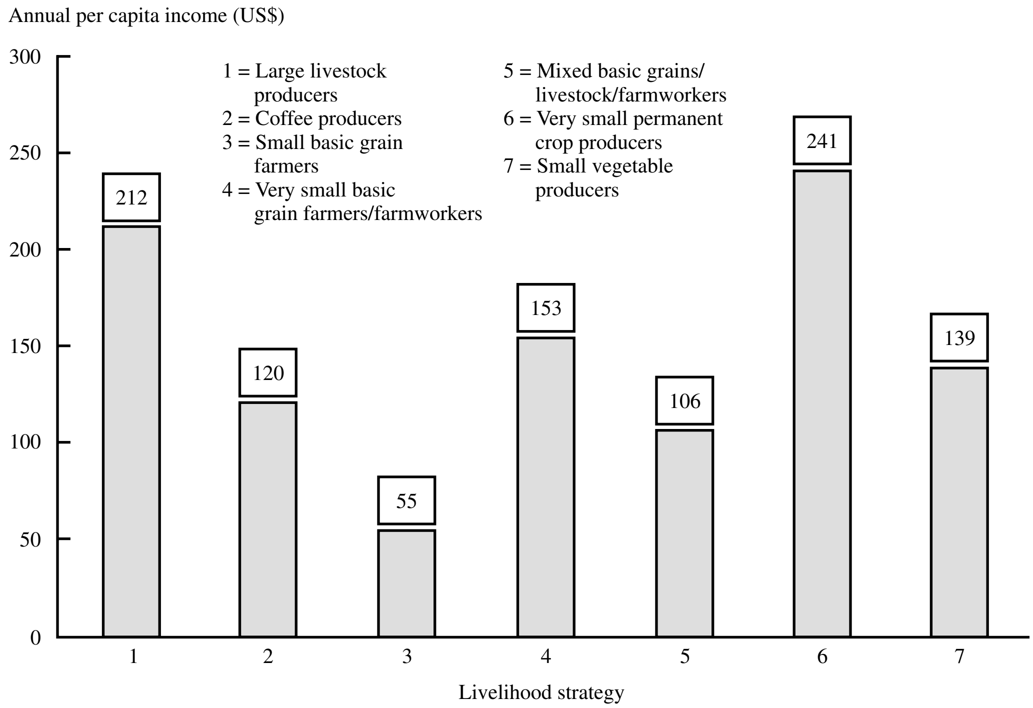
Households in cluster 5 account for nearly one third of the total sample and on average keep nearly two thirds of their farm under fallow and/or forest. Their livelihood is similar to that of households in cluster 4 but they hire more labor and devote more time to livestock activities.

Cluster 6 is a small group (12 households, representing 3 percent of the total sample) of permanent crop producers, who devote most of their land and time to intensive tree crop production such as fruits, oil palm, some sugarcane, and so forth.

Finally, cluster 7 consists of only eight households (2 percent of the total sample) most of which are vegetable growers or intensive livestock producers. These households work very little off-farm, probably because of the labor-intensive character of most vegetable crops. Below we describe the main characteristics of the various livelihood strategies in terms of assets and outcomes such as level and composition of household income. Shockingly, none of the livelihood strategies in the hillside areas are able to generate an average annual income above the extreme poverty line of US$365 per capita, let alone above the poverty line of US$550 per capita (Figure 4.1).[38] Differences in outcome variables can be regarded as the result of differences in asset endowments that, in turn, are causal factors for differences in livelihood strategies represented by the clusters.

[38]Total household income is defined as the sum of the net value of crop and livestock production (revenues minus costs) and income from off-farm salaried work (either farm or nonfarm), own business, and transfers. Own production, whether consumed by the household or sold, is included in the calculation of household income.

Figure 4.1 Annual per capita income in U.S. dollars, by livelihood strategy



Factors Associated with Household Livelihood Strategy Types

In this section we provide a more comprehensive characterization of each cluster according to its main asset characteristics.

The extensive character of livestock operations in cluster 1 is evidenced by relatively large farm holdings (32 ha on average), where on average the herd is worth nearly US$6,000. But even these households obtain about 30 percent of their total household income from working outside their own farm (Table 4.8). The livestock farms in this cluster are mostly located in lower altitude areas with relatively low population densities (Table 4.9).

Education is above average. Access to markets and public services is below average for these households, but given their livelihood focus on livestock keeping, this does not seem to negatively affect income. On the other hand, despite being the second richest household group in the IFPRI sample, average daily per capita income is still only US$0.58. However, the *average* per capita income is somewhat misleading because the poverty rate in this livelihood group is lower than in all the other groups. Therefore, there are some households for which this appears to be a poverty-exit livelihood strategy.

Most coffee farms in cluster 2 are relatively small (average farm size is 3.5 ha) and located at higher altitudes (above 1000 meters above sea level; see Table 4.9). Somewhat surprisingly, market access and education are below average for these households and they farm relatively poorer soils. These coffee producing households earned just over half the average per capita income of households in cluster 1 (Table 4.8). However, the survey was taken during the period when coffee prices collapsed (falling in 2000–02 to about half the price of previous years), so this may overstate chronic poverty among this group.

Subsistence basic grains producing households in cluster 3 have just over 2 ha

Table 4.8 Mean household net income and percentage composition, by livelihood strategy

Cluster number		1	2	3	4	5	6	7
		Livelihood strategy name						
Variables	**Total sample**	**Livestock producers**	**Coffee producers**	**Basic grains farmers**	**Basic grains farmers/ farmworkers**	**Mixed basic grains/ livestock/ farmworkers**	**Permanent crops producers**	**Annual crops/ intensive livestock producers**
Number of households	376	59	28	68	85	116	12	8
Total household income[a]	12,310	20,915	12,536	5,134	13,799	10,798	16,225	9,777
Standard error	1,646	7,531	2,646	1,125	2,491	2,089	3,665	3,499
Per capita income[b]	0.35	0.58	0.33	0.15	0.42	0.29	0.66	0.38
Standard error	0.04	0.18	0.05	0.03	0.08	0.05	0.18	0.24
Composition of household income:								
Percentage income from basic grains	34.3	30.4	0.0	79.2	17.5	30.0	22.3	41.4
Standard error	8.0	8.1	20.9	29.4	6.5	13.0	10.2	10.5
Percentage income from annual cash crops	1.3	5.3	0.0	0.0	0.0	1.2	0.0	0.3
Standard error	0.8	4.4	0.0	0.0	0.0	0.8	0.0	0.1
Percentage income from coffee	0.0	4.1	–22.9	0.0	0.6	1.1	0.0	0.0
Standard error	4.2	2.8	51.6	0.0	0.4	1.5	0.0	0.0
Percentage income from other permanent crops	6.9	2.4	4.0	24.4	0.5	4.5	5.2	1.1
Standard error	4.3	1.7	3.6	21.0	0.4	3.9	2.7	1.5
Percentage income from livestock	–3.5	31.0	83.2	–91.2	1.4	0.6	1.3	27.9
Standard error	27.6	8.6	75.4	135.6	1.8	29.6	1.4	7.0
Percentage income from off-farm agricultural work	38.9	13.6	16.7	9.4	76.1	55.5	38.7	4.3
Standard error	8.9	5.5	9.0	7.1	7.3	25.8	17.3	4.8
Percentage income from off-farm nonagricultural work	20.5	16.9	20.1	72.9	2.5	2.9	24.4	13.7
Standard error	14.6	8.2	9.2	77.1	1.2	1.0	9.3	15.1
Percentage income from transfers	34.7	6.6	1.1	103.3	14.0	33.5	19.7	13.0
Standard error	19.1	5.5	10.8	107.8	1.8	12.7	13.8	1.6
Percentage income from patio production	–1.0	1.3	–0.5	–4.1	0.5	–1.8	1.1	0.1
Standard error	1.0	1.4	0.4	2.1	0.3	2.2	0.9	0.3
Percentage net-rent income	–18.1	-8.8	0.0	–49.3	–7.0	–19.5	–0.3	–0.3
Standard error	13.0	7.5	0.0	64.0	3.0	13.2	0.2	0.5
Percentage of poor households[c]	92.6	77.1	99.1	97.3	94.4	95.8	95.2	86.2
Standard error	2.4	10.8	1.0	2.8	4.0	1.5	4.7	14.4
Percentage of extremely and desperately poor households[d]	92.3	75.5	99.1	97.3	91.8	88.4	94.5	77.0
Standard error	2.4	10.9	0.0	0.0	4.6	1.4	17.3	14.6

Note: Because household income is net of costs of production, income from particular sources may be negative (e.g., livestock losses greater than revenues), and the share of total net household income from a particular source may be less than zero or greater than 100%.

[a]In Lps per year.

[b]In US$ per day.

[c]Percentage of households with less than US$1.50 per capita per day.

[d]Percentage of households with less than US$1.00 per capita per day.

of land on average, which is slightly more than households in cluster 4, but they are the poorest group among all households, earning an average of just US$0.15 per person per day (Table 4.8). The explanation lies in the fact that these households rely nearly exclusively on basic grains production that has low profitability (partially caused by limited natural assets in terms of quantity and quality). They tend to be located at high elevations and on steep slopes, and have little in terms of other productive assets (Table 4.9). These households also have relatively low physical assets and work little outside their own farms, despite somewhat above-average market access. The probability of a female head is highest for this cluster (see also Box 4.2).

The livelihoods strategy of households in cluster 4 includes basic grains and off-farm employment. These households have the smallest landholdings, with less than 2 ha of farmland of which less than 20 percent is owned, on average. Thus, they need to rent land, but overall land access is limited. By working off-farm they are able to earn more than double (US$0.41 per person per day; see Table 4.8) the income of cluster 3 households, in spite of an above-average dependency ratio and below-average education (Table 4.9). It seems that limited access to land "pushes" these households to be more entrepreneurial and seek out alternative employment opportunities, in or out of agriculture. On the other hand, differences between the cost of buying food and the price received by farmers for food crops sold may mean that this group may be worse off than cluster 3 in terms of food security, despite higher calculated income per capita.

Households in cluster 5 on average have over 10 ha of land, of which nearly two thirds is kept either fallow or under forest. Their livelihood strategy is similar to households in cluster 4 but with considerably more land, so they hire (rather than sell) labor and devote a larger share of their time to livestock activities (which are less labor intensive than crop activities). However, their average daily per capita income of US$0.29 is about 30 percent less than that of households in cluster 4, but higher than households in cluster 3, which produce just basic grains. Apparently by working their own farms, these households have lower incomes than those seeking off-farm employment. On the other hand, these households may be less vulnerable to risks than those in cluster 4, as they have greater wealth and more diversified income sources. Education is slightly above average for this cluster, whereas both physical and natural assets, other than land, are about average (Table 4.9).

Households in cluster 6 represent a small group of permanent crop producers with small landholdings (2.4 ha on average) who devote most of their land and labor to intensive tree crop production such as fruits, oil palm, and so forth. These households have the highest average incomes in the sample (US$0.66 per capita per day). Table 4.9 shows that they have smaller than average household sizes and are located in favorable agroecological areas with high population densities, high rainfall, and good access to paved roads and public transportation, all of which are important for diversification into higher-value permanent crop production.

Finally, most households in cluster 7 are vegetable producers who allocate most of their labor to working on their own farms. Despite being relatively far from a paved road in areas with relatively low population densities, these households are close to a nonpaved road (Table 4.9), which gives them a sufficient degree of market access to specialize in vegetable production. Somewhat surprising is the fact that their average daily income during the survey year (US$0.38 per capita) was only slightly above average despite an average farm size of about 4.5 ha, good market access, and the relatively high educational level of the household heads. A possible explanation for the low incomes of this group is their dependence on middlemen for the marketing of their vegetables.

Table 4.9 Summary statistics regarding asset-related household characteristics, by livelihood strategy

	Total sample		Livelihood strategy 1		Livelihood strategy 2	
	Mean	Standard error	Mean	Standard error	Mean	Standard error
Number of households	376		59		28	
Natural capital						
Farm size[a]	14.3	2.4	45.6	9.4	5.0	0.8
Area of owned land[a]	7.7	1.6	22.7	6.7	3.2	0.8
Percentage of land with formal title	29.4	4.1	36.9	8.9	56.7	12.1
Rainfall during primary season[b]	1,005	17	943	37	917	41
Altitude[c]	2,231	127	1,220	198	3,845	169
Rainfall deficit secondary season[d]	14	3	18	7	1	1
Soil fertility[e]	2,846	67	2,834	159	2,572	171
Physical capital						
Value of machinery, equipment, and transportation[f]	3,698	631	6,023	1,113	6,590	3,612
Value of livestock[f]	19,703	5,077	87,336	23,146	4,029	848
Human capital						
Household size	6.1	0.2	6.1	0.5	6.2	0.6
Dependency ratio[g]	0.9	0.1	0.6	0.1	0.7	0.2
Female-headed household dummy (%)[h]	9.4	3.0	14.8	7.1	1.4	1.5
Percentage of female adults in the household[i]	49.7	1.3	44.7	2.1	51.4	5.1
Age of the household head	47.2	1.4	46.3	2.4	40.7	3.4
Median years of schooling[j]	2.8	0.2	3.4	0.3	1.9	0.3
Migration index[k]	0.08	0.02	0.21	0.07	0.17	0.13
Participation in programs/organizations (%)						
Conservation training[l]	17.7	4.5	7.4	5.3	29.2	13.7
Agricultural training[m]	7.6	1.9	5.8	5.2	5.5	3.9
Conservation extension[n]	7.3	2.1	7.0	3.9	1.0	1.0
Agricultural extension[o]	5.4	1.6	3.3	3.0	2.5	2.5
Participation in producers' organization[p]	7.2	3.7	7.9	5,5	14.2	7.5
Participation in rural bank/*caja rural*[p]	8.2	1.9	0.4	0.4	20.7	13.1
Participation in NGO program[p]	9.9	2.9	2.5	1.8	21.2	13.6
Geographic determinants of comparative advantage						
Population density[q]	104	12	51	9	81	10
Road density[r]	4.0	0.3	2.1	0.3	5.7	0.4
Market access[s]	73	7	99	13	85	14

[a]In manzanas (1 mz = 0.7 ha).
[b]In mm during the *primera* season (May–September); own calculations based on data from the nearest point in the atlas CD of CIAT (CIAT 2001).
[c]Average altitude of sampled plots on each farm as measured by a GPS in feet above sea level.
[d]Average for sampled plots during the *postrera* season (October–January) in mm (see footnote 33, Chapter 3).
[e]Approximated by potential maize yields (see footnote 34, Chapter 3).
[f]Value in Lps.
[g]Ratio defined as follows: (number of household members < 12 and > 70 years) / (number of household members between 12 and 70 years).
[h]1 = female head of household.
[i]Females > 12 years of age as a percentage of total household size.
[j]Median years of schooling of household members older than 7 years.
[k](Total number of months lived outside the household by adult household members) / (total number of adult household members × 12 months).

3		4		5		6		7	
Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
68		85		116		12		8	
3.4	0.4	2.7	0.4	15.3	4.0	3.4	0.4	6.3	1.3
1.2	0.6	0.55	0.3	9.3	3.4				
18.5	7.9	14.8	9.2	34.6	8.5	58.4	15.8	6.7	2.5
976	41	1,058	45	1,008	25	1,576	74	1,060	53
2,009	265	2,412	232	2,569	240	1,661	182	734	111
33	11	11	4	6	2	9	4	9	10
2,806	166	2,939	94	2,835	140	2,935	183	3,315	263
2,884	947	422	159	4,757	1,527	1,726	930	671	144
4,105	1,148	1,994	660	10,394	3,097	892	371	5,547	1,076
5.7	0.4	5.9	0.4	6.4	0.3	4.6	0.5	7.1	0.9
1.1	0.2	1.2	0.2	0.9	0.1	0.9	0.2	0.5	0.2
17.7	9.4	12.9	9.7	2.2	1.3	0.0	0.0	3.2	4.1
50.4	3.2	46.2	1.9	52.4	2.4	60.7	3.3	56.3	3.0
43.9	3.6	45.3	3.5	52.3	2.5	49.9	6.7	47.9	1.5
2.9	0.5	2.3	0.3	3.0	0.2	2.5	0.8	2.5	0.4
0.02	0.01	0.03	0.02	0.05	0.01	0.003	0.003	0.0008	0.001
1.8	1.0	16.1	8.7	32.5	10.7	23.5	15.2	0.0	0.0
4.1	1.7	4.5	2.5	10.5	4.3	38.7	21.1	12.8	12.5
12.5	7.5	5.2	3.0	7.2	3.9	18.2	16.6	0.0	0.0
1.8	1.2	4.6	2.7	8.3	4.0	37.4	21.2	0.5	0.6
0.3	0.3	1.3	0.9	14.4	10.5	0.6	0.7	0.0	0.0
13.9	5.6	5.7	3.1	7.8	2.9	0.0	0.0	10.8	12.0
2.4	1.4	14.9	8.2	12.7	6.4	18.2	16.6	0.0	0.0
132	28	125	33	99	23	263	103	52	9
4.0	0.4	4.8	0.6	4.3	0.5	3.3	0.2	2.0	0.2
60	13	62	18	74	8	88	60	24	18

[l] Dummy variable (= 1 if household has received conservation training, 0 if not).
[m] Dummy variable (= 1 if household has received crop technology training, 0 if not).
[n] Dummy variable (= 1 if household has received conservation extension visits, 0 if not).
[o] Dummy variable (= 1 if household has received crop technology extension visits, 0 if not).
[p] Dummy variable (1 = household participates, 0 otherwise).
[q] Number of persons per km^2 in the community based on the 2001 population census (INE 2002).
[r] Kilometers of roads/km^2 in the community (data obtained from CIAT 2001).
[s] Data obtained from CIAT. They reflect travel time from the center of the community to the nearest market outlet, using the most common form of transportation. The variable's values are based on geographical distance, road quality, slope, and natural barriers. The higher the value of the variable, the worse is market access.

Box 4.2 Gender in the Hillside Areas

Female-headed households (FHH) differ from male-headed households (MHH) in five characteristics:

1. *Household income:* on average, FHH have about 30 percent lower income than MHH.
2. *Importance of livestock:* FHH earn 23 percent of their household income from producing and selling livestock and livestock products, as opposed to only 8 percent for MHH.
3. *Proportion of rented land:* while MHH rent approximately 27 percent of their total farm area, the share is only 18 percent for FHH.
4. *The amount of government transfers received:* Even though FHH receive levels of remittances that are comparable to MHH, FHH receive less than half the level of government transfers (including pensions, school subsidies, pregnancy support, nutritional support, old-age support, and fellowships) of MHH.
5. *Degree of diversification:* Crop diversification is less common in FHH than MHH. FHH do not grow annual crops other than basic grains. Very few FHH grow permanent crops.

Some of these differences between MHH and FHH can be explained by the many competing demands for female labor.

CHAPTER 5

Econometric Results

In this chapter we present the estimation results of the econometric model described in Chapter 3 by category of dependent variable. In particular, we investigate the determinants of household livelihood strategies, land management practices, and use of labor and external inputs, and the impacts of these decisions on agricultural productivity and income. First we present the results of econometric analyses, which show partial effects of each variable on the response or outcome of interest, controlling for other factors. Then we present the total predicted impacts of selected changes in policy variables and other explanatory factors. Our discussion focuses on factors that are statistically significant at the 5 percent level or better, unless otherwise noted.

Livelihood Strategies

A multinomial logit model[39] was used to identify the main determinants of household-level livelihood strategies. The model included both biophysical and socioeconomic explanatory variables. Biophysical variables included in the model represent a household's natural capital and include the amount of land that is owned by the household; rainfall during the period May–September (*primera*) as an important indicator of agricultural production potential during the main growing season; rainfall deficit during the period October–January as the main limitation to crop production in the secondary growing season (*postrera*); altitude;[40] and soil fertility.[41] We also included the share of the household's total land holdings (owned plus rented in plus borrowed) that has a title as an explanatory variable. Ownership of land is expected to stimulate on-farm activities whereas a lack of own land can be expected to stimulate a household to look for off-farm work. The expected effects of land titles are various (Barham, Boucher, and Useche 2002; Boucher, Barham, and Carter 2002). Land that is titled can be used as collateral and therefore may stimulate livelihood strategies that require larger amounts of financial capital. Farmers may also be willing to invest more in land that is titled land than in land that has no title, even though this may be true for any land that is owned, with or without formal title.

[39]A multinomial logit model (Greene 1990) is appropriate when the dependent variable consists of multiple categories (e.g., livelihood strategies) and in our case relates the probability that a household chooses a given livelihood strategy to a number of asset-related explanatory variables.

[40]Based on Pender et al. (2001) we a priori expect altitude to have positive influence on the probability of cluster 2 (coffee farmers).

[41]See footnote 34 in Chapter 3 for an explanation of our methodology for measuring soil fertility.

The socioeconomic explanatory variables included in the model represent households' human capital and geographic determinants of comparative advantage. As explained in Chapter 3, we decided not to include other types of capital because of concerns that these may be endogenous to the choice of livelihood strategy.

Geographic determinants of comparative advantage are represented by population density, market access, and road density. Following Pender, Scherr, and Durón (2001), we expect population density to influence both crop choice and production technologies. Whereas improved market access can be expected to stimulate production of cash crops, the effect on adoption of conservation practices is often ambiguous (Pender et al. 2004). Higher road densities tend to lead to improved market access and are expected to stimulate cash crops. Moreover, better road connections are expected to facilitate off-farm work.

Human capital variables in the model include household size, dependency ratio, gender and age of the household head, proportion of adults in the household who are female, and the median education of household members. Size of the household determines the availability of family labor and as such is expected to influence both livelihood strategy and technology use. For example, to maximize employment for its members, large households may want to adopt a livelihood strategy that centers on working on the own farms. They may also find it easier to adopt labor-intensive production technologies. On the other hand, a high dependency ratio may be indicative of labor scarcity, which may stimulate livelihood strategies that require less family labor. Given a number of specific characteristics of female-headed households and the many competing demands on the time of female household heads (see Box 4.2 in Chapter 4), gender of the household head is expected to influence the choice of livelihood strategy. A higher proportion of female adults in the household decreases the availability of non-domestic labor (the fact that most female adults have children restricts their options for non-domestic work) and therefore may influence the household's choice of livelihood strategy as well as technology choice. Finally, households in which the average level of education is higher can be expected to have more members working off-farm (often in better remunerated occupations) and be more receptive to new technologies.

The results of our multinomial logit model are presented in Table 5.1. The coefficients represent the effect of each explanatory variable on the ratio of the probability of the household selecting the particular livelihood strategy considered, relative to the probability of selecting the basic grains only strategy.[42] In general terms the results suggest that livelihood strategies are associated with differences in both biophysical conditions (natural assets) and socioeconomic conditions (human assets and geographic determinants of comparative advantage) that jointly determine the way in which an individual household puts these assets to use. Note that there is little difference between the mean proportions of each cluster and the mean predicted probabilities of each cluster, indicating good fit of the model to the data.

To ease interpretation of the model results, we report the marginal effects of the

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[42] More precisely, the coefficient of a particular explanatory variable represents the impact of a unit change in that variable on the natural logarithm of the ratio of probabilities ("odds ratio") of the strategy represented by the particular column of the table, relative to the basic grains strategy. By exponentiating the coefficients, we can find the impact of the variables on the odds ratio. For example, the coefficient of –3.965 for the effect of female household head on the coffee producer strategy means that the odds ratio of choosing the coffee relative to the basic grains strategy for a female-headed household is less than 2 percent ($e^{-3.965} = 0.019$) of the odds ratio for a male-headed household. For any coefficients less than zero, the explanatory variable reduces the odds ratio, while for any coefficients greater than zero, the variable increases the odds ratio.

Table 5.1 Determinants of livelihood strategies (multinomial logit regression)[a]

Explanatory variables[b]	Livestock producers (cluster 1)		Coffee producers (cluster 2)		Basic grains farmers/ farmworkers (cluster 4)		Basic grains/livestock/ farmworkers (cluster 5)	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Natural capital								
Altitude	–0.00095	0.00127	0.00214**	0.00091	–0.00067	0.00086	0.00059	0.00092
Summer rainfall	0.00165	0.00148	–0.00475	0.00373	0.00091	0.00104	0.00147	0.00117
Rainfall deficit secondary season	–0.00825	0.00681	–0.02432	0.01728	–0.01835***	0.00660	–0.02628***	0.00779
Soil fertility	0.00032	0.00046	–0.00012	0.00049	0.00062*	0.00034	0.00039	0.00043
Owned land	0.20251***	0.05255	0.02757	0.11059	–0.52985*	0.27374	0.19469***	0.05277
Human capital								
Median schooling	0.07184	0.21005	–0.29940	0.18422	–0.17611	0.17871	0.23879	0.16939
Household size	0.10445	0.12784	0.01362	0.16298	–0.03015	0.10747	–0.00991	0.10817
Dependency ratio	–1.58529**	0.63010	–1.11618*	0.56986	–0.21426	0.46409	0.20291	0.41592
Female household head	–0.39686	0.78423	–3.96464***	1.50166	–1.29206	0.85613	–3.71278***	0.92736
Percentage of female adults	1.57140	1.77866	1.05151	2.97171	–2.53423	1.81363	4.52182**	1.97987
Age of household head	0.00332	0.02173	0.00336	0.02309	0.02956	0.01983	0.06815***	0.01724
Geographic determinants of comparative advantage								
Market access	0.13767*	0.07121	0.12030	0.07902	0.09003	0.05954	0.09858	0.06820
Road density	–0.08178	0.25495	0.85183**	0.33211	0.51997**	0.21144	0.31098	0.21955
Population density	–0.00805	0.00630	–0.02907***	0.00858	–0.00429	0.00414	–0.01523***	0.00503
Land tenure								
Percentage of land with title	–1.00209	1.15818	1.48094	1.04121	0.82708	1.19322	–0.74270	0.91573
Intercept	–3.45762	2.99668	–0.24639	2.98190	–3.05683	2.40960	–9.31718***	3.08394
Number of observations	59		28		85		116	
Proportion of observations	0.1791		0.0845		0.2142		0.3231	
Mean predicted probability of livelihood	0.1791		0.0845		0.2142		0.3231	

[a]Basic grains farmers (n = 68) is the excluded category. Strategies 6 and 7 were not analyzed due to limited numbers of observations. Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity.

[b]See Table 4.9 (Chapter 4) for definitions of explanatory variables.

*, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

explanatory variables on the probability of each livelihood strategy cluster (including the basic grains only category) in Table 5.2.[43]

Basic grains only farms are more likely in areas where rainfall deficits during the secondary season are greater, among households that own less land, if the household head is female, or younger, and in areas of higher population density. In general, subsistence basic grains production is the dominant livelihood strategy in more marginal and land-scarce areas, and among poorer and younger households.

Livestock production is more likely as the livelihood strategy in areas where the secondary season rainfall deficit is greater, among households with more land, lower dependency ratio, or a younger head. These findings are consistent with the theory of comparative advantage; that is, crop production is less profitable relative to livestock production in areas of marginal rainfall, provided that households have access to enough land to support their livestock.

The diversified basic grains/livestock/farmworker strategy is more common in areas with less rainfall deficit in the secondary season and among households that own more land, have a higher dependency ratio, are male headed but have more female adults, and where the head is older. This livelihood strategy appears to represent one destination in a household's life cycle; as households become more mature and acquire more land, female adults, and dependents, they seek and are able to diversify into off-farm activities as well as livestock. The opportunities for such diversification are greater in areas of higher agricultural potential because the main opportunities for off-farm employment are in agricultural activities on other farms, and such opportunities are likely to be more available in areas of higher agricultural potential.

Few factors are statistically significant predictors of the probability of either the coffee production or basic grains/farmworkers livelihood strategies. Only road density has a weakly significant positive association with coffee production. This association could reflect reverse causality: construction of roads may be greater where coffee is produced because of construction of roads by the Honduran Coffee Institute (IHCAFE).

Income Per Capita

Model Design

Annual per capita household income was hypothesized to depend on the household's livelihood strategy and asset portfolio. Compared to the multinomial logit model used in the previous section to explain the household's livelihood choice, we expanded the set of asset-related explanatory variables in a number of ways:

First, we included physical capital (i.e., the value of the farm machinery, equipment, and transportation assets owned by the household and the value of its livestock holdings) in the set of explanatory variables in the income regressions.

Second, we widened the set of human capital–related explanatory variables to include participation in training (separate variables for training in the use of conservation practices and more general cropping

[43] As described in the previous footnote, the interpretation of coefficients in a multinomial logit model can be difficult. The problem is compounded by the fact that the coefficients do not indicate what the net impact of a change in any explanatory factor on the probability of any particular category would be, as they do not account for the fact that the probability of the omitted cluster (basic grains only production) can change as a result of changes in the explanatory variables. The marginal effects reported in Table 5.2 address these problems, as they represent the marginal change in the probability of each category resulting from a marginal change in the explanatory variable. In the case of dummy variables (e.g., female-headed household), the marginal effect in Table 5.2 represents the change in the probability of the category from changing the variable from zero to one (e.g., from male- to female-headed household).

Table 5.2 Marginal effects of explanatory variables on probability of livelihood strategies (based on regression in Table 5.1)[a]

	Livestock producers (cluster 1)		Coffee producers (cluster 2)		Basic grains producers (cluster 3)		Basic grains farmers/ farmworkers (cluster 4)		Basic grains/ livestock/farmworkers (cluster 5)	
Explanatory variables	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Natural capital										
Altitude	–.0002169	.00016	.0000209	.00002	–.0000336	.00012	-5.28×10^{-6}	.00001	.0002349	.00018
Summer rainfall	.0000814	.00021	–.0000651	.00005	–.0001822	.00015	-1.75×10^{-6}	.00001	.0001677	.00026
Rainfall deficit secondary season	.0019682**	.00095	–.0000589	.00019	.0028531***	.00097	3.43×10^{-6}	.00005	–.0047658***	.00142
Soil fertility	1.56×10^{-6}	.00006	-4.73×10^{-6}	.00001	–.0000469	.00005	1.82×10^{-6}	.00000	.0000483	.00008
Owned land	.0077132***	.00295	–.0014551	.00102	–.0242181***	.00598	–.0040968	.00578	.0220569***	.00587
Human capital										
Median schooling	–.0169275	.025	–.0050631	.00416	–.0246726	.02195	–.002016	.00362	.0486791	.03063
Household size	.0168918	.01643	8.98×10^{-6}	.00153	–.0019294	.01306	–.0002548	.0007	–.0147167	.02007
Dependency ratio	–.2600907***	.07488	–.0102995	.00977	.0262542	.05021	–.0002379	.00255	.2443738***	.08716
Female household head	.2753881*	.16437	–.0114175	.00861	.3788361**	.17184	.0008819	.00473	–.6436886***	.07816
Percentage of female adults	–.3032317	.24489	–.0236718	.03917	–.4848707*	.28223	–.0341193	.06317	.8458935**	.38373
Age of household head	–.0076796**	.00305	–.0004552	.00042	–.0067819**	.00299	–.0000916	.0002	.0150082***	.00337
Geographic determinants of comparative advantage										
Market access	.0085825	.00678	.0003191	.00061	–.0137339	.00944	-6.42×10^{-6}	.00028	.0048387	.00988
Road density	–.0517271	.03436	.0071392*	.00437	–.0299766	.0269	.0019051	.00367	.0726594*	.04409
Population density	.0006731	.00102	–.0001899	.00016	.0017635**	.00072	.0000439	.00008	–.0022907*	.00123
Land tenure										
Percentage of land with title	–.0658304	.11968	.0232431	.01472	.0972167	.11906	.0087333	.01152	–.0633628	.1311

[a]Basic grains farmers (n = 68) is the excluded category. Strategies 6 and 7 were not analyzed due to limited numbers of observations. Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity.

*, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

technology training) and extension (again separate variables for extension regarding the use of conservation practices and extension related to general cropping technology).

Third, we included a number of social capital variables, including household participation in producer/*campesino* organizations, savings and credit organizations (rural bank and/or *caja rural*), and NGO programs.

Fourth, and following our arguments in Chapter 1 regarding the need for improved efficiency of public expenditures in rural areas, we specifically addressed the targeting issue, by analyzing how some of the program and policy relevant variables interact with the livelihood strategy variables in generating income.

We ran two different model specifications, one with and the other without interaction variables. The model specification without interaction variables indicates which of the policy-relevant variables are most significant and therefore require better understanding regarding which household types should be targeted when launching public investment programs that address these variables. The model with interaction variables will help us improve our knowledge regarding which household types would benefit most from such public investment programs and help public policy targeting.

We tested three different specifications of the income regression without interaction variables, the results of which are shown in Table 5.3. The three specifications of the income model include an ordinary least squares (OLS) model, a median regression (because of concerns about outliers) with bootstrapped standard errors, and an instrumental variables (IV) regression (because of potential endogeneity of some of the explanatory variables). Each of these specifications carries its own potential problems: the OLS model is likely to have some endogenous explanatory variables, the median regression model does not correct for sample weights, and the IV model may be influenced by weak instrumental variables. In the latter model we used the predicted values from the multinomial logit regression as instrumental variables for the livelihoods variables; predicted probabilities of participation for training and extension programs from Probit regressions;[44] and presence of organizations in the community as instrumental variables for the organizational participation variables.[45] First-stage regressions in the IV procedure confirmed the significance of the instruments for all endogenous explanatory variables. Hansen's *J* test of over-identifying restrictions was found not to be significant and therefore confirms the validity of our instrumental variables (see Table 5.3). On the other hand, the Hausman test indicates that the (more efficient) OLS model is preferred to the IV model and thus supports exogeneity of the potentially endogenous explanatory variables. As a result, in Table 5.4 we report only the OLS version of the model with interaction variables.

Model Results

The results confirm that households that follow a mixed basic grains/off-farm work livelihood strategy (cluster 4) earn significantly higher incomes than do pure basic grains farmers (cluster 3) (Table 5.3). There is also some evidence (though statistically weaker) that livestock farmers (cluster 1) also earn higher incomes. We do not find that households pursing the most diversified livelihood strategy (cluster 5) earn higher incomes in Table 5.3 (although there is a weakly statistically significant positive effect in the model with interactions in Table 5.4), possibly because these households still depend heavily on basic grains production (more than those in cluster 4).

The climate variables have insignificant association with income. Nevertheless, they

[44] The results of these Probit regressions are available on request from the authors.

[45] For more details see notes in Table 5.3.

still may have indirect impacts, via their effect on livelihood strategies. For example, even though moisture deficit in the secondary growing season (*postrera*) has a statistically insignificant direct effect on income in the regression, lower moisture deficits significantly increase the probability of a household following a basic grains/off-farm work strategy instead of basic grains only (Table 5.1), which is associated with significantly higher income. All regression specifications (OLS, IV, and median regression) indicate a strong and significant positive effect of soil fertility on income, and again there is also an indirect effect through the livelihood strategies because better soils are (weakly) associated with the basic grains/off-farm work livelihood strategy.

Interestingly, land ownership has a statistically insignificant association with income in all specifications, suggesting that greater land ownership alone does not guarantee higher income. Nevertheless, land ownership indirectly affects income through its effect on livelihood strategies, though these effects are mixed. More land significantly increases the probability of a household following a livestock-based strategy, which is associated with higher income levels in the OLS regression. However, greater land ownership is also associated with lower probability of the household following a basic grains/off-farm work strategy, which obtains higher income. No statistically significant direct or indirect effects of land titling on household income was found.

Regarding physical assets, ownership of machinery and equipment has a significant positive association with income in both OLS and IV regressions. The magnitude of the coefficient in the OLS model (the preferred model) suggests that an additional Lempira invested in equipment contributes 0.071 Lempiras of additional annual income per capita, or about 0.42 Lempiras of total household income on average, considering the average household size of six members. This suggests a high rate of return to investment in machinery and equipment, probably because the utilization of machinery and equipment increases the productivity of both labor and land, the former by speeding up agricultural operations and the latter through facilitating the adoption of improved production technologies. Further, equipment for storing, processing, and transporting agricultural products facilitates the marketing of agricultural products. Livestock ownership, on the other hand, does not have a statistically significant association with household income. The limited apparent impact of livestock assets on income may partially be due to high variance in estimated livestock incomes, which included negative values.[46]

Human capital has less effect on income than expected a priori. One reason for this may be the generally low levels of education in the hillside areas (see Table 4.2 in Chapter 4) and the relatively limited variation in education levels among households. Of our human capital variables, the dependency ratio has the biggest effect on income, and has both a direct negative effect (in both the OLS and IV income regressions) and an indirect negative effect by discouraging the livestock livelihood strategy, which is less likely to be followed by households with high dependency ratios (see Table 5.2). In

[46] Livestock income was calculated as (livestock revenues – livestock costs) where livestock revenue is defined as follows: livestock revenue = net revenue from animal sales minus purchases + value of (meat consumption and sales) + value of (dairy consumption and sales) + revenues for care services provided + change in value of the herd. Livestock costs are defined as the sum of costs associated with animal sales, costs of transportation of meat, cost of milk production, cost of care services used, cost of animal management, and cost of pasture management. Negative estimated livestock income does not necessarily imply measurement errors since livestock income may be highly variable, especially because we are including the effects of changes in stock. Indeed the seven largest livestock farmers all reported surprisingly low income earnings, largely caused by large decreases in reported value of the herd which may partially be linked to animal deaths caused by drought, theft, and so forth.

Table 5.3 Determinants of per capita income (Lps/year)

Explanatory variable	OLS regression[a] Coefficient	OLS regression[a] Standard error	IV regression[a] Coefficient	IV regression[a] Standard error	Median regression Coefficient	Median regression Standard error
Livelihood strategy (cf. basic grains)						
Livestock producer[b]	1,623.5230*	962.5431	70.5572	2,486.5990	32.8428	454.0015
Coffee producer[b]	834.9165	676.4722	1,167.2600	3,829.7530	808.3107*	438.6195
Basic grains/farmworker[b]	1,889.3320***	460.8879	1,330.5710	2,788.5730	788.7442***	251.1165
Basic grains/livestock/farmworker[b]	430.5966	443.9107	–968.0507	3,454.0970	318.5416	268.3193
Natural capital						
Altitude	–0.0220	0.1910	–0.0714	0.3302	–0.0123	0.0953
Summer rainfall (mm)	-0.8352	0.8043	–1.6540	1.2079	–0.5768	0.4508
Rainfall deficit in secondary season	1.1220	4.8257	–2.9611	8.5114	–1.7959	3.3290
Soil fertility	0.8673***	0.2894	1.4020**	0.5553	0.2982**	0.1281
Owned land	–1.3227	14.4535	4.8662	16.3507	12.2127	17.0358
Physical capital						
Value of machinery/equipment (Lps)	0.0713***	0.0211	0.0577**	0.0267	0.0517	0.0335
Value of livestock (Lps)	–0.0037	0.0059	0.0014	0.0066	–0.0041	0.0083
Human capital						
Median years of schooling	88.4105	123.2930	176.7856	155.9783	93.6611	69.3199
Household size	–127.1230	116.4705	–119.2688	125.3083	–23.7948	49.0279
Dependency ratio	–870.6289**	378.4489	–1,124.4160**	544.3765	–84.1046	178.1112
Female household head	–567.4572	646.6149	–843.3355	1,358.9280	176.7366	505.6722
Percentage of female adults	–1,105.4710	1,527.2610	165.7526	2,046.6620	–698.0940	1,036.5910
Age of household head	5.6683	15.1803	18.3637	25.2231	–0.5415	9.3418
Migration index	1,210.7600	1,627.4030	825.1992	1,695.1420	1,099.4230	1,663.7680
Geographic determinants of comparative advantage						
Market access	17.8614	48.3797	53.7810	67.5680	29.2209	21.4537
Road density	–111.4188	116.7664	49.0616	229.9084	52.4529	89.1523
Population density	2.0546	2.4666	3.4383	4.2206	0.1314	1.8710

Participation in programs/organizations						
Conservation training	–251.9122	530.4491	2484.5600	1692.9270	–13.2917	419.8787
Agricultural training	3012.6150**	1375.7960	4059.9010*	2152.7770	104.0036	534.3019
Conservation extension	–381.6559	787.4163	–837.6113	2557.0630	–266.3518	582.6470
Agricultural extension	–686.6864	1140.0850	–1,697.7960	3771.3880	162.6620	653.2229
Producer/*campesino* organization	235.0905	984.0464	–4,805.9990*	2799.4580	–717.9993	512.3013
Rural bank/*caja rural*	176.8674	545.3354	841.3126	1450.5870	–399.1735	335.3132
NGO program	143.3106	653.4940	–1649.3890	1594.3770	567.9256	524.7513
Land tenure						
Percentage of land with title	–157.9594	473.3970	–486.1503	881.7759	–112.2508	371.7585
Intercept	994.1077	1753.8290	–956.3957	2107.8030	739.9411	905.8188
Number of observations	342		342		342	
R^2	0.3149		0.1231[c]		0.1161[d]	
Hansen's *J* test of overidentifying restrictions			$p = 0.4719$			
Relevance tests of excluded instruments						
Livestock producer			$p = 0.0000$***			
Coffee producer			$p = 0.0000$***			
Basic grains/farmworker			$p = 0.0000$***			
Basic grains/livestock/farmworker			$p = 0.0000$***			
Conservation training			$p = 0.0000$***			
Agricultural training			$p = 0.0000$***			
Conservation extension			$p = 0.0561$*			
Agricultural extension			$p = 0.0001$***			
Producers'/*campesino* organization			$p = 0.0033$***			
Rural bank/*caja rural*			$p = 0.0000$***			
NGO program			$p = 0.0000$***			
Hausman test of IV vs. OLS model			$p = 1.0000$			

[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity.

[b]In the IV regression, instrumental variables include predicted probabilities of livelihood strategies (from regression in Table 5.1) and predicted probabilities of participation in programs and organizations from probit regressions including as explanatory variables participation in conservation training by the beginning of 2000, participation in agricultural or crop production training by 2000, existence of a producer or *campesino* organization in the community, existence of a rural bank or *caja rural* in the community, and existence of an NGO program in the community, and the explanatory variables in Table 5.1 reflecting agricultural potential, market access, population density, and human capital. The variables indicating participation in training by 2000 and existence of organizations in the community were also included separately as instrumental variables, in addition to being used to predict probabilities of participation. Full results available from the authors upon request.

[c]Centered R^2.

[d]Pseudo R^2.

*, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

Table 5.4 Determinants of per capita income, including interaction terms (Lps/year)

Explanatory variable	OLS regression[a] Coefficient	Standard error
Livelihood strategy (cf. basic grains)		
Livestock producer	1,186.5730	938.5464
Coffee producer	874.0251	658.4712
Basic grains/farmworker	733.7873**	361.5680
Basic grains/livestock/farmworker	654.8768*	383.3636
Natural capital		
Altitude	–0.1393	0.1841
Summer rainfall (mm)	–0.4716	0.7180
Rainfall deficit in secondary season	2.2529	4.4758
Soil fertility	0.9510***	0.2790
Owned land	5.5853	13.5103
Physical capital		
Value of machinery/equipment (Lps)	0.0072	0.0243
Value of livestock (Lps)	–0.0007	0.0060
Human capital		
Median years of schooling	–25.6262	95.3169
Household size	–232.9582**	96.5350
Dependency ratio	–788.7933**	326.4692
Female-headed household	–79.7882	633.1677
Percentage of female adults	–448.4123	1,230.0750
Age of household head	–10.1592	12.2177
Migration index	1,285.3690	1,714.7940
Geographic determinants of comparative advantage		
Market access	62.1511	39.8495
Road density	–58.2827	102.2556
Population density	5.5956***	1.9414
Participation in programs/organizations		
Conservation training	–445.1712	350.1854
Agricultural training	1,779.4080*	908.1467
Conservation extension	–333.2486	674.4493
Agricultural extension	–639.9922	614.9435
Producers'/*campesino* organization	–779.4486	560.3380
Rural bank/*caja rural*	–46.6406	448.6455
NGO program	131.4425	423.0769
Land tenure		
Percentage of land with title	–131.6669	437.3759
Interaction variables		
Livestock producer × value of machinery/equipment	–0.0006	0.0481
Livestock producer × agricultural training	10,446.7000***	1,687.8050
Coffee producer × value of machinery/equipment	0.5920**	0.0273
Coffee producer × agricultural training	–1,589.2100	1,211.7210
Basic grains/farmworker × value of machinery/equipment	2.2236***	0.3394
Basic grains/farmworker × agricultural training	–538.0840	2,821.6250
Basic grains/livestock/farmworker × value of machinery/equipment	0.1094***	0.0352
Basic grains/livestock/farmworker × agricultural training	–1,303.1760	1,108.0380
Intercept	567.6548	1,498.9580
Number of observations	342	
R^2	0.5339	

[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity.

*, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

the model with interaction terms (Table 5.4), we also find that the dependency ratio has a negative direct effect on income per capita, as does household size (which is not significant in the regressions in Table 5.3). Thus, having more dependents, and possibly larger families in general, appears to reduce income per capita. Regarding the effect of geographic determinants of comparative advantage on household income, we find statistically insignificant direct associations of market access, road density, and population density with income. However, there are indirect effects. For example, road density is significantly associated with higher probability of households pursuing the coffee and basic grains/farmworker strategies, the latter being associated with higher incomes in both the OLS and median regression and the former associated with higher incomes in the median regression. Higher population density reduces the likelihood of households pursuing coffee production or the basic grains/livestock/farmworker strategy, and the former is associated with higher income in the median regression, as mentioned previously, while the latter is associated with higher income in the model with interaction terms (Table 5.4). Thus, road access appears to contribute to higher incomes while population pressure leads to lower incomes, though these effects are via the indirect effect of these factors on households' choice of livelihood strategies.

We find no statistical evidence of an impact of short-term agricultural extension or longer term training focused on conservation on household income, but we do find a large and statistically significant positive association of more general agricultural training with household income (in both the OLS and IV models). The magnitude of this association is quite large: households that have received agricultural training earn more than 3,000 Lps per capita more in income. It is hard to believe that agricultural training could have such a large effect on income, and we must consider alternative explanations. One possibility is the endogeneity of participation in agricultural training; that is, households participating in such training may be those that already have higher incomes. The fact that these results control for many other factors that determine household income, and are robust in the IV model, which addresses the issue of endogenous participation, reduces our concern about this alternative explanation. Another explanation may be that this result is a statistical anomaly, resulting from outliers and errors in estimating income. The results in the median regression model, which is more robust to such errors, provide support for this explanation, given that the coefficient of agricultural training in this model is much smaller and statistically insignificant. However, we do not have full confidence in the median regression model either, because it is not able to account for the sampling probabilities of the households in the sample (hence this regression is not representative of the population of the 19 counties sampled for this study, but only for the sample households). Thus, there may be a positive impact of agricultural training on income, but we cannot be confident of this, and doubt that the impact is as large as the regression coefficients in the OLS and IV regressions suggest.

We also do not find robust statistical evidence that membership in NGO programs, producer organizations, or rural financial institutions have significant impacts on income. In the model with interaction terms we investigated whether the impacts of machinery/equipment and agricultural training vary across the different livelihood strategies, to help assess whether targeting of particular interventions to particular livelihood strategies would be warranted (Table 5.4). We find that the positive impact of machinery and equipment is mainly for households pursuing livelihood strategies involving coffee production, basic grains/farmworker, and basic grains/livestock/farmworker, with the magnitude of the impact being largest for basic grains/farmworkers, followed by coffee producers and households that follow the basic grains/livestock/farmworker strategy. For households pursuing off-farm employment, farm equipment may yield high returns by enabling them to spare labor for more remunerative off-farm opportunities, as well as possibly contributing to agricultural employment opportunities off their own farm (i.e., if the household members use their own equipment when working for other farmers). For households pursuing coffee production, ownership of equipment such as a sprayer is likely quite important to the profitability of the enterprise. Our results concerning the determinants of the value of perennial crop production (Table 5.9, discussed below), which show large impacts of external inputs such as fertilizer, pesticides, and herbicides on perennial production, support the argument that equipment to apply such inputs is a profitable investment in coffee production. Machinery and equipment appear to be much less remunerative for households pursuing basic grains or livestock production only.

In the model with interaction terms, we find that agricultural training has a significant positive association with incomes for basic grains only producers (incomes per capita of basic grains producers are 1779 Lempiras higher among those who have received training), though the effect is smaller than in Table 5.3 and only weakly statistically significant. We find a very large and strongly significant positive association of training with incomes of livestock producers (+10,447 Lempiras with training). Again, it is hard to believe that training could have such a large impact on these producers' incomes, and these results are not robust in a median regression version of the model.[47] Thus, if there are positive impacts of agricultural training programs, these positive impacts are greatest for livestock producers.

Adoption of Sustainable Land Management Practices

The determinants of land management practices are shown in Table 5.5. Three practices are analyzed—use of no burning, zero or minimum tillage, and incorporation of crop residues. Other land practices, including use of mulching, manure, and others, were not sufficiently common to permit reliable estimation of the parameters of the probit model specified in equation (4) in Chapter 3.[48] The regressions are estimated using parcel-level data, because this is the level at which data on these land management practices were collected. Subsequent regressions on external input use, labor use, and crop

[47]In the median regression version of the model with interactions, the coefficients of agricultural training and training interacted with livelihood strategies were statistically insignificant. The only statistically significant coefficient in that regression was the interaction of equipment/machinery ownership with the basic grains/farmworker livelihood strategy, for which the coefficient was positive and of similar magnitude to that reported in Table 5.3. Thus we have confidence that the returns to equipment and machinery are substantially higher for households in the basic grains/farmworker category, but less confidence in the other interaction results. These regression results are available from the authors on request.

[48]With a relatively small number of positive observations of the dependent variable and many dummy variables in a probit model, it often occurs that the dependent variable is always zero or always positive for one of the values of a given dummy variable. In this case, the model cannot be estimated with that explanatory variable included, and the STATA software automatically drops that variable and the observations for which the response is perfectly predicted by the dummy variable, and re-estimates a smaller version of the model. Effectively the model is deterministic for some observations, so a smaller stochastic model is estimated. This procedure resulted in a large number of dropped observations in the regressions for mulching and manure. Although these regressions are not reported, they are still used to determine predicted values of the probability of use of these practices, which are used as instrumental variables in the IV estimation of equation (1) in Chapter 3 (and discussed in section 5.6 below). Some of the predictions from such models are deterministic (i.e., for the observations that were dropped based on certain values of the dummy variables in the full model). The results of these regressions are available on request.

Table 5.5 Determinants of land management practices (probit regressions)[a]

	No burning		Minimum/zero tillage		Incorporate crop residues	
Explanatory variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Livelihood strategy (cf. basic grains farmers)						
Livestock producer	0.15738	0.38872	–0.15527	0.41943	–0.43337	0.49689
Coffee producer	–0.35487	0.38024	–0.73369	0.45014	–1.28124***	0.49666
Basic grains/farmworker	0.78447**	0.30482	–1.12176***	0.34645	–0.53155	0.38804
Basic grains/livestock/farmworker	0.50630*	0.29471	–0.62714*	0.36177	–0.31616	0.37204
Natural capital						
Altitude	0.00030***	0.00010	–0.00009	0.00008	0.00012	0.00012
Summer rainfall	0.00103***	0.00038	–0.00173***	0.00045	0.00115*	0.00061
Rainfall deficit in secondary season	0.00225	0.00292	–0.00364**	0.00184	–0.01211***	0.00462
Soil fertility	–0.00019	0.00014	0.00012	0.00013	–0.00055***	0.00019
Owned land	0.00251	0.00539	–0.00801	0.00566	–0.02065*	0.01055
Physical capital						
Value of machinery and equipment	0.00000	0.00001	–0.00002**	0.00001	0.00000	0.00001
Value of livestock	–0.00001	0.00000	–0.00001	0.00000	–0.00001	0.00001
Human capital						
Median years of schooling	–0.08699*	0.04756	–0.00228	0.04719	0.03489	0.07323
Household size	–0.02897	0.03625	0.03212	0.03475	–0.14574***	0.05228
Dependency ratio	0.16564	0.15702	0.06804	0.15746	–0.51304**	0.24315
Female-headed household	0.13520	0.41749	–0.53418	0.38125	0.96794**	0.43695
Percentage of female adults	–0.14056	0.67252	–0.08206	0.67728	–0.88524	0.92686
Age of household head	0.00872	0.00693	0.00382	0.00632	–0.00097	0.00886
Migration index	1.66290***	0.48703	0.45864	0.38737	0.73742	0.56510
Geographic determinants of comparative advantage						
Market access	0.01110	0.02158	–0.04532**	0.02099	0.01773	0.02513
Road density	0.24360***	0.06445	–0.18260**	0.07627	0.36662***	0.08917
Population density	–0.00084	0.00077	–0.00107	0.00111	–0.00244*	0.00126
Participation in programs and organizations						
Conservation training	0.24561	0.28844	0.91708***	0.25133	0.27376	0.34648
Agricultural training	0.47078	0.42046	–0.68528**	0.34801	–1.98802***	0.64474
Conservation extension	-0.33692	0.42501	–0.47262	0.31764	1.26840***	0.44800
Agricultural extension	0.86464**	0.38445	0.83674**	0.36259	2.19605***	0.43258
Producers'/*campesino* organization	0.09204	0.37328	0.23775	0.35666	–1.59090**	0.63683
Rural bank/*caja rural*	0.31194	0.30474	–0.83068**	0.34971	–1.80687***	0.41727
NGO program	–0.16339	0.33625	0.30088	0.27397	1.50439***	0.48059
Parcel characteristics						
Area of parcel (mz)	0.00803*	0.00458	0.01253	0.00921	0.02927***	0.00957
Travel time from parcel to residence (minutes)	0.00294*	0.00172	–0.00202	0.00235	–0.00525	0.00352
Travel time from parcel to road (minutes)	–0.00327	0.00481	–0.01164*	0.00700	0.00246	0.00512
Position on hill (cf. bottom)						
Top of hill	1.12731***	0.40867	–1.29756**	0.59294	0.19879	0.61334
Hillside	0.14117	0.23112	0.11731	0.23401	0.68288***	0.25952
Slope (cf. flat)						
Moderate slope	0.19763	0.25252	–0.11885	0.26331	–0.80551***	0.27468
Steep slope	–0.22478	0.31361	0.46503	0.32946	–1.33237***	0.41959
Land tenure						
Percentage of land with title	–0.14375	0.36723	0.39666	0.43907	–0.79819	0.58310
Plot tenure (cf. usufruct ownership)						
Full title	–0.14709	0.27352	–0.16568	0.40627	0.17501	0.52359
Occupied communal land	0.10696	0.38146	0.28144	0.47464	–0.38417	0.52371
Borrowed plot	–1.06753***	0.27888	0.11227	0.27148	–0.29208	0.32117
Rented or sharecropped	–0.87832***	0.32504	–0.05103	0.31612	–0.20013	0.32900

(continued)

Table 5.5—Continued

	No burning		Minimum/zero tillage		Incorporate crop residues	
Explanatory variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Prior investments on parcel						
Stone wall	1.08242***	0.36211	0.24601	0.41272	1.22839***	0.42266
Live barrier or fence	0.66462**	0.29597	0.81895***	0.28247	–0.55983*	0.28509
Trees planted	–0.77211***	0.27057	0.83221**	0.32330	–0.39188	0.46935
Land use in 1999 (proportion of parcel area; cf. basic grains)						
Other annual crops	–3.32715***	1.05913	–1.61588**	0.76402	0.35532	0.61075
Coffee	–1.33549***	0.34968	–1.80552***	0.40774	–2.11164***	0.58072
Other perennial crops	0.15966	0.35542	–1.61227***	0.43222	–1.69658***	0.63848
Unimproved pasture	–0.58040*	0.32005	–1.82105***	0.48260	–0.64926	0.39474
Improved pasture	0.44644	0.51457	–1.78035***	0.60140	0.39004	0.58035
Fallow	–1.37974***	0.29793	–0.60730**	0.30670	–1.29574***	0.32590
Forest	–0.37226	0.49586	–1.48522***	0.52589	–0.89019**	0.43228
Intercept	–3.09006***	0.94312	2.57981***	0.83330	0.56157	1.28975
Number of observations	776		776		776	
Proportion of positive observations	0.3377		0.2321		0.1711	
Mean predicted probability of positive observations	0.3424		0.2419		0.1641	
Hausman test of exogeneity of livelihood strategies and participation in programs/organizations (OLS vs. IV linear version of models)	$p = 0.9945$		$p = 1.0000$		NE	
Hansen's *J* test of overidentifying restrictions in IV linear model	$p = 0.7624$		$p = 0.8606$		$p = 0.6861$	

Note: NE means the Hausman test could not be computed due to a negative value of the test statistic. *, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity and non-independence of observations from different parcels from the same household (clustering).

productivity were estimated at the plot level, as these data were collected at the smaller plot level.[49]

No Burning

Many types of factors influence whether no burning is practiced, including livelihood strategy, natural capital, human capital, social capital (participation in programs and organizations), geographic determinants of comparative advantage, parcel characteristics, land tenure, and prior land investments and land use. Among natural capital variables, no burning is more common at higher elevation and where there is more rainfall in the primary (summer) rainy season (*primera*). The association of no burning with higher rainfall may be related to higher intensity of cultivation in areas of better agroclimatic conditions, which could reduce the need for burning to clear land. Another possible factor may be the increased risk of runoff as a result of higher rainfall, and the concomitant higher potential payoff of no burning.

No burning is more common among households for whom migration is important,

[49]Recall that a parcel is defined as a contiguous piece of land with a single tenure status, but possibly more than one land use, whereas a plot is a subunit of a parcel that has one land use (e.g., annual or perennial crop production, not both—unless these are planted in a mixed cropping or intercropped system).

perhaps because this practice can be labor saving (Deugd 2000). Households pursuing the basic grains/farmworker livelihood strategy are more likely than basic grains farmers to use no burning (and basic grains/livestock/farmworkers are more likely at the 10 percent level), possibly for the same reason (because households pursuing these livelihood strategies may have higher labor opportunity costs than pure basic grains farmers). No burning is more common in areas having better road access. Higher labor opportunity costs in such areas are likely to play an important role here, as may better access to information about this technology where road access is better.

No burning is more common among farmers participating in agricultural extension but, surprisingly, is not significantly affected by whether the household participated in conservation training or extension programs. This suggests that more general agricultural extension programs are providing training on this practice, even if it was not mentioned by survey respondents as a specific emphasis of these programs.

No burning is more common on parcels that are on top of a hill than at the bottom, consistent with the earlier result that it is more common at higher altitude. It is more common on farmers' own usufruct land than on borrowed or leased-in parcels, probably because of greater concern on the part of owners about the damage to investments and longer term soil fertility caused by burning. Consistent with this explanation, no burning is more common on parcels where prior investments in stone walls or live fences or barriers exist. However, it is less common on parcels where trees have been planted. This may be because no burning was seen by survey respondents as a specific practice that is associated with basic grains production, because burning is normally used to clear land for basic grains production. Thus, respondents may not have reported using "no burning" as a practice where other land uses such as perennial crops were more important, even if they were not using burning. Consistent with this, we find that no burning is more common where basic grains are a larger component of the prior land use than for most other land uses.

Zero/Minimum Tillage

Use of zero or minimum tillage is affected by many of the same factors as no burning, though not always in the same way. It is less common among basic grains/farmworkers and (weakly significantly) among basic grains/livestock/farmworkers than among farmers pursuing basic grains production as their sole livelihood strategy. This is likely because this technology is labor intensive (Schipper et al. 2005) and because households pursuing these other livelihoods likely have higher labor opportunity costs than basic grains farmers.

Use of zero or minimum tillage is less common where there is more rainfall in the summer, but also less common where there is more of a rainfall deficit in the second season. Where there is more summer rainfall, weeds are likely to be a greater problem, making it more difficult for farmers to do without tillage. The negative association of zero/minimum tillage with the rainfall deficit in the second season is puzzling. Perhaps in areas where moisture deficit is severe, there is less need to be concerned about weeds, so farmers may use neither tillage nor specific zero or minimum tillage methods of weed control (which require labor and/or herbicides). In results discussed later, we find that both herbicide use and hired labor are lower in areas with greater moisture deficits, consistent with this explanation.

Not surprisingly, use of zero/minimum tillage is less likely among households that own more machinery and equipment, since some of their equipment is used for tillage. We find no effect of any of the human capital variables on use of zero/minimum tillage, suggesting that human capital constraints are not binding for this type of technology.

Use of zero/minimum tillage is less likely in areas further from an urban market and in areas of higher road density. These findings are somewhat contradictory. They reflect the fact that market and road access can have ambiguous effects, depending on how they affect commodity prices, input prices and access, and labor opportunity costs at the farm level. By helping to increase commodity prices, reduce external input prices, and improve access to inputs and credit, better market and road access will tend to increase adoption of technologies that use external inputs, such as use of herbicides as part of a zero/minimum tillage practice. On the other hand, such improvements also can increase the opportunity costs of labor, thus tending to reduce use of labor intensive methods. Which impact dominates depends on how improvements in market and road access affect the prices and availability of these different factors, and which factors are used most intensively by the technology. In this case, it may be that access to an urban market has a greater effect on output and external input prices and availability than on labor opportunity costs, while road access within rural areas may have greater impact on local labor opportunity costs.

Farmers who participated in conservation training programs are, not surprisingly, more likely to use this practice, as are farmers who participated in general agricultural extension. As noted above, general agricultural extension programs appear to be providing training in conservation practices, even if these are not a specific emphasis. However, households participating in longer term general agricultural training are less likely to use zero/minimum tillage. Apparently such training programs are promoting other technologies or practices to a greater extent. Given the positive association of agricultural training with higher incomes of livestock producers, as noted earlier, it may be that these programs are more oriented to technologies for livestock production than to crop technologies such as conservation tillage. Households that are members of a rural bank or *caja rural* are less likely than others to use zero/minimum tillage. This may reflect the fact that such financial organizations often are associated with and promote rural nonfarm activities, which will tend to increase labor opportunity costs and thus may reduce households' interest in labor intensive farming practices. Zero/minimum tillage is less likely on top of a hill than the bottom of a hill. In valley bottoms, soils tend to be heavier and more difficult to till, so that zero/minimum tillage will be relatively more attractive there as a result. Zero/minimum tillage is more common on parcels where prior investments in live fences or barriers or tree planting have been made. Again, this may be because such parcels are more difficult to till, because of the root systems of the trees and shrubs. It also may be because these investments help to reduce weed problems, by increasing soil cover and shade.

Zero/minimum tillage is much more common on parcels where basic grains are the dominant land use. As with no burning, it appears that zero/minimum tillage is seen as a specific practice that is an alternative to the usual tillage practice for basic grains production, rather than simply the absence of tilling the land. Thus, even though tillage is not used in perennial crops, most survey respondents do not report using "zero tillage" on their perennial crops.

Incorporation of Crop Residues

Households whose livelihood strategy is mainly coffee production are less likely to incorporate crop residues than basic grains producers. This is not surprising, as this technology is not used for coffee production.

Crop residue incorporation is less common in areas where the moisture deficit in the second season is higher, and less common where soils are more fertile. In moisture deficit areas, crop residues are likely scarcer and needed as livestock fodder (because of less available grazing resources resulting from moisture limitations) or as a source of fuel, limiting farmers' interest in incorporating them. Where soils are more fertile, the productivity benefit of incorporating crop residues may be more limited.

Crop residue incorporation is less common in larger households and households with a higher dependency ratio, and more common in female-headed households. The negative association with household size is unexpected, as a larger household's family labor endowment is expected to favor labor intensive land management practices such as this. These results may reflect greater demand for such resources and greater poverty among larger households: larger households need more fuel for cooking and other purposes and poorer households may have less access to fodder for their animals or fuel sources, and thus may be less interested in incorporating crop residues. The positive association of female household head with crop residue incorporation was also unexpected; we are not sure why this was observed. The negative effect of the dependency ratio could be reflecting tighter labor constraints in households with more dependents, which inhibit adoption of this practice, but could also be due to greater poverty and scarcity of fodder and fuel that may be associated with high dependency.

Crop residue incorporation is more likely in areas with greater road density, but less likely (weakly statistically significant) in areas with higher population density. Greater road access may increase the returns to labor invested in labor-intensive land management practices such as crop residue incorporation, although this is contrary to our findings with regard to the impacts of road access on minimum/zero tillage. The negative association with population density likely reflects greater scarcity of fodder and fuel resources in more densely populated areas.

Crop residue incorporation is more likely to be used by households that participate in conservation extension programs or more general agricultural extension programs, but less likely to be used by households that participate in longer term agricultural training programs. The negative association with agricultural training but positive association with agricultural extension is similar to our findings with regard to zero/minimum tillage, and again may reflect more focus of agricultural training on technologies of benefit to livestock producers, and more focus of agricultural extension on conservation technologies for crop production. Households who participate in nongovernmental organization (NGO) programs are more likely to incorporate crop residues, while those who belong to producers or *campesino* organizations and those who belong to a rural bank or *caja rural* are less likely to incorporate residues. While NGOs appear to promote such conservation practices, other producer and financial organizations appear to promote more focus on other uses of household labor and resources.

Crop residues are more likely to be incorporated on larger plots, possibly because tillage using animal traction is easier on larger plots. Probably for a similar reason, crop residue incorporation is more common on hillsides than the bottom of a hill (soils tend to be heavier and harder to till at the bottom) and more common on relatively flat slopes than on moderate or steep slopes. Crop residue incorporation is more likely where stone walls have been constructed on the parcel, perhaps because of the complementary nature of stone walls and crop residue incorporation, as both measures help to conserve soil and soil moisture. Crop residue incorporation is less likely where other land uses besides annual crops are important. This is not surprising, as tillage practices are used mainly for annual crops.

Use of External Inputs

The determinants of external inputs use are shown in Table 5.6. The types of inputs considered include inorganic fertilizer, herbicides, and insecticides.[50]

[50] We also ran a similar regression for "other external inputs," which included fungicides, combined fertilizer and herbicides, and other input combinations. However, the mixed nature of the "other inputs" category complicates

Table 5.6 Determinants of external inputs use (probit regressions)[a]

Explanatory variable	Inorganic fertilizer Coefficient	Inorganic fertilizer Standard error	Herbicides Coefficient	Herbicides Standard error	Insecticides Coefficient	Insecticides Standard error
Livelihood strategy (cf. basic grains)						
Livestock producer	0.24385	0.33729	0.21818	0.34109	0.12659	0.29487
Coffee producer	–0.72896**	0.35246	–0.12077	0.41501	–0.22746	0.32889
Basic grains/farmworker	–0.30532	0.27920	–0.27314	0.25385	0.13032	0.22316
Basic grains/livestock/farmworker	–0.20071	0.29239	0.46907*	0.27815	–0.14757	0.25291
Natural capital						
Altitude	0.00017**	0.00007	–0.00052***	0.00008	0.00006	0.00007
Summer rainfall	–0.00159***	0.00036	–0.00025	0.00040	–0.00002	0.00036
Rainfall deficit in secondary season	–0.00684***	0.00239	–0.00663***	0.00201	–0.00065	0.00210
Soil fertility	–0.00002	0.00012	0.00034***	0.00013	0.00020	0.00013
Owned land	0.00153	0.00418	0.00445	0.00626	0.00230	0.00516
Physical capital						
Value of machinery/equipment	0.00000	0.00001	–0.00002**	0.00001	0.00000	0.00001
Value of livestock	–0.00001**	0.00000	0.00000	0.00000	0.00001***	0.00000
Human capital						
Median years of schooling	0.07650*	0.04435	–0.01894	0.05580	0.02446	0.04305
Household size	0.02229	0.02992	–0.06532*	0.03620	0.00537	0.02959
Dependency ratio	0.06531	0.14127	0.14857	0.13189	0.22809*	0.11992
Female-headed household	–0.11398	0.26028	–0.78988**	0.36775	0.07899	0.33464
Percentage of female adults	0.33151	0.52414	–0.21848	0.67677	–0.19563	0.54842
Age of household head	0.00623	0.00490	0.00406	0.00607	0.00595	0.00523
Migration index	0.06662	0.50657	0.31695	0.29395	0.10429	0.28872
Geographic determinants of comparative advantage						
Market access	0.00086	0.01665	0.03392*	0.01945	–0.02532	0.01841
Road density	0.14663***	0.05692	0.10496	0.06553	–0.01933	0.05458
Population density	0.00274***	0.00071	–0.00166*	0.00094	–0.00095	0.00094
Participation in programs/organizations						
Conservation training	0.28481	0.20604	0.33112	0.25495	0.25118	0.21249
Agricultural training	–1.14930***	0.28119	–1.42124***	0.38735	–0.57943	0.35292
Conservation extension	–0.38432	0.27825	0.07895	0.30864	–0.29906	0.27114
Agricultural extension	0.88001***	0.25951	0.59633*	0.32583	0.25873	0.29539
Producers'/*campesino* organization	–0.61477*	0.35906	1.14188**	0.45618	0.32364	0.28632
Rural bank/*caja rural*	0.23303	0.22161	0.13556	0.28924	0.17544	0.22915
NGO program	0.60055**	0.26727	0.35659	0.29006	0.22364	0.26005
Plot characteristics						
Area of plot (mz)	0.08706	0.05288	0.10967*	0.06646	–0.06643	0.06016
Travel time to residence (minutes)	–0.00094	0.00149	0.00407**	0.00176	–0.00361	0.00221
Travel time to road (minutes)	–0.01522***	0.00460	–0.01188***	0.00345	–0.00550	0.00544
Position on hill (cf. bottom)						
Top of hill	0.14670	0.32653	0.03752	0.38394	–1.25268***	0.39065
Hillside	–0.04619	0.22641	0.01308	0.25168	–0.32624	0.26849
Slope (cf. flat)						
Moderate slope	–0.16549	0.31865	0.33244	0.25131	–0.27555	0.28283
Steep slope	–0.22884	0.38720	0.42436	0.34020	–0.00102	0.34659
Land tenure						
Percentage of land with title	–0.21848	0.34606	–0.91379**	0.35691	–0.60509*	0.34671
Plot tenure (cf. usufruct ownership)						
Full title	0.15064	0.33770	0.65886**	0.28834	0.38159	0.29076
Occupied communal land	–0.28004	0.33807	–0.22612	0.31046	0.02242	0.33259
Borrowed	–0.26556	0.24419	0.20992	0.23766	–0.11311	0.23831
Rented or sharecropped	0.71788**	0.32525	0.61644***	0.21811	0.49782*	0.27828

Table 5.6—Continued

	Inorganic fertilizer		Herbicides		Insecticides	
Explanatory variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Prior investments						
Stone wall	0.27007	0.23714	0.00710	0.25687	–0.23022	0.26912
Live barrier or fence	0.21597	0.26706	0.03059	0.24456	–0.06302	0.22287
Trees planted	–0.69943**	0.35332	–0.21190	0.37590	–0.19980	0.29206
Land use—perennials	–1.20583***	0.20985	–1.56304***	0.20343	–0.07245	0.31670
Season (cf. 2000 1st season)						
2001 primary season (*primera*)	–0.14172	0.11307	0.05500	0.10067	0.14097	0.10686
2000 secondary season (*postrera*)	–1.11640***	0.27255	0.14039	0.13267	0.48980**	0.19836
2000 tertiary season (*apante*)	–0.38285	0.37800	–0.40316	0.35660	0.33461	0.35060
Intercept	0.25613	0.70615	–0.38856	0.81986	–1.66106**	0.82324
Number of observations	1,728		1,728		1,728	
Proportion of positive observations	0.4161		0.4166		0.1028	
Mean predicted probability	0.4174		0.4183		0.1029	
Hausman test of exogeneity of livelihood strategies and participation in programs/organizations (OLS vs. IV linear version of models)	$p = 1.0000$		NE		NE	
Hansen's J test of overidentifying restrictions in IV linear model	$p = 0.6042$		$p = 0.1296$		$p = 0.1014$	

Note: NE means the Hausman test could not be computed due to a negative value of the test statistic. *, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity and non-independence of observations from different plots from the same household (clustering).

Fertilizer

Coffee producing households are less likely to use fertilizer than those whose livelihood is focused on basic grains production. Consistent with this, fertilizer use is also less likely on perennial than annual plots, and on plots where trees are planted. On the one hand, these results are surprising, since we find also that perennial crop production responds very well to fertilizer use (results reported later in this chapter). On the other hand, coffee prices were at an all-time low during the survey period and many coffee farmers had cut back on input use.

Fertilizer is more likely to be used at higher elevation and less likely to be used in areas with higher summer rainfall and areas with greater moisture deficit. The negative effect of moisture deficit on fertilizer use is as expected, since moisture constraints can limit the uptake of plant nutrients. Consistent with this, we also find that fertilizer use is less likely during the drier second season than in the summer season. During the summer season, rainfall is generally adequate throughout the study area, so the negative effect of rainfall on fertilizer use during this season is probably related to problems of runoff and leaching in areas of excessive summer rainfall.

Fertilizer use is less likely in households that own more livestock. This may be because manure provided by livestock serves as a substitute or because households with

a clear-cut interpretation of the results which are therefore not reported here (but available from the authors on request). Similar to the regressions for mulching and manure, the "other inputs" regression results are still used to determine predicted values of the probability of use of "other inputs," which are used as instrumental variables in the IV estimation of equation (1) in Chapter 3 (and discussed later).

more livestock focus more on livestock production and farm their crops less intensively.

None of the human capital variables have a statistically significant (at 5 percent level) impact on fertilizer use, though education has a weakly significant (10 percent level) positive impact, similar to the findings by Nkonya et al. (2004) and others in Africa. More educated households may be more aware of the benefits of fertilizer use and its correct application, or better able to finance its purchase.

Fertilizer use is more likely in areas of higher road density and on parcels closer to a road. These results are consistent with our expectation that better market access facilitates use of such external inputs and is in agreement with findings for other countries (e.g., Uganda; see Nkonya et al. 2004). Fertilizer use is also greater in more densely populated areas. This is consistent with Boserup's (1965) theory of population induced intensification, as population pressure makes it difficult to restore soil fertility though long fallow periods.

Not surprisingly, participants in agricultural extension programs and NGO programs are more likely to use fertilizer. Participants in agricultural training programs are less likely to use fertilizer. As noted earlier, such programs appear to be more focused on livestock production than crop production.

Interestingly, fertilizer is more likely to be used on leased-in plots than on owner-operated plots. This may be because short-term tenants lack incentive to use fallow or manure as soil fertility management measures because these involve a greater element of investment, requiring a period of several years to yield their full returns. In addition, cash tenants have to earn sufficient income from the plot to be able to cover the rental cost of the land, whereas owner-operators may feel less pressure to farm as intensively. Even sharecroppers may farm leased-in land more intensively than landlords farm their own plots because of the transaction costs of monitoring the tenant, which require that higher yields be attained on leased land to offset such costs (Pender and Fafchamps 2001).

Herbicides

We find no strong statistically significant (at 5 percent level) effect of livelihood strategies on use of herbicides, but households pursuing the basic grains/livestock/farmworker livelihood strategy are somewhat more likely than basic grains farmers to use herbicides (weakly significant at 10 percent level). This may reflect higher labor opportunity costs of this group of farmers relative to basic grains farmers and/or their greater ability to finance herbicide purchases.

Herbicides are less likely to be used at higher elevation and where moisture deficits are greater, but more likely to be used where soils are more fertile. Weeds may not grow as well at higher elevation or where there are moisture deficits, but may be more of a problem in more fertile soils.[51]

Surprisingly, farmers who own more titled land are less likely to use herbicides. Herbicides are also found to be less likely to be used on perennial crops. The negative effect of land title may relate to credit access—by increasing access to credit, land titles may promote nonfarm activities rather than increased investments in agricultural inputs. Consistent with this, we find later that some types of agricultural labor use are less for households that have a larger share of titled land. In contrast to the negative association of share of land title at the household level with herbicide use, we find that herbicides are more likely to be applied to fully titled plots than to plots under usufruct ownership. This effect was not expected for herbicides, which are a short-term input rather than an investment.

[51]Some weeds thrive in low fertility soils, however. For example, striga is a common problem in nitrogen-deficient soils.

Households that own more equipment are less likely to use herbicides. This is consistent with the finding reported earlier that ownership of equipment is negatively associated with use of zero/minimum tillage, because some farm equipment is used for tillage and weed control.

Female-headed households are less likely to use herbicides than male-headed households. This may reflect tighter cash constraints facing female-headed households, or different attitudes about using agrochemicals among women farmers.

Households who participate in producers' organizations and (weakly significant) agricultural extension are more likely to use herbicides, while those participating in agricultural training programs are less likely to use herbicides. The impacts of agricultural extension and training programs are similar to the impacts of these programs on fertilizer use, probably for the same reasons.

Plot location also influences herbicide use. Herbicides are less likely to be used on plots further from a road, but more likely to be used further from the farmer's residence. The positive impact of road access on use of herbicides is consistent with the general expectation that road and market access promote greater use of external inputs, by reducing input costs relative to output value. The negative association with access to the residence may reflect the fact that herbicides substitute for labor used in weeding, as labor is more costly to provide on more remote plots because of time required to access such plots.

As with fertilizer use, herbicides are more likely to be used on leased-in plots than on owner-operated plots, probably for the same reasons. Herbicides are also less likely to be used on perennial than annual crops, perhaps because weeds are less of a problem for perennial crops, owing to suppression of weeds by shade and perennial leaf mulch.

Insecticides

Insecticides are more likely to be used by households that own more livestock. This may be because insect pests pose problems for livestock as well as crops, and/or because households with more livestock are better able to afford to buy insecticides. Insecticides are more likely to be used in the second than in the first rainy season, and less likely to be used on the top of a hill than on the bottom. Perhaps pests are more of a problem in these temporal and spatial settings.

As with herbicides, insecticides are less likely to be used by households with a greater share of titled land, and more likely to be used on leased-in land than on owner-operated land, probably for the same reasons. However, these results are only weakly statistically significant (10 percent level).

Labor Use

The determinants of labor use per manzana are presented in Table 5.7. We investigate determinants of the use of both family labor and hired wage labor.[52] We discuss results for both together, to consider possible substitution or complementarity among them.

Natural capital factors affect labor use. More hired wage labor is used at higher elevation, perhaps because labor-intensive cash crops are more likely to be grown at higher elevation. More family labor is used in areas where there is higher rainfall, probably because this requires greater efforts to weed and harvest, owing to greater biological productivity in such areas. Less hired labor is used (weakly significant at 10 percent level) in areas with greater moisture deficit, probably for a similar reason. Less family labor is used in the second season

[52]As noted in Chapter 3, we also ran a regression predicting use of hired piece rate labor and use the predicted values as an instrumental variable in the instrumental variable estimation of equation (1), but do not report the results here because of the small number of positive observations.

Table 5.7 Determinants of labor use (tobit regressions)[a]

	Family labor use (days/mz)[b]		Hired wage labor (days/mz)	
Explanatory variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Livelihood strategy (cf. basic grains)				
Livestock producer	–3.6100	6.3205	–10.2410*	5.7737
Coffee producer	–7.9222	7.9934	–9.9206	8.2371
Basic grains/farmworker	0.9790	5.7601	–1.5032	5.1500
Basic grains/livestock/farmworker	4.4992	6.4382	–8.2507	5.0360
Natural capital				
Altitude	0.0000	0.0020	0.0036**	0.0016
Summer rainfall	0.0224***	0.0086	–0.0097	0.0086
Rainfall deficit in secondary season	0.0236	0.0445	–0.0706*	0.0422
Soil fertility	–0.0012	0.0029	–0.0009	0.0026
Owned land	0.0014	0.0813	–0.0814	0.0734
Physical capital				
Value of machinery/equipment	–0.0003*	0.0002	0.0004***	0.0001
Value of livestock	–0.0001*	0.0000	0.0002***	0.0000
Human capital				
Median years of schooling	–0.7326	1.2437	1.4747	0.9697
Household size	2.1538***	0.6154	–3.6721***	0.6894
Dependency ratio	–4.5176	3.3445	1.4636	2.6294
Female-headed household	21.9849**	10.2728	–1.7671	5.8047
Share of female adults	–36.8114**	15.7084	–1.6982	12.6690
Age of household head	–0.1752	0.1356	–0.1783	0.1176
Migration index	–8.6723	8.4198	27.6126***	7.3490
Geographic determinants of comparative advantage				
Travel time index to urban market	–0.1512	0.2912	–0.1648	0.3387
Road density	2.8645**	1.2747	–0.0396	1.4126
Population density	–0.0113	0.0207	0.0308	0.0196
Participation in programs and organizations				
Conservation training	6.1096	5.4900	–2.2017	5.7117
Agricultural training	–8.2117	6.5839	3.2135	8.1599
Conservation extension	2.9481	6.5536	6.3576	5.8325
Agricultural extension	4.4464	7.1235	–19.3779**	8.2663
Producers'/*campesino* organization	0.5494	7.9785	11.4193	9.2664
Rural bank/*caja rural*	–9.4726	7.2311	15.4300**	6.1757
NGO program	5.7011	4.5959	–0.8278	5.2728
Plot characteristics				
Area of plot (mz)	–6.3779***	1.8164	2.0685*	1.1181
Travel time to residence (minutes)	–0.0273	0.0339	0.0675	0.0454
Travel time to road (minutes)	–0.1288*	0.0733	0.2385***	0.0797
Position on hill (cf. bottom)				
Top of hill	–19.1856	13.3887	11.6028	9.4709
Hillside	10.0316*	5.3255	–9.9754**	4.8401
Position on slope (cf. flat)				
Moderate slope	–6.3936	5.6521	3.6049	4.7771
Steep slope	1.1072	6.8305	–8.8178	5.9452
Land tenure				
Percentage of land with title	–16.5949**	7.8756	1.4751	8.0345
Plot tenure (cf. usufruct ownership)				
Full title	12.7344	9.0516	11.9276	7.9424
Occupied communal land	7.5671	4.7140	–3.0546	8.2915
Borrowed	–1.0708	5.6541	2.7660	4.1424
Rented or sharecropped	–3.7512	5.5005	–2.3022	7.9656
Prior investments on plot				
Stone wall	–10.0947*	6.0544	–7.9917	5.1394
Live barrier or fence	–0.3419	4.3768	5.0433	3.7515
Trees planted	–2.6454	5.7880	–6.5343	5.6434

Table 5.7—Continued

Explanatory variable	Family labor use (days/mz)[b] Coefficient	Family labor use Standard error	Hired wage labor (days/mz) Coefficient	Hired wage labor Standard error
Land use—perennials	–13.7584**	5.8836	–14.5078***	4.5511
Season (cf. 2000 1st season)				
2001 first season	–0.4063	2.2118	–0.1287	1.8184
2000 2nd season	–18.1700***	3.3959	–3.2221	3.9658
2000 3rd season	5.6504	11.4525	–8.2231	5.7946
Intercept	49.5369**	21.0043	20.0737	14.9900
Number of positive observations/total number of observations	1,600/1635		665/1635	
Hausman test of exogeneity of livelihood strategies and participation in programs/organizations	$p = 1.0000$			
Hansen's J test of overidentifying restrictions	$p = 0.0687$			

Note: *, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.
[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity and non-independence of observations from different plots from the same household (clustering).
[b]Exogeneity of livelihood strategies and participation in programs and organizations in the family labor regression was tested using a Hausman test comparing an OLS and IV version of the model (the instrumental variables for livelihood strategies and participation in programs and organizations were the same as those described in footnote b of Table 5.3), and was not rejected ($p = 1.000$).

(*postrera*) than the first (*primera*), also for a similar reason.

Land tenure also affects labor use. Households with a larger share of their land titled use less family labor on a given plot, possibly because such households have more off-farm and nonfarm opportunities as a result of better access to credit, as mentioned previously.

Physical assets affect labor use. Households that own more machinery/equipment or livestock use less family labor (significant for both variables at 10 percent level) but more hired wage labor. Wealthier households are apparently more able to substitute hired labor and equipment for family labor inputs.

Human capital also affects labor use. Not surprisingly, larger households use more of their own family labor and less hired labor. Having a larger family labor supply reduces the need to hire labor. Female-headed households use more family labor than male-headed households, but households with a larger share of female adults use less family labor. Apparently female-headed households must devote extra labor to food production, while male-headed households with more female labor may be able to diversify into other off-farm activities. These results are consistent with the findings (see Table 5.2) regarding the impacts of these variables on household livelihood strategies: female-headed households are less likely than male-headed households to be able to diversify into the category of basic grains/livestock/farmworker, while households with a higher ratio of female adults are more likely to diversify into this livelihood strategy. Households with members spending more time migrating for employment use more hired labor (but not significantly less family labor) in crop production, probably because they can better afford to hire labor.

Geographic determinants of comparative advantage also influence labor use. In areas of greater road density, use of family labor is greater, possibly reflecting greater returns to investment of family labor where road access is better. This effect apparently outweighs the effect of a possible increase in the opportunity cost of family labor as a result of better road access.

Participation in programs and organizations also influences labor use. Households with access to agricultural extension use less hired wage labor. This may be because such programs are targeted to poorer farm households that are less able to hire labor. Members of a rural bank or *caja rural* use more hired wage labor, suggesting that access to finance helps farmers afford to hire labor.

Plot characteristics also affect labor use. On larger plots, less family labor and more hired labor is used. Transaction costs of hiring and monitoring workers are probably less problematic for operations on fewer and larger plots than on smaller plots. Surprisingly, hired labor use is greater on plots that are further from a road. The reason for this is not clear. Part of the cost of hired labor is the cost of getting to the plots, which may greater for more remote plots. By contrast, use of hired labor is less on hillsides, possibly because hillsides are more difficult to cultivate and/or hillside farmers are less able to hire workers.

Family labor and hired wage labor use are lower on perennial crops than annual crops, consistent with findings elsewhere (see, e.g., Nkonya et al. 2004). Once established, perennial crops are apparently less labor intensive than annuals, except during harvesting.[53]

Value of Crop Production

The determinants of the value of crop production per manzana are estimated for annual crops and perennial crops in Tables 5.8 and 5.9, respectively. In each case, three models are presented: two structural models (the OLS structural model and the IV structural model) according to equation (1), and the OLS reduced form model according to equation (5) in Chapter 3.[54] In both tables, the results of tests of the IV structural models support the instrumental variables and identifying restrictions used in those models (i.e., the instrumental variables are relevant and the overidentifying restrictions are not rejected), but the Hausman test fails to reject the OLS structural model as the preferred model. Hence we will focus our discussion on the results of the OLS structural models, which are more efficient. We also discuss the results of the reduced form models.

Annual Crops

Of the most common land management practices used, only manure use is found to have a weak statistically significant impact on annual crop production (at 10 percent level) in both the OLS and IV models (Table 5.8). The coefficient of manure use in the OLS model (0.4546) implies that use of manure increases the predicted value of crop production by 58 percent.[55] The impact of manure is even larger in the IV model.

Several external inputs contribute significantly to higher production in the OLS model, including fertilizer, herbicides, and insecticides, with estimated impacts ranging from +26 percent for herbicide use to +32 percent for fertilizer use. These coefficients are not statistically significant in the

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[53] Labor use in these regressions is pre-harvest labor.

[54] The explanatory variables excluded from the structural models in Tables 5.8 and 5.9 were based on joint hypothesis (Wald) tests in unrestricted versions of both OLS and IV models, as explained in Chapter 3.

[55] That is, since the dependent variable is in natural logarithmic form, the impact of the dummy variable is given by exp(c_i), where c_i is the coefficient of dummy variable D_i, and exp( ) is the exponential function. In this case exp(0.4546) = 1.5755.

Table 5.8 Determinants of value of annual crops output per manzana (least squares and instrumental variables regressions)[a]

	OLS structural model		IV structural model		OLS reduced form	
Explanatory variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Land management practices						
No burning[b]	–0.06792	0.156465	0.24194	0.27528		
Minimum/zero tillage[b]	–0.05630	0.12789	0.03107	0.25541		
Incorporate crop residues[b]	0.06894	0.16798	–0.08689	0.25648		
Mulch[b]	–0.40335	0.30345	0.15300	0.41821		
Manure[b]	0.45460*	0.23776	0.72593*	0.39888		
External inputs						
Fertilizer[b]	0.28082**	0.11488	0.20976	0.27135		
Herbicide[b]	0.22801**	0.10973	0.41945	0.29840		
Insecticide[b]	0.24062**	0.11930	–0.36350	0.71325		
Other inputs[b]	0.08759	0.11812	0.45145	0.40347		
Labor inputs						
Family labor (days/mz)[b]	0.00543***	0.00141	0.00428	0.00576		
Hired wage labor (days/mz)[b]	0.01112***	0.00333	0.01613**	0.00723		
Hired piece labor (Lps/mz)[b]	–0.00007	0.00026	–0.00100	0.00177		
Season (cf. first season 2000)						
Primary season 2001	–0.09977	0.08580	–0.12463	0.09155	–0.10057	0.08036
Secondary season 2000	0.12141	0.12654	0.05234	0.23858	–0.08473	0.11730
Livelihood strategy (cf. basic grains)						
Livestock producer					–0.23380	0.23894
Coffee producer					–0.42670**	0.21057
Basic grains/farmworker					–0.43157**	0.17994
Basic grains/livestock/farmworker					0.04117	0.17657
Natural capital						
ln(altitude)	–0.02845	0.07864	0.01599	0.09483	0.02737	0.09545
ln(summer rainfall)	–0.15494	0.21561	–0.04020	0.24549	0.24348	0.25789
Rainfall deficit secondary season	–0.00626***	0.00214	–0.00524**	0.00230	–0.00611***	0.00228
ln(soil fertility)	0.19937	0.19235	0.37721	0.26935	0.03371	0.20348
Owned land					–0.00347	0.00241
Physical capital						
Value of machinery/equipment					0.00001	0.00000
Value of livestock					0.00000	0.00000
Human capital						
Median years of schooling					–0.03098	0.03143
Household size					0.02320	0.02419
Dependency ratio					–0.20449**	0.10098
Female-headed household					0.00805	0.16145
Share of female adults					0.07845	0.35903
Age of household head	–0.00061	0.00401	0.00023	0.00431	–0.00548	0.00389
Migration index					0.37866*	0.19972
Geographic determinants of comparative advantage						
Market access					0.00499	0.00872
Road density					–0.01589	0.03974
Population density					–0.00023	0.00055
Participation in programs/organizations						
Conservation training					0.17179	0.13273
Agricultural training					0.06963	0.21795
Conservation extension					0.34996	0.24163
Agricultural extension					–0.04053	0.21263
Producers'/*campesino* organizations					0.27846	0.25003
Rural bank/*caja rural*					–0.01289	0.18553
NGO program	–0.27237	0.25503	–0.17495	0.32503	–0.17440	0.17057

(continued)

Table 5.8—Continued

Explanatory variable	OLS structural model: Coefficient	OLS structural model: Standard error	IV structural model: Coefficient	IV structural model: Standard error	OLS reduced form: Coefficient	OLS reduced form: Standard error
Plot characteristics						
ln(plot area)	–0.17524**	0.08775	–0.28650**	0.13557	–0.31440***	0.07859
Travel time to residence (minutes)					–0.00036	0.00115
Travel time to road (minutes)					0.00291	0.00438
Position on hill (cf. bottom)						
Top	0.28868	0.22257	0.29311	0.24655	0.46062	0.29004
Hillside	–0.30291**	0.13837	–0.29523	0.19923	–0.33862**	0.16445
Slope (cf. flat)						
Moderate	0.40698***	0.15716	0.33047*	0.19053	0.40648**	0.19344
Steep	0.34977*	0.19735	0.25703	0.24958	0.31614	0.21165
Land tenure)						
Percentage of land with title					0.37852	0.25223
Plot tenure (cf. usufruct ownership)						
Full title					0.00273	0.26370
Occupied communal land					–0.32453	0.34176
Borrowed plot					0.07229	0.16237
Rented/sharecropped plot					0.07311	0.19977
Prior investments on plot						
Stone wall	–0.06216	0.23110	–0.09600	0.27324	–0.12243	0.26490
Live barrier or fence	0.18327	0.18752	–0.09745	0.17171	0.07861	0.18174
Trees planted	0.17513	0.16283	0.02449	0.19624	–0.16110	0.17488
Intercept	6.56722***	2.21250	3.91298	2.55770	5.56534**	2.57767
Number of observations	1,164		1,127		1,162	
R^2	0.2545		0.1631		0.2528	
Wald test of excluded variables	p = 0.3947		p = 1.000			
Hansen's J test of overidentifying restrictions			p = 0.8173			
Relevance tests of excluded instruments						
No burning			p = 0.0000***			
Minimum/zero tillage			p = 0.0000***			
Incorporate crop residues			p = 0.0000***			
Mulch			p = 0.0000***			
Manure			p = 0.0000***			
Inorganic fertilizer			p = 0.0000***			
Herbicide			p = 0.0000***			
Insecticide			p = 0.0022***			
Other inputs			p = 0.0000***			
Family labor			p = 0.0000***			
Hired wage labor			p = 0.0000***			
Hired piece labor			p = 0.0002***			
Hausman test of OLS vs. IV model			p = 0.4427		p = 0.1370[c]	

Note: *, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.
[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity and non-independence of observations from different plots from the same household (clustering).
[b]Instrumental variables used in the structural IV model include predicted values of each of the land management practices, input uses, and labor types from the regressions reported in Tables 5.5 (plus the ones for mulching and manure), 5.6 (plus the one for other inputs), and 5.7 (plus the variables in the reduced form that were excluded from the structural model).
[c]Test of exogeneity of livelihoods and participation in programs and organizations in the reduced form model.

Table 5.9 Determinants of value of perennial crops output per manzana (least squares and instrumental variables regressions)[a]

	OLS structural model		IV structural model		OLS reduced form	
Explanatory variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Land management practices						
No burning[b]	0.86841***	0.24690	0.68061	0.53733		
Minimum/zero tillage[b]	0.12134	0.28455	0.49370	0.82442		
Incorporate crop residues[b]	–0.55484	0.35857	–0.51798	0.61859		
Mulch[b]	0.25666	0.39745	0.75121	0.83371		
Manure[b]	–1.50113	0.99156	–1.52835	1.18355		
External inputs						
Fertilizer[b]	1.43689***	0.25978	1.70060***	0.42781		
Herbicide[b]	0.94603**	0.46414	0.72656	1.12530		
Insecticide[b]	1.34909***	0.20998	–0.45571	2.80747		
Other inputs[b]	1.21779***	0.22873	1.06297**	0.45145		
Labor inputs						
Family labor (days/mz)[b]	0.00234	0.00269	–0.00176	0.00424		
Hired wage labor (days/mz)[b]	0.01459***	0.00338	0.02182***	0.00594		
Hired piece labor (Lps/mz)[b]	–0.00001	0.00004	–0.00029	0.00030		
Livelihood strategy (cf. basic grains)						
Livestock producer	–1.11916***	0.38519	–0.93606**	0.46669	–0.22720	0.45501
Coffee producer	–1.42228***	0.38045	–1.08429***	0.36577	–1.15578**	0.46416
Basic grains/farmworker	–0.32967	0.32108	0.07751	0.45941	–0.12760	0.47147
Basic grains/livestock/farmworker	–0.78561***	0.22983	–0.46677	0.30168	0.01192	0.39051
Natural capital						
ln(altitude)	–0.47894**	0.22357	–0.54111	0.33314	0.24999	0.20885
ln(summer rainfall)	0.05464	0.68158	0.07850	0.74751	–1.42876*	0.74538
Rainfall deficit secondary season	–0.01762***	0.00493	–0.01650**	0.00767	–0.01157	0.00734
ln(soil fertility)	1.16059**	0.46990	0.90831	0.57090	2.19770***	0.81084
Owned land	–0.02028***	0.00420	–0.01893***	0.00575	–0.01475***	0.00559
Physical capital						
Value of machinery/equipment					0.00002*	0.00001
Value of livestock	0.00002***	0.00000	0.00002***	0.00001	0.00000	0.00001
Human capital						
Median years of schooling	0.16587***	0.05466	0.13198*	0.07018	0.12020*	0.06993
Household size	–0.06774	0.04687	–0.06726	0.04956	–0.01471	0.04671
Dependency ratio	0.31707**	0.14920	0.29917*	0.16935	–0.12972	0.20932
Female-headed household					–0.46433	0.61905
Percentage of female adults	–2.87884***	0.75356	–1.80657*	0.92683	–1.00297	1.28463
Age of household head					–0.01028	0.01124
Migration index					0.12845	0.35649
Geographic determinants of comparative advantage						
Market access	–0.03353*	0.01854	–0.03800	0.02433	0.00074	0.02795
Road density	0.16916**	0.06762	0.13855	0.08954	–0.00164	0.09408
Population density	0.00466*	0.00270				
Participation in programs/organizations						
Conservation training	0.67417**	0.33275	0.48589	0.31691	0.82336	0.53005
Agricultural training	–1.25931***	0.44257	–0.95626	0.60982	–1.50618**	0.59899
Conservation extension	–1.42356***	0.31426	–1.13488***	0.44350	–1.49975***	0.39320
Agricultural extension					0.36879	0.48500
Producers'/*campesino* organizations	1.13074**	0.44036	1.29532**	0.55764	0.50634	0.48157
Rural bank/*caja rural*					0.12837	0.53172
NGO program	0.77885**	0.34797	0.42070	0.60667	0.30771	0.51308

(continued)

Table 5.9—Continued

Explanatory variable	OLS structural model Coefficient	Standard error	IV structural model Coefficient	Standard error	OLS reduced form Coefficient	Standard error
Plot characteristics						
ln(plot area)	0.97522***	0.12199	0.95819***	0.17779	1.19736***	0.18691
Travel time to residence (minutes)	–0.00469	0.00297	–0.00650*	0.00376	0.00182	0.00323
Travel time to road (minutes)	0.00555	0.00648				
Position on hill (cf. bottom)						
Top	–1.41198***	0.34722	–1.32693***	0.50692	–0.38903	0.54143
Hillside	0.43458	0.29154	0.50877	0.34409	0.14637	0.37014
Slope (cf. flat)						
Moderate	–1.24307***	0.36389	–1.24865**	0.50377	–0.96998*	0.49065
Steep	–1.06756**	0.41541	–0.95267*	0.52513	–1.12428	0.72676
Land tenure						
Percentage of land with title					0.74152	0.48960
Plot tenure (cf. usufruct ownership)						
Full title					–0.27858	0.27774
Occupied communal land					–0.11355	0.41377
Borrowed plot					–0.63886	1.56946
Prior investments on plot						
Stone wall	0.64636	0.59362	0.71352	0.73612	0.08395	0.75437
Live barrier or fence	0.17207	0.47399	–0.13851	0.54041	0.46490	0.56137
Trees planted	0.56158**	0.22230	0.52050	0.35189	0.19811	0.34743
Intercept	3.33685	7.14800	5.30303	7.40575	–0.10824	8.15060
Number of observations	217		215		215	
R^2	0.8140		0.7585		0.7166	
Wald test of excluded variables	$p = 0.6815$		$p = 0.8971$			
Hansen's J test of overidentifying restrictions			$p = 0.6081$			
Relevance tests of excluded instruments						
No burning			$p = 0.0000$***			
Minimum/zero tillage			$p = 0.0000$***			
Incorporate crop residues			$p = 0.0000$***			
Mulch			$p = 0.0745$*			
Manure			$p = 0.0000$***			
Inorganic fertilizer			$p = 0.0002$***			
Herbicide			$p = 0.9975$			
Insecticide			$p = 0.6879$			
Other inputs			$p = 0.0000$***			
Family labor			$p = 0.0000$***			
Hired wage labor			$p = 0.0000$***			
Hired piece labor			$p = 0.08018$			
Hausman test of OLS vs. IV model			$p = 0.7513$		$p = 0.9995$[c]	

Note: *, **, *** mean statistically significant at 10%, 5%, and 1% level, respectively.

[a]Coefficients and standard errors adjusted for sampling weights and stratification, and are robust to heteroskedasticity and non-independence of observations from different plots from the same household (clustering).

[b]Instrumental variables used in the structural IV model include predicted values of each of the land management practices, input uses, and labor types from the regressions reported in Tables 5.5 (plus the ones for mulching and manure), 5.6 (plus the one for other inputs), and 5.7 (plus the variables in the reduced form that were excluded from the structural model).

[c]Test of exogeneity of livelihoods and participation in programs and organizations in the reduced form model.

IV model, though the magnitudes of the coefficients are similar or larger for fertilizer and herbicides, suggesting that identification problems in the IV model (which lead to larger standard errors) are mainly responsible for the insignificant results in that model.

Family labor and hired wage labor use also contribute significantly to the value of annual crop production in the OLS model, and the effect of hired wage labor is also significant in the IV model. Hired piece labor has a statistically insignificant impact in both regressions. This is perhaps because piece labor is used more for harvesting than for pre-harvest production activities.

Other factors that affect annual crop productivity (i.e., the value of crop production per manzana after controlling for input use) include rainfall deficit [negative (–) effect], plot size (–), being on a hillside compared to the bottom of a hill (–), and moderately sloped plots compared to flat ones (+). The negative effect of rainfall deficit and being on a hillside are as expected. The positive effect of moderate slope on productivity could be due to better drainage on moderately sloped plots and waterlogging problems on flat plots. The negative effect of plot size could be due to decreasing returns to scale in production at the plot level, differences in plot quality, or errors in measuring plot size.[56] Higher quality land may have been subdivided over time into smaller plots as a result of inheritance practices and higher demand for purchasing or leasing such land. However, errors in measuring plot size could also account for the negative correlation between plot size and value of production per manzana. Any positive error in the measure of plot size would tend to reduce the estimate of production per manzana (because dividing production by a larger area); conversely a negative error in plot size would lead to a higher estimate of production per manzana.

These results indicate that the main factors directly affecting production of annual crops are use of external inputs, manure, rainfall, and topography. Indirectly, many other factors may influence production by influencing use of external inputs and manure. The reduced form model tests which of these factors have significant impacts, whether directly or indirectly. The factors found to have statistically significant impacts in the reduced form model include rainfall deficit (–), the dependency ratio (–), migration (+, significant at 10 percent level), coffee producer and basic grains/farmworker livelihood strategies (–, compared to basic grains strategy), plot size (–), hillside (–), and moderate slope (+). The effects of rainfall deficit, plot size, and topography are similar to those in the structural model. In addition, the household's dependency ratio and livelihood strategy (including migration) have significant indirect effects on annual crops production, with greater dependency ratio and diversification into activities other than basic grains production leading to lower productivity in annual crops production.

These results show that there are costs of income diversification in terms of lost production of annual crops. This does not mean that such diversification is not worthwhile; indeed, our results on determinants of household income (discussed earlier) show that households pursuing some of these more diversified livelihood strategies earn higher income per capita on average. Still, this income gain may involve a potential tradeoff in terms of food security if high costs of transporting and marketing food in hillside areas mean that farmers who are net buyers of food must pay substantially higher prices

[56] Any of the three explanations offered for the negative coefficient of plot size could also explain the negative correlation between family labor use and plot size reported in Table 5.6.

when they purchase it than the prices net sellers of food receive when they sell.

Perennial Crops

Of land management practices, only no burning is associated with significantly higher production of perennial crops in the OLS model (Table 5.9). Based on the estimated coefficient, the impact of no burning is large, with predicted value of production 138 percent higher on perennial plots where no burning is used, controlling for other factors. The coefficient of the no burning variable is not statistically significant in the IV model, though of similar magnitude, again reflecting difficulties of identification in the IV model.

All types of external inputs are associated with statistically significant and quantitatively large positive impacts on perennial production in the OLS model, with these impacts ranging from +158 percent for herbicide to +321 percent for fertilizer. The impacts of two of these variables—fertilizer and other inputs—are also large and statistically significant in the IV model. The insignificant impact of herbicide and insecticide in the IV model may be due to the low predictive power of the instrumental variables in predicting use of these practices; that is, the relevance tests show that the instrumental variables are not statistically significant predictors of these practices ($p = 0.9975$ for herbicide and 0.6879 for insecticide).

Use of hired labor is associated with greater perennial production in both the OLS and IV models. Other types of labor use are not statistically significant determinants of perennial production in either model.

Many other factors are also significantly associated with productivity of perennial crops in the OLS structural model, including altitude (–), rainfall deficit (–), soil fertility (+), area of land owned (–), value of livestock owned (+), schooling (+), dependency ratio (+), share of female adults (–), livelihood strategy (livestock producers, coffee producers, and basic grains/livestock/farmworkers have lower productivity than basic grains producers), conservation training (+), agricultural training (–), conservation extension (–), membership in a producers' organization (+), participation in an NGO program (+), travel time to an urban market (–, 10 percent level), road density (+), plot size (+), plot position of top of hill compared to bottom (–), sloping plot (–), and presence of other trees planted on the plot (+). Most of these results are robust in the IV model.

The reduced form regression yields many results similar to those of the structural models. Factors influencing production of perennial crops, whether directly or indirectly, include summer rainfall (–, 10 percent level), soil fertility (+), land owned (–), schooling (+, 10 percent level), livelihood strategy (coffee producers have lower production per manzana than basic grains producers), agricultural training (–), conservation extension (–), plot size (+), and slope (–).

Many of these findings are as one would expect; for example, the positive effect of soil fertility, participation in some programs and organizations and market and road access on productivity. Others are puzzling, however; especially the finding of lower perennial crop productivity of coffee producers than those classified as basic grains producers. This finding may not be robust due to the small number of perennial plots operated by basic grains producers in our sample (14 plots). However, even when these observations are excluded from the regression, we still find that perennial crop productivity is significantly higher for the basic grains/farmworker livelihood strategy and basic grains/livestock/farmworker livelihood strategy than for the coffee producer livelihood strategy.[57] Perhaps this results

[57] There are at least 30 perennial plots operated by households pursuing each of the other livelihood strategies besides basic grains.

from production of non-coffee perennial crops by households pursuing other livelihood strategies besides coffee production. As suggested by the higher incomes of producers of non-coffee perennial crops (Table 4.8), the returns appear to be higher for other perennials besides coffee, at least during the survey year when world prices were very low.

The (weakly significant) negative association of perennial crop productivity with summer rainfall was also unexpected. Given the weak significance, this result may not be robust. But it may reflect greater problems with pests in more humid areas.

The negative impact of size of land ownership on perennial crop productivity is consistent with a large body of literature showing an inverse relationship between farm size and agricultural productivity in developing countries (e.g., Chayanov 1966; Bardhan 1973; Sen 1975; Berry and Cline 1979; Carter 1984; Feder 1985; Bhalla 1988; Benjamin 1995; Barrett 1996; Heltberg 1998; Lamb 2003; Nkonya et al. 2004), and suggests that labor or management constraints or land quality variations limit productivity of larger landholders.

The negative association of some types of agricultural training and extension programs with perennial crop productivity may also be due to management and other constraints, combined with the emphasis of these programs. As noted in our discussion of other results, agricultural training programs appear to be focused less on improvements in crop production than on livestock production. Given this, and the management and resource constraints that perennial crop producers face, it is not completely surprising that such programs could have a negative impact on perennial crop production. Similarly, conservation extension programs appear to focus more on practices suited to basic grains production, such as incorporation of crop residues, than on practices suited to perennial crops. These results illustrate that training and extension programs may involve tradeoffs, reducing productivity of some commodities even as they promote greater productivity and sustainability of other activities. This does not mean that such programs should be avoided, but such possible tradeoffs should be taken into consideration. In any case, there seems to be a need for additional curricula for training and extension aimed at different types of farm households.

Finally, the results suggest that several types of capital are complementary to perennial crops production, including natural capital, livestock, and human capital (education). Investments in such assets may therefore contribute to higher income from perennial crops production, as well as to increases in other sources of income.

Summary of Econometric Results

Table 5.10 summarizes the qualitative associations found in most of the econometric analyses between selected explanatory variables and the response and outcome variables investigated. Here we briefly recap the main findings, based on that table, as well as other findings discussed earlier (focusing mainly on results that are statistically significant at the 5 percent level in the preferred model specification).

Livelihood Strategy

Different livelihood strategies have significant implications for land management, input use, productivity, and household income. Compared to basic grains producers, livestock producers use less hired labor in crop production and obtain higher income per capita. Coffee producers are less likely to incorporate crop residues or use fertilizer, and obtain lower value of annual and perennial crop production per manzana. Their low returns to perennial crop production may be due to historically low coffee prices during the survey year, and lower returns to coffee than to other types of perennials. However, because coffee production is still more valuable than basic grains, coffee producers are

Table 5.10 Summary of qualitative impacts of key explanatory variables

	Livelihood strategy				Land management practices			External input use			Labor use		Crop production		
Explanatory variable	LS 1	LS 2	LS 4	LS 5	No burning	Zero/ minimum tillage	Crop residues	Ferti- lizer	Her- bicide	Insec- ticide	Family labor	Wage labor	Annual crops[a]	Perennial crops[b]	Income per capita[c]
Livelihood strategy (cf. basic grains)															
Livestock producer					0	0	0	0	0	0	0	–	0	0	+
Coffee producer					0	0	–––	––	0	0	0	0	––	––	0
Basic grains/farmworker					++	–––	0	0	0	0	0	0	––	0	+++
Grains/ livestock/farmworker					+	–	0	0	+	0	0	0	0	0	0
Natural capital/biophysical factors															
Altitude	0	++	0	0	+++	0	0	++	–––	0	0	++	0	0	0
Soil fertility	0	0	+	0	0	0	–––	0	+++	0	0	0	0	+++	+++
Owned land	+++	0	–	+++	0	0	–	0	0	0	0	0	0	–––	0
Summer rainfall	0	0	0	0	+++	–––	+	–––	0	0	+++	0	0	–	0
Rainfall deficit in second season	0	0	–––	–––	0	––	–––	–––	–––	0	0	–	–––	0	0
Physical capital															
Machinery/equipment value					0	––	0	0	––	0	–	+++	0	+	+++
Livestock value					0	0	0	––	0	+++	–	+++	0	0	0
Human capital/gender															
Median years of schooling	0	0	0	0	–	0	0	+	0	0	0	0	0	+	0
Household size	0	0	0	0	0	0	–––	0	–	0	+++	–––	0	0	0
Dependency ratio	––	–	0	0	0	0	––	0	0	+	0	0	––	0	––
Age of household head	0	0	0	+++	0	0	0	0	0	0	0	0	0	0	0
Female-headed household	0	–––	0	–––	0	0	++	0	––	0	++	0	0	0	0
Percentage of female adults	0	0	0	++	0	0	0	0	0	0	––	0	0	0	0
Migration index					+++	0	0	0	0	0	0	+++	+	0	0

Geographic determinants of comparative advantage															
Market access	+	0	0	0	0	−−	0	0	+	0	0	0	0	0	0
Road density	0	++	++	0	+++	−−	+++	+++	0	0	++	0	0	0	0
Population density	0	−−−	0	−−−	0	0	−	+++	−	0	0	0	0	+	0
Travel time to road (minutes)					0	−	0	−−−	−−−	0	−	+++	0	0	NA
Participation in programs/ organizations															
Conservation training					0	+++	0	0	0	0	0	0	0	0	0
Agricultural training					0	−−	−−−	−−−	−−−	0	0	0	0	−−	++
Conservation extension					0	0	+++	0	0	0	0	0	0	−−−	0
Agricultural extension					++	++	+++	+++	+	0	0	−−	0	0	0
Producers'/*campesino* organizations					0	0	−−	−	++	0	0	0	0	0	0
Rural bank/*caja rural*					0	−−	−−−	0	0	0	0	++	0	0	0
NGO program					0	0	+++	++	0	0	0	0	0	0	0
Land tenure															
Percentage of land with title	0	0	0	0	0	0	0	0	−−	−	−−	0	0	0	0
Plot tenure (cf. usufruct ownership)															
Full title					0	0	0	0	++	0	0	0	0	0	NA
Occupied communal land					0	0	0	0	0	0	0	0	0	0	NA
Borrowed					−−−	0	0	0	0	0	0	0	0	0	NA
Rented or sharecropped					−−−	0	0	++	+++	+	0	0	0	NA	NA
Prior investments															
Stone wall					+++	0	+++	0	0	0	−	0	0	0	NA
Live barrier or fence					++	+++	−	0	0	0	0	0	0	0	NA
Trees planted					−−−	++	0	−−	0	0	0	0	0	0	NA
Land use—perennials					−−−	−−−	−−−	−−−	−−−	0	−−	−−−	NA	NA	NA

Notes: +, ++, +++ mean coefficient positive and statistically significant at 10%, 5%, and 1% levels respectively. –, ––, ––– mean coefficient negative and statistically significant at 10%, 5%, and 1% levels respectively. NA means not applicable (variable not included in regression).

[a]Based on results of reduced form regression in Table 5.8.

[b]Based on results of reduced form regression in Table 5.9.

[c]Based on results of the OLS income per capita regression in Table 5.3.

able to compensate for lower productivity, and have insignificantly different income per capita from basic grains producers. Basic grains producers/farmworkers are more likely to use no burning and less likely to use zero or minimum tillage than basic grains only producers, probably owing to higher labor opportunity costs. These more diversified households obtain lower value of annual crop production per manzana, but still earn substantially higher income per capita because of their off-farm income. Households pursuing the even more diversified basic grains farmer/livestock producer/farmworker livelihood strategy are also more likely to use no burning and less likely to use zero or minimum tillage than basic grains only producers, but are more likely to use herbicides. We find insignificant differences in crop production and income between these households and basic grains producers, after controlling for other factors.

Natural Capital and Biophysical Factors

Households with more land are more likely to pursue the livestock production or the basic grains/livestock/farmworker livelihood strategy, and less likely to pursue the basic grains only livelihood strategy. Land ownership has insignificant direct effects on land management practices and household income, suggesting that access to land is not the most binding constraint to poverty reduction. However, land also has indirect effects on these via its effect on the household's livelihood strategy. For example, by promoting the diversified basic grains/livestock/off-farm strategy, greater land ownership tends to increase use of no burning, reduce use of minimum tillage, and increase household income, even though the direct effect of land ownership on these variables is insignificant. Greater land ownership is inversely associated with perennial crop yields, consistent with many other studies finding an inverse farm-size productivity relationship.

Soil fertility affects land management practices and outcomes. Farmers are less likely to incorporate crop residues on more fertile land, but are more likely to apply herbicides, and obtain higher perennial crop yield on more fertile land. Consistent with this, we also found strong yield response of crops, especially perennials, to use of fertilizers. As a result, households owning more fertile land obtain higher income per capita.

Rainfall during the second season is an important determinant of livelihood strategy: farmers in areas with greater moisture deficit are more likely to pursue livestock production or basic grains production, but less likely to pursue a diversified basic grains/livestock/farmworker strategy.[58] These results suggest that opportunities for income diversification into off-farm activities are more limited in areas of poorer agricultural potential, consistent with findings of Barrett, Reardon, and Webb (2001) and Reardon, Berdegué, and Escobar (2001). Rainfall deficits also have important direct impacts on land management, input use, and productivity, reducing use of zero/minimum tillage, incorporation of crop residues, fertilizer, herbicide, and hired labor, and annual crop yield. There are also important indirect effects of rainfall deficits via the impacts on livelihood strategies.

Land Tenure

We found no evidence of effects of land titling on livelihood strategies or land management practices. Contrary to expectations, households having a higher share of titled land are less likely to use herbicides or insecticides and use less family labor on a given plot than households with less share of titled land. Land titling also has statistically insignificant impact on crop yields and

[58] Pender, Scherr, and Durón (2001) found a similar result based on a community survey conducted in central Honduras.

income per capita. These findings contradict the common presumption that land titling would increase farmers' use of inputs, productivity, and income by increasing access to credit and tenure security. Apparently lack of land titles is not a major constraint to adoption of land management practices, inputs, or productivity in the regions studied.

There are some differences in land management of leased or borrowed versus owned plots. Adoption of no burning is less likely on borrowed and leased-in plots, probably because this improves soil fertility in the longer term, but perhaps at the expense of short-term fertility due to the release of nutrients by burning. By contrast, use of fertilizer, herbicides, and insecticides is more likely on leased-in than on owner-operated plots. We do not find any significant difference between leased-in and owner-operated plots in terms of annual crop yields, however.[59] Thus land tenancy arrangements appear to operate relatively efficiently, without significant differences in productivity on leased vs. owner-operated plots. Nevertheless, there may be some differences in the sustainability of land management on leased-in and borrowed plots, as evidenced by the lower propensity of tenants than owner-operators to adopt no burning practices.

Physical Capital

Ownership of machinery and equipment has significant impacts on land management practices, input use, productivity, and income per capita. Households owning more machinery and equipment are less likely to use zero or minimum tillage, or to use herbicides, probably because they own equipment for tilling the soil. Households owning more equipment use less family labor but more hired labor in crop production, probably because the opportunity costs of such farmers' time is higher and because they can afford to hire labor. Ownership of machinery and equipment is associated with higher value of production of perennial crops and with higher income per capita. Investigation of the interaction of machinery ownership with livelihood strategies in the income regression revealed that machinery and equipment investments are most remunerative to basic grains/farmworkers, coffee producers, and diversified basic grains/livestock/farmworkers. Larger amounts of machinery and equipment help a household to put its basic assets (land but especially labor) to more productive use and generate more income. This is especially important for households with relatively high opportunity costs of labor. Households owning more livestock are less likely than other households to use inorganic fertilizer, but are more likely to use insecticides. As with machinery ownership, greater livestock ownership is associated with less use of family labor and more use of hired labor in crop production, probably for similar reasons. However, we found insignificant impacts of livestock ownership on crop production and per capita income. Thus, investments in livestock do not appear to be a clear pathway from poverty for households in the regions studied.

Human Capital and Gender

Education has less influence on livelihood strategies and income than we expected, probably due to the limited amount of variation in education levels in our sample households. While low levels and little variation in formal schooling of hillside households seem to disable our statistical analysis of the effect of formal education, other research (Perry and Jaramillo 2004) suggests that in Honduras every year of additional education increases income by about 10 percent, with upper secondary education having the highest returns. Greater education is weakly associated with more use of fertilizer and greater perennial crop yields, possibly because of the effects of education on capital availability and farmers' knowledge.

[59] There were no leased-in plots used for perennial crops in the sample.

On the other hand, education is weakly associated with more burning, possibly because of higher opportunity costs of labor.

Household size also has insignificant effects on livelihood strategies, most land management practices, crop yields, and income per capita. Larger households use more family labor and less hired labor in crop production, as expected, and are less likely to incorporate crop residues or use herbicides.

By contrast to household size, the dependency ratio of the household has many significant impacts. Households with more dependents are less likely to pursue the livestock production livelihood strategy and more likely to pursue the basic grains/livestock/farmworker strategy. They are less inclined to incorporate crop residues and obtain lower annual crop yields and lower income per capita. High rates of fertility and dependency appear to be an important cause of low productivity and poverty in the study regions.

Gender has important effects as well. Female-headed households are more likely to be basic grains only producers and less likely to pursue the diversified basic grains/livestock/farmworker strategy. They pursue more labor-intensive agricultural practices than male-headed households; being more likely to incorporate crop residues, less likely to use herbicides, and using more family labor in crop production. Despite these differences, we find no significant direct differences between female- and male-headed households in terms of crop yields or income per capita, although differences in livelihood strategies still could lead to differences (e.g., female headed households may have lower incomes because they are more likely to pursue the lower income basic grains only livelihood strategy). Households with a larger share of female adults are more likely to pursue the basic grains/livestock/farmworker livelihood strategy, and use less family labor in crop production than others, likely owing to employment of female adults in other activities (domestic and off-farm).

Migration of family members influences land management and labor use. Households with members spending more time migrating outside of the village are more likely to use no burning and hire more wage labor. They obtain higher value of annual crop production per manzana (weakly significant). Thus migration may facilitate crop production by increasing households' ability to hire labor. Nevertheless, we find insignificant impacts of migration on household income per capita.

Geographic Determinants of Comparative Advantage

Surprisingly, distance to an urban market has insignificant impacts on livelihood strategies, the value of crop production, and income. This may be because most areas in the sample were relatively far from urban markets. In areas further from an urban market, farmers are less likely to adopt zero/minimum tillage, but more likely to use herbicides. Apparently, herbicides are not always used as part of a minimum tillage system, which in many cases involves instead increased use of labor for hand weeding.

In areas with higher road density, farmers are somewhat more likely to pursue coffee production or basic grains/livestock/farmworker livelihood strategies. In such areas, farmers are more likely to use no burning, incorporate crop residues and use fertilizer, and use more family labor in crop production. But they are less likely to use zero/minimum tillage than farmers in lower road density areas. Despite these differences, we find insignificant differences in crop production or income associated with road density.

On parcels further from a road, farmers are less likely to use zero/minimum tillage, fertilizer, or herbicides. They use less family labor but more hired labor on such parcels. Still, we find no significant differences in crop production as a result of distance from a road.

In areas of higher population density, farmers are more likely to pursue the basic grains only but less likely to pursue the basic grains/livestock/farmworker livelihood strategy. These findings are consistent with the effects of household-level land ownership discussed previously. In more densely populated areas, farmers are more likely to use fertilizer but less likely to incorporate crop residues or use herbicides. However, generally we do not find statistically significant impacts of population density on labor use, crop yields, or income per capita, even though higher population densities are weakly associated with higher perennial crop productivity.

Overall, the location variables have fairly limited impacts on crop production and income, though they influence livelihood strategies, use of various land management practices, external inputs, and labor.

Participation in Programs and Organizations

Participants in conservation-oriented training programs are more likely to use zero or minimum tillage than other households, but we find no significant differences in other practices, input use, labor use, productivity, or income. Participants in conservation extension programs are more likely to incorporate crop residues, but obtain lower value of production per manzana of perennial crops, probably because of the focus of such programs on basic grains production. Participants in more general agricultural training programs are less likely to use several practices and inputs in crop production, including zero/minimum tillage, incorporation of crop residues, fertilizer, or herbicides. They obtain lower value of perennial crop production per manzana, but higher income per capita than other households. The income effect of these programs is particularly large for livestock producers, suggesting that these programs are focusing more on livestock than on crop technologies.

Participants in general agricultural extension programs are more likely to adopt several land management practices and external inputs in crop production, including no burning, zero/minimum tillage, incorporation of crop residues, fertilizer, and herbicides, but use less hired labor. While we find insignificant impacts of these programs on value of crop production per manzana or income per capita, these programs do appear to contribute to the sustainability of agricultural production by promoting adoption of improved land management practices. Overall, these different programs have mixed but sometimes strong impacts on land management practices and use of external inputs and hired labor. Their impacts on crop production and income are more limited, with the most significant impacts associated with agricultural training programs, which apparently are promoting livestock activities at the expense of crop production.

Prior Land Investments

Use of no burning and incorporation of crop residues are more likely, while use of family labor is lower, on plots where stone walls have been constructed. Use of no burning and zero/minimum tillage is more likely while incorporation of crop residues is less likely on plots having live barriers or fences. Use of zero/minimum tillage is more likely and no burning and fertilizer is less likely on plots where trees have been planted. The reasons for all of these associations are not fully clear, though some likely involve complementarity or substitutability between prior investments and current land management practices (e.g., planting of trees or live barriers likely makes tillage more difficult, increasing farmers' propensity to use zero or minimum tillage). We do not find any statistically significant impacts of these investments on the value of crop production.

Land Use

The land use of the plot has substantial impact on what land management practices and inputs are used. Compared to annual plots, many practices and inputs are used less on perennial plots, including use of no burning, zero/minimum tillage, incorporation of crop residues, fertilizer, herbicides, family labor, and wage labor. Nevertheless, simple analysis of descriptive statistics (results not reported) shows that the value of production per manzana is higher on perennial than annual plots, owing to the higher prices of perennial crops.

Predicted Impacts of Changes in Selected Explanatory Variables

To better assess the magnitude of impacts (as opposed to just their direction and statistical significance) of particular factors on livelihood strategies, land management practices, input use, productivity, and household income, we present results of simulations of these impacts based upon the regression results presented earlier. In the simulations, we calculate the direct effect of changes in particular explanatory variables upon the dependent variables by altering the value of the explanatory variable (e.g., increasing population density by 1 percent) for each observation and predicting new values of the dependent variable based on the regression coefficients. For many dependent variables, the impacts of a change in a particular explanatory variable may come via multiple "channels." For example, an increase in road density can affect the value of crop yield by affecting households' choice of livelihood strategy, land management practices, labor, and purchased input use, as well as by possibly affecting local prices and hence the value of yields directly, independently of quantitative changes in yields. These indirect effects are estimated by predicting the effects of the change in the explanatory variable on all of these intermediate dependent variables, and then using these values to predict the value of crop yield. Combining the effects of these indirect and direct effects results in an estimate of the total impact of the change, which may be helpful to policymakers and others interested in our results.[60]

For our simulations, we focus on the impacts of changes in several policy-relevant variables that are found to have statistically significant impacts on at least one of our main response or outcome variables (livelihood strategy, land management, crop productivity, income): population density, road density, market access, amount of land owned, value of machinery and equipment owned, value of livestock owned, and median level of schooling of household members. For all of the simulations, we estimated the percent change in the dependent variables associated with a 1 percent increase in the explanatory variable.[61] Our simulation estimates for these variables thus represent response or impact elasticities. The results of the simulations are presented in Table 5.11. We discuss these by type of explanatory factor, focusing on results that are based on statistically significant regression coefficients and that are relatively large in quantitative terms.

Land Owned

Increased land ownership is predicted to increase pursuit of livelihood strategies involving livestock (livestock production and basic grains/livestock/farmworker), and reduce pursuit of the basic grains/farmworker strategy. Greater land ownership is predicted to reduce perennial crop yields significantly (elasticity = –0.21). This result suggests that increased allocation of land to smaller farms could result in increased average crop

[60]See Nkonya et al. (2004) for a detailed explanation of the simulation approach.

[61]When the dependent variable took on discrete values such as the livelihood strategy or use of land management practices or purchased inputs, the simulation results predict the percentage change in the probability of one of these discrete values occurring. For example, if the probability of a particular livelihood strategy increased from 0.1 to 0.15, that represents a 50 percent increase in probability. For the market access variable which is measured in terms of travel time to the nearest market, we simulated a reduction.

Table 5.11 Simulation results—Percentage change in selected variables

Variable	Population density increased 1%	Road density increased 1%	Market access increased 1%	Owned land increased 1%	Machinery/ equipment value increased 1%	Livestock value increased 1%	Median education increased 1%
Livelihood strategies							
Livestock	0.03	–0.45	–0.35*	0.12***			–0.04
Coffee	–0.55***	1.50**	–0.11	–0.11			–0.43
Basic grains	0.48	–0.95	0.42	–0.06			–0.07
Basic grains/farmworkers	0.14	0.73**	–0.02	–0.19*			–0.36
Basic grains/livestock/farmworkers	–0.26***	–0.04	–0.01	0.12***			0.42
Land management							
No burning	–0.05	0.78***	–0.06	0.01	0.01	–0.06	–0.13*
Minimum/zero tillage	–0.07	–0.81**	0.35*	–0.02	–0.05**	–0.05	0.06
Incorporation of crop residues	–0.18*	0.69***	0.05	–0.04*	–0.01	–0.08	0.31
External inputs							
Fertilizer	0.18***	0.24***	–0.03	0.02	0.01	–0.05**	0.09*
Herbicides	–0.11	0.19	–0.16*	0.04	–0.04**	0.02	–0.01
Insecticides	–0.09	–0.08	0.27	0.01	0.01	0.18***	–0.04
Labor inputs							
Family labor	–0.03	0.16**	0.05	0.00	–0.02*	–0.02*	–0.01
Wage labor	0.20*	0.05	0.04	–0.05	0.10***	0.16***	0.05
Value of annual crop yield							
Total effect	0.03	0.15	0.01	0.00	0.00	0.00	0.06
Value of perennial crop yield							
Direct effect	0.00	0.83***	0.32*	–0.24***	0.00	0.09***	0.34***
Total effect	0.13^{R}	0.72	0.39	$–0.21^{R}$	0.05^{R}	0.09	0.13^{R}
Income/capita							
Direct effect	0.07	–0.21	–0.07	0.00	0.13***	–0.04	0.12
Total effect	0.08	–0.11	–0.16	–0.02	0.13	–0.04	0.04

Notes: ^{R} means that the total impact estimated in the reduced form regressions in Tables 5.8 and 5.9 are the same sign and statistically significant at the 10% level. *, **, *** mean that the regression coefficient upon which the estimated direct effect is based is statistically significant at the 10%, 5%, or 1% level, respectively.

productivity.[62] Increased land ownership is predicted to have little impact on income per capita, consistent with our earlier finding in Chapter 4 that land access per se is not the most important determinant of poverty.

Machinery and Equipment Owned

Increased ownership of machinery and equipment is predicted to reduce use of zero/minimum tillage and herbicides slightly, while increasing hiring of wage labor significantly (elasticity = 0.10) with a concomitant decrease in the use of family labor. Higher endowments of machinery and equipment also lead to a slight increase in perennial crop productivity, and increase income per capita significantly (elasticity = 0.13). As noted earlier, investment in machinery and equipment appears to be most profitable for households pursing the basic grains/farmworker and coffee production livelihood strategies.

Livestock Owned

Promotion of livestock keeping is predicted to reduce use of inorganic fertilizer slightly, but to increase use of insecticides significantly. Increased livestock ownership is predicted to lead to more use of hired labor and slightly less family labor in crop production, and higher perennial crop yields, perhaps as a result of greater availability of manure and hence greater soil fertility. However, this result may also be a reflection of reverse causality (e.g., households with more productive coffee gardens are better able to afford livestock).

Education

An increase in education levels is predicted to reduce use of no burning, increase use of inorganic fertilizer slightly, and increase the value of perennial crop yields substantially (elasticity of direct impact = 0.34), controlling for use of land management practices and inputs (partial effect of education). However, the total predicted impact of increased education on perennial crop production is much less than this (elasticity of total impact = 0.13), in part because education reduces use of labor intensive practices. Increased education has a quantitatively small (and statistically insignificant) predicted impact on income per capita (elasticity = 0.04). Because education can reduce labor availability in the near term and has limited impacts on most livelihood strategies and agricultural productivity in our results, its impacts on income per capita are predicted to be limited, at least in the near term.

Overall, these results suggest that improved access to road infrastructure and markets, and investments in some types of household endowments such as education, can promote intensification of land management and increased agricultural productivity, at least in perennial crop production. Improving annual crop productivity appears to be more difficult, as does improving overall income per capita.

Population Density

Higher population density would be associated with lower probability of households choosing the coffee production or basic grains/livestock/farmworker livelihood strategies, and higher probability of basic grains production. Coffee production is particularly discouraged by higher population density (elasticity of –0.55) while basic grains production is encouraged (elasticity of 0.48). Thus, the subsistence basic grains livelihood strategy is a more dominant livelihood strategy in more densely populated settings. Increased population density is predicted to reduce incorporation of crop residues, but has limited impacts on other land management practices (controlling for farm size, labor endowment, and other household-level factors). Increased use of

[62]Although reallocating land from large to smallholders would tend to reduce the yields of smallholders, this would increase average yields because smallholders' yields are substantially larger than those of large landholders.

inorganic fertilizer is associated with greater population density, consistent with the Boserup (1965) model of population-induced intensification. Not surprisingly, use of hired labor is more likely in more densely populated settings, where there is greater availability of labor and possibly lower transaction costs of hiring labor. Despite these impacts, increased population density has fairly small predicted impacts on crop yields and household incomes. Marginal population growth is predicted mainly to induce increased use of purchased inputs and hired labor, and some shifts in livelihood strategies, without major impacts on land management, productivity, or income.

Road Density

Increased road density is predicted to be associated with significant shifts in livelihood strategies, toward coffee production and basic grains/farmworker strategies, and away from the less profitable basic grains strategy. Significant changes in land management practices are also predicted, with declining use of burning and minimum/zero tillage, but increased incorporation of crop residues. Not surprisingly, increased fertilizer and family labor use are also predicted. The value of perennial crop yields is significantly higher in areas with better road access. Overall, road development is associated with greater production of coffee, off-farm employment, more intensive use of labor and purchased inputs, higher use of some sustainable land management practices, and higher value of production of perennial crops, but has limited impacts on production of annual crops and income, even accounting for changes in livelihood strategies induced by road development.

The limited impact of road development on incomes is surprising. This may have resulted from migration patterns; that is, poorer people may move to areas where there are more roads and market opportunities. Unfortunately, it is not possible to test this hypothesis with our cross-sectional data. Further research on the impacts of roads and other public investments in Honduras using panel data would be valuable.

Market Access

As expected, livestock production is less prevalent in areas closer to market towns. Use of minimum/zero tillage is more common closer to market towns, while use of herbicides is less common. The value of perennial crop yields is higher closer to towns, probably as a result of higher prices received by farmers in such areas. As with road access, improved urban market access has surprisingly limited predicted impact on incomes, possibly for the same reason.

CHAPTER 6

Summary of Findings, Conclusions, and Policy Implications

In this report we used a quantitative approach, based on the sustainable livelihoods conceptual framework, to better understand how prospects for sustainable growth and poverty reduction can be stimulated in the rural hillside areas in Honduras. Our analysis was based mainly on household- and plot-level data collected for 376 farm households in 2001–02, supplemented with village-level agroecological and socioeconomic information. We started out with a statistical analysis describing the households' asset base according to income level. We then used factor and cluster analysis to identify the major livelihood strategies followed by rural hillside households based on their use of land and labor resources. We used a multinomial logit econometric model to assess the main determinants of these strategies as part of an integrated econometric framework analyzing the complex relationships between households' asset portfolios, livelihood choices, agricultural production, use of labor and external inputs, land management decisions, and income. Finally, we used the results of this econometric analysis to simulate the effects of changes in a number of policy-relevant variables on livelihood strategies, land management, crop productivity, and income.

Summary of Main Findings

In Honduras, nearly 60 percent of the poor (per capita income of less than US$1.50 per day) and two thirds of the extremely poor (per capita income of less than US$1.00 per day) are found in rural areas. Some 80 percent of all rural poor live in areas classified as hillside areas and most of them are also extremely poor. For the majority of these people the agricultural sector remains the dominant source of income. Nonagricultural activities are relatively rare in rural Honduras because of the physical distances from urban centers and towns and the lack of good road infrastructure and transport services (Cuellar 2003).

Past government policies and public investment strategies have not produced sufficient economic growth in the rural areas in general and the hillside areas in particular. Despite a series of structural reforms, the macroeconomic situation in Honduras remains precarious and characterized by decreasing external terms of trade, increasing external and internal deficits, and appreciation of the real exchange rate. Growth in the agricultural sector has been consistently lagging behind other sectors and the terms of trade of agriculture show a declining trend. Honduras has suffered from a number of natural and external economic shocks, including Hurricane Mitch in 1998 and a collapse of the price of coffee in 2001. While a higher endowment of a single asset does not necessarily lead to higher income (for example, we found no statistically significant relationship between land or livestock ownership and income), most hillside households have limited assets on which to base their livelihood strategies. Finally, Honduras suffers from a high degree of inequality, which is also increasing. High inequalities in asset distribution constrain how the asset-poor can share in the benefits of growth, even under appropriate policy regimes.

A major hypothesis in this report is that future policies and investments can be substantially improved by better targeting based on a sound knowledge of the composition of rural households' asset bases and related livelihood choices. Households in the rural hillsides in Honduras hold widely differing asset endowments and follow different livelihood strategies. The latter are determined by comparative advantages as reflected by a combination of biophysical and socioeconomic factors. While the vast majority (> 90 percent) of our sample households is poor, households that follow a livelihood strategy based solely on basic grain farming are the poorest, mainly because they usually live in isolated areas with relatively poor agroecological and socioeconomic conditions, and low profitability of basic grains production. Opportunities for off-farm work tend to be limited in these areas, although household strategies that combine basic grains production with off-farm work earn higher incomes.

Soil fertility has a strong direct positive impact on income while agroclimatic conditions such as higher rainfall and altitude have an indirect positive income effect because they stimulate more remunerative livelihood strategies. We found support for the inverse farm size–land productivity relationship: more land per se does not lead to higher income per capita, and households with less land are able to compensate by obtaining higher productivity or by pursuing off-farm activities. Land is therefore not the key constraint limiting the potential for higher incomes in the study regions. Land tenure also has no impact on crop productivity and household income, but adoption of sustainable land use practices such as no burning is higher on owner-operated than on leased plots.

Ownership of machinery and equipment enables households to raise labor and land productivity and is especially helpful for households with relatively high opportunity costs of labor, such as those pursuing off-farm employment or coffee production. We found no significant direct impacts of livestock ownership on crop productivity and per capita income, although households pursing livestock production as a livelihood strategy earn higher income than basic grains producers.

Human capital variables have mixed impacts. Households with more formal schooling have higher perennial crop productivity, but we did not find a statistically significant impact of education on per capita income. Households with higher dependency ratios follow less remunerative livelihood strategies and have lower per capita income. After controlling for other factors, the sex of the household head has no significant effect on crop productivity or per capita income, but does influence some land management and input use decisions. Hillside households are not generally recipients of significant amounts of remittances and we find no significant impacts of migration on per capita household income.

With the notable exception of agricultural training programs that are promoting livestock activities and appear to have a strong positive effect on the income of livestock producers, household participation in other training programs and organizations (conservation training and extension, general agricultural extension, producers' organizations, NGO programs, and rural savings and loans organizations) were found to have only limited effects on crop productivity and income. However, several of these programs are important for the sustainability of agricultural production: agricultural extension in particular plays a key role in promoting adoption of practices such as zero burning, zero/minimum tillage, and incorporation of crop residues.

Just like household participation in programs and organizations, geographic determinants of comparative advantage have fairly limited impacts on crop production and income, even though they do influence use of various land management practices, external inputs, and labor use. Road density has no statistically significant direct effect on per capita household income, despite its positive effect on the productivity of perennial crops, although it may indirectly promote higher incomes by promoting livelihood strategies other than basic grains production, such as those involving coffee production and off-farm employment. Better market access is weakly associated with higher value of production of perennial crops but not with higher income. Population density also has limited direct impact on crop productivity and per capita income, though it may have indirect effects by affecting farm size and livelihood strategies.

Conclusions and Policy Implications

The results of this study are somewhat disappointing in terms of showing ways to improve per capita income in the rural hillside areas in Honduras, which may partially be due to our sample selection which focused on counties where most communities and households are quite poor.[63] However, our results also demonstrate that there are no easy and straightforward solutions to the poverty problem in the rural hillside areas in Honduras. The asset portfolios of many households in these areas is often largely limited to their (unskilled) family labor and some land, and as a consequence these households have no other choice but to use their scarce assets to grow food for subsistence; mainly maize, beans, and sorghum. But this livelihood strategy is strongly associated with poor biophysical and socioeconomic conditions and extreme poverty, even if pure basic grains farmers may be more food secure than households with less land who combine basic grains growing with off-farm work. The strong focus on food security reflects the traditions and cultural ties of many rural households in hillside areas to farming; a relatively high degree of risk aversion (attempting to avoid food purchases as much as possible); and differences in the prices of buying versus selling food due to high transport costs, which favors the autarkic solution of self-sufficiency (de Janvry, Fafchamps, and Sadoulet 1991; Omamo 1998; Key, Sadoulet, and de Janvry 2000).

The fact that over the past 25 years agriculture has not been a strong engine of growth in rural Honduras presents a big challenge to policymakers and donor agencies alike. Many households in the rural hillside areas seem to be locked into a vicious cycle of producing basic grains mainly for subsistence consumption and using traditional production technologies that have low land and labor productivity, blocking the transition to other income-earning strategies that would possibly be more profitable. Our study makes clear that agriculture should form an integral part of the rural growth strategy in hillside areas. High reliance of rural households on agricultural and related income means that any strategy targeted to these areas will have to build upon the economic base created by agriculture. Even though agriculture alone cannot solve the rural poverty problem, those remaining in the sector need to be more efficient, productive, and competitive. The results of our

[63] With hindsight, we could also have sampled more relatively well-off communities to have more potential for drawing conclusions about determinants of income. We note, however, that there is quite large variation in agroecological potential, market access, and access to programs and organizations in our sample. A larger sample size (which unfortunately we could not afford) also could have helped to show more significant results.

study suggest a number of potential ways to break the vicious cycle and areas on which a public investment program may want to focus in order to achieve a significant positive impact on income, poverty reduction, and improved productivity and sustainability of agricultural production:

Invest in road infrastructure. We found evidence of a positive relation between road density and productivity of perennial crops. Moreover, our finding that the smallest farms with the highest proportion of off-farm work earn higher incomes than pure basic grains farmers suggests that improving off-farm work opportunities may hold substantial potential for increasing household income in the hillside areas. Relative to pure basic grains farmers, households that combine the growing of basic grains with off-farm work and coffee farmers live in areas with higher road densities. Roads may affect market access, and both market access and roads increase off-farm employment opportunities for households with limited stock of land who are "pushed" to look for off-farm work. Thus, road development can stimulate livelihood strategies that emphasize off-farm work with higher returns than working on their own farm.

Encourage family planning. Since high rates of dependency in the study regions are important causes of low productivity and poverty, family planning programs that succeed in lowering dependency ratios may help in raising per capita incomes.

Improve access to land. Improving access to land (not land titling per se) can have an indirect positive impact on income by enabling households to pursue more remunerative livelihood strategies such as livestock production. Given the inverse farm size–productivity relationship that we found, improved land access could also increase total crop production in hillside areas by enabling more productive smallholders to expand their production. This could be achieved by improving the operation of land rental markets. Besides evidence of the inverse farm size–productivity relationship, land redistribution programs seeking to increase smallholders' ownership of land may be justified on the basis of sustainability considerations, as adoption of certain soil conservation practices is larger on owned land than on rental land.

Broaden households' physical asset base. Promoting investments in households' physical asset bases (particularly machinery and equipment), through savings and credit programs or other means, can increase the returns to land and labor resources and raise incomes. Such investments should have a primary focus on crop producers but perhaps with a special focus on households that have relatively high opportunity cost of labor, such as those pursuing off-farm employment or coffee production.

Promote improved sustainability of agricultural production, taking into account local conditions. Measures that maintain or improve soil fertility can have a positive effect on agricultural productivity and household income, as evidenced by the strong positive impacts of soil fertility use of fertilizers on crop productivity (especially of perennial crops) and incomes. Moreover, soil moisture conservation measures may enable households with an exclusive focus on the production of basic grains to switch to a more remunerative livelihood strategy. Adoption of sustainable land use practices in crop production can be stimulated through conservation-oriented agricultural extension and training programs. Our results suggest that different land management technologies are suited to different types of farms and agroecological situations. For example, no burning is adopted more in areas possessing favorable agroclimatic conditions and access to roads by farmers that are pursuing off-farm employment as well as basic grains production, while zero/minimum tillage is adopted more on heavy soils in lower rainfall areas by poorer farmers that are producing basic grains only. Technical assistance programs should take into account such differences in suitability of land management practices in different contexts.

Develop and promote yield and income increasing production technologies. While improving the sustainability of agricultural production may increase yields in the long term, in the short to medium term land-saving production technologies are needed to increase the productivity and profitability of annual crops, particularly basic grains. Our findings suggest that use of both organic and inorganic fertilizers, as well as other chemical inputs such as pesticides, can contribute to higher productivity. Evidently, more emphasis of technical assistance programs on such productivity enhancing inputs, as well as on longer term conservation measures, is needed, given the limited impact such programs are found to have on productivity. Beyond technical assistance, improved technologies suitable for hillside areas are needed. The current capacity in Honduras for agricultural technology research in this area is very limited and the government may therefore try to find ways to disseminate appropriate agricultural technologies that have proven successful elsewhere but in similar agroecological and socioeconomic conditions.

Capitalize on the migration phenomenon. Migration has a positive effect on crop productivity and use of some inputs and land management practices. Currently remittances mostly serve as a source of finance for food and other goods, which can be expected given that poverty is deep among hillside households. But remittances are a potential source of finance for market-oriented productive activities and household diversification. To maximize returns from migration, the government should consider providing basic training to assist prospective migrants, assisting community-based initiatives aimed at investing remittances in a productive way, and improving financial systems to lower the transaction costs and risks associated with remittances.

In conclusion, this report has shown that household-level heterogeneity in the rural hillside areas of Honduras limits the appropriateness of "cookie-cutter approaches" to policies and programs designed to foster broad-based growth. Investment strategies should be formulated on broad regional bases, but options within regions should be tailored to local asset bases and livelihood strategies.

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