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ORIGINAL PAPER

Incorporating livelihoods in biodiversity conservation: a case study of cacao agroforestry systems in Talamanca, Costa Rica

R. M. Dahlquist · M. P. Whelan · L. Winowiecki · B. Polidoro · S. Candela · C. A. Harvey · J. D. Wulfhorst · P. A. McDaniel · N. A. Bosque-Pérez

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Abstract Over the past two decades, various organizations have promoted cacao agroforestry systems as a tool for biodiversity conservation in the Bribri-Cabécar indigenous territories of Talamanca, Costa Rica. Despite these efforts, cacao production is declining and is being replaced by less diverse systems that have lower biodiversity value. Understanding the factors that influence household land use is essential in order to promote cacao agroforestry systems as a viable livelihood strategy. We incorporate elements of livelihoods analyses and socioeconomic data to examine cacao agroforestry systems as a livelihood strategy compared with other crops in Talamanca. Several factors help to explain the abandonment of cacao agroforestry systems and their conversion to other land uses. These factors include shocks and trends beyond the control of households such as crop disease and population growth and concentration, as well as structures and processes such as the shift from a subsistence to a cash-based economy, relative prices of cacao and other cash crops, and the availability of market and government support for agriculture. We argue that a livelihoods approach provides a useful framework to examine the decline of cacao agroforestry systems and generates insights on how to stem the rate of their conversion to less diverse land uses.

R. M. Dahlquist (✉) · M. P. Whelan · L. Winowiecki · B. Polidoro · C. A. Harvey
Department of Agriculture and Agroforestry, CATIE, Apdo. 7170, Turrialba, Costa Rica
e-mail: rdahlquist@vandals.uidaho.edu

S. Candela
Department of Natural Resources and Environment, CATIE, Apdo. 7170, Turrialba, Costa Rica

R. M. Dahlquist · L. Winowiecki · B. Polidoro · P. A. McDaniel · N. A. Bosque-Pérez
Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339, USA

N. A. Bosque-Pérez
e-mail: nbosque@uidaho.edu

J. D. Wulfhorst
Department of Agricultural Economics and Rural Sociology, University of Idaho, Moscow, ID 83844-2334, USA

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Introduction

Land use change, including the expansion of intensive agriculture, is one of the most cited explanations for biodiversity loss worldwide (Sala et al. 2000). Rates of forest conversion have been especially rapid in the American tropics, where estimates of net deforestation range from 22,000 to 44,000 km^2 per year (Wright and Muller-Landau 2006). In response, researchers in conservation biology seek to promote less intensive agriculture such as multistrata agroforestry systems that provide farmers with income while protecting biodiversity (McNeely and Scherr 2003; Schroth et al. 2004). Cacao (*Theobroma cacao*) agroforestry systems demonstrate great potential to fulfill these goals due to their ability to maintain avian, mammalian, and other forms of biodiversity amidst the increasing international demand for cocoa beans and chocolate-based products (Rice and Greenberg 2000). Multistrata cacao agroforestry systems that include timber, fruit, and native forest species contribute to biodiversity conservation by providing habitat for species, enhancing landscape connectivity, and reducing edge effects between forest and agricultural land (Johns 1999; Guiracocha et al. 2001; Reitsma et al. 2001; Harvey et al. 2006). These systems can also benefit farming households. The shade provided by agroforestry systems can help preserve soil temperature and moisture regimes that improve nutrient cycling and can increase nutrient-use efficiency of the system (Young 1997). Fruit and timber species can provide alternative and supplemental sources of income to households and buffer them for greater economic security in times of low prices (Rice and Greenberg 2000).

Given their potential benefits to both biodiversity and farming households, cacao agroforestry systems have been promoted as an alternative to more intensive land uses. However, the continued presence of cacao agroforestry systems depends upon land use decisions at the household level. Since smallholder production accounts for between 70 and 90% of world cacao production (CABI 2001), understanding the factors influencing farmer decisions is crucial if cacao agroforestry systems are to be successfully promoted. While the importance of including socioeconomic factors in agroforestry research is increasingly recognized (Schroth et al. 2004; Shapiro and Rosenquist 2004; Montambault and Alavalapati 2005), agroforestry research in general has focused more on biophysical aspects of agroforestry systems than socioeconomic factors (Mercer and Miller 1998; Nair 1998). Similarly, research on the conservation value of cacao agroforestry systems has focused primarily on their contribution to on-farm and landscape-level biodiversity, although wider perspectives exist on this issue (see Schroth et al. 2004).

We employ components of a livelihoods approach in order to identify socioeconomic factors affecting cacao agroforestry systems. A livelihood consists of a household's capabilities, assets, and activities required for a means to a living (Chambers and Conway 1991; Carney et al. 1999). Originally developed in the 1980s in the context of Farming Systems Research and Education, the framework for a livelihoods approach arose as an effort to develop more effective poverty reduction strategies by including household decision-making and constraints on farming households within analyses (Carney 1998). This approach has also been used to link conservation and rural development

(Boyd et al. 1999; Hulme and Muphree 2001), as it provides a methodology for examining the economic, social, and institutional factors that influence household land use. Livelihoods analyses include the vulnerability context of the household, household assets described as five types of capital, and the structures and processes that mediate household livelihood strategies (Department for International Development 2003). In this paper, we will focus on two aspects of the livelihoods approach: the vulnerability context, which consists of trends and shocks that are largely outside the immediate control of households, and structures and processes, which include socioeconomic and institutional factors that are both endogenous and exogenous to the social world in which households participate (Ellis 2000; Department for International Development 2003).

Talamanca case study

We present the Bribri and Cabécar indigenous territories of Talamanca, Costa Rica as a case study of an area in which cacao agroforestry systems have declined since the late 1970s despite numerous interventions (Acuña 2002) and in which the inclusion of livelihoods analyses in conservation projects could help mitigate the conversion of land to less diverse, more intensive agricultural systems such as monoculture plantain (*Musa* AAB). Cacao grown in Talamanca is sold only to organic markets and is produced without agrochemical inputs. Comparisons of land uses in the territories have found higher mammal and beetle species richness in cacao and banana (*Musa* spp.) agroforestry systems than in monoculture plantain (Harvey et al. 2006) and avian species richness in both managed and abandoned cacao farms that is slightly higher than that of forest (Reitsma et al. 2001). The greater diversity found in cacao agroforestry systems can approximate the structural and floristic complexity of the previous forest (Somarriba and Harvey 2003; Suatunce et al. 2003). The position of cacao agroforestry systems within the larger agricultural matrix of Talamanca may also contribute to biodiversity conservation (Harvey et al. 2006), since cacao agroforestry systems can serve as a buffer zone between monoculture agriculture and protected areas (Gamez and Ugalde 1988).

In contrast to cacao, plantain in Talamanca is grown primarily in monoculture with very few shade or fruit trees and with application of agrochemicals in varying amounts and frequencies (Polidoro and Dahlquist unpublished data). The effects of these agricultural practices on on-farm biodiversity include reduced habitat quality and connectivity, increased fragmentation and deforestation, and species loss due to toxic agrochemical use (Henriques et al. 1997; The Nature Conservancy 2005). Agrochemicals can also negatively affect biodiversity in off-farm areas through movement to and pollution of nearby aquatic and coastal resources (Castillo et al. 1997; Castillo et al. 2000; Lowrance et al. 2001). In Talamanca, monoculture plantain is grown on floodplain soils, where previous research has linked the loss of native riparian vegetation to decreased aquatic habitat and water quality (Pringle et al. 2000), as well as increased flooding events, soil erosion, and landscape instability (Sanchez-Azofeifa et al. 2002; Thoms 2003). Given the negative consequences of monoculture systems for biodiversity in Talamanca, researchers and conservation planners continue to promote cacao agroforestry systems for their conservation value. However, conversion of land to less diverse systems continues in areas where plantain can be cultivated.

Recognizing the factors that encourage the spread of less diverse agricultural systems and the corresponding decrease of more diverse systems, such as cacao agroforestry systems, can benefit conservation efforts. The objectives of this study are to: (1) examine factors influencing the presence of cacao agroforestry systems in the landscape of Talamanca within a livelihoods framework, and (2) identify strategies to mitigate abandonment of cacao agroforestry systems in Talamanca, with potential applications for other regions where cacao is grown. We use a combination of methods including compilation of economic and production data, review of gray literature produced in Talamanca, interviews with local stakeholders, and triangulation to assess these factors and their implications for conservation.

Site description

Indigenous territories

The Bribri and Cabécar indigenous territories of Costa Rica are located in southeastern Costa Rica in the canton of Talamanca within the Meso-American Biological Corridor, which comprises the largest remaining tract of contiguous forest in Central America (Palminteri et al. 1999). The landscape within the territories includes the floodplain of the Talamanca Valley, surrounded by undulating foothills that give way to the high montane regions of the Talamanca mountain range. The Atlantic slopes of the Talamanca range encompass both humid tropical forest and premontane wet forest life zones (Holdridge 1967). Annual precipitation increases with altitude from approximately 2,600 mm of rain at 40 masl to 6,400 mm at 1,000 m asl (Borge and Castillo 1997). Within the Talamanca region, the Bribri and Cabécar indigenous territories are considered extremely valuable for biodiversity conservation, as they are surrounded by several national and international protected areas (Palminteri et al. 1999).

The Bribri and Cabécar indigenous territories support a population of about 10,000 inhabitants (Municipality of Talamanca 2003) and contain 43,690 ha and 22,729 ha, respectively (Borge and Castillo 1997). Talamanca is the poorest canton in Costa Rica, with more than a third of the population unemployed or under-employed and the highest concentration of poverty occurring within the indigenous territories (Municipality of Talamanca 2003). Indigenous peoples have been historically marginalized in Costa Rica, and the territories have limited access to health care, education, infrastructure, and road access (Gómez Valenzuela 2001). The major sources of income in the territories are plantain, organic banana, organic cacao, and wage labor. Currently, the Talamanca region is responsible for 95% of Costa Rican cacao production, 52% of plantain production, and 90% of organic banana production (Municipality of Talamanca 2003). Cacao in Talamanca long predates the Spanish colonial presence, and the Bribri and Cabécar used it historically for a ceremonial drink (Villalobos and Borge 1998; Somarriba and Beer 1999). The cacao tree figures prominently in Bribri and Cabécar narratives of origin (Murillo and Segura 2003), and some within the indigenous population still consider cacao sacred.

Landscape attributes

Topographical and geomorphological variations contribute to distinct land use patterns in the landscape of the indigenous territories. An estimated 17,000 ha of agricultural land exists within the territories, 60% of which is located within the Talamanca Valley (Borge and Castillo 1997). The valley contains highly variable, fertile soils that have high base status and organic matter content, classified as Entisols (Polidoro et al. in press).

In contrast, the foothills are a mosaic of acidic, low-fertility soils with high clay content, classified as Ultisols, intermixed with less acidic, slightly more fertile soils, classified as Inceptisols (Winowiecki unpublished data). Although cacao natively grows on floodplain soils in the Amazon basin and was cultivated in the Talamanca Valley by the United Fruit Company (UFC), it can also grow on steep slopes and low-fertility soils. Despite this ability, research indicates that low-pH soils with high aluminum saturation greatly inhibit cacao yields (Baligar and Fageria 2005). In contrast to cacao, plantain and organic banana production for commercial purposes is limited to well-drained, sandy-textured soils on low-gradient slopes (Robinson 1996) such as those in the floodplain of the Talamanca Valley. Attempts to grow plantain in the foothills have been unsuccessful after one harvest (Winowiecki and Whelan unpublished data). These variations in soil type and slope have contributed to the current pattern: banana and plantain dominate the valley, while cacao remains the major cash crop that can be widely produced on the low-fertility soils of the foothill slopes. It is important to note that this variation in landscape and corresponding soil characteristics is responsible in part for the distribution of land uses within the territories (Fig. 1).

Description of farms

Household landholdings in the indigenous territories can include multiple plots of land with different land uses (Whelan 2005). Cacao is managed at a low intensity, and canopies of cacao agroforestry systems in the territories vary in tree species composition and amount of shade. These include systems with scattered shade trees of only one species, intercropped systems with a variety of timber and fruit species including banana, and 'rustic' systems in which cacao is grown under thinned forest trees (Somarriba and Harvey 2003). The canopy of banana agroforestry systems often contains remnant trees of the original forest or naturally regenerated laurel (*Cordia alliodora*), and is generally less floristically diverse than that of cacao (Guiracocha et al. 2001; Suárez Islas 2001). Households often intercrop cacao and banana in agroforestry systems, since they are compatible as organic

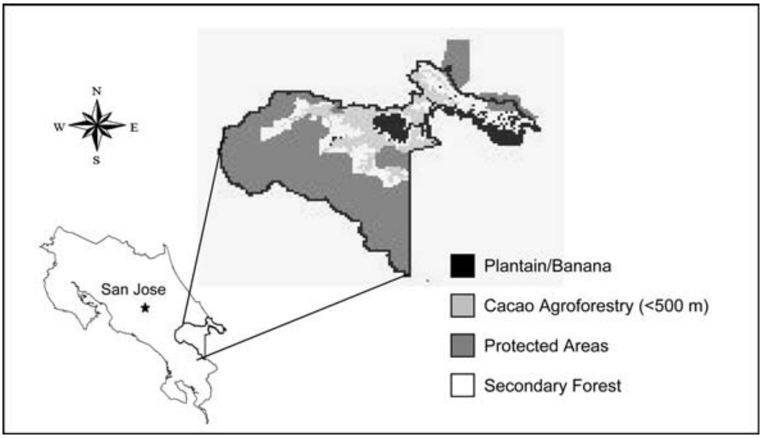


Fig. 1 Dominant land uses in Talamanca, Costa Rica

cash crops and can grow under shade. These systems may emphasize one crop over the other. Plantain grown without agrochemical inputs can also be included in agroforestry systems, either for household consumption or for sale as low-quality produce. While much of the valley is cultivated for plantain or organic banana production, cacao agroforestry systems still exist in valley communities, particularly in those closer to the foothills. Household landholdings in the valley are generally much smaller than those in the foothills (Morera et al. 1999; Whelan 2005). Foothill farms tend to be more diversified, with areas dedicated to shifting cultivation of annual crops and fallows, as well as primary forest and cacao and banana agroforestry systems (Somarriba et al. 2003).

Methods

Integration of local and national information

Much of the information on the indigenous territories is unpublished or gray literature, such as theses or project reports of government agencies, non-governmental organizations (NGOs), and private consultants. In the absence of systematic and comprehensive research in this area, we compiled this information on Talamanca along with national and international data on price, production, and export trends in cacao and plantain in Costa Rica in order to identify and characterize trends affecting cacao in Talamanca. These data include yield and land use statistics obtained from the Asociación de Pequeños Productores de Talamanca (APPTA), cacao prices obtained from the International Cacao Organization (ICCO), land use, yield, trade, and price information obtained from FAO databases (http://fao.faostat.org), and comparisons of production systems within the indigenous territories (Deugd 2001; Hinojosa Sardan 2002; Municipality of Talamanca 2003; Yepez 1999). Although we cannot conduct additional analyses from these sources, we employ these secondary data as the relevant and available cases related to our regional analysis. In addition, several authors of this paper have conducted participatory research projects in both the biophysical and social sciences in the indigenous territories over the past two years (2004–2006), in land uses including cacao, banana, plantain, and basic grains. Although anecdotal, our own experiences and participant observation in the indigenous territories provide context for our analysis of factors influencing cacao production.

Household and key informant interviews

Thirty exploratory semi-structured interviews were conducted with regional key informants, which included staff of government agencies and NGOs, Bribri and Cabécar local extensionists, and residents. Semi-structured interviews were based on an interview guide of open-ended questions which gave respondents latitude to describe their responses using terms and language most familiar to each of them, and not bound to predetermined answers (Mikkelsen 1995). Key informants with knowledge related to land use and livelihoods in the indigenous territories were selected through snowball sampling (Berg 1995). Guiding questions for semi-structured interviews included past and current land use, factors influencing each land use, and household livelihood strategies. Information from key informant interviews was used to develop an interview guide of open-ended questions for semi-structured interviews with households as well as additional background to develop criteria for community selection (Whelan 2005).

Eight communities within the indigenous territories were selected considering a combination of the following criteria: an elevation gradient; access to infrastructure; access to services; and total number of households. Four foothill and four valley communities were selected. Communities were classified into three zones designated as remote, intermediate, and accessible based on access to infrastructure and services (Table 1). The total number of households in the eight communities was estimated using health records and census data, supplemented by information corroborated with local informants. A random sample of at least 10% of households in each zone was selected, with a total of 82 households across the three zones (Table 1). Two key factors limited development of a larger sample: (1) the sizes of some communities limit the total number of potential respondents, making the local community members characteristic of rare populations for survey sampling; and (2) resource constraints only allowed for access to a limited percentage of the remote zone communities due to their locations. The mean household size and percent ethnic background are also listed in Table 1 to reflect a demographic profile of the respondents.

Five pre-test interviews were conducted using an interview guide prior to administering the full household survey. Survey interviews with households were combined with a participatory mapping exercise of farm land use and cropping history. Survey interviews also included an open-ended discussion of the future possibilities of organic production in Talamanca.

Data analysis

Interview data were coded and descriptive statistics were calculated. Responses to open-ended questions in semi-structured interviews can vary widely. When households gave multiple responses to a question, responses were aggregated by topic and the percentage of households mentioning each topic was calculated.

Land use trajectory diagrams were constructed by compiling changes in land use history from the mapping exercise. Since household interviews did not specify exact time periods for cropping history, land uses were designated sequentially as 'Former use III' (oldest land use) followed by 'Former use II', 'Former use I,' and ending with 'Current use'. Thicker lines between land uses in the diagrams correspond to more prevalent land use patterns. Although the process of land use change is not always linear and can include gradual shifts and rotations, the land use trajectory diagrams display this change in linear form for ease of presentation.

Triangulation

Information gained through literature review and interviews was triangulated through participant observation and group discussions. Participant observation included living with households for a month and a half in each of the different zones, informal conversations with indigenous farmers and other household members, participating in activities of households, and observations from personal experience through working in the indigenous territories. Several group discussions for feedback were held in each zone following completion of the semi-structured interviews.

Table 1 Characteristics of communities sampled

	Remote zone				Intermediate zone		Accessible zone
Community	San José Cabécar	High Cohen	Orochico	High Mojoncito	Low Mojoncito	Sepecue	Shiroles
Distance from Bribri[a] (km)	40	36	25	22	19	17	13.5
Altitude (masl)	500	500	200	175	150	100	50
Total households	10	12	24	25	45	126	300
Households interviewed	2	3	3	7	11	24	32
Percent interviewed	20%	25%	13%	28%	24%	19%	11%
Mean household size (st. dev.)	6.3 (±2.8)				4.6 (±2.1)		4.9 (±2.2)
Mean age of head of household (female)	38.0 (±11.7)				34.3 (±10.5)		38.5 (±12.3)
Mean age of head of household (male)	41.4 (±9.0)				38.1 (±8.9)		42.6 (±13.1)
Mean household landholdings (ha) (st. dev)	57.0 (±65.3)				42.1 (±55.1)		6.8 (±11.0)
Mean plot size (ha) (st. dev)	7.2 (±20.1)				6.5 (±18.9)		7.6 (±21.6)
Percent Bribri	69%				80%		68%
Percent Cabécar	31%				13%		17%
Percent other	0%				7%		15%

[a] Bribri is the nearest urban center with access to infrastructure outside the indigenous territories

Table 2 Conservation and development efforts promoting cacao in Talamanca

Organization	Project	Date
Coopetalamanca[a]	Rehabilitation of abandoned cacao farms	1984
ANAI[a]	Diversification of agroforestry systems Promotion of new cacao genotypes	1984–1991
Asociación de Pequeños Productores de Talamanca (APPTA)[a, c]	Reforestation in cacao farms, thinning and pruning	1987–1990 1991–1995 1995–2000
Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)[b, d]	Planting of timber and leguminous shade species with cacao	1989–1999
The Nature Conservancy[f]	EcoEnterprise fund for chocolate	2000
CATIE and World Bank Global Environmental Fund[e]	Biodiversity in cacao agroforestry systems	2001–2004
CATIE	Environmental service payments for aboveground carbon storage	2004–2006

[a] Acuña 2002, [b] Beer 1991, [c] Hinojosa Sardan 2002, [d] Somarriba et al. 2001, [e] Somarriba et al. 2003, [f] Niler 2002

Results

Abandonment and shifting of cacao agroforestry systems

Extension and research support promoting cacao agroforestry systems in the indigenous territories began in the mid-1980s (Table 2). These projects introduced improved production methods such as pruning, grafting of superior local germplasm, enrichment with fruit trees, and improvement of the shade canopy, and also provided workshops to train farmers and local extensionists in these practices. Projects also distributed cacao and shade tree seedlings for rehabilitation of abandoned cacao farms. Despite these efforts, land use has shifted away from cacao production in areas where other cash crops can be grown. Total cacao production in Costa Rica has declined from a peak of 32,500 ha harvested in 1968 to only 3,550 ha harvested in 2005 (Fig. 2a). Our household survey showed that of 42 plots that emphasized cacao when the household first began managing the land, only one (2%) remained in cacao at the time of the study. Cacao agroforestry systems were replaced by banana agroforestry (36%), mixed agroforestry (24%), and plantain (21%) (Fig. 3). Though mixed agroforestry systems often retained some cacao, they shifted to emphasize other crops, especially banana. While 30% of households surveyed had at least some cacao at the time of the study, only 36% of these sold their cacao for cash income. The remaining households either had abandoned their cacao or used it only for household consumption.

This trend of cacao agroforestry system abandonment or shifting to emphasize other crops can be understood in the framework of the vulnerability context in which households choose their livelihood strategies, and the structures and processes that influence livelihoods. Shocks and trends comprising the vulnerability context in Talamanca include crop disease, population growth, and concentration in population centers. Structures and processes include socioeconomic factors such as the shift from a subsistence to a cash-based economy, the relative prices of cacao and other cash crops, and institutional factors such as the availability of capital and government support for agriculture (Fig. 4).

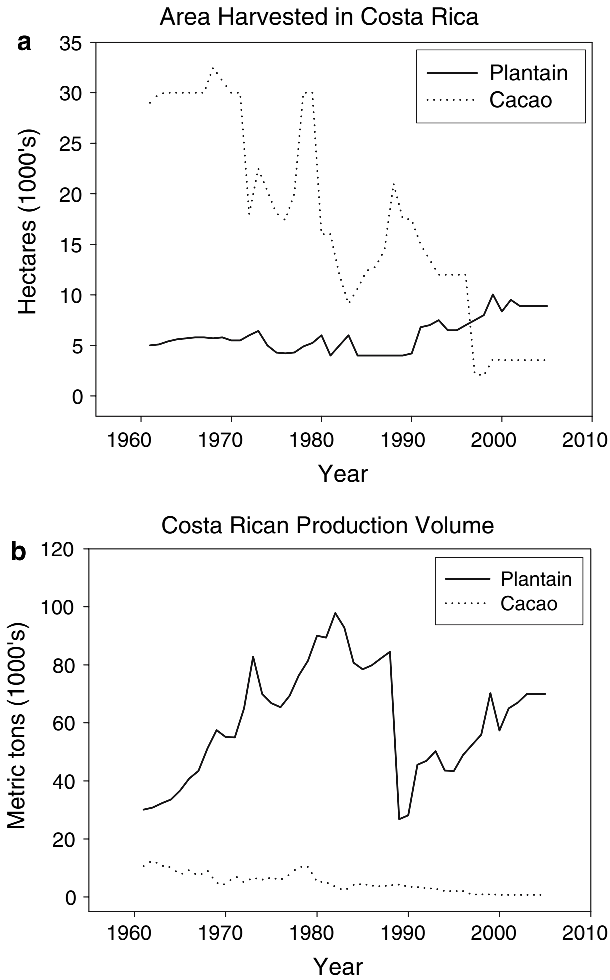


Fig. 2 (**a**) Area in Costa Rica harvested for plantain and cacao. (**b**) Costa Rican production volume of plantain and cacao. (*Source:* FAO databases, http://faostat.fao.org)

Vulnerability context

Monilia

The fungal disease monilia (causal agent: *Moniliophthora roreri* Cif.) was a devastating shock to livelihoods throughout Talamanca when it arrived in the late 1970s, and continues to be one of the major factors limiting cacao yields (Villalobos and Borge 1998). Fungal spores of monilia infect young cacao pods, resulting in rotting and discoloration within the pod, partial or complete destruction of the beans (Ampuero 1967), and deformation or death in small pods (Campuzano 1980). The spores are dispersed from diseased pods, mainly through convection currents within the farm and wind (Evans 1981). Pod losses due to monilia range from 10% to 100% and have led to the abandonment of cacao cultivation in some parts of Latin America (Phillips-Mora 2003). The disease was first reported in Costa Rica in 1978 (Enriquez and Suarez 1978). Between 1978 and 1983, the area of land harvested declined from 30,000 ha to 9,100 ha (Fig. 2a), and total cacao production in

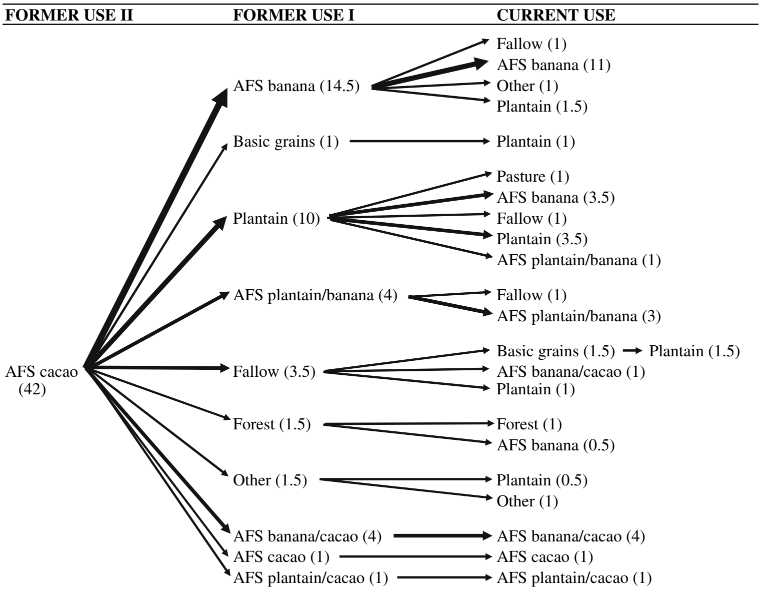


Fig. 3 Shifts out of cacao agroforestry systems for household plots whose management began with cacao agroforestry systems in 8 communities in Talamanca. Thicker lines reflect more common land use pathways. Numbers of plots are in parentheses. AFS = agroforestry systems. 'Other' includes tubers, fruit trees, and home gardens. *Source:* Whelan 2005

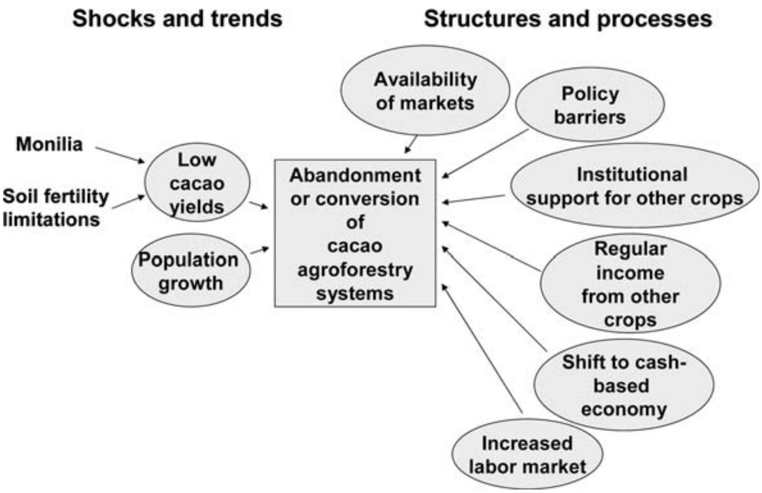


Fig. 4 Factors influencing abandonment and conversion of cacao agroforestry systems in Talamanca

Costa Rica declined by 79% (Fig. 2b). Cacao production in Costa Rica has never since recovered to pre-monilia levels. Our household survey showed that all households who had abandoned their cacao or shifted it to other crops mentioned monilia as the determining factor in their decision.

Control methods for monilia remain limited. Since cacao in Talamanca is grown for organic markets, control of monilia with synthetic fungicides is not an option for farmers (Krauss et al. 2003). Copper-based fungicides can be used in organic production, but are not economical when cacao yields are low or in areas with high rainfall (Hernández 1991, cited in Soberanis et al. 1999). No resistant cultivars are available, although work is ongoing to develop monilia-resistant germplasm (Phillips-Mora et al. 2005). The removal of diseased pods has been promoted in other regions as a cultural control practice (Soberanis et al. 1999; Leach et al. 2002), and biological control with fungal antagonists has also been investigated (Krauss and Soberanis 2002). Pod removal and biological control have both been tested in Talamanca, but results so far are inconclusive on the efficacy of these methods and their profitability (Krauss et al. 2003). Given the lack of profitable control methods and drastic yield losses, monilia continues to be a major barrier to reversing the production decline of cacao for many farmers in Talamanca.

Demographic trends

Demographic trends within the indigenous territories also form part of the vulnerability context affecting households and their livelihood strategies. Increased population pressure on cultivated land, for example, can be an important influence on transformations in agricultural production (Boserup 1981). The population of the indigenous territories has surged from 2,790 inhabitants in 1973 to 10,292 by 2000 (Yepez 1999; Municipality of Talamanca 2003). The population has also become more concentrated in the Talamanca Valley. Although the valley constitutes only 18% of the indigenous territories, over 80% of the population resides on these flat and fertile lands (Borge and Castillo 1997). These trends are due to both overall population growth and immigration of non-indigenous peoples. In the late 20th century, several groups of non-indigenous residents migrated to Talamanca due to drought in Guanacaste, Costa Rica, conflict in Nicaragua, and employment opportunities with the petroleum explorations of the Costa Rican Petroleum Refinery (RECOPE) (Villalobos and Borge 1998).

Pressure on land is likely to intensify as population growth continues. From 1976 to 1991, land under cultivation more than quintupled from 2,000 to 10,700 ha, largely due to an increase in plantain and organic banana production (Yepez 1999). More than half of households interviewed (59%) stated that they did not have enough land to meet their needs. When asked how much land they needed, the mean response was 7.8 ha. Our survey found that in the communities with better access to basic infrastructure and services, some households had no land at all (15.6%), while 22% of households had 1 ha or less. Present conditions leave many households with few options but to cultivate limited landholdings intensively while complementing on-farm activities with off-farm sources of income. In the communities of our study region that had less population pressure on land, group discussions with key informants indicated that cacao agroforestry systems were often abandoned and left to return to secondary forest. In areas with greater degrees of population pressure, cacao was predominantly replaced by banana agroforestry systems or plantain, or remained only partially in cacao production while shifting to emphasize other crops (see also Yepez 1999). These changes illustrate the role of demographic trends in household decisions to either intensify production of agroforestry systems or abandon cacao agroforestry systems to pursue other livelihood strategies.

Structures and processes: socioeconomic and institutional factors influencing livelihoods

Cacao production in Talamanca is also limited by structures and processes that favor the cultivation of alternative crops. These include the development of a cash-based economy, increased availability of domestic and international markets for plantain, higher and more regular income from plantain sales, wage labor opportunities in plantain, and a favorable policy context for plantain compared to organic crops. The economy within the indigenous territories has shifted from subsistence to a cash-based economy. This shift began with commercial production of cacao by the UFC in 1909 (Villalobos and Borge 1998). After the UFC withdrew from the Talamanca Valley in the 1940's, local residents continued to cultivate cacao as a cash crop (Villalobos and Borge 1998). The immigration of wage laborers and cash crop producers intensified the transition to reliance on cash income. When cacao production was no longer profitable following the onset of monilia in 1978, the demand for continued cash income led to the adoption of other cash crops such as plantain and organic banana. Plantain began to replace cacao as a cash crop in 1983–1984 (Fig. 5), when U.S. transnational companies and Nicaraguan importers began purchasing

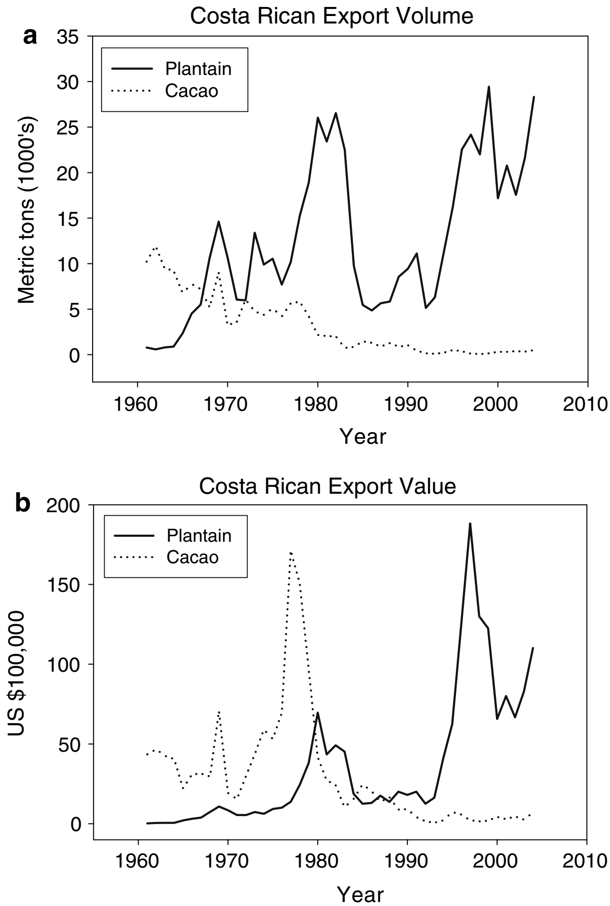
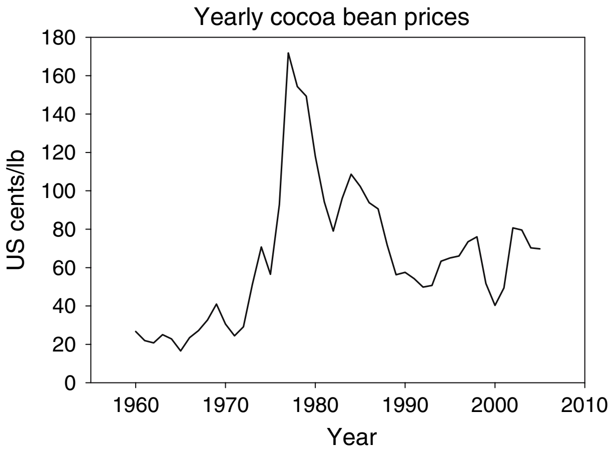


Fig. 5 (**a**) Volume of annual Costa Rican exports of plantain and cocoa beans. (**b**) Value of annual Costa Rican exports of plantain and cocoa beans. (*Source:* FAO databases, http://faostat.fao.org)

Fig. 6 International cocoa bean prices (*Source:* International Cacao Organization, http://www.icco.org/menustats.htm)



plantains in Talamanca (Somarriba 1993). By the late 1980s, the plantain market provided more financial security than cacao due to low and fluctuating cacao prices (Fig. 6). By contrast, markets for organic cacao and organic banana did not develop until the early 1990s (Hinojosa Sardan 2002).

Although an organic market for cacao in Talamanca exists, plantain provides higher and more regular income. Available estimates of average yearly gross income per hectare vary widely (Table 3), and systematic comparisons of cash crops in Talamanca do not exist beyond these sources. These estimates come from several previous studies conducted within the indigenous territories, some of which relied on interview data (Deugd 2001; Hinojosa Sardan 2002; Winowiecki unpublished data) and one on on-farm production data (APPTA production data 2004). An estimate of gross annual income for cacao was also calculated from yield and price data available from the FAO (FAOSTAT data 2006, http://faostat.fao.org). Some studies were conducted within only one production year (APPTA production data 2004; Deugd 2001; Hinojosa Sardan 2002; Winowiecki unpublished data).

Table 3 Available estimates of yearly income and benefit/cost ratios for primary cash crops in Talamanca

Crop	Frequency of harvest	Average yearly gross income/ha	Benefit/cost ratios
Cacao	1–2 times per year	\$19 ± 16[e]	0.14[e]
		\$80–120[a]	0.78 ± 0.80[c]
		\$111 ± 73[b]	1.54[f]
		\$270 ± 88[c]	
Banana	Every 2 weeks	\$160–240[d]	0.97[e]
		\$200 ± 143[e]	1.81 ± 0.66[c]
		1100 ± 339[c]	
Plantain	Every 1–2 weeks	\$600 ± 397[e]	3.42[e]
		\$700–\$3,500[f,g]	3.68[f]

Modified from [a] Winowiecki unpublished data; [b] Yield and price data 1991–2002, FAOSTAT data 2006, http://faostat.fao.org; [c] Deugd 2001; [d] APPTA production data 2004; [e] Hinojosa Sardan 2002; [f] Yepez 1999; [g] Municipality of Talamanca 2003

Some do not state their duration and methods with enough specificity for full comparison, but do provide additional context for understanding the patterns of factors affecting cacao production (Municipality of Talamanca 2003; Yepez 1999). Sample sizes from these studies vary from 6 farms (Deugd 2001) to 71 (Hinojosa Sardan 2002) to 325 farms (APPTA production data 2004). While these sources provide widely variable estimates of gross income from the three major cash crops in Talamanca, they illustrate a general pattern: plantain generates the highest gross income, followed by banana and finally cacao. Studies that calculated the benefit/cost ratios for these crops show the same pattern, with a benefit/cost ratio less than 1 for cacao compared to over 3 for plantain (Table 3). Costs of production in these studies included labor, services such as transportation, and purchased inputs (Deugd 2001; Hinojosa Sardan 2002). Some of the differences among studies may be due in part to different methods of calculating labor costs. In particular, including household labor as a cost may result in underestimating the benefit/cost ratio for cacao (Deugd 2001), since many households rely on the labor of family or traditional group work days for which they do not pay wages. However, each study alone presents the same pattern of a lower benefit/cost ratio for cacao compared to banana or plantain.

The results of our household interviews correspond to this pattern. Only 2% of households considered cacao an important source of income, compared to 23% for plantain (Fig. 7). Lower income from cacao results in part from low cacao prices, due to both international price trends (Fig. 6) and the lack of competition among cacao buyers in Talamanca (Andrade and Detlefsen 2003). Only two local associations in Talamanca currently buy cacao for one export market, whereas a variety of buyers exists for plantain

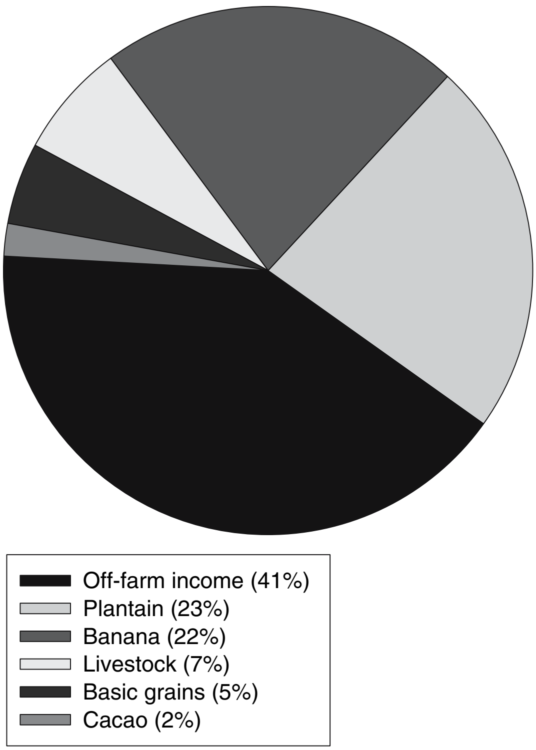


Fig. 7 Household responses to the question: What are important income sources for your household?

for national and export markets. In open-ended discussions with respondents, 44% of households who commented on the future of organic agriculture in the indigenous territories mentioned low or unstable prices as obstacles. Regularity of income is also important because of the demand for a continuous supply of cash in an area with limited access to credit and savings mechanisms. While cacao has one major harvest per year, with one or two secondary harvests, plantain can be harvested and sold on a regular weekly or bi-weekly basis. Responses from households indicate that this cash structure affects livelihood strategies and decisions about land use.

Plantain farms also provide opportunities for wage labor due to their higher management intensity. Off-farm income has become an increasingly important livelihood strategy for households in the indigenous territories. When asked to list important sources of household income, 41% of households mentioned off-farm labor (Fig. 7). Labor invested in cacao production now carries the opportunity cost of wages that could be earned in plantain farms. This contributes both to low cacao yields and increased reliance on plantain for income. We found that of the 10 households that employed permanent labor, 80% used that labor in plantain. Of the 16 households that employed labor irregularly, 73% used that labor in plantain. In foothill communities which are unable to sell to plantain and organic banana markets, 80% of households had at least one member who worked as a wage laborer. This trend is also seen in valley communities, where households with limited landholdings often depend upon wage labor in plantain farms.

The lack of institutional support available for cacao compared to plantain has contributed to the decline of cacao agroforestry systems in areas where plantain can be grown. Institutional support for cacao existed in the form of research efforts and promotion of diverse farms by NGOs during the 1980s (Table 2). However, that support was not enough to compete with support offered to plantain growers from the Costa Rican government and national and international plantain buyers. Plantain exporters have received economic incentives such as tariff exemptions or reductions and tax credits (Somarriba 1993; Mora 2005). In the indigenous territories, plantain buyers provide farmers with tools and agrochemical inputs and later deduct them from the sale of plantain, enabling households with little or no resources to begin plantain production (Whelan 2005). In our survey, 26% of total households reported receiving informal credit from plantain middlemen, who operate between producers and multinational corporations or national wholesale buyers. In the more accessible zone, 53% of households had access to informal credit, and all of this credit was from plantain middlemen. Also, the Costa Rican government provides extension services for plantain growers (Garcia 2003). Of the households in our survey, 9.8% mentioned receiving visits by government extensionists for plantain production, but none mentioned receiving a visit from a government extensionist for cacao production.

Organic certification requirements and legislation for timber sales from agroforestry systems are potential obstacles to cultivating cacao within the territories. Organic certification requires yearly inspections paid for by farmers. A three-year transition period with no chemical inputs is required to convert from plantain to organic systems (Soto 1998). Requirements also include an 8 m buffer zone separating organic farms from plantain farms with chemical use (Ecocert Canada 2006). Given the present conditions of land scarcity and poverty in Talamanca, farmers may be reluctant to take land out of production in order to meet these requirements. For example, 76% of households who responded on the subject of organic agriculture mentioned agrochemical use in nearby plantain as a barrier to the spread of organic systems. Only 4% of households surveyed considered cultivating cacao in the future. Similarly, current forest legislation acts as a disincentive to cultivate agroforestry systems. Timber harvests must be conducted with advance permission from the indigenous territories' development associations and payment of fees. According to Costa Rican and local indigenous law, farmers can only harvest trees from designated agricultural land with a maximum harvest of three trees of over 50 cm diameter at breast height per hectare and up to 9 trees per year, including fallen trees (Candela 2006). This strict legislation, combined with the excess fees and costs of tree harvesting, limits the potential of timber products to augment income from diversified farms.

Discussion

Efforts to promote cacao agroforestry systems as a conservation tool would benefit by addressing factors limiting cacao production. Our analysis indicates that producing cacao as a livelihood strategy remains bound to a variety of local, regional, and global factors. Low international market prices may inhibit farmer motivation to expand cacao production if they also have the choice to grow plantains for a higher and steadier income. Related to this, local buyers' organizations may help buffer global fluctuations in price, but can also set lower prices. Regional or local pricing may then relate to the presence or lack of a cooperative structural arrangement that would include or exclude indigenous farmers in economic decisions within the market. The prevalence of monilia in Talamanca drastically reduces cacao yields, and no control methods currently exist that would be feasible for farmers within the indigenous territories. This multiplicity of factors highlights the complexity that smallholders face in choosing livelihood strategies with tradeoffs beyond individual control. An important next step in addressing the factors limiting cacao production would be to conduct a sensitivity analysis to identify the response of profit gained from cacao production to each factor. A sensitivity analysis of organic cacao agroforestry systems in Belize identified labor-saving management practices and availability of credit as strongly influencing profit, while profit responded weakly to changes in cacao price policy and not at all to changes in timber sale prices (Rosenberg and Marcotte 2005). A similar analysis in Talamanca could help organizations promoting cacao to focus efforts on factors with a greater effect on profit for cacao farmers. While our analysis does not attempt to comment on the relative importance of each factor, in the following section we discuss potential avenues to address the limitations of cacao cultivation in Talamanca. Although many of these are specific to the Talamanca region, they illustrate the general importance of including an understanding of livelihoods in conservation efforts involving the promotion of diverse agricultural systems.

Addressing the vulnerability context

Continued research on feasible monilia control methods for farmers in Talamanca is needed in order to raise cacao yields and income generated from cacao agroforestry systems. A participatory evaluation of cultural and biological control for monilia in Talamanca found that both weekly pod removal and treatment with fungal antagonists reduced disease incidence (Krauss et al. 2003). However, neither practice was profitable during the two years of the study, and the authors recommended further research on combinations of the two strategies (Krauss et al. 2003). An evaluation of one project of the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Talamanca recommended the use of locally available fungicides such as compost tea, effective microorganisms (EM) products available from EARTH University, and supermagro, a biofertilizer with fungicidal properties (Altieri 2004). Increased extension efforts are also necessary to disseminate improved control methods. If monilia remains a major constraint to cacao production, it is extremely unlikely that farmers in Talamanca will consider cacao a profitable cash crop compared to banana or plantain.

Efforts to promote improved management practices such as shade canopy rehabilitation, pruning, and grafting of local superior varieties should be continued to help to raise cacao yields. In the Talamanca Valley, an increasing population on fixed land resources continues to reduce the available land per household. Consequently, cacao agroforestry systems will require more active management to compete with more intensified systems. While cacao cultivation is traditionally an extensive, low-management land use, improving management on a small area of land may be a viable strategy (Altieri 2004). Soil management techniques could also improve yields on low-fertility soils. These include practices which decrease nutrient leaching from the system, increase soil pH, minimize soil erosion, and increase soil fertility status through introduction of nitrogen-fixing shade trees.

Another strategy to improve cacao agroforestry systems is to manage several components more intensively, such as the timber and fruit species present in addition to cacao. Biweekly banana harvests from mixed systems can provide the regular income needed to sustain household livelihoods between cacao harvests. Improved management and marketing of organic banana in mixed agroforestry systems with cacao could contribute to the viability of these systems. Plantain can also be grown in organic agroforestry systems, although cosmetic insect damage excludes it from export and results in a lower price for sale to the national market. A simulation model comparing mixed plantain, timber, and cacao agroforestry systems with monocultures of each crop in Panama found that the mixed agroforestry systems provided higher and more stable net incomes (Ramirez et al. 2001). While no one solution will alleviate all biophysical limitations for cacao production, a combination of management techniques may help to increase cacao yields and encourage farmers to plant and maintain cacao agroforestry systems.

Improving structures and processes

Increasing institutional support

Institutional support for cacao in the form of capital, extension efforts, and infrastructure is currently far below that available for plantain, which benefits from both public and private support at both the farm level and regional and international levels. Policies that provide incentives for organic production and cacao agroforestry systems are necessary if agroforestry systems with organic products are to expand beyond current levels. Technical support from government extension agencies and NGOs would provide incentives to keep cacao in production. Many local farmers have received training as extensionists in cacao management practices such as pruning and grafting. However, funding to employ them runs out when a project ends. Finding ways to keep local extensionists employed would help provide the institutional support needed to improve production in cacao agroforestry systems. Institutional support for cacao on the local level could also be improved by providing better access to tools and credit options for households interested in improving management practices. In addition, cacao farmers are currently not organized enough to collectively negotiate with buyers for better prices. Efforts to unite cacao farmers through community organizing and workshops on negotiation techniques could empower them to demand better prices for their product.

Modifications in current legal structures are necessary in order to remove disincentives for organic production in agroforestry systems. Although well intended, the certification process, buffer zone, and three-year transition period unfortunately act as regulatory barriers for households interested in changing to organic production. Changes in this process or financial support such as credit for households during the transition period would make this transition more feasible. Also, legal changes to allow for increased sale of timber products within sustainable limits would improve the profitability of diverse agroforestry systems. The current law regulating the sale of timber products is a national law administered by the indigenous governing bodies and could be modified to allow farmers to harvest timber sustainably in agroforestry systems while still protecting forested areas. An analysis of timber harvests in agroforestry systems in Talamanca concluded that timber could be extracted at double the current rate and still be sustainable (Suárez Islas 2001). Finally, efforts by the National Forestry Financing Fund (FONAFIFO) and CATIE to institute legal structures to allow for environmental service payments and the sale of carbon credits from land uses such as cacao agroforestry systems should be continued. The potential for including diverse organic banana agroforestry systems could also be explored.

Generating additional income from cacao products

Transformations toward a cash economy have created new pressures for households to generate cash income through both on-farm and off-farm activities. A livelihoods focus reveals the importance of the regularity and diversity of income. Adding value to cacao through roasting, packaging, and marketing of chocolate products could diversify the Talamanca cacao market beyond its present reliance on only two buyers, offer households a more regular income, and generate off-farm employment opportunities. The Association of Indigenous Women of Talamanca (ACOMUITA) has sought to add value to cacao by acquiring equipment to process and package chocolate, with financial and technical support from the World Bank, USAID, and CATIE. While initial efforts are promising, there is room for improvement in quality control, packaging, marketing, and the involvement of more cacao-growing households within the territories. These efforts could benefit from increased support such as providing market liaisons outside the indigenous territories. There is presently an opportunity to reach local and national tourist markets by filling a niche for certified organic and indigenous-grown chocolate products. Diversification out of sole reliance on export markets would have the added benefit of buffering household livelihoods in times of commodity price fluctuations.

Agro-tourism also offers potential for generating higher incomes for cacao-producing households. Tourism in Talamanca has grown in the last several decades, including cultural and ecological tourism within the indigenous territories (The Nature Conservancy 2005). The Community Ecotourism Network of Talamanca was created in 1998, a product of the work of development organizations such as the Talamanca Ecotourism and Conservation Association (ATEC), the Association ANAI (formerly the Association of New Alchemists), and the Talamanca-Caribbean Biological Corridor Association. This network has trained local guides and offers tours of communities growing organic cacao, where tourists are presented with information about cacao agroforestry systems and served cacao as a beverage and in processed form. While these efforts to add value to cacao cultivation through agro-tourism are still in their initial stages, they offer potential for expansion to more communities within the indigenous territories.

Certified products such as organic cacao and banana can provide farmers with additional income through premium prices for organic products. Since the continued production of organic products depends on consumer demand, campaigns to generate awareness of ecological and social issues in agricultural production form a crucial part of any effort to promote cacao agroforestry systems as a conservation tool. One example is the certification of origins currently being developed for coffee, which allows consumers to purchase coffee based on the significance of a particular place and its people. Most of Talamanca's cacao is currently exported to only one company and processed with cacao from other places. Developing a certification of origins could differentiate Talamanca cacao products and potentially increase the price farmers receive for their cacao.

Conclusions

Incorporating a livelihoods framework into biodiversity conservation efforts that include agriculture can help identify the constraints households face for competing land uses and the socioeconomic and institutional structures and processes involved in land use change. Equipping conservation efforts with this understanding could improve the promotion of diverse agroforestry systems as an alternative to monoculture. In places such as Talamanca where diverse agroforestry systems compete with a profitable and well-supported monoculture cash crop, conservation efforts to promote diverse agricultural systems must take into account the social and economic incentives for farmers to convert land to monoculture. Talamanca also demonstrates the importance of diversifying sources of income, recognizing both on-farm and off-farm opportunities, to compete with incentives for conversion to monoculture. In addition, our case study identifies intensified agroforestry systems that manage several cash crops as potential profitable alternatives to monoculture. These include regularly harvested crops such as banana or plantain that can provide continuous short-term income in addition to the seasonal income generated from cacao. Conservation efforts promoting more diverse land uses would benefit from greater inclusion of farmers and awareness of the social and economic realities that influence their livelihood strategies. While addressing factors that influence household livelihoods and land use may seem a difficult task or outside the expertise of conservationists, it is essential for the success of biodiversity conservation efforts that seek to include agricultural systems on private lands.

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