MARKETS AND BIODIVERSITY IN THE YUCATAN

by

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This paper is part of a work-in-progress that deals with the interaction between markets, non-farm income and biodiversity in a community in the Yucatan Peninsula. Biodiversity indices are calculated and socio-economic trends analyzed in order to understand the process of increasing reliance on urban markets by rural populations and the loss of biodiversity. Some policy implications regarding interdisciplinary work and biodiversity conservation are drawn.

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Introduction

Farm households in developing countries participate in farm as well as non-farm activities. It is well known that farm household diversify their economic activities into non-farm activities in order to cope with crop shortfalls and to overcome credit and land market constraints. Diversification is an attempt to deal with different types of farm risks. Therefore, theories of farmer behavior under risk have been proposed to explain land allocation decisions by farm households (Meng:1997)[1]. A good example is the theory explaining the continued cultivation of traditional varieties by looking at the risk-averse behavior of farmers under some type of production risk (Meng:1997). This is particularly important in the context of rainfed agriculture in the tropics where there is a high risk of crop failure.

Access to non-farm income has other important objectives besides reducing income risks from production failure. It is also known that consumption smoothing is another objective in the overall household diversification strategy. In rural areas where consumption is tied to production fluctuations, it has been advanced that households first satisfy a minimum level of consumption and then they venture into cash crops. Therefore it is important to consider subsistence requirements first in order to explain the diversification of household land allocations. It is assumed that non-farm income may have the same effect of smoothing consumption as the land allocation decisions to use multiple crops within a single farm.

It is also advanced in the literature that access to non-farm income can overcome cash and credit constraints. The presence of credit market failures and land constraints in less developed countries induce households to seek other sources of income to overcome these constraints. Access to off-farm income also has important implications for the incidence of rural poverty and inequality and eventually on food security and rural development depending on the well-functioning of rural markets.

Given the importance of non-farm income, it is worthwhile to analyze the impacts of off-farm income on poverty, rural development and its potential role in biodiversity conservation. The link with biodiversity is due to the nature of most rural economies around the world. Rural economies in poor countries are for the most part biomass-based subsistence economies; that is, the rural populations eke out a living from products obtained directly from plants and animals (Dasgupta and Maler:1995). The plants and animals in the forest is the equivalent to what some economists call "natural capital". The value of this natural capital refers to its direct values such as the one derived from direct consumption of resources and indirect values such as the ones not directly consumed but essential to the production of resources (UNEP:1995). Biodiversity, which in this particular case refers to the mix of species and individual organisms, gives an indirect value to the productivity of the whole system. The value of biodiversity for forest resource users may be limited to some simple extraction activities because of the lack of knowledge of the value of the services that biodiversity provides to society as a whole.

[1] For theories of farmer behavior under risk, see Fafchamps (1992), Finkelshtain and Chalfant (1991), Feder (1980)

The Problem of the Loss of Biodiversity

Biodiversity is the paradigm of the XX century about what we have and about what we are losing (Halffter et. al.:1992), yet its precise meaning is still being debated. The concept of biodiversity is usually understood by ecologists and conservationists as species richness or the number of species and/or genetic diversity (alpha diversity). But biodiversity also manifests itself between habitats (beta diversity) and in the heterogeneity at the geographical level (gamma diversity). What precisely is biodiversity elicits many answers. At a basic level, biodiversity is the result of the evolutionary process that results in the existence of different modes of being but at another level, biodiversity is simply a measurement of the heterogeneity of a system, for example, biodiversity refers to the quantity and proportion of different biological elements contained in a system. Thus the estimation of biodiversity depends on the scale that defines the problem (Halffter et. al.:1992).

In this paper, we take an ecological view of biodiversity, that is at the ecological level, biodiversity has two expressions in the analysis of communities: diversity present in a particular place, also known as alpha diversity; and spatial heterogeneity, also known as beta diversity. In particular, we are interested in alpha diversity, which is a function of the quantity of species in the same habitat, because it is the more important component of diversity in the humid tropics (Halffter et. al.:1992).

It is well known that the tropics are the most diverse systems and that biodiversity decreases as we move longitudinally away from the tropical areas. The tropics cover 7.14 percent of the land surface but contain at least 50 percent of the species in the planet (Dirzo:1998). The loss of biodiversity is mainly seen as the reduction in the number of species and its proximate cause is the destruction of habitats through deforestation. The global problem of deforestation has attracted a great deal of attention because the rate at which it is occurring is alarming. It is estimated that the rate of global deforestation is between 0.7 - 1 percent annually where 0.7 percent is equivalent to a forest the size of Costa Rica (Dirzo:1998).

The societal importance of biodiversity can be appreciated at different levels. At one level, biodiversity is present in the process of oxygen production, soil regeneration and water availability. At another level, biodiversity serves as a source of raw materials for products used in human consumption. For rural populations, biodiversity provides 25 percent of the fuelwood for cooking, 50 percent of the fiber used in textiles and almost 50 percent of the medicine and food used by humans (Benitez et. al.:1997). Nevertheless, it is in these rural areas that the problem of the loss of biodiversity is accentuated. In the particular case of Mexico, a striking example is provided by the destruction of the Bajio Zone mostly made up of low tropical deciduous forest which has disappeared by about 95 percent. Dirzo (1998) claims that the same fate awaits the Tuxtlas region in Veracruz.

Ecologists have stressed that biodiversity also plays a role in the evolution of ecosystems by providing the units through which both energy and materials flow and by providing an ecosystem with resilience. Resilience is the capacity of an ecosystem to recover from perturbations, shocks, and unexpected events. The problem lies in the fact that information is costly and the poor are able to command less information than the rich (UNEP:1995). But this problem of information is related to the problem of poverty. The rural poor are constrained in their access to credit, insurance and capital markets; therefore, distortions are present such as domestic animals assuming a singularly important role as an asset (Dasgupta and Maler:1995). As these authors point out there is evidence in Sub-Saharan Africa of farmers with extra cattle as a form of insurance. Livestock is also said to be a major form of investment in rural communities in Mexico where remittances are significant as a proportion of total income. Extensive cattle management tends to be one of the causes of the changes in the use of land which leads to deforestation and the consequent loss of biodiversity. In Mexico, the threat to biodiversity comes mostly from the conversion of forests and secondary vegetation to agricultural and pasture areas (Gonzales-Iturbe:1992).

Mexico is considered one of the mega-diverse countries in the world. The World Bank and the World Wildlife Fund (WWF) have described Mexico as the country with the highest biodiversity in Latin America and the Caribbean. Mexico has a high diversity of reptiles (717 species of which 53 percent are endemic); it occupies the second place in mammals with 449 species of which 33 percent are endemic, and it occupies the fourth place in amphibious with 282 species of which 63 percent are endemic (Gonzalez-Iturbe:1992). The same author affirms that the Mexican flora is also rich in species and endemism. Mexico has 2,000 species of flowering plants of which 50-60 percent are endemic. Among the endemic species are found 50 percent of the *Phaseolus* (beans), 82 percent of the *Agave* (henequen), 88 percent of the *Salvia*, and 75 percent of the *Scutellaria*. Mexico is also considered one of the most important centers of plant domestication in the world and it is estimates that 180 genotypes have been domesticated here for consumption uses, for inputs into the fabrication of textiles as well as for ornamental uses.

The Yucatan Peninsula in particular although not among the richest species sites in Mexico such as Chiapas or Veracruz, nevertheless it has approximately 184 endemic species and a great diversity of ecosystems such as high evergreen tropical forest, medium sub-evergreen tropical forest, low tropical deciduous forest, swamp tropical and savanna vegetation (Gonzales-Iturbe:1992). Yet, Yucatan is also one of the poorest states. Even in the more dynamic cities such as the medium-sized cities of Yucatan and in the more dynamic sectors such as servicies, 30 percent of those employed earned the equivalent of one or two minimun wages (approximately US$ 2-5 a day). The agricultural sector is even more problematic because close to 50 percent of those working did not receive any income.

Poverty is also present at the macro-level. There is recent literature on the interactions of poverty and environmental degradation (Perrings:1989, Dasgupta:1993). It is well known that the countries with the highest levels of biodiversity tend to be also those with significant degrees of poverty. It is also generally accepted that one of the causes of poverty is the unequal distribution of assets and income and that those with few assets and income tend to over-exploit their resources. Since it is argued that the 1980s have been a decade marked by increased polarities in the distribution of income in Mexico as well as in other countries in Latin America, it is of interest to know how non-farm income changes the distribution of income and what the implication of this will be for natural resource management.

It seems evident that rural populations are natural resource dependent as argued by Dasgupta (1993). Therefore, the environmental resource-base of rural communities must form part of any analysis of their production activities. Part of this examination of the resource-base or natural capital is the study of biological diversity. The popular belief is that biodiversity derives its economic value mostly from its potential uses of genetic material for pharmaceutical purposes. In rural areas, the loss of biodiversity is also strongly linked to the problem of food security. International discussions of the loss of biodiversity are alarming mainly because the destruction of the forests brings about the loss of the chance to utilize important genetic resources in the industrialized world while there is little international discussion of the value of the rainforests for the local populations (Shiva et. al.:1995). According to McNeely et al. (1990), human usage of the rainforests can be analyzed under three main aspects: ecological functions, subsistence values, and commercial usage. Informational problems are present here since the forest-resource users are aware of the subsistence value but may not be aware of the commercial opportunities of other potential uses of biodiversity and there is limited knowledge about the ecological functions of biodiversity in their communities.

Managed Systems

Since the 1980s, social scientists have been questioning the social construction of nature which has led to the awareness of the subtle and not-so-subtle ways in which different cultures modify their natural surroundings. Place (1998) contends that "Some researchers have even argued that the much-publicized biodiversity of the tropical rainforests was partly the result of human activities, especially swidden cultivation and the management of forest succession during periods of non-cultivation". This seems to be the case in the Yucatan Peninsula where there has been a great deal of human intervention in the forest.

Yucatan is covered with tropical dry forest that has been used extensively by the Maya population for hundreds of years. The principal land uses in the Henequen Zone, comprised of the northern part of Yucatan, are: *milpa* production which consists of shifting cultivation for the production of maize, beans, and horticultural crops, home gardens in which trees, shrubs, crops and animals are produced, and secondary low deciduous forest which is the source of fuel, timber, medicinal plants, etc. These homegardens are also a repository of many species of plants.

It is essential to look at human intervention in understanding the loss of biodiversity in the Yucatan Peninsula as in finding ways to conserve it. A corollary to this proposition is that the conservation of biodiversity should not be confined to protected areas. It is known that protected areas cover only 3 percent of the world's land area, making it imperative to seek the conservation of biodiversity in other land areas as well (Gomez-Pompa and Kaus:1992).

In the Yucatan Peninsula, there is a wide range of definitions covering the concept of protected areas. Overlapping the different definitions of protected areas under federal, state and even municipal levels, one could look at total area under protection as an indicator of the success in protecting species. In the State of Yucatan, 7.47 percent of the total state surface is under some form of protection which translates to approximately 293,679 hectares (Sosa: 1996) This is insufficient to protect the flora and the fauna according to most biologists since Yucatan already presents a high degree of vegetation disturbance where 60 percent of its total surface is under some form of agricultural, cattle or forestry use. Therefore, much of the flora could be protected through *in-situ* conservation and the active management of natural resources by rural populations already engage in these activities within their managed systems. It has been found that these systems may even have more biodiversity than the natural vegetation.

The Yucatan Peninsula also offers a unique historical opportunity to intensify their managed systems because of the reduction in one of the traditional monocrops, henequen. Henequen (*Agave fourcroydes Lemarie*) cultivation was the most important agricultural activity in the state of Yucatan. Most of the fiber, both for national and international markets, was originally produced in the Peninsula. At the beginning of this century, the Yucatan Peninsula produced 96 percent of total world production. Henequen plantations had serious repercussions on the ecology and population distribution of the region. From a demographic point of view, the labor requirements of henequen plantations caused significant migrations between regions and increased the population density with the area which is known today as the Henequen Zone. But the henequen industry like most enclave economies was subject to international market conditions. The price fluctuations of the fiber showed a declining trend for the most part of this century due to competition from production in other countries and the introduction of synthetic fibers. The Mexican government responded to this trend by heavily subsidizing this economic activity starting in the 1960s. By 1973, it was clear that the state had to diversify their economic activities since the collapse of the henequen industry was eminent.

The trend towards globalization and market liberalization resulted in the end to all subsidies in 1992 and the elaboration of a new economic development plan for the state. This plan, called the “Regional Development Plan for the Henequen Zone”, has only started to be implemented. Unfortunately, the local producers were not included in the planning process so their needs, ideas and experiences have not been directly taken into account. Notoriously lacking is women’s participation even though women have traditionally been managers of some managed production systems such as the homegardens. But there is also an opportunity to increase biodiversity by moving away from a monocrop such as henequen to a more diverse number of species in searching for new economic alternatives.

In order to study the interactions of markets, non-farm income, rural population and biodiversity, we are currently conducting a project in the municipality de Hocaba, one of 62 municipalities in this zone of the state of Yucatan. The main objective in this part of the study is to examine farm and non-farm income and the implications for natural resource management and biodiversity. It is also intended to shed some light on the socioeconomic characteristics of those in charge of these managed systems in order to see what type of producers are more likely to intensify production.

Description of the Community under study

The municipality de Hocaba is made up of the *ejido* of Hocaba (pop. 5,317 with approximately 764 households) about 41 Km from Merida and the *comisaria* of Sahcaba (with approximately 200 households). The population is mostly young with about 65 percent below 30 years of age. The economically active population (PEA) is 34 percent. The municipality does not have any flowing water but underground water. Median temperature is 24.1 C and precipitation of about 60 millimeters. The landscape is mostly flat with permeable soil called rendzina. The vegetation is low tropical deciduous forest with abundant secondary vegetation, the most common species are *amapola, bojom, caoba, cedro, ceiba, chaca, ramon, zapote, tamarindo, flamboyan, chukum, jabin* and *kaniste*. The wildlife is mostly small animals like *mapache*, rabbits, squirrels and *tuza* as well as some reptiles and birds.

Farmer's activities include the traditional *milpa* which is mostly dedicated to maize cultivation (4-5 maize varieties) along with four other crops such as frijol (2-3 varieties) and other minor crops such as *jicama*, watermelon etc. The *milpa* system is done under the "*roza-tumba-quema*" (RTQ) system and Yucatan is known to have the highest extension of land under this system in the country (around 140,000 ha.) Some argue that population pressure and the *roza-tumba-quema* system have reduced the "fallow" period from 18-25 years (considered the ideal time for regeneration) to the current 4-8 years and therefore have reduced the productivity of the *milpa* system. Others think that it is due to the less and less available land for farmers as other economic activities are promoted such as citrus plantations and in particular cattle raising (Teran and Rasmussen:1994).

The community also has what is called *henequenales abandonados* or abandoned hénequen plantations which are either semi-abandoned at different stages of growth or completely abandoned. This may a misnomer because they do use it for different purposes such as handicraft production, fuelwood extraction, etc. These areas could also be cleared for *milpa* production. Recently, there has been an increase in the demand for henequen that has not been met by local producers, as a consequence hénequen is being imported. Nevertheless, the price seems to remain around four pesos (US$ .50 c.) per kilo because of the monopolistic nature of the industry where three producers controlled almost the entire henequen exports of the State. These producers acquire the enterprises as a result of the privatization of the henequen industry in 1992.

Official statistics indicate that there are areas called "natural vegetation" and "secondary vegetation", the former is referred to undisturbed areas and the latter is where there has been human activity. The "secondary vegetation" predominates and is part of the natural stock of the farmers even though it continues to decrease in size. This area is under communal property and it is used for *milpa* production, for extracting fuelwood and for hunting. There is indication that there are problems finding wood of the necessary size for home building and also scarcity of *huano* for roofing, all of which mostly come from the communal property which is being depleted. These definitions are not useful because they are unclear and they seem to overlap each other. Fieldwork is necessary to delineate the geographical boundaries of these managed systems.

Natural Resource Management and Homegardens

In addition to *milpa* and other forest activities, almost all households have a homegarden, also known as *solar* within their living quarters and are considered to be part of their homes. These homegardens maintain a great variety of fruit crops, animals and it is also good to experiment with other maize varieties.

There is relatively little known about homegarden systems. Research on home gardens have given attention to emulating the natural environment, gardens are the ultimate step in forest emulation (Budowski:1990) From an economic point of view, homegardens are important because they allow farmers to achieve a certain degree of food self-sufficiency and perhaps also the capability to avoid dependency on imported inputs such as fertilizers and pesticides. Others have analyzed home gardens as sustainable land-use systems which avoid environmental deterioration but as Torquebiau (1992) points out these authors have failed to provide quantitative evidence to make such claims.

One standard definition of a homegarden is given by Niñez (1985) who defines it as:

> "a subsystem within larger food procurement systems which aims at the production of household food items not obtainable either through permanent shifting agriculture, hunting, gathering, fishing, livestock husbandry, or wage earning".

Another definition is found in Torquebiau (1992):

> " Home gardens are agroforestry land-use systems with multipurpose trees and shrubs in intimate association with seasonal and perennial agricultural crops and livestock, within the compound of individual houses, and under the management of family labor"

This latter definition is very useful for an economic analysis due to the fact that it delineates clearly the geographical limits of the homegardens and their labor input requirements. Labor requirements, although the most prominent input, are said to be minimal. Table 1 shows the labor and cash requirements in various homegardens throughout the world.

Table 1: Labor and cash requirements in the homegarden

Place of the homegarden	*Size*	*Time spent*	*Cash inputs*	*Source*
Philippines	500 sq. mts.	2 hr. /day		Sommers (1982)
Lima	200 sq. mts.	50 min./day	$2.8 for 5 months	Niñez (1985)
Sri Lanka	n.a.	13-57 man-days/year		Luu (1989)
Mexico	n.a.	17-22 days/year	.01-.04 percent of total cash income	Alvarez-Buyla et.al. (1989)
Java	n.a.	n.a.	10 percent of output	Bompard (1986)
Abdoellah	n.a.	1.6 hr./day	8 percent of total expenses	Ochse and Terra

Source: Torquebiau (1992)

Home gardens also seem to have a high diversity yet little is known about what socioeconomic factors account for this high/low indicator of biodiversity. This may be of interest if one is quantifying whether home gardens are sustainable or not. In the present study, we try to avoid the debate on sustainability and concentrate on biodiversity *per se* and its usefulness to farmers. A high diversity of foods and income from plant species may be a valuable asset for future breeding programs in the form of germplasm banks (Torquebiau:1992). According to the same author, the high diversity of crops and the low density per species in the home garden along with the different biological cycles of the crops are all factors which reduce the risks associated with pests and diseases (Torquebiau:1992).

A thorough economic study of the homegardens should include an examination of the patterns of labor demand made by the homegardens. Here, one needs to describe the requirements and the flexibility of labor demand, the allocation of labor according to gender/age and to what extent there is use of traditional knowledge and practices. How does labor demand compete or complement other farm and non-farm activities and whether it is necessary to use hired labor. It seems that cash inputs are also minimal throughout the year so that liquidity-constraint farmers do not need access to credit and can manage their homegardens with very little cash.

Homegardens in the Henequen Zone in Yucatan

Homegardens in the Yucatan Peninsula are located alongside the living quarters of the household as an annex to the house. In the Yucatecan homegarden, one finds trees, shrubs, and herbs that are selected under several criteria such as edible fruit production, medicinal, ornamental and other uses. According to Rico-Gray et. al. (1990), studies of Yucatecan homegardens have traditionally emphasized lists of plant species present with little quantitative data, i.e. number of gardens sampled, area sampled, number of species, number of individuals present in the garden, and species comparisons between gardens.

The scarce data available on Maya home garden soils indicate these are very fertile but little is known regarding nutrient cycling in the system. Their fertility is maintained despite the practice by women who customarily sweep and burn the accumulated leaf litter. It seems that litter production of this agro-ecosystem with an average of about 2,959 gm-2 year-1 is high. Decomposition patterns for the litter of the main species indicate that it may be feasible to improve litter recycling by composting to improve soil fertility (Montanez:1998).

Households in Hocaba spend an average of 947.6 total hours a year on the care and maintenance of the homegarden. This number weighted by the number of available labor per household (members who are older than eight years) means that households dedicate about a total of 39 days a year to their homegarden[2]. De Janvry et. al. (1997) findings show that the proportions of *ejidatarios* (members of an *ejido*) who engage in backyard activities (a proxy for homegardens) increased from 63 percent to 75 percent between 1990 and 1994. These

[2] This number may be overestimated due to double counting. The total number of hours were divided by a day's work to convert to days (118.45) and in turn we divided this number by the average number of members working in the homegarden (3) which gives us 39 days a year.

households' objective was first for consumption and then the surplus was sold in the market. The most interesting finding is that in 1990 90.4 percent of households were engaged in these activities mainly for consumption while in 1994 99 percent did so (DeJanvry:1997). This seems to sustain the hypothesis that in times of hardships, homegarden activities become more prevalent among the household survival strategies.

Non-Farm Income and Markets

The economic concerns of the municipality revolve around finding economic alternatives to the decline of the henequen industry and the low productivity of the *milpa* (1.5 tons/ha. with fertilizers and 0.7-0.5 tons/ha. without fertilizers in the first year of production). The main agricultural problems are lack of "*montes altos*", rainfed conditions, lack of arable land, high input prices (pesticides and herbicides) and declining fertility due to shorter *fallow* periods. Among the alternatives currently in practice are pig farming, small cattle production, and bee keeping. The state is also vigorously promoting the establishment of in-bond companies (commonly known as *maquiladoras*) in the rural areas, in particular in the so-called Henequen Zone. The first one came to the state of Yucatan in 1980 but there are close to 110 *maquiladoras* distributed across 25 municipalities, 21 of which are located in the Henequen Zone. They employ approximately 20,714 workers, 40-45 percent of them in the textile industry (Yucatan has a highly skilled textile artisan labor force). Out of this number, 12,371 come from the Henequen Zone. In Hocaba, there is a type of maquiladora operated by Campi which employ approximately 30 workers. The poultry animals come from outside of the community and the sales are directed back to the city. The main magnet of workers are the textile maquiladoras which employ an even greater number of workers from Hocaba and other adjacent areas. A bus picks up these workers for different *maquiladora* sites in Merida.

The maquiladora strategy is part of two other trends towards market liberalization in Mexico. These other strategies are the privatization of state enterprises and the export-oriented nature of economic activities. In Yucatan and in particular in the Henequen Zone, these trends have meant the privatization of Cordemex, the state industrial plant of henequen which retired 37,000 *ejidatarios* and sold the State enterprise to private entrepreneurs for US$ 5.5 million[3]. This was the end of any significant collective production of henequen. Since, Yucatan is not a traditional exporter state except for henequen fiber, their industrial policy has been two-fold: the diversification of economic activities away from henequen production and the concerted effort to lure maquiladora plants to Yucatan.

Nevertheless, as in other Latin American countries where the capital of the country tends to concentrate the industrial activity, Mérida concentrates 50 percent of business enterprises. Moreover, Mérida and 7 other municipalities have 65 percent of all the registered enterprises in the State[4]. These middle-sized municipalities provide the jobs that attract the rural populations forming a kind of satellite cities with a number of smaller rural communities around them. These satellite cities are connected with the rural communities through the labor markets and somewhat through the product markets. This phenomenon has recently attracted the attention of social

[3] These four private enterprises had sales of US$ 22.5 million during the past year.
[4] The 7 municipalities are: Motul, Progreso, Ticul, Valladolid, Uman, Oxkutzcab and Tizimin.

researchers and some have called it the "ru-urbanization" process. The henequen crisis of 1992 and the 1994 crisis of the Mexican economy have expelled thousands of rural farmers to these cities in search of employment but unlike the massive abandonment of rural areas in favor of the big cities in the 1970s, now the rural workers work in these satellite cities but continue to live in their rural homes.

Even though there continues to be a flow of migrants to more attractive cities in terms of economic activities such as tourism in the Cancun area, there is a great deal of rural people who participate in Mérida's labor markets as a strategy to diversify their household income. Authors such as Banos (1996) propose that there is also a tendency to increase the number of household members per dwelling in order to pool resources as a survival strategy. He also points out the generation gap between the young and the old. While the young tend to almost entirely dedicate themselves to non-agricultural activities, those still engaged in *milpa* production are the older members. The non-agricultural income derived from the young' participation in the city's labor market tends to be of remarkable significance in the household's budget. Table 2 shows the importance of non-agricultural income in the community of Hocaba.

TABLE 2
Total Yearly Household Income by source

	Amount	Percentage
Agricultural income	166,304	9.54%
Non-agricultural income	1,576,570	90.46%
Total Household income	1,742,874	

Source: Household surveys by author representing 11 percent of the population.

As shown in Table 2, non-agricultural income constitutes the overwhelming proportion of total income. It seems that households in Hocaba depend mostly on non-agricultural income for their survival. This new articulation is more of the commuter-type since young adults go to work in Mérida and return daily or weekly to their homes in the rural areas. To the extent that there continues to be an attachment to the land, it is expected that agriculture will not be completely abandoned. But this may only be true for the older members of the household. Banos' (1996) research shows that there is a clear division of labor. The older generation continues to be attached to the land by practicing the *milpa* while only 3 percent of the young adults practice it. The question is whether 10 or 20 years from now, a lot of the traditional knowledge of agricultural practices will be lost. The same author also points out that there has been a significant increase in the number of young people who go to school presumably to be better prepared for the urban labor markets. The increase is so dramatic that there is no significant difference between the percentage of young people from the rural areas who attend school and the young people in the urban areas who do the same. This figure is around 37 percent. Thus it appears that the new generation is preparing to enter the urban labor markets in greater numbers.

Our household surveys indicate that while 33 percent of the households did not report any income from agricultural activities, only 3.5 percent of the households reported zero income from non-agricultural activities but all of these households were not directly linked to agriculture since their income came solely from their henequen pensions. Thus, practically all households in the community of Hocaba have some form of access to non-agricultural income; moreover, while two-thirds were engaged in both, only one third were solely dedicated to non-agricultural activities.

It is interesting to compare these results with the survey done in 5 different municipalities of the Henequen Zone of Yucatan in 1991 by Banos (1996). According to the latter survey, it was found that 43 percent of the households were completely separated from agricultural activities that is they neither engaged in *milpa* production nor did they engage in henequen production but were rather completely tied to the urban labor markets. From our surveys as reported above about, 33 percent reported only non-agricultural income but 20 percent of this group reported *milpa* production even though no cash income was generated from this source. Thus the relevant number to compare with the Banos' survey is 25 percent. This result suggests that a possible response to the economic crisis and in particular to the end of the henequen industry in this Zone, has been a return to some form of intensification of *milpa* production and homegarden production. For example, our surveys also report that only two of the households surveyed did not have some form of homegarden production[5].

We suggest that there may be two trends developing in the Henequen Zone in the Yucatan. One is the overwhelming dependence of the rural population, in particular the young adults, on the urban labor markets. Two, there is a return to some form of agricultural activity especially by the older members because the economic crisis has affected both the rural and the urban areas. In general, given the closeness of a lot of these communities to Mérida and other medium-sized cities, and a fairly well developed interconnection of roads and highways to these cities, rural workers are opting for commuting to the urban centers without completely leaving the countryside. This is understood by the many maquiladora plants that pick up workers all over the countryside and take them to their production plants in Mérida and returns them to their rural homes at the end of the workday.

These trends suggest that although life in the countryside will change in many ways, there is a potential for conservation of the natural resources. On the one hand, rural people still depend on some form of agricultural activities mostly for self-consumption and on the other hand, access to non-farm income decreases production risks and could potentially loosen liquidity constraints for investment in agricultural productivity. The implication for biodiversity conservation in these areas are twofold: there is a rich cultural attachment to the land by rural farmers that will explain some of their persistence in doing *milpa* in spite of its lack of economic viability and because of the recurrent crisis there is also an incentive to intensify their corn production and their homegardens which may function as a form of insurance in time of economic turmoil and constitute the main contribution of the male head of the household.

To examine more closely the implications of these trends for biodiversity conservation, we analyzed the level of alpha biodiversity found in the homegardens in Hocaba and related these indices to the socio-economic characteristics of these households.

[5] A closer look to these two homegardens revealed that one was an unusual case in which the homegarden was not within the confines of the establishment but in another location. See also DeJanvry et al (1997).

Biodiversity Analysis

An analysis of the biodiversity found in the Yucatecan homegardens was carried out by calculating several diversity indices. Since we are referring here to diversity at the species level, we calculated alpha diversity for each of the homegardens in the community of Hocaba using a simple index of species richness or the number of species present or absent in the homegarden (S). In addition, we calculated the Shannon-Wiener index (H') which also takes into consideration species evenness. The index of species richness and the Shannon-Wiener index reveal the heterogeneity of homegardens in terms of the variety of species. 64 species were present in the community and the number of species present in the individual homegarden ranged from 2 to 42 species for those highly diverse ones. On average, a homegarden had about 14 different species of plants. The Shannon-Wiener index ranged from 3.28 to 0.143 with an average of 1.8 for all the homegardens. As found in Jimenez (1998), some of the species found belong to the *caducifolius* which is expected given that the surrounding vegetation is mainly low deciduous tropical forest but one also finds species common in the medium tropical forest which are not found in the surrounding vegetation. This suggests that the native population is in the process of plant domestication of these species.

Using the indices calculated above, homegardens were ranked from the highest to the lowest. Two groups were formed from the above ranking. One composed of the top 15 households ranked according to their biodiversity index (HDI) and another group composed of the bottom 15 in terms of the same indices (LDI). The results are shown in Appendix 2[6]. Another important biological finding is that the index of species evenness is higher on an average in the low diversity group. This index goes from 0 to 1, the closer to one the more homogeneous the population or the less dominant species present. It may be the case that the HDI group has many species present but a handful of them dominate the homegarden while the LDI group may have less species present but evenly distributed according to the number of individuals. Both criteria, species richness and species evenness are important in evaluating the degree of biodiversity present in the homegarden.

As shown in Appendix 2, the HDI group has more members per household including those older than 8 years of age, therefore the number of hours dedicated to the care of the homegardens is almost three times the number of hours in the other group. The size of their homegarden is also larger and they have a greater number of animals present. These households also receive more subsidies on an average than the LDI group. It is interesting to note that the LDI group seems to be the one less tied to agriculture. It is observed that this group has only one person with some cattle, none of them hunt, engages in handicraft production or collects forest products and only one person engages in henequen production. Any homegarden activity tends to be for self-consumption since only 4 out of these 15 households sell any products from their homegarden while 12 out of 15 households in the HDI group sells their homegarden products. Table 3 shows a list of the most common species used by the households. They mostly use these species for self-consumption and any surplus is sold in the local market.

[6] The list of variables used in the analysis is found in Appendix 1.

TABLE 3

Most commonly sold plant species from the homegardens of Hocaba

SPECIES NAME	USE
Ramon (*Brosimum alicastrum Sw.*)	Fodder
Guaya (*Talisia olivaeformis Radlk*)	Human consumption/sale
Bananas (*Musa x paradisiaca L.*)	Human consumption / sale
Lemon (*citrus spp.*)	Human consumption / sale
Sour orange (*Citrus aurantium*)	Human consumption / sale
Cebollina (*Allium sp.*)	Human consumption

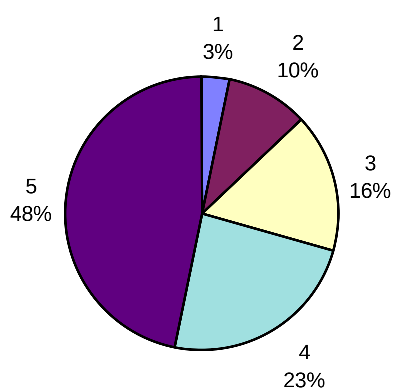
Source: Socioeconomic surveys by author (1998)

Even though the HDI group receives more total income than the LDI group, it only receives on average over 8 percent more non-agricultural income but almost twice as much agricultural income than the LDI group. This is supporting evidence that the richer households in terms of income and biodiversity do continue to invest in agricultural activities perhaps as a way to protect themselves against the ups and downs of the urban markets.

The poorer group in terms of its low biodiversity index and in terms of income received has a 9:1 ratio of non-agricultural to agricultural income while the HDI group has a 5:1 ratio. It is also observed that the two different sources of income are not distributed in the same fashion.

Figure 1

Non-Farm Income Distribution (by Quintiles)



As shown in Figure 1, the share of non-agricultural income clearly increases as one moves up the income distribution ladder and it tends to favor the upper quintile of the income distribution. The lower quintile of the income distribution receives only 3% of total non-agricultural income while the top quintile receives 48% of this type of income.

Figure 2

Farm Income Distribution (by Quintiles)

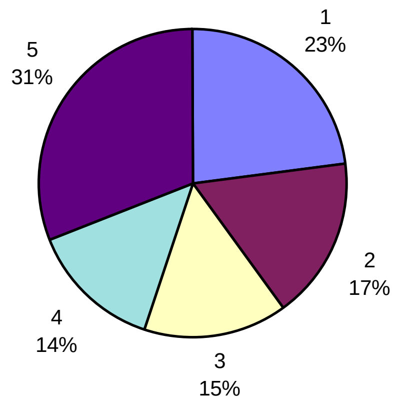


Figure 2 shows a more egalitarian distribution of income derived from agricultural income. It shows that the bottom quintile benefits more than the other quintiles with the only exception of the higher quintile.

To the extent that non-agricultural income is becoming more prominent, the income inequalities will be accentuated which could very well lead to more families becoming completely separated from agricultural production. This will translate into the abandonment of the milpa and even the homegarden to the point of completely migrating out of their rural dwellings. It is not so much the access to non-agricultural income that separates the two groups but rather the presence of other complementary agricultural-related activities. As shown before, the LDI group does not engage in any hunting, artisan work or forest product collection. This lack of diversification of activities seem to characterize the group with LDI. The reason may lie in the increasing inequality that perpetuates a situation of poverty among these households.

Income from non-agricultural activities will influence the overall capacity of the household to acquire assets which allows them to diversify. Other research has shown that low income households in agro-ecological zones with low agricultural potential tend to build an asset base “rich” in migration assets while in zones with dynamic agriculture, households accumulate assets relevant to other economic activities. But complete migration is not a panacea. Poverty only shifts to the urban areas when these households migrate to the city.

A further exploration of the data was done by carrying out a principal component analysis (PCA) in order to see what homegardens are grouped together by similarities in their socio-economic characteristics.

Principal Component Analysis

In order to examine the socio-economic factors that explain the differences in the homegardens in Hocaba, a principal component analysis was carried out. The results are as follows:

Summary of Results from PCA

Principal Component	Variance explained	Cumulative %	Variables with higher loadings[7]
First	18.94	18.94	ths, rie, hpl
Second	12.01	30.95	mie, och, iag
Third	9.65	40.60	heq, ina, art
Fourth	9.23	49.83	mie, och, sub

Source: Author's analysis

It can be seen from the above table that the PCA provides some insights into the important socio-economic variables grouping the homegardens but the overall percentage of explanation for the first four components is relatively low (49.83 percent). This could be due to the fact that the PCA is only of an exploratory nature and some variables that are important may have been omitted. Nevertheless, the variables shown in this analysis as the more important ones in explaining the variation in the socioeconomic characteristics of the households with homegardens are the expected ones. For example, the variable showing the management of the homegardens, i.e. the total number of hours dedicated to the homegarden (ths), especially to the care of plants (hpl) and the diversity index (rie) show prominently. Also, as the table above shows, the constraints to homegarden management such as the number of members in the home (mie) and those older than 8 years of age (och) as well as total agricultural and non-agricultural income should be considered in analyzing the links between markets, diversity of the homegardens and the socio-economic characteristics of those households.

Conclusions and Policy Recommendations

Village economies are very complex even though the communities are not large in terms of area or population. Some economists have recently paid attention to this complexity and employ more sophisticated tools of analysis to understand the dynamics of village economic life (Adelman and Taylor:1997). But biodiversity conservation posits other challenges that require interdisciplinary studies. The obvious dependence of rural communities on their so-called natural capital warrants collaborative work with natural scientists. The picture of community life portrayed here is an attempt to engage in multidisciplinary work.

The cultivation of henequen plantations during most part of Yucatecan history has undoubtedly contributed to the loss of biodiversity in the region. The continuing increase in the number of hectares dedicated to cattle raising is another major contributor to the loss of biodiversity. The attempts to mitigate these trends through the creation of protected areas has

[7] For a list of the nomenclature of these variables see Appendix 1.

been insufficient. These areas are the sub-systems that are still managed by rural populations mostly of Mayan origin. The Henequen Zone in particular with one-third of the State's population (excluding Merida) has witnessed the liquidation of any form of social production of henequen with the consequent expulsion of thousands or henequen workers.

The search for economic alternatives to the plantation model has included the diversification into other crops such as citrus and horticulture as well as the attraction of maquiladora plants to the rural areas. The latter strategy seems to have few possibilities of being something other than the old model of development by displacement (Zarate-Hoyos and Albornoz:1998). The pattern continues to be the daily migration of young workers to the intermediate cities in search of urban jobs. This infusion of money has the potential to affect agricultural productivity by releasing land and credit constraints allowing farmers to take more risks. This study shows that the richer households in terms of income also have the richer homegardens in terms of biological diversity. They are also well-diversified which allows them to potentially take risks and either increase land under cultivation, purchase more inputs, engage in the cultivation of new cash crops or expand current cash crop production. There is evidence in our study that the HDI group indeed is a well diversified group in terms of economic activities but it is not clear if there is necessarily agricultural growth present.

The Henequen Zone is characterized by a rocky soil with very thin layers of topsoil which prevents a high degree of mechanization where the only form of agriculture seems to be rainfed. This limits the possibilities of promoting large-scale projects and agricultural growth as the major force behind non-farm income opportunities. At the same time, if non-agricultural activities are highly correlated with urban economic activities, the *milpa* and the homegardens will continue to be a sort of insurance against the economic cycles in the urban economy. This presents an opportunity to promote and enhance the milpa and homegarden in order to make them more efficient and more productive systems that can sustain their livelihoods and conserve biodiversity at the same time.

Some recommendations emerge from this study. Any efforts to promote *in-situ* conservation need to clearly delineate the geographical boundaries, particularly in light of the recent reforms in land tenure systems. The conservation of certain species could be at the household level or at the community level. Conservation of other species may require studies between communities or even larger landscapes. Following Meng (1997), caution must be taken because measures of diversity indicate different factors influential in determining diversity outcomes; thus, some indices are more efficient than others in identifying high-diversity households. We found in this study a slight variation in the ranking using the species richness (S) and the Shannon-Wiener index (H'), other indices also need to be considered.

The economic characteristics of high diversity households such as number of members in the household, number of hours invested in homegarden maintenance, the presence of other economic activities related to the rural environment and the income received from the sale of homegarden products will serve to make up a profile of such households. This will serve for the next stage of the project which will attempt to model the behavior of these households in choosing the species to be planted. The behavioral model posits that diversity outcomes are shaped primarily by variety selection, rather than management of the variety conditional on the initial selection of variety. The estimated probabilities of a household choosing to cultivate certain species can be used to monitor changes in existing levels of diversity and to take a more active role in encouraging certain particular species cultivation.

There is also a need to engage in multidisciplinary research in order to establish sound methodologies or to create new ones. Economists may not have a comparative advantage in collecting plant samples in homegardens but they have a lot to say about the underlying economic and social forces behind the loss of biodiversity. The collaboration need not be limited to the proper selection of indices and the interpretation of biological and economic data but should start at the ground level, that is in sampling selection, designing surveys, and most of all in specifying initial objectives. Our study benefited from the insights of biologists and biology students participated in the survey collection, nevertheless, several data collection problems regarding plant species arose.

Policies that promote access to non-agricultural opportunities such as education have been advanced in order to provide households with access to non-agricultural activities. As shown before, statistics show that effectively the rate of school attendance in rural areas and Mérida are almost identical. But this may not have a positive influence on rural development since migration is highly associated with high educational levels. It is the more educated who tend to migrate out of the rural areas. These younger workers are also de-linked from agricultural activities and as a consequence a certain level of traditional knowledge will be lost in the next ten to twenty years. This trend will have implications for the proper management of natural resources and biodiversity.

The most effective policy is to increase the income level of the rural population. Economists tend to favor subsidies because they are less distortionary. Results from this study indicate that of the 85 households in the survey, 44 of them (52 percent) did some milpa production in 1997 but only 11 received subsidies from the government. PROCAMPO subsidies are given to those producers of maize who cultivate at least one hectare but the average size of the milpa in Hocaba was around ¾ of a hectare. There are many small producers who depend strongly on corn production for their subsistence but do not have access to these subsidies. A more egalitarian distribution of these subsidies is called for. Currently, there is no subsidy for homegarden production other than seeds but a subsidy could be given according to certain species sought to be conserved if they fit into the consumption and use patterns of households.

Nonetheless, no amount of subsidies or other cash transfers will compensate for the lack of government investment in infrastructure and rural development projects that make use of native biological diversity. As suggested by McNeely (1988), these can include the development and marketing of foodstuffs, medicines, arts, crafts, and other products from native plants and animals. Agricultural education and training should also be considered in order to serve as a medium to promote the conservation message.

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Appendix 1

List of socio-economic variable names

Description of the variables used

mie	Number of household members
och	Number of household members older than 8 years
mec	Number of mecates (20x20 sq. mts) under milpa production
sub	Amount of government subsidies for milpa or henequen production
hen	Amount of land under henequen production
mts	Size of the homegarden in square meters
ani	Number of animals in the homegarden
caz	(1) if household engages in hunting; (2) otherwise
art	(1) if the household engages in handicraft production; (2) otherwise
iag	Income derived from agricultural activities
ina	Income derived from non-agricultural activities
ing tot	Total income of the household from all sources
mon	(1) if the household collects forest products; (2) otherwise
ths	Total number of hours dedicated to homegarden care and maintenance
hpl	Total number of hours dedicated to care and maintenance of plants in the homegarden
iso	Income derived from sale of homegarden products
S	Number of plant species present in the homegarden
H'	Shanon/Wiener Index
E'	Eveness index

Appendix 2

Socio-economic Characteristics of Households with High and Low Diversity Indices (S)

HH #	mie	och	mec	sub	hen	mts	ani	caz	art	iag	ina	ing. tot	mon	ths	hpl	iso	S	H'	E'
18	6	4	0	0	0	3900	160	2	1	0	22275	22275	2	2514	1760	1275	42	2.37	0.481
21	4	4	40	30	20	600	30	2	2	6195	12790	18985	0	2488	1344	1305	38	3.28	0.695
13	7	7	30	0	62	1241	39	2	1	1130	19212	20342	0	1568	1424	1792	36	2.92	0.516
105	6	6	12	0	0	968	51	2	1	5720	12660	18380	0	2070	1350	3060	35	2.04	0.562
20	7	6	0	0	0	1600	29	2	2	1300	24510	25810	0	2277	1913	70	33	2.15	0.45
24	6	6	17	0	0	800	10	2	1	975	20660	21635	0	804	336	100	29	2.98	0.736
50	14	9	0	0	0	600	0	2	2	2760	40560	43320	0	756	756	0	29	2.95	0.637
12	5	5	10	319	0	1190	24	2	1	1050	5145	6195	3	209	128	75	29	2.6	0.583
40	8	8	25	480	0	1800	33	1	2	5496	1335	6831	1	6036	3772	1185	28	1.92	0.448
27	7	6	0	0	0	200	14	2	1	1260	23363	24623	0	488	20	795	27	2.74	0.66
1	5	4	0	0	0	2000	18	2	2	0	13415	13415	0	2700	900	215	26	2.38	0.638
54	10	8	25	15	0	na	23	1	2	15182	14920	30102	0	1847	572	1644	25	1.12	0.754
117	7	7	200	515	20	1600	29	1	2	3695	14170	17865	1	629	264	100	24	2.53	0.666
85	6	3	0	0	0	400	9	2	2	3340	14560	17900	0	213	32	0	22	2.5	0.571
108	5	5	0	0	0	800	0	2	2	0	18200	18200	0	2206	2172	0	22	1.97	0.492
AVG	6.87	5.87	23.93	90.60	6.80	1,179.9	31.27	1.80	1.60	3,206.9	17,185.0	20,391.87	0.47	1,787.0	1,116.2	774.40	29.7	2.43	0.59
58	7	7	0	0	0	250	5	2	2	0	9100	9100	0	522	156	0	5	1.44	0.862
8	10	7	200	25	300	2500	15	2	2	325	17705	18030	0	533	168	25	5	1.29	0.867
114	0	1	0	0	0	200	0	2	2	0	11233	11233	0	1876	1876	0	5	1.08	0.714
63	11	10	0	0	0	1500	0	2	2	3000	2650	5650	0	458	458	0	4	1.36	0.975
61	4	4	0	0	0	500	7	2	2	0	10568	10568	0	546	364	0	4	1.01	0.833
66	5	4	40	0	0	625	1	2	2	3300	0	3300	0	817	270	0	3	1.04	0.943
46	10	9	0	0	0	400	16	2	2	0	18300	18300	0	229	47	0	3	1.04	0.943
56	6	6	50	0	0	400	0	2	2	4800	16230	21030	0	42	42	0	3	1.04	0.943
45	4	3	0	0	0	400	7	2	2	3240	8400	11640	0	922.7	194.667	0	3	0.868	0.84
90	9	9	25	500	0	600	10	2	2	7150	1400	8550	0	1118	26	200	3	0.849	0.846
60	7	6	22	0	0	1920	0	2	2	0	26000	26000	0	364	364	0	2	0.693	1
59	5	3	0	0	0	300	0	2	2	0	17140	17140	0	252	252	0	2	0.693	1
55	6	4	100	478	0	1800	74	2	2	4238	43200	47438	0	227.5	45.5	600	2	0.637	0.952
47	2	2	0	0	0	900	55	2	2	0	37200	37200	0	24	24	0	2	0.637	0.752
16	3	3	0	0	0	900	25	2	2	0	17932	17932	0	822	796	262	2	0.143	0.925
AVG *	5.93	5.20	29.13	66.87	20.00	879.67	14.33	2.00	2.00	1,736.9	15,803.9	17,540.73	0.00	583.55	338.88	72.47	3.20	0.92	0.89

Appendix 2

Socio-economic Characteristics of Households with High and Low Diversity Indices (S)

Tot Avg	5.9	5.1	20.7	84.8	16.8	2763.2	17.6	1.9	1.8	1,956.5	18,547.9	20,504.4	0.4	947.9	628.6	468.6	13.8	1.8	0.8
* 3 Questionnaires were eliminated																			