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Sustainability of Home Gardens in the Community Tziscao, La Trinitaria, Chiapas, Mexico

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Abstract: Home gardens are commonly considered to be healthy, efficient land use systems which have great potential to satisfy local needs and mitigate environmental degradation. The objective of this study was to analyze sustainability of home gardens in the community Tziscao in the municipality La Trinitaria, Chiapas, Mexico using a sample of 30 families. Researchers analyzed environmental, technological, economic and social aspects of the gardens, taking into account attributes of stability, efficiency, adaptability, productivity, profitability, self-administration and equity through the use of 20 indicators. Sustainability was evaluated using the Framework for Evaluating Natural Resource Management Systems Incorporating Sustainability Indicators (MESMIS according to its Spanish acronym) and multivariate statistics. With respect to the optimum researchers identified three levels of sustainability: low (32%), medium (43%) and high (57%). Stability was the only attribute with high values for the three groups of gardens (82%) while the remaining attributes at least in the low and medium sustainability groups showed values below 50%. Those indicators which most greatly influenced ($p<0.05$) sustainability of the gardens were net margin, innovative practices, tools, total beneficiaries and organization.

Key words: Stability, efficiency, adaptability, productivity, profitability, self-administration, equity, multivariate statistics

INTRODUCTION

The home garden is a traditional system of agricultural production which involves raising trees, shrubs, herbaceous vegetation and domestic animals within peasant households (Kumar and Nair, 2004). The garden also provides an economic and recreational activity for the family and represents a rural Mexican cultural expression (Gonzalez, 2003). In Southeastern Mexico, home gardens are also referred to as backyard patios, household gardens, mixed gardens, orchards and sites (Jimenez *et al*., 1999).

In a study of Mayan home gardens in the community Yaxcaba in the Yucatan Peninsula, De la Cerda and Mukul (2008) found that such agroforestry systems fulfill important family needs such as spaces for recreation for the entire family and for domestic activities such as drying firewood and washing and hanging clothing to dry. They also found that home gardens are an important source of plant diversity, identifying 59 ornamental species, 42 tropical fruit species, 21 vegetable species and a variety of species of medicinal plants and trees for lumber and firewood.

According to Montagnini (2006), home gardens contribute to food security in three important ways: they provide direct access to a diversity of nutritious foods; they increase families acquisitive power as they may sell excess production. For example in the community San Jose, Belize, food and wood products obtained from the garden provide 62% of family income (Levasseur and Oliver, 2000) and during periods of economic scarcity, the family recurs to foods provided by the garden.

Home gardens are commonly considered to be healthy, efficient, sustainable land use systems due to the fact that they satisfy needs of the local population and mitigate environmental degradation. Nevertheless, few studies carry out quantitative analyses of the garden's function that is the widespread perception that these systems are sustainable is not necessarily based on existent quantitative evidence (Torquebiau, 1992).

According to Astier and Gonzalez (2008), several general principles allow for measuring sustainability; these include productivity, stability, adaptability, self-administration and equity which allow for understanding the capacity of socio-ecosystems to be productive, self-regulating and also transformative. These

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attributes make the concept of sustainability operative and allow for evaluating the performance of socio-environmental systems in order to guide practices and policies directed toward sustainable natural resource management.

The framework for Evaluating Natural Resources Management Systems Incorporating Sustainability Indicators (MESMIS according to its Spanish acronym) is a flexible methodological tool developed in Mexico to evaluate sustainability of natural resource management systems with emphasis on small farmers in their local context (Masera *et al*., 1999).

This study aims to identify the level of sustainability of home gardens in the community Tziscao in the municipality of La Trinitaria, Chiapas, Mexico. With this goal, researchers characterize family production units in terms of their components, subsystems and interactions in order to evaluate sustainability of the gardens.

The ejido (a form of collective land-holding) Tziscao is a highly marginalized community of 1376 inhabitants of the Chuj Maya ethnic group. Tziscao has a surface of 3238 ha and lies on the eastern border of the Natural Protected Area Lagos de Montebello National Park. It is located within the Mesoamerican Biological Corridor (MBC), one of the world's principle areas of biodiversity and includes those lakes with the greatest tourism importance in this region (Montebello, Pojoj, 5 Lagos, Tziscao and Internacional). The community is located close to the Guatemalan border. Vegetation is mesophile mountain forest (cloud forest) and pine-oak-sweetgum forest (Arriaga *et al*., 2002).

MATERIALS AND METHODS

This study involved 30 families of the community Tziscao who were interested in improving their home gardens. Of these families, 7 belong to an organization called Lagos de Colores, created 20 years ago with one of its objectives being to produce organic coffee. For the past 2 years, this organization has been working with Heifer International on a variety of projects to strengthen the families' food sovereignty.

Eight other families participate in the bottled preserves business Voz de la Selva making marmalade, fruit in syrup, liqueurs and fruit and vegetable preserves. Three other families belong to the organization Flor de Montebello whose principal objective is growing orchids and three other families belong to the Democratic Campesino Popular Front of Trinitaria which among other objectives, promotes environmentally friendly agricultural practices. Nine families do not belong to any organization. In order to obtain information, researchers carried out direct field observations, laboratory analysis, structured interviews (Dixon and Leach, 1993) and participatory workshops. Researchers carried out a diagnostic study of the family production unit through structured interviews and field observation in order to identify characteristics (such as surface, type of inputs, agricultural calendar, profitability and type of products) of the different components (livestock raising, coffee growing, cornfield). Researchers also identified relationships among these components and between them and the home garden through flow charts based on Hart (1985) who proposes a systems focus to analyze agro-ecosystems in terms of components, interactions among components, inputs, outputs and system limits.

Researchers characterized the home gardens by analyzing technological, economic, social and environmental sustainability indicators through structured interviews, field visits, participatory observation, sampling and lab analysis of samples. Aspects included in analysis of the gardens are shown in Table 1.

This study of garden sustainability is transversal and incorporated the Framework for Evaluating Natural Resources Management Systems Incorporating Sustainability Indicators (MESMIS). It has a multidimensional systems focus in which the system is evaluated according to five attributes: productivity, adaptability, self-administration, equity and stability (Masera *et al*., 1999).

In order to compare the different home gardens, an optimal value was determined for each indicator, according to a bibliographic reference (as in the case of soil quality) or using the maximum or minimum value of data obtained (as in the cases of production costs and number of hours dedicated to garden activities). Values were then standardized to percentages. With the standardized data researchers carried out an analysis of conglomerates using K-median statistics of the SPSS program, Version 15 through which researchers established three different groups of gardens classified by level of sustainability (high, medium and low) according to their approximation to the optimum values of the indicators used. As an innovation to the MESMIS methodology, researchers carried out a discriminant canonical analysis with multivariate statistics using the SPSS program, version 15 in order to identify those variables which most greatly influence sustainability of the home gardens.

Table 1: Indicators grouped by area of evaluation to characterize home gardens in the ejido Tziscao

Areas of evaluation	Attributes	Indicators	Characteristics	Methods of measuring	Units of measure
Environmental	Stability	Soil quality in terms of: Resistance to erosion Nutrient availability Nutrient retention	Organic matter and texture pH value CEC value	Sampling and lab analysis	K factor Non-dimensional Cmol⊕ kg^{-1}
	Efficiency	Biological resources	Species of flora and fauna by anthropocentric category of use	Interview and observation	List of flora and fauna
		Diversity of flora	Abundance Richness Density	Interview and direct measurement	No. of individuals No. of species Individuals ha^{-1}
Technological	Adaptability	Innovative practices adopted	Practices learned through workshops and/or courses	Interview and observation	No. of practices
		Magical-religious agricultural practices	Technological-cultural practices not commonly recognized by Western science	Interview	No. of practices
		Tools, equipment and inputs	Hand and mechanical tools, equipment and inputs	Interview	No. of tools
Economic	Yield (Productivity)	Total productivity in terms of: products sold products for self-provisioning	Number of items produced by category (vegetables,fruit, animals, ornamental plants, herbs, medicinal plants) sold and consumed	Interview	Kg or local unit of measurement/year
	Profitability (Income)	Value of products	Price of garden products in the area	Price in local stores	Dollars
		Garden production costs	Operational and structural costs throughout 1 year	Interview	Dollars
		Net margin/garden/year	Value of production minus costs	Financial calculation	Dollars
Social	Self-administration	Organization	Organizations to which growers belong	Interview	No. of organizations
		Training and advisory	Courses and/or workshops in which growers participate in 1 year	Interview	No. of courses
	Equity	Family beneficiaries who do not work in the garden	Persons who benefit from the garden though they do not participate in garden labor	Interview	No. of beneficiaries
		Total family beneficiaries	Total beneficiaries (family members)	Interview	No. of beneficiaries
		Hours worked	Time dedicated to garden labor	Interview	No. of h $year^{-1}$

RESULTS AND DISCUSSION

Characterization of the family production unit: The Family Production Units (FPU) included in this study carried out a variety of agricultural activities in order of importance: home garden, coffee raising, corn field within the ejido, cattle raising and corn field outside the ejido (Fig. 1). The FPU also carry out non-agricultural activities which provide a monetary income such as tourism services, commerce and wage labor, subsidies from a variety of governmental programs and remittances from family members abroad principally in the United States. Tourism provides the majority of economic resources which are often used to maintain agricultural activities such as the corn field and coffee raising which may involve economic losses due to high cost of labor and low sale price. Continuation of maize and coffee crops is important for the families of Tziscao due to the fact that they provide basic foods (maize, beans, vegetables) and involve environmentally friendly activities such as raising shade grown coffee.

Cattle raising is another activity which provides monetary income which may be used to subsidize other agricultural systems such as corn cultivation or coffee raising. Home gardens as they are not production systems with commercial objectives are part of the domestic landscape and follow dynamics other than agricultural activities. Most families make an effort to maintain their garden and many of the sub-products of other systems such as harvest waste from corn fields and coffee plantations are used to make compost to fertilize garden vegetables and/or fruit. Added to the fact that labor is provided by family members, this helps keep production costs low.

Stratification of gardens: With the K-Median multivariate analysis of conglomerates of the sustainability indicator standardized by percentage, gardens were classified into 3 groups:

- The 1st group includes gardens which had the lowest values for the sustainability indicators and therefore were considered to represent low sustainability. This group consists of 8 families of which 4 do not belong to any organization, 3 belong to a fairly weak organization and only one belongs to a fairly strong organization

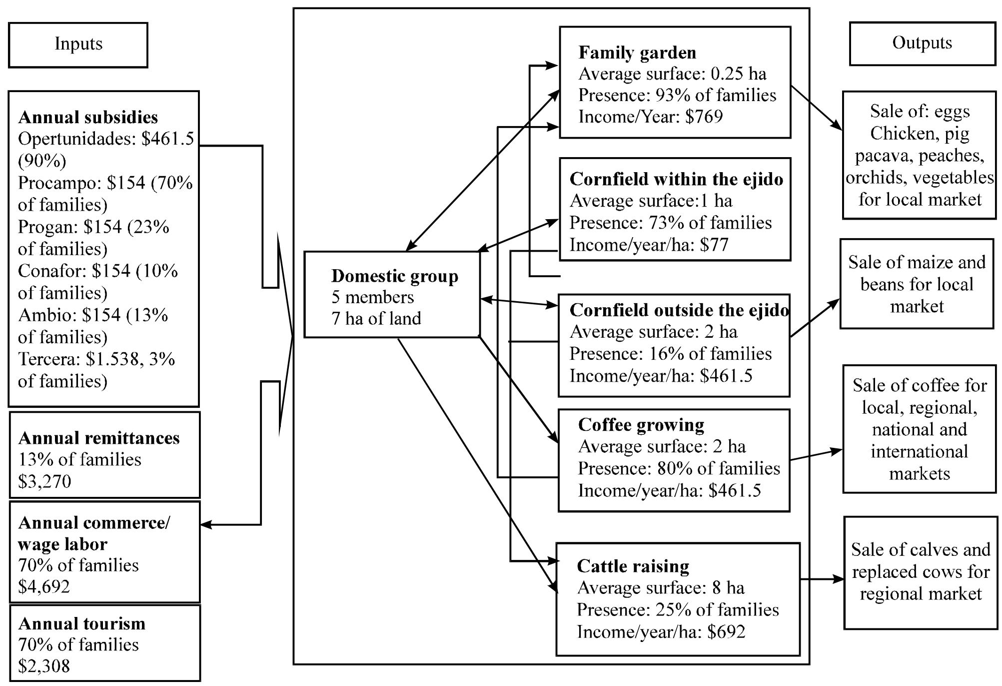

Fig. 1: Unit of production of a model family from the ejido Tziscao, La Trinitaria, Chiapas

- The 2nd group includes those gardens which had intermediate values for sustainability indicators and were considered to be fairly sustainable. This group consists of 13 families of those which 8 belongs to different organizations which were fairly strong or weak as well as 5 families who do not belong to any organization
- The 3rd group has the highest values for the sustainability indicators and therefore these gardens were classified as highly sustainable. This group consists of 7 families of which 3 belong to a very strong organization, 3 belong to a fairly strong organization and one participates in four organizations (with varying levels of organization) (Fig. 2)

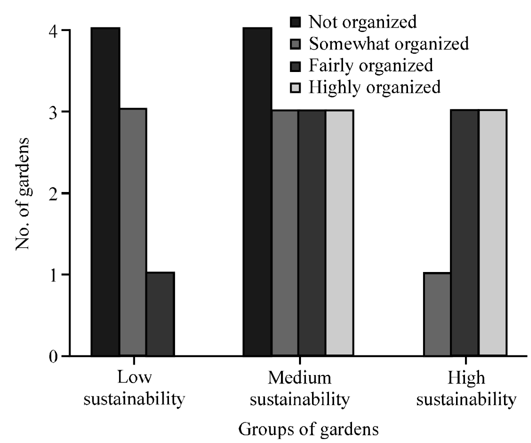

Fig. 2: Levels of organization of the 3 groups of gardens classified according to level of sustainability

It should be mentioned that researchers only analyzed 28 gardens due to the fact that two families in the study currently do not have a garden as they designated their garden areas for businesses.

Environmental area of evaluation

Stability

Soil quality: One attribute of stability of an agro-ecosystem is the resistance of its soil to degradation and maintenance of soil fertility. In the home gardens, the K value (erodibility) was 0.20 for the group of gardens with low sustainability and 0.19 for those with medium sustainability indicating that they are moderately susceptible to hydric erosion. This is due to the fact that the majority of the gardens have soils with clay-loam or clay textures and in very few cases, loam and sandy clay texture but there is a notable presence of soils very rich in organic matter (9.7% organic matter on average).

Soil pH had a value of 7.1 for the low sustainability gardens, 6.6 for those of medium sustainability and 6.6 for those which are highly sustainable. These pH values indicate favorable soil conditions with respect to availability of nutrients for plants (Landon, 1991) and fall in the optimum category for most commercial crops. These pH results coincide with those found by Ochoa (1996) in home gardens in Chamula in the Chiapas Highlands.

As a consequence of the predominance of clayish soil texture and the high level of soil organic matter, Eation Exchange Capacity (CEC) had a value of 50.2 for the low sustainability gardens, 48.5 for those of medium sustainability and 48.8 for those with high sustainability. These values (>40 cmol ⊕ kg^{-1}) represent a very high nutrient retention capacity suggesting that under these conditions, nutrients face little susceptibility to losses due to lixiviation or runoff (Landon, 1991). These CEC values are greater than those found by Ochoa (1996) in the Chamula home gardens which range from 23.15-29.89. In this way, the parameters of soil quality determined show that the majority of home gardens examined show favorable soil fertility conditions for plant growth as well as low risk of soil degradation which provides stability to the system suggesting that the gardens fulfill the function of soil conservation. This coincides with results obtained by Alalyon-Gamboa and Gurri-Garcia (2008) who found high levels of soil fertility in home gardens in Calakmul, Campeche regardless of whether they grew for market or self-provisioning and that described by Ochoa (1996) who reports that women of Chamula recognize the soils of their patios as ic'al cuc lum-good black sandy soil and they consider their soil to be good for crops and even transport it in sacks to other horticultural plots.

Efficiency

Biological resources: The following backyard animals are found in the gardens studied: chickens (*Gallus gallus)*, ducks (*Anas* sp.), geese (A*nser anser*), turkeys (*Meleagris gallipavo*), rabbits (*Oryctolagus cuniculus*), and pigs (*Sus escrofa*). Ducks, geese or rabbits were only found in 5% of the gardens, turkeys in 10% of the gardens and pigs in 20% of the gardens.

Chickens, the animal species with the greatest presence were found in 90% of the gardens with a range of 4-100 chickens per family. Chickens are important as they provide meat and eggs (protein) to the family diet throughout the year. Unlike the chickens, ducks, geese, turkeys and rabbits which are principally raised for self-provisioning, pigs principally fulfill a commercial function. This coincides with Mariaca *et al.* (2007) who indicate that domestic fauna of home gardens play the role of the family piggy bank and are a reserve of animal protein.

Among the gardens, 133 flora species were found: 59 food species (28 fruits, 23 vegetables and 8 pulses, grains and tubers), 21 medicinal plants and herbs, 18 lumber and firewood species and 35 ornamental species. This approximates that found by Lerner (2008) in the home gardens of Suclumpa, Salto de Agua, Chiapas where 142 flora species were recorded.

The most frequent tree crops were: pacaya (*Chamaedorea aguilariana*), guava, banana, orange and peach. Vegetables had a low presence in the gardens though the species found in most gardens was chayote (*Sechium edule*). Beans were only found in 10% of the gardens and corn in 20%, since these crops are mostly planted in cornfields. Another food product of importance to the family is malanga (*Xanthosoma* sp.), found in the majority of gardens.

The fact that food species including fruit are the most abundant, coincides with that reported by Chandrashekara (2009) in home gardens of Kerala, India and that found by Mendez *et al*. (2001) in gardens of Nicaragua where most fruit production is citrus for self-provisioning. This has a positive impact on nutrition, due to the fact that according to Jin *et al*. (1999), fruits are an important source of sugars, vitamins and fiber.

Lack of dependence on a single product not only has nutritional and economic implications but also favors nutrient recycling and regulation of local biological process such that lack of dependence on a single crop is an indicator of the system's ecological efficiency.

Among flora species found, medicinal plants are important because the people of Tziscao still preserve some herbal medicine practices to treat minor illnesses. Similarly, orchids have great value due to the fact that they have been the most abundant flowers in the region and are also highly prized by tourists. Nevertheless, most families have also introduced ornamental plants from other regions into their home gardens. According to Agelet *et al*. (2000), medicinal and ornamental plants play a very important role in gardens in Catalonia since for these families, these plants follow food plants in abundance and furthermore, >50% of medicinal plants used in the region are cultivated in home gardens.

Diversity: Average species richness of flora (food, wood, herbs and ornamental plants) was 24 in the low sustainability group, 38 in the medium sustainability group and 43 in the high sustainability group. This data is very similar to that obtained in home gardens of Suclumpa, Salto de Agua, Chiapas (Lerner, 2008) in which an average of 33 flora species were found per home garden.

The lowest average plant density found was 685 individuals ha^{-1} and the highest 4920 greater than that found in the study previously mentioned in which the highest density was 2200 individuals ha^{-1}.

With respect to differences in species cultivated in each garden, each family develops a different combination according to their specific resources and objectives. From an environmental perspective, this is a way of adapting to particular, changing local circumstances and making efficient use of resources. Although, differences exist in productivity among the gardens as a whole, this variety makes the system energetically efficient (Moya *et al*., 2003).

Environmental sustainability is reinforced by efficient use of space to produce certain crops which demonstrates Tziscao families' knowledge of the possibilities of their local environment. Greater knowledge leads to greater differentiation and more efficient use of distinct micro-habitats. For example due to their form of propagation, pacaya groves within the garden create small surface areas with closed canopies which propitiate soil conservation as they protect soil from rain and wind erosion, promoting weed control, humidity retention and soils rich in organic matter.

Technological area of evaluation

Adaptability: This attribute of sustainability consists of indicators of innovative practices adopted, magical-religious agricultural practices and tools, equipment and inputs. Results are shown in Table 2.

Innovative practices found in the gardens were use of solar driers, composting and vegetable cultivation.

About 70% of families participating in this study belong to organizations which foment training. Nevertheless, many workshops and courses have not led to successful results due to lack of coordination between the topic addressed by the presenter and the felt needs of workshop participants. Another important aspect is lack of follow-up as a single course does not allow for profoundly addressing a given topic and failure to provide posterior advisory impedes families from successfully adopting new practices.

Although these innovations were transmitted by an organization through workshops and later adopted by the families, many of these practices recover traditional management of local natural resources. Such innovations involve only minor adjustments such as producing organic fertilizer with local inputs and cultivation of traditional crops. According to Rebollar *et al*. (2008), care and attention of the home garden is based on residents' empirical knowledge of their ecosystem with a focus on wise use and conservation.

Magical-religious agricultural practices found in the gardens were: following lunar phases to carry out a certain agricultural activity punishment of unproductive trees, observation and follow-up of biotic and abiotic indicators of meteorological phenomena, categorization of the function of weeds in relation to crop plants, following cabanuelas (the belief that the 1st 12 days of January allow for indicate the weather for the 12 months of the year), the concept of the good or bad hand in agricultural activities, effects of a pregnant woman passing by certain crops and use of a red cloth on plants and animals to counteract the evil eye.

Researchers observed that home gardens are important to conservation of ancestral agricultural and cultural knowledge and practices. These practices are being lost as new generations abandon agriculture in search of other economic activities outside the rural areas. Nevertheless as the home garden still exists such practices are conserved to some extent and have been adapted over time.

The most widely used tools in the home garden are machete, hoe, shovel, pick and rake. Of these, the most common is the machete; the average family has 4. This coincides with that reported by Jimenez and Perez (2000) in gardens in Jitotol de Zaragoza, Chiapas where only hand tools are used (hoe, pick, sharpening file and machete) not mechanical tools. The garden also serves as a place for conservation and adaptation of use of traditional tools, since it allows for their continued use despite the fact that use of such tools has diminished in homes which have turned toward non-agricultural economic activities such as tourist services or commerce. About 75% of gardens studied do not use external inputs but rather practice natural management or organic practices such as composting. This is the case principally because predominant crops are a diversity of fruit species for self-provisioning which coincides with that reported by Ake (1999) in the home gardens of Hocaba, Yucatan where the author observed that agrochemical use is infrequent due to the diversity of plants and the fact the

Table 2: Average and optimal values for technological sustainability indicators

				Average value by sustainability group		
Attributes	Indicators	Unit	Optimum values	Low	Medium	High
Adaptability	Innovative practices	No.	3	0 (±0)	1.2 (±1.09)	2.1 (±0.69)
		%	100	0	41	71.4
	Magical-religious agricultural practices	No.	9	5.6 (±2.5)	6.3 (±1.5)	7.5 (±1.27)
		%	100	62.5	71	84
	Tools	No.	31	9.7 (±4.8)	13.1 (±8)	17.6(±7.52)
		%	100	31.5	42.4	56.7

relative placement of these diminishes risk of pests. This diversity and relative placement of plants is an important aspect given that it contributes to home gardens being an adequate agroforestry system for soil conservation, production of healthy food and nutrient recycling as they are adapted to particular circumstances of the local environment and make use of available resources.

About 25% of families use agrochemicals in their home gardens; these are families who also plant corn and/or beans in their gardens.

Economic area of evaluation

Yield

Productivity: The greatest average production per sustainability garden group was 2, 876.64 kg year^{-1} corresponding to the high sustainability group while the lowest average production is 973 kg corresponding to the low sustainability group (Table 3).

The majority of production corresponds to plant foods particularly fruits which coincides with that reported by Chandrashekara (2009) in home gardens of Kerala, India. Vegetables marketed and also used for self-provisioning are chayote, onion, squash, radish, cucumber and lettuce. Tree crops used also for both these purposes are banana, avocado, peach and pacaya. Other crops grown include sugarcane, malanga, corn and beans. The percentage destined for self-provisioning or sale depends on the category and quantity of foods obtained from the garden. For example, 80% of vegetable and chicken production is destined to self-provisioning.

Nevertheless in the case of fruit and egg production approximately half is destined to self-provisioning and the other half to sale (Table 3). This coincides with that reported by Jimenez and Perez (2000) in the gardens of Jitotol de Zaragoza, Chiapas.

Profitability

Net margin: The greatest average annual net margin was $1,661 corresponding to the high sustainability garden group while the lowest average net margin was $87, corresponding to the low sustainability group (Table 3). Annual income for plant products ranged from $321-$1,567 (Table 3) coinciding with that reported by De la Cerda and Mukul (2008) for gardens of Yaxcaba, Yucatan (of similar sizes as those of Tziscao) where annual income for these products ranged from $267-$2,309. Maximum value for net margin for annual income from plants in the Tziscao gardens was $1,084 while in the Yaxcaba gardens it was 1,260$.

Production, consumption and sales of fruit and other tree crops are considerably higher than for other food products (Fig. 3) which coincides with that reported by Jimenez and Perez (2000) in gardens of Jitotol de Zaragoza, Chiapas. Thus, the largest proportion of total monetary income received by the family from the garden comes from tree crops principally coffee and pacaya (Table 3).

In the garden, plants provide a greater production and economic value than animals; plants also have lower production costs. This is due to the fact that most gardens do not use external inputs (agrochemicals and

Table 3: Average and optimal values for economic sustainability indicators

Attributes	Indicators	Units	Optimum value	Average value by sustainability group Low	Medium	High
Yield	Total production	kg year^{-1}	4,824	973(±683)	1,375 (±794)	2,876(±1,461)
		%	100	21	30	60
	Plant	kg year^{-1}		721 (±772)	1,135 (±823)	2,508(±1,307)
	Animal	kg year^{-1}		251 (±262)	240 (±180)	368 (±441)
	Total consumption	kg year^{-1}	1,500	290 (±254)	740 (±330)	963 (±195)
		%	100	26	52	64
	Plant	kg year^{-1}		239 (±280)	594 (±335)	809 (±260)
	Animal	kg year^{-1}		50 (±79)	146 (±88)	154 (±109)
	Total sales	kg year^{-1}	3,843	398 (±551)	540 (±676)	1,717(±1,497)
		%	100	11	12	45
	Plant	kg year^{-1}		310 (±537)	353 (±664)	1,518(±1,325)
	Animal	kg year^{-1}		186 (±185)	88 (±120)	199 (±356)
Profitability	Value of production	US$ year^{-1}	3,202.5	801.5 (±504)	1,416 (±793.5)	2,604(±1,695)
		%	100	15	25	43
	Plant	US$ year^{-1}		321 (±429)	854 (±806)	1,567(±785.5)
	Animal	US$ year^{-1}		480 (±522)	562 (±336)	1,041 (±1490)
	Costs of production	US$ year^{-1}	240	715 (±407)	845 (±438)	947 (±764)
		%	100	43	39	35
	Plant	US$ year^{-1}		417 (±269)	484 (±279)	483 (±192)
	Animal	US$ year^{-1}		298 (±355)	361 (±408.5)	464 (±757)
	Net margin	US$ year^{-1}	2,749	87 (±529)	571 (±866)	1,661(±1,053)
		%	100	4	19	50
	Plant	US$ year^{-1}		-95.5 (±519)	370 (±772)	1,084 (±794)
	Animal	US$ year^{-1}		183 (±259)	201 (±260)	577 (±771)

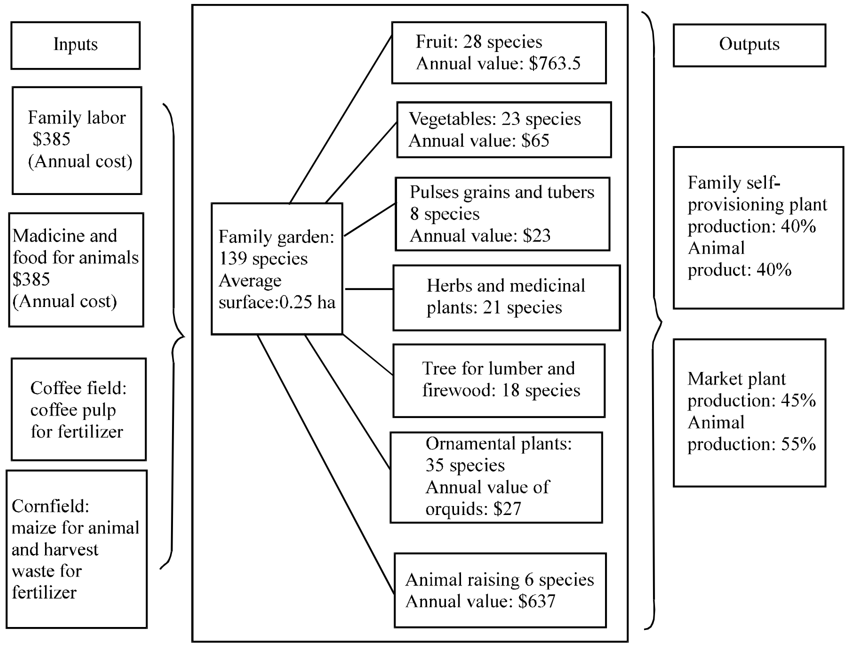

Fig. 3: Components of the typical family garden of the ejido Tziscao, La Trinitaria, Chiapas

Table 4: Average and optimal values for social sustainability indicators

Attributes	Indicators	Units	Optimum values	Average value by sustainability groups: Low	Medium	High
Equity	Beneficiaries who do not work in the garden	No.	8	1.5 (±1)	2.5 (±1.6)	3.1 (±2.7)
		%	100	19	32	39
	Total beneficiaries	No.	11	4.1 (±2)	5.5 (±1.7)	6 (±2.3)
		%	100	37.5	50	54.5
	Hours worked	Hours/year	192	700 (±382)	775 (±445)	772 (±307)
		%	100	39	33	29
Self-administration (±0.90)	Organization	No.	3	0.25 (±0.46)	0.7 (±0.48)	1.9
		%	100	8	23	62
	Training	No.	6	1.5 (±2.2)	2.8 (±2.5)	3.4 (±2.7)
		%	100	25	46	57

seeds) as they practice organic and/or natural management and the only considerable cost of production is family labor (Fig. 3). Therefore, net margin from income for plant products is higher than that of animals. This was also found by Ake (1999) for gardens of Hocaba, Yucatan. Among the animal production economic activities carried out within the garden site is pig raising although few families raise pigs since the ejido demands that certain sanitary infrastructure exist such as septic tanks for animal waste in order to avoid bad odors due to the fact that the ejido is a tourist site. Most families who raise pigs concentrate on fattening piglets. In the sample studied, only one family breeds pigs while 4 fatten piglets. This activity brings a per pig income of $38.50.

Orchids are the only ornamental plant destined for market. These are extracted from the natural environment of Tziscao and nearby areas and in most cases are purchased for resale by residents of nearby communities generally from Guatemala.

This activity is carried out without any government permission to extract or market but given the importance of orchids to the community, they created the Rural Production Society Flor de Montebello which is in the process of trying to obtain permission for extraction from the appropriate authorities in order to regulate this activity. They also offer training to their members on orchid reproduction, management and care.

Production costs were observed to be very similar among the 3 garden groups. Nevertheless, net margin varied, being greatest in the high sustainability garden group (Table 3). This is due to the fact that the economic value of production is highest in the gardens which are most sustainable since production is greater.

Social area of evaluation

Self-administration

Organization and training: Table 4 shows the number of organizations to which the families participating in the study belong and the number of trainings in which they participate over the course of a year. Organized groups to which the families participating in the study belong generally focus on strengthening projects such as coffee production (Lagos de Colores and Flor de Trinitaria), orchid management (Flor de Montebello) and making preserves (Voz de la Selva). Nevertheless, their areas of interest have included topics related to improving home gardens including capability for food self-provisioning, raising foul, vegetable raising, fruit production and reproduction of ornamental plants.

Researchers also observed a strict relationship between type of organization to which the family belongs and level of sustainability of the home garden. This concurs with that explained by Foladori (2002) when referring to social sustainability based on empowerment and self-governance and mechanisms and agencies which promote these values leading to local improvements which have a high impact to the population.

Equity

Family participation in the garden: Beneficiaries and annual hours dedicated to garden labor are shown in Table 4. In Tziscao, family members other than the male head of the family have greater participation in the garden than in other systems which make up the family production unit. In the case of other systems such as the coffee plantation, cornfield and cattle raising, generally males especially heads of families have greater participation; youth participate in few families and women less so. Nevertheless as the garden is part of the domestic space, women's participation is high as is that of children. On average, Tziscao families dedicate approximately 14 h per week to garden labors (Table 4). This figure is lower than that found by Mendez *et al.* (2001) for gardens of Masaya, Nicaragua in which the family devotes approximately 32.6 h week^{-1} to garden labor. This difference is related to other activities carried out by the family as the greater number of economic activities within the nuclear family, the less time is devoted to the home garden.

Comparative Synthesis of sustainability indicators and attributes: From the data previously described, the average value for all the sustainability indicators was 32% for the low sustainability group, 43% for the medium sustainability group and 57% for the high sustainability group (Fig. 4 and 5). Values close to 100% indicate greater sustainability as 100% represents the optimum value.

As may be observed, the highest values for the 3 groups of gardens correspond to the attribute of stability which is represented by soil quality. This attribute is the

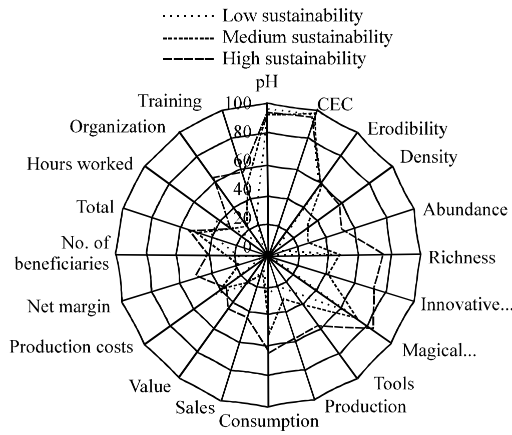

Fig. 4: Distribution of sustainability indicators (%) in the 3 groups of gardens

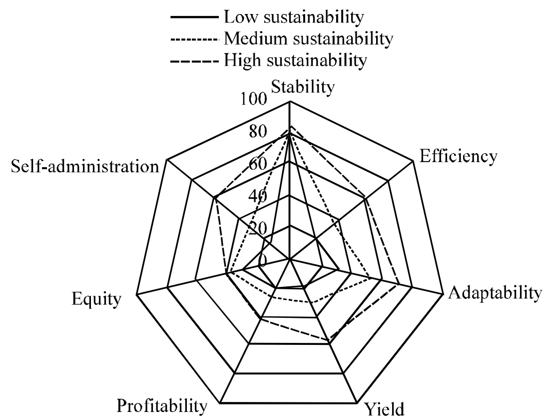

Fig. 5: Graphic representation of the sustainability evaluation per attribute. Values are the average of the indicators included in each attribute

only one for which all 3 groups are >50% which generally indicates that Tziscao home gardens maintain a high level of soil conservation. This coincides with that reported by Priego *et al.* (2009) in cocoa groves under a diversified peasant production scheme in the Mexican state of Tabasco in which stability of these systems proves to have high values which are close to optimum.

Although, differences exist in technology, productivity and management among the groups of gardens, soil quality has been maintained over time thus propitiating adequate conditions for planting diverse crops which represents a strength for the system.

Among the different groups of gardens, the data which vary the least are those corresponding to attributes of stability and equity. This means that for the majority of the gardens without distinguishing their level of sustainability, conditions of soil quality and repartition of people in garden labor are very similar that is these indicators are not responsible for variation in sustainability among the gardens.

The beneficiaries and participation of family members in their gardens is low and this is similar for the 3 groups. This indicates in general that costs and benefits are not appropriately distributed among those who participate in Tziscao home gardens. Furthermore, their participation is continually decreasing. This is relevant, since according to Ostrom (2009), the outcomes of group self-organization is related to other variables of socio-economic systems such as the ability to share knowledge and experiences which strengthens the system.

In order to determine those indicators which most greatly influence differentiation among the 3 groups of gardens and as a consequence their level of sustainability researchers carried out a discriminant canonical analysis with the group of data obtained for all indicators from the three groups of gardens. With this researchers generated two discriminant canonical functions which are shown in Table 5 and Fig. 6.

Both functions prove to be significant according to the Lambda de Wilks' statistic; function 1 explains 99% of existing variation among the three groups of gardens while function 2 explains 1% indicating that the gardens differ principally through function 1. This function shows the level of importance of each indicator and that which has the greatest weight is net margin which together with innovative practices and organization are the indicators which show the greatest variation among the 3 garden groups.

Table 5: Standardized coefficients of the discriminant canonical function

	Functions	
Indicators	1	2
Total net margin	1.283	0.650
Innovative practices	0.873	0.647
Tools	0.814	-0.235
Total beneficiaries	0.963	0.406
Organization	0.904	-0.705

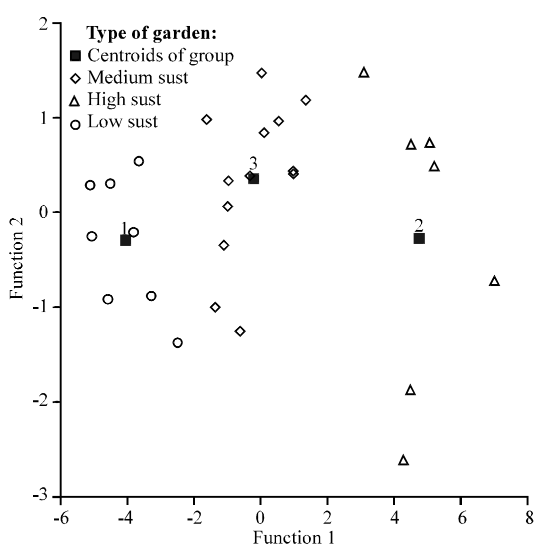

Fig. 6: Graph of discriminant canonical functions

CONCLUSION

The home gardens of Tziscao play an important role in the family production unit since besides being present in most families (93%), they require a large quantity of inputs which come from other sub-systems principally the coffee plantation and the cornfield. Resource use is optimized due to the fact that harvest waste from coffee, corn and beans are used to make organic fertilizer which later may be used to grow vegetables.

The garden system occupies less surface area than other components of the family production unit but has a greater diversity of cultivated species and greater economic yields, despite the fact that this system is not geared toward commercial goals.

The home gardens of Tziscao show different levels of sustainability: low, medium and high. However, the gardens with high sustainability rate only 57% with respect to the optimum.

Indicators for soil quality of the Tziscao gardens show values close to optimal which allows for environmental sustainability and represents a system strength. Differences in biological efficiency among the three groups of gardens due to biodiversity vary notably; this does not depend on ecological resources but rather family preferences.

Net margin also proved to vary considerably among the three groups of gardens (low 4%, medium 19% and high 49%) and although gardens in Tziscao are not principally oriented toward marketing, it is important to improve profitability of the system as it provides an incentive for the family and may be responsible for the continuity or lack thereof of the garden within the family production unit.

The families' capacity for self-administration has a considerable impact on sustainability of the garden since those families whose gardens are highly sustainable principally belong to organizations which are very or somewhat strong while the majority of families who have gardens with low sustainability do not belong to any organized group or belong to a weak organization. Thus, it is important to strengthen the organizational capacity of the families of Tziscao so that a greater number of families may join an organized group and so that these organizations may become stronger.

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