CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

International Development and Agricultural Economics

Master's thesis

# Urban agriculture in Honduras: Agrobiodiversity and performance of home gardens in the departments of Choluteca and Valle

**Supervisor**

Vladimir Verner

**Author**

Ayleen Eugenia Torres Rosales

Prague-Suchdol, 2017

## Declaration

“I hereby declare that I worked on my Master’s thesis “Urban agriculture in Honduras: Agrobiodiversity and performance of home gardens in the departments of Choluteca and Valle” by myself and that I used only literature resources listed in references”

In Prague-Suchdol 27 of April 2017,

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Ayleen Eugenia Torres Rosales

# Acknowledgement

I would like to thank my master thesis supervisor Ing. Vladimír Verner, Ph.D. from the Department of Economics and Development, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, for his time and guidance during the completion of this thesis. I would also like to thank Ing. Brennie de Alarcón and Grupo Terra for their assistance during data collection. Special thanks to Ing. Walter Pavón for sharing his wide knowledge in the study area. I would like to acknowledge the farmers who provided the data on their home gardens and demographic and socio-economic characteristics. Last but not least, I would like to thank my family, my friends, and my partner for all the support and motivation during my work on this master thesis.

# Abstract

Agrobiodiversity as a subset of natural biodiversity includes the plant genetic resources used for food and agriculture. Maintaining this agrobiodiversity in home gardens results in a functioning, productive, resilient ecosystem that provides farmers with the means to generate income and satisfy dietary needs. However, diversification of plant species in home gardens is shaped by external and internal factors. This thesis aims to identify whether changes in the socioeconomic profile and demographic characteristics of households would influence the agrobiodiversity of local home gardens in Honduras and how.

This study was conducted in fifty home gardens identified to be suitable for our analysis across the peri-urban communities of Los Planes, Namasigue, and Pespire in department of Choluteca, and Playa Blanca, Puerto Sierrra, and Ojochal in the department of Valle. The survey was based on data collected during August and September, 2015, gathering socioeconomic background information such as number of household members, household income, size of a garden, as well as ethnobotanical knowledge of home gardeners.

Two biodiversity indices, Shannon-Wiener and Margalef, were calculated. Linear regression models identified home garden age, total cash, home garden size and number of female household members as variables having potential influence on agrobiodiversity. Based on the results, we can conclude that the agrobiodiversity of home gardens in south-central Honduras was significantly influenced by the socio-economic and demographic indicators. Home garden age was strongly connected to diversity; older gardens were found to be more diverse, as farmers added plant species to the home gardens with time. Greater income resulted in a decrease in agrobiodiversity; farmers lacked interest in diversifying plots with crops that were not cash crops, as they had the possibility to rely on external products. Conversely, there was a slight trend in increasing agrobiodiversity with home garden size, but no significant pattern can be established. Nevertheless, for a more accurate result, more data should be analysed.



**Key words:** Diversity indices; Demography; Ethnobotany; Commercialization; Food security; Honduras.

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# 1 Introduction

In the last two centuries, cities have become increasingly associated with technological progress and modernity. As a result, over half of the world's population is now living in urban environments, and unsustainable urbanization is a major problem many countries are recently facing (CoDyre et al., 2015). In Latin American countries, specifically in Honduras, people tend to believe that living standards in cities are higher than those of rural areas. Since power has been very centralized for the last hundred years, governments invest more in cities, thus making them develop faster than rural areas. This lack of support for small farmers has resulted in an absence of documentation on agrobiodiversity and best practices for commercialization (Perdomo, 2009). When people move from the countryside to the cities, the food they consume is more likely to have been transported long distances, and is often of lower quality or nutritional value (Barthel and Isendahl, 2013; Bernholt et al., 2009). This, combined with rising prices and concerns about food insecurity, has led to more interest in producing food locally and sustainably in the form of an urban home garden. A specific agricultural system located near the family house, often largely directed towards fulfilling local subsistence needs (Bernholt et al., 2009). Extensive research has been carried out on indigenous people's home gardens in the developing world (Mosina et al., 2014; Thompson et al., 2009; Vlkova et al., 2011; Coomes and Ban, 2004; Méndez et al., 2001; Wezel and Bender, 2003) with a primary focus on preserving their traditional knowledge of agroecosystem management, as well as creating a sustainable source of food and income. Our study will focus on urban agriculture in the departments of Choluteca and Valle in Honduras. It will document the agrobiodiversity, species richness, and the commercialization of home garden production under changes in the socio-economic characteristics of the households. In addition, it will evaluate whether increasing commercialization and/or off-farm income leads to higher or lower agrobiodiversity.

Maintaining this agrobiodiversity results in a functioning, productive, resilient ecosystem that provides farmers with the means to adapt to changing environmental conditions, and forges strong connections between people, cultures, and the lands in which they live (Galluzzi et al., 2010). Species richness plays an important role in home gardens, conserving them as multifunctional biological resources. This study will examine to what extent species richness is influenced by factors such as garden size, garden age, number of members per household, among others, in the departments of Choluteca and Valle in Honduras.

Household income generated by commercialization of produce and off-farm activities is another factor that influences biodiversity. Households with a higher income usually maintain more perennials and an overall higher plant biodiversity in their gardens because wealthy people tend to have more space, greater mobility, higher quality seeds, and better access to fertilizers (Bernholt et al., 2009). In rural locations, home gardens are generally quite diverse, offering a wide range of products. This diversity appears to reduce the risk of pests, offer stable yields, and makes year-round crop availability possible. Urban agriculture could potentially generate opportunities for recycling organic waste, provide jobs and incomes, improve nutrition, promote education, and strengthen community bonds. Despite having these benefits, households use only a small portion of food from their gardens and rely on their purchases from markets and shops to satisfy their household needs, while reducing their dietary diversity. In developing countries it is market demand that shapes the structure of home gardens (Thompson et al., 2009), thus leading to the questions, 1) How effective is it to rely on home gardens to conserve agro-biodiversity? and 2) How much do home gardens contribute to food security?

# 2 Literature review

## 2.1 Introduction to home gardens

A home garden is generally defined as an agroforestry system nearby the gardener's house, comprising a mixture of different vegetation strata such as trees, shrubs, and herbs, in association with annual and perennial agricultural crops and small livestock. A home garden does not necessarily have to be located in the proximity of the household residence to be classified as such, but can also be established at some distance from it, so long as it maintains defined structural and functional characteristics (Thompson et al., 2009). Home gardens are also not restricted to rural areas. Mosina et al. (2014) have described urban and peri-urban domestic gardens as enabling urban inhabitants to interact with the natural world, resulting in an enhanced appreciation and understanding of the important ecological, social, and psychological functions of green areas. More than just a segment of a dwelling place, these complex microenvironments have been considered as sustainable and diversified niches shaped by a close interaction between human cultures and nature. Home gardens function has been described as a kind of integrated unit in which solar energy is transferred through plants to animals and man, and matter cycled and recycled, providing services such as pollination, refuge for micro- and macro-fauna, and allowing for gene-flow between plant populations inside and outside of the garden (Soemarwoto et al,1975 and Galluzzi et al, 2010). This makes them an important study area for ethnobotanists and agroeconomists. Plant species accumulate in home gardens, where they are protected and experimented with until conditions are favourable for transplanting. Because of their specialized edaphic, microclimatic, and biotic conditions which make them markedly different from the surrounding landscape, they are often used as staging areas (Coomes and Ban, 2004; Guarino and Hoogendijk, 2004; Galluzzi et al., 2010). Overall, home gardens can be seen as a tree-crop-animal unit that is managed by families to fulfil subsistence needs, as well as a place for relaxation and socializing (Bernholt et al., 2009; Méndez et al., 2001; Wezel and Bender, 2003).

## 2.2 Urbanization and market orientation of home gardens

Home gardens can exist in regions with either high or low human population densities, and are always located close to human dwellings. The main difference between rural and urban gardens lies in their purpose and use, which results in different species cultivated. A rural home garden is regarded as a natural asset through which a livelihood can be attained (Mosina et al., 2014). While gardens in an urban setting may also fulfil subsistence needs as well, they are often more market-oriented than rural ones. Urban gardens still share many functional and structural features with rural gardens, but can vary from complex agroforestry systems with distinct vertical and horizontal vegetation strata to much simpler systems centred on the production of annual crops (Thompson et al., 2009). Rural home gardens contribute to the production of goods for home consumption and cash income generation, and can include fruits, vegetables, herbs, spices, livestock products, as well as non-food items such as medicines, timber, craft materials, forage, and fuel (Aguilar-Støen et al., 2008; Thompson et al., 2009). Studies carried out by Mosina et al. (2014) in urban and peri-urban communities in the northern region of South Africa show that food production in domestic gardens is important for households in remote areas and becomes less important for households near an urban centre. Gardens on the outskirts of a city were distinguished by a higher percentage of exotic species and ornamental plants, with food plants playing a supplementary role. Gardens in more remote areas, however, were characterized by a higher percentage of food and medicinal plants, as well as higher numbers of indigenous plants showing similarities to the natural surrounding vegetation. In this case, the hypothesis that food production in domestic gardens becomes less important along a rural to urban gradient is supported. This trend was already documented by Eichemberg et al. (2009) in southeast Brazil, who found that a high number of ornamental plants in urban gardens were associated with the aesthetic role of gardens in cities, as they are not needed for subsistence, except among low income inhabitants. It was also observed in southwest Niger (Bernholt et al., 2009), where constant economic and demographic pressure as well as high market demand has led traditional home gardens in the direction of ornamentalization and commercialization. The related cultural and socioeconomic changes may lead to decreasing plant diversity (especially of local species) in gardens, dominance of a few exotic species/improved varieties for cash crop production, impoverishment of dietary diversity of gardeners' households, or loss of indigenous knowledge.

Results from Bernholt et al. (2009), show that the lowest agrobiodiversity was observed in an urban commercial garden, which was largely dominated by *Lactuca sativa*. However, the highest Shannon index was found as well in a very large commercial garden where many rare species were cultivated. In urban and peri-urban gardens in central Sudan, a declining trend in the presence of upper strata trees and shrubs was observed nearer to urban areas and with an increasing focus on commercial production. Polyculture practices such as the inter-cropping of radish (*R. sativus*), courgette (*Cucurbita pepo* L.), cucumber (*Cucumis sativus* L.), and eggplant (*Solanum melongena* L.), and the shading of celery (*Apium graveolens* L. var. dulce Pers.) using a taller strata of the fence category species castor oil plant (*Ricinus communis* L.) were observed in a small number of gardens at central Sudan (Thompson et al., 2009). Some species of weed such as Bermuda grass (*Cynodon dactylon* L. Pers.), nut grass (*Cyperus rotundus* L.), and lotus sweetjuice (*Glinus lotoides* L.) were commonly removed when they competed with other crops because they had no commercial value, despite being recognized by farmers as beneficial. The abandonment of species such as apple-ring acacia (*Faidherbia albida* (Del.) A. Chev.) white galled acacia (*Acacia seyal* Del.), and the fruit species *Z. spina-christi,* together with exotic tree species including neem (*Azadirachta indica* Juss.), and the fruit tree *Pithecellobium dulce,* along with the demand for firewood, is leading to the swift decrease of the already under-represented taller tree strata, which might further impact biodiversity (Thompson et al., 2009). Urbanization and the easy access to markets it brings with it, was also reported to have a negative effect. The supply of diverse food and the demand for certain crops seem like the main influences leading gardeners from subsistence to semi-commercial or commercial production. This may lead to a decline in the number of perennials and the prevalence of fast-growing, mostly exotic vegetables, resulting in less variety in gardens (Shrestha et al., 2002; Abdoellah et al., 2006). Nevertheless, other studies reported that garden species diversity might in fact be positively influenced by market proximity and/or ‘semi-commercialization’, particularly if there is demand for traditional crops in urban centres (Wezel and Ohl, 2005; Kehlenbeck et al., 2007).

## 2.3 Home gardens and agrobiodiversity conservation

While it is commonly acknowledged that life forms in the natural world are becoming less diverse under increasing human pressure on the Earth's ecosystems, there is a lower level of awareness that agrobiodiversity is under a similar threat. In the last two decades, the importance of genetic resource conservation has received increased attention. In this context, the role of home gardens as stockpiles of biological diversity has been acknowledged, along with their structural complexity and multifunctionality, which enables the provision of different benefits to ecosystems and people. Studies conducted in various countries have proven that high levels of plant diversity, especially in terms of traditional crop varieties, are conserved in home gardens (Galluzzi et al., 2010). Home gardens' contribution to conservation efforts resides in their ability to represent agrobiodiversity at multiple levels over small spaces (Hodgkin, 2001). By harbouring species with different life cycles, which required diversified cultivation practices and serve numerous purposes (food, fodder, medicine, fuel and fibre, ritual, or ornamental), home gardens become living repositories for a vast array of end-products, exhibiting a notable richness of species (Galluzzi et al., 2010). For example, studies carried out by Aguilar-Støen et al. (2008) in south-western Mexico, found species richness to be quite high (2.87), with 233 different plant species. Similar results were documented in Nicaragua by Méndez et al. (2001) 324 different plant species in 20 home gardens. This is possibly related to the farming practices in these regions – particularly in respect to plant exchange and storage – combined with the unifying management of different land uses, which contributes to higher species richness.

Home gardens are often said to be sustainable. This argument is based partly on the idea that the sustainability of man-made agroecosystems increases with their plant diversity, which also leads to improved nutrition in households managing species-rich systems as compared to species-poor ones (Bernholt et al., 2009). Home gardens are also seen as an important land use system for *in situ* conservation of plant genetic resources (Eyzaguirre and Linares, 2004), particularly of local species such as indigenous leafy vegetables, which are better adapted to local agro-ecological conditions and said to have a higher nutritional value than exotic leafy vegetables (Bernholt et al., 2009). In urban and peri-urban gardens in Sudan, 84 plant species from 35 plant families were identified, of which 47 were used as crops mainly for commercial production of fruits, vegetables, spices and condiments, grains, and fodder. Out of 3 different locations where the study was conducted (Thompson et al., 2009), the urban gardens at Tuti Island recorded the lowest level of average biodiversity having a mean species richness of 1.7 and a Shannon index of 0.4, in which monocultures of the perennial crops *Citrus aurantiifolia* L. and *Medicago sativa* L. were a major feature. However, it was the only location where seed re-production was found, indicating the importance gardeners attributed to local germplasm. The peri-urban gardens of El Halfaya, which was the only location where the production of some spices and condiments was recorded, had a mean species richness of 3.7 and a Shannon index of one. Despite the threat of urbanization to agrobiodiversity, it was in the urban area of Shambat where gardens had a higher plant agrobiodiversity in terms of cultivated species richness: 4.4 species per farm, 0.85 evenness, and Shannon index of 1.2. In this area, indigenous leafy vegetables were common. Similar results were obtained by Bernholt et al. (2009), in the 51 surveyed gardens in south-western Niger, a total of 116 plant species were grown, the majority of them for the production of particularly exotic species of fruits or vegetables grown for sale. In the cold season, an average of 14 species was cultivated per garden. The Shannon index was 0.96 and evenness was 0.39. Commercial gardens had a species richness similar to that of subsistence gardens, but a lower evenness (0.005), caused by the dominance of a few vegetable species. For about 30% of the plants with a non-medicinal main use, gardeners mentioned medicine as a secondary use. However, not all respondents, especially younger ones, had retained the traditional knowledge about medicinal plants and their uses. Ornamentals were rarely planted. It is well-known that the Shannon index will fall if a single species dominates, even if the overall species richness is high (Drescher, 1998). This trend was observed in several gardens surveyed in south Niger (Bernholt et al., 2009), where a dominance of a few annual species such as *Lactuca sativa* or *Hibiscus sabdariffa*, combined with the low abundance of many perennial species (*Adansonia digitata* or *Moringa oleifera*) resulted in low diversity indices despite the high species richness. In terms of composition, high diversity of species with an immediate use in the homestead is the most prominent feature of home gardens (Hoogerbrugge and Fresco, 1993). Predominance of fruit trees is common, especially when these are essential for the diet of household members in terms of fibres and vitamins (Mitchell and Hanstad, 2004). Other edible species, wild or domesticated, are the next most represented category. In Nicaragua, fruit and multi-purpose trees, medicinal, ornamentals, and plants for timber and construction were present in more than 85% of them (Méndez et al., 2001). The majority of ornamental species were flowers and indoor plants, which were grown under different levels and types of shade, either directly in the soil or in pots or bags. Diversity was highest for ornamentals (180 species), followed by fruit, multi-purpose and timber/construction trees (86 species in these three categories). Only three perennial shrub species were recorded (Méndez et al., 2001). In Cuba, a total of 101 different plant species were found with an average number of 18 to 24 species per home garden for the three villages. In all study villages, evenness of total species distribution was similar (71 to 74%). Occurrence and abundance of certain species showed to be different between the humid home gardens in the north-eastern region and the semi-arid home gardens in south-eastern region of Cuba (Wezel and Bender, 2003). Higher diversity of plants found under semi-arid conditions seems to be related to two factors: plants which could be planted due to irrigation and the higher number of medicinal plants found in the home gardens (Wezel and Bender, 2003). In central Vietnam, the richest home garden contained 24 species, whereas the poorest gardens held only 2. The high abundance of plant species found in these home gardens was caused by high number of individuals of some cultivated species, i.e., *Arachis hypogaea*, *Bambusa balcooa* Roxb., *Manihot esculenta*, and *Saccharum officinarum* L. These villages showed low mean diversity ranging from 0.54 to 0.78 (Vlkova et al., 2011).

Human cultures wield a profound influence on the diversity of the eco-systems they belong to and the differences even among neighbouring fields and gardens can often be explained by their cultural and economic values. When families and communities spend work and leisure time in home gardens, they turn them into culturally constructed spaces (Eyzaguirre and Linares, 2004) where ethnobotanical knowledge is actively preserved. Customs, traditions and aesthetic considerations are instrumental in determining the identity of the garden, with different crops or varieties maintained because of the significance of each in a family's traditions or preferences. Frequently, garden crops are maintained in cultivation because of personal affection and commitment of single gardeners, resulting in maintenance of a greater portion of intra-specific diversity than the market permits. The overall contribution surveyed gardens in south-western Niger (Bernholt et al., 2009) make towards *in situ* conservation of indigenous species may be questioned. Over 70% of all plant species cultivated in these gardens were of exotic origin, with only a few local species present. As mentioned previously, with increasing market orientation of a garden, local species with low market value are often the first to be removed. Interviewed gardeners highly appreciated the cultivation of marketable exotic crops, using improved planting material offered by local traders and an outreach program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Sahelian Centre, located in southern Niger. Even though, no conclusions about the future transformation trends of these gardens can be drawn, a general increase of their degree of market orientation may be assumed. However, we can see in different studies (Aguilar-Støen et al., 2008; Coomes and Ban, 2004) that home gardens function as reservoirs of biodiversity has been acknowledged by farmers and unlike upland and lowland swiddens, home gardens are the primary source of ornamental species and medicinal plants, as they are continuously cultivated and their relative permanence permits the accumulation of plant species. The future of traditional home gardens and the genetic reservoir they represent is uncertain with the many changes brought on by increasing demographic and economic forces. The global shift towards large-scale agriculture is gradually simplifying agricultural systems and landscapes and eroding the sophisticated knowledge of traditional farming practices (Anderson, 1993). Monocultures replacing rural areas once used for the production of services (home gardens, wooded areas, living fences, pastures) have caused a reduction of local species, primitive varieties, and wild relatives. Furthermore, while “modern” varieties of landraces often offer higher yields under intensive growing conditions, when these conditions are not met for geographical or technical reasons, they performed poorly (Galluzzi et al., 2010).

## 2.4 Impact of household characteristics on agrobiodiversity of home gardens

The composition of plant species in home gardens usually reflects deliberate management strategies. However, plant species richness and diversity are often very dynamic and strongly depend on a combination of agroecological as well as socioeconomic factors that, as a result, shape their structure. Published studies agree on the positive correlation between the economic status of household and agrobiodiversity. For example, a study made by Coomes and Ban (2004) on home gardens in Peruvian Amazon have shown that households that are economically better off may have more interest in plant species diversity in order to have more opportunities to collect different species (via more frequent and/or extensive travel, social position, etc.), and more time to spend on gardening. In these cases, home garden diversity appears to be seen more as a social than economic advantage – as a source of pride as well as gifts (products or plants themselves) that can build social capital. Such findings are consistent with those of other researchers working beyond the Amazon basin (Zimmerer, 1991) and those in Niger by Bernholt et al. (2009), where the highest species richness and diversity, particularly of perennial and local species, was found in large, peri-urban, commercial gardens managed by relatively wealthy, elderly gardeners with large families and a regular off-farm income. Besides income, home garden diversity is strongly related also to land ownership, which suggests that in the Peruvian Amazon, where most households depend fundamentally upon agriculture for sustenance, wealthier households tend to hold greater plant diversity in their gardens. This correlation between land wealth and home garden diversity arises because households with more agricultural fields are more likely to have different types of fields, e.g. swidden, transitional, orchards, forest fallows, and fields in distinct environments, e.g. upland as well as lowland, raising total crop diversity in their farming portfolios (Coomes and Ban, 2004). In Niger, the abundance of fruit trees was slightly higher in owned gardens as compared to rented ones (24 versus 5 tree individuals per garden). These gardens had high species richness and density (Bernholt et al., 2009). This trend is also reflected in Nepal, where poor households facing more restricted access to land manage less agrobiodiversity than relatively better off households (Adhikari et al., 2004), confirming the idea that farmers with less land rights are less willing to make long term investments, and the diversity they maintain is likely to be lower. gardeners possibly maintain overall higher plant species richness and diversity than poor ones because wealthy people in general have more land, greater mobility, and better access to new genetic material, while poor people generally do not have much land or available credit for long-term farm projects. The lower Shannon index found in rented as compared to owned gardens in southwest Niger (Bernholt et al., 2009) may have been caused by economic pressures on gardeners to generate enough income from their rented plots, thus focusing on cultivation of a very small number of profitable cash crops. Lack of secure tenure was also found to severely constrain tree planting in urban and peri-urban areas for gardeners in central Sudan (Thompson et al., 2009). A cluster analysis in southwest Niger (Bernholt et al., 2009), showed that the garden types most suitable for *in situ* conservation of plant genetic resources are those managed by wealthier, more educated people, who were not completely dependent on the generation of cash income through their garden, or those managed by elderly, retired gardeners with large families. In these gardens, not only the highest total species richness, but also the highest number of local species was found, though the latter were often only present in low abundances. In Nicaragua (Méndez et al., 2001), management strategies such as zonation and plant species selection were affected by a family's income, for example home gardens that were not used to generate income were mostly devoted to fruit trees. For those families that did not rely on products for consumption or income, home gardens were important as a space for work and relaxation. Although dependence on home gardens may vary according to specific conditions at a given time, i.e. availability of cash paying jobs, they remain a flexible resource that is consistently utilized to meet the needs of the family. In Eastern Europe's transition economies, as infrastructures and market access evolve and off-farm job opportunities become more available, people tend to depend less on their own produce and gardens' composition and diversity are gradually simplified, with a predominance of perennials, ornamentals and low-maintenance species (Galluzzi et al., 2010). Nevertheless, the development of niche markets may reverse this trend and revitalize cultivation of traditional crops or varieties, which may be commercialized as traditional specialties and provide income opportunities to gardeners (Galluzzi et al., 2010).

Many of the problems local farmers face are nature-oriented, such as natural hazards like floods, soil degradation and water shortage, which was documented in central Vietnam, where studied home gardens appear to be a consistent and adaptable resource (Vlkova et al., 2011). This is contrary to the situation observed in Niger, where home gardens have been found that total species richness continuously decreased from 115 species in the cold season to 100 in the hot season to 77 in the rainy season (Bernholt et al., 2009).

The large differences of plant species composition, richness, and diversity among seasons are clearly related to the changes in weather throughout the course of the year. With moderate temperature and lower potential of evapotranspiration, cultivation of annuals and horticulture seemed to be more suitable. Even though we can consider that soil properties and species seasonality is part of the natural cycle, it can clearly show how the lack of natural resources does limit the species diversity and the contribution of gardens to household food supply. A supporting example for this trend was found by Wezel and Bender (2003) in home gardens in Cuba, where due to proper irrigation mechanisms, it was possible to find higher plant diversity under semi-arid conditions. Frequent and often careless use of pesticides was reported to be common in the surveyed gardens in Niger, which may have consequences for food quality and safety. In some short duration vegetables, residues of pesticides might be high, as well as contamination with pathogens where wastewater was used for irrigation. This, together with the frequent use of mineral fertilizers, raises concerns about negative externalities of intensive urban and peri-urban gardening in some of the surveyed gardens (Bernholt et al., 2009). On the contrary, in home gardens in Nicaragua, very few external inputs were used. Small applications of synthetic fertilizer formulas (N-P-K, at unknown concentrations) and pesticides for ornamentals, coffee, and passion fruit, were performed only once a year in few home gardens. Most families said that they could not afford to purchase external inputs. In some gardens, farmers claimed that they maintained fertility by keeping a diversity of plants that shed leaves and branches, which 'feed the soil'. In these gardens, litter was left to decompose or was piled as compost. In other home gardens, litter was occasionally burned (Méndez et al., 2001). Commercialization depends heavily on hybrid seeds, fertilizers, and pesticides, as shown in all three study locations in Sudan (Thompson et al., 2009), where monocultural commercial production began to rely on external inputs when the focus of gardeners shifted from subsistence to commercial production.

## 2.5 Home garden characteristics

Age was found to have a positive influence on agrobiodiversity in home gardens, which was already documented in the Peruvian Amazon, where older gardens are inclined to be more diverse, especially in regards of perennial fruit tree crops, medicinal plants, and plants that provide construction materials. According to Coomes and Ban (2004) this can be explained by the fact that, with time, more species are added in the home gardens. This trend was also explained by Kehlenbeck et al. (2007), who found that the gardener's age can influence plant diversity positively because as time passes, gardeners try to cultivate new crops, while they continue to plant well-tried species. However, in southern Mexico, it was found by Aguilar-Støen et al. (2008) that younger home gardens are more diverse than older ones. When either younger or older people move to a new homestead, they bring with them plants they have received as gifts from relatives, as well as plants from the old site to use in their new garden. It is also common for neighbours and friends to bring plants to new homesteads, and due to these exchanges, home gardens become more diverse. In the Peruvian Amazon, younger gardens sometimes serve as pioneer fields for developing households, and the gardens are dominated by non-fruit staples; over time, fruit species, especially perennial tree crops, come to dominate the gardens. Such shifts in diversity and composition may reflect changing soil and environmental conditions in gardens over time (Coomes and Ban, 2004). On the other hand, studies from Vlkova et al. (2011) in home gardens in central Vietnam, showed that there was no substantial correlation between home garden age and diversity, while the Margalef index was slightly decreasing with higher age of the home garden, the Shannon-Wiener index was increasing.

From the results of the above studies, we can consider home garden age as an influential factor in home garden biodiversity. However, in order to establish a positive or negative trend, more studies need to be conducted.

Garden size was found to have an effect on species richness in some studies (Bernholt et al., 2009; Vlkova et al., 2011). In the case of Niger, while the total species richness was only slightly correlated with garden size, larger gardens had a higher number of perennial and local plant species. The number of vegetation layers increased with garden. Overall species number and Shannon index were positively correlated and increased with garden size. In central Vietnam, home gardens were categorized into four size classes based on their area: small (≤0.26 ha), medium (0.27–0.52 ha), large (0.53–0.78 ha), and commercial (≥0.79 ha). Results showed that home garden size affects the abundance of the species but not the number of species. Furthermore, the differences in the mean Margalef index and mean Shannon index implied that size affects species richness. Accordingly, higher diversity was represented in smaller home gardens. The decrease of the Shannon-Wiener index as garden size increases is due to the dominance of only a few species in large home gardens (Vlkova et al., 2011). According to different studies (Aguilar-Støen et al., 2008) there is a positive relation between size and diversity in so-called natural ecosystems, while in home gardens, no strong connection between size and diversity was found. Some people are more interested in plants and gardening than others, and will often try to acquire more plants for their garden, regardless of its size. The particular interests of the farmers and their family mean that size does not necessarily limit the distribution and abundance of species. In the Peruvian Amazon, garden size was found not to be related to species richness, in part because land remains plentiful in the village. Elsewhere, in more urbanized communities, the size of the garden may be influential. However, this is still under discussion, and more information will be needed in order to define a clear pattern.

## 2.6 Demographic composition of the household

The number of household members per $m^2$ of garden area and kinship affiliation has also been taken into account as one of the foremost socioeconomic factors that are also correlated with species richness (Bernholt et al., 2009). Households belonging to larger kin groups tend to have more diverse gardens, as do those with families that possess high social standing and an interest in plants (Coomes and Ban, 2004). In Nicaragua, the amount of labour invested in a home garden was related to the size of the family (labour availability) and its level of dependence on the home garden. Children and young adults below the age of 25 were not regularly engaged in home garden work. High labour investment did not necessarily result in a higher number of plant species; two of the most intensively managed home gardens i.e. with a high number of plant species, had labour inputs below the sample mean. In both cases, one person who was very knowledgeable and experienced worked fulltime to maintain the home garden. This suggested that the quality and consistency of the labour were more influential on home garden agroecological characteristics than the amount of work hours invested (Méndez et al., 2001).

However, a shortage of labour force for irrigating the plots contributes to a decrease in agrobiodiversity. In 81 urban home gardens of the semi-arid region of Sudan, a low mean of 3 species per garden was reported, but an even lower total species richness (32 spp.) was found, which was likely caused by the lack of irrigation (Gebauer, 2005). Under humid conditions, however, plant species richness in home gardens is often much higher. A total of 338 species was found in home gardens of humid Mexico (Alvarez-Buylla et al., 1989). Thus, the role of sample gardens for supplying households with fresh products seemed to decline from the cold to the hot and the rainy season, as well as from humid to semi-arid areas, although some gardens maintain a high number of annual vegetable individuals even in the less favourable seasons or conditions. Sustaining a garden during the hot season or in less humid areas, largely depends on the ability of a household to invest in time (for frequent irrigation), knowledge, and money for infrastructure such as pipes and water pumps, has also been reported in other studies (Bernholt et al., 2009; Vlkova et al., 2011) where gardeners declared their desire for cultivating more trees, but mentioned the lack of water as an issue. Most families said that they could not afford to hire outside labour.

Gender, on the other hand, is another factor to consider when looking at agrobiodiversity. In southwest Niger, the 11 gardens managed by women were smaller than those managed by men, with mean sizes of 312 and 1,010 $m^2$, respectively. While 64% of the gardens managed by women were subsistence gardens, 95% of those managed by men were commercial ones. Species richness was lower in gardens managed by women compared with those managed by men (10 versus 15), but Shannon index and evenness were higher (1.24 versus 0.89; 0.56 versus 0.35). In these gardens operated by women, numbers of species and of individuals of perennials were much lower compared with those operated by men (species number 1.4 versus 7.2; individual number 33 versus 388), whereas richness of local species was only slightly lower (1.2 versus 3.2) (Bernholt et al., 2009).

However, only few studies showed the effects of gender on plant species richness and diversity. Women are often reported to play a significant role in *in situ* conservation of plant genetic resources in home gardens by cultivating local species for subsistence, whereas men are often more interested in introduction and cultivation of exotic cash crops (Eyzaguirre and Linares, 2004; Bernholt et al., 2009). In Latin American countries, such as Belize, Mexico, Venezuela, and Ecuador, crops destined principally for subsistence or for sale in small quantities in local markets are managed by women 80% of the time (Howard, 2006). Women in Italy and Peru were also found to be aware of the importance of conserving agrobiodiversity in home gardens and tended to pass on knowledge to the husbands, children, and neighbours (Galluzzi et al., 2010).

Women are usually responsible for a large part of food production, which is linked to food security. There is a strong connection between women and the production of medicinals, spices, condiments, ornamentals, as well as subsistence-oriented plants such as roots, tubers and vegetables (Trinh et al., 2003; Howard, 2006).

Jackson (1993) suggests the role of women in the management and conservation of biodiversity is related to specific contexts. When women fail to take care of the home garden, it is generally regarded as lack of ability, rather than interest. The patio is an extension of the home, considered a domestic space, and as such, is the responsibility of women to look after it. Thus, the aesthetics of the home garden seem to be the responsibility of women. As a result of their active engagement in traditional management practices, the role of women in home gardens has increasingly been valued globally (Aguilar-Støen et al., 2008).

In home gardens in central Vietnam, it was reported that both men and women participate in the establishment, maintenance, and management of local home gardens, but both are individually responsible for different plant species and certain home garden functions. In the case of women, most, if not all, were involved in household and home garden chores, apart from other work. Men worked more frequently outside the household than women; outside work was limited to agricultural or urban labour or small-scale commercial activities (Vlkova et al., 2011). In Nicaragua, home gardens were the third most frequent activity for both sexes. Labour inputs by gender were varied, and seemed to depend more on the number of women and men than on assigned roles for the different sexes. Exceptions where a clear division of tasks were observed lay in the commercial production of coffee and fruit trees, which was managed by the men of the family, and of ornamental plants, which were managed by the women (Méndez et al., 2001).

A study conducted in Bangladesh indicated that light tasks like watering, fertilizing, weeding, and fencing (in 65%, 52%, 56% and 53% of cases respectively) were mainly done by women. Both pre-harvesting and harvesting activities were also carried out mostly by women. It was found that women on average spend 6-8 hours a week working in the home garden, while men were found to spend only 4-5. On the other hand, it was found that more labour-intensive tasks like digging holes, pruning and planting species (in 55%, 53% and 52% of cases respectively) were undertaken by men (Akhter and Alamgir, 2010). Timber extraction, land clearing, tree pruning and thinning, construction of structures and fences, and chopping undesirable growth of specific species are activities that are also primarily carried out by men (Benjamin, 2000; Patterson, 2000).

In some cultures, tasks are clearly defined by gender. For example, among the Ka´apor in Brazil (Baleé, 1994), women specifically are responsible for planting cotton (*Gossypium* spp.), Indian shot (*Cannaindica*), job's tears (*Coix lacryma jobi*) and pipiriwa (*Cyperus corymbosus*), which are used exclusively by women for textiles or for body decoration. Men on the other hand, only plant maize. Among the Piaroa in Mesoamerica, it is also men who are responsible for planting maize, as well as tobacco (*Nicotiana tabacum*) (Heckler, 2004).

## 2.7 Home gardens and population dynamics: Migration-Mobility

Migration is altering communities and landscapes in Latin America significantly. Due to recent changes in the agricultural sector, farmers in Mexico are increasingly finding alternative livelihood strategies outside of agriculture, often involving migration (Eakin et al., 2006). These changes affect farmers' lives in many different ways – especially with the introduction of new plants into their farming systems. The presence of species from other provinces may point to the possibility of exchange of ethnobotanical information on these species. Furthermore, households' members give home garden products to neighbours and relatives, and this exchange strengthens relationships. Different authors (Aguilar-Støen et al., 2008) note that the knowledge of local people is dynamic and dependent on external opportunities and constraints. Local floras are enriched through past and present plant movements related to the movement of people. As people are expanding outwards in search of jobs (from nearby towns or cities to transnational migration), their home gardens will be enriched and diversified accordingly. The flow of seeds and plants is not unidirectional; migrants will move plants both from abroad and to their international destinations.

## 2.8 Home garden role in resilience and climate change

Ecological resilience was originally conceived in forest ecology (Holling, 1973), and is connected to the interrelated behaviour of sets of species over time in spatially defined areas (Folke, 2006). Social-ecological resilience is defined as the ability to absorb shocks, utilize them, reorganize, and continue to develop without losing basic functions (Carpenter and Folke, 2006; Galluzzi et al., 2010). Integrating management practices in the home garden with those in other land uses encourages heterogeneity and aids farmers in handling changing conditions such as climactic events and changes to policy. Management practices that allow a variety of land uses to develop lead to more diverse, resilient ecosystems, which is related to increased capacity to adapt to change (Carpenter et al., 2001).

In southern Mexico, land use units are located along an altitudinal gradient where different land use units are used with different purposes, but their management is integrated (Aguilar-Støen et al., 2008). The irregular organization of land uses and settlement in the landscape reflects the different levels of comparative advantage in social, political, and ecological parameters, an example of the links between ecosystem and social resilience. This resilience should be seen as an attribute of the community, not only of individuals or households (Aguilar-Støen et al., 2008). One often overlooked function of home gardens is their contribution to environmental regulation. For example, practices in southern Mexico are consistent with practices observed in other sites (Del Angel-Pérez and Mendoza, 2004), which are strongly connected to the knowledge that people have of the place where they live, its environmental conditions, the everyday activities of the people there, and memories of past events (Netting, 1993; Nazarea, 2006). A large portion of agrobiodiversity thrives under complex agroecosystems like home gardens. On-farm conservation in gardens is a ‘‘dynamic’’ solution which ensures the perpetual adaptation of species and landraces within their changing environment, and depends upon both human and biological components of the ecosystem. The multi-layered arrangement of different plant species that characterizes home gardens has been shown to make them sustainable and resilient ecosystems in which differentiated root structures utilize nutrients from various soil levels and both ground and aerial space are efficiently utilized (Eyzaguirre and Linares, 2004). Control of soil erosion and soil fertility are often augmented by the presence of trees, with fallen leaves providing natural mulching and the build-up of humus. A generally reduced application of chemical fertilizers and pesticides protects natural habitats for wild flora and fauna and maintains high microorganism diversity (Birol et al., 2005; Galluzzi et al., 2010).

Home gardens are often used as testing plots for new crops, as nurseries for plantlets later destined for planting in open fields, and as sites for domestication of weedy forms (Kulpa and Hanelt, 1981; Leiva et al., 2001), which may also be used directly within the household. Minor or ‘‘relic’’ crops never or no longer cultivated in larger commercial fields have been found in carefully surveyed home gardens. This is the case for lima bean in Cuba, sponge gourd in Nepal (Hodgkin, 2001), *Lavatera arborea* L. in the small island of Linosa off the coast of Sicily (Hammer et al., 1997) and *Camelina sativa* Crantz, *Raphanus sativus* L. and *Panicum miliaceum* L. in Poland (Kulpa and Hanelt, 1981; Galluzzi et al., 2010). The predominant subsistence orientation of garden cultivation and the ensuing increased flexibility in farming practices encourages the introduction and maintenance of wild species (Guijt et al., 1995), indigenous crops (Juma, 1989), and traditional varieties (Negri, 2003; Negri and Polegri, 2009). This results in significant intra-specific diversity (Eyzaguirre and Linares, 2004) which not only increases a species’ chance for adaptation and survival over time, but also provides crucial material for breeding and for establishing, complementing, or restoring germplasm collections (Castineiras et al., 2007). The presence of crop wild relatives allows gene exchange with the crops themselves: natural crosses between domesticated forms and their wild or weedy relatives still consistently occur in or around home gardens and wild germplasm has often been utilized by farmers to create and improve crops by experimenting in backyard gardens (Galluzzi et al., 2010).

Home gardens also function as reservoirs of plant varieties. Maize (*Zea mays*), bean (*Phaseolus vulgaris*), coffee (*Coffea spp*.), and sugar cane (*Saccharum officinarum*) varieties that are no longer in use are “stored” in the home garden to ensure that the variety will not disappear. Some plants (old varieties and/or local varieties) are favoured for various reasons (their adaptation to local conditions, their taste etc.). For instance, in Mexico, when a new variety of sugar cane was introduced, the local variety, which was better tasting but susceptible to pests, became less common. Some plants of the old variety were kept in a home garden and after some time, regained popularity and were transferred back to the fields and other home gardens. In another example, a governmental agency launched a program to increase maize productivity by utilizing a new variety. The new variety certainly produced more, but it required chemical fertilizers to grow and mechanical equipment to separate the grains from the cob. The fertilizers and equipment resulted in extra expenses for the farmers and after some time, they went back to the old variety. This was possible only because farmers had kept seeds from the old variety in their home gardens (Aguilar-Støen et al., 2008).

The reservoir and the experimental-field functions of the home garden are particularly important not only for the conservation of biodiversity, but also for subsistence farming systems and practices suitable for marginal lands. Farmers in southern Mexico manage their home gardens as one component of the overall production system, which includes patches of coffee forest gardens, fallows, maize, and forests. Farmers in Mexico have succeeded in managing and promoting maize diversity (Perales et al., 2003) and probably the diversity of many other species largely by experimenting in their own fields. The objective of farmers is not to maintain static genetic conditions (Perales et al., 2003), but rather to improve, adapt, and innovate their farming practices. Because farmers have both a theoretical and a practical approach, they are able to improve flawed elements in their farming systems (Aguilar-Støen et al., 2008).

At larger levels of analysis (when combining diversity of all home gardens), it is evident that through practices such as plant exchange, seed storage, and the dispersion of seeds and plants in different land uses, farmers avoid homogenization and encourage plant diversity. In doing so, farmers manage their lands for resilience, taking advantage of the patchy distribution of resources and optimizing labour allocation. This way of managing their different land use units has allowed for the reestablishment of plants and plant varieties (e.g., maize, coffee, sugar cane, or shade trees) and for protecting land against environmental fluctuations (Aguilar-Støen et al., 2008).

One approach to investigate and compare urban resilience is to assess the degree of diversity in the options available to urban communities in relation to food resource production and distribution over the long-term, and how this played out during severe crises (Barthel et al., 2012). Social-ecological memory captures vital relations between humans and living ecosystems that affect the ability of people to respond to disturbance (Folke et al., 2003), defined as the means by which knowledge, experience, and practice about how to manage a local ecosystem and its services are retained in a society and revived and transmitted through time (Barthel et al., 2012).

## 2.9 Food security of home gardens families

The extensive study of home gardens has increased in the past few decades, mainly because they have come to be considered as an efficient model of sustainable agroecosystems, with high biodiversity and a limited use of external inputs, preventing soil degradation through good nutrient cycling, and in this way, providing a reliable and varied food supply to the families that keep them (Méndez et al., 2001). Food security has been broadly defined as the situation when people have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs (FAO, 1996), and the food system as "the chain of activities connecting food production, processing, distribution, consumption, and waste management, as well as all the associated regulatory institutions and activities" (Pothukuchi and Kaufman, 2000). However, big cities mainly feed themselves by global food systems that depend on fossil fuels to gather foodstuffs from the all over the world, often with harmful environmental impacts (Deutsch, 2004; Folke et al., 1997). While such high global connectivity between cities and remote food supplies can decrease cities' vulnerability to food shortages and build resilience during medium-severe crises, sudden severances of supply lines due to regional political, economic, and cultural conflicts in a country can be a constant threat to the survival of societies (Ernstson et al., 2010). For example, throughout history, urban food security was more susceptible to disruptions in the supply system brought on by political upheavals in the eastern Mediterranean, rather than climatic irregularities. In particular, the loss of Egyptian and North African territory to the Muslim expansion during the 7th and 8th centuries AD dramatically transformed the food supply system (Haldon, 1990), shifting food production and grain supplies to lower-level food production units known as "oikos" (household farmsteads or communities of farmsteads). The most severe threats to the urban food security in Constantinople were the sieges and blockades that occurred on average every 65 years or so, severing distant food and water supply lines. The most severe siege, at the end of the 14th century, lasted eight years, but did not succeed in starving out the urban population. This is likely due to the above mentioned reorganization of food production (Barthel and Isendahl, 2013). This is evident now where home gardens in urban and peri-urban agriculture play a significant part in livelihood strategies for households and contribute to regional food security. This role has particular importance in sub-Saharan Africa, where it was estimated that over 50% of the population will live in urban areas by 2020, with the urban population growing from 294 million in 2000 to 724 million in 2030 (Marshall, 2007). Due to the high birth-rate and the arrival of migrants from rural areas triggered by low soil fertility, erratic rainfall, and poor infrastructure, leading to a constant increase in food demand. It is in such a context that, all over Africa, urban and peri-urban has become an increasingly important activity for improving the quality and quantity of food intake. Worldwide, urban and peri-urban agriculture is estimated to produce as much as one-seventh of the total food supply (Drescher, 1998). African cities such as Bamako in Mali or Lubumbashi in Democratic Republic of Congo are reportedly self-sustaining in the supply of vegetables through urban and peri-urban agriculture (Bernholt et al., 2009).

Urban and peri-urban agriculture home gardens may create opportunities for the recycling of organic waste and waste water, and provide jobs, income, and improved nutrition for many of the poorest urban residents. Such benefits enhance the potential for urban and peri-urban agriculture to improve food security in many cities of the Tropics and Subtropics, where undesirable seasonal climatic events, civil unrest associated with political instability, and poor infrastructure development results in unreliable food supplies from more distant rural areas (Thompson et al., 2009; Bernholt et al., 2009). However, all these benefits are increasingly threatened by heavy competition for urban land use and by food safety issues related to the uncontrolled use of waste materials, effluent and agricultural chemicals in highly intensive agriculture often found in close proximity to residential areas. In general, the majority of people in villages in developing countries depend on the products from their home gardens for sustenance. This was true in Cuba for the period from 1989 to 1993, where the average daily supply of calories was dangerously low (1.780 kcal per capita), and three quarters of the Cuban people were suffering from malnutrition. However, globally, the degree to which the home gardens contribute to the provision of household food varies a lot. For Cuban farmers, the home gardens produce many fruits and vegetables for self-consumption which are not cultivated on their fields, as well as livestock products such as meat and eggs. In many parts of the world, home garden systems provide an additional food supply for many people, but in rare cases it can be a complete food supply large enough to sufficiently provide tubers or cereals (Wezel and Bender, 2003). In developing countries, home gardens owned by pensioners or people with a regular job can significantly improve the provision of the household with food because regular wages or pensions are very low. In home gardens of Nicaragua, home consumption was 100% for most fruit trees and herbaceous food species (Méndez et al., 2001). In general, production in home gardens is year-round, unlike the seasonal harvest of farmers' fields. Although yields are normally low, this is more than compensated by the diversity and nutritious nature of the products (Fernández and Nair, 1986; Wezel and Bender, 2003). Nevertheless, there are newly emerging positive trends in home gardening, which encourage people to maintain biodiversity in rural or urban gardens. In developing countries, the nutritional value of local, neglected horticultural species has been evaluated and their cultivation in family gardens promoted to guarantee the intake of vitamins and micro-nutrients (Odhav et al., 2007).

The establishment of food producing gardens, often based on local seed systems and traditional crops in areas of intense urbanization, is becoming an important tool for making cities more sustainable while also providing marginal areas of the population with work opportunities, healthier food, and strengthening their cultural identity (Galluzzi et al., 2010). In high-income countries, the growing demand for healthier lifestyles and closer connection to nature has awakened an interest in sustainable agricultural systems and ''traditional'' food products, capable of connecting consumers to the natural and cultural heritage of a community or geographical region (Galluzzi et al., 2010). Many urban citizens of the developed world have taken up some form of self-production of food in their terraces, roofs, gardens or courtyards, as well as in communal areas shared between neighbours (Bhatt and Farah, 2009; Bradley, 2009). In various countries, municipalities (or other institutions such as The National Trust in the UK) assign unused public urban space to the local population or to specific groups, most often pensioners or school children (Galluzzi et al., 2010).

Agrobiodiversity is an integral part of agricultural production and food security and has proven to be invaluable to environmental conservation (Thrupp, 2000). Optimizing utilisation of local crops can provide healthy nutrients, especially vitamins and minerals from fruits and vegetables as part of a healthier diet (Kahane, 2013). In addition, local crops are better adapted to local natural conditions, so less fertilizer and inputs are needed. Agrobiodiversity also helps sustain soil health and habitat for important pollinators and natural pest predators, and supports ecosystem services (Biodiversity International, 2016). Therefore, high agrobiodiversity is vital to having a sustainable system.

# 3 Aims of the thesis

## 3.1 Aim of the thesis

The aim of the thesis was to document whether changes in the socioeconomic profile and demographic characteristics of households would influence the agrobiodiversity of local home gardens and if yes, how.

Specific objectives of the thesis were to:

- Document topic-relevant household demographic and socio-economic characteristics as well as basic information about the farm.
- Document plant species that occur at local home garden to quantify agrobiodiversity of home gardens.
- Document how plant species are used by local households (ethnobotanical knowledge).
- To acknowledge farmers´ future expectations in regards to their agricultural activities.

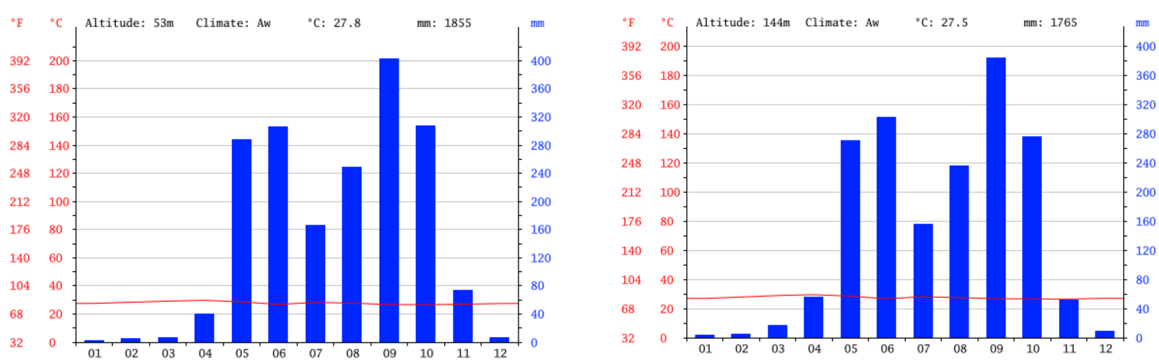
## 3.2. Research question

This study intends to answer the question whether socioeconomic changes would lead to higher commercialization, and if commercialization and/or off-farm income is increased, will it result in higher or lower agrobiodiversity?

# 4 Methodology

## 4.1 Study area characteristics

This study was conducted in fifty home gardens across the peri-urban communities of Los Planes, Namasigue, and Pespire in department of Choluteca, and Playa Blanca, Puerto Sierrra, and Ojochal in the department of Valle. The actual territory of Choluteca is 4,397 km$^2$, and Valle is 1,618 km$^2$, both are located in the south of the country. The climate in these areas is tropical savannah, which consists of two seasons: one dry season starting in January and ending in April, February being the driest, and one rainy season that starts in May and ends in October. Figure 1 provides the basic data on temperature that ranges between 27˚C and 34˚C in winter and 28˚C and 40˚C in summer, with an average temperature equal to 24.9˚C, annual relative humidity around 70% and an average annual rainfall slightly exceeding 1,000 mm (Climate-data.org, 2015).




Choluteca region

Valle region

**Fig. 1** Climate data in focused departments
Source: Climate-data.org (2015)

The population of the department of Choluteca has reached 447,852 inhabitants with a population density of 102 inhabitants per km$^2$, from which 69% worked in agriculture. In Valle, the population has reached 178,561 inhabitants, with a density of 110 inhabitants per $km^2$, out of which 66% worked in agriculture (INE, 2015).

Focused area is located within the Pacific slope, in the Choluteca river watershed, which has an area of 7,848 $km^2$. Its annual contribution is 1,032 $hm^3$ and the length of the river is 349 km, extends along the department of Choluteca, and constitutes the most important water source for agricultural irrigation systems in the area. Soils in the study area are characteristic for severely deficient in nutrients and containing low levels of organic material. The area however significantly contributes to the supplies of basic grains to the central and southern areas of the country, but their potential as a source of production has declined due to severe changes in climate conditions, particularly decreasing amount of precipitation (Castellano et al., 2010). This lack of a steady rainy season, together with the lack of capital for improving irrigation systems, pest prevention, fertilizers, and purchasing improved seeds, has made cultivation increasingly more challenging for farmers.

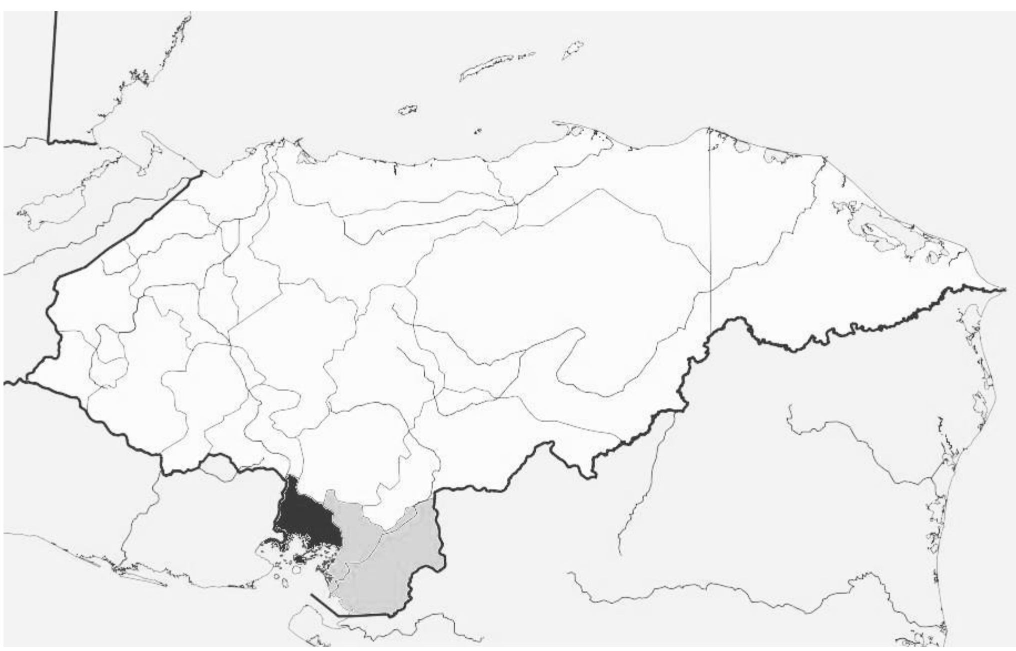


**Fig. 2** Map of the departments of Choluteca and Valle
Source: author, based on Google maps (2015)

Over the last few years, drought has led to famine in these departments, due to losses in most of the cultivated crops. In 2012, in these and other communities of Choluteca and Valle, losses were estimated at 95% of the crops of basic grains. Most of the cornfields remained ungrown due to the lack of rain it is believed that some 25,000 families in the south and north of Choluteca and Valle are the most affected because of the scarcity of these basic grains (FAO, 2003).

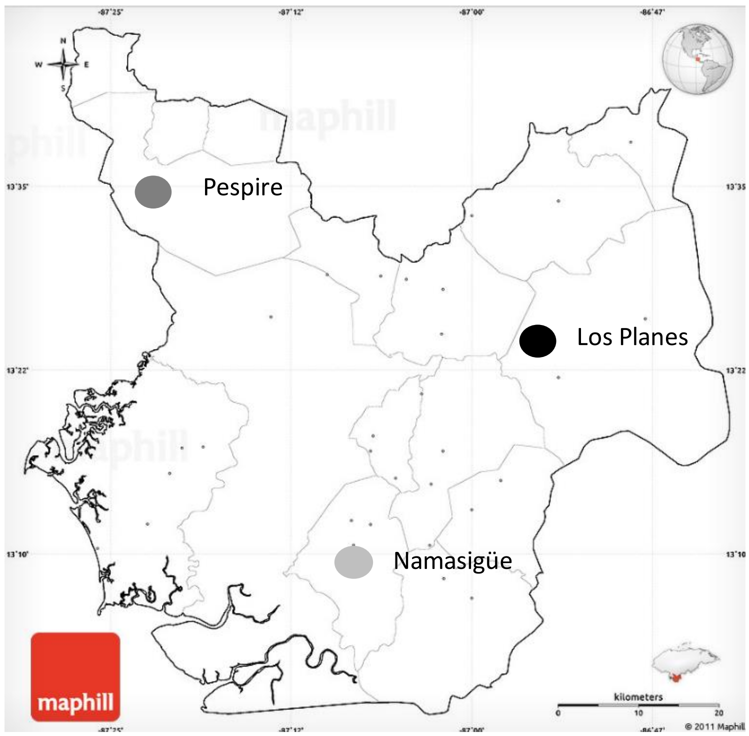



**Fig. 3** Map of Choluteca
Source: Maphill (2015)

**Table 1** Overview of targeted villages

| Village name | Village area ($km^2$) | Number of households in village |
|---|---|---|
| Los Planes | 124 | 4,035 |
| Ojochal | 103 | 3,200 |
| Playa Blanca | 80 | 1,700 |
| Pespire | 337 | 5,277 |
| Puerto Sierra | 170 | 2,138 |
| Namasigue | 200 | 6,110 |

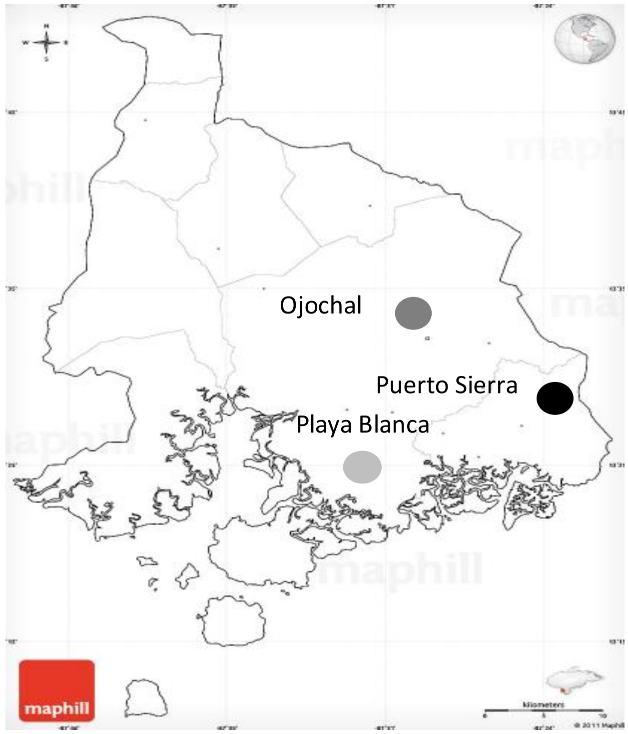



**Fig. 4** Map of Valle
Source: Maphill (2015)

## 4.2 Data collection

Data collection began in August 2015. This time was chosen because farmers were easier to approach during this key period of the year, as they were harvesting their crops and re-cultivating their land (SAG, 2015). Selection of suitable study areas was made between August 16th and 20th with the help of retailers and farmers who sold their products in the local markets of the south-central region. They provided information of possible areas where farmers would be willing to cooperate with this study. With a list of possible study areas, a further consultation was conducted with social workers in programs of corporate social responsibility from Grupo Terra, the division of environmental impact, and Fundacion Agrolibano, who helped identify production areas in the communities of Playa Blanca, Puerto Sierrra, Ojochal in the department of Valle, Los Planes, Namasigue, and Pespire in the department of Choluteca. Transect walks in the selected communities helped identify home gardens suitable for this study.

A structured questionnaire with 18 questions gathering socioeconomic background information such as number of household members, household income, size of a garden, as well as questions related to ethnobotanical knowledge of the plants was developed. Questionnaires were considered the most effective research tool due to the high number of active respondents and the short time available to conduct these interviews (Mathur and Sundaramoorthy, 2013). Questionnaires were prepared and conducted in the Spanish language, and formulated in a considerate and respectful manner.

From September 12th to September 30th, visits were made to the farmers. Not all met the requirements and not everyone wanted to participate in the survey. Applying a snowball method (Bernard, 2002), surveys were distributed among 50 households, while 11 were residing in the community of Los Planes, 11 in Ojochal, 8 in Playa Blanca, 8 in Pespire, 7 in Puerto Sierra, and 5 in Namasigue. Through direct observation, interviews, and transect walks at each of the selected home gardens, the necessary information from both measurements and descriptions of parcels of land, crop types, quantities sown, amounts harvested, the percentages of these crops for household consumption, and the percentages for the sale and use of different plants and crops found in their plots was gathered. As data gathered mainly through the interviews among households, all responses were supported by observations and transect walks in the studied area. Furthermore, complementary data was obtained through direct communication with sellers from different local markets in the south-central region.

## 4.3 Data processing and analysis

### 4.3.1 Ethnobotanical knowledge

Ethnobotanical knowledge plays an important role in maintaining cultural identity and traditional knowledge. It involves passing on knowledge about local medicinal plants and traditional recipes and is a key feature of cultural rituals and festivals (Galluzzi et al., 2010).

Informant- consensus and use value methods were applied to assess ethnobotanical knowledge of farmers and household members. From the list of plants present in each garden, farmers identified the use of each part. Each plant sample citation and different use was recorded. (Mathur and Sundaramoorthy, 2013)

### 4.3.2 Agrobiodiversity quantification

The standard statistical methods were used to calculate data using MS Office Excel ®.

Species richness was estimated using the Margalef index (DMg).

$$DMg = \frac{S-1}{\ln(N)} \quad (1)$$

S the number of species, N total number of individuals in the sample.

Margalef index measures species richness, which means the number of species an area contains and does not count the relation between abundance of species. It is highly sensitive to sample size. The range of Margalef index is 0-∞ (Magurran, 1988; Gamito, 2010).

Shannon-Wiener index (H) were also calculated for every garden.

$$H = -\sum_{i=1}^{S} piln(pi) \quad (2)$$

Where pi proportion of the species relative to the total number of plants.

Shannon-Wiener index is one of the most well-known and widely-used diversity indices. It measures the diversity, so it relates to the number of species in the community and to the relative abundance of each species, and accounts for both abundance and evenness of the species present. The index expresses the uncertainty of predicting the species from a random sample. The uncertainty decreases along with decrease of evenness and with the number of species, i.e. the value of the Shannon index increases as diversity increases. Shannon-wiener index expresses the uncertainty of predicting the species of a random sample. The average value ranges from 1.5 - 3.5 (Magurran, 1988).

### 4.3.3 Linear regression

The relations and dependency between agrobiodiversity represented by the above mentioned indices and socio-economic characteristics were identified by employing a multiple linear regression analysis. The variation in dependent variable explained by the independent variables is best estimated by the regression model R square (Kabir and Webb, 2009; Landon-Lane, 2004).

**Table 2** Independent variables used in linear regression and correlation analysis

| Variable | Description | Units of measuring | References |
|---|---|---|---|
| Farmer's age | Age of household head | years | Kehlenbeck et al. (2007) |
| Farmer's gender | Sex of household head | if male, then 1 | Howard, (2006), Lope Alzina (2006) |
| Household size | Number of household members | number | Quan and Anh (2006) |
| Female household members | Number of female household members | number | Akhter and Alamgir (2010), Dietrich (2011) |
| Dependent members | Number of people younger than 15 and older than 60 | number | Landon-Lane (2004) |
| Home garden age (HG age) | Age of home garden | years | Coomes and Ban (2004), Aguilar-Støen et al. (2009) |
| Home garden size (HG size) | Total area of home garden | $m^2$ | Mendez (2000), Kabir and Webb (2008), Vlková et al. (2011) |
| Farm size | Total area of farm, area of home garden and house included | $m^2$ | Quan and Anh (2006) |
| Total cash income | All cash income generated by household per one year from both farm and off-farm activities | Lps | Yongneng et al. (2006) |

# 5 Results

## 5.1 Households and home gardens characteristics

From the 50 surveyed gardens, the number of family members varied from 1 to 7, with an average of 5 members per family, 40% of them being female, with ages ranging between 0 and 20 being the most represented at 21%, ages ranging between 20 and 29 coming in second with 26.4%, followed by ages 40-49 with 19.4% (table1). The majority (53.4%) of the participants were educated up to primary level while 40.5% had attained secondary education and 5.2% were illiterate.

**Table 3** Socio-economic characteristics of the study sample (n = 50)

| Socio-economic variable | | Number | % |
|---|---|---|---|
| Gender | Female | 100 | 39.84 |
| | Male | 151 | 60.16 |
| Age (years) | <20 | 73 | 29.08 |
| | 20-29 | 67 | 26.69 |
| | 30-39 | 32 | 12.75 |
| | 40-49 | 42 | 16.73 |
| | 50-59 | 25 | 9.96 |
| | >60 | 12 | 4.78 |
| Highest level of education | No education | 13 | 5.18 |
| | Primary | 138 | 54.98 |
| | Secondary | 98 | 39.04 |
| | Tertiary | 2 | 0.8 |
| Occupation | Unemployed | 103 | 41.04 |
| | Employed (off-farm) | 42 | 16.73 |
| | Self-employed | 106 | 42.23 |

The home gardens from the 6 different villages were established between 10 and 80 years ago, and their sizes vary between 200 and 42,264 $m^2$ (see Table 4). All of the gardeners owned their cultivated land, the majority of them having inherited it. They all reported that they were born in the area or had lived most of their life there. Although most of the households comprised different vegetation strata, only a few of them reported that they were concerned by aesthetics and the distribution of vegetation.

**Table 4** Characteristics of the surveyed households by villages

| Village name | Number of surveyed households | Household Size | | Home garden size | | Home garden age | |
|---|---|---|---|---|---|---|---|
| | | members | range | $m^2$ | range | years | range |
| Los Planes | 11 | 5.27(±0.61) | 4-6 | 11718.65 (±5001.39) | 7044 - 24654 | 35.27 (±9.46) | 20-50 |
| Ojochal | 11 | 4.81(±1.26) | 2-7 | 16063.63(±10682.33) | 200 - 31698 | 32.27 (±10.93) | 10-52 |
| Playa Blanca | 8 | 5.37(±0.99) | 4-7 | 20691.75 (±9224.26) | 10566 - 38742 | 37.75 (±14.23) | 20-62 |
| Pespire | 8 | 4.37(±1.21) | 3-6 | 23597.4 (±10134.55) | 10566 - 42264 | 47.25 (±15.80) | 30-80 |
| Puerto Sierra | 7 | 5 (±1.30) | 3-7 | 13383 (±4390.91) | 7044 - 17610 | 40.42 (±14.78) | 19-60 |
| Namasigue | 5 | 5.4(±1.01) | 4-7 | 19018.8 (±4226.4) | 14088 - 24654 | 40,8 (±17.05) | 10-60 |

In general, home gardens have been described as natural assets through which families manage to fulfil subsistence needs. However, home gardens surveyed in this study showed a main focus on producing and commercializing their crops, with 40-90% of production of cash crops being intended for sale rather than towards food security.

Farmers of these six different villages acknowledged that the primary function of their home gardens is to generate income, while the secondary function is to provide their households with sufficient food. That is why 52% stated that they rotate their crops. Of this number, 22% rotated their crops every 2 years, 12% every 3 years, and 18% every four years. Thanks to this, they claim that they can prevent soil degradation and maintain productivity in their lands. Four of them also mentioned that they required external inputs such as fertilizers. Garden litter was left to decompose itself on the soil surface. None of the farmers hired labour or machinery.

Regardless of these practices and the degree of biodiversity of their home gardens, farmers acknowledged that they have not been able to ensure stable yields or achieve an efficient use of their land resources due to the prolonged draughts during the dry season, where they reported losses of at least 1/8 of their cultivation to the entire cultivation. Despite this (Bernholt et al., 2009), diversity appears to offer stable yields and make year-round crop availability possible.

While 70% of the respondents reported to have off-farm income, just 4% expressed a desire to switch entirely to an off-farm activity. The most common off-farm occupations held by men were as melon cutters, fisherman, moto taxi drivers, convenience store clerks, and in construction, while women were typically teachers, housekeepers, and cooks. This has resulted in less interest in maintaining a diverse home garden, and more interest in cultivating cash crops, leading to more commercial production units rather than more conservation sites. This, combined with the trend of younger generations getting less involved in agricultural practices, and the correlation between having a higher-level of education and less farming experience, represents a threat to traditional knowledge continuity among generations.

## 5.2 Home garden species composition and ethnobotanical knowledge

A total of 61 plant species from 35 families were cultivated in 50 surveyed gardens, belonging to eight different villages in the south-central departments of Choluteca and Valle. The most frequently cultivated families were Cucurbitaceae with seven species, followed by Fabaceae and Poaceae with four species, and Anacardiaceae and Solanaceae with three species. The most cultivated species were *Zea mays* L. and *Phaseolus vulgaris* L., followed by *Byrsonima crassifolia* (L.) Kunth and *Cymbopogon citratus* (L.) Spreng. During the surveys, *Coriandrum sativum* L., *Cucumis sativus* L., *Daucus carota* L., *Manihot esculenta* Crantz, and *Raphanus sativus* L. were mentioned by less than three home gardeners, while *Zea mays* L. and *Phaseolus vulgaris* L. were mentioned by 92% of those surveyed. These represent a valuable cash crop as well as a main dietary component of household members.

**Table 5** Ethnobotanical data on plant species cultivated in Choluteca and Valle home gardens

| Botanical Name | Family | Vernacular Name | Part Used | Purpose of use | Citations (use report) |
|---|---|---|---|---|---|
| *Aloysia polystachya* Griseb. & Moldenke | Verbenaceae | Burrito | leaf | medicine | 11 |
| *Acacia farnesiana* (L.) Willd. | Fabaceae | Acacia | trunk | firewood | 4 |
| | | | leaf | spice | 4 |
| | | | fruit | fodder | 4 |
| *Allium cepa* L. | Amaryllidaceae | Cebolla | bulb | vegetable | 6 |
| *Aloe* L. | Asfodeláceas | Sábila | leaf | medicine | 13 |
| *Anacardium occidentale* L. | Anacardiaceae | Marañon | fruit | dessert fruit | 5 |
| | | | trunk | construction material, medicine | 5 |
| *Annona muricata* L. | Annonaceae | Guanábana | fruit | dessert fruit | 16 |
| *Annona squamosa* L. | Annonaceae | Anona | fruit | dessert fruit | 15 |
| *Arbutus unedo* L. | Ericaceae | Madroño | fruit | dessert fruit | 5 |
| | | | trunk | medicine | 5 |
| *Aspidosperma megalocarpon* Müll.Arg. | Apocynaceae | Carreto | trunk | construction material | 12 |
| *Azadirachta indica* A.Juss. | Meliaceae | Nim | trunk | medicine | 17 |
| | | | leaf | medicine | 17 |
| | | | Fruit | medicine | 17 |
| *Bactris guineensis* (L.) H.E. Moore | Arecaceae | Coyol | trunk | construction material | 17 |
| | | | fruit | fruit, fermentation | 17 |
| *Beta vulgaris* L. | Amaranthaceae | Remolacha | root | vegetable, medicine | 5 |
| *Brassica oleracea var. capitata* L. | Brassicaceae | Repollo | leaf | vegetable | 14 |
| *Buddleja globosa* HOPE | Scrophulariaceae | Matico | leaf | medicine | 6 |
| *Byrsonima crassifolia* (L.) Kunth | Malpighiaceae | Nance | fruit | dessert fruit | 24 |
| | | | trunk | medicine | 24 |
| *Capsicum annuum* L. | Solanaceae | Chile verde | fruit | vegetable | 18 |
| *Carica papaya* L. | Caricaceae | Papaya | fruit | dessert fruit | 7 |
| | | | seed | medicine, gene source | 7 |
| | | | exudates | medicine | 7 |
| *Catharanthus roseus*(L.) G.Don | Apocynaceae | Guajaca | flower | medicine | 12 |
| | | | whole plant | ornamental | 12 |
| *Ceiba pentandra* L. | Malvaceae | Ceiba | trunk | construction material | 3 |
| | | | seed | environmental uses (fertilizer) | 3 |
| *Chamaemelum nobile* L. | Asteraceae | Manzanilla | flower | medicine, ornamental | 5 |
| *Citrullus lanatus* (Thunb.) Matsum .& Nakai | Cucurbitaceae | Sandia | fruit | dessert fruit | 10 |

| Botanical Name | Family | Vernacular Name | Part Used | Purpose of use | Citations (use report) |
|---|---|---|---|---|---|
| *Citrus aurantifolia* (Christm.) Swingle | Rutaceae | Limón | fruit | dessert fruit | 8 |
| | | | leaf | spice, medicine | 8 |
| *Cocos nucifera*L. | Arecaceae | Coco | trunk | firewood | 14 |
| | | | fruit | dessert fruit | 14 |
| | | | trunk | construction material | 14 |
| | | | leaf | construction material | 14 |
| *Codiaeum variegatum* (L.) Rumph. ex A.Juss. | Euphorbiaceae | Croton | whole plant | ornamental | 4 |
| *Coriandrum sativum* L. | Apiaceae | Cilantro | seed | spice | 2 |
| | | | whole plant | spice | 2 |
| *Cucumis melo* L. | Cucurbitaceae | Melón | fruit | dessert fruit | 14 |
| *Cucumis sativus* L. | Cucurbitaceae | Pepino | fruit | vegetable | 1 |
| *Cucurbita argyrosperma* Hort. | Cucurbitaceae | Ayote | fruit | vegetable | 4 |
| *Cucurbita* L. | Cucurbitaceae | Calabaza | seed | fruit | 6 |
| | | | fruit | vegetable | 6 |
| *Cucurbita moschata* Duchesne Ex Lam. | Cucurbitaceae | Zapallo | seed | fruit | 4 |
| | | | fruit | vegetable | 4 |
| | | | immature fruit | vegetable | 4 |
| *Cucurbita pepo* L. | Cucurbitaceae | Pipian | fruit | vegetable | 5 |
| *Cupressus lusitanica*Mill | Cupressaceae | Cedro | trunk | construction material | 11 |
| *Crescentia cujete* L. | Bignoniaceae | Jicaro | fruit | construction material | 3 |
| | | | seed | oil, sugar, fuel | 3 |
| *Cymbopogon citratus* Stapf | Poaceae | Zacate de limón | leaf | medicine, spice | 22 |
| *Daucus carota* L. | Apiaceae | Zanahoria | root | vegetable | 1 |
| *Echeveria elegans* A. Berger | Crassulaceae | Suculenta | whole plant | ornamental | 3 |

| Botanical Name | Family | Vernacular Name | Part Used | Purpose of use | Citations (use report) |
|---|---|---|---|---|---|
| *Enterolobium cyclocarpum* (Jacq.) Griseb. | Fabaceae | Guanacaste | trunk | construction material, firewood | 6 |
| | | | fruit | medicine | 6 |
| | | | seed | fuel | 6 |
| | | | root | medicine | 6 |
| | | | exudates | construction material (adhesive) | 6 |
| *Ficus carica* L. | Moraceae | Higo | fruit | dessert fruit | 5 |
| *Ficus insipida* WILLD | Moraceae | Ficus | trunk | construction material | 5 |
| *Gossypium hirsutum* L. | Malvaceae | Algodón | fiber | construction material | 4 |
| *Ipomoea batatas* (L.) Lam. | Convolvulaceae | Camote | tuber | tuber | 4 |
| | | | leaf | medicine | 4 |
| *Laurus nobilis*L. | Lauraceae | Laurel | trunk | construction material | 13 |
| | | | leaf | spice, medicine | 13 |
| *Mangifera indica* L. | Anacardiaceae | Mango | fruit | dessert fruit | 7 |
| | | | leaf | firewood | 7 |
| | | | trunk | firewood | 7 |
| | | | seed | gene source | 7 |
| *Manihot esculenta* Crantz | Euphorbiaceae | Yuca | tuber | starch, tuber | 2 |
| | | | stem | firewood, environmental uses (fertilizer) | 2 |
| | | | seed | gene source | 2 |
| *Moringa oleifera* Lam | Moringaceae | Moringa | flower | fruit | 6 |
| | | | leaf | environmental uses (fertilizer, fungicide) | 6 |
| | | | trunk | firewood | 6 |
| *Musa balbisiana* | Musaceae | Plátano | fruit | fruit | 6 |
| *Parthenium hysterophorus*L. | Asteraceae | Escoba amarga | leaf | medicine | 3 |
| *Pennisetum purpureum x Pennisetum thyphoides* | Pennisetum sp | Alosin | whole plant | fodder | 2 |

| Botanical Name | Family | Vernacular Name | Part Used | Purpose of use | Citations (use report) |
|---|---|---|---|---|---|
| *Phaseolus vulgaris*L. | Fabaceae | Frijol | seed | pulse | 46 |
| | | | string | legume | 46 |
| *Poincianella eriostachys* (Benth.) Britton & Rose | Fabaceae Lindl. | Pintadillo | seed | gene source | 5 |
| *Pouteria sapota* (Jacq.) H.E.Moore & Stearn | Sapotaceae | Mamey | trunk | construction Material | 8 |
| | | | fruit | dessert fruit | 8 |
| *Raphanus sativus L.* | Brassicaceae | Rábano | root | vegetable | 1 |
| *Saccharum officinarum L.* | Poaceae | Caña de azúcar | stem | gene source, fruit | 3 |
| *Solanum lycopersicum* L. | Solanaceae | Tomate | fruit | vegetable | 10 |
| *Solanum tuberosum* L. | Solanaceae | Papa | tuber | tuber | 11 |
| *Sorghum spp* | Poaceae | Maicillo | seed | cereal | 16 |
| *Spondias purpurea* L. | Anacardiaceae | Jocote | fruit | dessert fruit | 4 |
| | | | trunk | medicine | 4 |
| | | | root | medicine | 4 |
| *Stenocereusaragonii* (F.A.C.Weber) Buxb. | Cactaceae | Cardón | whole plant | ornamental | 5 |
| *Swietenia macrophylla* KING | Meliaceae | Caoba | trunk | construction material | 4 |
| *Terminalia catappa* L. | Combretaceae | Almendro | leaf | medicine | 15 |
| | | | fruit | fruit | |
| | | | seed | fruit | |
| *Zea mays* L. | Poaceae | Maíz | seed | cereal | 47 |

Farmers identified the main purposes of these plants to be food, medicine, construction materials, firewood and fuel, spices, gene sources, ornamentals, environmental uses, and fodder, from which four major uses of domestic garden plants were food (38%), medicine (21%), construction materials (13%), and firewood and fuel (8%) (Fig. 5). From the edible plants, the most represented were fruits (*Byrsonima crassifolia* (L.) Kunth, *Annona muricata* L., *Cucumis melo*, *Annona squamosa* L., and *Cocos nucifera* L. were the most frequently mentioned) at 19.64%, vegetables (*Capsicum annuum* and *Solanum lycopersicum* L.) at 12.50%, and edible tubers (*Solanum tuberosum* L.) at 2.68%.

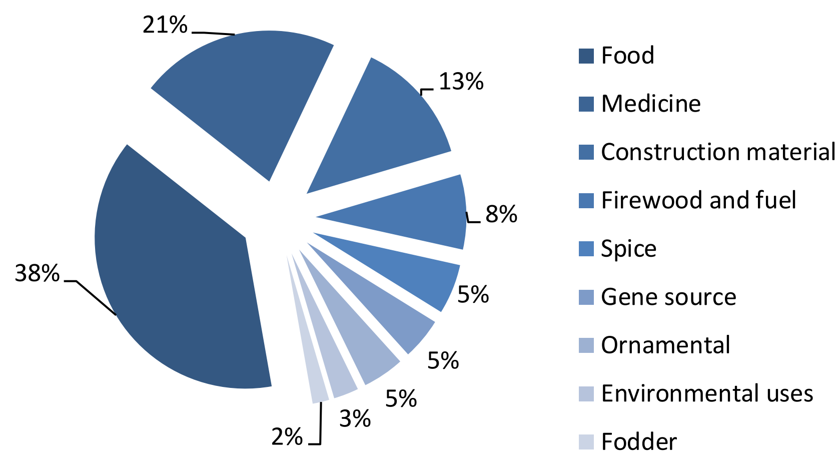



**Fig. 5** Purpose of Use

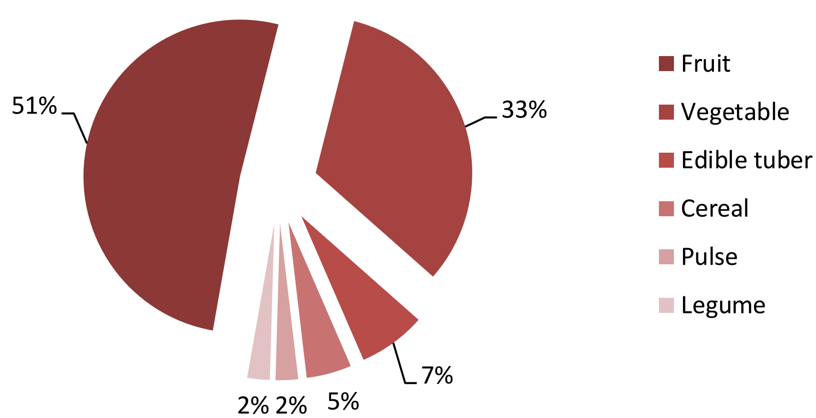



**Fig. 6** Edibles

From the plant species that were used solely for their medicinal properties, the most represented were *Aloe* L. *Buddleja globosa* HOPE, *Chamaemelum nobile*, and *Parthenium hysterophorus* L., although *Cymbopogon citratus* has an important use as a spice in Asian countries like Vietnam (Vlkova et al., 2011). However, in these areas of Honduras, even though farmers recognize its culinary use, they claim that the main purpose of its cultivation was for the preparation of infusions which have medicinal benefits.

The most frequently found species whose trunks were used for construction materials according to farmers were *Aspidosperma megalocarpon* Müll.Arg., *Cupressus lusitanica* MILL, *Ficus insipida* WILLD, *Poincianella eriostachys* (Benth.) *Britton & Rose, Swietenia macrophylla* KING, and *Ceiba pentandra* L. The high value of these species as timber was acknowledged by 4 farmers, who expressed a desire to invest more of their land resources into their cultivation. Leaves from *Cocos nucifera* L. were commonly used for housing. The fruit of *Crescentia cujete* L., which is native to Central and South America, has a lightweight and durable shell that is commonly used to make vessels for serving or drinking.

From the trees whose trunks were used for firewood, the highest mentioned species were *Acacia farnesiana* (L.) Willd. and *Enterolobium cyclocarpum* (Jacq.) Griseb. (whose seeds are used for fuel), and other multi-purpose species like *Mangifera indica* L. (from which both leaves and trunks are utilized), *Citrus aurantifolia*, and *Moringa oleifera* Lam.

Species used as spices included the leaves of *Laurus nobilis* L., and as a whole plant, *Coriandrum sativum* L. Seeds of *Carica papaya* L., *Mangifera indica* L., *Manihot esculenta* Crantz, and *Poincianella eriostachys* (Benth.) Britton & Rose were used as gene sources, while the stem of *Saccharum officinarum* L. was used for re-cultivation.

In total, five plant species were identified as ornamentals, of which 3 were ornamental (*Codiaeum variegatum* (L.) Rumph. ex A. Juss., *Echeveria elegans* A.Berger, and *Stenocereusaragonii* (F.A.C.Weber) Buxb), and one was identified as both ornamental and medicinal (*Chamaemelum nobile*). *Catharanthus roseus* (L.) G.Don was recognized for its medicinal purposes by farmers; locals, however, neglected this use.

Seeds of *Ceiba pentandra* L. were used as fertilizer as well as the stems of *Manihot esculenta* Crantz. The leaves of *Moringa oleifera* Lam were used both as fertilizer and fungicide.

Since the gardeners did not have any livestock, they had no interested in cultivating species for use as fodder, although they could recognize *Pennisetum purpureum x Pennisetum thyphoides*, which was not intentionally cultivated, and *Acacia farnesiana* (L.) Willd, which was used for other purposes.

## 5.3 Plant species diversity in home gardens

From the total number of species identified in all the surveyed home gardens, Pespire had the highest with 50 species observed, and a mean of 13.25, followed by Puerto Sierra, with a total of 44 species observed and a mean of 12 species per home garden. Subsequently, in Playa Blanca, a total of 42 species were observed and the mean number of species was 11.50 (table). The richest home garden contained 21 species, whereas the poorest gardens just held 2 species.

**Table 6** Plant species diversity in home gardens within studied villages

| Observed Characteristics | Los Planes (n = 11) | Ojochal (n = 11) | Playa Blanca (n = 8) | Pespire (n = 8) | Puerto Sierra (n= 7) | Namasigue (n= 5) |
|---|---|---|---|---|---|---|
| Total no. of observed species | 39 | 35 | 42 | 50 | 44 | 36 |
| Mean no. of species/HGD | 10.64 | 9.55 | 11.5 | 13.25 | 12 | 12.2 |
| Mean Margalef index/HGD | 0.85 | 0.74 | 0.89 | 1.04 | 0.95 | 0.95 |
| Mean Shannon- Wiener index/HGD | 1.36 | 1.39 | 1.42 | 1.59 | 1.61 | 1.66 |

The mean Margalef index reflecting the species richness of the surveyed gardens ranged from 0.74 represented by El Ojochal, where 11 home gardens were surveyed, to 1.04 in Pespire, where data from 8 home gardens was collected (see Table 6)

Shannon index has been calculated in many home garden units around the world, mainly in tropical regions, representing both evenness and abundance of species, with wide variations.

Though knowledge about studies estimating Shannon index in Honduras is limited, in this study, comprising the south-central region of Honduras, specifically in the departments of Choluteca and Valle, mean diversity was calculated, varying from the lowest of 1.36 in the village of Los Planes to the highest of 1.66 found in the village of Namasigue.

## 5.4 Agrobiodiversity patterns

The home gardens were classified into five different size ranges from 200 to 7,044 $m^2$, 7,045 to 14,100 $m^2$, 14,110 to 21,000 $m^2$, 21,100 to 28,100 $m^2$, and 28,110 to 42,264 $m^2$. This classification defers from the common use classification of home gardens which range from less or equal than 2,600 $m^2$ to equal or more than 7,900 $m^2$. This could be due to the cheap cost of land in this region, making the land easy to acquire compared to other regions in Honduras and worldwide. In addition, farmers also perceived home gardens in a greater perspective – as a piece of land surrounding their family houses, very diversified in use and with no clear ownership.

According to this classification, home gardens whose sizes ranged from 200 to 7,044 $m^2$ held a mean number of 9 species per garden, 7,045 to 14,100 $m^2$ was 11, 14,110 to 21,000 $m^2$ was 12.17, 21,100 to 28,100 $m^2$ was 11.67, and 28,110 to 42,264 $m^2$ was 15. Although home garden size can seem to slightly influence the amount of species observed, results for Margalef index and Shannon index fluctuated wildly, thus preventing any pattern of species richness and diversity from being established.

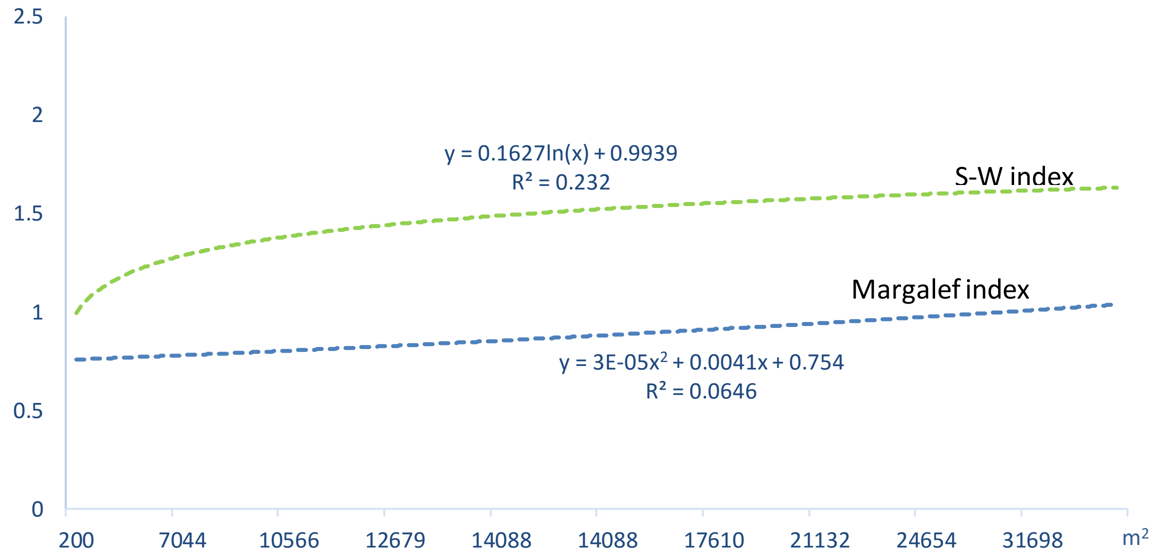



**Fig. 7** Home garden size

Another factor that has been noted to influence the diversity of home gardens is garden age (Coomes and Ban, 2004; Aguilar-Støen et al., 2008). According to the results obtained by this study, the amount of the species observed increased with the age of the garden, as well as the Margalef index for species richness, which followed a constant trend, rising as garden age increased. On the other hand, although Shannon index fluctuated as garden age increased, overall, results can reflect a pattern of Shannon index increasing with garden age. The diversity of home gardens is also strongly influenced by the age of the garden.

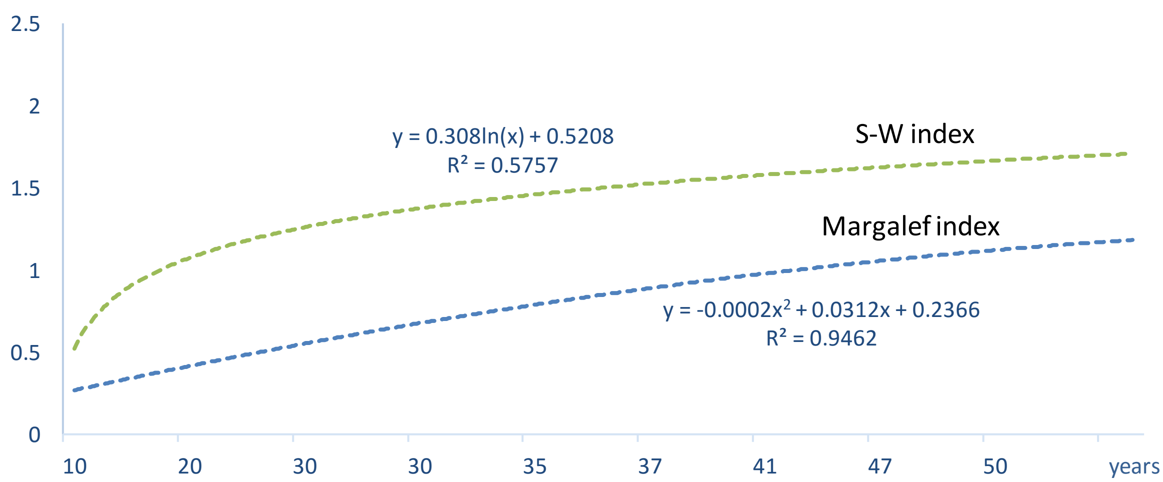



**Fig. 8** Home garden age

Contrary to what other studies have indicated, generating a greater income resulted in a decrease in Margalef index and Shannon index. This could be explained by a lack of interest in diversifying plots with crops that are not cash crops, as farmers have the possibility to rely on external products acquired from other farmers or local markets to fulfil dietary needs.

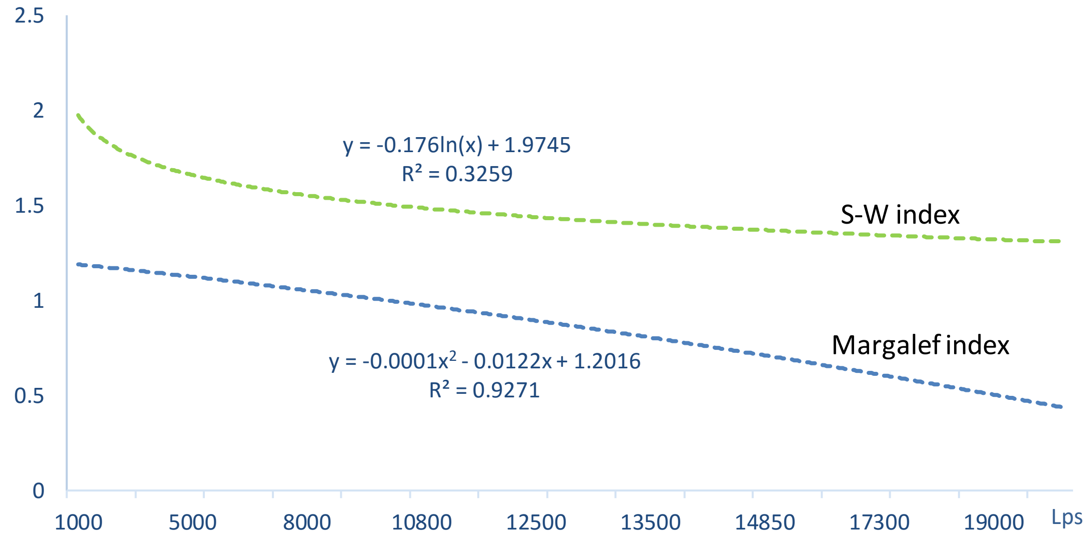



**Fig. 9** Household total cash income

### 5.5 Role of demography and socio-economic characteristics in species richness: Margalef index

The dependency between species richness and chosen indicators is shown in Table 7. We can see that there are four significant indicators: household size (p = 0.050), female household members (p = 0.056), home garden age (p = 0.001), and total cash income (p = 0.002). Positive correlation was found in farmer's age, farmer's gender, female household members, dependent members, home garden size, home garden age, and total cash income. Household size correlated negatively. Socio-economic characteristics explain more than 90% of agrobiodiversity variability ($R^2$= 0.972).

**Table 7** Linear regression results: Margalef index vs socio-economic characteristics

| Independent variable | Coefficients | t Stat | P-value |
|---|---|---|---|
| Intercept | 0.488 | 2.622 | 0.012 |
| Farmer's age | 0.001 | 0.888 | 0.380 |
| Farmer's gender | 0.101 | 1.528 | 0.134 |
| Household size | -0.001 | -2.013 | 0.051* |
| Female household members | 0.024 | 1.964 | 0.056* |
| Dependent members | 0.008 | 0.951 | 0.347 |
| HGD size | 0.000 | -0.229 | 0.820 |
| HGD age | 0.014 | 7.068 | 0.001* |
| Total Cash | 0.000 | -4.080 | 0.002* |

## 5.5 Role of demography and socio-economic characteristics in species diversity: Shannon-Wiener index

Table 8 shows the results of linear regression, which identified female household members (p=0.033) and total cash income (p=0.041) as the only significant variables that would influence agrobiodiversity of surveyed home gardens. Furthermore, there were variables positively influencing agrobiodiversity, e.g. farmer's age, dependent members, home garden size and total cash income, while the rest of them, farmer's gender, household size, female household members, and home garden age, were influencing agrobiodiversity negatively.

**Table 8** Linear regression results: Shannon-Wiener index vs socio-economic characteristics

| Independent variable | Coefficients | t Stat | P-value |
|---|---|---|---|
| Intercept | 1.932 | 2.962 | 0.005 |
| Farmer's age | 0.007 | 1.840 | 0.073* |
| Farmer's gender | -0.047 | -0.204 | 0.839 |
| Household size | -0.001 | -0.398 | 0.692 |
| Female household members | -0.093 | -2.211 | 0.033* |
| Dependent members | 0.009 | 0.283 | 0.779 |
| HGD size | 0.000 | 1.542 | 0.131 |
| HGD age | -0.002 | -0.322 | 0.749 |
| Total cash income | 0.000 | -2.112 | 0.041* |

The coefficient of determination ($R^2$= 0.596) showed, how the variation of values of the dependent variable are explained by the values of independent variables. In other words, more than half of the values fit the model.

## 5.6 Farmers expectations

The majority of farmers expected to buy additional land to cultivate more. They also showed interest in cultivating more medicinal plants, fruit plants and other edibles, and commercial woods to increase sales. 20% of them were looking into alternatives to cultivate more resistant seeds that would adapt better to the long drought, while 18% were willing to diversify their gardens in order to be able to depend more on their produce. 15 % were willing to at least keep their harvest and were expecting to lose less due to climate conditions, and 10% were willing to cultivate less and look for other income-generating options in order to switch from agricultural practices.

## 5.7 Commercialization vs Agrobiodiversity

Historically, cultivation of plants was primarily intended for domestic consumption. However, with increasing production surpluses, produce could be sold in local markets (Kala, 2010). In the studied home gardens in Choluteca and Valle, apart from the concern of food security, farmers are focused on cash generation by selling commodities produced in their home gardens. For them, this represents a crucial aspect of their farming system.

Income according to the interviewed farmers was gained from crops that are grown specifically for sale. These cash crops were mainly represented by beans (*Phaseolus vulgaris* L.), maize (*Zea mays* L.), nance (*Byrsonima crassifolia* L.) Kunth), lemon grass (*Cymbopogon citratus* L.), and Annona (*Annona muricata* L.). In addition, planting commercial woods such as big leaf mahogany (*Swietenia macrophylla* KING) and white cedar (*Cupressus lusitanica* MILL) was part of the new market strategies the majority of farmers wanted to implement.

Cash coming from selling these crops significantly enhanced the economic situation of the family by maintaining their household and fighting poverty. Most farmers commercialize their produce through wholesalers that transport the goods to the main markets of the region, including the capital city, Tegucigalpa. Around 30% of farmers sell their products in local markets and 16% sell them in the main port where they also have the opportunity to sell them to traders. Just a small amount (8%) sell the products to small distributors and retailers in the town.

As expected, wholesalers that commercialize the product were the main point of contact for high market-oriented home gardens. Better market access leads to decrease of biodiversity (Kehlenbeck et al., 2007) and may be caused by pushing gardeners to more commercial productions. By comparing the prices for which the farmers sell their products and the prices by which they are sold in the main farmers' market of Tegucigalpa, a 50-70% increase on the original price was evaluated. However, to evaluate the opportunities of farmers to shorten the supply chain, a marketing and transaction cost needs to be estimated.

# 6 Discussion

The findings of this thesis show that in comparison to other tropical countries, higher numbers of plant species were found in locations such as Masaya, Nicaragua, where 324 species were identified, and gardens had an average of 70 plants per garden (Méndez et al., 2001); Southern Mexico (Aguilar-Støen et al., 2008), in which 233 plant species were recorded; Eastern Cuba, where gardens had a total of 101 different plant species; and Peruvian Amazon, where compared to other cultivated fields, home gardens held the highest plant diversity with a total of 82 species and a mean of 16.3 plants per garden. In peri-urban gardens in central Sudan, where a declining trend in the presence of trees and shrubs was observed, and the focus on commercial production was increased, it was possible to identify 84 plant species. In south-western Niger, where high market demand has pushed traditional home gardens towards commercialization, 160 plant species were found.

Home garden age was found to be strongly connected to home garden diversity, as in the case of home gardens located in the Peruvian Amazon, where older gardens were found to be more diverse. This is supported by other authors (Coomes and Ban, 2004), who explain that with time, more plant species are added to the home gardens, making the gardens more diverse. In this particular study, as home gardens were found to have been inherited in approximately 90% of cases, food trends and needs changing over time might have contributed to the increase in the amount of plant species. This runs contrary to studies in south Mexico, where young gardens were more diverse than older ones, or in central Vietnam, where no correlation between age and diversity was recognized.

A positive correlation between species richness and garden size was found in several studies (Bernholt et al., 2009; Vlkova et al., 2011) where results showed that the size of the garden affects species richness, where larger gardens had a higher number of perennial and local plant species. The results of this study did not show any significant pattern in regards to garden size. This is consistent with different studies (Coomes and Ban, 2004) that state that size is not a limiting factor. As in Peruvian Amazon, land was readily available; due to the low quality of the soil, the value of the land was lower than in other parts of the country, thus making it easier to acquire.

As in Nicaragua, the amount of labour devoted to farming activities was related to family size, as well as to the gender of family members. Children did not regularly participate in home garden activities, nor did women, who were reported to have less farming experience, although were found on average to have a higher level of education than men. Most of the surveyed farmers did not invest in higher labour; it was the most knowledgeable and experienced members of the household who maintained the home gardens.

Regarding home gardens that are owned by women, no comparison can be made on agrobiodiversity indexes, since only one home garden was completely managed by women, and in the majority of families, women were generating income through off-farm activities. However, as showed in different studies (Eyzaguirre and Linares, 2004; Bernholt et al., 2009) women have a direct influence on plant species richness and diversity. In our study, women were concerned about cultivating local species for subsistence and conserving agrobiodiversity in the home gardens. They possessed ethnobotanical knowledge, particularly in regards to the medicinal uses of multi-purpose plant species. They also focused on the aesthetics and distribution of ornamentals and spices.

Migration is another factor that has been changing the agricultural sector. 20% of families reported that at least one family member had left the household and found a different livelihood strategy outside of agriculture. Although they still contributed to the household income, this differs from migration in the case of Mexico, where farmers and household members' mobility helped to introduce new plant species into their gardens.

As pointed out by Bernholt et al. (2009) and Vlkova et al. (2011), farmers commonly struggle with lack of water resources for crop irrigation, a problem which has only gotten worse in recent years due to prolonged droughts in these particular regions of Honduras, where farmers have reported significant loss of their cultivation. In order to better cope with these difficulties, they try to improve their irrigation systems by using drip irrigation. 92% of the families acknowledged that the lack of natural resources such as water supplies, soil quality, and climate conditions represented the main challenge of managing a home garden.

Agrobiodiversity degradation is linked to a strong orientation on cash crop production. This strong orientation on only a few crops is destroying the variety of plants in the home gardens studied. As documented by Barbier (1989) and Maxwell and Fernando (1989), a resulting problem is that the dependency on a narrow range of crops could be dangerous in case of a pest attack or decrease in market price.

Today's trend is focusing only on a few key staples "cash-crops." 75% of the world's food is generated from only 12 plants and 5 animal species (FAO, 1999). This heavy reliance on a narrow diversity of food crops puts future food and nutrition security at risk. Globalization of the food system and marketing is related to loss of agrobiodiversity. The replacement of local varieties by improved or exotic varieties and species causes genetic erosion, population pressure and urbanization, deforestation, and over-harvesting of non-timber forest products (Long, 2003; FAO, 2004; Kahane et al. 2013). The prevention of a further decrease in agrobiodiversity should be receiving special attention.

## 6.1 Recommendations

Regarding the strengthening role of home gardens in on-farm conservation of plant genetic resources and associated traditional ethno-botanical knowledge.

We can suggest:

When aiding farmers after long droughts with governmental programs such as "Programa Municipal para el Cultivo" and "Preparando Mi Parcela", it should be taken in consideration all the different plant species the home gardens hold, without neglecting non-cash crops species, since they also represent important resources with its specific purpose of use.

# 7 Conclusion

Home garden age was strongly connected to home garden diversity; older gardens were found to be more diverse, as farmers added more plant species to the home gardens with time. On the other hand, there was a slight trend in increasing agrobiodiversity with home garden size, but no significant pattern can be established.

Generating a greater income resulted in a decrease in agrobiodiversity. Farmers lacked interest in diversifying plots with crops that were not cash crops, as they had the possibility to rely on external products acquired from other farmers or local markets to fulfil dietary needs.

The diversity in the surveyed home gardens was lower than those yielded by other studies of home gardens in the tropics. However, it must be noted that the study was carried out in a limited number of home gardens which may have influenced the amount of identified plant species in the area.

Although both species diversity and richness were found to be relatively low, the surveyed home gardens were important reservoirs of local food plant species which complemented family diet, contributed to socioeconomic status of the households, and had an important role in the *in situ* conservation of useful plants (i.e. jicaro).

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