CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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Bachelor Thesis

# How socioeconomy, demography and farming history influence agrobiodiversity of homegardens in subsistence farming system in central Vietnam?

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## Declaration

I hereby declare that this thesis entitled "How socioeconomy, demography and farming history influence agrobiodiversity of homegardens in subsistence farming system in central Vietnam?" is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague, 15 April 2016

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Martina Snášelová

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## Abstract

Agrobiodiversity represents an essential part of the sustainability of homegardens, which are traditional farming systems with an important role in the maintaining the sustainability of household economy in tropical areas. Household, as a basic economic unit of farming systems, consists of natural, human and capital resources. Those resources together with external environment shape the diversitification of farm and household actitivies, goals or ability to face any challenges and/or threats. The thesis attempts to identify crucial demographic and socio-economic factors influencing agrobiodiversity of homegardens in subsistence farming systems in central Vietnam. The survey was based on data collected in the period of 2008-2012 in three villages of Phong My Commune, situated in the buffer-zone of Natural Reserve in central Vietnam. Data were collected in two phases. First phase documented agrobiodiversity of 101 homegardens and demographic data of their owners. Second part gathered further information on demography as well as social and economic background of 147 households. Total number of 36 households was suitable for our analysis. Three biodiversity indices, Shannon-Wiener, Margalef and Simpson's, were calculated. Linear regression models identified household size and dependent members as variables having potential significance that influence agrobiodiversity. According to correlation analysis, increasing cash income and homegarden size tend to decrease the species diversity and richness. On the other hand farmer's age and number of female household members correlated positively. Based on the results achieved, we cannot conclude that agrobiodiversity of homegardens in central Vietnam is significantly influenced by the socio-economic and demographic indicators. This could be caused for example by the strong cultural background of Vietnamese homegardens or by the specific situation of Vietamese centrally planned and rapidly growing economy. Nevertheless, for better understanding of that issue, more analysis using more convenient data and indices as well as considering also macroeconomic environment should be considered.

**Key words:** homegardens, agrobiodiversity, household economy, sustainability, demography, Vietnam

## Abstrakt

Agrobiodiverzita je základním prvkem udržitelnosti domácích zahrad, které představují tradiční farmářský systém s významnou rolí v zabezpečení udržitelnosti ekonomiky domácností v tropických oblastech. Domácnost, jako základní ekonomická jednotka farmářského systému, se skládá z přírodních, lidských a kapitálových zdrojů. Tyto zdroje, společně s okolním prostředím, ovlivňují diverzifikaci aktivit spojených s farmou a domácností a dále diverzifikaci cílů a schopnosti čelit výzvám a/nebo hrozbám. Tato studie se pokouší identifikovat klíčové demografické a socio-ekonomické faktory ovlivňující agrobiodiverzitu domácích zahrad v samozásobitelských farmářských systémech v centrálním Vietnamu. Výzkum je založen na datech posbíraných v letech 2008 až 2012 ve třech vesnicích Phong My komunity, která se nachází v nárazníkové zóně přírodní rezervace v centrálním Vietnamu. Data byla sbírána ve dvou fázích. První fáze dokumentovala agrobiodiverzitu a demografická data ve 101 zahradách. Druhá část sbírala další informace o demografii a také sociálním a ekonomickém pozadí ve 148 domácnostech. 36 domácností bylo vhodných pro naši analýzu. Byly spočítány tři indexy biodiverzity, Shannon-wiener, Margalef a Simpson's. Modely lineární regrese indentifikovaly, že potenciál statisticky významně ovlivňovat agrobiodiverzitu má počet členů domácnosti a počet závislých členů. Na základě korelační analýzy bylo zjištěno, že zvyšující se příjem a velikost zahrady má tendenci snižovat druhovou rozmanitost a bohatost. Naopak farmářův věk a počet žen v domácnosti vykazovaly pozitivní korelaci. Na základě námi dosažených výsledků nemůžeme konstatovat, že by agrobiodiverzita domácích zahrad v centrálním Vietnamu byla významně ovlivněna socio-ekonomickými a demografickými indikátory. To může být způsobeno například silnou vazbou obyvatel na jejich kulturu a tradice a také specifitou vietnamské centrálně plánované a rychle rostoucí ekonomiky. Pro lepší porozumnění problému by bylo vhodné zvážit provedení dalších analýz, které by používaly vhodnější data a indexy a braly by v úvahu i makroekonomii prostředí.



**Klíčová slova:** domácí zahrady, agrobiodiverzita, ekonomika domácností, udržitelnost, demografie, Vietnam

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# 1 Introduction

Homegardens represent a unique phenomenon among farming systems worldwide, and they play significant role in food and cash security of household especially in tropical regions (Kumar and Nair, 2006). Homegardens traditionally represent a subsistence oriented farming systems. We already mentioned their role in food supply and thus household economy, but they also provide many ecosystem services and help to conserve cultural tradition (Landon-Lane, 2004). Providing all of these benefits, they are simultaneously considered sustainable. Compared to other land-use systems, they have higher level of agrobiodiversity (Galluzzi et al., 2010). The bigger agrobiodiversity provide numerous services and can help make agricultural ecosystems more resilient and productive and can contribute to better nutrition, productivity and livelihoods (Biodiversity international, 2016). At the moment, with the increasing population, biodiversity confronts many pressures and problems and is experiencing extraordinary decline. Agrobiodiversity is influenced by multiple factors and one set of the most relevant is socio-economic characteristics (Abdoellah et al., 2006; Peyre et al., 2006). For understanding the agrobiodiversity and the homegardens globally it is necessary to understand relationships between agrobiodiversity and factors that are influencing it.

# 2 Literature review

## 2.1 Introduction to homegardens

Homegardens, also known as backyard gardens, kitchen gardens, dooryard gardens or household gardens represent traditional and very diverse land-use systems with multiple physical, social and economic functions and roles (Fernandes & Nair, 1986; Kumar & Nair, 2004; Huai and Hamilton, 2009). They vary all over the world according to location, type, particular utilization and the socio-economic and cultural characteristics of their owner (Kabir and Webb, 2009). However they have several similar attributes. Homegarden can be described as a mixture of deliberately planted multipurpose trees, shrubs and annual and perennial agricultural crops, such as fruit, vegetable, plantation crops, herbs, ornamental and medicinal plants, and include also livestock and other domestic animals such as bees and fish and all of that is surrounded by some kind of boundaries (Fernandes & Nair, 1986; Kumar & Nair, 2004; Kabir & Webb, 2009).

**Figure 1** Example of typical homegarden in central Vietnam

Source: Verner et al. (2009)

The characteristic feature of homegarden is its multi-layered vegetation structure. Homegardens are typically in a close distance to the homestead for security, convenience and special care reasons (Kumar and Nair, 2004; Huai and Hamilton, 2009; Kabir and

Webb 2009), or they are located within a certain distance from homestead, where it is not possible to have it close to the house, as in the case of tree gardens or urban gardens. If they receive the same level of constant attention from the owner's household and have similar structural and functional properties as other homegardens located near homes, they could be also classified as homegardens (Drescher et al, 2006). Homegardens have been hypothesized as being the oldest form of agriculture in Southeast Asia and their origin is dated 13,000 to 9,000 B.C. (Wiersum, 2006). Homegardens are not static because they have evolved over centuries as people changed from an exclusively hunting and gathering lifestyle and settled in small farming communities and they have always played a central role in household security (Kumar & Nair, 2004).

## 2.2 Main roles of homegardens in rural livelihood

### 2.2.1 Food security

Since the history of homegardening is very long, people learned very well how to use it, particualary to ensure their own subsistence requirements. Food production could be thus considered as a basic function of tropical homegardens, which have general role in ensuring the food security through direct access to a diversity of nutritionally rich food. Big diversity of products helps cover the dietary needs of all members of the household. Because of wide range of crop species, with different production cycles and rhythms, homegarden can ensure the food availability throughout the year (Christanty et al., 1986; Karyono, 1990; Ellis, 1998). Besides protein and carbohydrate, homegardens provide the range of essential vitamins, minerals and oils. Carbohydrate starches derive from root vegetables like potato, sweet potato, taro, banana, cassava and yam, carbohydrate sugars derive from many kinds of fruits, protein and oils come from beans, seeds and nuts, and vitamins and minerals from fruit and vegetables (Landon-Lane, 2004). Beside the food production people also use many other important non-food products coming from homegardens such as medicinal herbs, spices, fuel, wood, construction materials, fiber, fodder and pharmaceuticals (Landon-Lane, 2004).

### 2.2.2 Cash security

Besides food security, cash generation in form of extra income generated by selling

commodities produced in homegardens represents another important role of this specific farming system. Historically, cultivation of plants was primary intended for the domestic consumption, however with increasing production surpluses could be sold on local markets (Kala, 2010). Income is also gained from crops that are grown specifically for sale. These comodities are called cash crops. Extra cash coming from selling crop like tea, coffee, cocoa and others can significantly enhance the economic situation of the family and it helps to fight the poverty. However, there are few problems linked with strong orientation on these cash crops production. One of the most relevant one, is agrobiodiversity degradation. Strong orientation on only few crops destroys the variety of plants in homegarden. Next problem is that the dependency on narrow range of crops could be dangerous in case of pest attack or decrease of market price (Barbier, 1989; Maxwell and Fernando, 1989). Another income could be generated through adding value to garden products. For example, in the mountain areas of Nepal, where there are only walking tracks to reach markets, people add value to garden vegetables by drying, grinding and packaging them as soup and curry mix. The high value related to weight and durability of the products means they can be carried to market. (Landon-Lane, 2004)

### 2.2.3 Environmental services

Homegardens are not only used by people but they can also serve the surrounding environment through providing shelter for wild animals, preventing soil erosion, support polliantion, ensure good nutrient cycling and efficient use of light, water and other resources. They are great areas for *in situ* conservation. We can find there rare and endangered species, cultivars and landraces and many local crop varieties. Compared to other agroecosystems, they have bigger species and genetic diversity (Kehlenbeck and Maass, 2006;Guillazz, 2010). They are also a key site for domestication of wild plants and for testing new crops, their varieties and farming techniques (Huai and Hamilton, 2009). Additionally, healthy, comfortable and beautiful environment in homegardens could be good place for rest or meetings and children's play. Gardens, and the people who work in them, help local agriculture to develop and diversify by exchanging knowledge of practices and technologies, trading seeds and animal breeds, and also by sharing knowledge and collaboration in marketing. They improve education and skills development and strengthen communities (Landon-Lane, 2004). As it was said above, homegarden are usually nearby the house so it is an ideal place for drying, processing and storing farm products. A

productive homegarden can also contribute to safe recycling and management of household wastes through composting or as animal feed, by utilizing waste water and by providing a place for a latrine (FAO, 1995; Landon-Lane, 2004).

### 2.3 Economy and management

Homegardens are characterized by low capital input, such as labour, cash and other resources alongside with providing high level of production (Huai and Hamilton, 2009). Production equals respiration and inputs balance the outputs, therefore they represent the 'steady-state' system and that is one of the reasons why they are considered sustainable (Kumar and Nair, 2004). Homegardens have a huge potential to meet economic, social, environmental, and institutional conditions for sustainable livelihoods and that is why they could perfectly contribute to sustainable agricultural production (Nair, 2006). Homegardens are managed particulary by household members. In the management of homegardens all household members including children and elders are involved. Specific role in homegarden management is given to women, who play the key role in the utilization of agricultural and forest resources and who´s role is usually more important compared to men (Akhter and Alamgir, 2010). Work in a homegarden is integrated into the daily maintaining of household that traditionally falls on women shoulders (Landon-Lane, 2004). Centuries of practical experience have given women a unique decision-making role and knowledge about local crop and farm animal management, ecosystems and their use. They are responsible for the selection of seeds, management of small livestock and for the conservation and sustainable use of plant and animal diversity (FAO, 1999). Women are usually responsible for a large part of food production, which is linked to food security. There is strong connection between women and subsistence production and production of medicinals, spices, condiments and ornamentals (Howard, 2006). Food and subsistence-oriented plants such as roots, tubers and vegetables fall also more into domain of woman (Trinh et al., 2003). According to study from Bangladesh, light works like watering, fertilizing, weeding and fencing (in 65%, 52%, 56% and 53% of cases respectively) were mainly done by women. Women dedicate most of their time to the pre-harvesting activities, however harvesting is also carried out mostly by women. The average time they spend in the homegarden is 6-8 hour/week. On the other hand, men spend 4-5 hours/week working in Bangladesh homegarden (Akhter and Alamgir, 2010). Special labour division of work also involves works related to livestock. Among non-Mayan Mesoamerican

populations, men are typically responsible for field crop and cattle production and women for homegardening and small livestock (usually pigs and chickens) (Howard, 2006). On the other hand, it was found that labor-intensive and hard work tasks like digging holes, pruning and planting species (in 55%, 53% and 52% of cases respectively) were done by men (Akhter and Alamgir, 2010) Also timber extraction, land clearing, tree pruning and thinning, construction of structures and fences and chopping undesirable growth of specific species or crops are the domain of men (Benjamin, 2000; Patterson, 2000).

## 2.4 Role of homegardens in farming systems sustainability

As the world population increase constantly, the sustainable and environmental friendly systems are more and more important. Torquebiau (1992) says that sustainable agricultural system should fulfill several main requirements related to resources base, system´s functionality and the impact on other systems (soil conservation, the efficient use and conservation of natural resources, the use of biological interactions between elements of the agricultural system, the use of inputs that are easily available and of inputs and practices that ensure both human health and environmental conservation, meet the farmers' energy needs and also needs for subsistence, strengthen cooperation between local community members and ensure that social equity, cultural integrity, ethnic and gender issues). Although homegardens generally are regarded as sustainable production system, it is difficult to prove this statement by quantitative data and these studies are rare. Anyhow, homegardens fulfill more or less these demands quite well and thus they support both ecological and social sustainability. Agrobiodiversity, as an important part of homegardens, is related to most of these demands and helps them to meet these conditions. Therefore it could be considered as a foundation of agricultural sustainability.

### 2.4.1 Agrobiodiversity: a foundation of agricultural sustainability?

Agrobiodiversity or agricultural biodiversity is shortly defined, as it is evident from the name, as a biological diversity on lands used for agricultural purposes (Brookfield and Stocking, 1999). It is a vital subset of biodiversity and represents the genetic resources for food and agriculture. It includes variety and variability of harvested crops, livestock breeds and their wild relatives, fish species, trees and their products, micro-oraganisms, pollinators and other insects (such as bees, butterflies, earthworms and greenflies), that

contribute to agricultural production (FAO, 2004). These taxa are deliberately introduced by the farmer or are present in the agroecosystem even without the awareness of the farmer. Agro-biodiversity is related only to the human-managed systems or to modified biological diversity used for general agricultural purposes and many components of agrobiodiversity would not even survive without this human interference (FAO, 2004). This diversity exists at the ecosystem, species, and genetic level and is the result of natural selection processes and interactions among farmers and fishers and the environment over thousands of years (Biodiversity international, 2016). As the human activity shapes and conserves the biodiversity, local knowledge and culture can be considered as parts of agrobiodiversity too.

According to Long et al. (2003) agrobiodiversity can be divided into four levels:

1) variety diversity or genetic diversity
2) agricultural species diversity
3) agroecosystem diversity
4) management system diversity

For our purposes tho most important would be the species diversity.

Agrobiodiversity is fundamental for agricultural production and food security and it is a valuable component of environmental conservation (Thrupp, 2000). Better utilization of local crops can provide valuable nutrients, especially vitamins and minerals from fruits and vegetable as part of a healthier diet (Kahane, 2013). Beside that, local crops are better adapted to local natural conditions therefore less fertilizer and inputs are needed. Agrobiodiversity has a good influence on sustaining soil health and habitat for important pollinators and natural pest predators, and supports ecosystem services (Biodiversity international, 2016). Big agrobiodiversity is thus a prerequisite for a system to be sustainable.

### 2.4.2 Agrobiodiversity in homegardens

Compared to other agroecosystems, homegardens are characterized by great agrobiodiversity (Galluzzi et al., 2010). In general, homegardens are influenced by

multiple factors. Agro-ecological factors (biological, physical, chemical) such as soil and climate (rainfall, temperature, relative humidity, wind, etc.) cannot be controled by the household. But socio-economic and demographic characteristics such as needs of household, dietary habits, resources, preferences, market opportunities and demands, prices, food safety, age, education, number of family members, gender, geographic location, water availability, garden size and history, agricultural policy, market needs, food culture and household preferences have major influence of vegetation structure in homegardens (Christanty et al., 1986; Coomes and Ban, 2004; Huai and Hamilton, 2009). As we can see, garden diversity varies depending on the combination of external and internal factors. All these factors influence agrobiodiversity as well and the species distribution in homegardens is often determined by the combination of environmental, cultural and socio-economic factors and market demands (Fernandes and Nair, 1986; Albuquerque et al., 2005). Any change in these factors would lead to the changes in species composition of homegardens as well (Abdoellah et al., 2006; Peyre et al., 2006). Agrobiodiversity has a huge range of positive effects on quality of homegardens.

According to FAO (2004) agrobiodiversity:

- Increases productivity, food security, and economic returns
- Reduces the pressure of agriculture on fragile areas, forests and endangered species
- Makes farming systems more stable, robust, and sustainable
- Contributes to pest and disease management - Using diversity allows farmers to reduce the risk of loss caused by the spread of pests and diseases without investing in high chemical inputs.
- Conserves soil and increases natural soil fertility and health - Different crop species and varieties require different minerals, soils and amounts of water to thrive in. Diverse crops also attract and sustain a variety of pollinators that contribute to the production. It also provides conditions for natural pest predators.
- Contributes to sustainable intensification
- Diversifies products and income opportunities
- Helps maximize effective use of resources and the environment
- Reduces dependency on external inputs
- Improves human health and nutrition and provides sources of medicines and

vitamins

- Conserves ecosystem structure and stability of species diversity
- Gives farmers the options to manage climate risks and helps buffer the effects of extreme weather such as droughts or floods
- 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

At present time, agrobiodiversity, along with local knowledge, culture and skills of farmers, faces many ecological and social problems and is rapidly disappearing (Galluzzi et al., 2010). One of the most important has been the Green Revolution agriculture. As it was said above, today's trend is focusing only on few key staple "cash-crops". Nowadays, 75% of the world's food is generated from only 12 plants and 5 animal species (FAO, 1999). The heavy reliance on a narrow diversity of food crops puts future food and nutrition security at risk. Another problem related to loss of agrobiodiversity is globalization of the food system and marketing. The replacement of local varieties by improved or exotic varieties and species causes genetic erosion, population preasure and urbanization, deforestation and over-harvesting of non-timber forest products (Long, 2003; FAO, 2004; Kahane et al. 2013). The prevention of further decrease of agrobiodiversity should be receiving a special attention.

### 2.4.3 Agrobiodiversity and household resources perspective: Gender issue

Particularly women play an important role in biodiversity conservation. They are also interested in conserving homegardens because they offer substantial benefits, such as food security, income, health care and environmental benefits. Woman often decide where the particular plants should be cultivated. They cultivate ornamental and medicinal plants and are responsible for firewood (Dietrich, 2011). In Latin America women are more likely to manage crops destined principally for subsistence or for sale in small quantities in local markets in 80% and 88% of the cases respectively (Howard, 2006). Women were found to be aware of the importance of homegarden conservation and tend to motivate the husbands, children and neighbors to conserve the agrobiodiversity of homegardens. That is why the role of women in traditional management practices has increasingly been appreciated globally (Akhter and Alamgir, 2010). Men use homegardens as experimental

stations. For example, in a case study site in the Yucatan, Mexico, men use homegardens to test new maize varieties and preserve traditional varieties that they do not wish to plant in their fields (Howard, 2006; Lope Alzina, 2006). Men are involved in homegardening principally in relation to crops with high commercial value (Trinh, 2003; Howard, 2006; Rao and Rao, 2006). Men may grow specific homegarden crops of their own but most homegarden species are related to women, while trees are often related to male (Howard, ;2006). In some cultures there are noticeable concepts of masculinity and femininity. For example among the Ka'apor in Brazil (Baleé, 1994), women are exclusively responsible for planting cotton (*Gossypium* spp.), Indian shot (*Cannaindica*), job's tears (*Coix lacryma jobi*) and pipiriwa (*Cyperus corymbosus*), which are used only by women for textiles or for body decoration. Only men plant maize. Among the Piaroa in Mesoamerica, it is also men who plant maize, and they strictly plant tobacco (*Nicotiana tabacum*) (Heckler, 2004).

### 2.4.4 Agrobiodiversity and household resources perspective: Age structure of household members

Age represents a crucial indicator for labour division at household level, which subsequently influences the biodiversity. According to Kehlenbeck et al. (2007) gardener's age can influence plant diversity positively probably because of the fact, that over the years gardeners try to cultivate new crops, while they continue to plant well-tried species. Additional bonus of homegarden related to age is that homegarden can improve the status of disabled and elderly people. They are often considered non-productive dependents in a household but limited care of a home garden, post-harvest and value-adding activities provide them safe and feasible opportunities to contribute to household food and income (Landon-Lane, 2004).

### 2.4.5 Agrobiodiversity and land/natural resource perspective: homegarden characteristics

As stated earlier, homegardens appear all around the world. We can find them both in tropical and temperate climate and in rural and urban surroundings. But they are most popular in tropics and subtropics especially humid lowlands with high population density and mainly in rural areas (Kumar and Nair, 2006). It can be assumed that plant diversity is affected by size of homegarden, which was already observed for example by Mendez

(2000) in study focused on homegardens in Nicaragua and Kabir and Webb (2008) in Banglades. Vlková et al. (2011) discovered that higher diversity was represented in smaller gardens. The worldwide average size of homegarden units is around 0.1-0.5 ha (Fernandes and Nair, 1986). Homegarden diversity is also strongly related to the age of homegarden. Few studies have been reported (Coomes and Ban, 2004; Aguilar-Støen et al., 2009) and it is thought that home garden age influence plant species richness positively, but the results are not very clear and another analysis should be conducted.

### 2.4.6 Agrobiodiversity and tradition

Tradition and culture have also big impact on agrobiodiversity. As an example can serve growing of five kinds of fruits which represent five elements in Vietnamese culture nad is used during the Vietnamese festivals (Trinh et al., 2002). We can assume that agrobiodiversity is affected by commercialization and state policies (Trinh et al., 2002). Better market access leads to decrease of biodiversity (Kehlenbeck et al., 2007) and may be caused by pushing gardeners to more commercial productions.

## 2.5 Homegardens in Vietnam

Home gardening in Vietnam has a long tradition and it is a domain of poor people. The total area of homegardens in Vietnam is about 200,000 ha which represent 4% total area under agricultural production (Trinh, 2002). Trinh et al. (2003) classifies traditional Vietnamese homegardens into four types according to their main functions and main species:

1) homegardens with fruit trees
2) homegardens with pond and covered livestock area
3) homegardens with vegetables
4) homegardens with forest trees

The number of species in homegardens in Vietnam ranged from 0.7 to 2.7/100 $m^2$. In comparison to other parts of Vietnam, the central Vietnam with an average 0.8 species/100$m^2$ are the least diverse district (Trinh et al., 2003). Homegardens in Vietnam supply more than 50% of vegetables, fruits, and herbs (Trinh et al., 2003), so they are

significant part of food security just as elsewhere in the world. It helps to solve the problem with lack of food and starvation, which is rather current in Vietnam. In rural areas of Vietnam, approximately 45 percent of children and 40 percent of women are malnourished (FAO, 2000). One of the most commonly bred species of livestock are pigs and buffalo (Trinh al., 2003), although ducks and other poultry are common too. In Vietnam and parts of China, the vegetable-animal-fishpond garden relies on recycling residues, animal and human wastes manure. Pond weed provides animal feed, plant residues feed fish, water is used for irrigation and mud is used for soil dressing (Landon-Lane, 2004). This practice also supports already mentioned sustainability.

# 3 Aim of the thesis

The aim of the thesis was to find out whether there is any relation between the demographic and socio-economic characteristics of the households and the agrobiodiversity of the homegardens among the subsistence farming systems in central Vietnam.

The specific objectives of the thesis were to:

(i) identify suitable homegardens and to quantify their levels of agrobiodiversity;
(ii) obtain and/or calculate relevant demographic and socioeconomic characteristics of selected homegardens;
(iii) estimate the impact of demographic and socio-economic indicators on agrobiodiversity via suitable stastical methods.

# 4 Methodology

## 4.1 Study site description

The research was conducted in the Phong My commune, Thua Thien Hue Province, in central Vietnam, around 50 km north-west off Hue city. The commune is nestled near buffer-zone of Phong Dien Natural Reserve, which was established in order to protect local ecosystems against disturbances associated with rapid rural development. The climate is characterized as equatorial monsoon climate, category Am according to Köppen (Kottek, 2006) with colder and humid winter season (from August or September till December or January) and hot and dry summer season, which is caused by seasonal winds (monsoons). The average annual temperature is around 25°C and relative humidity reaches 85-88%. The annual rainfall reaches 2,500-3,000 mm and is concetrated in the winter period (Tuan et al., 2003). Large variability in elevation is typical for local terrain. Eastern flat part of commune is approximately about 50 m above sea level, while the western mountainous part exceeds the altitude 1,500 m above sea level. Due to steep hills and the short distance to the sea, there is a risk of floods during the monsoon period. The typical types of soils are alluvium and red/yellow feralite soils. The total area of Phong My commune is 39,400 ha with 11 villages and around 1,200 households (Vlkova et al., 2011; Polesny et al., 2014).

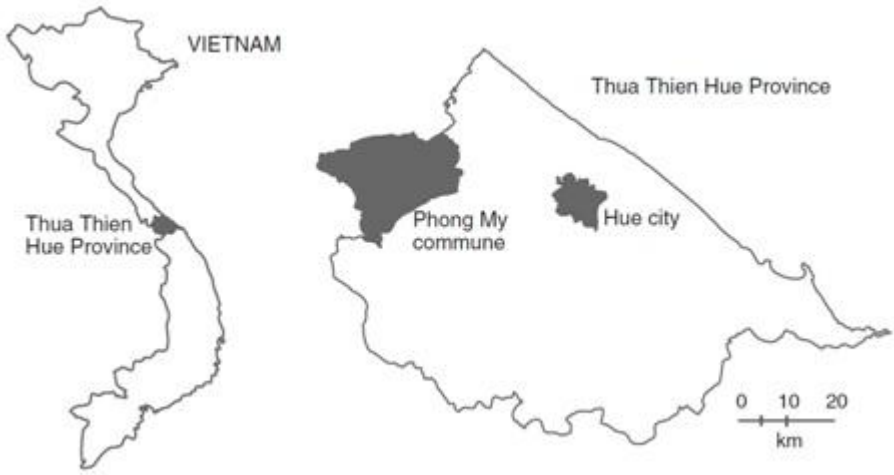


**Figure 2** Map of the study site

Source: Vlkova et al. (2011)

## 4.2 Data collection

Firstly, for the purpose of compilation this bachelor thesis, we used data collected in the period between 2008 and 2012 during the implementation of the Czech ODA projects "Sustainable development of Phong My commune, Vietnam" number 8/Mze/B and "Renewable Energy Resources for Rural Areas in Thua Thien Hue Province" number 13/2012/02, and were already used for other publications (Vlkova et al., 2011; Polesny et al., 2014; Roubik et al., 2016). Nevertheless, for the general impression, particular steps of data collection are described to provide the reader the possibility to understand our approach as well as to use our methodology for any research purposes.

**Table 1** Demographic and socio-economic characteristics of chosen villages

| Village | Area (ha) | Population | Total number of households | Households in study (*) | Number of poor households | Average household size |
|---|---|---|---|---|---|---|
| Phong Thu | 104 | 239 | 44 | 28 (63.64%) | 4 | 5.43 |
| Hung Thai | 269 | 282 | 65 | 4 (6.15%) | 12 | 4.34 |
| Hoa Bac | 82 | 230 | 51 | 4 (7.84%) | 11 | 4.51 |

*Percentage of total number of households

Data collection on homegarden agrobiodiversity was realized during the summer 2008. The survey was conducted at 101 randomly selected homegardens within three villages, i.e. Phong Thu, Hung Thai and Hoa Bac. Communication with all respondents was carried out in Vietnamese and subsequently translated into English via interviewer-administrated semi-structured questionnaires with the head of the household. It gave us information about socioeconomic background of the household, ethnicity, homegarden history and its major characteristics. Additionally, the respondents were asked questions about their ethnobotanical knowledge on plants cultivated in their homegardens, only ornamental plants and weeds were excluded. All data were registered immediately on field notebook and subsequently processed for depth statistical analysis. Data on demographic and socio-economic characteristics were collected via similar approach during March and April in 2009 among 147 households and household attitudes towards homegardens were obtained in May 2012 among 83 households. For our study we were able to select 36 hosuseholds which have complete and most suitable data for the purpose of our study.

## 4.3 Data processing and analysis

We used standard statistical methods for processing the data. All data were inserted into MS Office Excel® and subsequently in STATISTICA ©StatSoft 10.0 for further calculation. We used three indices to calculate the specific kinds of agrobiodiversity: Shannon-wiener and Simpson's index for measuring the diversity and Margalef index for measuring the species richness.

### 4.3.1 Agrobiodiversity quantification

Shannon-wiener index $H = -\sum_{i=1}^{S} pi \ln(pi)$

where *pi* is proportion of the species relative to the total number of plants, *S* is the number of species.

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, so it accounts for both abundance and evenness of the species present. 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).

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

where *S* is the number of species, *N* is the total number of individuals in the sample. Margalef index measures species richness, which means the number of species an area contains. Margalef index does not count with the relation between abundances of species and it is highly sensitive to sample size. The range of Margalef index is 0-∞ (Magurran, 1988; Gamito, 2010).

Simpson's index $D = \sum pi^2$

Simpson's index is used to estimate dominance of the species. Simpson's index gives more weight to the more abundant species in a sample. The addition of rare species to a sample causes only small changes in the value of D. With increasing diversity, dominance decreases. Simpson's index is a similarity index, saying that the higher is the value the lower is diversity. However, for the purpose of our study we have used Simpson's reciprocal index 1/D. The value of this reciprocal index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher is the value, the greater is the diversity. The maximum value is the number of species (Simpson, 1949).

### 4.3.2 Linear regression

The relations and dependency between agrobiodiversity represented by 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).

### 4.3.3 Correlation analysis

In order to identify potential correlation between agrobiodiversity and demographic and socio-economic indicators, correlation analysis was applied as well. We intentionally identified farmer's age, female household members, homegarden's age, homegarden size and annual cash income. The reason for choosing these specific characteristics was availability of information in scientific literature about the similar issue. We chose 90% confidence level.

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

| Variable | Description | Units of measuring | Data collected | References |
|---|---|---|---|---|
| Farmer's age | Age of household head | years | Vlkova 2008 | Kehlenbeck et al. (2007), |
| Farmer's gender | Sex of household head | if male, then 1 | Vlkova 2008 | Howard, (2006), Lope Alzina (2006) |
| Household size | Number of household members | number | Vlkova 2008 | Quan and Anh (2006) |
| Female household members | Number of female household members | number | Vlkova 2008 | Akhter and Alamgir (2010), Dietrich (2011) |
| Dependent members | Number of people younger than 15 and older than 60 | number | Vlkova 2008 | Landon-Lane (2004) |
| Homegarden age (HG age) | Age of homegarden | years | Vlkova 2008 | Coomes and Ban (2004), Aguilar-Støen et al. (2009) |
| Homegarden size (HG size) | Total area of homegarden | $m^2$ | Vlkova 2008 | Mendez (2000), Kabir and Webb (2008), Vlková et al. (2011) |
| Farm size | Total area of farm, area of homegarden and house included | $m^2$ | Vlkova 2008 | Quan and Anh (2006) |
| Total cash income | All cash income generated by household per one year from both farm and off-farm activities | USD | Verner 2009 and 2012 | Yongneng et al. (2006) |
| Terrain of homegarden (Terrain of HG) | incline of homegarden | if slope, then 1 | Vlkova 2008 | Kehlenbeck et al. (2007) |
| Perception of water conditions | water conditions of homegarden | if good, then 1 | Vlkova 2008 | Trinh et al. (2003) |

# 5 Results

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

Table 3 shows results of linear regression, which identified household size as the only significant variable that would influence agrobiodiversity of targeted homegardens (p=0.050). Futhermore, there were variables positively influencing agrobiodiversity, e.g. farmer's age, household size, homegarden size and perception of water conditions, while the rest of them, farmer's gender, female household members, dependent members, homegarden age, farm size, total cash income and terrain of homegarden, were influencing agrobiodiversity negatively.

**Table 3** Linear regression results: Shannon-Wiener index vs socio-economic characteristics

| Independent variable | Coefficients | t Stat | p-value |
|---|---|---|---|
| Intercept | 0.135 | 0.223 | 0.824 |
| Farmer's age | 0.004 | 0.415 | 0.681 |
| Farmer's gender | -0.159 | -0.409 | 0.685 |
| Household size | 0.185 | 2.062 | 0.050* |
| Female household members | -0.137 | -1.050 | 0.303 |
| Dependent members | -0.059 | -0.574 | 0.570 |
| HG age | -0.001 | -0.100 | 0.920 |
| HG size | 0.000 | 0.336 | 0.739 |
| Farm size | -0.000 | -0.268 | 0.790 |
| Total cash income | -0.000 | -0.477 | 0.637 |
| Terrain of HG | -0.002 | -0.009 | 0.992 |
| Perception of water conditions | 0.287 | 0.796 | 0.433 |

Note: * is significance level at 90%

The coefficient of determination ($R^2$=0.258) showed, how the variation of values of the dependent variable around the mean was explained by the values of independent variables. In other words, only around one fourth of the values fit the model.

Figure 3 shows that none of the chosen indicators significantly influenced agrobiodiversity of targeted homegardens. However, we can see that agrobiodiversity was positively influenced by number of female members in household, farmer's age and homegarden age. On the other hand, increasing household income and homegarden size had negative impact on species diversity. The correlation shows that household income had the most influencing effect on agrobiodiversity (p = 0.173). Values of Shannon-Wiener index tend to be unequally distributed and they are rather low or high.

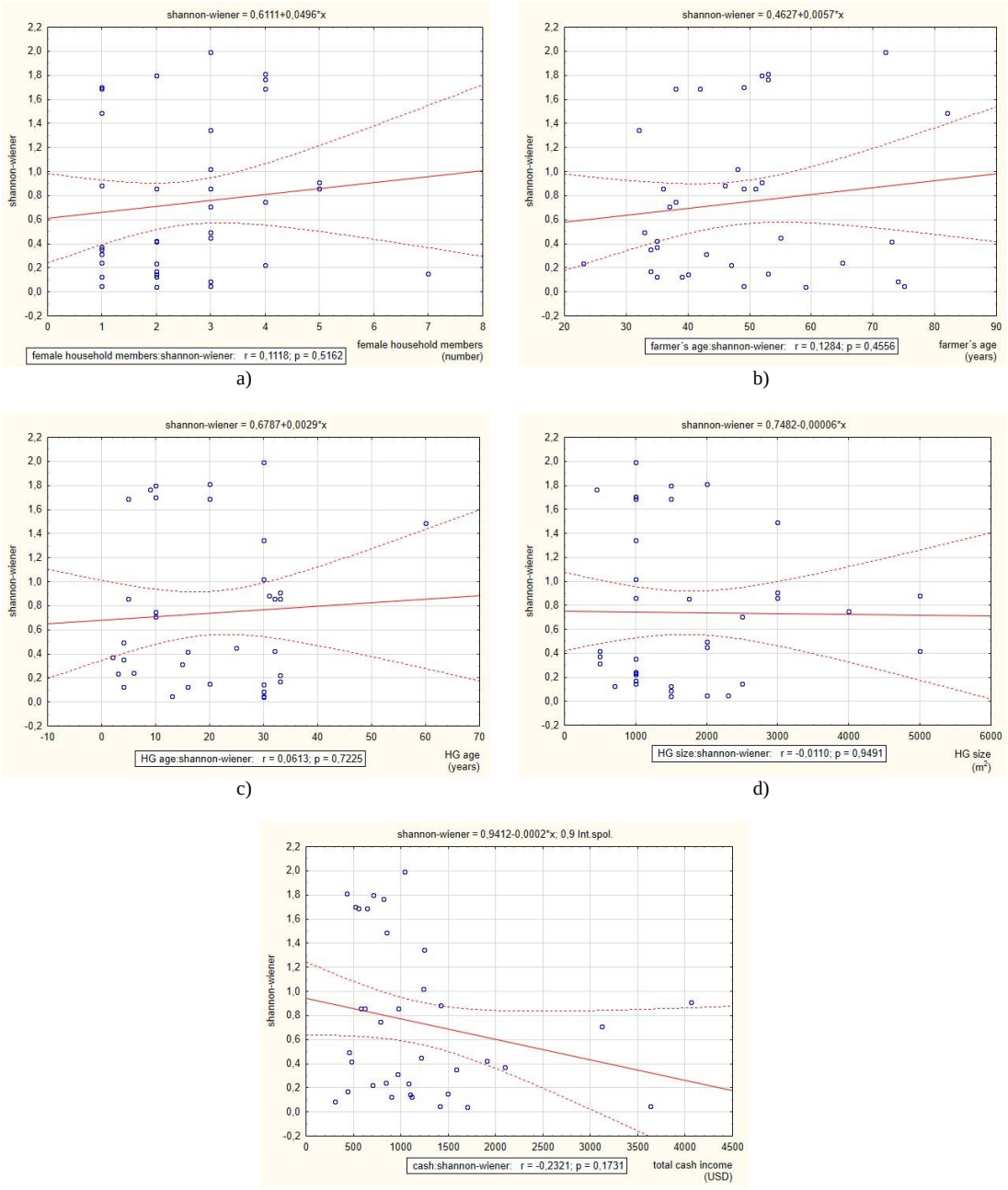


**Figure 3** Correlation between chosen demographic and socio-economic indicators and agrobiodiversity: Shannon-Wiener index
Note: a) female household members, b) farmer's age c) HG age d) HG size e) total cash income

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

The identification of dependency between species richness and chosen indicators is based on the result in Table 4. We can see that there are even two significant indicators,

households size (p = 0.046) and dependent members (p = 0.008). Positive correlation was found in case of farmer's age, farmer's gender, household size, total cash income terrain of homegarden and perception of water conditions. The rest of characteristics, namely female household members, dependent members, homegarden age, homegarden size and farm size, correlated negatively. Socio-economic characteristics explain nearly one half of agrobiodiversity variability ($R^2$=0.473).

**Table 4** Linear regression results: Margalef index vs socio-economic characteristics

| Independent variable | Coefficients | t Stat | p-value |
|---|---|---|---|
| Intercept | 0.747 | 1.227 | 0.231 |
| Farmer's age | 0.000 | 0.016 | 0.986 |
| Farmer's gender | 0.352 | 0.907 | 0.373 |
| Household size | 0.189 | 2.097 | 0.046* |
| Female household members | -0.062 | -0.475 | 0.638 |
| Dependent members | -0.296 | -2.868 | 0.008* |
| HG age | -0.002 | -0.261 | 0.795 |
| HG size | -0.000 | -0.671 | 0.508 |
| Farm size | -0.000 | -1.072 | 0.293 |
| Total cash income | 0.000 | 0.523 | 0.605 |
| Terrain of HG | 0.315 | 1.134 | 0.267 |
| Perception of water conditions | 0.465 | 1.289 | 0.209 |

Note: * is significance level at 90%

As in the case of Shannon-Wiener, Figure 4 shows that these five main indicators did not significantly explain values of diversity of targeted homegardens. However, there is a visible tendency that agrobiodiversity was positively influenced by number of female members in household and farmer's age. Negative influence of agrobiodiversity was discovered within household income, homegarden size and contrary to Figure 3 in homegarden age. According to bigger reliability of the model, we could see that there are independent variables in Figure 4 with the lowest p values out of all of our correlation graphs. Homegarden size (p = 0.118) was the indicator with the biggest impact on species richness. The distribution of the values of Margalef index was relatively equally distributed contrary to Shannon-Wiener and Simpson's.

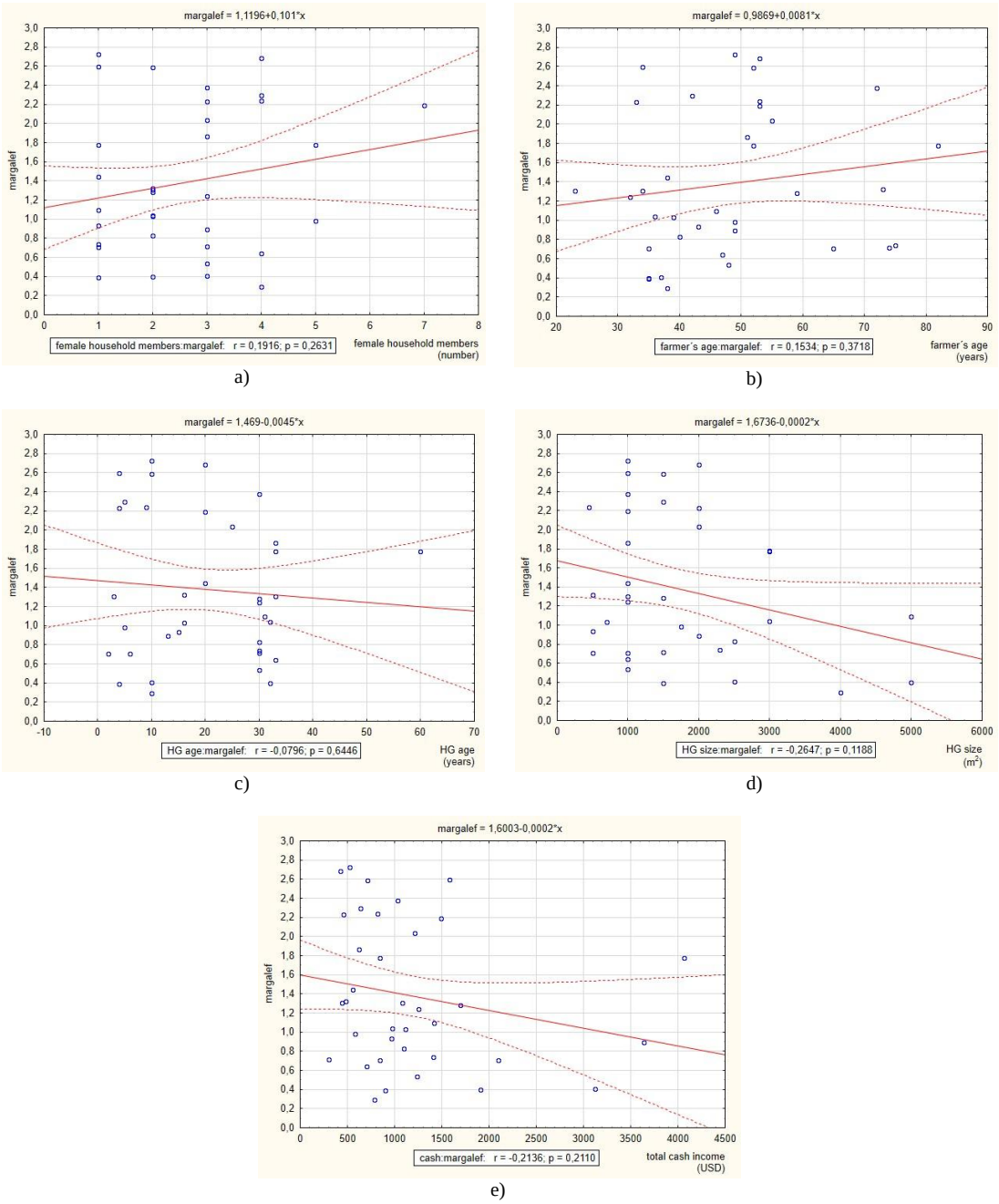


**Figure 4** Correlation between chosen demographic and socio-economic indicators and agrobiodiversity: Margalef index
Note: a) female household members, b) farmer's age c) HG age d) HG size e) total cash income

## 5.3 Role of demography and socio-economic characteristics in species diversity: Simpson's index

Relatively high p-values demonstrate that there was no significant correlation between indictors and Simpson's index (Table 5). However, the variable with the lowest p-values and therefore the most significant one, was the homegarden size again (p = 0.111).

**Table 5** Linear regression results: Simpson's index vs socio-economic characteristics

| Independent variable | Coefficients | t Stat | p-value |
|---|---|---|---|
| Intercept | 0.597 | 0.476 | 0.638 |
| Farmer's age | 0.017 | 0.817 | 0.421 |
| Farmer's gender | -0.380 | -0.473 | 0.639 |
| Household size | 0.306 | 1.652 | 0.111 |
| Female household members | -0.269 | -0.998 | 0.327 |
| Dependent members | -0.029 | -0.138 | 0.891 |
| HG age | -0.004 | -0.184 | 0.855 |
| HG size | 0.000 | 0.108 | 0.914 |
| Farm size | -0.000 | -0.073 | 0.941 |
| Total cash income | -0.000 | -0.353 | 0.726 |
| Terrain of HG | 0.117 | 0.204 | 0.839 |
| Perception of water conditions | 0.423 | 0.568 | 0.574 |

This model of linear regression was the most unreliable. The value of $R^2$ (0.192) shows that only one fifth of the variation in agrobiodiversity was explained by socio-economic and demographic indicators, which means that our data did not fit this model properly. Despite the bigger inconvenience of this correlation model then in the case of Figure 3, the positive and negative influences of species diversity by chosen indicators were the same (see Figure 5).

Agrobiodiversity was positively influenced by increasing number of female members in household, farmer's age and homegarden age, while bigger household income and homegarden size caused decrease of species diversity. The strongest corelation was detected in case of farmer's age. The older was the farmer the bigger was the species diversity. The most common value of Simpson's index, representing species diversity was around 1.

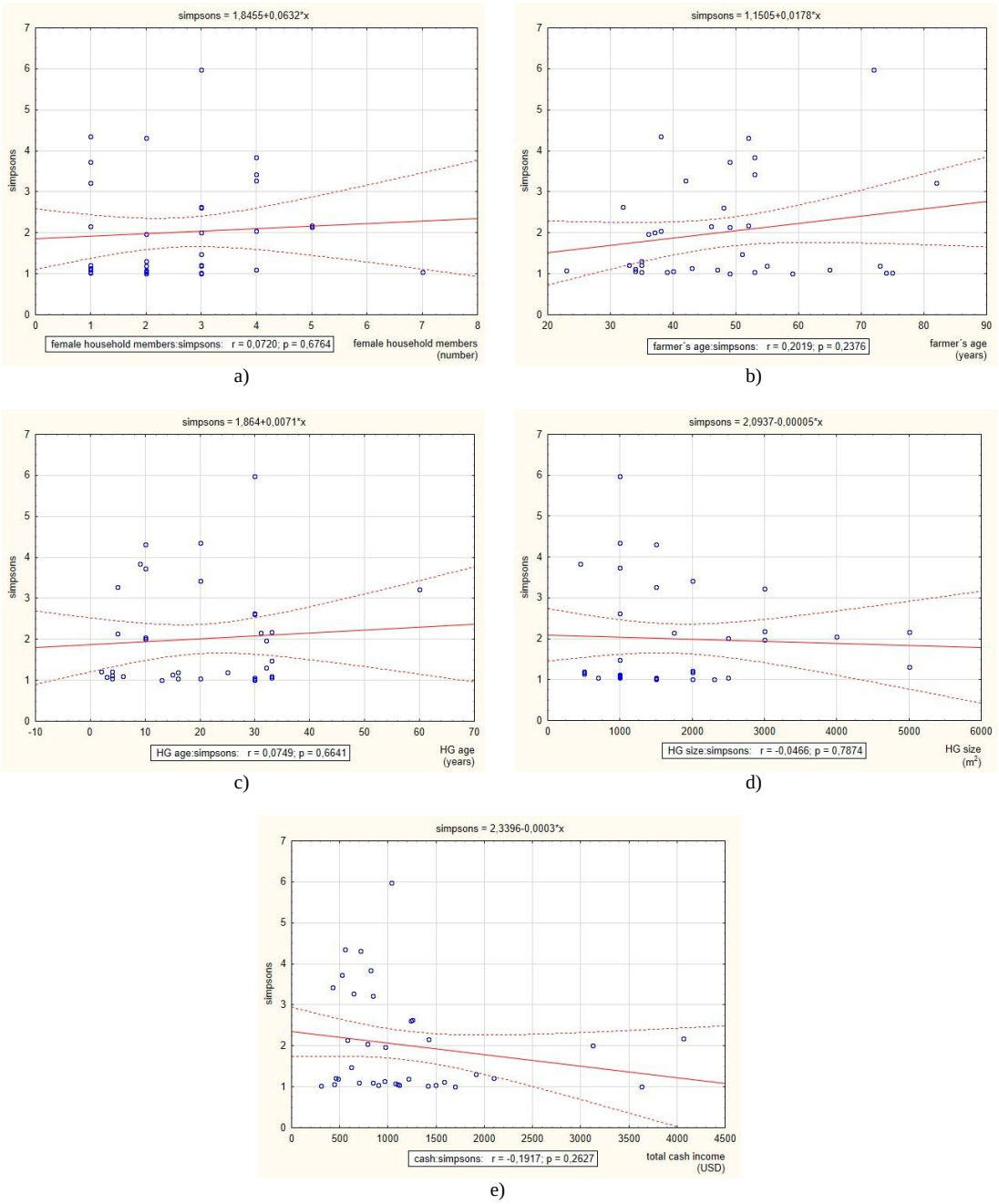


**Figure 5** Correlation between chosen demographic and socio-economic indicators and agrobiodiversity: Simpson's index

Note: a) female household members, b) farmer's age c) HG age d) HG size e) total cash income

# 6 Discussion

Our study analysed in what extent demographic and socio-economic indicators may influence agrobiodiversity of rural homegardens in central Vietnam. In the literature review of this thesis we found that homegardens are very important part of the life of people living in tropics (Kumar and Nair, 2006). They represent source of food and income and provide many other services (Landon-Lane, 2004). Homegardens are considered sustainable, partly also thanks to their extraordinary agrobiodiversity (Torquebiau, 1992; Biodiversity international, 2016). Vegetation structure is definitely influenced by natural conditions, but socio-economy and demography also have great impact on it (Christanty et al., 1986; Coomes and Ban, 2004; Huai and Hamilton, 2009). Linear regression models identified particularly household size (Shannon-Wienner, Margalef) and number of dependent members (Margalef) as the most influencing factors. Both Shannon-Wiener ($R^2$=0.258) and Simpson's index ($R^2$=0.192), which express species diversity, had relatively low $R^2$ values, therefore we can say that agrobiodiversity in general is not as much significantly influenced by socio-economic and demographic indicators as we presumed. However, we came to interesting conclusions, that based on our results household indicators significantly influence species richness (Margalef index). According to $R^2$ value, these characteristics explained about 48% of variation in species richness. This could be caused by the fact that abundance has no influence on this index value. Nevertheless, based on the correlation models, we could estimate certain tendencies. Increasing number of female household members and farmer's age caused increase of agrobiodiversity. On the other hand, homegarden size and total household cash income correlated negatively. There is one exception in the case of homegarden age, which correlated positively with Shannon's and Simpson's index and negatively with Margalef. All three linear regression models are less reliable, based on low values of $R^2$, which could be caused by numerous further mentioned aspects.

One of the indicators, whose impact on agrobiodiversity of targeted homegardens was difficult to estimate, was the total size of each garden. Nevertheless, homegarden size plays an important role in agrobiodiversity, which was observed in Kerala. There was a tendency documented that with an increase in size of homegardens there was an increase in the Simpson's index (non-reciprocal) and decrease in the Shannon's index (Peyre et al., 2006).

In other words, increasing size of homegarden caused a decrease in diversity and evenness of species and an increase of dominance of the most abundant species, similarly to Vlkova et al. (2011). In this manner, we would have to conclude that impact of homegarden size on its agrobiodiversity is more similar to the situation in Peru (Coomes and Ban, 2004), where diversity was not related, statistically significant, to the size of the garden. It was probably caused by low homogeneity of local homegardens as some of the households were more oriented on cash-crops and had strong tendencies to focus on a few species only.

Another important indicator influencing agrobiodiversity in our study was cash income. Significant negative correlation between household income and species richness indices was observed. Similar situation was observed in China (Yongneng et al., 2006) where increasing off-farm income caused decrease of species richness. However it is not easy to document such relationships and to reliably quantify this dependency between households profile and species diversity and richness. It is frank to say that agrobiodiversity is influenced, apart from the indicators we used in our study, by numerous aspects that were not taken into account in this study. For example, in Vietnam it is mainly the specific high cultural significance attached to local homegardens (Trinh et al., 2003). Another aspect is that Vietnam was for more than two decades witnessing an intensive economic growth, which has influenced also the whole agricultural sector of the country (World Bank, 2000; FAO, 2006; IMF, 2016). Thus, there is an expectation that such a rapid development has influenced not only the economy, but it had significant effect on homegarden agrobiodiversity as well. Furthermore, current species distribution was also a result of recent policy changes in land tenure and opening up of markets (Trinh, 1998). Rapid socio-economic changes put enormous pressure on household resources to generate adequate income. This tendency is usually supported at local level by cooperatives and top-down driven supply-chains. Increasing income could solve problems with cash balance at short- or medium-term period, but household members may suffer from decreasing of food availability and nutrition security as well as from other environmental services. This deficiency could be lost due to agrobiodiversity decline (Thrupp, 2000; Kehlenbeck et al., 2007).

As mentioned earlier, our results are less relevant and we have to follow several tendencies obtained particularly from correlation analysis. An impact of household characteristics on

agrobiodiversity in central Vietnam should be further studied as there is still demand for research of the relationships between agrobiodiversity and both demographic and socio-economic indicators. Deeper analysis of these relationships could contribute to agrobiodiversity conservation and to preservation of sustainability of homegardens, the unique agroecosystem, which has a potential to provide food, cash as well as environmental services for local population.

Low relevancy of our results happened due to following limitations. As mentioned above, most of our models were not convincing according to low values of R. We had to give a priority to the results from correlation analysis to obtain at least some tendencies between chosen variables (see Table 3, 4, 5 and Figure 3, 4, 5). Those limitations could be explained by the following three steps. First, it was possible that not all relevant variables were collected in required quality, which could be caused by using local translator and by the fact, that data were collected in long time period of several years 2008-2012. Second, there may be a strong random component in the decision making of households toward homegarden composition that may have not been captured by the analysis. The last one is that homegardening systems in central Vietnam may reflect non-linear relationships between household characteristics and agrobiodiversity. None of these features could be assessed using our statistical tests. Last, but not least, we included in our survey three villages but the majority of data we used for our analysis was obtained just in one of them.

# 7 Conclusion

Our study analysed 36 homegardens in central Vietnam with the aim of finding in what extent the demographic and socio-economic indicators may have influenced their agrobiodiversity. Based on our results, agrobiodiversity in general, was not very significantly influenced by socio-economic and demographic indicators. Nevertheless, certain correlation between increasing number of female household members and farmer's age and higher agrobiodiversity was documented. On the other hand, homegarden size and particularly total cash income of the household correlated negatively. So we could conclude that households which have more female members and are managed by older farmers would tend to follow strong Vietnamese tradition in homegardening and thus they are more diversified, while young farmers with larger gardens would generate higher income from dominance of a few species, more market-oriented.

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