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Faculty of Tropical AgriSciences

Urban homegardens at the crossroad in the time of socioeconomic transition: Example of Hue City, Vietnam

MASTER'S THESIS

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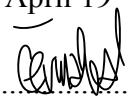
Declaration

I hereby declare that I have done this thesis entitled “Urban gardens at the crossroad in the time of socioeconomic transition: Example of Hue City, Vietnam” independently; all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, April 19th, 2023



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Adéla Čermáková

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Abstract

Urban agriculture can have many types, varying from green parks with useful plants to backyard gardening with poultry and livestock farming. This Master's thesis focuses on traditional homegardens in Hue City, central Vietnam. It aims to investigate the sustainability and dynamics of this land use under current socioeconomic and climate dynamics. Data were collected through direct observation, interviews, and semi-structured questionnaires with 64 garden owners. 86 species belonging to 44 botanical families were identified, with 2 to 19 species per homegarden. The most frequently observed plant species were *Musa* spp. (70%), followed by *Ipomoea batatas*, *Citrus grandis*, *Bouea macrophylla*, *Artocarpus heterophyllus*, *Areca catechu*, and *Ananas comosus*. Most species were of multipurpose use, while the major use categories reported were food (97%) and medicine (13%). The most abundant cash crops were fruits (areca, pomelo, Marian plum, jackfruit, banana, guava and pineapple). Agrobiodiversity was quantified using the Shannon-Wiener (1.25), Simpson (0.60), and Margalef indices (1.12). The association between agrobiodiversity and market orientation of homegardens was documented, but no statistical significance was found. Additionally, hierarchical cluster analysis revealed the existence of three types of homegarden, i.e. (1) homegardens rich in biodiversity, (2) traditional homegardens, and (3) commercial homegardens. The highest species richness and diversity were found in semi-extensive, peri-urban, least commercial gardens managed by elderly gardeners. Respondent runs gardens to ensure fresh and healthy food, continuity of family traditions and reduced food expenses. Interviewed households did not perceive any pressure related to urbanisation development but were more sensitive to problems with climate dynamics and market chain imperfections. In the context of the Covid-19 pandemic, it was found that it primarily affected the economic situation of surveyed homegardeners. Our research findings highlight the need for promoting homegardens in Vietnam as a traditional land use system for sustainable development. Policies should consider the impact of urbanisation pressure and focus on the multi-functionality of homegardens beyond just commercialisation for income generation.

Keywords: agrobiodiversity, cluster analysis, commercialisation, ethnobotany, perceptions, sustainability

A list of abbreviations

CGIAR	Consultative Group for International Agricultural Research
FAO	Food and Agriculture Organisation
HH	Household
HGD	Homegarden
HUAF	Hue University of Agriculture and Forestry
RUAF	Resource Centres on Urban Agriculture and Food Security
UN	United Nations
UN DESA	United Nations, Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UA	Urban agriculture
UPA	Urban and peri-urban agriculture

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1. Introduction

Homegardens can be described as the oldest land-use system that contributes to household food security, local subsistence economy, and nutritional status. This traditional farming system has been found in rural and urban areas (Soemarwoto 1987; Kumar & Nair 2004; Landon-Lane 2011; Galhena et al. 2013; Whitney et al. 2018; Abdoellah et al. 2020). Nevertheless, the rapid urbanisation process has significantly changed this farming system, affecting the availability and quality of land, water, and other resources needed for home gardening. The world's steadily growing population has been a major trend in the 20th and 21st centuries. Over half of the world's population lives in cities; by 2050, an estimated two-thirds will live in urban areas. Small and medium-sized cities in Asia and Africa are expected to account for most future urbanization growth. Although these rapidly growing city environments offer enormous opportunities, there is also a gap related to the challenges and risks associated with such development. That's why urban and peri-urban agriculture has gained increasing attention over the past few years. Urban agriculture refers to the cultivation, processing, and distribution of food through the cultivation of plants and rarely includes raising livestock in and around cities (Eigenbrod & Gruda 2015; FAO, Rikolto, and RUAF 2022; UN 2022).

Urban homegardens, as they are a type of urban agriculture, provide a wide range of benefits to cities (urban areas) and their surrounding areas (peri-urban areas). For example, they can improve health by producing fresh, nutritious food for self-consumption and purchased food. At the same time, they benefit the environment by reducing agriculture's growing carbon and water footprint. Carbon emissions are reduced because transporting fruit and vegetables from other regions or countries is unnecessary. Also, they can improve the air and promote water and organic waste recycling. Moreover, homegardens provide a source of income for households. Simply put, they can make healthy food more affordable and accessible to the poorest urban dwellers (De Bon et al. 2010; Lee et al. 2010; Thompson et al. 2010; Eigenbrod & Gruda 2015; Poulsen et al. 2015; Kurfürst 2019; Akaeze & Nandwani 2020; Diehl et al. 2020; Pham & Turner 2020; Zasada et al. 2020; Follmann et al. 2021).

As a result of urban expansion, homegardens might go under changes that may affect the food security of local people. Rapid urban growth has been leading to land use competition, and productive agricultural land is becoming scarce. Thus, the declining size of homegardens might threaten cultivated diversity and household livelihood. In addition, reduced benefits from homegardens, namely source of income or food, might force farmers to seek employment in the off-farm sector and abandon or rent out their land (Peroni et al. 2016; Prihatini et al. 2018; Lowe et al. 2021). The transformation of homegardens into commercial production units is another effect of urbanization on this farming system. The demand for food is rising due to the rapid development of market economics and demographic pressures. However, this transformation has led to decreased plant diversity, with local species being substituted by introduced ones and the domination of commercial crops (Bernholt et al. 2009; Mohri et al. 2013; Prihatini et al. 2018; Abdoellah et al. 2020). Thus commercialisation combined with the declining size of homegardens might threaten cultivated diversity and household livelihood.

With its high urbanization rate (Lee et al. 2010; Kurfürst 2019) and strong tradition of homegardening (Gladis et al. 2001; Trinh et al. 2003), Vietnam provides an excellent example of the challenges and opportunities faced by this farming system in the context of urbanization. There has been considerable research on homegardens in Vietnam (Hodel et al. 1999; Hung et al. 2001; Trinh et al. 2003; Vlkova et al. 2011; Mohri et al. 2013; Pijika et al. 2015; Timsuksai & Rambo 2016), but it has been focused on rural areas and studies on urban homegardens are lacking. Therefore the Master's thesis focuses on the homegarden practices of urban farmers of Hue City, Vietnam and their contribution to their livelihood.

2. Literature review

2.1 Urban agriculture

Food production in and around cities has been present as long as histories have recorded cities. However, the term and concept of urban agriculture have been officially used for the first time during the 1990s. Its definition may vary, showing urban and peri-urban agriculture's dynamic and multifunctional nature. The concept is dynamic and comprises various farming systems, from subsistence production and processing at the household level to fully commercialised agriculture (FAO, Rikolto, and RUAF 2022).

One of the most frequently cited definitions of urban and peri-urban agriculture (UPA) is by Mougeot (2000): "*Urban agriculture is located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, and grows or raises, processes and distributes a diversity of food and non-food products, (re-) uses largely human and material resources, products and services found in and around that urban area, and in turn supplies human and material resources, products and services largely to that urban area*." In short, urban and peri-urban agriculture can be defined as the production of food and other outputs and related processes on land and other spaces within cities and surrounding regions.

UA integrates a wide range of functions illustrated in Figure 1 (Mougeot 2000; Galhena et al. 2013; Stewart et al. 2013; Eigenbrod & Gruda 2015; Lal 2020). However, its main strength is its contribution to increased food and nutritional security through improved access to food and increased income. The increased amount of food grown at home can prevent hunger and malnutrition. The nutritional status and health of household members have improved thanks to the availability of fresh, healthy homegrown food, mainly fruit and vegetables. In addition, direct access to food often allows impoverished households to consume a more diverse diet than they could otherwise afford (Maxwell et al. 1998; Mougeot 2000; Maxwell 2003; Weinberger & Lumpkin 2005; Zezza & Tasciotti 2010; Galhena et al. 2013; Orsini et al. 2013; Eigenbrod & Gruda 2015; Lal 2020).

UA is beneficial to the local and household economy. It generates employment opportunities within the agriculture sector in urban areas instead of being solely limited to rural regions. Local farmers and vendors can benefit from the demand for local food and agricultural products. In addition, it is assumed that UA provides so call "cost opportunity". Domestic producers can increase income access by consuming home-produced food that is cheaper to produce than buying from the market and by selling or trading their products. Higher cash income positively influences food security thru greater access of households to food products, both in quantity and quality (Agbonlahor et al. 2007; Galhena et al. 2013; Orsini et al. 2013; Stewart et al. 2013; Eigenbrod & Gruda 2015). It also decreases transportation expenses for transferring agricultural products from rural areas to local markets (Nugent 2000; Drescher 2006).

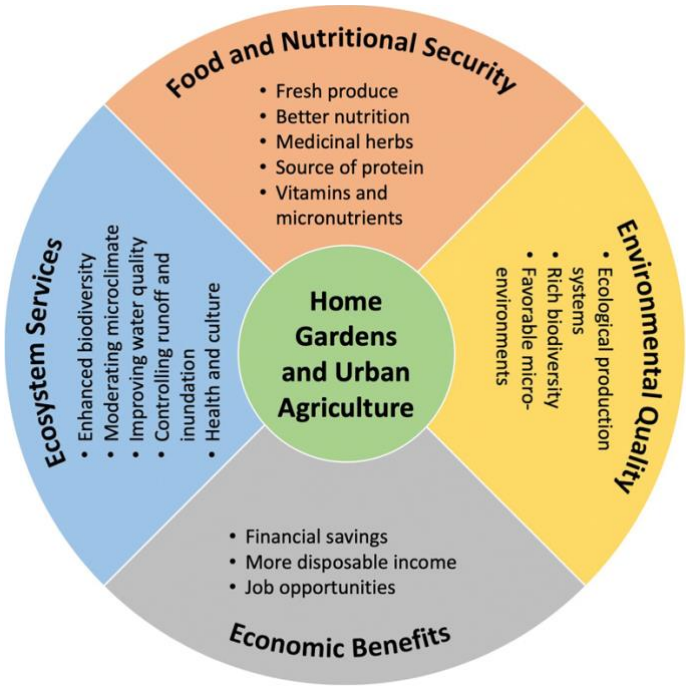


Figure 1. Food, environmental, economic, and ecosystem service benefits of homegardens and urban agriculture (Source: Lal 2020)

UA with urban green spaces offers several ecosystem services, mainly with improved local biodiversity (Allison et al. 2004; Vitiello et al. 2009; Krishnan et al. 2016). Growing different types of plants and animals can increase biodiversity in the urban environment. It can lead to

better conservation of local species and improved habitats for other animals. UA improves overall soil quality and reduces the risk of soil erosion, which can protect urban areas from flooding and other environmental problems. Expanding areas with green vegetation and trees within the cities favours their microclimate (Eigenbrod & Gruda 2015; Lwasa & Dubbeling 2015; Krishnan et al. 2016). Plants can help clean the air and absorb toxic substances and emissions, reducing health risks for city dwellers. Urban farming contributes to the reduction of the ecological impact of the cities by both waste recycling and by reducing emissions for transport (Ghosh 2004; Drescher 2006; de Zeeuw 2010), packaging, storage, etc., since the production areas are close to the final consumers (Ghosh 2004; Drescher 2006; Konijnendijk & Gauthier 2006; Coffey & Coad 2010; de Zeeuw 2010).

UPA has been found to play an essential role in many cities worldwide, especially in developing countries, where population growth, urbanization, and urban food insecurity pose challenges for cities (Drechsel & Dongus 2010; Orsini et al. 2013; Stewart et al. 2013; Salim et al. 2019). However, there is a significant difference between developed and developing countries. Speaking of UPA in developed countries, we mean mostly gardening, which is more of a way of spending leisure time and relaxation rather than a way of living. But what does UPA look like in developing countries? Unlike the developed world, the growing cities in the global south need to become more self-reliant in food production to satisfy the food demand of urban dwellers (Bernholt et al. 2009; De Bon et al. 2010; Bousbaine et al. 2020; Diehl et al. 2020; Follmann et al. 2021). Therefore, interest in urban agriculture has dramatically increased in recent years with the growing population and rapid urbanization as a strategy to reintroduce agriculture into the city and to cope with these problems (Orsini et al. 2013; FAO, Rikolto and RUAF 2022).

UA has many forms and sizes, from balconies, rooftops, and front or backyard gardens to community plots and indoor farms. FAO, Rikolto and RUAF (2022) divide forms of UA into four categories: (1) Home-based gardening, (2) Community-based and other shared gardening, (3) Commercial crop production, livestock and fisheries, (4) Institutional food growing. These categories are admittedly very broad, and each includes multiple types. At the same time, these four categories are not entirely distinct from each other, and some types

may overlap in some aspects. Some examples of urban agriculture that we can find around the world are shown in Figure 2.

(a) Urban homegarden
(Source: Covington 2022)

(b) Urban farming in Madagascar
(Source: Dubbeling et al. 2019)

(c) Community garden in Los Angeles
(Source: Bennet 2023)

(d) Private appropriation of the sidewalk in Vietnam
(Source: Kurfürst 2019)

(e) Rooftop urban farm in Paris
(Source: Goodnet 2019)

(f) Urban greenhouse
(Source: Millcreek Gardens 2019)

Figure 2. Examples of urban agriculture around the globe

2.2 Homegardens as a type of urban agriculture

One of the most common types of UPA in the tropics are homegardens (FAO, Rikolto, and RUAF 2022). Generally, homegardens are recognized as agricultural land-use systems that provide subsistence for gardeners and their families. Besides that, they can be used for the production of cash crops. Most homegardens usually consist of crops, multipurpose trees, and shrubs closely associated with livestock (Fernandest & Nair 1986, Kumar & Nair 2004, Landon-Lane 2011, Galhena et al. 2013, Whitney et al. 2018, Abdoellah et al. 2020). Soemarwoto (1987) also reported that homegardens are characterised by a mixture of several or many annual or perennial species grown in association and commonly exhibiting a layered vertical structure of trees, shrubs, and ground-cover plants, which recreates some of the properties of nutrient recycling, soil protection, and effective use of space above and below the soil surface to be found in forests. Homegardens are typically but not always close to family houses and can generally be found in all ecological regions in tropical areas and even continental climates (Fernandest & Nair 1986, Kumar & Nair 2004; Drescher et al. 2006). However, homegarden main advantage lies in its multipurpose character, as they contribute to food, environmental, economic, and ecosystem service benefits (Mougeot 2000; Ali 2015; Galhena et al. 2013; Stewart et al. 2013; Lal 2020).

Homegardens can be applied to rural as well as urban areas, where the land space becomes a limiting factor (Fernandest & Nair 1986; Ali 2015; Galhena et al. 2013; Whitney et al. 2018; Abdoellah et al. 2020; Lowe et al. 2021). Functions of homegardens are similar worldwide, focusing primarily on livelihood or income generation. On the other hand, the structure and size vary widely and depend on the location of the homegarden (Ali 2015; Drescher et al. 2006).

Vietnamese homegardens, as an indigenous method of production, often combine vegetable and fruit gardens with fish ponds and livestock. Therefore, they are called VAC (Vuon-Ao-Chuong) systems, translated as "garden-pond-livestock". Different socioeconomic and geographical factors influence the types of homegardens in Vietnam. Homegardens can be categorized into two main types: extensive and intensive. Extensive homegarden systems appear to be more prevalent. The shape, size, soil conditions, plant species, and animal use

vary greatly among homegardens, significantly impacting their design (Quat 1995; Gladis et al. 2001; Trinh et al. 2003; Edwards 2010; Mohri et al. 2013; Pijika et al. 2015). Nevertheless, the basic structure, garden, pond, and livestock are always typical. Although there are various homegardens in Vietnam, they can be classified based on primary production systems, homegarden structure and composition (Table 1).

Table 1. Classification of Vietnamese homegarden structure

Type of homegarden	Location
Homegardens with fruit trees	South Vietnam
Homegardens with ponds and covered livestock	Red River delta and Central Vietnam
Homegardens with vegetables	Red River delta and Central Vietnam
Homegardens with forest trees	Northern Vietnam (mountainous regions occupied by minority nationalities)

(Source: Quat 1995; Trinh et al. 2003)

These types merely reflect the primary production system within a category of homegardens; by definition, they almost always include aspects of all the types mentioned (Figure 3).

Vietnamese homegardens are a controlled environment where each species is carefully chosen and planted. Consequently, these gardens have no "weeds" or unwanted plants - every plant serves a purpose, even if only as pig feed (Gladis et al. 2001; Pijika et al. 2015; Timsuksai & Rambo 2016). For example, common plant species cultivated in Vietnamese homegardens are banana, jack fruit, pomelo, mandarin orange, sweet potato, luffa, taro, guava, ceylon spinach, papaya and ginger (Quat 1995; Trinh et al. 2003; Vlkova et al. 2011; Pijika et al. 2015). Fruit trees, shrubs, tuber crops, vegetables, and herbs dominate their flora. Although ornamental species are grown in almost every Vietnamese homegarden, this has generally been done in low numbers. Except for those plants which are commercially grown, e.g., *Gladiolus* spp. and *Polianthes tuberosa*. As a result, the diversity within a Vietnamese garden regarding ornamentals might seem relatively low, but many plants belong to several use groups simultaneously. For example, fruit trees of ornamental character are also used for

medicine – in general, many plants can be used for several different purposes (Quat 1995; Gladis et al. 2001; Pijika et al. 2015).

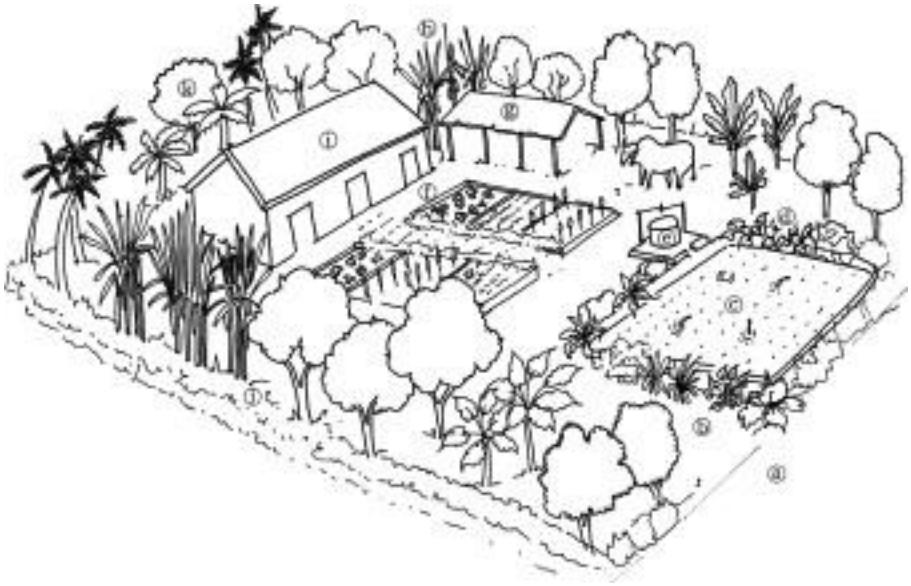


Figure 3. Schematic view of Vietnamese homegarden (Source: Mohri et al. 2013)

Homegardens have a great cultural significance in Vietnam (Quat 1995; Gladis et al. 2001; Trinh et al. 2003). The following Vietnamese folk tale, illustrating the cultural connection between homegardens and species composition, is a prove of it.

"The story tells about two brothers who were very close to each other. But their relationship changed when the older brother fell in love with a beautiful woman. The couple married, and the woman started living with the two brothers. The younger brother felt hurt and neglected because the brother gave all his attention to the woman and decided to leave. He walked a long way through a thick forest until he reached a river. But it was so vast that he couldn't cross it. So he sat and waited and waited until he died and turned to stone. Meanwhile, the older brother felt remorseful about how his younger brother had left and decided to look for him. He walked for a long time and had to pass through a dense forest until he came to the same river as his brother. He could not cross it, so he sat down on a rock, waited until he died, and turned it into a palm tree. The wife became worried because her husband did not return for a long time, and she went to look for him. She also walked through the forest until

a wide river stopped her she could not cross. She sat on a stone, leaned against a palm tree, and waited for her to die. Then, she turned into a vine winding around a tree, growing up and up in search of her husband." Based on the story, Vietnamese people associate the palm tree with the Areca palm, the vine as betel from their homegardens and the stone as $Ca(OH)_2$ together. The areca nut, betel leaf and $Ca(OH)_2$ are eaten as a tradition during the wedding to remind the married couple that husband, wife, and relatives should love and understand each other (Trinh at el. 2003).

2.3 Population growth and challenges connected to urbanization

The world's population has recently reached eight billion and continues to grow. The future of the world's population is urban - most of the population growth is concentrated in cities and urban areas. It is assumed to increase by 68% in 2050, whereas almost 90% of this growth is happening in Asia and Africa (UN DESA 2019; World Bank 2021; Asian Development Bank 2022; UN 2022).

Regarding urbanization trends in Asia, the growth in its urban population since 2000 has been more significant than in Western Europe or North America. Being the most populated continent in the world, it has and continues to experience massive population growth and urbanization. Its population in urban areas was 2.11 billion in 2015, making it home to over half of the world's urban population. As we advance, the highest increase in urban population between 2020 and 2050 is expected in South Asia at 81%. Then another 58% in Southeast Asia and 20% in East Asia. The need for better economic or social opportunities drives migration in general in Asia. People's decision to migrate to urban areas may be influenced by the search for a better standard of living with better business opportunities, education, and improved health care (Akaeze & Nandwani 2020; World Bank 2020; Asian Development Bank 2022; Cabannes et al. 2022).

Urbanization, commonly defined as the migration of people from rural to urban areas, has been a major trend in the 20th and 21st centuries. The urbanization process is closely related

to the three dimensions of sustainable development - economic, societal, and environmental. Ensuring food for humanity, mostly in cities, involves this complex system. How urbanization is managed, and its proper understanding has a considerable influence. Well-managed urbanisation, based on an appropriate sense of long-term population trends, helps maximise its benefits. But, at the same time, it can minimise the adverse effects of growing urban populations and environmental degradation, especially in low-income and lower-middle-income countries where is the most rapid urbanisation expected. On the other hand, unplanned or poorly managed urban expansion can undermine sustainability due to urban sprawl, pollution, and environmental degradation (FAO 2011; UN DESA 2019; World Bank 2020; Asian Development Bank 2022)

The process of urbanization is a common trend in many developing countries. While the trend of suburbanization, i.e. displacement of city centres and population moving to suburban areas, has prevailed in Europe and North America in recent years, developing countries are facing the exact opposite – i.e. a rapidly growing percentage of the population living in cities (Opitz et al. 2016; World Bank 2021). Vietnam is no exception, as you can see in Figure 4.

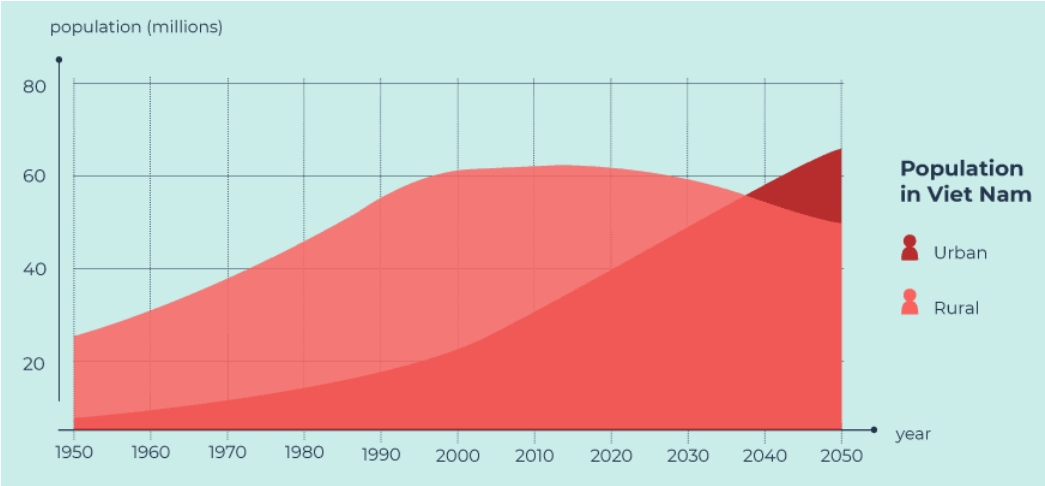


Figure 4. Urban and rural population in Vietnam (Source: UN DESA 2019)

Urbanization in Vietnam started with the initiation of economic reforms (Đổi Mới) in 1986, which led to rapid economic growth (World Bank 2020; Asian Development Bank 2022; Mulia et al. 2022). Although the urbanization level of Vietnam is still low compared to the global average, it has been higher than the average in other developing countries and

Southeast Asia in recent years. With a population of 97 million people, one-third live in urban areas, with 1 to 1.3 million people moving to the city each year (Lee et al. 2010; Nữ et al. 2012; Nguyen et al. 2016; Kurfürst 2019; UN DESA 2019; Pham & Turner 2020; Thi et al. 2020; World Bank 2020). As a result, the country has been exposed to the negative impacts of urbanization, such as traffic congestion, accidents, poor provision of services and service delivery and environmental pollution.

With the growing population come significant challenges for the future of global food production. The agri-food sector will play a central role, especially in urban places where rural–urban migration is putting pressure on urban food systems and where the dependency on rural hinterlands to supply food is reaching the limits of sustainability. The production of agrifood systems has to be more intensive and adaptive to feed and nourish the ever-increasing population of cities, reduce human and environmental health risks, and secure economic opportunities for the urban poor (Asian Development Bank 2022; CGIAR 2022).

As a result of urban expansion, homegardens are going under changes that may affect the food security of local people. Rapid urban growth has led to competition over land use, and productive agricultural land is less available and is becoming scarce. Thus, the declining size of homegardens has threatened cultivated diversity and household livelihood. In addition, reduced benefits from homegardens, mainly income or food, might force farmers to seek employment in the off-farm sector and abandon or rent out their land (Peroni et al. 2016; Prihatini et al. 2018; Lowe et al. 2021).

Another effect of urbanization on traditional homegardens is their transformation into commercial production units. The commercialisation of homegardens is caused mainly due to the rapid development of market economics and demographic pressures that drive demand increase. As a result, their functions are changing from subsistence to commercial, plant diversity is decreasing, and local species have been substituted by introduced ones, which leads to commercial crops domination (Bernholt et al. 2009; Mohri et al. 2013; Ali 2015; Prihatini et al. 2018; Abdoellah et al. 2020).

3. Aims of the thesis

There has been considerable research on homegardens in Vietnam (Hodel et al. 1999; Hung et al. 2001; Trinh et al. 2003; Vlkova et al. 2011; Mohri et al. 2013; Pijika et al. 2015; Timsuksai & Rambo 2016), but it has been focused on rural areas and studies on urban homegardens are lacking. Therefore, the thesis aims to document and assess the management, utilisation and perception of homegardens in the changing urban environment of Hue City, Central Vietnam. To meet this aim, four specific objectives were set as follows:

1. Firstly, to collect ethnobotanical data on the composition, utilisation and commercialisation of useful plant species grown in local homegardens
2. Secondly, to document the socioeconomic characteristics of gardeners
3. Thirdly, to quantify agrobiodiversity of selected homegardens
4. Lastly, to document potential changes in current and past awareness and perception of households toward homegardens development

We asked four central research questions to fill this scientific gap: (1) What is the species composition and use in the surveyed urban area of Vietnam? (2) What is the level of agrobiodiversity in the surveyed Vietnamese homegardens? (3) What influences agrobiodiversity in homegardens of Hue? (4) How do owners perceive their gardens in the urban environment?

4. Methodology

4.1 Study site characteristics

The fieldwork was conducted in the medium-sized city of Hue, Thua Tien Hue province in Central Vietnam (Figure 5). In 2021, the total population of Thua Thien Hue province was 1,153,795, with 52.82% of people living in the city and 47.18% of people living in rural areas. Hue was the imperial capital of Vietnam under the Nguyen Dynasty (1802-1945) and is currently the capital city of Thua Thien Hue Province. Hue City is one of Vietnam's most densely populated cities, with approximately 1,844 persons/km^2 and a population of 491,346 habitats. It has a total area of 266.46 km^2 with 36 units, including 29 wards and seven communes (Nguyen 2017; Braun et al. 2020; Thua Thien Hue Statistical Yearbook 2021).

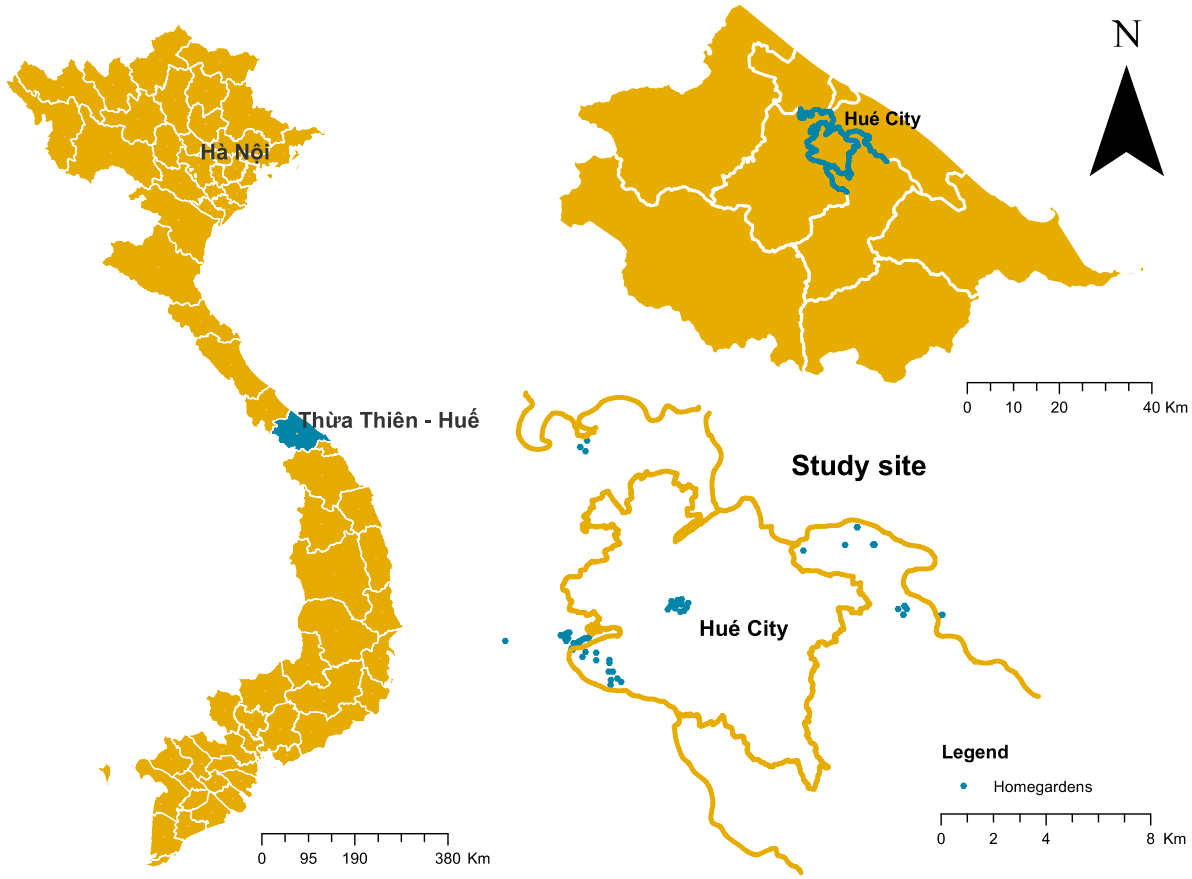
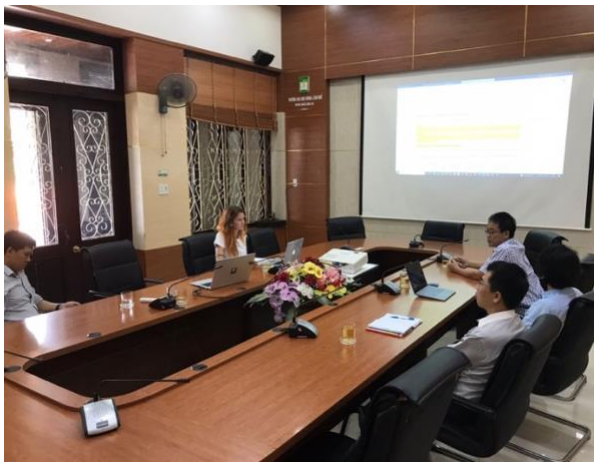


Figure 5. Location of the Hue City, Thua Thien Hue Province, Central Vietnam

Generally, the climate in central Vietnam is characterised by distinct tropical wet and dry seasons, variable temperatures, and eastern tropical monsoons. Hue City is located at latitude 16°20'-16°450' and longitude 107°35'-16°200' with an elevation between 5-1,760 m above sea level. Annual precipitation rates are amongst the highest in Vietnam, ranging between 2,500–3,000 mm, mainly concentrated from September to December. On the other hand, the dry season is from May to September, with dry air from southwest winds. Also, it has high humidity, with an average annual level of 85 to 88%. The yearly average temperature is 25°C, with an average temperature of 29 to 30°C during summer and 20 to 23°C in winter (Haase et al. 2020; Dung et al. 2021). Hue City is located approximately 10 kilometres from the coast. It is divided by the Perfume River into a north-western part, dominated mainly by the structure of the Imperial City, and the more urbanized south-eastern part. Perfume River is the longest river in the province, with a basin area of 2,830 $km^{2,}$ and it is the primary source of domestic and irrigation water for agriculture (Haase et al. 2020; Dung et al. 2021; Thua Thien Hue Statistical Yearbook 2021).

4.2 Research design and data collection

Research started with expert team meetings and questionnaire development (Figure 6).



(a)

(b)

Figure 6. Meeting of the expert team at HUAF (a) and direct observation of homegarden (b)

Hue City was selected through convenient and purposive sampling due to its location, rich history in homegardening and rapid recent socioeconomic development (Trinh et al. 2003;

World Bank 2020). The survey was undertaken in urban and peri-urban areas selected through a multistage sampling approach in agreement with experts from HUAF and presented in Figure 5. The first step was a pilot investigation through direct observation of homegardens around the city and interviewing their owners and other household members. Consequently, discussions with HUAF experts and key stakeholders resulted in developing a structured questionnaire comprising 26 questions, mixing multiple choices, free listing, and Likert scale questions. Then, the questionnaire was tested on four households (Figure 7) and modified according to responses. Finally, respondents were selected using a combination of snowball and convenient methods (Tongco 2007; Vlkova et al. 2011).

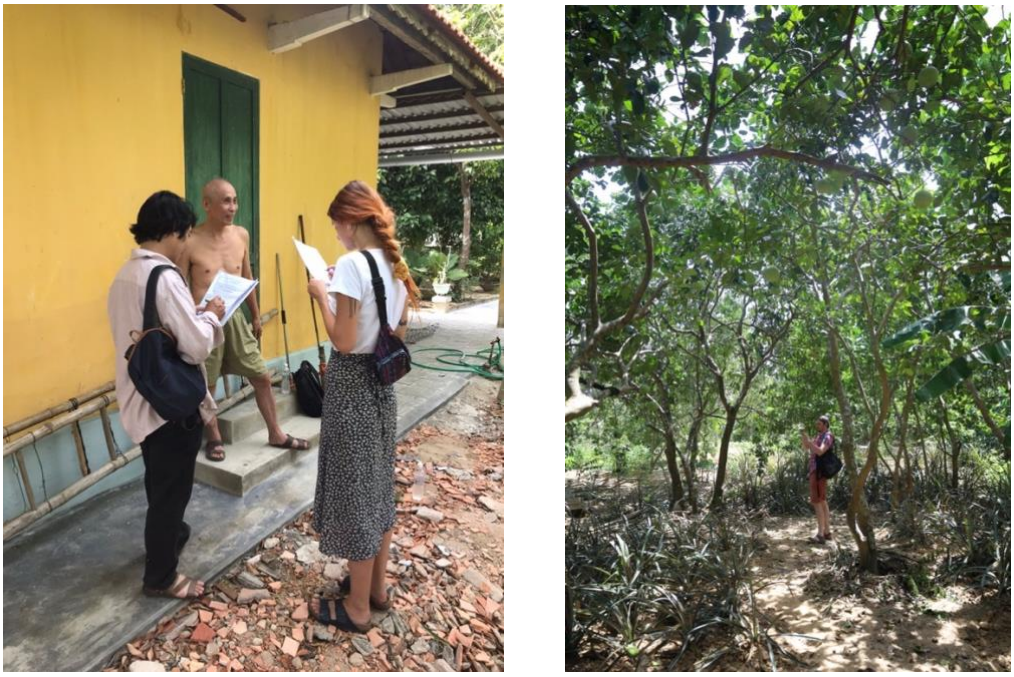


Figure 7. Pretesting of the questionnaire

A questionnaire survey was conducted by HUAF between July and November 2022 (before the rainy season usually starts). Specialists from a partner university interviewed altoghether 100 homegarden owners, of which 64 were filled entirely and suitable for masters thesis. Homegardens were inventoried using the field methods such as direct observation and semi-structured interviews (Vogl et al. 2004; Vlkova et al. 2011). The respondent was always the household head, predominantly men whose age ranged from 32 to 95 years (Table 2). Since interviewees speak Vietnamese, the interviews were conducted in the Kinh language and

collected data were subsequently translated into English (the English version of the questionnaire is in Annex 1).

Table 2. Characteristics of the respondents per district

District	Informants	Male	Female
Thuy Van	5	4	1
Huong Toan	3	2	1
Thuy Thanh	6	4	2
Huong Ho	12	12	0
Huong An	11	10	1
Thuy Bieu	12	9	3
Kim Long	15	9	6
Total	64	50	14

The questionnaire was divided into four chapters. The first part recorded basic information about the household head and household, including gender, age, education level and the number of family members. Furthermore, we asked about their financial situation, credits, annual livelihood and cash income diversification. The second part consisted of questions related to homegarden such as their gender aspect, size and age. Then, respondents answered Likert scale questions about reasons to have homegarden, problems related to homegarden, and the most important cash inputs. The third part recorded information related to urban planning in Hue City – urban pressure, compensation for the loss of the land and further assistance. Finally, respondents were asked to list plant species grown in their homegarden. Respondents used free-listing and filled in the following ethnobotanical information on species name, number of individuals of each species per homegarden together with plant part used and mode of use, harvest time, final consumer, who decided to cultivate that species and time perspective in the past and future.

Less-known plant samples were taken by Dr. Khoa Tran Dang during the fieldwork and processed into the voucher specimens by putting samples into newspaper and pressing them with a wooden plant press. Finally, voucher specimens were taken to the Hue University of Agriculture and Forestry for further identification.

4.3 Data analysis

Collected data were cleared, summarized, entered and coded in MS Office Excel. Then, the standard statistical methods were applied in Jamovi software version 2.3 (The Jamovi Project 2022). Due to the respondents' willingness to answer, in-depth analyses were only applied to questionnaires that did not lack any data. That is why 36 homegardens were excluded from the analysis. Unfortunately, regular rainy seasons and floods postponed the delivery of the final version in late-February 2023.

4.3.1 Documenting knowledge and use of plants

Plant species were identified and classified in cooperation with Dr. Khoa Tran Dang and verified (synonyms and authorities) according to International Plant Names Index (2023). In addition, the ethnobotany approach was used to document knowledge and use of plants, particularly the frequency of citation and use-value.

Frequency of Citation

The frequency of citation was used to determine the importance and incidence of a citation for each specific species (Albertin & Nair 2004). The calculation is straightforward as it is the sum of informants that mention the use of the plant species.

Use-Value

The local importance of each species cited was calculated using Use-Value (UV) with the following formula:

$$UV = \sum Ui/n \quad (1)$$

Ui = the number of uses mentioned by each informant for a given species, n = the total number of informants (Rossato et al. 1999; Silva & Albuquerque 2004; modified from Phillips & Gentry 1993a, 1993b). UV will be high if the value is nearone1, indicating many use reports for a given plant and centrality of plant species among informants, while the UV

will be low if its value is close to 0, which shows not many use reports for a given plant species.

4.3.2 Quantification of useful agrobiodiversity

The agrobiodiversity was quantitatively analysed using relevant and standard indices and indicators. The following indices were calculated:

Margalef Index

The homegarden species richness was calculated using the Margalef Index that was already used in other studies (see, e.g.), which aimed to document x (Margalef 1969):

$$D_{MG} = \frac{(s-1)}{\ln(n)} \quad (2)$$

Where s is the number of species recorded, and n is the total number of individuals in the sample.

Shannon-Wiener Index

The level of agrobiodiversity was calculated by using the Shannon-Wiener index and was calculated by the following equation (Magurran 1988):

$$H' = -\sum_{i=1}^{R} p_i \ln p_i \quad (3)$$

Where pi is the proportional abundance of I species in the number of individuals of all the species. The Shannon-Wiener index is higher when the relative abundance of the different species in the sample is even and is low when a few species are more abundant than the others.

Simpson's diversity Index

Simpson's index (Simpson 1949) describes the probability that a second individual drawn from a population should be of the same species as the first. The range is from 0 to 1, where values close to 1 indicate high diversity and values close to 0 indicate low diversity. Simpson's index is calculated with the following formula:

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i-1)}{N(N-1)} \quad (4)$$

Where n is the number of individuals of each species, and N is the total number of individuals of all species.

4.3.3 Cluster analysis – differentiation of homegarden types

A hierarchical cluster analysis was applied to classify 64 homegardens using the number of species, Shannon-Wiener index and homegarden size as the main variables (Thompson et al. 2010; Vlkova et al. 2011). Ward's minimum variance method was used to identify homegarden types with Euclidean distances as a dissimilarity measure.

Each type of homegarden was consequently characterised using the following variables: (1) number of plant species; (2) plant abundance; (3) HGD size; (4) Shannon-Wiener index; (5) Margalef index; and (6) HH gender; (7) HH age; (8) HH education; (9) HH gardening experience; (10) HH off-farm job; (11) market orientation; (12) farming system; (13) gender of HGD worker; (14) gender of HGD income decision maker. Three homegardens were regarded as outliers because of their enormous size, so they were excluded from the statistical analysis.

4.3.4 Motivations and perceptions of homegardeners towards current challenges

The Likert scale was used to provide information about the motivations and perceptions of gardeners. In the analysis of reasons to run homegardens, answers were rated on the level of importance on the scale from 1 (extremely important) to 5 (not important). In analysing major

problems related to homegardens, answers were rated on the level of importance on the scale from 1 (most serious problem) to 5 (not serious problem). Finally, descriptive statistics (means and standard deviations) were applied to get the impression of the motivations and perceptions of 64 gardeners.

5. Results

5.1 Households and homegardens characteristics

Characteristics of the surveyed households are displayed in Table 3. Most families (75%) were led by males and the remaining 25% by females. The average age of the household head was approximately 68 years, whereas the youngest was 35 years old, and the oldest was 95 years old. The average number of family members was around six and varied from one to nine people. The average length of a household's head schooling was 8.97 years and ranged between 1 and 12 years. Additionally, 72% of household heads had an off-farm job. Household heads gardened on average for 32 years. The surveyed homegardens ranged from 108 to 6,480 m^2, and the average size was 1,358 m^2. An example of a typical homegarden in Hue is shown in Figure 8. Regarding the division of roles in the homegardens, 84% of males did the gardening, and 45% of females decided about income.

Table 3. Characteristics of the surveyed households and homegardens

Observed characteristics	Mean	Range
HH[a] head age	67.58 (±13.52)	32-95
HH head schooling	8.97 (±2.40)	1-12
No. of HH members	4.56 (±1.82)	1-9
HH head gardening experience	31.58 (±12.71)	10-60
HGD[b] size (m^2)	1,358.04 (±1,125.80)	108-6,480

[a] HH – household
[b] HGD – homegarden

Regarding economic characteristics, 88% of respondents were slightly or moderately satisfied with their economic situation. In addition, 67% of respondents said they have a better financial position than ten years ago, and five respondents said it is worse.

Furthermore, two families declared having a credit to promote their homegarden provided by a bank or garden-development project.

For most gardeners, the homegarden is an essential source of income, which is subsequently used for various purposes. For example, 88% of respondents use the earnings from the homegarden to cover their daily living expenses. The rest of the costs are mostly returned to the garden by purchasing fertilizers (34%), seeds and planting materials (23%), plant protection products (16%) and manure (5%). In addition, three respondents use homegardens income to hire the additional labour force, and four buy garden tools or pay for repairments in the garden area. The rest of the respondents (14%) use the money to provide education for their children, pay for health care, reinvest the money or save it.

Figure 8. A typical homegarden in Thuy Van district

5.2 Ethnobotany inventory and use of species in urban gardens

Altogether we identified 86 different cultivated plant species belonging to 44 botanical families, most represented by Cucurbitaceae (8 species), Solanaceae (6 species), Rutaceae (5

species), Fabaceae (5 species) and Asteraceae (5 species). Less than five species represented the remaining 39 families. The number of species ranged from 2 to 19 per homegarden, and the average number of species was eight per homegarden. Some examples are shown in Figure 9. The most frequently observed plant species were *Musa* spp. (70%), followed by *Ipomoea batatas* (59%), *Citrus grandis* (50%)**,** *Bouea macrophylla* (39%), *Artocarpus heterophyllus* (36%), *Areca catechu* (31%), *Ananas comosus* (31%), *Capsicum* spp. (27%), *Basella alba* (22%), *Psidium guajava* (20%) and *Sauropus androgynus* (20%).

Figure 9. Examples of cultivated species
(*Musa* spp. on the left, *Durio zibethinus* on the right)

The plant uses were categorized into nine use categories: food, medicine, ceremonial, animal feed, material or construction, wood, cosmetics, ornamental and others. Whereas 97% of species served as food, 13% as medicine, 7% for ceremony purposes and 2% as animal feed (*Ipomoea batatas*, *Manihot esculenta*). But at least 21% of all species were characterised by

multiple uses, usually combining food and medicinal purposes. The proportion of plant parts used is shown in Figure 10, and fruit (14.94%), leaf (34.48%) and whole plant (14.94%) were the main parts used. The species name, frequency, use value, mode of use and part of use encountered during the study, with 11 of the most frequent species being highlighted, are given in Table 4.

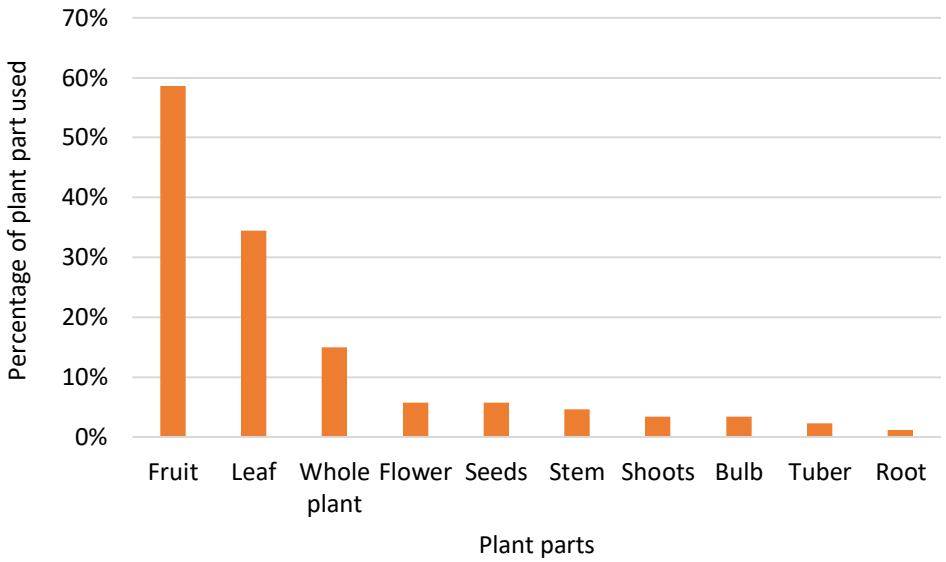


Figure 10. The proportion of plant parts used

Table 4. Ethnobotanical data on plant species cultivated in urban and peri-urban homegardens of Hue City

Species	Scientific name	Local name	Botanical family	F (%)	UV	Use	Part used
Aloe Vera	*Aloe vera* (L.) Burm. f.	Lô hội	Asphodelaceae	1.56	2.00	Food Medicine	Leaf
Amaranth	*Amaranthus* L.	Rau dền	Amaranthaceae	17.19	1.00	Food	Whole plant Leaf
Ambarella	*Spondias dulcis* Parkinson	Cóc	Anacardiaceae	1.56	1.00	Food	Fruit
Areca	***Areca catechu* L.**	**Cau**	**Arecaceae**	**31.25**	**1.30**	**Food Ceremony Other**	**Fruit**
Asian spinach	***Basella alba L.***	**Mồng tơi**	**Amaranthaceae**	**21.88**	**0.07**	**Food**	**Leaf**
Asparagus	*Asparagus officinalis* L.	Măng tây	Asparagaceae	1.56	1.00	Food	Shoots
Avocado	*Persea americana* Mill.	Bơ	Lauraceae	3.13	1.00	Food	Fruit
Banana	***Musa* L.**	**Chuối**	**Musaceae**	**70.31**	**1.22**	**Food Ceremony Cosmetics Other**	**Whole plant Flower Fruit**
Basil	*Ocimum* L.	Rau thơm	Lamiaceae	4.69	1.33	Food Medicine	Whole plant Leaf
Betel	*Piper betle* L.	Trầu không	Piperaceae	3.13	2.00	Food Ceremony	Leaf
Bitter melon	*Momordica charantia* L.	Mướp đắng	Cucurbitaceae	10.94	1.00	Food	Fruit
Black beans	*Vigna mungo L.*	Đậu đen	Fabaceae	3.13	1.00	Food	Seeds
Bottle gourd	*Lagenaria siceraria* (Molina) Standl.	Bầu	Cucurbitaceae	9.38	1.00	Food	Fruit
Burmese grape	*Baccaurea ramiflora* Lour.	Dâu tiên	Phyllanthaceae	9.38	1.00	Food	Fruit
Canadian goldenrod	*Solidago canadensis* L.	Hoàng anh	Asteraceae	1.56	1.00	Ceremony	Flower
Cassava	*Manihot esculenta* Crantz	Sắn	Euphorbiaceae	9.38	1.00	Food Animal feed	Tuber

Table 4. Continued

Species	Scientific name	Local name	Botanical family	F (%)	UV	Use	Part used
Chilli	***Capsicum* L.**	**Ớt**	**Solanaceae**	**26.56**	**1.00**	**Food**	**Fruit** **Leaf**
Cilantro	*Eryngium foetidum* L.	Ngò gai	Apiaceae	6.25	1.00	Food	Whole plant Leaf
Cinnamon	*Cinnamomum verum* J. Presl	Quế	Lauraceae	1.56	1.00	Food	Leaf
Citronella	*Cymbopogon* L.	Sả	Poaceae	18.75	1.17	Food Medicine	Leaf Shoot Stem
Coconut	*Cocos nucifera* L.	Dừa	Arecaceae	4.69	1.00	Food	Fruit
Cochinch	*Solanum procumbens* Lour.	Cà gai leo	Solanaceae	1.56	1.00	Medicine	Fruit
Cowpea	*Vigna unguiculata* (L.) Walp.	Đậu đũa	Fabaceae	3.13	1.00	Food	Seeds
Crown daisy	*Glebionis coronaria* (L.) Cass. ex Spach	Rau tần ô	Asteraceae	1.56	1.00	Food	Leaf
Cucumber	*Cucumis sativus* L.	Dưa leo	Cucurbitaceae	3.13	1.00	Food	Fruit
Custard apple	*Annona reticulata* L.	Na	Annonaceae	1.56	1.00	Food	Fruit
Dragon fruit	*Selenicereus undatus* (Haw.) D.R.Hunt	Thanh long	Cactaceae	6.25	1.00	Food	Fruit
Eggplant	*Solanum melongena* L.	Cà tím	Solanaceae	3.13	1.00	Food	Fruit
Fig	*Ficus carica* (Miq.) Endl.	Vả	Moraceae	9.38	1.00	Food	Fruit
Fish mint	*Houttuynia cordata* Thunb.	Diếp cá	Saururaceae	1.56	1.00	Food	Leaf
Gac fruit	*Momordica cochinchinensis* (Lour.) Spreng.	Gấc	Cucurbitaceae	4.69	1.00	Food	Fruit
Galangal	*Alpinia galanga* (L.) Willd.	Riềng nếp	Zingiberaceae	1.56	1.00	Food	Stem Rhizomes
Garlic chives	*Allium tuberosum* Roxb.	Hẹ	Amaryllidaceae	1.56	1.00	Food	Leaf
Gold fruit	*Diospyros decandra* Lour.	Thị	Ebenaceae	3.13	1.00	Food	Fruit
Green beans	*Vigna radiata* (L.) R.Wilczek	Đậu xanh	Fabaceae	1.56	1.00	Food	Seeds
Green tea	*Camellia sinensis* (L.) Kuntze	Chè	Theaceae	1.56	1.00	Food	Leaf
Guava	***Psidium guajava* L.**	**Ổi**	**Myrtaceae**	**20.31**	**1.00**	**Food**	**Fruit**
Jackfruit	***Artocarpus heterophyllus* Lam.**	**Mít**	**Moraceae**	**35.94**	**1.00**	**Food**	**Fruit**

Table 4. Continued

Species	Scientific name	Local name	Botanical family	F (%)	UV	Use	Part used
Kangkong	*Ipomoea aquatica* Forssk.	Rau muống	Convolvulaceae	7.81	1.00	Food	Leaf Stem
Katuk	***Sauropus androgynus* (L.) Merr.**	**Bông ngọt**	**Phyllanthaceae**	**20.31**	**1.00**	**Food**	**Whole plant** **Fruit** **Leaf**
Laksa leaves	*Persicaria odorata* (Lour.) Soják	Rau răm	Polygonaceae	1.56	1.00	Food	Leaf
Leaf mustard	*Brassica juncea* (L.) Czern.	Cải bẹ xanh	Brassicaceae	12.50	1.00	Food	Leaf Fruit
Lemon	*Citrus limon* (L.) Burm. f.	Chanh	Rutaceae	12.50	1.13	Food Medicine	Fruit
Lettuce	*Lactuca sativa capitata* L.	Xà lách	Asteraceae	6.25	1.00	Food	Leaf
Litchi	*Litchi chinensis* Sonn.	Vải	Sapindaceae	3.13	1.00	Food	Fruit
Longan	*Dimocarpus longan* Lour.	Nhãn	Sapindaceae	4.69	1.00	Food	Fruit
Lotus	*Nelumbo nucifera* Gaertn.	Sen	Nelumbonaceae	1.56	2.00	Food Medicine	Seeds Flower
Lucuma	*Pouteria lucuma* (Ruiz & Pav.) Kuntze	Trứng gà	Sapotaceae	1.56	1.00	Food	Fruit
Maize	*Zea mays* L.	Ngô	Poaceae	1.56	2.00	Food Other	Whole plant
Mandarin orange	*Citrus reticulata* Blanco	Quýt	Rutaceae	3.13	1.00	Food	Fruit
Mango	*Mangifera indica* L.	Xoài	Anacardiaceae	3.13	1.00	Food	Fruit
Mangosteen	*Garcinia mangostana* L.	Măng cụt	Clusiaceae	18.75	1.00	Food	Fruit
Marian plum	***Bouea macrophylla* Griff.**	Thanh trà	**Anacardiaceae**	**39.06**	**1.00**	**Food**	**Fruit**
Ming aralia	*Polyscias fruticosa* (L.) Harms.	Đinh lăng	Araliaceae	3.13	1.50	Food Medicine	Leaf
Mugwort	*Artemisia vulgaris* L.	Ngải cứu	Asteraceae	6.25	1.25	Food Medicine	Leaf Shoots
Okra	*Abelmoschus esculentus* (L.) Moench	Đậu bắp	Malvaceae	6.25	1.00	Food	Seeds Fruit

Table 4. Continued

Species	Scientific name	Local name	Botanical family	F (%)	UV	Use	Part used
Orange	*Citrus* × *sinensis* (L.) Osbeck	Cam	Rutaceae	7.81	1.00	Food	Fruit
Pandan	*Pandanus amaryllifolius* Roxb. ex Lindl.	Lá dứa	Pandanaceae	4.69	1.00	Food	Leaf
Papaya	*Carica papaya* L.	Đu Đủ	Caricaceae	17.19	1.18	Food Medicine Ceremony	Flower Fruit
Parsley	*Petroselinum crispum* (Mill.) Fuss	Ngò	Apiaceae	1.56	1.00	Food Medicine	Leaf
Peach	*Prunus* L.	Đào	Rosaceae	1.56	1.00	Food	Fruit
Peanut	*Arachis hypogaea* L.	Lạc	Fabaceae	1.56	2.00	Food Other	Whole plant
Pennywort	*Centella asiatica* (L.) Urb.	Rau má	Apiaceae	3.13	1.00	Food	Leaf Stem
Pepper	*Piper nigrum* L.	Tiêu	Piperaceae	4.69	1.00	Food	Fruit
Perilla	*Perilla frutescens* (L.) Britton	Tía tô	Lamiaceae	6.25	1.25	Food Medicine	Whole plant Leaf
Pineapple	***Ananas comosus* (L.) Merr.**	**Dứa**	**Bromeliaceae**	**31.25**	**1.00**	**Food**	**Fruit**
Piper lolot	*Piper sarmentosum* Roxb.	Lốt	Piperaceae	7.81	1.00	Food	Leaf
Pomelo	***Citrus grandis* var. *grandis* Hassk.**	**Tranh trà**	**Rutaceae**	**50.00**	**1.00**	**Food**	**Fruit**
Pomelo	*Citrus grandis* Hassk.	Bưởi	Rutaceae	12.50	1.00	Food	Fruit
Pumpkin	*Cucurbita moschata* Duchesne	Bí rợ	Cucurbitaceae	10.94	1.00	Food	Fruit Leaf
Purple yam	*Dioscorea alata* L.	Khoai mỡ	Dioscoreaceae	3.13	1.00	Food	Tuber
Sapodilla	*Manilkara zapota* (L.) P.Royen	Hồng xiêm	Sapotaceae	12.50	1.00	Food	Fruit
Sapote	*Achras sapota* L.	Xa pô chê	Sapotaceae	1.56	1.00	Food	Fruit
Sesame	*Sesamum indicum* L.	Vừng	Pedaliaceae	7.81	1.00	Food Other	Whole plant
Sponge Gourd	*Luffa aegyptiaca* Mill.	Mướp hương	Cucurbitaceae	1.56	2.00	Food	Fruit
Star apple	*Chrysophyllum cainito* L.	Vú sữa	Sapotaceae	7.81	1.00	Food	Fruit

Table 4. Continued

Species	Scientific name	Local name	Botanical family	F (%)	UV	Use	Part used
Star fruit	*Averrhoa carambola* L.	Khế	Oxalidaceae	6.25	1.00	Food	Fruit
Sweet potato	***Ipomoea batatas* (L.) Lam.**	**Khoai lang**	**Solanaceae**	**59.38**	**1.03**	**Food** **Animal feed**	**Tuber** **Leaf**
Taro	*Colocasia esculenta* (L.) Schott	Khoai sọ	Solanaceae	7.81	1.00	Food	Whole plant Leaf Stem
Tea tree	*Melaleuca alternifolia* Cheel	Tràm trà	Myrtaceae	1.56	1.00	Food	Leaf
Tomato	*Solanum lycopersicum* L.	Cà chua	Solanacea	3.13	1.00	Food	Fruit
Tonkin creeper	*Telosma cordata* Merr.	Thiên lý	Apocynaceae	3.13	1.00	Food	Flower
Watermelon	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Dưa Hấu	Cucurbitaceae	1.56	1.00	Food	Fruit
Wax gourd	*Benincasa hispida* (Thunb.) Cogn.	Bí đao	Cucurbitaceae	9.38	1.00	Food	Fruit
Yardlong bean	*Vigna unguiculata* (L.) Walp.	Đậu dải	Fabaceae	1.56	1.00	Food	Fruit

5.3 Agrobiodiversity and commercialisation trends of local homegardens

Species diversity, richness and evenness were calculated for 64 homegardens (Table 5). In total, it was observed 86 species (some examples are shown in Figure 11). The richest homegardens contained 19 species, whereas the poorest garden held just 2 species. The average diversity index value for homegardens in the study area was Shannon-Wiener 1.25, Margalef 1.12 and Simpson's index 0.60. A higher value of Simpson's index reflects less evenness in the homegarden, implying that plant diversity is more or less on the higher level.

Table 5. Plant species diversity in homegardens

Observed characteristics (n^a = 64)	Mean	Range
Number of species/HGD[b]	8.06 (±3.63)	2-19
Shannon-Wiener index/HGD	1.25 (±0.48)	0.06-2.31
Margalef index/HGD	1.12 (±0.51)	0.14-3.01
Simpson's index/HGD	0.60 (±0.21)	0.02-0.99

[a] n – number of surveyed households
[b] HGD – homegarden

Figure 11. Examples of cultivated crops in the homegardens (*Ananas comosus* on the left, *Arachis hypogaea* on the right)

Among the food crops, out of 86 species, 67 were commercialized to generate an income. In order to identify the commercialisation character of the surveyed homegardens, the average values of the production sold on the market were calculated. Based on this, species were

defined as mainly cash crops. The most cited species are shown in Figure 12. 19 species were not used for selling at all (*Aloe vera*, *Allium tuberosum*, *Alpinia galanga*, *Asparagus officinalis*, *Arachis hypogaea*, *Camellia sinensis*, *Cucumis sativus*, *Melaleuca alternifolia*, *Piper betle*, *Polyscias fruticosa*, *Pouteria sapota*, *Sesamum indicum*, *Solanum procumbens, Solanum lycopersicum*, *Solidago canadensis*, *Vigna mungo, Vigna radiata, Vigna unguiculata* and *Zea mays*).

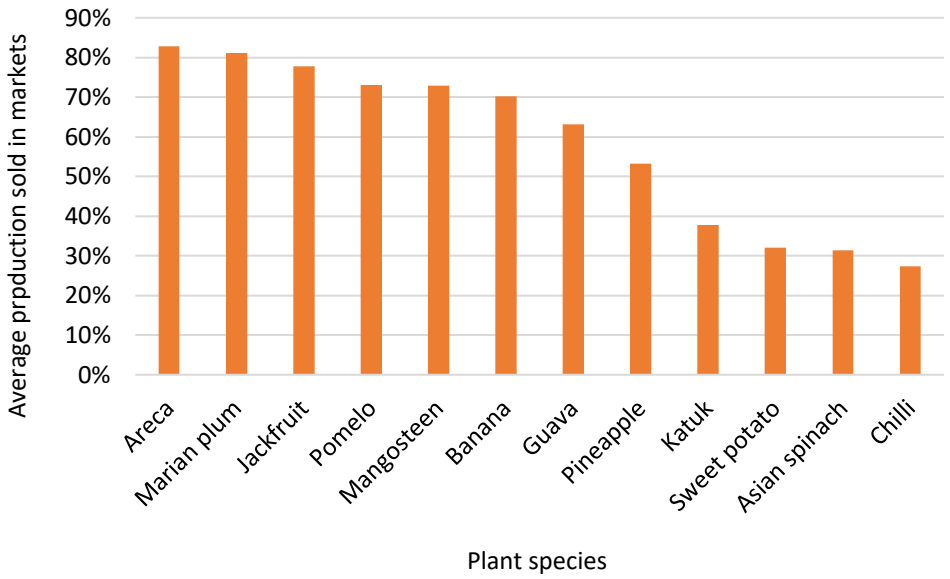
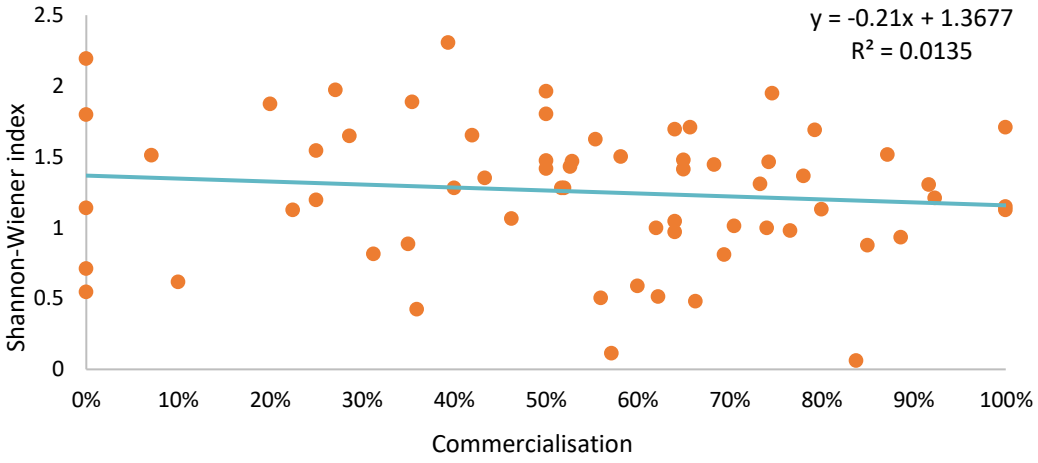
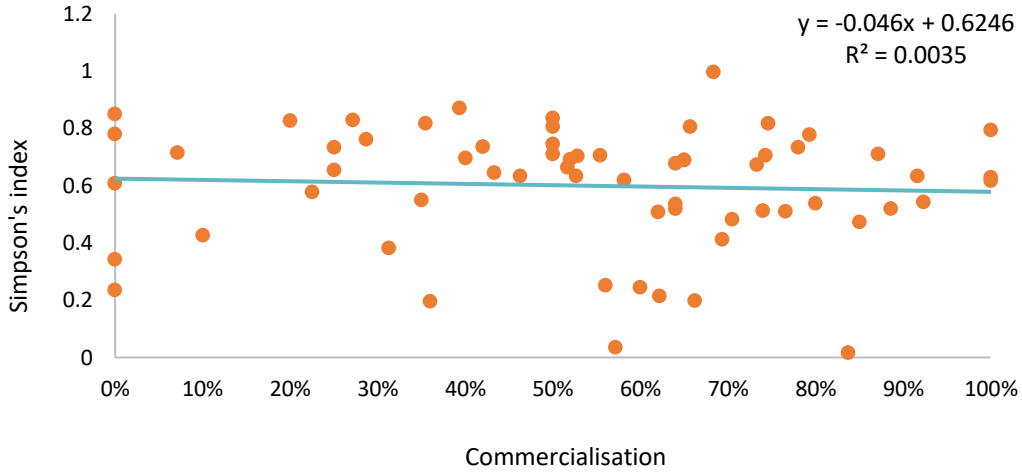


Figure 12. The level of market-orientation among the most frequently cited species

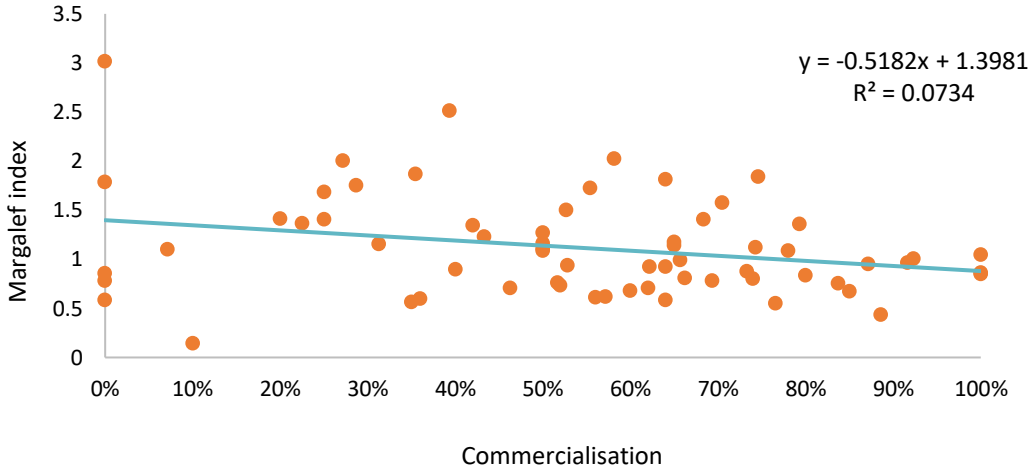
To explore any connection between the homegarden's commercialisation level and its agrobiodiversity, a correlation was made between the mentioned commercialisation and the Shannon-Wiener, Simpson and Margalef indices (Figure 13).



a. Correlation coefficient = -0.1163; R^2 = 0.0135; p-value = 0.360



b. Correlation coefficient = -0.0592; R^2 = 0.0035; p-value = 0.642



c. Correlation coefficient = -0.2709; R^2 = 0.0734; p-value = 0.030

Figure 13. Associations between commercialisation and agrobiodiversity in selected homegardens (a) Shannon-Wienner index, (b) Simpson's index, and (c) Margalef index

A statistically significant correlation was documented only between the Margalef index and commercialisation (p-value lower than 0.05). In the other two indices, no statistically significant correlation was reported (p-value higher than 0.05). Therefore, Hierarchical cluster analysis was conducted to see potential types of homegardens in Hue City. Based on cluster analysis using a dissimilarity index of 8.0 as a cut-off point, the 61 selected homegardens were categorised into three clusters (Figure 14). Based on the characteristics (size of HGD, number of species, diversity indices and species abundance) we have decided to name Group 1 as Homegardens with rich biodiversity, Group 2 as Traditional homegardens and Croup 3 as Commercial homegardens (Table 6).

Table 6. Characteristics of homegarden types in Hue City based on cluster analysis

	Homegarden types		
	Rich in biodiversity (n = 24)	Traditional (n = 22)	Commercial (n = 15)
HGD size (m^2)	1,077.00 (± 442.17)	699.22 (± 295.65)	1,917.60 (± 298.25)
Number of species	11.29 (± 3.68)	5.95 (± 1.62)	6.00 (± 1.69)
Abundance	2,612.68 (± 5,383.75)	454.75 (± 475.26)	3,568.07 (± 4,995.29)
Shannon-Wiener index	1.72 (± 0.24)	1.03 (± 0.31)	0.92 (± 0.45)
Simpson's index	0.76 (± 0.07)	0.54 (± 0.20)	0.47 (± 0.23)
Margalef index	1.57 (± 0.50)	0.93 (± 0.30)	0.74 (± 0.22)
HH gender (% of women)	25.00 (± 44.20)	31.82 (± 47.73)	6.67 (± 25.78)
HH age (years)	67.83 (± 14.81)	66.80 (± 13.94)	67.33 (± 10.57)
HH education (years)	8.88 (± 2.51)	8.50 (± 2.89)	9.60 (± 1.30)
HH HGD experience (years)	29.71 (± 14.37)	33.23 (± 11.26)	30.47 (± 11.29)
HH off-farm job (% of HH who have an off-farm job)	70.80 (± 46.40)	72.72 (± 45.59)	73.28 (± 45.82)
HGD female labour (% of women contribution to HGD management)	12.50 (± 33.81)	18.20 (± 39.53)	13.34 (± 35.24)
HGD female role in the decision-making process (% of women as major decision-makers on HGD income use)	50.00 (± 51.10)	40.94 (± 50.31)	46.71 (± 51.60)
Market orientation (%)	47.04 (± 25.62)	54.40 (± 28.17)	57.74 (± 26.14)
Farming system (subsistence = 0-50%; commercial = 51-100%)	45.80 (± 50.91)	59.14 (± 50.29)	73.34 (± 45.77)

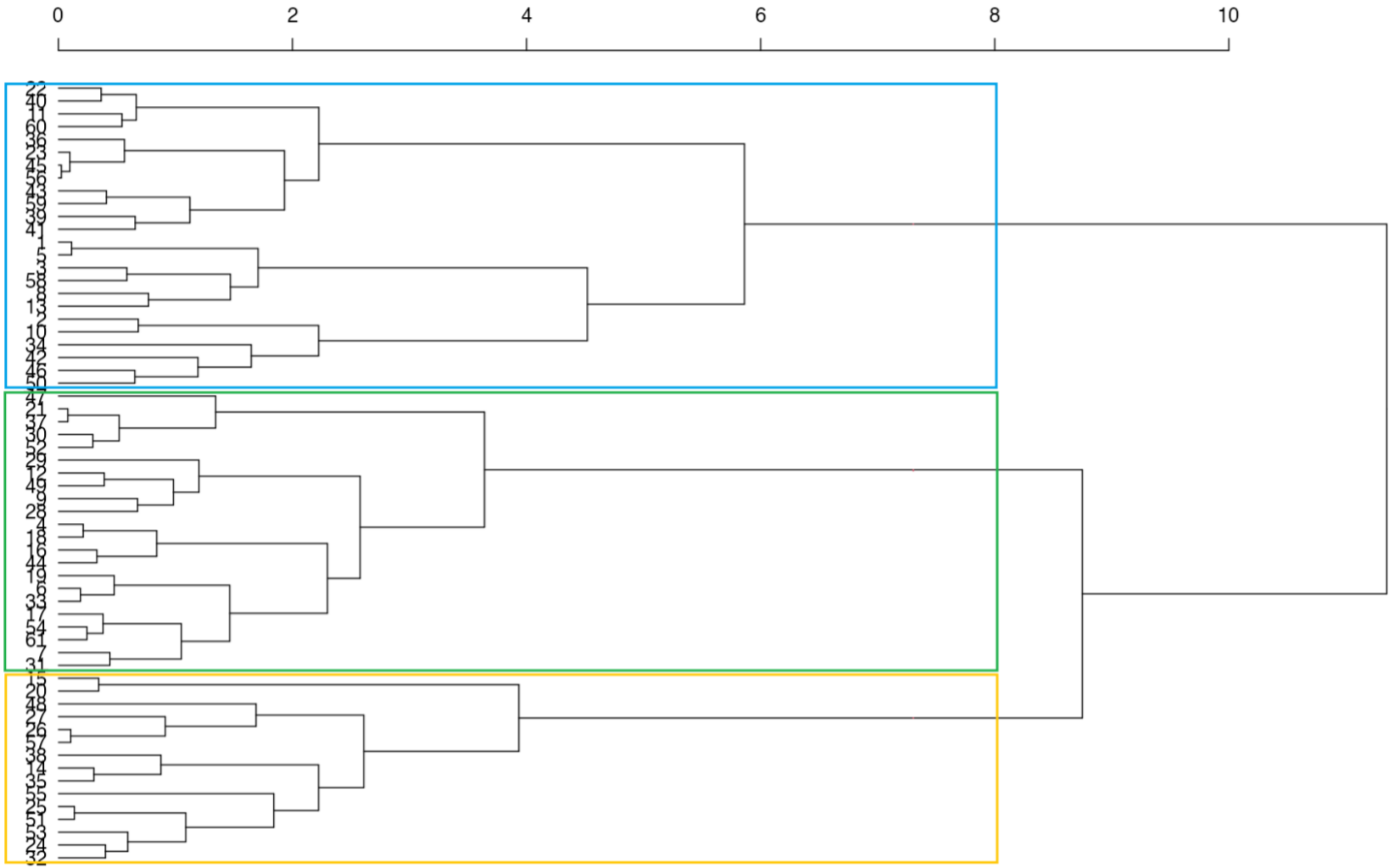


Figure 14. Cluster dendrogram of Hue homegardens based on Ward's method with Euclidean distances as a measure of dissimilarity

Household head age, education level and off-farm job were more or less the same within the clusters. Type 1 was constituted of 24 gardens of mid-size (average 1,077 m^2), which were characterised by the highest number of species (average of 11.29 species) and highest diversity (highest Shannon-Wiener, Simpson and Margalef indices). Also, Type 1 was the least commercialised, with 47% of plant production sold on the markets, therefore practised subsistence farming. Whether some part of the production was sold, women participated in decisions about using the income from the garden to the same extent as men.

Types 2 and 3 comprised 22 and 15 gardens and had more or less the same number of species (±6). Homegardens from Type 2 were the smallest in size (average 699 m^2) and had the lowest abundance (455 individuals). Type 2 had the most women as household heads (31.8%) of all three groups, with the higher number of women contributing to the management of homegarden. Moreover, household heads had the amplest gardening experience (33.23 years).

On the contrary, homegardens from Type 3 were the most extensive (1,918 m2 on average) and had the highest plant abundance (3,568 individuals). Furthermore, the household heads from Type 3 were primarily men, as only 6% of women were the head of the household, and they were the most educated. Moreover, they practised a commercial farming system, and these households had the highest percentage of plant production sold in the markets (57.74% of production).

5.4 Motivations and perceptions of homegardeners towards current challenges

The main reason for running a homegarden (measured on a scale of importance from 1 to 5) was to provide fresh food for household members, which is healthy and tasty, followed by continuity in family traditions and reduced food expenses (Figure 15). Nevertheless, homegardens are perceived as a pleasant environment and a place to keep biodiversity (free choice of species – homegarden is an expression of myself).

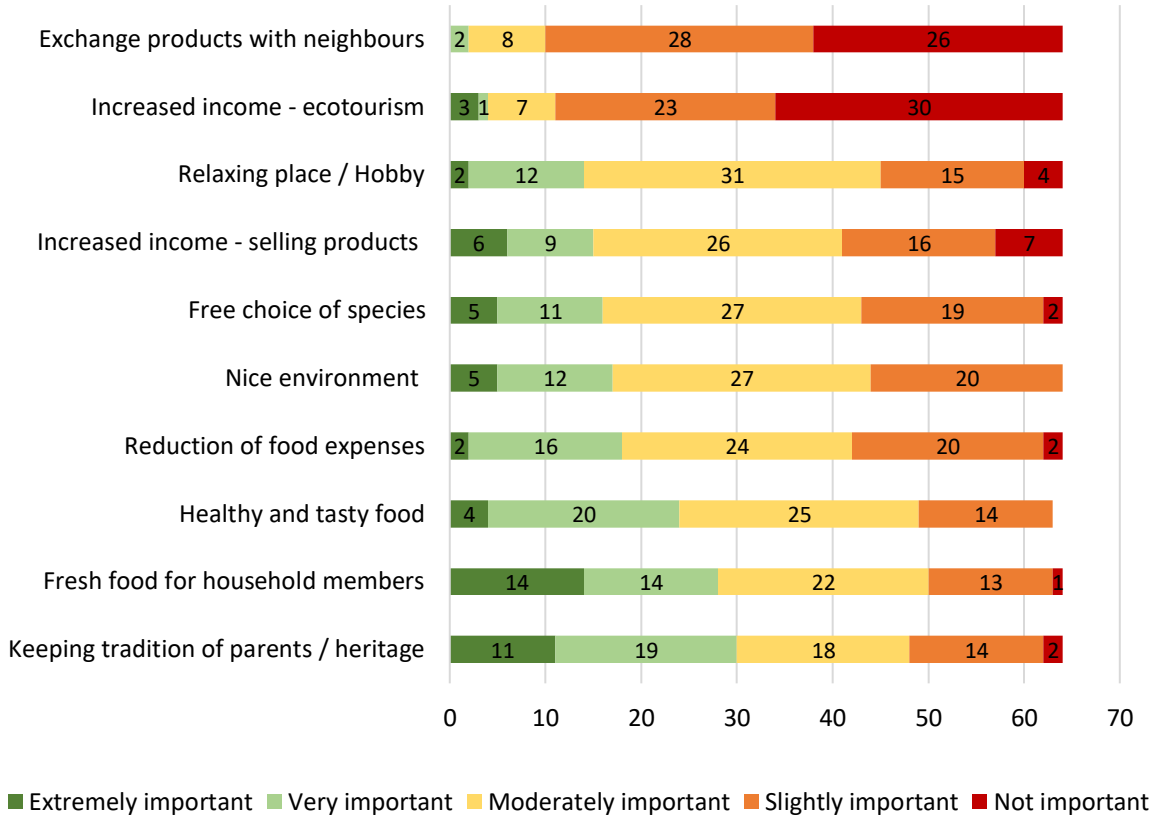


Figure 15. Reasons for running a homegarden

Still, homegardens are not recognized as providers of public goods. HGD owners did not see potential in ecotourism or exchanging products with neighbours.

Our respondents were interviewed about whether they perceive and face any challenges connected with current development and urban environment changes. In total, 10 out of 64 households agreed that they are influenced by urban pressure to some extent. In contrast, most respondents did not perceive any direct pressures connected to urbanization. For example, 36% of respondents neither agreed nor disagreed (Figure 16). Nine respondents also reported that their land is part of urban planning, which causes a loss of land for production and reduced income. In addition, 42% of respondents stated that there is a possibility of compensation for the loss of rights to use land and property on the land in the form of providing a new plot of land, financial compensation or assistance with finding a

new job. Moreover, seven gardeners stated that there is a possibility to be educated on emerging risks during rapid urbanization and on careful usage of compensation money provided by land planners.

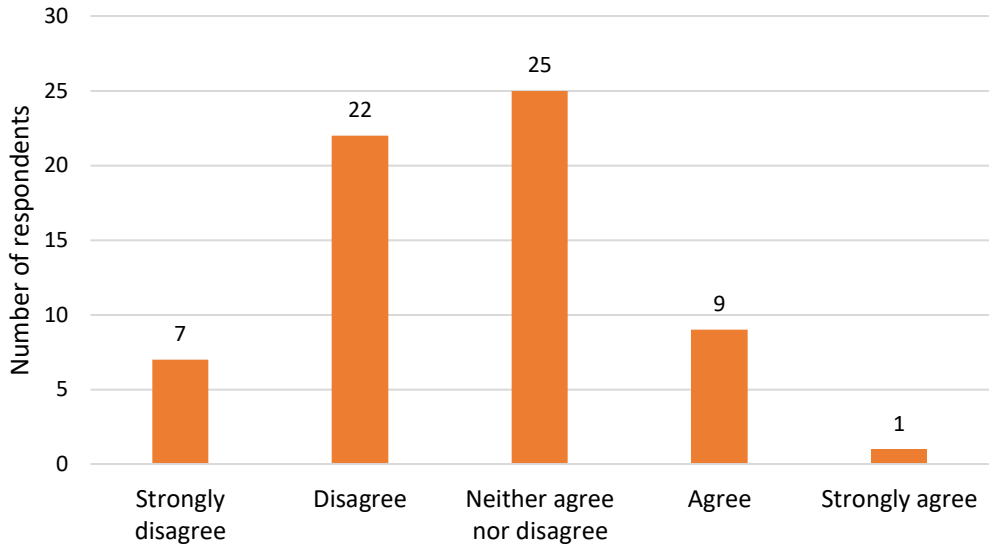


Figure 16. Households' negative perception of urban pressure on homegardens

Subjective pressure on household agricultural activities was further analyzed by identifying specific problems faced by respondents (Figure 17). On a scale of importance from 1 to 5, 1 was considered the most serious problem, and 5 was considered no problem. Pests and diseases were the major concerns of gardeners in terms of production. This was followed by a combination of climatic, family and economic problems in the form of damages caused by weather changes, limited family labour and price fluctuations. An interesting finding was that the problems associated with urbanization (pollution, land scarcity, real estate pressure, and water shortage) were not considered significant. At the same time, homegardeners did not observe a problem in the lack of finances and the quality of seeds or seedlings.

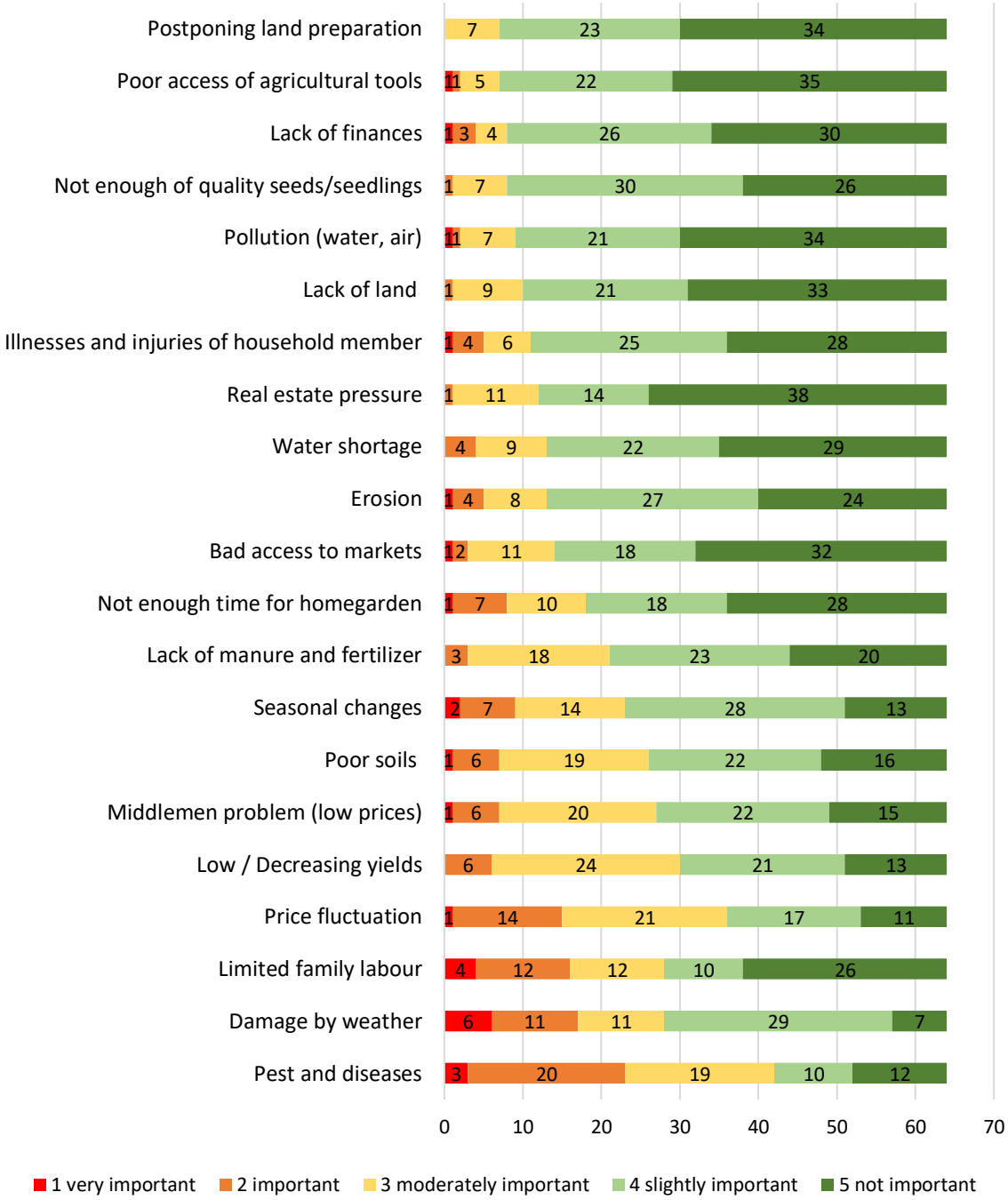
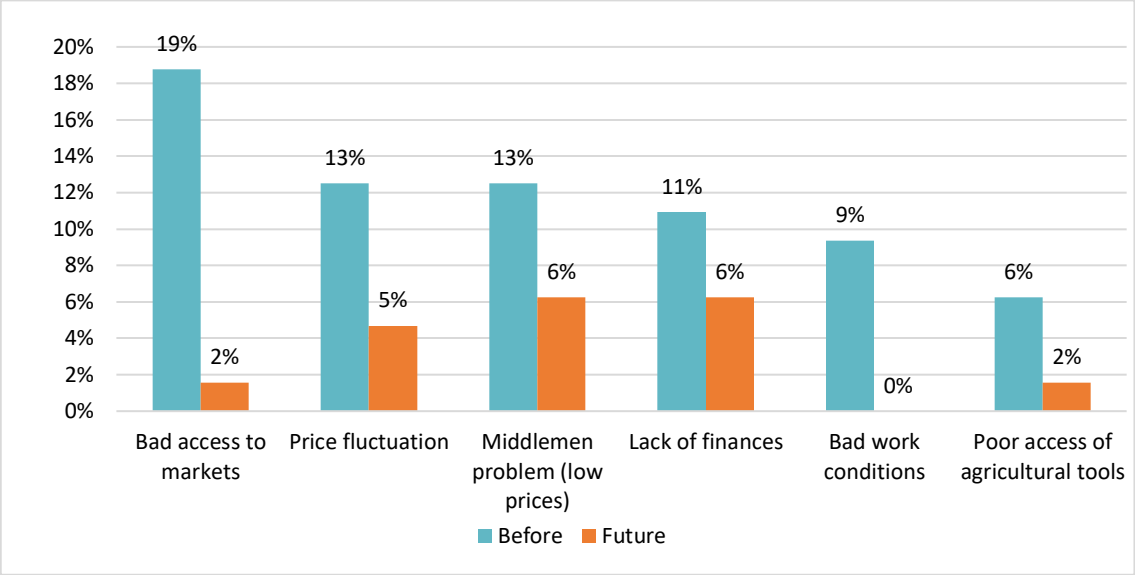


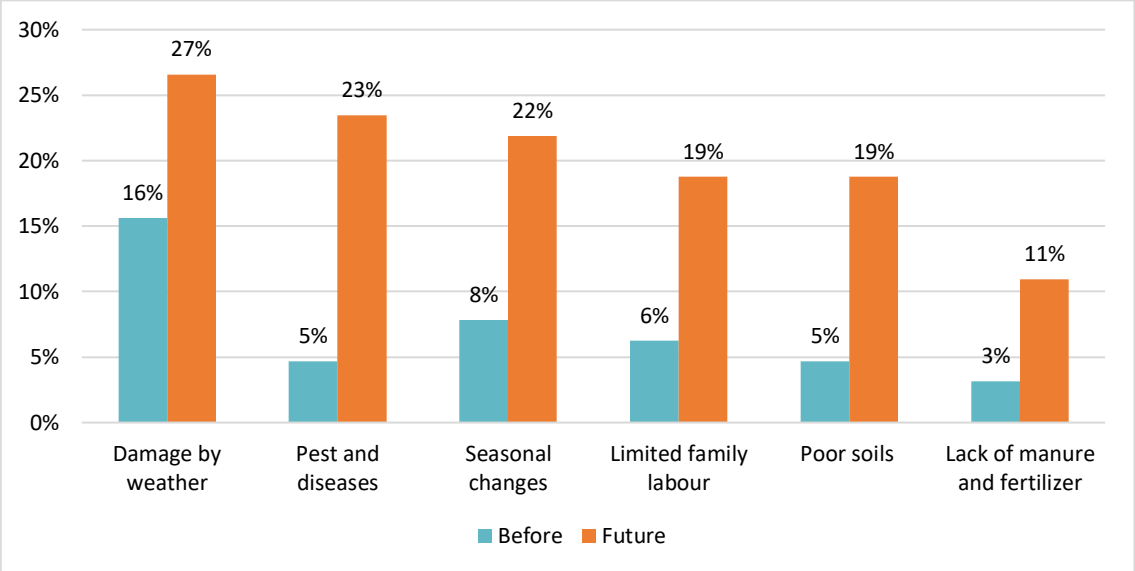
Figure 17. Major problems related to homegardens perceived by interviewed households

To capture the evolution of homegarden-related problems over time, we asked respondents how they perceived problems in the past and how they thought they would evolve in the future. Gardeners were most likely to comment on issues mentioned in Figure 18, which

were primarily related to economic issues and problems associated with climate change affecting the productive capacity of homegardens.



(a) Value chain problems



(b) Production problems

Figure 18. Perception of problems related to homegardens in time
(a) Value chain problems, (b) Production problems

Overall, respondents assume that the problems associated with climate change influencing the productivity of homegardens will worsen. On the other hand, economic problems have

been more serious in the past and are not seen as a threat by many respondents in the current and future situation.

Lastly, we evaluated the potential impacts and problems associated with the recent Covid-19 pandemic on homegardens. Based on the answers, we found that the pandemic mainly affected the economic situation. 34% of respondents agreed that the pandemic influenced the prices of the markets. Primarily, they could not sell their plant production. And if they managed to sell, they earned much less money because the selling prices were about 30-80% lower than before the pandemic.

6. Discussion

6.1 Homegarden characteristics

In our study, we surveyed characteristics of homegardens. Specifically, we focused on the size of the gardens. Although there is no standard to classify the typical size of homegardens, the average size of homegardens worldwide ranges from 1,000 m^2 to 5,000 m^2 according to different geographical and ecological regions (Fernandes & Nair 1986; Kumar et al. 1994). Therefore, in our study, the average homegarden size was 1,358.04 m^2, varying from 108 m^2 to 6,480 m^2 corresponding to the stated range of sizes of gardens worldwide. Homegardens studied in the same geographical region of Thua Thien Hue province ranged from 450 m^2 to 12,500 m^2 (Vlkova et al. 2011) and 130 m^2 to 15,000 m^2 (Minh et al.2015). Trinh et al. (2003) also observed homegardens in Vietnam, whose size ranged from 200 m^2 to 22,000 m^2. The difference in the size of homegardens between our study and the two Vietnamese studies mentioned above could be due to their location. Vlkova et al. (2011) and Minh et al. (2015) studied a rural area, and Trinh et al. (2003) focused on three rural areas and one peri-urban area. However, if we look more closely at their results, the gardens from the suburban area show similar sizes (range 800-7,200 m^2) to ours. Pham & Turner (2020) examined urban gardens in Lào Cai, another Vietnamese city and showed a similar range of sizes from 190 m^2 to 6,500 m^2. Compared to other studies on urban homegardens in the tropics (WinklerPrins 2002; Eichemberg et al. 2013; Peroni et al. 2016; Zasada et al. 2020), the size of the homegarden was even smaller. For example, in the case of Brazil (Peroni et al. 2016), urban, peri-urban and rural HGD were examined. Urban homegardens were the smallest (mean 281 m^2), followed by rural (324 m^2) and per-urban (593 m^2). Homegardens in India (Zasada et al. 2020) ranged from 10 to 2,000 m^2 and had an average size of 152 m^2. In contrast, a study from Niger (Bernholt et al. 2009) provides evidence of relatively large urban and peri-urban homegardens ranging in size from 37 m^2 to 10,355 m^2.

6.2 Ethnobotany inventory in urban homegardens

Several authors report that species composition is strongly related to local culture and traditions (Trinh et al. 2003; Smith et al. 2006; Orsini et al. 2013). This was confirmed in the survey of the gardens, as some of the most abundant plants were areca palm, banana, chilli, and pomelo, which are the species that have high cultural significance in Vietnam and are used during various ceremonies and festivals. In terms of species composition, with the move to the city, homeowners have often maintained plantings of ornamental species (Clarke et al. 2014; Kurfürst 2019; Zasada et al. 2020). In Chinese gardens, biodiversity and species richness vary according to a hierarchy of needs, from ornamental plants to more useful edibles, with gardens closer to the urban centre growing more ornamental crops (Clarke et al. 2014). This was not the case in our study, as no ornamental species were recorded. However, seven respondents mentioned that they would like to include ornamental species such as apricot blossom, orchids and bonsai in their garden in the future. Therefore, this trend towards growing more ornamental crops was confirmed to a small extent.

6.3 Agrobiodiversity and commercialisation trends of local homegardens

The recent socio-economic changes are causing a shift from subsistence-oriented homegardens to commercial homegardens, even in areas with traditionally high ecosystem diversity (Oparaocha 1998; Abdoellah et al. 2006; Prihatini et al. 2018; Abdoellah et al. 2020). This trend is exemplified in Vietnamese gardens, which have taken on a more commercial role (Trinh et al. 2003; Minh et al. 2015; Mulia et al. 2022) since the implementation of "Renovation policies" (Doi Moi) between 1986 and 1992. These policies allowed for market access, private ownership of land and businesses, and international investment, enabling homegardens to generate a valuable cash income by selling surplus food crops or producing in-demand commodities (World Bank 2011). However, despite the benefits of increased revenue, this shift may lead to a reduction in ecosystem diversity in the long run (Abdoellah et al. 2006; Prihatini et al. 2018; Abdoellah et al. 2020). For example, homegardens with monoculture longan trees (*Dimocarpus longan*) have become widespread

in southern Vietnam (Trinh et al. 2003). At the same time, homegarden policies have been issued in the last decade. However, even these focus only on the income benefits of the gardens (Mulia et al. 2022).

Despite the high market orientation of the local homegardens, we found a relatively high agrobiodiversity represented by 86 species from 44 botanical families. The average number of species was eight per homegarden varying from 2 to 19. According to the Shannon-Wiener index, species diversity ranged from 0.06 to 2.31. Similarly, Trinh et al. (2003) noticed that homegarden commercialisation did not lead to biodiversity loss. We compared our result with the species diversity in a similar region but in a rural area of Vietnam (Vlkova et al. 2011). In rural homegardens was observed 67 species belonging to 35 families, with the Shannon-Wiener index from 0.39 to 1.75. The results indicate that species richness and diversity in our urban and peri-urban homegardens were higher than in rural areas. Based on previous studies, this is not entirely common (Peroni et al. 2016; Prihatini et al. 2018). Peroni et al. (2016) registered more diverse homegardens from rural areas than urban and peri-urban homegardens. Rural homegardens had an average richness of more than three times higher than urban and peri-urban homegardens.

Abdoellah et al. (2006), using their typology of commercial and non-commercial homegarden types, found in rural Indonesia that commercial homegardens are more extensive than non-commercial ones and have a higher number of individuals. This statement is consistent with our results from the cluster analysis. Classified commercial homegardens in our study based on market produce had an average size of 1,917 m^2 and the highest abundance of 3,568 individuals.

We could think that the greater the size of homegarden, the greater the species richness (Lamont et al. 1999). For example, in Niger, higher diversities of species were present in extensive periurban gardens (Bernholt et al. 2009). However, this relation was not found in our study nor the study of urban homegardens in Brazil by Eichemberg et al. (2009). Also, a previously mentioned study from rural homegardens in Indonesia showed a low correlation between the number of species and homegarden size, suggesting that homegarden size is probably not the main factor determining species diversity (Abdolleah et al. 2006). Of the

gardens in our study, the medium-sized homegardens with the highest Shannon-Wiener index were the most species-rich, followed by the most extensive and smallest homegardens with similar numbers of species.

Regarding commercialisation, the effect of household head characteristics on commercialisation rates was previously examined. According to Abdoellah et al. (2020), household heads' education level was the main factor determining homegarden commercialisation. Higher education had a negative effect on the commercialisation of homegardens. Household heads with lower levels of education had no alternative sources of income and therefore relied mainly on their homegardens to generate income. This was not borne out in our study, as the cluster analysis showed that the HH of the most commercial gardens were the most educated.

Despite the location of homegardens in urban and peri-urban areas and their commercial character, we can conclude that a relatively high agrobiodiversity of homegardens in Hue City has been maintained. Based on the economy of scale (Kafle et al.2023), which refers to the cost advantages that arise when a gardener increases its production, we can say that homegarden size provides space for the commercial character of the homegarden output. Simultaneously, however, increasing the size of homegardens and promoting cultivation has contributed to the growth of plant species diversity over the years (Abdoellah et al., 2020).

6.4 Motivations and perceptions of homegardeners towards current challenges

The main reasons for running homegardens in areas of Hue City were to provide healthy and tasty, fresh food for household members and to reduce food expenditure. This reason to have homegarden has been confirmed in other urban areas (Pillai et al. 2016; Lewis et al. 2018; Home & Vieli 2020; Pham & Turner 2020). A fundamental reason was to continuity of family traditions. This is also evident from a study by Trinh et al. (2003), who highlighted the high cultural importance attached to homegardens during socio-economic changes in Vietnamese agriculture. A similar result was mentioned by Kirkpatrick & Davison (2018) as a motivation for having a homegarden, where the reason was the pattern for growing

vegetables in their family. Respondents ranked reduced food spending as the third reason in order of importance. Although gardeners sold a large percentage of their produce at the market, increased sales revenue was not reported as significant. This is particularly interesting in the context of recently adopted homegarden policies that promote the economic importance of homegardens in Vietnam (Mulia et al. 2022).

A common problem for urban gardens is increased demographic pressure on available land. Increasing urban development competes with land needed for gardening (Zasada 2011; Opitz et al. 2016; Pham & Turner 2020; Abdulai 2022). Findings from another Vietnamese city show that this urban practice remains precarious, albeit more so in newly urbanising sectors, due to irregular land access and confusing city authority regulations (Pham & Turner 2020). In Ghana, urbanisation pressures have adversely affected staple crop production through declining land availability, low crop harvest, and the dropping of some crops (Abdulai 2022). But despite this apparent space constraint, homegardens are common in many urban environments (WinklerPrins 2002; Trinh et al. 2003; Bernholt et al. 2009; Eichemberg et al. 2009; Eichemberg et al. 2013; Peroni et al. 2016; Pham & Turner 2020; Zasada et al. 2020), and as the results indicate, our respondents did not perceive any of the urban pressure. Moreover, some of them even strongly disagreed with this problem. The study area's local, cultural and perhaps political context could explain such observation.

Also, urban gardens have been investigated in the context of the recent Covid-19 pandemic (Lal 2020; Montefrio 2020; Marques et al. 2021). These studies show interest in homegardening has increased, and its positive benefits have been investigated. However, our study focused on covid-related problems that have affected local homegardens. In addition, the pandemic affected the economic site of homegardening since the respondents were unable to sell their products, and sale prices were approximately 30-80% lower than before the pandemic. This fact highlights the commercial side of homegardens.

6.5 Limitations and suggestions for further research

Based on studies confirming the pressure on urban agriculture caused by the urban environment (Zasada 2011; Opitz et al. 2016), we expected the Hue urban homegardens from our research to be under pressure from urbanisation and, to some extent, commercialisation. The result, and surprise, was that none of the predicted pressures was confirmed in our study. Furthermore, garden owners did not perceive any pressure or threat associated with the urban environment. However, cultural and social factors may have influenced owners' responses. Therefore, even in connection with the current trend of urbanisation, it is crucial in future research to still consider its potential impacts on homegardens. Moreover, despite considerable commercialisation, these gardens have maintained relatively high biodiversity. Thus, the possible aspect that affected the structure of urban homegardens was commercialisation rather than the pressure of urbanisation.

The diversity of crops in homegardens supports their multi-functionality. They can generate substantial income and provide benefits such as food and nutrient security, gender equality, and climate change mitigation. Therefore, political support is needed to help ensure the multi-functionality of homegardens.

Therefore if I could come up with some recommendations or suggestions for further research, I would prioritize examining two critical aspects that hold immense relevance in today's urbanized world. Firstly, to investigate the impact of urbanization pressures on urban homegardens, which have a rich cultural history in Vietnam and require preservation. And secondly, to explore their commercialization in the context of maintaining agrobiodiversity. Likewise, homegarden policies should not primarily focus on income benefits (Mulia et al. 2022). However, rapid population growth and limited land in Vietnam have also called for an enhanced role for homegardens in maintaining social and environmental benefits, in addition to income generation.

7. Conclusion

This Master's thesis documented an ethnobotanical inventory, utilisation and commercialisation of useful plant species grown in 64 Vietnamese homegardens in the urban and peri-urban areas of Hue City, together with the perception of households toward homegardens as a response to the socioeconomic dynamics. 86 species belonging to 44 botanical families were identified, and most were of multipurpose use. *Musa* spp. was the most frequently observed species, followed by *Ipomoea batatas* and *Citrus grandis*. The agrobiodiversity of local homegardens was evaluated based on Shannon-Wiener, Simpson and Margalef indices. Despite the location of homegardens in urban and peri-urban areas and their commercial character, a relatively high agrobiodiversity has been maintained.

In conclusion, research findings have shown that Hue urban homegardens were not under urbanisation pressure. However, cultural and social factors may have influenced these results, and it is still essential to consider the potential impacts of urbanisation on homegardens in future research. Political support is needed to help ensure the multi-functionality of homegardens, as they provide significant benefits such as food security, gender equality, and climate change mitigation. For further research, we recommend examining the impact of urbanisation pressures on urban homegardens and exploring their commercialisation in maintaining agrobiodiversity. Homegarden policies should focus on supporting social and environmental benefits provided by homegardens, in addition to income generation.

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Appendices

Appendix 1. Questionnaire: Homegardens in Hue City, central Vietnam

1. Location and contact details.

District:		**GPS/Location:**		**Questionnaire No.:**	
Name:		**Street + Number:**		**Phone number:**	

2. Household head and homegarden head characteristics.

Note: Characteristics of the person responsible for homegarden if differ from HH head. Interview both together.

	Gender	Age (years)	Relation to HH head (wife, brother, sister ...)	Years of schooling	Gardening experience (years)	Do you have an off-farm job?
HH head	□ Male □ Female		X			□ Yes □ No
Responsible for garden	□ Male □ Female					□ Yes □ No

3. Gender aspects of homegardens:

	Gender
Who works mainly in the garden?	□ Male □ Female □ Both
Who decides on harvest utilization?	□ Male □ Female □ Both
Who decides on the use of income from homegarden?	□ Male □ Female □ Both

4. Born here?

□ Yes □ No If not, how many years have you lived in this area? ..... years

5. The number of people living together in the house most of the year:

No of children (0-14): ..... No of adults (15-59): ..... No of elders (61+): .....

6. How old is the homegarden? ..... years

□ Inherited □ Purchased □ Rented □ Given for free

7. Size of the homegarden: ..... sao

8. Do/Did you teach your children gardening basics?

□ No □ Yes, if yes, why? .....

Do children help you? □ Yes □ No

9. Do you use homegarden products for food preparation/cooking?

□ Every day □ 5 times/week □ 3 times/week □ 1 time/week □ Never

10. Has Covid-19 somehow influenced your homegarden? (markets, ecotourism, community support etc.?)

11. Do you receive any assistance "from outside" to manage, produce or even sell products from your homegarden?

□ No □ Yes

if yes, how?

□ Selling □ Inputs □ General information □ Suggestion for new species

□ Other, specify: .....

12. **Do you face urban pressure (infrastructure, new buildings, pollution etc.) on your homegarden?**
□ Strongly disagree □ Disagree □ Neither agree nor disagree □ Agree □ Strongly agree

13. **Is your land part of the urban planning? If yes, does it somehow affect your household?**
□ No □ Yes
if yes, how? .....

14. **Do you know whether you can be compensated for losing land use rights and assets on land?**
□ No □ Yes
if yes, how? □ New land □ Financial compensation □ Assistance with new job

15. **Do land planners educate you on possible emerging risks during rapid urbanization and on careful usage of compensation money?**

16. **Are you satisfied with your financial situation?**
□ Not at all satisfied □ Slightly satisfied □ Moderately satisfied □ Very satisfied □ Extremely satisfied

17. **Is your financial situation better or worse than it was 10 years ago?**
□ Same □ Better □ Worse

18. **Do you have a credit to run or promote your homegarden?**
□ No □ Yes,
if yes, what kind? □ Bank □ Moneylenders □ Garden-development project
□ Other, specify .....

19. **How is the income from homegarden used?**

....

20. Annual livelihood (yes/no) and cash income diversification (thousands VND; %).

Farm (if you have, e.g., rice, cassava, maize)	Homegarden (products)	Homegarden Eco/-tourism	Fishing/ Fish farm (Pond)	Livestock / Animals	Own a business, e.g., shop, restaurant etc.	Regular wage	Rent money	Money from relatives/friends	Money from other people (community, neighbours)	If other, please specify (government, pension etc.)

Note: First row – Ask the farmer whether he/she is running particular activity (yes/no).
Second row – Ask the farmer how much money the activity brings. In case of no financial inflows, put 0.

21. The most important cash inputs related to your homegarden:

Input	Hired labour	Animal feed	Veterinary	Fertilizer	Pesticides	Land preparation	Pay-back for credit	Seeds/ Seedlings	Water	Transport to market
Importance	□ 1	□ 1	□ 1	□ 1	□ 1	□ 1	□ 1	□ 1	□ 1	□ 1
	□ 2	□ 2	□ 2	□ 2	□ 2	□ 2	□ 2	□ 2	□ 2	□ 2
	□ 3	□ 3	□ 3	□ 3	□ 3	□ 3	□ 3	□ 3	□ 3	□ 3
	□ 4	□ 4	□ 4	□ 4	□ 4	□ 4	□ 4	□ 4	□ 4	□ 4
	□ 5	□ 5	□ 5	□ 5	□ 5	□ 5	□ 5	□ 5	□ 5	□ 5

Note: 1 very important, 2 important, 3 moderately important, 4 slightly important, 5 not important

22. During which months following events occur to your household/farm and homegarden (if yes, mark "X")?

Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Past experience
Household and farm:													**(5-10 years)**
Not enough food													□ Earlier □ Same □ Later
Not enough cash/money													□ Earlier □ Same □ Later
Floods													□ Earlier □ Same □ Later
Harvesting of main products													□ Earlier □ Same □ Later
Planting of main products													□ Earlier □ Same □ Later
Rice/Annuals harvest													□ Earlier □ Same □ Later
Off-farm activities important													□ Earlier □ Same □ Later
Homegarden:													
Working more in garden													□ Earlier □ Same □ Later
Extra use of water													□ Earlier □ Same □ Later
Application of fertilizers/chemicals													□ Earlier □ Same □ Later
Harvesting major garden products													□ Earlier □ Same □ Later
Protection against pests and diseases													□ Earlier □ Same □ Later
Selling most of homegarden harvest													□ Earlier □ Same □ Later
Visitors coming to homegarden													□ Earlier □ Same □ Later

23. Reasons to run/have homegarden.

Fresh food for household members	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Plants making food tasty and healthy	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Reduction of food expenses	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Relaxing place / Hobby	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Keeping the tradition of parents/heritage	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Increased income - selling products	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Increased income - ecotourism	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Exchange products with my neighbours	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Nice environment (shade, windbreak ...)	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important
Free choice of species which I can plant	□ Not at all important	□ Slightly important	□ Moderately important	□ Very important	□ Extremely important

24. Major problems related to homegarden.

Type of problem	**Importance** **1 – most serious, 5 – less**	**Coping strategy** (open question)	**Past experience**	**Forecast**
Insects, diseases, pests	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Water shortage	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Lack of land	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Lack of manure and fertilizer	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Not enough quality seeds/-lings	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Poor soils	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Poor access to agricultural tools	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Limited family labour	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Not enough time for homegarden	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Illnesses + injuries of HH member	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Lack of finances	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Damage by weather	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Theft / Stealing by other people	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Pollution (water, air)	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Bad work conditions	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Middlemen problem (low prices)	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Bad access to markets (transport)	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Price fluctuation	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Real estate pressure	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Low / Decreasing yields	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Erosion	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Long winter - seasonal changes	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better
Postponing land preparation	□ 1 □ 2 □ 3 □ 4 □ 5		□ Worse □ Same □ Better	□ Worse □ Same □ Better

25. Crop species in your homegarden.

Note: Use free listing. Check individuals and more spp (differ from those mentioned).

Species **Useful diversity**	**No. of individuals per garden** **Or per m^2 in the case of herbs, small plants (try to estimate the total area planted)**	**Part used** **1.** Whole plant **2.** Bulb **3.** Bark **4.** Seed **5.** Flower **6.** Fruit **7.** Leaf **8.** Root **9.** Stem/stalk **10.** Tuber **11.** Shoots	**Mode of use** **1.** food **2.** medicine **3.** material/construction **4.** animal feed **5.** firewood **6.** ornamental **7.** sacred/ceremonial **8.** cosmetics **9.** other, specify	**Final consumer** **1.** Household **2.** Market **% Estimate if you can**	**Diver/Reason/ Inspiration for planting (info, decision)** **1.** Family **2.** Market **3.** Neighbours **4.** HGD project **5.** Gov't **6.** Wild	**Harvest time** Which months? 1-12 Jan=1 Dec=12	**Grown 5 years ago** **Yes=1** **No=0**	**Plan to grow in 5 years** **Yes=1** **No=0**

26. Would you like to add some more species to the garden in the future?

□ No □ Yes,
if yes, specify reason(s) and species:
□ Market opportunities □ Food for family □ Medicine □ Ornamental

Species: ....