Homegardens dynamics and livelihood security in Yucatán, Mexico: A mixed methods approach

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I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

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UNIVERSITY OF SUSSEX

PHD IN DEVELOPMENT STUDIES

JENNIFER CASTAÑEDA NAVARRETE

HOMEGARDENS DYNAMICS AND LIVELIHOOD SECURITY IN YUCATÁN, MEXICO: A MIXED METHODS APPROACH

SUMMARY

Homegardens are complex agroforestry systems that combine vegetable and animal components in an ecological balance that has allowed them to survive for centuries. In Yucatán, Mexico, homegardens have played a key role in the livelihood security of rural families since pre-Hispanic times. Nonetheless, homegardens are dynamic, and their transformations have been accelerated since the 1980s, in the aftermath of the neoliberal reforms. In increasingly diversified and urbanised livelihoods, a variety of pathways have been observed, most of them diminishing and even undermining the contribution of homegardens to livelihood security.

The literature on homegardens is extensively focused on describing their properties and functions; however, there is scant knowledge about the socioeconomic determinants of homegardening patterns, their dynamics and about how homegardening interact with other livelihood strategies. This doctoral research aims to contribute to fill these research gaps. The thesis focuses on the study of the relationship between homegardening and livelihood security in the context of rural urbanisation. In doing this, the research followed a multi-sited case study design and a mixed methods approach, aiming to capture both spatial and temporal dimensions of rural urbanisation. The research took place in four communities located across the peri-urban – rural spectrum in Yucatán, Mexico.

The contribution of homegardening to livelihood security was found to decrease over time, although the pace of lessening varied across the peri-urban – rural spectrum. Alternative pathways were identified in addition to this dominant trend, where some households managed to maintain highly diverse homegardens. Household characteristics, such as wealth, the size of the household and ethnicity were found to influence these alternative pathways. Food security was identified as the main contribution of homegardening to livelihood security. The relationship between homegardening and household food security was observed to depend on homegarden diversity and its interaction with other livelihood sources, particularly social programmes and urban jobs. The rural-urban location of the household was also found to mediate these interactions. The findings shed light on how the relationship between homegardening and livelihood security works in an increasingly urbanised context, and on the complementarities and trade-offs in the interactions between homegardening and other livelihood strategies.

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DINÁMICAS DE LOS HUERTOS FAMILIARES Y LA SEGURIDAD DE LOS MEDIOS DE SUBSISTENCIA EN YUCATÁN, MÉXICO: UN ENFOQUE DE MÉTODOS MIXTOS

RESUMEN

Los huertos familiares son complejos sistemas agroforestales que integran elementos vegetales y animales en un balance ecológico que les ha permitido sobrevivir por siglos. En Yucatán, México, los huertos familiares han tenido una contribución importante en garantizar el sustento de las familias rurales desde tiempos prehispánicos. Sin embargo, los huertos familiares son dinámicos y sus transformaciones se han acelerado desde la década de 1980, como consecuencia de la instrumentación de las reformas neoliberales. En un contexto donde los medios de vida son cada vez más diversos y urbanos, una variedad de trayectorias de cambio se ha observado, la mayoría de las cuales han disminuido la contribución de los huertos familiares en el bienestar de los hogares yucatecos.

La literatura sobre huertos familiares se centra predominantemente en describir sus propiedades y funciones; sin embargo, el conocimiento sobre los determinantes socioeconómicos de los diferentes arreglos de los huertos es escaso, al igual que sobre sus dinámicas de cambio y sobre cómo los huertos familiares interactúan con otras estrategias para garantizar el sustento de los hogares. Esta investigación doctoral tiene como objetivo llenar estos vacíos de conocimiento, contribuyendo a la comprensión de la sostenibilidad de los huertos familiares. La tesis se centra en el estudio de la relación entre huertos familiares y la seguridad de los medios de subsistencia en un contexto de urbanización rural. Para ello, la investigación siguió un diseño de caso de estudio multi-localizado y un enfoque de métodos mixtos, con el objetivo de capturar las dimensiones espaciales y temporales del proceso de urbanización. La investigación se llevó a cabo en cuatro comunidades localizadas en un gradiente peri-urbano-rural, en Yucatán, México.

La contribución de los huertos como medio de subsistencia ha disminuido a través del tiempo; sin embargo, el ritmo de esta disminución difiere a lo largo del gradiente peri-urbano-rural. Trayectorias de cambio alternativas a esta tendencia dominante también fueron identificadas, donde algunos hogares se han ingeniado para mantener huertos familiares altamente diversos. Estas trayectorias alternativas son influenciadas por características de los hogares, tales como su nivel económico, el tamaño del hogar y el origen étnico. La principal contribución de los huertos familiares como medio de subsitencia se observó en la seguridad alimentaria. La relación entre los huertos y la seguridad alimentaria de los hogares depende de los arreglos particulares en el manejo de los huertos y su interacción con otros medios de vida, particularmente con los programas sociales y los trabajos urbanos. La ubicación rural-urbana de los hogares también media estas interacciones. Los hallazgos de esta investigación contribuyen a la comprensión de los huertos familiares como medios de subsistencia en un contexto cada vez más urbanizado, así como de las complementariedades e intercambios que ocurren entre los huertos familiares y otros medios de vida.

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U JEELBESA'AL PACH PAK'AL YÉETEL LE MA'ALOB KUXTAL ICH YUCATANE', MEXICO: JUNP'ÉEL XA'AK'A'AN UTIA'AL U K'ÁATCHI'ITA'AL MÁAK

KONKIINSXOOK

Le pach pak'alo'obo' ku antalo'ob ma' taalami múuch che'ob yéetel pak'alo'ob ku talo'ob x'iiwo'ob yaanal yéetel aalak'o'ob bey k'áax ku cha'ile' kuxtal ya'ab jo'ok'aal ja'ab. Ich Yucatane', Mexico, le pach pak'alo'obo' ku k'a'anantal utia'al le ma'alob kuxtal ti' le ch'i'balilo'ob ku kuxtalo'ob ich mejen kaaj takti táanil le kastlano'ob k'iinil. Ba'ale' le pach pak'alo'ob ts'o'ok u jeelpajal tak tu ja'abil 1980 tuméen yanchaj reformas neoliberales. Le kéen jook'oko'ob ti' noj kaaje yaan jejáas meyajo'ob ku jelpajal u túukulo'ob, le beetik le pach pak'alo' ku p'aatal paachi ich le ma'alob kuxtalo' tu yootocho'ob u Yucatane'.

Tuláakal le k'aatchi'xook pach pak'aalo' ku ya'aliko'ob bixi; ba'ale' yaan junp'íit u taam k'aóolil ti' u xookil úucha'ano'ob yóolal u yóotsilil le láak'tililo'ob yéetel bix u kuxtal le láak'o'obo'. Beyxan yaan jun píit yits'atil ti' u jejeláas yéetel ti' bix u ch'aliko'ob le pach pak'alo'ob yéetel u yaanal meyajo'ob uti'al le ma'alob kuxtal ti' le ch'i'balilo'ob. Lela' k'áat kaxan tsikbal doctoradoa' u beetik tumben yits'atil ku nahtsik le bíin úuchuk ti' le pach pak'alo'ob. Le ánaltee' ku xokik bix yanik ich le pach pak'al yéetel le ma'alob kuxtal ti le ch'i'balilo'obo' ku kuxtalo'ob ich kaajo'ob táan u jelpajalo'ob bey noj kaajo'ob. Le kaxan tsikbala' ts'o'ok u beeta'ab ich jeejela'as kaajo'ob yéetel meyajnaj jejela'as tsoolol utia'al xookbil le jeel u kúuchilo'ob yéetel u kiinilo'ob. Le kaxan tsikbali' beta'ab ich kanp'éel kaajo'ob naats' yéetel náach Tho', Yucatán, México.

Le áantaj pach pak'alo'obo' utia'al le ma'alob kuxtal ts'o'ok u junp'íital ichil le jaabo'obo'; ba'ale' le ts'o'ok u junp'íital yaan jeejela'as ichil le kanp'éel kaajo'obo'. Kaxanta'ab jeejela'as beelilo'ob ti' jeel ti' ts'éets'ek najio'ob yaan ya'ab che'o'ob, buka'ah yaan ya'ab ch'i'ibalil yéetel t'ux yaan ya'ab aalak'o'ob. Bix le k'ex kuxtala' ku beychaja wá yaan taak'inti'ob, wa beyxan ku t'aniko'ob Maaya. Le áantaj le pach pak'alo'ob utia'al le ma'alob kuxtal ku ts'o'ok kaxta'ab ich le tojóolal ti' janal. Le pach pak'alo' ku yaantaj utia'al u tojóolal tia'al u yaantal junp'éel ma'alob janal. Lela' ku beytal wá ku kanáantil u paak'aal beyxan wá yaan aantajo'ob. Wá ku meyajo'ob ti noj kaakalo'obe' ma' tu beyta'al u kan'aatiko'ob u paak'alo'ob. Le kaxan k'áatankilo ku yáantaj utia'al u na'atal junp'éel ma'alob kuxtal ti' le paach paak'áalo' yéetel u láak' meyajo'ob.

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List of acronyms

CA	Capability Approach
CONEVAL	Mexican Council for the Evaluation of the Social Development Policy
ESRC	Social Research Council
FAO	Food and Agriculture Organisation of the United Nations
FCS	Food Consumption Score
FCS-N	Food Consumption Score Nutrition Quality Analysis
IIED	International Institute for Environment and Development
INEGI	Mexican Institute of Statistics and Geography
ODK	Open Data Kit
PCA	Principal Components Analysis
PPT	Backyard Livestock Production Programme
PRI	Institutional Revolutionary Party
PSM	Propensity Score Matching
PST	Backyard Social Production Programme
RIMISP	Latin American Centre for Rural Development
SAGARPA	Mexican Ministry of Agriculture, Cattle Industry, Rural Development, Fishery and Food
SL	Sustainable Livelihoods Framework
STEPS	Social, Technological and Environmental Pathways to Sustainability

Glossary of words in Spanish and Mayan

Mayan

Chan: Small

Ma'alob k'iin: Good morning.

Mixba'al: Nothing.

Pib (mucbipollo): Main traditional dish of the Janal Pixan celebration. It is made of maize dough, chicken, pork and different species. It is covered with banana leaves and usually baked under the ground.

Janal Pixan: Mayan Yucatecan version of the Day of the Dead celebration. The literal translation is "food of the souls".

Spanish

Antorcha Campesina: Social and political movement.

Atole nuevo: Sweet drink made of maize.

Campesino: Traditional farmer, peasant. One that makes a living from agriculture.

Canícula: period of low rainfall and high temperatures.

Ejido: Legal form of communal property of lands.

Hacienda: Large state.

Ejidatario: One that has usufruct rights on land owned by the community.

Henequenero: Sisal (*Agave sisalana* Perriné) cultivator.

Huerto familiar: Homegarden.

Maquiladora: Manufacturing company under a special import-export taxation regime.

Mecate: Land with an extension of 400 m^2.

Milpa: Swidden traditional agriculture system based on maize, beans and squash.

Milpero: One that cultivates the *milpa*.

Patio: Backyard.

Parcela: Smallholding.

Pozol: A thick maize-based drink with a sour taste.

Solar: Unit used by the Spanish government during the Colonial times to distribute and organize the land. The solar had an extension of 2,500 m^2.

Tamal: Maize dough steamed containing meat, vegetables or fruit.

Tortilla: Thin, round flat bread made of maize or wheat flour.

Chapter 1. Introduction

"Please wait a moment. I need to hurry to go to the mill. Grandma is waiting for me!"

Lool-be left the house, running gracefully with a bucket full of maize grains, trying not to lose her sandals while her feet were flying through the white dust. The stranger, a lady in her thirties, sat on a rock under the shadow of a leafy breadnut tree. She waited patiently while making notes and eating a plum she found on the road. It was not her first time in town, she had been seen around for about a month.

"We are back!" Shouted Lool-be with a friendly smile. "This is my grandma Carmelita."

"*Ma'alob* niña," greeted Carmelita.

The stranger smiled and when she was about to greet back, Lool-be interrupted: "Do you speak Mayan? Grandma only speaks Mayan, but she understands Spanish."

"A little, *ma'alob k'iin,*" good morning, replied the stranger in Mayan with a funny accent.

"Do you think we could continue our conversation?" Asked the stranger to Lool-be. "The next part of the survey is on the plants and animals you have."

"Right now I am a bit busy, I have to feed the chickens and then I have to help with the cooking. But I can show you the *patio* if you want," said Lool-be while preparing the maize dough to feed the animals.

"Thanks, that would be nice and if you don't mind I can come back later when you and your grandma have some time to talk."

Lool-be is 20 years old, her name means 'flower of the pathway' in Mayan. She lives in Sahcabá, a small community located in Yucatán, in southeastern Mexico. She is the oldest of four children. Lool-be completed upper-secondary studies two years ago. She wants to keep studying, but her parents cannot afford to send her to the capital city where she could go to university. In the meantime, she is helping her grandparents and taking care of her siblings.

The chickens and a small dog surrounded Lool-be as soon as she started spreading small balls of the maize dough.

"As you can see, we have many trees: sweet oranges, bitter oranges, limes, plums, mangos, mamey, achiote" the list stopped and after a deep breath Lool-be continued: "Bananas, palms, breadnuts, sugar apples, nectarines, guayas," the list stopped again.

"I think we have more than ten orange trees and full of fruit!" Lool-be exclaimed with innocent surprise.

"Do you want some? They are falling off the tree."

"Yes, thank you very much!" Replied the stranger with a broad smile.

"Grandma also grows some herbs and chillies. I'd rather help her watering the plants than feeding the chickens," moaned Lool-be.

"But I am the only one that helps granny, I am the oldest. Well, to be honest, grandpa sometimes helps when he doesn't go to the *milpa.*"

"This maize comes from his *milpa,*" said Lool-be proudly, pointing at the leftovers of maize dough spread on the ground. "Grandma also uses it to make *tortillas*."

"Are your parents around?" Asked the stranger curiously.

"No, they are working in Mérida. Mom is coming back in the evening, she works as a housekeeper. And dad is a construction worker, he only comes back on the weekends."

"So, is he coming back tomorrow, just in time to eat *pib*?"[1] asked the stranger, referring to the traditional Mayan *tamal* cooked in an underground pit.

"Hopefully he will be on time for the prayers and for eating *pib,*" said Lool-be wishfully. "He is a good man, he works very hard and takes care of us; but sometimes, instead of coming home, he stays until late drinking with his friends at the corner beer shop."

A discontented expression overtook Lool-be's face and an awkward silence interrupted the conversation.

"Lool-baaa! Baaa! Baaa!" A little mischievous boy approached, calling Lool-be, while pulling her t-shirt.

"Stop! Can't you see that I am talking with the lady?" Lool-be said loudly to the boy.

"Sorry, he's my brother Pepe. He's the youngest. He didn't want to drink *pozol*[2] in the morning and I think he is hungry now," apologised Lool-be to the stranger.

"Here, have a tangerine and wait a moment," said Lool-be to her brother while pulling the fruit from the tree.

"Morniiing! Morniiing!" Lupita, the neighbour, was calling at the entrance of the house.

"What's up, Lupita?" shouted Lool-be.

"I brought the flowers your grandma asked for to place on the altar", Lupita replied.

"Thanks, Lupita. How much is it?"

"*Mixba'al*", said Lupita. "Nothing, just give me a few banana leaves for my *pib."*

Lool-be went to get the machete, cut some leaves and handed them to Lupita.

"I am excited because we are getting ready for *Janal Pixan*," said Lool-be, smiling at the

[1] The *pib* or *mucbipollo* is the main traditional dish of the *Janal Pixan* celebration, the Mayan Yucatecan version of the Day of the Dead. The *pib* is made of maize dough, chicken, pork and different species. It is covered with banana leaves and usually baked under the ground.

[2] A thick maize-based drink with a sour taste.

thought of the traditional 'Day of the Dead' celebration.

"Several neighbours and friends have come to our house to ask for the leaves of the banana trees for cooking their *pib*. Grandma will slaughter some chickens and one of my aunties will slaughter a pig. I will get some bitter oranges and achiote from the *patio* to prepare the meat. Too much work to do, but the reward is worth it.

Why don't you come back tomorrow? All the family is coming, and you are welcome to try the grandma's awesome *pib.*"

1.1 Background

Lool-be is a fictional character, but her story illustrates what this thesis is about and the real stories you will find in it. Besides transporting the reader to the research context, the aim of introducing the thesis with this short story is to portray some of the feelings and experiences I, as an independent researcher, faced in the field. These feelings and experiences may not be emphasised enough in the academic analysis that comprises the bulk of this thesis. This research is about people, changes in livelihoods, and processes of urbanisation, with a particular focus on homegardens. Homegardens, such as the Lool-be's *patio,* are small-scale agroforestry systems formed by plants and animals and integrated in the dwelling space. They provide different resources and represent living and productive spaces where social and cultural reproduction takes place. For several decades, the academic literature has celebrated the exceptional properties of the homegardens that have allowed them to survive in different forms and contexts for centuries, namely, their diversity, productivity, stability, sustainability and equitability (Soemarwoto and Conway, 1992). However, this narrative does not fully reflect the present role of homegardens in increasingly diversified, urbanised and precarious livelihoods.

The decades of the 1960s and 1970s witnessed the emergence of modernisation as the dominant development model in many developing countries (Bryceson, 1996; Baños Ramírez, 2002). In Mexico, this model took the form of import substitution policies in its early stages, while in the 1980s and 1990s these were abandoned in favour of market liberalisation reforms (Bryceson, 1996; Fry, 2011). As a reflection of this adoption and pursuit of the neoliberal paradigm since the 1980s, agricultural policy in Mexico has promoted market integration and agricultural modernisation (Klepeis and Vance, 2003; Lerner *et al.*, 2013). However, for most smallholder farmers, these policies have resulted in a 'crisis-transformation context', characterised by a cost-price squeeze and growing competition among producers in an increasingly dynamic, uncertain and risk-prone environment (Baños Ramírez, 2002; Thompson and Scoones, 2009; Fry, 2011)

Rural households have diversified their livelihoods in order to cope with this 'crisis-transformation context' (Ellis, 1998; Fry, 2011). Different livelihood trajectories have been observed in and out of farming activities. The dominant trend involves households shifting to off-farm activities, either in the same community or in urban areas. However, the role of agriculture in rural and even peri-urban livelihoods has not completely disappeared (Radel *et al.*, 2010). This transition, involving the transformation of mainly rural-based livelihoods

into more urbanised ones, has been referred to as *'rural urbanisation'* (Zhijun, 2004; Roberts, 2016). In this research, rural urbanisation is defined as a demographic, economic, social and cultural transition expressed in: population growth; off-farm diversification; increasing participation of women in the labour market; intensified connection with urban areas; improvement of social infrastructure and education levels; change of the family structure and 'modernisation' of lifestyles and values (c.f. Baños Ramírez, 2001; Satterthwaite and Tacoli, 2003; Zhijun, 2004; Cloke, 2006; Satterthwaite *et al.*, 2010).

The agglomeration of population in urban areas has facilitated improved access to formal markets and job opportunities, and a broader provision of infrastructure and services (Hoang *et al.*, 2008; Satterthwaite *et al.*, 2010; Tacoli and Satterthwaite, 2013). Nonetheless, it has also had negative effects, such as: increased food insecurity; illegal settlements; conflicts over land and water; health hazards; erosion of social capital; and depletion and contamination of natural resources (Mendez-Lemus, 2012; Becker, 2013; Lange *et al.*, 2013). Moreover, rural-urban interactions operate across several channels. Access to markets, for example, does not only depend on spatial proximity but also on the affordability of transportation costs; access to market information; social institutions involving power, control and exclusion; and access to land, labour and capital (Tacoli, 1998; Diyamett *et al.*, 2001).

A consequence of rural urbanisation and the related rapid change in land use has been the loss of biodiversity and Mexico is not the exception (Moreno-Calles *et al.*, 2014; Pietersen *et al.*, 2018). Mexico is considered the 12th most megadiverse country in the world (Becerril *et al.*, 2014). The biological diversity of the country has interacted and co-evolved with its cultural richness over thousands of years, where people have transformed entire landscapes and domesticated a wide array of plant and animal species (Moreno-Calles *et al.*, 2014). Agroforestry systems, such as homegardens, are emblematic examples of biocultural management and conservation (Moreno-Calles *et al.*, 2014; Moreno-Calles *et al.*, 2016; Pietersen *et al.*, 2018). Nonetheless, in the last decades these agroforestry systems have faced increasing land pressures, loss of species, abandonment of traditional practices and loss of the related knowledge (Moreno-Calles *et al.*, 2014; Pietersen *et al.*, 2018). In the course of these transformations, a variety of pathways have been observed, most of them diminishing and even undermining the contribution of homegardening to livelihood security.

Against this background, this thesis focuses on how rural urbanisation is changing the role of homegardening as a livelihood strategy. The geographical coverage of the research is Yucatán, a state located in the southeast of Mexico. In Yucatán, the homegarden, together with the *milpa*, a swidden agriculture system based on maize, beans and squash, have traditionally played a key role in the livelihood security of rural families, producing an abundance of resources despite the shallow and stony soils of Yucatán (García de Miguel, 2000; Jiménez-Osornio et al., 2003).

The biocultural diversity and complexity of the homegardens of Yucatán and their role in the livelihoods of rural families have attracted the attention of numerous scholars (See Chapter 2). Yucatán shows a rich cultural heritage due to its Mayan and Spanish history. It has the highest proportion of indigenous people in Mexico, the Mayas, who represent more than half of the Yucatecan population (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2014). However, like many other developing regions, it faces the paradox of having substantial biocultural richness and a population suffering from high levels of rural deprivation and malnutrition (Pingali, 2007; Becerril *et al.*, 2014). Over a third of the Yucatecan population suffers from some level of food insecurity, according to official records (Secretaría de Desarrollo Social, 2016).

1.2 Aim and scope

This doctoral thesis aims to contribute to the understanding of how rural urbanisation influences the role of homegardening as a livelihood strategy. Livelihood strategies are understood as the activities and choices people make to obtain their means of living, usually involving trade-offs between outcomes (c.f. Bebbington, 1999; Babulo *et al.*, 2009; Fisher *et al.*, 2013). In this thesis I assess how homegardening contributes to people's livelihoods using the concept of 'livelihood security': the ability of a household to maintain and improve its livelihood outcomes (Lindenberg, 2002). The following overarching research question is addressed: ***How does rural urbanisation influence the contribution of homegardening to livelihood security in Yucatán, Mexico?***

In order to answer the overarching research question, the concept of rural urbanisation was disentangled in terms of its temporal and spatial dimensions. Moreover, from the different livelihood outcomes homegardening contributes, the analysis focused on food security. Three interrelated research sub-questions are addressed:

(i) *How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?*

(ii) *How and why do homegardening patterns vary across the peri-urban – rural spectrum in Yucatán, Mexico?*

(iii) *How does homegardening contribute to food security across the peri-urban – rural spectrum in Yucatán, Mexico?*

Five concepts are central to this research: homegarden, homegarden diversity, rural urbanisation, livelihood security and food security (Figure 1.1). Accordingly, this thesis builds on the literature on homegardens, economics of biodiversity, agrarian change, livelihoods and wellbeing. In order to capture the spatial and temporal dimensions of rural urbanisation, a mixed methods approach is followed. Both longitudinal and cross-sectional methods of enquiry were applied. The study took place in four field sites located in Yucatán, Mexico, across a peri-urban – rural continuum and involved over 12 months of research in three distinct phases.

1.3 Significance of the study

The literature on homegardens is vast, but it is primarily focused on describing their properties and functions. There is scant information about the socioeconomic determinants of homegardening patterns, their dynamics and about how homegardening interacts with other livelihood activities. By providing new evidence and insights from in-depth empirical research in Yucatán, I am aiming to fill this gap. Although the contribution of homegardens to food security is broadly recognised in the literature, there is little knowledge of how this relationship works in practice. Therefore, in this thesis I am also seeking to provide new data on how homegardens are contributing to food security, what household and community characteristics mediate this relationship, and how development interventions promoting homegardens could be improved.

From a methodological point of view, this study shows how building on a cross-section of disciplines and following a mixed methods approach can contribute to a better understanding of complex bio-social phenomena. It illustrates how qualitative methods can inform quantitative data analyses and provide explanations to the patterns and trends captured from quantitative analysis.

1.4 Structure of the thesis

In order to answer the overarching research question and sub-questions I have posed, the thesis is divided into three main sections. Section I includes the introduction and chapters 2 to 4, which provide the contextual, theoretical and methodological framework for the empirical analysis. Section II comprises chapters 5 to 7, which present the main empirical results from the quantitative and qualitative research. Each of these three chapters begins with analysis at the community level and then proceeds with analysis at the household level. And Section III includes chapter 8, which synthesises the theoretical discussion and the empirical findings and outlines some broader policy relevant lessons.

In the first section of this thesis, chapter 2 provides an overview of the literature on homegardens, describing the research gaps this research aims to fill. The state-of-the-art of the literature is examined, with a particular focus on the contribution of homegardening to livelihood security. The role of biodiversity in mediating the contribution of agro-ecosystems in peoples' livelihoods is also discussed. In addition, building on agrarian change literature, the main transformations faced by the homegardens are examined. Chapter 3 draws on elements of the Sustainable Livelihoods Framework and the Capability Approach in order to frame the relationship between homegarden diversity, rural urbanisation and livelihood security. Building on these different conceptual insights and approaches, I introduce a hybrid Endowments-based Livelihoods Framework and discuss the theory of change tested in this research.

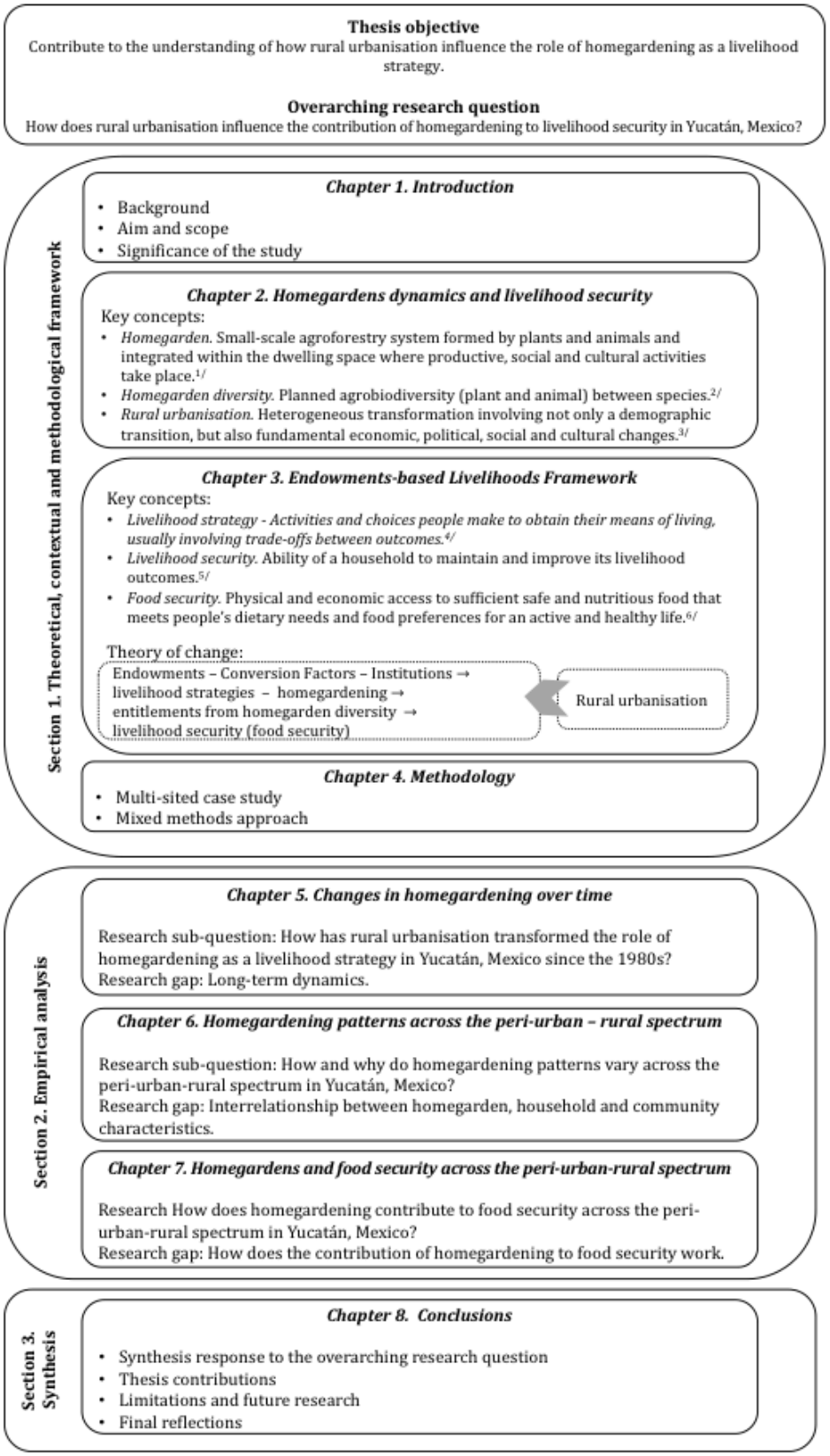
Chapter 4 describes the methodology followed for answering my research questions. A multi-sited case study design was selected to capture the differences and commonalities between the four field sites in how rural urbanisation was influencing the contribution of homegardening to livelihood security. For this purpose, the research took place in four communities showing different levels of urbanisation and located in two distinct historical and economic regions of Yucatán, Mexico. The mixed methods approach applied in this study is described in detail in this chapter. Qualitative methods were used to gain a more comprehensive understanding of the context and the history that have shaped the evolution of homegardening as a livelihood strategy. They were also employed to document the life histories of selected individuals to explain how different factors that have shaped the long-term management and use of homegardens in different settings. Finally, quantitative methods were used to provide broader insights into household and community-level trends and changes, capturing the complex intersections between homegarden diversity, household and community characteristics.

The second section of this thesis is formed by the empirical analysis, chapters 5 to 7. Chapter 5 addresses the temporal dimension of rural urbanisation, whereas chapters 6 and 7 address the spatial dimension across a peri-urban – rural spectrum. Chapter 5 examines the evolution of the homegarden in the last decades, responding to the first research sub-question*:* ***How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?*** Drawing on longitudinal qualitative and quantitative information, chapter 5 discusses the main transformations observed in the homegardens and in the participation of people in other livelihood activities. Chapter 6 describes the different patterns of engagement in homegardening and explains how they relate to household and community characteristics. This chapter thus responds to the second research sub-question: ***How and why do homegardening patterns vary across the peri-urban – rural spectrum in Yucatán, Mexico?*** Chapter 7 goes a step further, examining how management patterns determine the contribution of homegardening to food security. The interaction of homegarden diversity with other household and community characteristics is studied, addressing the third research sub-question: ***How does homegardening contribute to food security across the peri-urban – rural spectrum in Yucatán, Mexico?***

Finally, in the third and last part of this thesis, chapter 8 presents the conclusions. This last chapter synthesises the research findings from the temporal and spatial dimensions of rural urbanisation, providing a unified answer to the overarching research question: ***How does rural urbanisation influence the contribution of homegardening to livelihood security in Yucatán, Mexico?*** In addition, chapter 8 reflects on the contributions and implications of this thesis and acknowledges its limitations and areas for future research.

Figure 1.1 summarises the structure of the thesis.

Figure 1.1 Structure of the thesis



1/ c.f. Fernandes and Nair (1986), Jiménez-Osornio et al. (2003), Kumar and Nair (2004), Hernández Sánchez (2010) and Mariaca Méndez (2012); 2/ Kontoleon et al., 2009; 3/ c.f. Baños Ramírez (2001), Satterthwaite and Tacoli (2003), Zhijun (2004), Cloke (2006) and Satterthwaite *et al.* (2010); 4/ c.f. Bebbington, 1999; Babulo *et al.*, 2009; Fisher *et al.,* 2013; 5/ Lindenberg (2002); 6/ FAO (2008).

Chapter 2. Homegardens dynamics and livelihood security

Introduction

In Chapter 1 I described how people's livelihoods, in Mexico and other developing contexts, have undergone profound transformations involving, in many cases, a reduced role of the homegarden in people's livelihood security. This chapter elaborates further the conceptualisation of homegardens, how and in what ways they contribute to livelihood security and the main factors underpinning their transformation.

The first section of the chapter provides a definition of the homegarden and describes its most distinctive characteristics. The second section discusses the role of the homegarden as a livelihood strategy, explaining the main functions it performs, how these relate to livelihood security and how biodiversity mediates this relationship. The third section describes the particular characteristics of homegardens in the Yucatan Peninsula and how they have contributed to people's livelihood security. The fourth section addresses the main drivers of homegarden transformations. Drawing on a review of the state-of-the-art of the general literature on homegardens, the fifth section discusses the research gaps I am seeking to respond to in this thesis. Finally, the chapter concludes by emphasising how homegardens are defined in this research; the role of the homegarden as a livelihood strategy; and how this thesis will address the aforementioned research gaps.

2.1 An introduction to homegardens

Homegardens have been part of rural food systems for centuries. In Southeast Asia their origin is traced back to between 13,000 and 9,000 B.C., starting with the accidental propagation of seeds (Soemarwoto, 1987; Soemarwoto and Conway, 1992; Wiersum, 2006). Kumar and Nair (2004) cite illustrations of homegardens in the Indian epics Ramayana and Mahabharata dating back to 7000 B.C and 4000 B.C. In Mesoamerica, there is evidence of the existence of homegardens since the year 6,000 B.C. (Mariaca Méndez, 2012). The characteristics of homegardens vary depending on the physical environment, and the ecological, socioeconomic, political and cultural features of the particular context (Soemarwoto and Conway, 1992; Abdoellah *et al.*, 2006; Pérez-Vázquez *et al.*, 2012). This explains why there is not a broad accepted definition of homegardens (Fernandes and Nair, 1986; Hoogerbrugge and Fresco, 1993; Kehlenbeck and Maass, 2004; Kumar and Nair, 2004; Galhena *et al.*, 2013).

2.1.1 Definition

Different terms have been used around the world to refer to homegardens. Some English names include: agroforestry homegardens, backyard gardens, compound farms, dooryard gardens, homestead farms, household gardens, house gardens, kitchen gardens, mixed gardens and village forest gardens (Fernandes and Nair, 1986; Lope-Alzina and Howard, 2012). In this thesis I adopt the term homegarden as the English equivalent of the Spanish terms '*huerto familiar*' and '*solar*' frequently used in my research context. Accordingly, I define homegardens as small-scale agroforestry systems formed by plants and animals and integrated within the dwelling space where productive, social and cultural activities take place (c.f. Fernandes and Nair, 1986; Jiménez-Osornio *et al.*, 2003; Kumar and Nair, 2004; Hernández Sánchez, 2010; Mariaca Méndez, 2012). In defining homegardens in this way I am designating them as interlinked social and ecological systems, while emphasising their value as livelihood strategies.

2.1.2 Characteristics

Figure 2.1 presents some of the most distinguishable characteristics of the homegardens documented in the literature. In a study of the Javanese homegardens, Soemarwoto and Conway (1992) found that "the diversity and the intensive household care that is given to the homegarden result in a unique combination of high levels of productivity, stability, sustainability, and equitability" (Soemarwoto and Conway, 1992, p. 95). I placed these properties at the core of the description of homegardens, trying to depict how other socioeconomic and agroecological characteristics contribute to this desirable quartet.

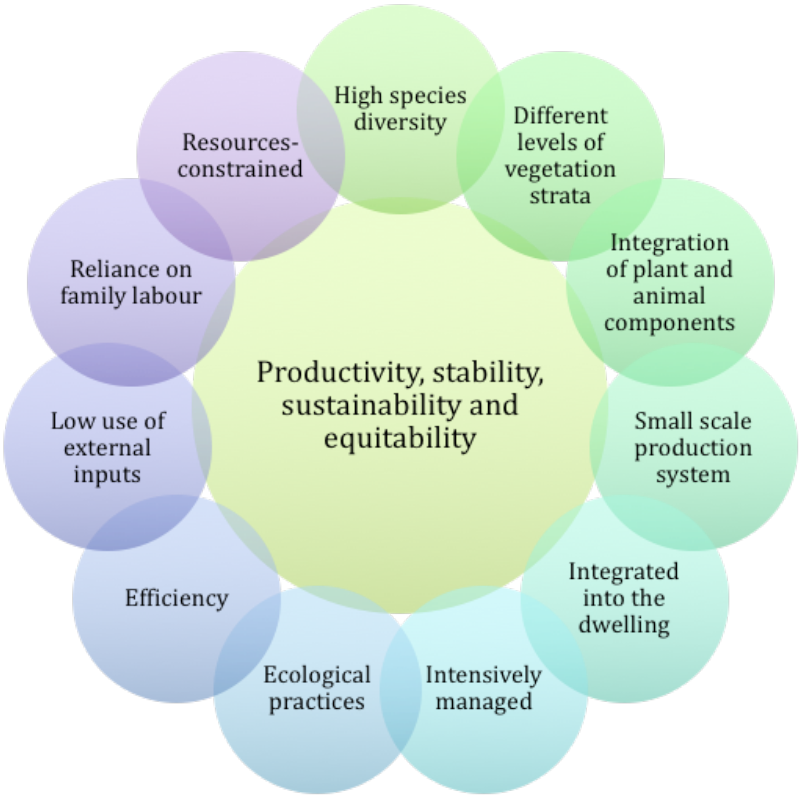
In Soemarwoto and Conway's study these four properties are defined as:

(i) Productivity. Output of valued product per unit of resource input;

(ii) Stability. Constancy of productivity in the face of small disturbing forces arising from normal fluctuations and cycles in the surrounding environment;

(iii) Sustainability. Ability of the agroecosystem to maintain productivity when subject to a major disturbing force; and

(iv) Equitability. Evenness of distribution of the productivity of the agroecosystem among the human beneficiaries, i.e. level of equity that is generated (Soemarwoto and Conway, 1992, p. 96).



Source: Own elaboration based on Drescher *et al.* (2006), Fernandes and Nair (1986), Galhena *et al.* (2013), Hoogerbrugge and Fresco (1993), Kumar and Nair (2004), Mekonen *et al.* (2015), Montagnini (2006), Landreth and Saito (2014), Lope-Alzina and Howard (2012), Soemarwoto (1987).

Figure 2.1 Main characteristics of the homegardens across the world

Some of the most emblematic ecological features of the homegardens are their high diversity (Nair and Kumar, 2006); the integration of plant and animal components (Fernandes and Nair, 1986; Jimenez *et. al*., 2003; Kumar and Nair, 2004); and within the plant component, a multi-story structure of tubers, herbs, flowers, crops, shrubs and trees (Fernandes and Nair, 1986; Kumar and Nair, 2004). The high species diversity allows the system to be productive across different seasons of the year; the integration of plants and animals enhances the nutrient cycling process and contributes to soil fertility; while its multi-story structure contribute to its resilience, for example, tall plants protecting those shorter from strong wind and providing shadow (Kumar and Nair, 2004).

Homegardens are small-scale production systems; however, they can vary considerably in size even within communities. They can be as small as a few square meters, as observed in Zambia ($10m^2$) (Hoogerbrugge and Fresco, 1993); Bangladesh ($30m^2$) (Drescher *et al.*, 2006); and Mexico ($50m^2$) (Castañeda-Navarrete *et al.*, 2018); but also as large as a few hectares, as in Sri Lanka (2.5 ha.) (Perera and Rajapakse, 1991); the Brazilian Amazonia (3

ha.) (Yamada and Osaqui, 2006); and Ethiopia (7 ha.) (Abebe *et al.*, 2006). Moreover, homegardens are not only production systems, but they also represent a living space and a social space, since they are usually located close to or integrated into the dwelling (Kumar and Nair, 2004; Drescher *et al.*, 2006; Mariaca Méndez, 2012; Galhena *et al.*, 2013).

Given the small size of homegardens, households tend to manage them intensively with the resources at hand, resulting in high productivity and efficiency levels (Soemarwoto and Conway, 1992). 'Traditional' homegardeners usually follow ecological practices such as intercropping and crop rotation and take advantage of nutrient cycling, for example, feeding animals with plants and using animal manure to fertilise plants (Jacob and Alles, 1987; Hoogerbrugge and Fresco, 1993; Kumar and Nair, 2004; Mekonen *et al.*, 2015). As a consequence of these practices, their expenditure on external inputs is usually low. In addition, labour mainly comes from family members. All the family members, women and men, from the children to elderly people get involved in homegardening; however, the division of tasks varies across cultures. In Latin America, homegardens are perceived as female spaces, although men and children also contribute to the management (Ángel Pérez and Mendoza, 2004; Howard, 2006; Lope-Alzina, 2007; Dietrich, 2011). In other contexts, such as Ethiopia (Mekonen *et al.*, 2015), Swaziland (Malaza, 2003) and Vietnam (Trinh *et al.*, 2003), the distribution of the tasks depends on the use of the crops. Men tend to dominate commercial crops, while subsistence crops are primarily women's responsibility. This dependence on family labour, and the key role women tend to play, favours a more equitable distribution of the benefits obtained from the homegarden than happens with commercial plantations (Soemarwoto and Conway, 1992).

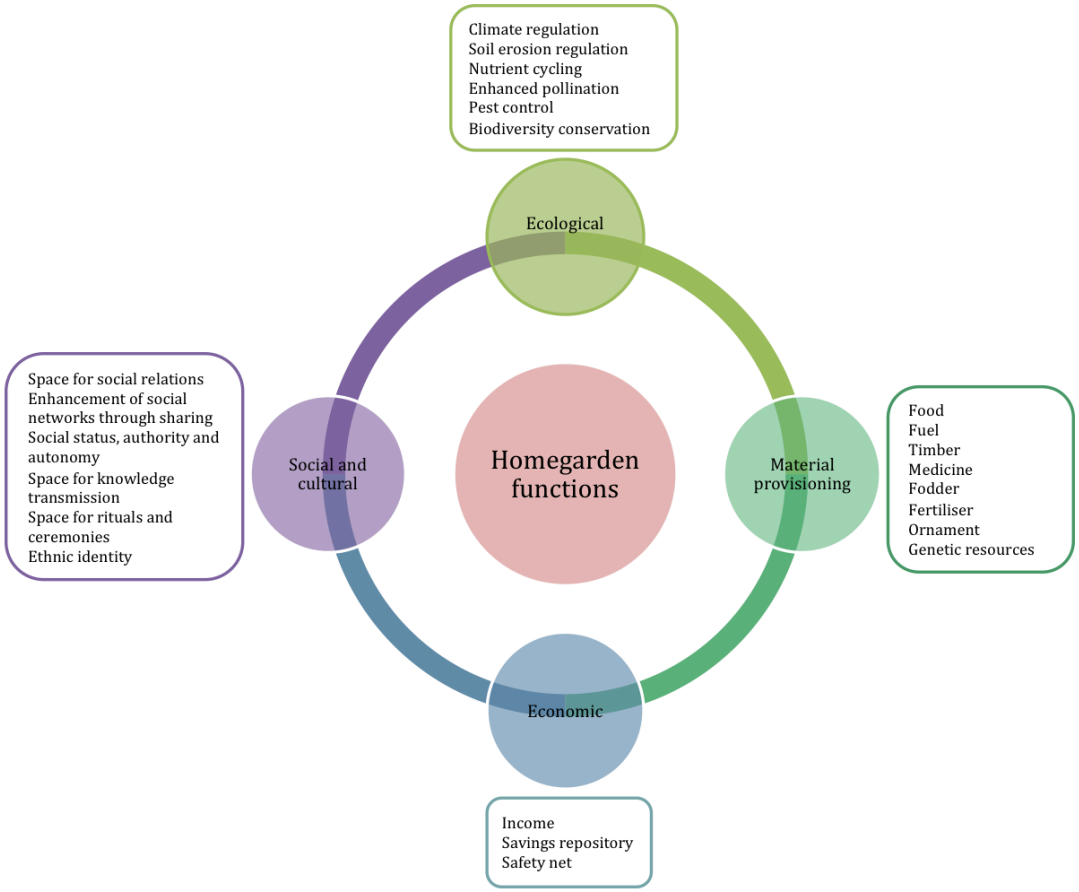
As Nair (2006) reflected more than two decades ago, the literature on homegardens tends to focus on the positive characteristics of these multi-functional agroforestry systems. Nonetheless, some of the literature has also documented the constraints and difficulties faced by the homegardeners, most of which describe the limited resources they possess: lack of land property rights (Hoogerbrugge and Fresco, 1993; Miller *et al.*, 2006; Thaman *et al.*, 2006); limited access to suitable and sufficient land (Thaman *et al.*, 2006); low soil fertility (Hoogerbrugge and Fresco, 1993; Thaman *et al.*, 2006; Galhena *et al.*, 2013); inadequate access to water (Hoogerbrugge and Fresco, 1993; Thaman *et al.*, 2006; Galhena *et al.*, 2013); restricted access to agricultural inputs (Hoogerbrugge and Fresco, 1993; Thaman *et al.*, 2006; Galhena *et al.*, 2013); labour shortages (Hoogerbrugge and Fresco, 1993; Thaman *et al.*, 2006; Galhena *et al.*, 2013); excessive post-harvest losses (Galhena *et al.*, 2013); and limited market opportunities (Ibid.)

The particular characteristics of the homegardener and the other household members, such as age, education and wealth, interact with contextual characteristics to determine the particular structure of the homegarden, its species diversity and management arrangements (Guerra Mukul, 2005; Drescher *et al.*, 2006; Kehlenbeck *et al.*, 2007; Lope-Alzina and Howard, 2012; Poot-Pool *et al.*, 2012). These arrangements, in turn, determine the functions performed by the homegardens and thus, their potential contributions to the livelihood security of the household. The next sub-section discusses some of the most common functions performed by the homegardens and how these contribute to people's livelihood security.

2.2 The homegarden as a livelihood strategy

The focus of this research is to understand how homegardens contribute to livelihood security. Consequently, it follows an anthropocentric approach to describing homegarden functions, grouping these according to how they contribute directly or indirectly to livelihood security or wellbeing (Polishchuk and Rauschmayer, 2012; Mohri *et al.*, 2013; Landreth and Saito, 2014). Figure 2.2 shows a four-category classification that groups homegarden functions into: (i) ecological; (ii) material provisioning; (iii) economic; and (iv) social and cultural. This classification is mainly based on the Millennium Ecosystem Assessment framework (2005), but also builds on research on the specific benefits homegardens provide to humans (Jiménez-Osornio *et al*., 2003; Abdoellah *et al.*, 2006; Mariaca Méndez, 2012; Lope-Alzina and Howard, 2012; Mohri *et al.*, 2013; Landreth and Saito, 2014).

Ecological functions correspond to those labelled as regulating and supporting services in the Millennium Ecosystem Assessment framework (2005), further developed by the Ecosystem Services for Poverty Alleviation (ESPA) Programme (Schreckenberg *et al.*, 2018). These functions determine the base of the system and constrain the ability of the homegarden to provide the other three groups of functions. Some examples of these functions are nutrient cycling, control of soil erosion, enhanced pollination, pest control and biodiversity conservation. Ecological functions depend on the balance within the homegarden system and are related to its sustainability. They also contribute to making climate more bearable. For example, homegardens contribute to regulating house temperature and humidity and help to protect the house from the wind (Jiménez-Osornio *et al.*, 2003).



Source: Own elaboration based on Abdoellah *et al.* (2006), Jiménez-Osornio *et al*. (2003), Landreth and Saito (2014), Lope-Alzina and Howard (2012), MA (2005), Mariaca Méndez (2012), Mohri *et al.* (2013).

Figure 2.2 Homegarden functions

Material provisioning functions refer to those tangible and more immediate uses, such as food, fuel, timber, fodder, medicinal and ornament (Lope-Alzina and Howard, 2012). These material provisioning functions contribute to the food security, nutrition and health of the household members (Chi Quej, 2009; Landreth and Saito, 2014). Although homegardens are rarely the main source of food, the fruits, vegetables, spices and animals produced within this agroecosystem are a complement to staple crops and represent significant sources of vitamins, minerals and proteins (Abdoellah *et al.*, 2006; Wiersum, 2006; Kehlenbeck *et al.*, 2007; Mohri *et al.*, 2013). Moreover, material provisioning functions also involve the role of the homegardens as spaces of experimentation for improving crop varieties and testing new species (Howard, 2006; Miller *et al.*, 2006; Lope-Alzina and Howard, 2012; Mariaca Méndez, 2012).

Economic functions derive from the material provisioning. Homegarden products are sources of income, although relatively small in comparison with other livelihood activities (Hoogerbrugge and Fresco, 1993; Galhena *et al.*, 2013). Nonetheless, some studies have

found a contribution to household income of over 50% (Hoogerbrugge and Fresco, 1993). In addition, homegarden livestock and poultry represent a savings repository in contexts where financial services are scarce (Mariaca Méndez, 2012). These savings are usually used to smooth health and weather shocks (García de Miguel, 2000; Gurri García, 2012).

Finally, homegardens represent a space of social and cultural reproduction and as such, they perform social and cultural functions (Mariaca Méndez, 2012). Homegardens provide a social and cultural space where the family gathers together, rituals and celebrations take place (García de Miguel, 2000; Howard, 2006; Cámara-Córdova, 2012; Lope-Alzina, 2012; Lope-Alzina and Howard, 2012). Homegardens are regarded as biocultural repositories since they enable the conservation of both biodiversity and traditional knowledge (Lope-Alzina and Howard, 2012; Mariaca, 2012). The transmission and conservation of — dynamic — traditional knowledge has been identified as a significant enabler of the development and sustainability of the homegarden (Mulyoutami *et al*., 2009). Evidence has also been found on how homegardens contribute to reinforce ethnic identity among migrants (Greenberg, 2003). Gifts and exchanges derived from homegardens are also used to create and maintain social networks (Howard, 2006; Lope-Alzina and Howard, 2012). Moreover, since women tend to participate actively in homegardening, these traditional agroecosystems represent for them "sources of authority, autonomy, status, social networks and visible public spaces of recognition" (Howard, 2006, p. 176).

2.2.1 Biodiversity and livelihood security

Biological diversity, as defined by the UN Convention on Biological Diversity, is understood as the "variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems[3]" (CBD, 1992, p. 3).

There is increasing evidence on the role of biodiversity as enabler of the benefits people derive from the environment. Positive effects of biodiversity have been found on the provision of ecosystem services such as soil erosion control, pest control and nutrient cycling (Balvanera *et al.*, 2006; Mace *et al.*, 2012). More diverse ecosystems are associated to greater resilience against nutrient perturbations and invading species (Balvanera *et al.*, 2006). Biodiversity has also been linked to buffering effects on the spreading of infectious

[3] An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit (MA, 2005, p. V).

diseases, not only to plants and animals (Balvanera *et al.*, 2006; TEEB, 2011), but also to humans (MA, 2005; TEEB, 2011).

In the context of agricultural systems, the term agrobiodiversity is frequently used to refer to both *planned diversity*, the crops and livestock managed by farmers, and associated biota, such as soil microbes and fauna, weeds, herbivores, and carnivores (Kontoleon *et al*., 2009). Considering that diversity between species tend to be more relevant for food security purposes than intra-species diversity (Berti and Jones, 2013), the focus in this thesis is on *planned agrobiodiversity (plant and animal) between species.*

The most widely documented benefit of agrobiodiversity is food security. The diversity in agricultural systems can contribute to food security through food provision; income generation; and smoothing weather, disease and economic shocks (Landon-Lane, 2011). Biodiversity is also associated with ecosystem services that support agricultural production including: soil fertility (Altieri, 2004; Jarvis *et al*., 2007), pollinators (Jarvis *et al*., 2007), pest control (Altieri, 2004; Balvanera *et al.*, 2006; Jarvis *et al*., 2007) and *in situ* conservation (Reyes-Garcia *et al*., 2013).

Although there is increasing evidence on the role of biodiversity in supporting the supply and resilience of ecosystems services and on how people use biodiversity, few studies have documented the causal link between biodiversity and dimensions of wellbeing (Berti and Jones, 2013; Jones *et al.*, 2014; Roe, 2014; Kumar *et al*., 2015). Food security is one aspect of wellbeing that has been studied in relation to on-farm diversity. There is evidence of positive associations between planned agrobiodiversity and diverse measures of food security in East and West Africa; South and South-East Asia; and Latin America.

In rural Ethiopia, the number of food groups produced is associated to children dietary diversity (aged 6-59 months) (Hirvonen and Hoddinott, 2017). In rural Zambia, positive associations are found between production diversity (crops) and household dietary diversity, children dietary diversity (aged 6–23 months) and children height for age Z-scores and stunting status (aged 24–59 months) (Kumar *et al.,* 2015). In Malawi, using data from a nationally representative survey, positive associations are found between farm diversity (crop and livestock) and household dietary diversity (Jones *et al.*, 2014). In rural Kenya, positive associations are found between the number of livestock kept in homegardens and household food security measured through food stocks and the number of daily consumed meals (Musotsi *et al*., 2008); and between agricultural biodiversity

(crops, animals and wild species collected for food purposes) and children dietary diversity[4] (Ekesa *et al*., 2008). In rural Benin on-farm diversity (crops) is found to be positively associated with household dietary diversity (Adjimoti and Kwadzo, 2018) and mothers' dietary diversity (Bellon *et al*., 2016).

In rural Afghanistan, positive associations are found between crop diversity and dietary diversity in the regular season; and between livestock species diversity and dietary diversity throughout the year (Zanello *et al.,* 2019). In rural Nepal, household production diversity, measured through the number of food groups produced, is positively associated to maternal dietary diversity, children dietary diversity (aged 6-59 months) and children's weight-for-height z-scores (Malapit *et al*., 2015). From national representative data, positive associations are found between crop diversity and both calorie consumption and household dietary diversity in Bangladesh (Sraboni *et al.,* 2014); and between crop diversity and household dietary diversity in India (Bhagowalia *et al.*, 2012). In Jambi Indonesia, production diversity (crop and livestock) is associated with higher household dietary diversity (Sibhatu *et al.*, 2015).

In rural Guatemala, crop and animal species richness, from *milpas*, homegardens and coffee plantations, is found to be associated with higher dietary diversity (Luna-González and Sørensen, 2018). In rural Peru, positive associations are found between crop variety (number of crops) and individual dietary diversity and food variety consumed (Chávez Zander, 2014). And in rural Mexico, positive associations are found between crop diversity and children dietary diversity (aged 24-58 months) (Dewey, 1981).

Despite the evidence on the positive association between species diversity and food security, how this relationship works is not well understood. Most of the studies that have found positive results also conclude that the relationship between planned agrobiodiversity and food security is complex and dependent on household and context characteristics (c.f. Jones *et al.*, 2014; Luna-González and Sørensen, 2018; Sibhatu and Qaim, 2018; Zanello *et al.,* 2019). Additionally, there is also a significant number of studies that have found null or negative associations. From a review of 45 studies, Sibhatu and Qaim (2018) find that over 20% reported non-significant associations, while over 60% reported non-significant or negative results for sub-samples of the observations or after controlling the analysis for household and community characteristics. Sibhatu *et al*. (2015) also suggest that

[4] Variety of foods in a diet over a given period of time, typically measured by counting the number of different foods or food groups (Berti and Jones, 2013, p. 187).

contributions of farm diversity to food security may diminish or even turn negative when production diversity is already high, increasing income trade-offs.

Studies examining the relationship between species diversity and food security have highlighted access to markets —measured through physical distance, income or wealth, food prices, market crop diversity and transport costs— as a factor that complements production diversity and, in some cases, has an even larger effect on food security (c.f. Dewey, 1981; Bhagowalia *et al.*, 2012; Jones *et al.*, 2014; Bellon *et al.*, 2016; Hirvonen and Hoddinott, 2017; Zanello *et al.,* 2019).

Factors that have been identified as significant confounding factors in determining food security outcomes include:

- Context characteristics such as infrastructure and remoteness (Adjimoti and Kwadzo, 2018); agroclimatic conditions (Hirvonen and Hoddinott, 2017); and seasonality (Chávez Zander, 2014; Bellon *et al*., 2016; Zanello *et al.,* 2019).
- Household characteristics such as age (Jones *et al.*, 2014; Chávez Zander, 2014; Luna-González and Sørensen, 2018); education (Jones *et al.*, 2014; Kumar *et al*., 2015; Luna-González and Sørensen, 2018); household size (Jones *et al.*, 2014; Kumar *et al*., 2015; Luna-González and Sørensen, 2018); gender of the household head (Jones *et al.*, 2014); women's empowerment (Malapit *et al*., 2015); access to sanitation and cooking facilities (Dewey, 1981; Kumar *et al*., 2015; Luna-González and Sørensen, 2018); and storage facilities (Adjimoti and Kwadzo, 2018).

2.3 The Yucatecan homegardens

Rural families in Yucatán, Mexico, traditionally based their subsistence on two main agroecosystems, the *milpa* and the homegarden, complemented by forest management and apiculture (Terán and Rasmussen, 1994; García de Miguel, 2000; Jiménez-Osornio *et al.*, 2003; Poole *et al.,* 2007). The *milpa*, considered a male space, is cultivated under swidden agriculture techniques, with maize, beans and squash as the main crops (García de Miguel, 2000; Lope-Alzina, 2007; Blundo Canto, 2014). The *milpa* has been the main farming system in Yucatan and Mesoamerica for over five thousand years (Mariaca Méndez, 2015). During the wet season forest trees are cut down, usually between one and three hectares per farmer, and let dry out to be burned during the dry season when the planting occurs (Benjamin, 2000; Blundo Canto, 2014). The burning of vegetation releases nutrients held in the organic matter, particularly important for cultivating in the Yucatecan shallow soils

(Terán and Rasmussen, 1994). Cleared areas are cultivated for between two and three years followed by a fallow period for soil recovery (Ibid.).

Homegardens in this region are areas that have been transformed by the inhabitants to establish their dwellings (Jiménez-Osornio *et al.*, 2003). Although relevant, their livelihood importance is lower than the *milpa* (Terán and Rasmussen, 1994; Cuanalo de la Cerda *et al.*, 1998). The homegardens are considered to be mainly female spaces, although children and elderly people are also involved in their management and young and middle-aged men usually help with some of the heaviest tasks (Jiménez-Osornio *et al.*, 2003; Howard, 2006; Lope-Alzina, 2007; Chi Quej, 2009; Dietrich, 2011). Despite they have different location, the homegarden is usually regarded as part of the *milpa* system, since the *milpa* provides the main staples, while the homegarden complements the diet, providing spices, vegetables, fruits and animal protein (Terán and Rasmussen, 1994; Cuanalo de la Cerda *et al.*, 1998). The better off *campesinos* complement the *milpa* and homegarden production with the crops and fruits grown in the *parcela*, an additional piece of land that tends to have irrigation infrastructure and is mainly managed for commercial purposes (Lope-Alzina and Chavez-Servia, 2001; Cuanalo de la Cerda and Guerra Mukul, 2008).

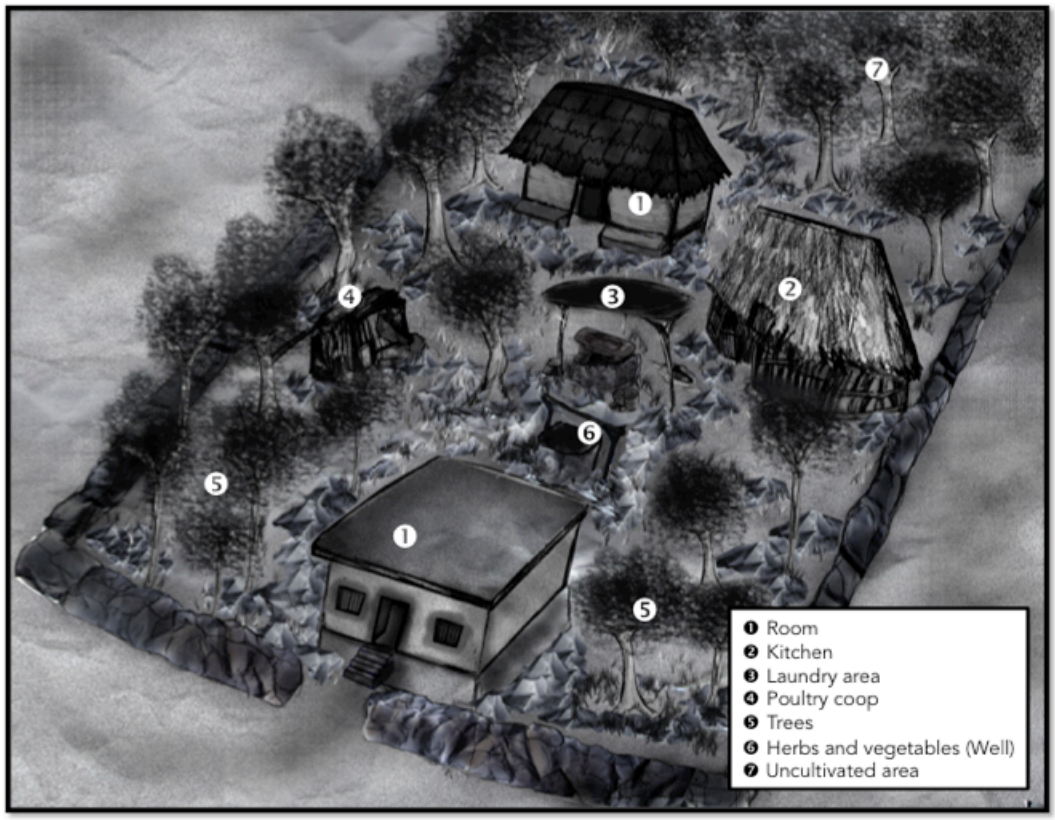
2.3.1 Characteristics

The homegardens of Yucatán documented in the literature range in size from 80m^2 to 20,000m^2, with an average of 2,000m^2 (Castañeda-Navarrete *et al.*, 2018). Some common elements in the structure of the homegardens in this region are: trees, herbs, vegetables, ornamental plants, poultry coops, pigsties, kitchen, laundry areas, sanitation facilities, houses or rooms, and uncultivated areas (Herrera Castro, 1994; Jiménez-Osornio *et al.*, 2003; Cámara-Córdova, 2012; Lope-Alzina and Howard, 2012). Figure 2.3 depicts one of the homegardens surveyed in Hocabá, Yucatán. This homegarden still possesses most of the traditional components documented in the literature on the region, though as it is shown in Chapter 5, the 'typical' structure of the homegarden has changed along with people's lives.

The characteristics and functions of the Yucatecan homegardens are very similar to those already discussed. Homegardens in this region are very diverse in biological terms. For example, up to 387 plant species have been documented in the homegardens of a single community (Herrera Castro, 1994). These plants include native and introduced species from all over the world. Spaniards introduced most of the non-native species in the 16th century, although some homegardens still contain pre-Columbian plants in proportions as high as 70 per cent (Mariaca Méndez *et al.*, 2010; Lope-Alzina and Howard, 2012). The main

animal species found in the homegardens of the region are: chickens, turkeys, pigs, dogs and cats (Chi Quej, 2009; Lope-Alzina and Howard, 2012; Lope-Alzina, 2017). Some of the most abundant plant species are:

- Citrus (*Citrus aurantium* L.*, Citrus limón* (L.) Osbeck*, Citrus reticulata* Blanco*, Citrus sinesis* (L.) Osbeck, *Persea americana* Mill.),
- Breadnut tree (*Brosimum alicastrum* Sw.),
- Spanish cedar (*Cedrela odorata* L.),
- Tree spinach (*Cnidoscolus aconitifolius* (Mill.) I.M. Johnst),
- Palms trees *(Sabal mexicana* Mart.),
- Bananas *(Musa paradisiaca* L.),
- Sugar-apples (*Annona squamosa* L., *Annona reticulata* L.),
- Plums (*Spondias purpurea* L) and
- Mangos (*Mangifera indica* L.) (Xuluc Tolosa, 1995; Ruenes Morales *et al.*, 1999).



Drawing by Eric Alonso Méndez Salazar, homegarden located in Hocabá, Yucatán.

Figure 2.3 Traditional homegarden structure in Yucatán

2.3.2 The Yucatecan homegarden as a livelihood strategy

People´s uses of homegarden diversity in the Yucatan Peninsula have been widely documented, particularly those of plant diversity (c.f. Smith and Cameron, 1977; Herrera Castro, 1994; Xuluc Tolosa, 1995; Jimenez *et. al*., 2003; Guerra Mukul, 2005; Chi Quej, 2009; Hernández Sánchez, 2010). Homegarden species are mainly used as food and condiments; medicine; fodder and other animal feed; construction materials; dye; timber and firewood; as a tool; ornament; and ritual.

As a livelihood strategy, the Yucatecan homegarden complements the diet throughout the year with food and spices that satisfy social and cultural preferences (Caballero, 1992; Greenberg, 2003); generates savings from reducing market purchases (Aké *et al.,* 2012; Cahuich Campos, 2012); works as a savings repository (Vara Morán, 1980; Salazar *et al*., 2015); and generates income from the sales of the surplus (Cuanalo and Guerra, 2008; Chi Quej, 2009; Cahuich Campos, 2012). The role of the homegarden as biocultural repository has also been highlighted by the homegarden literature on the region (Jiménez-Osornio, 2004; Lope-Alzina and Howard, 2012; Mariaca, 2012). As discussed in the previous sections, this role of conservation of biodiversity and traditional knowledge enhances the provision of homegarden goods, such as food and income.

Although the uses of homegarden species have been extensively studied, few studies have assessed the contribution of the Yucatecan homegardens to wellbeing dimensions, such as food or income security. Exceptions include studies by Aké *et al.* (2002); Chi Quej (2009); Alayón, (2012); and Salazar *et al.* (2015) who estimate that homegarden sales represent from 3 per cent to more than 50 per cent of the household income. Animal species tend to generate higher income flows than plant species (Salazar *et al.*, 2015), but considering the inputs needed to raise the animals, this activity has also found to be less profitable, at least from a mainstream economic perspective (Aké *et al*., 2002; Cuanalo and Guerra, 2008).

In terms of contributions to food security, Stuart (1993) finds that homegardens of Yaxcabá, Yucatán, provide 10 per cent of protein intakes, 55 per cent of vitamin A and 73 per cent of vitamin C. Leatherman and Goodman (2005) observe positive associations between the availability of mangos and chaya[5] (a leafy plant) in the homegardens and higher intakes of vitamins A and C. Furthermore, Salazar and Magaña (2016) find homegardens together with the *milpa* supply, on average, around 60% of food needs.

[5] *Cnidoscolus chayamansa* Mc Vough.

Despite this evidence on the role of homegardens in people's livelihood security, none of the studies reviewed address the relationship between homegarden diversity and the benefits derived from it. The one exception identified is the study by Becerril *et al.* (2014) who find negative association between crop diversity (number of crops) in the *milpa* and the homegarden and overweight. They find that households with higher species diversity, in the *milpa* and the homegarden, were less likely to present overweight. However, these scholars also acknowledge that these households tended to be poorer and thus had to depend more on own food production.

2.4 Homegarden dynamics

Homegardens are dynamic systems that have been evolving since pre-Hispanic times. One of the main early drivers of change was the arrival of the Spanish colonisers in the Yucatán Peninsula. Between the years 1550 and 1560, the Mayan population were forced to leave their settlements and moved to 'organised towns' (González Jácome, 2012; Mariaca Méndez, 2012). The building of fences was also required, affecting hunting activity, since homegardens were previously used as a lure for attracting wild animals (Mariaca Méndez, 2012). This displacement involved the transformation of land ownership from communal to private, and the -relative- rupture of the extended family into single-family units, both for evangelisation and military-domination purposes (García de Miguel, 2000; Baños Ramírez, 2002).

The *solar*, which was the unit used by the viceregal government to distribute and organise the land, had an extension of 2,500 m^2 (González Jácome, 2012; Mariaca Méndez, 2012), a dimension very close to the average size of the present homegardens of Yucatán -2,000m^2- (Castañeda-Navarrete *et al.*, 2018). Spanish colonisers introduced new techniques, tools and species. Some of the plant species introduced were: oranges, lemons, limes, grapefruits, bananas, onions, garlic, carrots, spearmint, cucumbers, and parsley, among others (González Jácome, 2012; Lope-Alzina and Howard, 2012; Mariaca Méndez, 2012). Some of the introduced fauna were: pigs, chickens, cats and dogs (Chi Quej, 2009; González Jácome, 2012; Lope-Alzina and Howard, 2012; Mariaca Méndez, 2012).

Changes in homegardens have accelerated since the 1980s as part of the transformations faced in the rural space in the aftermath of the neoliberal reforms, as was discussed in the previous chapter. Rural transformations have been characterised by demographic

transitions and changes in the economic, social, cultural and environmental arenas, challenging the rural-urban divide (c.f. Baños Ramírez, 2001; Satterthwaite and Tacoli, 2003; Zhijun, 2004; Cloke, 2006; Satterthwaite *et al.*, 2010).

Rural households have increasingly diversified their livelihoods, shifting from agriculture to a 'recombinant *bricolage*' of livelihood strategies (Bernstein and Byres, 2001; Rigg, 2006; Borras, 2009; Du Toit and Neves, 2014). Rural households have variously adopted a combination of market/non-market, capitalist/non-capitalist and multi-sited urban/rural strategies to sustain their living (Du Toit and Neves, 2014; Fairbairn *et al.*, 2014). Yet the de-agrarianisation process has not completely undermined the role of agriculture in rural livelihoods. Within the *bricolage* of livelihood strategies, agriculture keeps an important role as a safety net against the fluctuations of market-oriented livelihoods, at least among some households (Du Toit and Neves, 2014; Fairbairn *et al.*, 2014). Nonetheless, rural households are becoming increasingly "semi-proletarianized, semi-globalised and semi-urban" (Hecht, 2014, p. 878).

No matter the context, a common trend observed in homegardening settings around the world is population growth with the consequent division of land (Soemarwoto and Conway, 1992; Kumar and Nair, 2004; Wiersum, 2006; Chávez García, 2012). This division of land has reduced the size of the homegardens and diminished the availability of land for open field cultivation systems (Wiersum, 2006; Chávez García, 2012). Since homegardens tend to play a complementary role in the farming system, less land for the main farming activities can lead either to an intensification of homegarden cultivation or to an abandonment of the farming system all together, as has been observed in Indonesia (Wiersum, 2006) and Mexico (Chávez García, 2012). Land grabbing, a factor studied in the agrarian change literature, but not yet examined by homegarden studies, is likely to have a similar effect on the availability of cultivable land.

Improvements in infrastructure and other public services are another manifestation of urbanisation. An effect of these is to facilitate the access to goods, services and labour markets. An increasing commercialisation of homegarden products has been broadly documented in Ethiopia (Abdoellah *et al.*, 2006), India (Kumar and Nair, 2004), Indonesia (Soemarwoto and Conway, 1992; Abdoellah *et al.*, 2006; Wiersum, 2006) and Spain (Kumar and Nair, 2004). A greater commercial role has generally meant specialisation and increases in homegarden productivity in the short-term; however, different researchers have warned that these transformations threaten the sustainability of homegardens, increasing their

dependence on external inputs and undermining their multifunctionality (Soemarwoto, 1987; Abdoellah *et al.*, 2006; Peyre *et al.*, 2006; López Barreto, 2017). For example, by turning homegardens into private spaces (Soemarwoto, 1987), diminishing their social role (Ibid.) and neglecting the animal component of the system (Abdoellah *et al.*, 2006; Mellisse *et al.*, 2018). Although this greater emphasis on cash-crops generally leads to reductions in homegarden diversity, exceptions to this rule have been found in India (Peyre *et al.*, 2006) and Ethiopia (Mellisse *et al.*, 2018). However, these studies do not explain the reasons behind these alternative pathways.

The changes in people's livelihoods have been accompanied by cultural and social transformations in the organisation of the rural family in particular and across rural society in general (Baños Ramírez, 2001; Ellis, 2006; Rigg, 2006). An intensified connection with urban centres, together with a broader access to formal education, TV, mobiles and Internet, has modified people's aspirations and a so-called 'acculturation', especially among young people (Baños Ramírez, 2001; Vogl *et al.*, 2002; Howard, 2006). Rural households are becoming smaller and based on the nuclear family, rather than in the extended family; consumption is being separated from production; and rural populations are increasing their preferences for industrialised food and off-farm livelihoods (Baños Ramírez, 2001; Baños Ramírez, 2002). Nonetheless, this is not a smooth or linear 'modernisation' process, but a post-traditional stage where the agrarian and traditional 'past' merges with the 'modern', urbanised and uncertain 'present' (Baños Ramírez, 2001).

The consequences of these cultural and social transformations for homegardening go from the availability of more financial resources to invest in the homegarden (Guerrero Peñuelas, 2007); introduction of new species and new techniques (Kumar and Nair, 2004; Guerrero Peñuelas, 2007; Lope-Alzina and Howard, 2012); increasing aesthetic function of the homegardens (Wiersum, 2006; Hernández Sánchez, 2010); to the loss of traditional knowledge (Hoffmann, 2003; Howard, 2006; Cano-Ramírez *et al.*, 2012); decreasing use of medicinal plants (Kumar and Nair, 2004); less interest in homegardening (Guerrero Peñuelas, 2007); food commoditisation (Kumar and Nair, 2004; Howard, 2006); and the ageing of gardeners (Soini, 2005).

A parallel trend to the decreasing interest in homegardening in urbanising rural areas is an increasing interest in agriculture in urban areas, e.g. through allotments, community gardens or homegardens (Nair, 2006; Kortright and Wakefield, 2011; Taylor and Lovell, 2014). This flourishing of urban farming has different causes. It has been promoted as a way

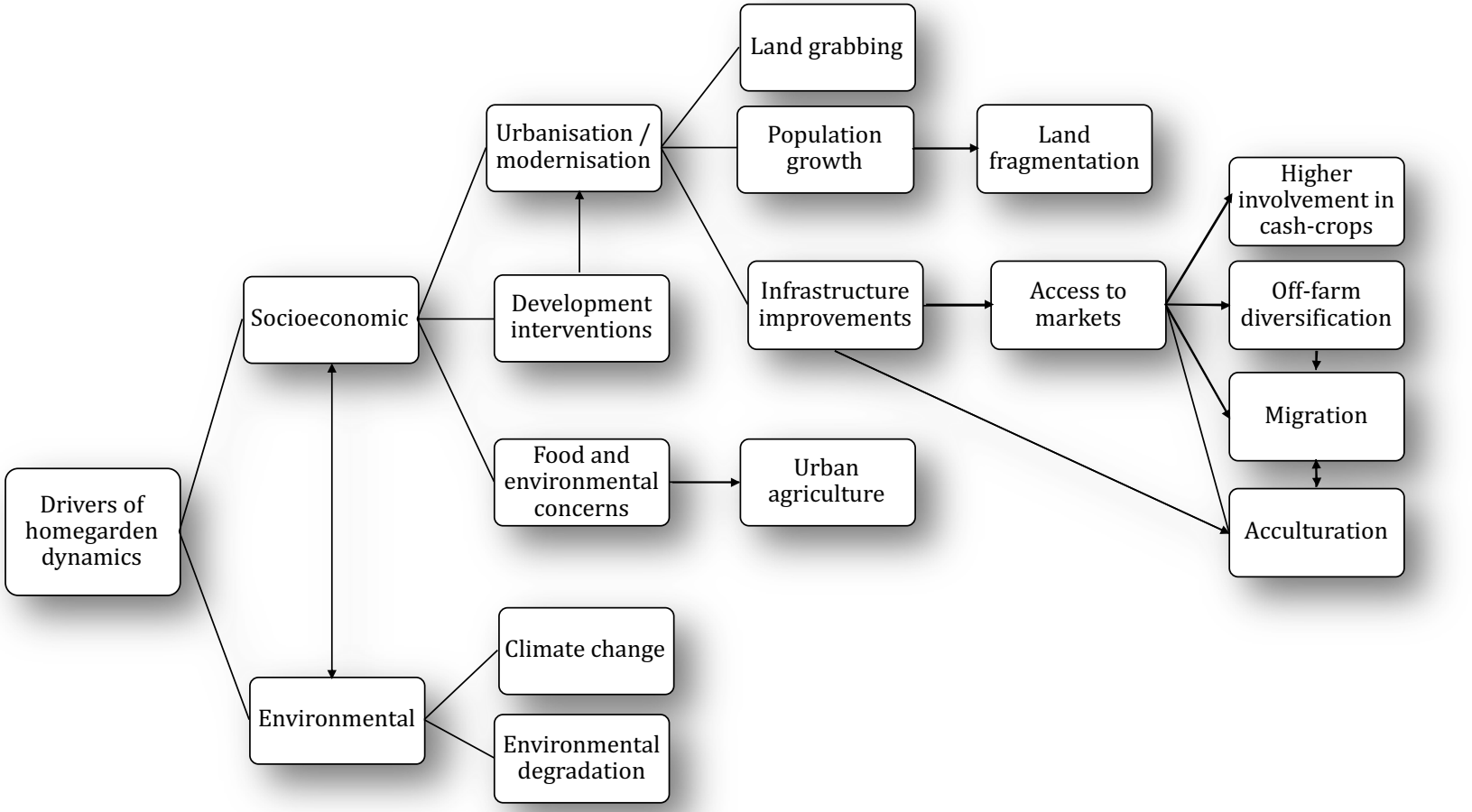
to contribute to food security and strengthen social cohesion in poor neighbourhoods, and it has also become a response to concerns on the negative effects of the mainstream food production system (Drescher *et al.*, 2006; Kortright and Wakefield, 2011; Taylor and Lovell, 2014). Thaman *et al.* (2006) highlights the potential role of urban homegardens to preserve traditional knowledge. Furthermore, in urban and peri-urban centres, agriculture in general is found to constitute a risk-coping strategy against the uncertainty of job markets and to compensate for low non-farm incomes (Satterthwaite *et al.*, 2010; Mendez-Lemus, 2012; Lerner *et al.*, 2013).

Development interventions have also transformed dwelling spaces, creating new concrete structures, and introducing tap water, but have also displaced homegarden species, contributed to the erosion of traditional knowledge and increased the dependence on external inputs, threatening the sustainability of the homegarden system (Soemarwoto, 1987; Mariaca Méndez, 2012; López Barreto, 2017).

Climate change and environmental degradation are likely affecting homegardening. Climate change is altering the predictability of rainfall and the occurrence of extreme events such as floods, droughts and hurricanes, which in turn disrupt farming activities that depend on predicable weather patterns (Soini, 2005; Landon-Lane, 2011; Devereux *et al.*, 2012; Mohri *et al.*, 2013; Landreth and Saito, 2014). Soil depletion, water scarcity and water contamination are also factors pushing people into off-farm livelihoods (Tacoli, 1998; Landon-Lane, 2011; Landreth and Saito, 2014). Nonetheless, there is evidence that homegarden systems show higher resilience to climate change than mono-crop production systems and that nutrient cycling helps to reduce soil erosion (Altieri, 2004; Linger, 2014).

Figure 2.4 summarises the drivers of homegardens transformations discussed in this section. The drivers have been grouped in two categories: i) socioeconomic, including the social, economic and cultural changes; and ii) environmental, including changes in weather patterns and in the availability and quality of natural resources.

After this review of the homegarden dynamics, the next section discusses the state-of-the-art of the literature on homegardens and the research gaps this thesis aims to address.

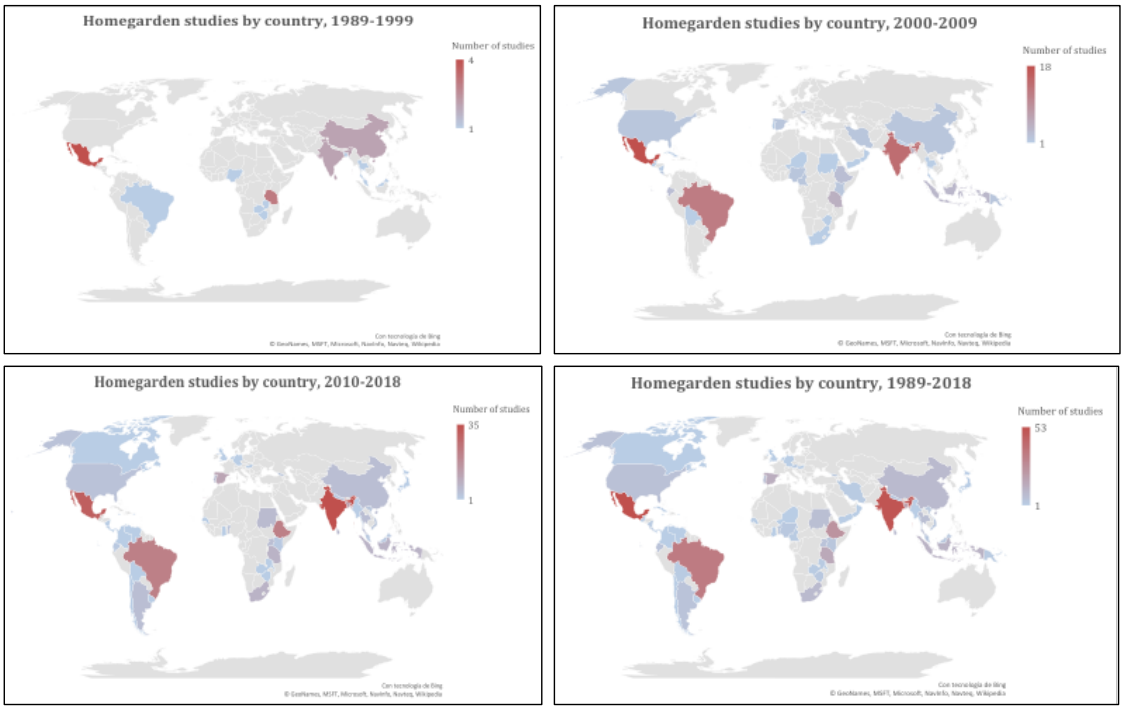


Source: Own elaboration based on Soemarwoto (1987); Soemarwoto and Conway (1992); Vogl *et al*. (2002); Kumar and Nair (2004), Sorni (2005); Abdoellah *et al.* (2006); Howard (2006); Wiersum (2006); Hernández Sánchez (2010); Chávez (2012); Lope-Alzina and Howard (2012); Mariaca (2012); Mohri *et al*. (2013); Melisse *et al.* (2018).

Figure 2.4 Drivers of homegarden transformations

2.5 Research gaps

Homegardens are ecologically divided into two categories: tropical and temperate (Galhena *et al.*, 2013). As figure 2.5 shows, tropical gardens dominate the literature on the topic, with special focus on Central and South America, South and South-East Asia, the Pacific Islands, and East- and West Africa. Nonetheless, homegarden literature in temperate contexts has grown in the two last decades, including studies in countries such as Austria, Canada, Czech Republic, Germany, Hungary, Portugal, Spain, United Kingdom and the United States.

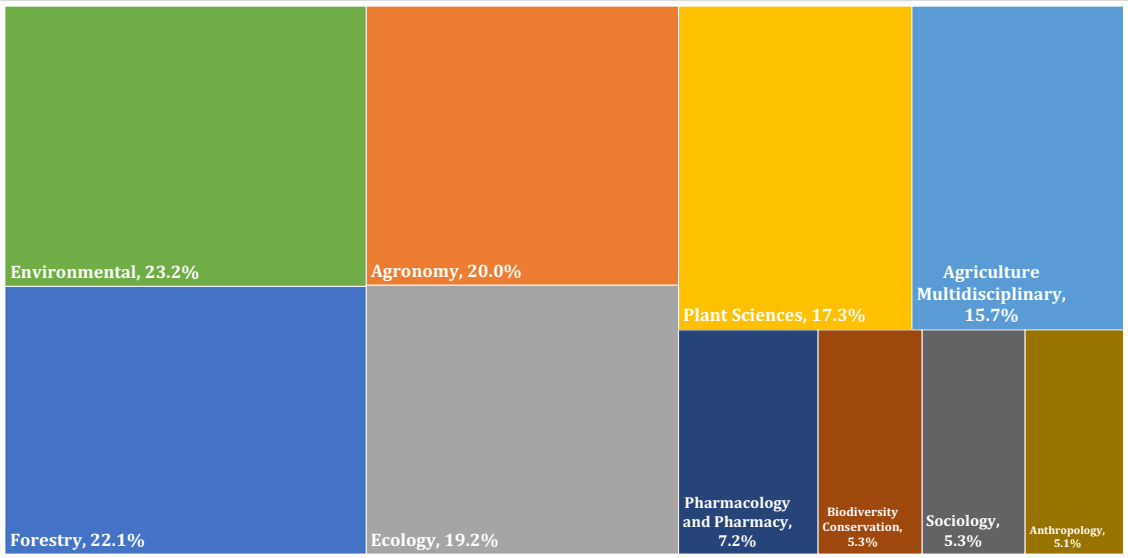


Source: Author's elaboration based on search in Scopus and Web of Science.

Figure 2.5 Homegarden studies by country over time, 1989-2018

Although the literature on homegardens was scarce in the 1980s, the interest in homegardening research has increased in the last two decades. However, most of the studies are merely descriptive and tend to focus on the ecological characteristics of the homegardens, giving less attention to their social and economic dimensions (Nair, 2006; Lope-Alzina and Howard, 2012; Castañeda-Navarrete *et al.*, 2018). Using the terms 'homegarden' and 'home garden' a total of 375 studies were identified from a search in Scopus and Web of Science databases of peer-reviewed literature. As figure 2.6 shows, most of the studies on homegardens are found in fields from the natural sciences. About a half of the studies are located within the fields of environmental sciences, environmental studies and forestry; while social sciences all together only contained 16%.

Some aspects that have been neglected in the literature on homegardens include: seasonal and long-term dynamics (Wiersum, 2006; Lope-Alzina and Howard, 2012); interrelation between the ecological features of the homegarden and the socioeconomic and cultural characteristics of the household and the communities where they are located (Peyre *et al.*, 2006; Pérez-Vázquez *et al.*, 2012; Castañeda-Navarrete *et al.*, 2018); homegarden knowledge (Lope-Alzina, 2017); resilience contribution (Jiménez-Osornio *et al.*, 2003); and homegardens in urban settings (Nair, 2006).



Source: Author's elaboration based on search in Scopus and Web of Science.
Note: One study can be classified in more than one category.

Figure 2.6 The top ten fields of peer-reviewed studies on homegardens, 1989-2018

An extensive review of the literature on homegardens in the Yucatán Peninsula was conducted, both in English and Spanish. A total of 112 studies were reviewed systematically, including 54 book chapters, 13 dissertations, 33 journal articles, six books, four PhD thesis and two research reports (Castañeda-Navarrete *et al.*, 2018). For each study a form was filled including: an abstract, key words, discipline, location, sample size, diversity figures and key uses of the species documented. The research gaps identified from this review were very similar to those observed in the literature worldwide.

A common characteristic to most of the studies reviewed was that they involved an inventory of species. These inventories, though relevant to capture accurate species and varieties diversity data, are time-consuming and thus constrain the number of homegardens that can be surveyed. The average sample size was 29, with a minimum size of one homegarden and a maximum of 189 (Ibid.). Considering the heterogeneity of the homegardens and the households that own them, these small sample sizes limit the

possibility to arrive to sound conclusions in the relation between homegarden and household characteristics.

As discussed in sections 2.2. and 2.3, another research gap identified was the linkages between biodiversity and wellbeing, including food security. This gap is shared by both the homegardens literature and the broader literature on the wellbeing benefits of biodiversity. It was also noticed that in the Yucatán Peninsula, as in the rest of the world, homegarden studies tend to focus only on the plants, neglecting the animal component (Ibid.).

Based on the research gaps identified in the literature, this thesis focuses on three key areas aiming to add to the understanding of how homegardens contribute to people´s livelihoods:

i. ***Long-term dynamics*.** Given data restrictions, there are few studies analysing the transformations of the homegardens or other agricultural systems over a long period of time, and those addressing long-term dynamics are mostly based on document analysis (c.f. Lazos Chavero, 1995; García de Miguel, 2000; Hernández Sánchez, 2010; Radel *et al.*, 2010; Chávez García, 2012; González Jácome, 2012; Serrano Ysunza, 2016). This thesis draws on life histories and panel survey data to capture long-term dynamics of homegarden management and livelihoods diversification.

ii. ***Interrelationships between homegarden, household and community characteristics*.**

a. *Within-group differences.* The few studies analysing the linkages between homegardening, livelihood strategies and livelihood outcomes are focused on general patterns, either 'rich' and 'poor' or 'rural' and 'urban', neglecting the differences within groups. (Babulo *et al.*, 2009; Tesfaye *et al.*, 2011; Poot-Pool *et al.*, 2012; Poot-Pool *et al.*, 2015). These approaches do not assess how the interaction of different household and community characteristics shape homegardening and livelihood security. This thesis investigates both between- and within-group differences.

b. *Interactions and trade-offs between livelihood strategies*. The contribution of homegardens to livelihood security has been mainly analysed in isolation. However, considering the intensity of livelihood diversification and rural-urban linkages in the research context, this thesis analyses how homegardening interacts with other strategies, and the trade-offs and complementarities households face in these decisions.

c. *Spatial dynamics*. Literature on the spatial dimensions (rural-urban) of homegardens focuses on variations in diversity, management practices, use and degree of commercialisation at the community level (c.f. Rico-Gray *et al.*, 1990; García de Miguel, 2000; Ángel Pérez and Mendoza, 2004; Bernholt *et al.*, 2009; Molebatsi *et al.*, 2010; Poot-Pool *et al.*, 2015; Peroni *et al.*, 2016; Salazar-Barrientos and Magaña-Magaña, 2016). However, with the exception of permanent migration, these studies do not analyse the influence of rural-urban interactions in homegardening and the related livelihood outcomes (Greenberg, 2003; Guerrero Peñuelas, 2007; Cano-Ramírez *et al.*, 2012). This thesis analyses spatial dynamics at household level through the participation in urban jobs and other off-farm activities.

d. *Animal component of the homegardens*. Most of the literature on homegardens follows an ethnobotanical perspective, neglecting the animal component, which is often vital to local livelihoods. Of the literature on homegardens in the Yucatán Peninsula, less than 20 per cent of the studies reports animal diversity (Castañeda-Navarrete *et al.*, 2018). This thesis covers both, the animal and the plant components of the homegardens and analyses how the type and level of diversity of these components varies depending on household and community characteristics.

iii. ***Contribution of homegardens to household food security*.** Though the role of homegardens in nutrition and food security is acknowledged in the literature on the Yucatán Peninsula, only four systematic studies were identified on this topic (Stuart, 1993; Leatherman and Goodman, 2005; Becerril *et al.,* 2014; Salazar-Barrientos and Magaña-Magaña, 2016) and only one of them examining the relationship between biodiversity and nutrition outcomes (obsesity) (Becerril *et al.,* 2014). This research gap was surprising considering that there are several public programmes promoting homegardens in Yucatán aiming to contribute to food security. Moreover, in the worldwide literature, a gap was identified in terms of how the relationship between homegardening and food security works (Masset *et al*., 2012). This thesis examines how homegardens are contributing to household food security and how development interventions promoting homegardens could be improved.

2.6 Conclusions

This chapter defined the homegarden as a small-scale agroforestry system that represents a productive, social and cultural space. As discussed in this chapter, homegardens have contributed to people's livelihood security for centuries; however, rural transformations are challenging the traditional understanding of the role of homegardening as a livelihood strategy and its interactions with other on-farm and off-farm activities.

Four key homegarden functions contributing to people's livelihood security are identified: (i) ecological; (ii) material provisioning; (iii) economic; and, (iv) social and cultural. Considering the increasing evidence on how biodiversity mediates the provision of these functions, this research uses measures of different types of planned diversity between species to capture the functions performed by homegardens in the study sites. The next chapter presents the framework adopted to examine the relationship between homegarden diversity and livelihood outcomes, while Chapter 4 provides details on how it is operationalised.

Three research gaps are addressed in this thesis: (i) long-term dynamics; (ii) interrelationships between homegarden, household and community characteristics; and (iii) the contribution of homegardens to food security. Rural urbanisation has intensified the heterogeneity between and within households and communities. Although general trends in the relationship between homegardens and livelihood security have been documented in the literature, this thesis seeks to uncover different trajectories of change and to explain their underlying causes. Drawing on life histories and panel survey data, Chapter 5 examines long-term dynamics of homegarden management and livelihood diversification, discussing the differences and commonalities between households. Seeking to disentangle the complexity and diversity that exists in the relation between homegarden, household and community characteristics, Chapter 6 draws on household survey data of four communities to provide a typology of homegardens. As described in this chapter, despite the evidence on the positive association between species diversity and food security, how this relationship works is not well understood. Chapter 7 contributes to fill this research gap, uncovering factors that mediate this relationship.

The next chapter presents the theoretical framework used to address these research gaps.

Chapter 3. Endowments-Based Livelihoods Framework

Introduction

Chapters 1 and 2 showed how an intensified connection between rural and urban areas has transformed people's livelihoods in Yucatán, resulting in heterogeneous effects in their engagement with homegardening. This chapter provides an analytical framework to understand how households convert their resources and rights into livelihood outcomes through a creative *bricolage*[6] of livelihood strategies, including homegardening. The first section describes key elements of the Sustainable Livelihoods Framework, and the Capability Approach, discusses their strengths and drawbacks, and draws on these elements to propose a hybrid *Endowments-based Livelihood Framework (ELF)*. The second section synthesises this proposed framework with the literature reviewed in Chapter 2 and presents a theory of change on how the contribution of homegardening to livelihood security is hypothesised and tested in this thesis. The chapter concludes by discussing how the proposed framework is applied in this thesis.

3.1 Endowments-based Livelihoods Framework

This research draws on elements of the Sustainable Livelihoods Framework, and the Capability Approach, building mainly on the work of Sen (1993); Scoones (1998, 2015); Bebbington (1999); Leach *et al*., (1999); Dawson and Martin (2015); and Lienert and Burger's (2015).

The Sustainable Livelihoods Framework (SLF) is used for explaining how people define their livelihood portfolio, the role of homegardening in this portfolio and the outcomes people derive from it. SLF approaches can be dated back from the first observations of rural conditions; however, it was not until the work of Chambers and Conway (1992) that the first formal definition of SLF appeared (Scoones, 2009). Based on Chambers and Conway's work, researchers from the Institute of Development Studies proposed the following definition:

> A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance

[6] Making the best of the available resources (Louridas, 1999, Baker and Nelson, 2005, Rosenlew, 2012, Debnath and Bardhan, 2018).

> its capabilities and assets, while not undermining the natural resource base (Scoones, 1998, p. 5).

The SLF is regarded as an alternative to mainstream economics approaches for studying rural contexts (Ellis, 1998; De Haan and Zoomers, 2005; Scoones, 2015). The framework is considered a starting point to understand the complexity, diversity and uncertainty of the highly dynamic rural landscapes (Scoones, 2009). Accordingly, the SL's definition of a livelihood captures both economic and non-economic attributes of how people make a living, including social and public services and the social relationships and institutions that mediate people's access to these (Ellis, 2000).

The SLF involves the so-called 'asset pentagon', which includes natural, physical, human, social and financial assets over which livelihoods are built (Scoones, 2015). Donohue and Biggs (2015) provide the following definition of the five types of capital:

i) Human: Labour available to the household, i.e. its health, education and skills.
ii) Physical: Capital created by economic production processes.
iii) Natural: Land, water and biological resources.
iv) Financial: Stocks of money to which the household has access.
v) Social: Networks and connections, both formal and informal (Donohue and Biggs, 2015, p. 392).

These assets or capitals are one of the most contentious concepts of the SLF framework. Three main drawbacks are identified in the academic and policy literature: (i) the simplification of livelihoods to economic units in most of the empirical studies; (ii) the exclusion of other important types of assets, such as those political and cultural; and (iii) the simplification and commodification of natural resources, looking at them as stocks rather than a set of complex systems (Pelenc, 2010; Scoones, 2015). Beyond the discussion of the asset pentagon, the SLF has been criticised for the simplification of the analysis on how politics and power mediate access to assets and to the outputs people derive from them; and for its failure to engage with broader development debates on politics (Ellis, 1998; De Haan and Zoomers, 2005; Scoones, 2015, 2009).

In order to address some of the weaknesses of the SLF, I complement it with Sen's Capability Approach (CA), which evaluates people's wellbeing in terms of a combination of doings and beings (Sen, 1993). The CA involves a critique of the dominant utilitarian framework which bases welfare assessment mainly on means, such as income and assets, rather than on the ends of people´s wellbeing (Robeyns, 2005). The CA considers means as instrumental to

achieve doings and beings, such as being adequately nourished, being in good health, achieving self-respect or being socially integrated (Sen, 1993).

In Sen's approach, 'capability' is understood as "a person's ability to do valuable acts or reach valuable states of being" (Sen, 1993, p. 31); while the actual beings and doings achieved are referred to as 'functionings'. A key distinction of the CA, in comparison with other welfare approaches, is to avoid endorsing a predefined list of capabilities or functionings (Clark, 2005). Sen (1993) argues that capabilities should not be defined by academics but by people themselves, influenced by their personal characteristics and context-specific social arrangements (Clark, 2005; Robeyns, 2005).

The CA, nonetheless, has also been criticised for not accounting sufficiently for how institutions and power relationships mediate access to 'endowments' and 'entitlements' (Leach *et al.* 1999). In the CA, 'endowments' are defined as the "rights and resources that social actors have" (Leach *et al.* 1999, p. 233); while 'entitlements' involve a "set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces'' (Sen, 1984, cited in Leach *et al*., 1999, p. 232), that is, the good and services people derive from their endowments.

Previous studies have also combined elements of the SLF and the CA, addressing some the drawbacks discussed above. For example, Leach *et al*. (1999); Dawson and Martin (2015); and Lienert and Burger (2015) build on elements of both frameworks to explain how institutions, social relations and individual characteristics mediate access to natural resources and how people benefit from them. These authors build on seminal work on institutions and power dynamics from sociological, anthropological and new institutional economics perspectives, such as: Giddens (1984), Berry (1989), North (1990), and Ribot and Peluso (2003). Moreover, drawing on the work of Bourdieu (1979), Kleymeyer (1994) and Rasnake (1989), among others, Bebbington incorporates cultural practices into the SLF framework. He explains that cultural practices "can be the basis of maintenance and enhancement of other capitals" (Bebbington, 1999, p. 2034).

Figure 3.1 depicts the hybrid Endowments-based Livelihoods Framework (ELF) developed for this study. The aim of this framework is to analyse how people convert their resources and rights into wellbeing achievements through the livelihood strategies they choose. The elements of this framework, their connections and how they build on the SLF and the CA are discussed below.

Source: Author based on Babulo *et al.* (2008); Bebbington (1999); Dawson and Martin (2015); Leach *et al.* (1999); Lienert and Burger; Robeyns (2005) and Scoones (1998; 2015).

Figure 3.1. Endowments-based Livelihoods Framework (ELF)

3.1.1 Institutions and conversion factors

The double middle arrows of the outer circle depict a bi-directional relationship between the individual and the institutional arrangements. Formal and informal institutions are distinguished. Formal institutions include property rights, public policies and other social arrangements legitimised by the state; while informal institutions include social norms and codes of behaviour (Leach *et al.*, 1999). Institutions constrain or enable people's actions; however, this is not a deterministic relationship, as people's behaviour also reproduces and changes existing institutions (Ibid.).

Institutions interact with the characteristics of differentiated actors in mediating access, use and benefit from resources (Leach *et al.*, 1999; De Haan and Zoomers, 2005). In the CA, the concept of 'conversion factors' is used to explain how individual characteristics, social

arrangements and the broader environment interact in shaping how people achieve wellbeing outcomes. Robeyns (2005) identifies three different types of 'conversion factors': i) personal conversion factors, which are individual's characteristics that shape how a person can convert the characteristics of the commodity into a doing or being; ii) social conversion factors, or the social arrangements, both formal and informal, that interact with individual characteristics, such as social norms, gender roles, discriminating practices and power relations; and iii) environmental conversion factors, which include broader context characteristics, such as climate and geographical location.

Accounting for the heterogeneity of households, due to differences in conversion factors, is particularly relevant in the Latin American context, where inequality and ethnicity are significant factors in explaining access to resources and livelihood outcomes (Poole et al., 2007).

Although power dynamics are implicitly captured in this framework, an adequate analysis on politics and power dynamics may benefit from a different framework addressing explicitly power dynamics and the negotiation and conflict processes involved (Leach *et al*., 1999; De Haan and Zoomers, 2005; Scoones, 2009). Politics and power dynamics analyses are outside the scope of this thesis.

Chapter 5 describes the historical context of the study sites in more detail, discussing how institutional and economic transformations have shaped household's livelihood pathways.

3.1.2 Endowments and entitlements

The ELF is based on endowments – resources and rights – which are constrained by the socio-ecological and political-economic environment. These endowments are then transformed into 'entitlements', the goods and services people utilise. In the case of homegardens, relevant endowments would include land, traditional knowledge, family labour, social networks, access to water, access to forest resources, tools, plants, seeds, animals and income accumulated in previous years.

The benefits derived from the four homegarden functions described in Chapter 2, can thus be understood as a set of goods and services, 'entitlements' in the CA jargon, for example: food, income, climate regulation, space for social relations and biocultural conservation. Individual characteristics, preferences, agency, and context-specific features – 'conversion factors' – influence the conversion of the endowments into entitlements (Sen, 1993;

Robeyns, 2005). Household decisions also mediate the conversion of 'endowments' into 'entitlements', as discussed in section 3.1.4.

Chapter 6 examines the entitlements derived from the homegardens in the study sites and the relevant characteristics at both community and household level that influence the conversion of homegarden resources – 'endowments' – into 'entitlements'.

3.1.3 Capabilities and livelihood security

Entitlements, in turn, enrich people's capabilities (Leach *et al*., 1999). The 'capability' of a person to convert 'entitlements' into wellbeing achievements is determined by individual characteristics, agency, social arrangements and broader context features (Sen, 1993; Robeyns, 2005). Agency here is understood as the "intrinsic motivation and feeling of competence to act in pursuit of goals" (Dawson and Martin, 2015, p. 84).

Sen's 'capability' concept involves the freedom of the people to decide from their possible alternatives of doings and beings which ones to achieve (Sen, 1993). Thus, the actual beings and doings achieved, 'functionings' are a sub-set of people's capabilities (Ibid.). Depending on their particular capabilitiy set, household members decide which wellbeing outcomes to achieve, 'functionings', and this achievement is mediated through the selection of a *bricolage* of livelihood strategies, homegardening being one of them.

The last stage of this process is the achievement of 'functionings', or 'livelihood outcomes' in the SLF jargon. Livelihood outcomes related to homegardening include: being healthy, being nourished, being safe, being productive and partaking in social sharing. These 'functionings' or 'livelihood outcomes' constitute, in practice, the evaluation space of people's wellbeing, their actual achievements (Sen, 1993; Saith, 2001). In this thesis I assess people's wellbeing achievement in terms of their livelihood outcomes using the concept of 'livelihood security': the ability of a household to maintain and improve its livelihood outcomes (Lindenberg, 2002).

Chapter 7 evaluates the contribution of homegardens to people's livelihood security, focusing on the food security dimension. Following Sen's perspective, livelihood security is operationalised in terms of people's meanings of a 'good life' and their perceptions on how homegardens contribute to it. Chapter 7 also examines how community and household characteristics mediate the conversion of homegarden benefits into food security.

3.1.4 Livelihood strategies

Livelihood strategies are understood as the activities and choices people make to obtain their means of living, usually involving trade-offs between outcomes (c.f. Bebbington, 1999; Babulo *et al.*, 2009; Fisher *et al.*, 2013). Nonetheless, following the SLF perspective, it is acknowledged that the selection of livelihood strategies involves both intentional and unintentional choices (De Haan and Zoomers, 2005).

As discussed in Chapter 1, livelihood diversification is a dominant strategy observed in urbanising rural contexts around the world. Livelihood diversification is defined as "a heterogeneous social and economic process (…) differentiated in its causes and effects by location, demography, vulnerability, income level, education and many other factors." (Ellis, 1998, p. 29). In this thesis, the role of homegardens in livelihood security is assessed in the context of livelihood diversification, examining how homegardening interacts with other livelihood strategies.

3.1.5 Dynamics

The framework recognises the non-static nature of livelihoods (Leach *et al*., 1999). This is implicitly represented by the circular shape and arrows included in the visual depiction of the framework; and explicitly, by the inclusion of drivers of change, shocks and stressess. The arrows linking endowments, entitlements, capabilities and livelihood outcomes depict both a sequential process and how entitlements and livelihood outcomes accumulated in the past define and constitute the endowments in the present time.

Drivers of change are included in the framework to capture long-term transformations and how people respond to these, a research gap identified in the livelihoods literature (Scoones, 2015). De Haan and Zoomers (2005) use the term 'livelihood pathways' to refer to the patterns of livelihood activities observed over time among particular social groups. Drawing on life histories and household survey panel data, Chapter 5 examines the drivers of change in the role of homegardening as a livelihood strategy and the 'pathways' followed by differentiated households.

Shocks, stresses and drivers of change are placed inside and outside the livelihood outcomes process, to represent that they do not constitute an externality to the system, but that the way they affect livelihood outcomes depends on the specific household's endowments, entitlements and the particular context (Sabates-Wheeler and Devereux, 2012). In rural contexts, livelihoods tend to be seasonal, showing variations in food and

income availability correlated with seasons (Ibid). Seasonal stresses create imbalances between food consumption needs, energy expenditure (on-farm and off-farm labour) and food availability (Ibid.). Livelihood diversification is a common strategy to seasonal stresses and unexpected shocks (Ellis, 1998). Although a seasonal analysis is outside the scope of this thesis, the contribution of homegardens to manage stresses and shocks is analysed in chapters 6 and 7.

3.2 Theory of change: Homegardening and livelihood security

Figure 3.2 presents the theory of change tested in this thesis on how homegardens contribute to livelihood security. It synthesises the ELF discussed in this chapter with the literature on homegardens discussed in Chapter 2. Building on these two bodies of literature, the theory of change is based on two keys assumptions: (i) differentiated households engage and benefit differently from homegardening and from other livelihood strategies; and (ii) there exist complementarities and trade-offs between homegardening and other livelihood strategies.

The first box of Figure 3.2 depicts how household endowments and conversion factors are captured in this research through household characteristics, while the institutional framework is accounted for through the analysis of the historical context of the communities and their rural-urban location. Following the ELF, these household and community characteristics are hypothesised to influence and constrain the livelihood options and choices of the households (second box of the figure). Given these characteristics, households may decide to engage or not in homegardening and to opt for different patterns of diversity.

Patterns of homegarden diversity are included in the theory of change to represent how they result in different homegarden entitlements (e.g. food, ornaments, income, space for social relations), depicted in the third box of the figure. Based on the analysis of types and levels of homegarden diversity, Chapter 6 examines the entitlements derived from homegardening in the study sites. Relevant characteristics, at community and household level, influencing the conversion of homegarden resources – 'endowments' – into 'entitlements' are examined, as well as the interactions with other livelihood strategies, such as urban jobs and social programmes.

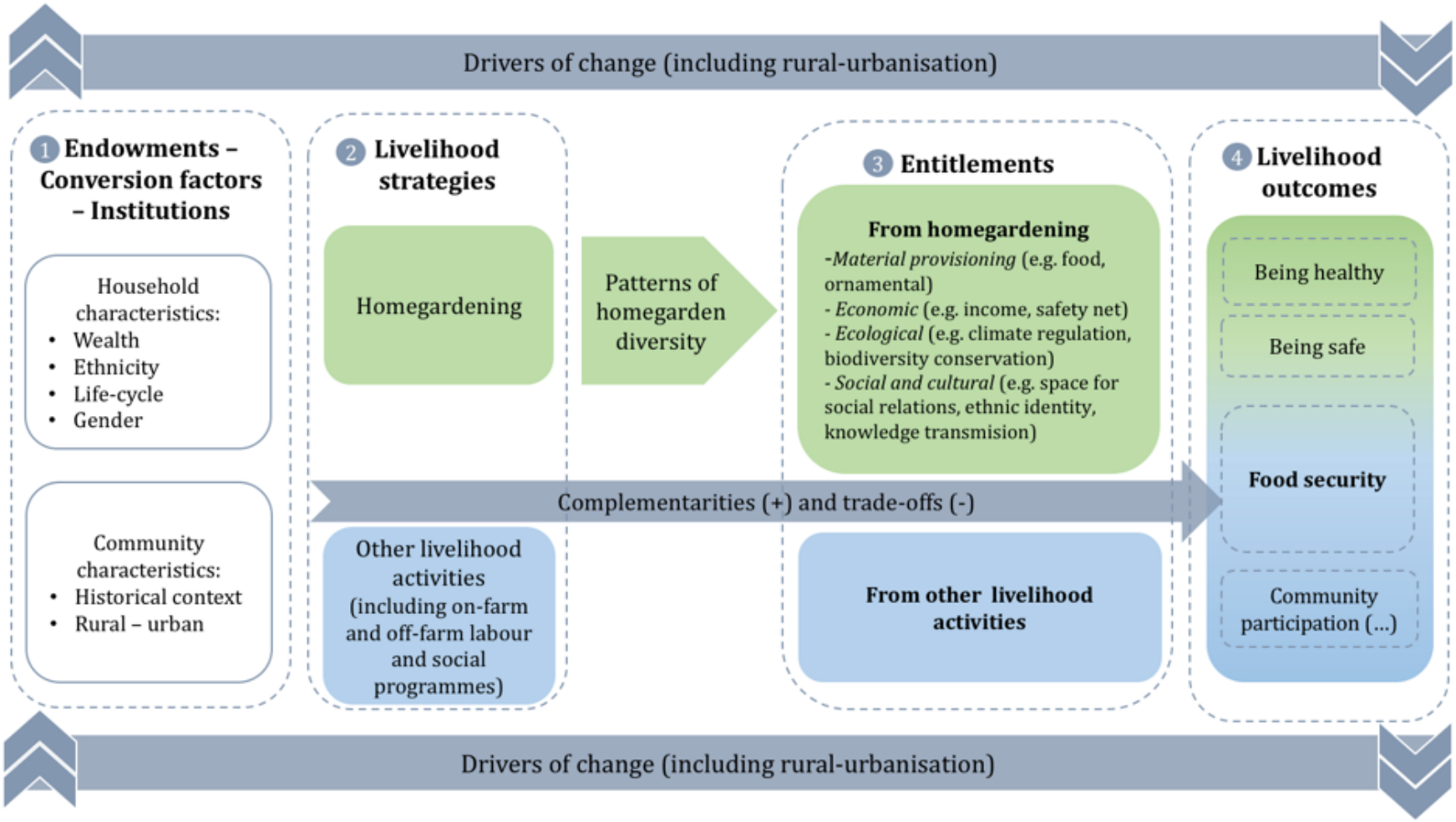
As depicted by the horizontal arrow connecting livelihood strategies with livelihood outcomes, complementarities and trade-offs result from the interaction of different

livelihood strategies. For example, paid jobs can generate income for both, purchasing food and investing in the production of food in the homegarden. However, participation in paid jobs can also reduce the time available to engage in homegardening, those causing a trade-off between the outcomes from paid jobs and the outcomes from homegardening. These complementarities and trade-offs, in turn, would result in different livelihood outcomes.

As discussed in Chapter 2, homegardening contributes to different dimensions of livelihood security, that is, the ability to maintain and improve livelihood outcomes such as being healthy, being safe and community participation. Nonetheless, food security is identified as its main contribution, both from the literature review and from fieldwork results. Homegarden diversity contributes to food security through different channels, including: the provision of nutritious food that meets people's preferences; income generation; smoothing weather, health and economic shocks; and supporting ecological functions that contribute to soil fertility and pest control.

The 1996 World Food Summit's definition of food security is adopted in this research: "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2008, p. 1). Chapter 7 evaluates the contribution of homegardens to food security and examines how community and household characteristics mediate the conversion of homegarden diversity into food security. Some complementarities and trade-offs with other livelihood activities are also studied.

Drivers of change, including rural urbanisation, are depicted at the edges of the framework. The bi-directional arrows indicate how these drivers shape and are shaped by household's responses. Chapter 5 examines how institutional, environment and economic transformations, including rural urbanisation, at community and regional level have shaped livelihood pathways at household level and how household characteristics also influence these trajectories.



Source: Author.

Figure 3.2. Theory of change of the contribution of homegardening to livelihood security

3.3 Conclusions

This chapter provides a hybrid Endowments-based Livelihoods Framework to analyse how people convert their resources and rights into livelihood achievements through the selection of a *bricolage* of livelihood strategies. Its novelty comes through its integration of key elements of the Sustainable Livelihoods Framework and the Capability Approach, building on and extending previous studies and approaches. This framework provides an analytical tool to study livelihoods as a dynamic phenomenon, while accounting for household and context differences.

The theory of change presented in section 3.2 describes how I apply the ELF in this study to analyse how rural urbanisation influences the contribution of homegardening to livelihood security. It is based on two keys assumptions: (i) differentiated households engage and benefit differently from homegardening and from other livelihood strategies; and (ii) there exist complementarities and trade-offs between homegardening and other livelihood strategies. Chapter 4 elaborates on the methods and variables used to test this theory of change, while the central empirical section of this thesis, chapters 5, 6 and 7, tests different elements of it.

Chapter 5 situates the study in the historical context of the researched regions, linking the drivers of change at meso- and macro level to the differentiated homegarden transformations and the occupational transitions observed at household level. Chapter 6 examines the relationship between household and community characteristics and the different entitlements provided by the homegardens. In this analysis, measures of different types of homegarden diversity are used as proxy variables of the entitlements provided by the homegardens. Finally, Chapter 7 evaluates the contribution of homegarden diversity to household's food security, examining the interaction with other livelihoods, including complementarities and trade-offs, and how community and household characteristics mediate the conversion of the entitlements derived from homegardening into food security.

Chapter 4. Methodology

Introduction

In Chapter 3, I introduced an Endowments-based Livelihood Framework and explained how I intend to use it to guide the analysis on how rural urbanisation influence the contribution of homegardens to livelihood security. In this chapter, I describe the different steps followed to collect and analyse the quantitative and qualitative data, and the decisions and challenges involved in each step. A multi-sited case study design was followed, together with a multi-phase, mixed methods approach.

A multi-sited case study design was followed in order to capture common patterns and differences between and within the communities and households. The first section of this chapter discusses the advantages and challenges of the research design selected. The research took place in four communities located within a peri-urban – rural spectrum in Yucatán. The second section of the chapter describes the characteristics of the field sites and explains why they were selected.

A mixed methods approach was followed in the collection and analysis of data. Three sequential phases of fieldwork were conducted: (i) an exploratory phase, where focus group discussions, participatory workshops and key informant interviews were conducted in order to get a better understanding of the context, and on how people define a 'good life'; (ii) an inferential phase, where secondary data and household surveys were collected, in order to capture a diversity of households and homegardens; and (iii) an explanatory phase, where life history interviews were conducted and preliminary results were shared and discussed. The third section of the chapter describes these three phases in detail and discusses the main challenges that I encountered in each of them. The fourth section addresses the techniques applied in the data analysis.

The fifth section of the chapter describes how I sought quality assurance of the data collected, and the later analysis, throughout this research. The sixth section presents a critical reflection on my positionality as an engaged social scientist and the power dynamics I observed in the field between different local actors. Finally, the chapter concludes by summarising the methodology followed, and by discussing how it relates to my main research question and sub-questions.

4.1 Research design

This research navigates between critical realism and positivism as philosophical stances. Following critical realism, this research accepts that there is a real world that exists independently of our identification, perceptions and constructions of it; while recognising that our understanding of this real world is a subjective construction (Maxwell and Mittapalli, 2010; Iosifides, 2012). From a critical realistic perspective, an integrated combination of qualitative and quantitative methods were applied in an inductive way to generate hypotheses on the relationship between homegardening and livelihood security. Then, from a positivist perspective, these hypotheses were tested by applying in-depth interviews and quantitative analysis techniques. Instead of only describing causalities as regularities and common patterns, following a critical realism approach, I have sought to identify the key causal mechanisms that help to explain dynamic interrelationships and recognise the relevance of between-group and within-group diversity (Pawson and Tilley, 1997; Maxwell and Mittapalli, 2010).

In order to address the temporal and spatial dimensions of rural urbanisation, the research design involved longitudinal and cross-sectional data collection and analysis. Longitudinal methods, such as panel survey data and life histories, were applied to address the first research gap presented in Chapter 2, long-term dynamics, and to respond to the first research sub-question: ***How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?*** Cross-sectional methods, such as focus group discussions and household surveys, were applied to address the second and third research gaps presented in Chapter 2: the interrelationship between homegarden, household and community characteristics; and the contribution of homegardening to food security. Cross-sectional methods also helped to answer to the second and third research sub-questions: ***How and why do homegardening patterns differ across the peri-urban –rural spectrum in Yucatán, Mexico? and How does homegardening contribute to food security across the peri-urban –rural spectrum in Yucatán, Mexico?***

A multi-sited case study design was followed in order to capture common patterns and differences between and within the communities and households (Bishop, 2010; Yin, 2014). More specifically, the research followed an embedded multiple-case design, selecting four communities located in Yucatán, México as case studies along the rural-urban continuum, but also considering households as sub-units of analysis (Cohen *et al.*, 2011; Yin, 2014). Some of the main advantages of case study designs are that they can: (i) help to explain cause and effect relationships (Simons, 2009; Cohen *et al.*, 2011); (ii) produce context dependent

knowledge (Flyvbjerg, 2006); and (iii) provide insights into similar situations and cases (Cohen *et al.*, 2011). Moreover, the multi-site design helps to understand a phenomenon through multiple representations of it in two or more settings, and produces data that distinguishes between within-site and cross-site patterns (Bishop, 2010; Chmiliar, 2010).

Nevertheless, following a multi-sited case study design creates several methodological and logistical challenges. It requires more time and labour than single case studies, and data analysis can be also more demanding (Bishop, 2010; Chmiliar, 2010). In addition, identifying patterns, common themes and differences across the data collected in different sites can become overwhelming (Bishop, 2010). To address these challenges, I conducted a multi-phase fieldwork, which allowed me to gain a comprehensive understanding of the context of the four communities and to spend enough time analysing the data and reflecting on the results at key stages.

Following a mixed methods approach helped me to triangulate information and to minimise the trade-offs between qualitative and quantitative methods, such as: depth versus scale, analysability versus representativeness, subject-driven versus researcher-directed, active involvement versus passive involvement and specific versus general. (Temu and Due, 2000; Chambers, 2001; Kanbur, 2001). However, one of the drawbacks of this approach is that it generally requires more resources than purely qualitative or quantitative studies (Creswell and Plano Clark, 2011). For me, it translated into spending a full 12 months in the field, divided over two periods, and to applying for complementary funding to cover additional fieldwork expenses. In addition, I immersed myself into the mixed methods literature in order to obtain guidance on to how to meaningfully connect and integrate both methods.

The main difficulty of applying mixed methods was to develop the appropriate skills. Since my background is in Economics, during the PhD I participated in different courses and workshops involving qualitative research methods. In addition, I had the opportunity to teach a workshop on participatory research methods at the undergraduate level in Mexico. This helped me to test what I learned from the participatory workshops taught by Professor Robert Chambers at the Institute of Development Studies and the related readings. I also attended to courses on quantitative methods in order to refresh my previous knowledge. Nonetheless, I was aware of my limited experience using qualitative methods and when needed I asked for advice from my supervisors and from other researchers on the field.

Table 4.1 summarises the research design

Table 4.1 Research design

<table>
<tr><th colspan="3">Thesis objective</th></tr>
<tr><td colspan="3">Contribute to the understanding of how rural urbanisation influences the role of homegardening as a livelihood strategy.</td></tr>
<tr><th colspan="3">Overarching research question</th></tr>
<tr><td colspan="3">How does rural urbanisation influence the contribution of homegardening to livelihood security in Yucatán, Mexico?</td></tr>
<tr><th colspan="3">Key concepts</th></tr>
<tr><td colspan="3">Livelihood strategy - Activities and choices people make to obtain their means of living, usually involving trade-offs between outcomes.[1/]
▪ Homegarden - Small-scale agroforestry system formed by plants and animals and integrated within the dwelling space where productive, social and cultural activities take place.[2/]
▪ Homegarden diversity - Planned agrobiodiversity (plant and animal) between species.[3/]</td></tr>
<tr><td colspan="3">Livelihood security - Ability of a household to maintain and improve its livelihood outcomes.[4/]
▪ Food security - Physical and economic access to sufficient safe and nutritious food that meets people's dietary needs and food preferences for an active and healthy life.[5/]</td></tr>
<tr><td colspan="3">Rural urbanisation - Heterogeneous transformation involving not only a demographic transition, but also fundamental economic, political, social and cultural changes.[6/]
Temporal dimension (Changes over time) — Spatial dimension (Differences across the peri-urban–rural spectrum)</td></tr>
<tr><th colspan="3">Research gaps</th></tr>
<tr><td>Long-term dynamics</td><td>Interrelationship between homegarden, household and community characteristics</td><td>How does the contribution of homegardening to food security work</td></tr>
<tr><th colspan="3">Research sub-questions</th></tr>
<tr><td>(Chapter 5)
RSQ1: How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?</td><td>(Chapter 6)
RSQ2: How and why do homegardening patterns vary across the peri-urban – rural spectrum in Yucatán, Mexico?</td><td>(Chapter 7)
RSQ3: How does homegardening contribute to food security across the peri-urban – rural spectrum in Yucatán, Mexico?</td></tr>
<tr><th colspan="3">Hypotheses</th></tr>
<tr><td>H1: Urbanisation of rural communities has reduced the importance of homegardening as livelihood strategy through opening up off-farm job opportunities and triggering social and cultural changes.

H2: Alternative pathways to this dominant trend, where homegardening is still a relevant livelihood strategy, are also observed.</td><td>H3: Homegarden diversity shows an increasing peri-urban – rural gradient.

H4: Household and community characteristics interact in defining homegardening patterns.</td><td>H5: Homegarden diversity is positively associated with household food security.

H6: Household and community characteristics mediate how homegarden diversity contributes to food security.</td></tr>
<tr><th colspan="3">Methods</th></tr>
<tr><td colspan="3">Multi-sited case study
▪ 4 communities with different urbanisation levels
▪ Units of analysis: Communities and households</td></tr>
<tr><td>Key methods:
▪ Panel survey data analysis
▪ Life histories
▪ Documental review

Key variables (changes in):
▪ Levels of homegarden diversity
▪ Livelihood strategies / occupations
▪ Household and community characteristics, including: location (rural-urban), wealth, ethnicity, education, size and age</td><td>Key methods:
▪ Focus group discussions
▪ Participatory workshops
▪ Cross-sectional survey analysis
▪ Documental review

Key variables:
▪ Types and levels of homegarden diversity
▪ Household and community characteristics, including: location (rural-urban), wealth, ethnicity, education and age
▪ Other livelihood strategies: urban jobs and participation in social programmes</td><td>Key methods:
▪ Focus group discussions
▪ Participatory workshops
▪ Key informant interviews
▪ Cross-sectional survey analysis

Key variables:
▪ Types and levels of homegarden diversity
▪ Food consumption
▪ Household and community characteristics, including: location, wealth, ethnicity, education and age
▪ Other livelihood strategies: urban jobs and participation in social programmes</td></tr>
</table>

[1/] c.f. Bebbington, 1999; Babulo et al., 2009; Fisher et al., 2013; [2/] c.f. Fernandes and Nair (1986), Jiménez-Osornio et al. (2003), Kumar and Nair (2004), Hernández Sánchez (2010) and Mariaca Méndez (2012); [3/] Kontoleon *et al.*, 2009; [4/] Lindenberg (2002); [5/] FAO (2008); [6/] c.f. Baños Ramírez (2001), Satterthwaite and Tacoli (2003), Zhijun (2004), Cloke (2006) and Satterthwaite *et al.* (2010).

4.2 Selection of the field sites

The field sites selected for this study are located in Yucatán, a state in the Southeast of Mexico. It is part of the Yucatán Peninsula, which also comprises the states of Campeche and Quintana Roo. Yucatán has a population of about 1.9 million inhabitants, 16 per cent of whom live in rural areas (Instituto Nacional de Estadística y Geografía, 2010). It is one of the least developed regions in Mexico, with 48.9 per cent of the population living in poverty (Consejo Nacional de Evaluación de la Política Social, 2012). Yucatán has the highest proportion of indigenous population in Mexico, just under 52 per cent (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2014). The dominant indigenous group in Yucatan are the Mayas, who have faced historical discrimination. Mayan peoples are subject to a dual discourse, one that values their cultural heritage but at the same time discriminates against and marginalises 'real life' indigenous peoples (Bracamonte and Lizama, 2003; Robles-Zavala, 2010). This discrimination is mirrored in their living conditions: the poverty headcount ratio for indigenous people is over 70 per cent (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2014)

Yucatan is a limestone platform with shallow and stony soils; however it is possible to find more fertile and deep soils in the South (the citrus region), while the stoniest soils are located in the North (the sisal region) (Caballero, 1992; García de Miguel, 2000; Barrera-Bassols and Toledo, 2005). Yucatán has a predominantly flat topography with elevations no higher than 400 meters and absence of streams and rivers (Barrera-Bassols and Toledo, 2005). Rain filters through the limestone plateau and forms underground rivers at depths of around 23 meters. These underground rivers constitute the main source of water of Yucatán (Cuanalo de la Cerda and Guerra Mukul, 2008). The climate is tropical, with a wet season from June to October and a dry season from November to May, and an annual mean temperature of 26°C (Barrera-Bassols and Toledo, 2005; Blundo Canto, 2014). During the wet season Yucatán also faces a mid-summer drought or *canícula*, a period of low rainfall and high temperatures (Mardero *et al.*, 2015). Annual rainfall increases from the northwest to the southeast of the Peninsula (500-1,500 mm/y), ranging from semi-dry to sub-humid and humid tropical (Barrera-Bassols and Toledo, 2005, p. 16). These seasonal variations in rainfall and temperature determine the times of on- and off-farm work and the quality and quantity of the harvest (Blundo Canto, 2014; Mardero *et al.*, 2015). Furthermore, since the 1980s a decrease in rainfall in the Yucatán Peninsula has been observed, while droughts are becoming more frequent (Mardero *et al.*, 2015).

Four communities were selected to represent two historical regions: the sisal and the *milpa* regions. As I explain in more detail in Chapter 5, these two regions represent different modes of engagement in agriculture and distinct urbanisation transitions. Moreover, within each region, the communities were chosen to represent different levels of urbanisation, which may be influencing different outcomes in homegardening. The communities selected were: Hocabá (peri-urban, sisal region), Sahcabá (semi-rural, sisal region), Yaxcabá (semi-rural, *milpa* region) and Kancabdzonot (rural, *milpa* region). An additional criterion applied to select these communities was the existence of previous studies on homegardens, and accessibility of data, so that I could conduct a follow-up survey, as explained in section 4.4.3. Table 4.2 presents selected characteristics of the field sites.

Table 4.2 Selected characteristics of the field sites

Indicator	**Hocabá (Sisal region)**	**Sahcabá (Sisal region)**	**Yaxcabá (*Milpa* region)**	**Kancabdzonot (*Milpa* region)**
	Peri-urban			Rural
Location				
Distance to Mérida[1/]	41 Km.	55 Km.	108 Km.	126 Km.
Distance to Cancún[2/]	274 Km.	271 Km.	237 Km.	224 Km.
Socio-demographics				
Population	4,127	1,922	3,007	963
Population density (per km^2)	1.10	1.72	1.61	1.33
Proportion of indigenous inhabitants	49.9%	89.8%	59.4%	88.9%
Illiterate population (15 years old and over)	16.8%	24.5%	13.4%	17.6%
Mean years of schooling	6.2	5.3	6.5	5.8
Housing *(access to)*				
Electricity	97.2%	97.4%	95.6%	92.1%
Tap water	98.1%	95.6%	94.2%	94.1%
Sanitation facilities	93.0%	76.9%	51.8%	45.5%

1/ Capital city of Yucatán.
2/ Main touristic centre in the Yucatán Peninsula.
Source: Google maps - INEGI (2018). *Yucatán Map.* Available from: https://www.google.com/maps/place/Yucat%C3%A1n/ (Accessed: 28 May 2018). INEGI (2010) *Censo de Población y Vivienda 2010*. Mexico. Ortiz Pech, R., (1999) *Estudio de la estructura económica del municipio de Hocabá, Yucatán a través de la matriz de contabilidad social base 1997*. Universidad Autónoma de Yucatán.

Although some indicators of the level of urbanisation, such as the distance to Mérida, the capital city, and housing characteristics show a monotonic pattern from the peri-urban community to the rural one, from the rest of the indicators the differences in the urbanisation level were not as clear. Hocabá can be claimed to be the most urbanised and Kancabdzonot the least urbanised; while Sahcabá and Yaxcabá are situated in an intermediate level of urbanisation. The criteria followed for this classification considers

urbanisation as a gradient rather than a dichotomy (Tacoli, 2003; Chomitz *et al*., 2005; Lerner and Eakin, 2011). A combination of three dimensions was used to define the three different levels of urbanisation: community size (Anzaldo and Barrón, 2009), remoteness (Chomitz *et al*., 2005), and cultural practices (Cloke, 2006). These dimensions are then operationalised using as indicators: absolute numbers of population and population density (Chomitz *et al*., 2005; Anzaldo and Barrón, 2009); distance to the metropolitan areas and access to infrastructure (Unikel Spector, 1968; Chomitz *et al*., 2005; Lerner *et al*., 2013); proportion of indigenous inhabitants (Unikel Spector, 1968).

The four communities are located in two municipalities: Hocabá and Yaxcabá. Hocabá is a municipality located in the Northeast of the Yucatán Peninsula, which was formerly called sisal region. It was in this region where sisal[7] production took place for more than a century. Hocabá comprises a territory of 94.83 Km^2 and a population of 6,061 inhabitants, distributed in six localities. However, 99.8% of the total population (6,061) lives in two of these six localities: Hocabá (the municipality seat) and Sahcabá. Cambisol soils are the most widespread in Hocabá, while leptosol soils are dominant in Sahcabá (Instituto Nacional de Estadística y Geografía, 2009a). Both types of soils, but particularly leptosol soils, are not favourable for agriculture (García de Miguel, 2000; Barrera-Bassols and Toledo, 2005). In official statistics Hocabá is considered a semi-urban[8] municipality and shows a medium level of social deprivation (Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2015; Instituto Nacional para el Federalismo y el Desarrollo Municipal, 2017) [9].

Yaxcabá is a municipality located in the Eastern region of Yucatán, region known as *milpera* or maize growing. This region has been more isolated than the sisal region and people's livelihoods are still highly attached to traditional agriculture. A brief history account of both regions is provided in Chapter 5. Yaxcabá comprises a territory of 1,474Km^2 and a population of 14,802 inhabitants. It is divided in 66 localities, only five of these with a population over 500 inhabitants, among them Yaxcabá and Kancabdzonot (Instituto Nacional de Estadística y Geografía, 2010; Uribe Briceño, 2016; Instituto Nacional para el Federalismo y el Desarrollo Municipal, 2017). In both, Yaxcabá and Kancabdzonot, the dominant soils are luvisol, which are relatively advantageous for agriculture (García de Miguel, 2000; Instituto Nacional de Estadística y Geografía, 2009b). In official statistics Yaxcabá is considered a rural municipality displaying a high level of social backwardness

[7] *Agave sisalana* Perriné*, henequén* in Spanish and *ki* in Mayan.
[8] See Appendix A for a further explanation of these classifications.
[9] This index aggregates variables measuring education levels, access to health services, household facilities and assets.

(Consejo Nacional de Evaluación de la Política de Desarrollo Social, 2015; Instituto Nacional para el Federalismo y el Desarrollo Municipal, 2017). Figure 4.1 depicts the geographical location of the field sites.

Source: Google maps - INEGI (2018). Yucatán Map. Available from: https://www.google.com/maps/place/Yucat%C3%A1n/ (Accessed: 28 May 2018).

Figure 4.1 Location of the field sites

The access and quality of the infrastructure in the field sites shows a decreasing peri-urban – rural gradient. The four sites have health clinics where primary services are provided from Monday to Friday. However, the access to sanitation facilities in the households shows large disparities. In the peri-urban community, over 90% of the households had sanitation facilities; this dropped to just over 70% in the semi-rural community of the sisal region, and fell to around 50% in the semi-rural and rural communities located in the *milpa* region (Instituto Nacional de Estadística y Geografía, 2010).

The four sites have schools from preschool to the upper-secondary level, as table 4.3 shows. At the secondary level the schools were technical, which means that the students are trained to perform a trade or other technical occupation, but they have the option to continue studying at a higher level (Secretaría de Educación Pública, 2017). In Kancabdzonot, the rural community, the schools at the secondary level are TV schools. These schools have a *TV-teacher* as facilitator, instead of having different teachers for each course (Secretaría de Educación Pública, 2017). Moreover, local authorities provide transportation support for young people from Kancabdzonot who want to study at the upper secondary level in Yaxcabá (Alvarado Sosa, 2016).

Table 4.3 Schools by education level, Hocabá and Sahcabá 2017

Education level	Hocabá (peri-urban, sisal region)	Sahcabá (semi-rural, sisal region)	Yaxcabá (semi-rural, *milpa* region)	Kancabdzonot (rural, *milpa* region)
Preschool	2	1	2	1
Primary	2	1	2	1
Lower-Secondary	1	1	1	1[1/]
Upper-Secondary	1	1	1	1[1/]

[1/]TV schools.
Source: Secretaría de Educación Pública. Sistema Nacional de Información de Escuelas. Available from: http://www.snie.sep.gob.mx/SNIESC/ (Accessed: 5 June 2017).

4.3 Data collection

A multiphase mixed methods design was followed in data collection. This involved three phases: i) exploratory, ii) inferential and iii) explanatory. This approach helped me to first familiarise with the context; then conduct a household survey, which was a follow-up of previous studies; and finally go back to a selection of households to gain a better understanding of the underlying reasons of different livelihoods and homegarden diversity trajectories. The last phase also involved the sharing and discussion of preliminary results, which enlightened the later data analysis and was a way to give something back to the communities studied. Data collection involved a total of 12 months in the field. Figure 4.2 depicts these sequential phases of data collection.

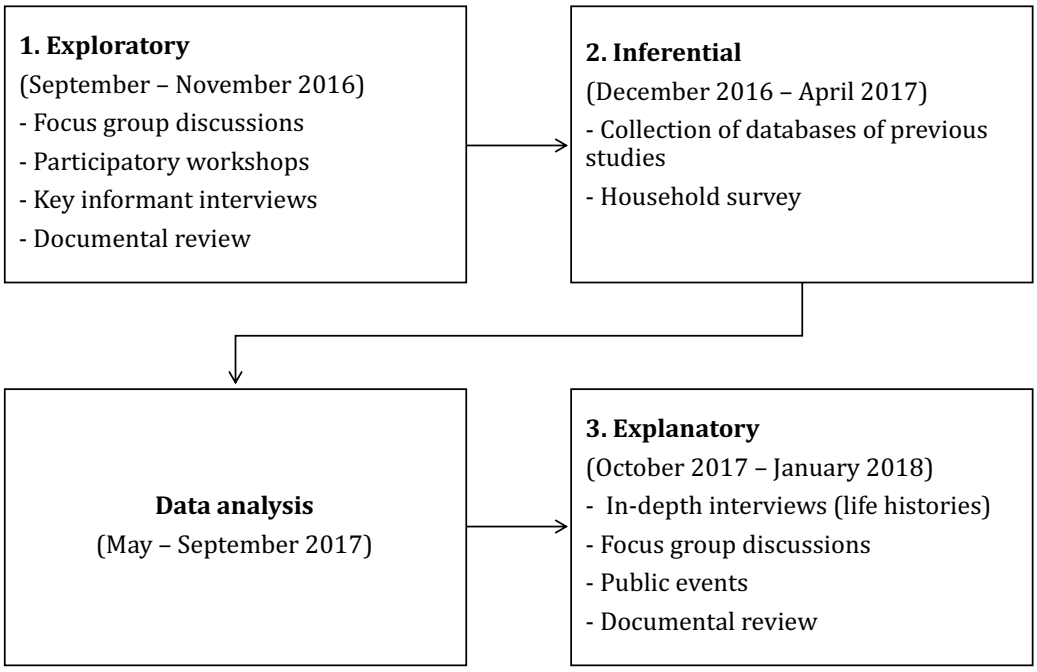


Figure 4.2 Multi-phase fieldwork

4.3.1 Exploratory phase

This phase took place from September to November 2016. The aim of the exploratory phase was to become familiar with the context; build rapport with research participants; explore people's perceptions and valuations of homegardens; and ideas regarding what a good life meant to them. This phase included 8 focus group discussions with an average of 9 participants and 7 participatory workshops with an average of 29 participants. Of the total number of participants, 74.4% were women and 25.6% were men. The average age of female participants was 43 years old and of male participants was 57 years old. When possible, one or two undergraduate students or local young people helped me facilitating the discussion or taking notes. Local researchers were my main gate-openers, who usually introduced me to or gave me contact details of local people who also acted as gate openers with other local people.

Participatory visual techniques were used in the focus groups and community workshops. Each session lasted two hours on average. Visual techniques were used to elicit information on everyday people's lives and the main plants cultivated in the homegarden. These techniques were used in order to facilitate the participation of non-literate people (Chambers, 1994; Pretty *et al.,* 1995), build rapport (Mosse, 1995) and reduce distance between the researcher and the research participants (Chambers, 1994). Furthermore, participatory approaches allowed me not only to capture people's perceptions but also to understand better the context within they were co-constructed (Mosse, 1995; Laderchi, 2001).

Guidance from different handbooks on participatory research techniques was followed (Pretty, 1990; Mascarenhas and Kumar, 1991; Pretty *et al.,* 1995; Jones, 1996; Chambers, 2012). The techniques used included: community mapping, preference matrices and seasonal calendars. Appendix B describes how these techniques were applied. These techniques were adjusted to the topic and to the research context, as suggested by Jones (1996). Figure 4.3 shows pictures from a participatory workshop and a focus group discussion.

Figure 4.3 Focus group discussion in Kancabdzonot and participatory workshop in Yaxcabá

One of the main challenges I faced during this first phase of fieldwork was to ensure that enough research participants were included in the focus group discussions. After some failed attempts, I asked local researchers for advice and also approached local authorities to invite people to the focus groups. This strategy helped me to gain access to people; however, it also biased the characteristics of the people I had access to. In most of the cases they were mainly women who were participating in government programmes or courses. In order to get access to men's views, in each field site I approached the chief of the *ejido* to organise meetings with a small group of *ejidatarios*[10]. Nonetheless, young men's views were less represented in this research. In Yaxcabá (semi-rural, *milpa* region) and Sahcabá (semi-rural, sisal region) the groups invited by local authorities were over 20 people, thus they were divided in sub-groups and instead of focus group discussions, participatory workshops were conducted, repeating the same activity in each sub-group and then discussing the results all the group together.

In addition, 24 key informants were interviewed in order to obtain data on the main development interventions and on the fruit and vegetables market. These key informants included: government officials based in Mérida, the capital city; local authorities; and petty traders of fruit and vegetables in the four communities. Official documents and local literature on homegardens were also consulted. This fieldwork phase coincided with the *Tenth Mexican Conference of Ethnobiology*, which took place in Mérida, the capital city of Yucatán, on 19-23 September 2016. There I was invited to write a literature review chapter

[10] The *ejido* is a legal form of communal property of lands. This was an achievement of landless peasants after the Mexican Revolution (1915). This type of property provides usufruct rights on land that is owned by the community and managed for public benefits, primarily agriculture (Fenzi, 2015). However, it can be transferred for private use if all the rights holders agree to it.

on the homegardens of the Yucatán Peninsula, which was published in September 2018 and helped me to gain a comprehensive insight on the literature on homegardens of the region.[11]

4.3.2 Inferential phase

The exploratory phase helped me to gain a better understanding of the context and people's perception, which helped me to refine the questionnaire I used in the household survey. Moreover, the exploratory phase allowed me to identify existing research on the regions of interest, so that I could conduct the follow-up of the homegardens previously studied. The inferential phase comprised from December 2016 to April 2017. The aim of this phase was to collect data from a wide range of households in order to describe and explain commonalities and differences in homegardening patterns between and within the four field sites.

Databases of previous studies were obtained for the four communities. With the exception of Yaxcabá (semi-rural, *milpa* region), previous studies followed random sampling, which facilitated aggregating new households to the original sample to account for population growth. The additional households were selected following a proportionate stratified random sampling approach. This type of sampling involves dividing the population into mutually exclusive and mutually exhaustive subgroups (strata) and then taking a simple random sample in each subgroup (Singh, 2007). This approach facilitated the selection of households that were evenly geographically distributed. For doing this, maps of each field site were obtained and divided into four sections, so that each section contained the same number of households. The sampling variables used were diversity measurements of homegardens from previous studies, and the sample size was computed for a confidence level of 95%.

[11] Castañeda-Navarrete, J., Lope-Alzina, D.G. y Ordóñez-Díaz, M. J. (2018) "Los huertos familiares en la Península de Yucatán". In: Ordoñez-Díaz, M.J. (Ed.) *Atlas Biocultural de Huertos Familiares en México*. Chapter 9. UNAM. Mexico. Pp. 716-835.

The sample size was computed using the following formula for population means estimations:

$$n = \frac{z^2\sigma^2 N}{e^2(N-1) + z^2\sigma^2}$$

Where:
n= the sample size
z= the z score for 95% level of confidence.
σ^2= the estimated variance of the Shannon diversity indices[12] or number of vegetal species, depending on data available for each community.
N= the population size.
e= the tolerable margin of error or precision of the estimate, 0.15 for Shannon diversity index and 2 for the number of vegetal species.

Table 4.4 presents the sample size computed for each community and the actual number of households surveyed. A total number of 324 households were surveyed. The cross-sectional analysis considered 316 of these, the 8 additional households were only considered in the longitudinal analysis. This helped to compensate for the purposive sampling applied in the previous study of Yaxcabá (semi-rural, *milpa* region) that I used as baseline, since a high proportion of the original households were located in one geographic section of the community.

Table 4.4 Sample size

Community	Total number of households	Sample size	Number of households surveyed
Hocabá (peri-urban, sisal region)	1,059	96	98
Sahcabá (semi-rural, sisal region)	454	82	81
Yaxcabá (semi-rural, *milpa* region)	722	84	92
Kancabdzonot (rural, *milpa* region)	253	50	53

The household survey covered the following themes: homegarden characteristics, including a list of all the plant and animal species; housing characteristics; respondent's perceptions on homegarden dynamics and wellbeing meanings; socioeconomic characteristics of the household members; food consumption; and the support received in the household from development actors. The questionnaire was designed based on: (i) the information collected during the exploratory phase; (ii) household surveys (Ortiz Pech, 1999; Becerril *et al*., 2014; Blundo Canto, 2014); (iii) homegarden studies (García de Miguel, 2000; Chi Quej, 2009;

[12] Section 4.4.1 describes how this index is computed.

Hernández Sánchez, 2010; Galhena, 2012; Universidad Autónoma de Yucatán and Secretaría de Desarrollo Social, 2015); and (iv) on the World Food Programme's methodology for collecting food consumption data (WFP, 2008; 2015). Appendix C presents an English version of the questionnaire used. The main respondent was the housewife or the household head. Table 4.5 summarises key characteristics of survey respondents.

Table 4.5 Household survey respondents

Relationship with the household head	Proportion	Average age
Male household head	19.4%	60
Female household head	13.3%	60
Wife	55.6%	47
Other (daughter, son, daughter-in-law)1/	11.7%	34

1/ Although daughters, sons and daughters-in-law were identified as main respondents, their role usually was to translate their parents' (in-laws) responses.

Survey responses were collected using the mobile platform Open Data Kit (ODK). An electronic pilot survey was applied to seven households located in the peri-urban community. The survey was adjusted accordingly and after this experience I decided to collect the surveys both in paper and electronically, to avoid losing eye contact during the survey. Support of 41 research assistants was obtained to conduct the surveys, of these: 8 were from Mérida (capital city), 10 from Hocabá (peri-urban, sisal region), 7 from Sahcabá (semi-rural, sisal region), 12 from Yaxcabá (semi-rural, *milpa* region) and 4 from Kancabdzonot (rural, *milpa* region). I provided training to all research assistants, who normally worked in pairs to ensure accurate collection of the data using both paper and ODK mobile devices. I supervised the enumerators while they were in the field and also served as part of the team collecting data from respondents.

4.3.2.1 Homegarden inventories

An inventory of planned agrobiodiversity including managed plant species and domesticated vertebrate animals was conducted as part of the household survey. Common species name, number of individuals of each species and uses were recorded with the help of research participants. We asked for the vegetable and animal species they had in their homegarden, questions 11 and 14 of the household survey questionnaire (Appendix C). These questions were usually answered by walking around the homegarden with the respondent and by identifying and counting all the relevant plants and animals and discussing their use and value.

Conducting focus group discussions in the first phase of fieldwork and having enumerators from the community helped to build rapport and to get access to most of the households. However, there were a few exceptions where we were not granted access to the homegarden. In these cases, we had to rely on what we were observing from outside and the information provided by the owner. Appendix D presents the list of plant species recorded in the field sites. Scientific names and the type of plants were identified using as reference Flores *et al.* (2013) and Chi Quej (2009).

The size of the homegarden was self-reported in most of the households surveyed. The reason for this was that research participants repeatedly expressed their discomfort with the enumerators measuring their plots. This mistrust was due to cases in the past where 'strangers' had taken advantage of local people, taking away assets, money or even their land. We sought to assure them that their data would be used for academic purposes only and would be treated with a high degree of confidentiality and sensitivity.

Biodiversity surveys may be considered a less accurate method to capture species diversity in comparison with the dominant practice, in ethnobotany studies, of collecting voucher specimens. However, the aim of this research was *not* to provide a detailed description of the homegarden species. This type of study has been widely conducted in the Yucatan Peninsula as documented in a review of 112 homegarden studies in the region (Castañeda *et al.*, 2008). Ethnobotany studies usually involve small sample sizes, since the collection of voucher specimens is labour-intensive. In the aforementioned review, an average sample size of 29 plots was found. In addition, ethnobotany studies tend to adopt purposive sampling targeting the most diverse homegardens in order to capture as many species as possible.

In contrast with ethnobotany studies, the purpose of this research is to have a general picture of the different types and levels of homegarden diversity as a proxy variable of the main functions performed by the homegardens. As I explained in Chapter 2, I wanted to cover a broader number of households in order to understand the socioeconomic determinants of the patterns and dynamics of the homegardens. This allowed me to find statistically significant relationships between the physical characteristics of the homegardens and the socioeconomic characteristics of the households, as I describe in chapter 6.

Biodiversity surveys are tested methods applied, among other fields, in nutrition studies and the economics of biodiversity. Examples of studies using this method include: Salazar-Barrientos and Magaña-Magaña (2016) on the contribution of the *milpa* and the homegarden in food self-sufficiency in rural Mexico; Kumar, Harris and Rawat (2015) on how household agricultural production diversity affects the diets and nutrition of young children in rural Zambia; Blundo (2014) on the role of women in agrobiodiversity in rural Mexico; Galhena (2012) on the role of homegardens in food security in post-conflict Sri Lanka; and Musotsi, Sigot and Onyango (2008) on the role of homegardening in food security in rural Kenya.

Moreover, even ethnobotany studies have started to apply non-traditional methods, such as free-lists and participatory four-cell analysis, to assess species richness and diversity. For example, Oyarzun *et al.* (2013) captured species diversity using both a participatory four-cell[13] and physical inventories. They found consistency greater than 70% between both data sets. The reliability of the species diversity data collected in this research was tested against a database of three species diversity collected in 2015 in Kancabdzonot by Biology undergraduate students supervised by a multidisciplinary team of scholars with extensive experience on homegarden research. As presented in Table 4.6, although the diversity results obtained from my data collection were slightly lower, these are comparable to those obtained from detailed physical inventories.

Table 4.6 Comparison of data collection methods,

Statistic	Tree diversity (Shannon diversity index)[14]		Consistency
	UADY-SEDESOL, 2015	Castañeda, 2017	
Median	1.83	1.74	95%
Mean	1.74	1.64	94%
Min	0	0	100%
Max	2.95	2.21	75%

4.3.3 Explanatory phase

The explanatory and last phase of field work was conducted from October 2017 to January 2018. The aim of this final phase was to understand the underlying reasons for the different transformations faced by the homegardens and the related livelihood strategies. The

[13] In implementing the PFCA, the authors involved representatives from 172 households in community-level workshops to generate a list of species maintained in each farm. After generating a general community- level list, participants received a blank card on which they were asked to note the specific species found on their farm.
[14] Section 4.4.1 describes how this index is computed.

inferential phase allowed me to identify specific households with distinct characteristics, which provided insights into the differences in homegardening management strategies and livelihood outcomes.

The quantitative analysis of panel data sets (See section 4.4.2 for further details) helped me to identify different homegarden diversity and household occupations trajectories. A sample of these households, representing key trajectories, was purposively selected to be further explored in the explanatory phase of fieldwork. The selected households represented different combinations of homegarden diversity (low / high) and occupational transitions (on-farm / off-farm).

In-depth life histories were conducted with respondents in 24 households. In each case I tried to interview the main homegarden manager or the household head and visited them at least twice. Where possible, sketches of the homegardens and their transformations were developed with the guidance of the research participants. Eric Alonso Méndez Salazar, Fernando Ismael Álvarez Frausto and Zazil Yamile Gamboa Tun, recently graduated visual artists, provided support making final copies of the homegardens drawings, which were later shared with each informant. Some of their illustrations are used in this thesis.

Life histories are systematic accounts of past events, delivered via the spoken word, within the contexts in which they occur (Gough, 2008; Palmer, 2010). Life histories have proved to be useful in providing insights into: the social and cultural context of the teller, the history of a larger group, reasons of behaviours, lived realities, hidden spheres and connections, etc. (Miller, 2000; Kothari and Hulme, 2003; Palmer, 2010). Nonetheless, I was also aware of the drawbacks of using life histories, such as: (i) their time-consuming nature; (ii) the information provided by the narrators not always being accurate; and (iii) such an introspective process reminding the storyteller of uncomfortable experiences (Panos Institute, 1999; Miller, 2000; Carling, 2012). To address these challenges, I triangulated the information from the life histories with that obtained from the panel datasets, focus group discussions and other interviews. In addition, I asked for advice from local researchers and development practitioners to avoid sensitive topics, and I tried to be cautious and empathetic when research participants showed unexpected reactions. The purpose of using life histories within this research was to obtain a more comprehensive understanding of the motivations behind the different livelihood trajectories followed by the research participants. The interviews were largely undirected, having as starting point the question:

How has your homegarden changed over time? I then focused on asking about the reasons for these changes.

During this last phase of fieldwork preliminary results were shared and discussed with the communities. This was done in five focus groups and four public events. Figure 4.4 presents a picture of one of the five focus groups, and Figure 4.5 shows an example of the visual material used to share and discuss the results. These posters contain information, in Spanish and Mayan, of the most abundant plant and animal species found in Kancabdzonot, the rural community, and of the food consumption frequency. In addition, official documents and literature on the history of the context were reviewed during this phase. I received the support of one research assistant who helped me as translator in some of the in-depth interviews. Table 4.7 presents a breakdown by field site of the activities conducted in each of the three fieldwork phases.

Figure 4.4 Focus group discussion in Kancabdzonot

Figure 4.5 Example of the visual material used in focus group discussions and public events

Table 4.7 Fieldwork activities by field site

Fieldwork activities	Hocabá (Peri-urban, sisal region)	Sahcabá (Semi-rural, sisal region)	Yaxcabá (Semi-rural, *milpa* region)	Kancabdzonot (Rural, *milpa* region)	Mérida (Capital city)	Total
First phase: Exploratory (September - November 2016)						
Focus group discussions	3	1	1	3	0	8
Participatory workshops	0	4	3	0	0	7
Key informant interviews	4	3	5	4	8	24
Second phase: Inference (December 2016 - April 2017)						
Household survey	98	81	92	53	0	324 (316 cross-sectional)
Third phase: Explanatory (October 2017 - January 2018)						
In-depth interviews (number of households)	5	6	5	8	0	24
Focus group discussions	1	1	1	2	0	5
Public sharing events	1	1	1	1	0	4

4.4 Data analysis

4.4.1 Homegarden diversity

Homegarden species richness was analysed using counts of plant and animal species, while species diversity was analysed using Shannon diversity indices. The Shannon index captures the species diversity, accounting for the relative abundance of each species in relation to the overall cropping pattern (Sunwar *et al.*, 2006, Reyes-Garcia *et al.,* 2013). It is calculated through the following formula:

$$H = -\sum_{i=1}^{n} p_i \ln p_i$$

Where n represents the total number of individuals and p_i represents the proportional abundance of species i, i.e. number of individuals of specie i divided by n.

4.4.2 Homegarden typology

A typology was obtained to clarify the complexity and diversity of the homegardens surveyed. Of the vast literature on homegardens, only 16 studies were identified that proposed a classification or typology. The main statistical methods applied in these studies to obtain the different categories were: principal components analysis (PCA), and cluster analysis, either together or separately. Of the 16 studies, 14 based their categories on the number or type of plant species. Only four of these studies used in addition to plant diversity, information of other characteristics of the homegardens, such as structure, functions or management. Moreover, two of the 16 studies did not use plant diversity data to obtain their classification, but information on homegardens dependence, productive specialisation and household income. Appendix E summarises the rationale followed and the categories used in these studies.

Principal components analysis (PCA) and cluster analysis were applied for obtaining a typology of the homegardens surveyed. PCA was used to identify the variables with the highest weight (loadings) in explaining the variance of the data. To perform this analysis, a subset of homegarden characteristics were selected based on fieldwork observations. The qualitative information collected in the explanatory and last phase of fieldwork was crucial to clarify the main differences between homegardens and to understand the underlying reasons of these differences. This information guided the PCA. The variables selected to perform cluster analysis were: a Shannon diversity index of trees; a Shannon diversity index of food herbs (aromatic and vegetables); and a Shannon diversity index of food animals and the proportion of ornamental plants.

Cluster analysis was first applied to obtain thresholds of the four grouping variables. This approach was followed because using continuous data generated a very uneven distribution of observations across the groups. Dummy variables were created with these thresholds. Furthermore, different cluster methods were tested to find the method that best suited the data and the purpose of the typology. The preferred method was hierarchical agglomerative, using the average linkage technique and Sneath and Sokal's binary coefficient as a similarity measure (Hawkins *et al.*, 1982; Stata, 2003). The observations

were grouped into four distinct homegarden categories, as Table 4.8 shows. Of the 316 surveyed homegardens in the cross-sectional database, 50.9% were classified as kitchen gardens; 29.4% as multifunctional homegardens, 12% as ornamental homegardens and 7.6% as savings repository homegardens. The characteristics of each of these categories are further discussed in chapter 6.

Table 4.8 Characteristics by homegarden category

Clustering variable	Kitchen garden		Multifunctional homegarden		Ornamental garden		Safety net homegarden		Anova *p* value
Trees diversity (Shannon index)	1.390	⊙	1.834	⊙	1.164	⊙	0.906	⊙	<0.01
Food herbs diversity (Shannon index)	0.375	⊙	0.756	⊙	0.260	⊙	0.417	⊙	<0.01
Food animals diversity (Shannon index)	0.002	⊙	0.741	⊙	0.000	⊙	0.710	⊙	<0.01
Proportion of ornamental plants	0.077	⊙	0.117	⊙	0.637	⊙	0.157	⊙	<0.01

Note: ⊙above the threshold by more than 10%; ⊙±10% the threshold value; ⊙below the threshold value by more than 10%. Threshold values: trees diversity 1.3; food herbs diversity 0.45; food animal diversity 0.25; proportion of ornamental plants 0.4.
Observations: Hocabá 98; Sahcabá 81; Yaxcabá 84; Kancabdzonot 53.
Source: Survey data (December 2016-April 2017).

Using these four categories, differences in household characteristics and location were tested using the Anova, Kruskal-Wallis H and Chi-squared tests. Moreover, a multinomial logistic model was estimated, having the homegarden typology as dependent variable and household characteristics (X_i) as independent variables. The household characteristics included in the model were: size of the plot, average age of the household members, average education of the adults, youth dependency ratio, language spoken by the household head, gender of the household head, wealth[15], rural-urban interactions and subsidies. These variables are described in Chapter 6. The location of the household was not included in the regression analysis, since this would have meant to break the data in 4 (communities) x 4 (typology) = 16 different subgroups, leaving too few observations to compute a sound regression model. Nonetheless, the results from the model are discussed in relation with the differences observed in the geographical distribution of the four categories of homegardens using descriptive statistics.

The multinomial logistic model is a discrete choice model that allows the prediction of a dependent variable that includes more than two possible outcomes. Then the probability that a household with characteristics X_i chooses a particular category of homegarden is expressed as:

[15] Appendix F shows the methodology followed to compute the wealth index.

$$\Pr(homegarden = j) = \frac{\exp\,(x_i B_j)}{1 + \sum_{j=1}^{3} \exp\,(x_i B_j)} \text{ for } j = 0,1,2,3$$

With J=0, kitchen garden (base outcome); 1, multifunctional homegarden; 2, ornamental garden; 3 safety net garden (Greene, 2008).

Multinomial logistic models assume independence of irrelevant alternatives (IIA), which means that the inclusion or exclusion of alternatives do not affect the relative probabilities of choosing the remaining alternatives (Ibid.). This assumption was tested using the Hausman-McFadden Test. The IIA assumption was not rejected[16]. Sensitive analysis of the effects of multicollinearity using different specifications of the model was conducted. Moreover, the standard errors were adjusted for clustering. The cluster variables used were the four communities. This approach allowed the errors to be correlated within each community.

4.4.3 Panel datasets

Panel data sets were constructed using databases from previous studies as first rounds, and the data I collected from the household survey as second round. I am very thankful to the researchers who allowed me to use their data. In Hocabá and Sahcabá (sisal region) the data came from Ortiz Pech (1999), having 1997 as base year; the data from Yaxcabá (semi-rural, *milpa* region) came from Guerra Mukul (2005), having 2004 as base year; and the data from Kancabdzonot came from UADY (2015) and from Quintana Loeza (2015), having 2010 as base year. Although I drew on these previous studies to guide my fieldwork activities, the quantitative longitudinal analysis only included the first three communities. I took this decision because the database I planned to use in Kancabdzonot (Quintana Loeza, 2015), containing data from 2010, was not detailed enough to allow me to conduct a reliable analysis. The panel data sets constructed included 53 observations in Hocabá, 21 observations in Sahcabá and 26 observations in Yaxcabá.

With these data I described the general trends in homegarden diversity and occupational profiles. In doing this I applied the typology described in section 4.4.1 and grouped the categories into low (kitchen and ornamental garden) and high (safety net and multifunctional homegarden) diversity groups for the data of 2016-2017. For the first round of data sets I obtained typologies using low and high categories, adapting the methodology I applied on the 2016-2017 data to the variables available in each case. Thus,

[16] Chi-squared=1.10; *p*-value=1.

diversity levels were defined within each data set, this approach allowed me to compare datasets even if there may be discrepancies on how data were collected.

4.4.4 Food security analysis

Food consumption scores (FCS) were computed to analyse the contribution of homegardens to food security. This approach was followed since the FCS methodology has been broadly tested, it is easily adaptable to particular contexts and because the information used to compute FCS do not require to have specialised nutrition knowledge. The FCS is a composite index that captures dietary diversity, food frequency, and relative nutritional importance of different food groups (World Food Programme, 2008). The FCS is computed "using the frequency consumption of different food groups consumed by a household during the 7 days before the survey" (World Food Programme, 2008, p. 8). Once the food consumption data is collected, as shown in Appendix C, the steps for computing the FCS are as follow:

a) Group all food items into specific food groups: main staples; pulses; vegetables; fruit; meat and fish; milk; sugar; oil; and condiments.
b) Sum all the consumption frequencies of food items of the same group and recode the value of each group to a maximum of 7.
c) Multiply the frequency value by the weight assigned by the World Food Programme: main staples - 2; pulses - 3; vegetables - 1; fruit - 1; meat and fish - 4; milk - 4; sugar – 0.5; oil -0.5; and condiments - 0.
d) Sum the weighted food group scores (World Food Programme, 2008).

Cluster analysis was performed to define context specific thresholds that accounted for the high consumption of sugar and fat in the field sites. Table 4.9 presents the FCS ranges used for this analysis and how household food security status was determined.

Table 4.9 Food consumption scores by household food security status

Food consumption score	Food security status
0-51.5 (Poor)	Food insecure
52-76 (Borderline)	Food secure
>77 (Acceptable)	Food secure

Source: Survey data (December 2016-April 2017).

Food consumption score nutrition quality analysis (FCS-N) was also conducted. FCS-N looks at how often a household ate foods rich in a certain nutrient (protein, vitamin A and hem iron), assuming that the number of times a household ate food particularly rich in this nutrient can be used as a measure of likely adequacy of that nutrient (World Food Programme, 2015). To perform this analysis, information of subgroups of food was

collected as shown in Table 4.10. Households were classified in three categories according to their consumption frequency: 0 days, 1-6 days and 7 days.

Table 4.10 Subgroups and micronutrients used in food consumption score nutrition quality analysis (FCS-N)

FCS Food Group	Subgroups used in FCS-N	Micronutrients
Pulses	Pulses	Protein
Milk and dairy	Dairy	Protein
		Vitamin A
Meat, fish and eggs	Flesh meat	Protein
		Hem iron
	Organ meat	Protein
		Vitamin A
		Hem iron
	Fish	Protein
		Hem iron
	Eggs	Protein
		Vitamin A
Vegetables	Orange vegetables	Vitamin A
	Green vegetables	Vitamin A
Fruits	Orange fruits	Vitamin A

Source: World Food Programme, (2015) Food Consumption Score Nutritional Quality Analysis (FCS-N). Rome, p. 10.

Probit regression models were estimated to analyse the relationship between homegarden diversity and food security, controlling by household and community characteristics. Since endogeneity of homegarden diversity could be affecting the model, a first attempt was made in applying an instrumental variable probit model and using the size of the plot, the age of the plot, the occupation of the household head and different combinations of these variables as instrumental variables. However, exogeneity of homegarden diversity was not rejected[17]. A pooled regression of the four communities was estimated in addition to specific regressions by community, type of homegarden[18] and poverty status of the households. The split regressions were conducted to analyse how location, homegarden characteristics and poverty status were influencing the relationship between homegarden diversity and food security. In the pooled regressions standard errors were adjusted for clustering, using the communities as cluster variables. The dependent variable entering the model was a binary variable indicating if the household was food secure or not, and the independent variables (X_i) were: homegarden diversity, age of the household head, youth dependency ratio, average education of the adults of the household, language spoken by the household head, gender of the household head, wealth, rural-urban interactions, subsidies and location. Then the probability that a household with characteristics X_i is food secure is expressed as:

[17] Wald test of exogeneity (correlation=0), p-value>0.400 for all the different specifications.
[18] In these regressions the most diverse and the least diverse homegarden categories were merged to leave only two categories of homegardens.

$$\Pr(food\ security = 1|X_i) = \Phi(X_i'\beta)$$

Where $\Phi(.)$ represents the standard normal distribution (Greene, 2008).

Similar regressions were conducted, having the frequency in the consumption of micronutrients as dependent variables.

4.4.5 Mediation analysis

Mediation analysis was performed to analyse whether the income effect from urban jobs was able to compensate the loss of food from the homegarden. Mediation analysis is used to decompose the effect on a variable in its direct and indirect (through an intervening variable) components. In this case the dependent variable was food security status, the direct effect was from urban jobs and the intervening variable was homegarden diversity. The control variables were: age of the household head, youth dependency ratio, average education of the household, language spoken by the household head, gender of the household head and household wealth. Buis' (2010) method was applied for this decomposition. All the regressions and the related tests were conducted using the data analysis and statistical software Stata 14.

4.4.6 Social policy analysis

Propensity-score matching (PSM) was used to analyse the effect of social policy on homegarden diversity. PSM was applied to control for household characteristics that affected the probability of participation in the programmes and were also correlated with homegarden diversity (selection bias). The propensity score is the computed *a priori* probability that a household is in the treatment group, given certain household characteristics that influence both treatment assignment and the response variable of interest (Reilly, 2018). A probit model was used to compute the propensity scores. Then households with similar propensity scores from the control and treatment groups were paired, and the average treatment effect was estimated by the differences in their outcomes: ATE = $E[y_1] - E[y_0]$ (Greene, 2008; Reilly, 2018). The matching was performed using the kernel technique, assuming an Epanechnikov kernel function. The kernel is a function that weights the contribution of each control group member, giving greater weight to those comparator units within the control group that provide the better match with the treatment unit member (Reilly, 2018). Robustness of the matching method was tested and sensitivity analysis on unobserved variables was also performed. Appendix G presents these tests.

4.4.7 Qualitative analysis

Qualitative analysis helped to refine the quantitative tools, such as the household survey questionnaire. It also allowed me to generate hypotheses on relevant household characteristics influencing homegardening patterns later tested using quantitative analysis. Furthermore, insights from this work helped me shed light on factors that were not statistically significant from the quantitative analysis; to provide explanations for the patterns and trends captured from quantitative analysis; and to illustrate the findings from my quantitative data.

Notes from the focus group discussions, the participatory workshops and public events were typed and coded in the software NVivo 11. I recorded most of the interviews I conducted and when the research participant did not allow me to record it I took detailed notes. I transcribed the audios and typed the notes into NVivo 11. The responses of the research participants were anonymised. The inputs from the life histories interviews were coded using 17 categories, which reflected the main drivers of the long-term dynamics of homegardens, the underlying causes and consequences of these drivers. These categories can be grouped under five different topics which were identified from literature review and quantitative analysis: (i) changes in the homegarden; (ii) occupation transitions; (iii) drivers of change; (iii) reasons for homegardening; and (iv) responses to shocks and macro drivers of change.

4.5 Quality assurance

Quality of the data collected, and the later analysis, was sought throughout the research. This involved rigorous preparation for data collection, including: using previously tested instruments of data collection; getting advice on the design of the household survey questionnaire and sampling strategy, both from my doctoral supervisors and from researchers in the field; conducting a household survey pilot; and providing training to enumerators.

During data collection, quality of the survey data was ensured by conducting household surveys in pairs and myself alternating with different enumerators to ensure questions were well understood and ethics procedures were correctly followed. This also allowed me to learn from the local research assistants on how to better approach people and how to better explain the nature and aims of the research. I conducted daily checks of the data collected in order to identify and clarify inconsistencies and missing data as soon as

possible. Quantitative data analysis followed rigorous methodological standards, as described in section 4.4.

Since all the focus group discussions, workshops and interviews were conducted by me, sometimes helped by local research assistants who facilitated translation, robustness of qualitative information was ensured through keeping detailed research records. I took detailed notes of all interviews and when possible, interviews were recorded. I transcribed all the interviews recorded soon after they were conducted. In addition, detailed descriptions of the focus group discussions and workshops were developed and discussed with my doctoral supervisors.

4.6 Ethics and reflexivity

The research was conducted with integrity and transparency, respecting the rights and dignity of the participants. This, in line with the Research Governance Code of Practice of the University of Sussex (University of Sussex, 2014) and the Framework for Research Ethics of the Economic and Social Research Council (ESRC, 2016). The research purpose was explained to the participants either in Spanish or Maya, and voluntary consent was requested. In most of the cases consent was granted orally since research participants did not feel comfortable signing a document, especially since some of them were illiterate. Confidentiality of personal information and anonymising of research participants was ensured.

Nonetheless, as Sultana (2007) argues, ethical research implies more than filling forms and following formal guidelines. Ethical research "is produced through negotiated spaces and practices of reflexivity that is critical about issues of positionality and power relations at multiple scales" (Sultana, 2007, p. 382). To conduct this reflexive practice, I adopted Payne's (2004, p. 191) definition of reflexivity:

> The practice of researchers being self-aware of their own beliefs, values and attitudes, and their personal effects on the setting they have studied, and self-critical about their research methods and how they have been applied, so that the evaluation and understanding of their research findings, both by themselves and their audience, may be facilitated and enhanced.

Throughout this chapter I have reflected on the challenges posed by the methods selected. Thus, in this section I will focus on the first part of Payne's definition of reflexivity: on my beliefs, values, attitudes and personal effects. May and Perry (2011) use a metaphor of a car driver on a road to exemplify this dimension of reflexivity. The knower (researcher) is the

driver; the known, the road; and the windscreen, the context and culture of knowledge production that would inform and shape the way the driver perceives the road (known).

To understand my 'windscreen', I started this reflexive process by questioning myself about my positionality. Following the practice of other researchers, I positioned myself both as an insider and an outsider of the field sites (Sultana, 2007; Rubin, 2012; León Himmelstine, 2017). I am partially an 'insider', since I am Mexican and I have been living in Mérida, the capital city of Yucatán for 22 years. I speak fluent Spanish and basic Mayan. I was also an insider because my physical appearance is non-white and I have a mixed-ethnic background. Therefore, I had a common language to communicate with the research participants and my physical appearance was also similar to them. However, I also positioned myself as an 'outsider' and the differences between my identity and the identity of the research participants became even more evident during the fieldwork. I was an outsider since I was born and grew up in Mexico City. I am also a middle-class woman who has had the privilege of completing postgraduate studies both in Mexico and in a foreign university. In contrast, most of the research participants had a lower economic status and had fewer opportunities to formal education, particularly at the tertiary level. Despite being recurrently recognised as an outsider by the research participants, having parents who came from a working-class background and spending my first years of life in a peri-urban area of Mexico City, helped me to be empathetic with the everyday struggles of the research participants.

During fieldwork I also reflected on the differences between my beliefs and values and those of the research participants. Yucatán is a very conservative region where Roman Catholic values still prevail. This was not new to me, since I grew up in a Catholic family and my values and beliefs have been heavily influenced by this religion. Nonetheless, I do not practice this religion anymore and some opinions of my research participants about sexual orientation, marriage and the role of woman at home were opposed to my views. It was not uncommon to find research participants expressing surprise to meet a woman over thirty years old concerned more with studying than with getting married, or worry over who would be cooking and cleaning for my father and brother since I was away in the field and my mother had passed away a few years ago. Moreover, some practices of traditional medicine and magical beliefs were strange to me. In these situations, I always tried to express interest and be respectful and to avoid any confrontation. I focused on listening and learning from an ancient and complex culture with which I was only partially familiar, despite living in the same region for more than two decades.

Furthermore, I sought to reflect on the power dynamics embedded in the relations with the research participants. Being a young woman, a student, and speaking Maya helped me to build rapport with people of the communities. However, I was aware that being a middle-class educated woman who came from the city represented a power disparity with some of the research participants. To reduce this imbalance, I tried to speak less and listen more; to observe, learn and understand instead of judging; and to participate actively instead of just being a spectator and an annoying inquisitor. Aware of these power differences, I applied participatory research methods to try to 'hand over the stick' and acknowledge and support the agency of my respondents. However, it must be acknowledged that the involvement of my research participants in the study was limited to the generation of knowledge and some initial analysis and discussion. Research participants conducted some analyses during the exploratory focus group discussions and I drew on their insights to design the survey questionnaire. I conducted the quantitative analysis alone, but shared and discussed preliminary results with my research participants during the last phase of fieldwork, as explained in section 4.3.3.

Nevertheless, being a woman represented a power disparity of its own in a very male dominated culture and I had to be very careful of my personal safety and the safety of my female research assistants. Furthermore, in the relation with government officials and local authorities the power disparity tended to be against the researcher. However, my positionality as a student from a UK university gave me access to interviews and official documents. Moreover, being an alumnus of the main public university and having experience in academia, helped me to obtain advice from local researchers and access to their databases.

4.7 Conclusions

In this chapter I discussed the advantages and challenges of selecting a multi-case study design and a multi-phase, mixed methods approach. I described how I collected and analysed the data and the reasons behind each decision. I also explained how I ensured adherence to strict ethical practices, maintaining confidentiality and respect for local values and perceptions. Finally, I reflected on my own positionality and the power dynamics I experienced in the field.

The selection of a multi-case study design helped me to capture the differences and commonalities between the four field sites in how rural urbanisation is influencing the

contribution of homegardening to livelihood security (my overarching question). My interest in rural urbanisation was the main motivation for choosing four distinct communities across the rural-urban spectrum. Moreover, in order to understand the underlying reasons of the intra-community and inter-community patterns observed, it was important to connect and integrate qualitative and quantitative methods.

To collect the data, I used focus group discussions, participatory workshops, key informant interviews, household surveys and retrospective life history interviews. Qualitative methods allowed me to gain a more comprehensive understanding of the context and the history that have shaped the evolution of the role of the homegardening as a livelihood strategy in Yucatán, Mexico (my first research sub-question). Furthermore, the integration of qualitative observations and quantitative analysis helped me to get a broader insight, capturing the diversity and complexity in the intersection between homegarden, household and community characteristics. This allowed me to address the second and third research sub-questions: ***How and why do homegardening patterns differ across the peri-urban – rural spectrum in Yucatán, Mexico?*** And ***How does homegardening contribute to food security across the peri-urban –rural spectrum in Yucatán, Mexico?*** The answers to these sub-questions are provided in chapters 5, 6 and 7, where I bring together the findings from the qualitative and quantitative methods.

In the next chapter, I address the first research sub-question: ***How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?*** The chapter will draw on literature review, panel data sets and life histories, as explained in this chapter.

Chapter 5. Changes in homegardening over time

Introduction

The previous chapters provided a theoretical and methodological background to the findings I present in this and the next two chapters. Chapter 2 situated the research in the body of literature on homegardens and, specifically, on how homegardens contribute to livelihood security and on the recent debates on homegarden dynamics. Chapter 3 provided a theoretical framing to the analysis of how rural urbanisation shapes the relationship between homegardening and food security. Chapter 4 discussed how the selection of a multi-site case study design and the use of mixed methods helped to address the spatial and temporal dimensions of rural urbanisation, as well as the diversity and complexity in the relationship between homegardening and food security. This chapter provides a historical account of homegardening in the field sites, addressing the first research sub-question: ***How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s****?*

The research was carried out in four field sites in two historically and economically distinct areas, the sisal and the *milpa* regions, as described in chapter 4. The history of these regions has shaped the pathways followed, into and out of farming activities, and the pace of rural urbanisation.

The first section of this chapter describes the history of the field sites, linking it to the recent evolution in the occupational profiles of the communities. The second section draws on the retrospective life histories, explaining the main drivers of long-term dynamics and how households have responded to these transformations. The third section draws on panel household survey data to delineate different household trajectories, focusing on the transformations of the homegardens and the related occupational transitions. The fourth section presents four case studies illustrating the main household trajectories discussed in previous sections. The chapter concludes by discussing the main findings, focusing on how rural urbanisation has transformed the role of homegardening as livelihood strategy.

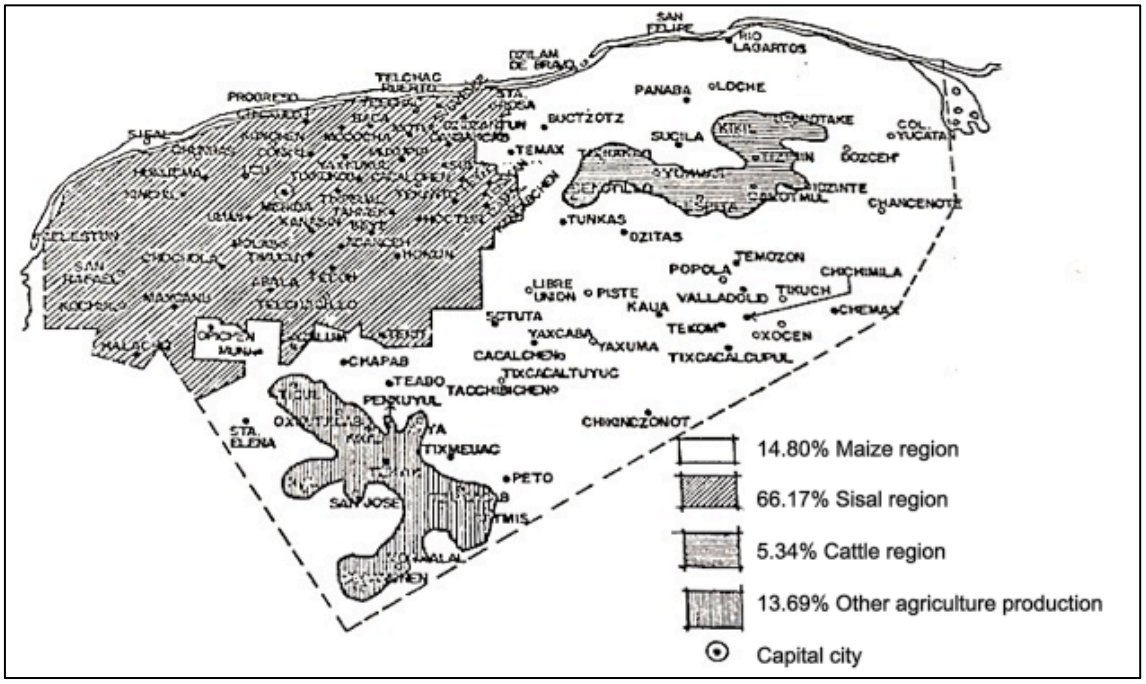
5.1 Historical context

This section provides a succinct background of the economic history of Yucatán and in particular, of the two regions covered in this research. The aim is to show how history has differentially influenced the policy agendas and the livelihoods in the sisal and the *milpa* regions, explaining the present disparities in the patterns of engagement in homegardening.

The Yucatán Peninsula was never of particular interest to the Spanish Crown because there were no minerals in the region (De Landa and Garibay, 1978; Quezada, 2001; Baños Ramírez and Castañeda Navarrete, 2007). During Colonial times the main economic activities were agriculture and animal husbandry. The agriculture sector was based on the *milpa* system, which represented the main source of maize and other cereals and pulses (De Landa and Garibay, 1978; Baños Ramírez and Castañeda Navarrete, 2007). By 1845, twenty years after the end of the Mexican Independence War, three distinct economic regions could be identified in Yucatán: (i) sugar production in the South, West, Southwest and Southeast; (ii) cattle and maize in the North, based on forced labour; and (iii) *milpa* subsistence production and forestry management in the Central and Eastern regions, where most of the Mayan population lived. At that time, commercial sugar production was the main activity of the Peninsula (Villanueva Mukul, 1990). Nonetheless, sisal[19] cultivation soon eclipsed sugar production. Sisal was used to obtain fibre in high demand in the U.S. agricultural sector, particularly from wheat producers (Baños Ramírez, 2017). This mono-crop cultivation of the sisal replaced the production of cattle and maize in the *haciendas*[20] located in the Northeast of Yucatán, becoming the main driver of the regional economy for more than a century (Villanueva Mukul, 1990; Ortiz Yam, 2013). This was not, however, a smooth transition. Mayan peasants were dispossessed of their lands by the owners of the sisal-producing *haciendas*, undermining the *milpa* system and having negative effects on the availability and affordability of maize (Ortiz Yam, 2013; Baños Ramírez, 2017).

The geographic configuration of the economic activity of Yucatán remained almost unchanged until the 1960s, as a result of the high dependence on the sisal production and the relative isolation of the Yucatan Peninsula (Figure 5.1) (Villanueva Mukul, 1990; Baños Ramírez, 1996). It was only in the twentieth century when the investment in railway infrastructure and roads allowed the Peninsula to have a closer connection with the rest of Mexico (Baños Ramírez and Castañeda Navarrete, 2007).

[19] *Agave sisalana* Perriné and *Agave fourcroydes* Lem.*; henequén* in Spanish and *ki* in Mayan.
[20] Large estates.



Source: Villanueva Mukul, E. (1990), La formación de las regiones en Yucatán. In: Baños Ramírez, O. Ed. Sociedad, estructura agraria y Estado de Yucatán. Yucatán, Universidad Autónoma de Yucatán, p. 186.

Figure 5.1 Agricultural regions of Yucatán, 1957

In the 1960s the economic landscape started to be redrawn. It was in this decade when sisal production showed a steeper decline, citrus production was promoted in the South and cattle production became more important in the East (Villanueva Mukul, 1990; Baños Ramírez, 1996). Signs of the end of the sisal boom started appearing since the 1920s (Baños Ramírez, 2017). The introduction of more sophisticated technology in the US agricultural sector, the emergence of synthetic textile fibres and increasing competition from other producers of sisal in Africa and Asia led to steady decline in sisal production in Yucatán after a long era of prosperity, at least for the elites (Albornoz Mendoza and Ortiz Pech, 2000; Baños Ramírez, 2001; Baños Ramírez, 2017). In the 1940s, as a last attempt to revive the 'green gold', the State assumed a monopoly in the cultivation and manufacturing of sisal fibre in the region (Baños Ramírez, 2017).

As a further response to the decline of the production and manufacturing of the sisal fibre, during the 1980s the government promoted other types of manufacturing, commerce and service activities (Baños Ramírez, 1996). Mérida, the capital city, concentrated the economic activity, with the consequent attraction of rural migration. By 2010, over 50% of the population of Yucatán lived in the metropolitan area of Mérida, and 90% of the market production was located in this area (Castañeda Navarrete, 2012).

5.1.1 Sisal region: Hocabá (peri-urban) and Sahcabá (semi-rural)

The settlement of Hocabá dates back to pre-Hispanic times (Cano Salazar, 2000). It is located in the heart of the sisal region, which also comprised 57 other municipalities (Baños Ramírez, 1993). In the north of Yucatán, the *milpa* was combined with sisal cultivation, and forest fallows ranged between 20 and 30 years (Cano Salazar, 2000; Pascual, 2002). However, by 1960 most of the *ejido* land was used only for sisal cultivation, causing forest vegetation almost to disappear, which negatively affected the *milpa* system (Pascual, 2002; Ortiz Yam, 2013). It was during that decade when sisal production showed a sharp decline (Baños Ramírez, 2001). From 1960 to 1990 sisal production reduced by 74.4% (Baños Ramírez, 2001, p. 102).

Several factors caused the decline of sisal production. On the market side, a reduction in the international prices was observed, along with a higher competition from synthetic textile fibres, and other sisal producers around the world (Albornoz Mendoza and Ortiz Pech, 2000; Baños Ramírez, 2001; Baños Ramírez, 2017). On the policy side, since the early 1980s the national government followed a neoliberal economic policy, involving drastic reductions in public spending (Baños Ramírez, 2001). This change in the economic policy aimed to balance the public finances, which had been hit by a decrease in the oil prices and an increase in the interest rates (Castañeda Navarrete, 2007). For the agricultural policy this meant a higher emphasis on market integration and agricultural modernisation (Klepeis and Vance, 2003; Lerner *et al.*, 2013). This approach was reflected in the land property reforms of 1992, which allowed the marketisation of lands formerly held in usufruct under the *ejido* system, and ended the distribution of *ejido* lands to farmers (Klepeis and Vance, 2003; Schmook and Vance, 2009; Lerner *et al.*, 2013). In the case of the sisal *ejidos*, a so-called 'individualisation' process took place after 1990, getting ahead of the 1992 land reform and ending collective production (Baños Ramírez, 2001).

After the collapse of sisal production under the State management in 1993, the *henequeneros* (sisal cultivators) faced a critical situation, with minimal subsidies and low-forest lands, which were not fertile enough for *milpa* cultivation (Baños Ramírez, 2001). Nonetheless, some of these former sisal cultivators went back to the *milpa* production and also tried the cultivation of some other vegetables (Cano Salazar, 2000; Baños Ramírez, 2001). An alternative pathway, especially among the youngest, was migration. However, this was not a new livelihood strategy, migration movements from the sisal region increased since the 1970s, having as main push factor a demographic growth that was higher than

land availability (Baños Ramírez, 2001). In the 1990s the sisal region was the main source of migrant workers to Mérida, the capital city, and to Cancún, the main touristic centre in the Peninsula (Baños Ramírez, 2017).

The occupational transition faced in Sahcabá (semi-rural) has been more rapid than the one experienced in Hocabá (peri-urban), as Table 5.1 shows. In Sahcabá, people moved away from agriculture faster than in Hocabá, even though Sahcabá is considered more rural than Hocabá in terms of access to infrastructure. From 1990 to 2017 the proportion of people working in the primary sector reduced by 75.4% in Hocabá and by 91.3% in Sahcabá. In 1990, agriculture was the main employment sector in both communities; however, in 2017 the commerce and services sector was the main employer of people living in Hocabá and the manufacturing sector was the main employer of people living in Sahcabá. Some factors that explain the more rapid transition towards off-farm occupations in Sahcabá are: the promotion of sisal handcrafting by different development actors; the lower availability of paid-jobs inside the community; and more expensive and less frequent transportation in this community, in comparison with Hocabá. These last two factors make it difficult for the men of Sahcabá to spend enough time in the community to continue cultivating their *milpas*.

Table 5.1 Distribution of workers by economic sector, Hocabá and Sahcabá (1990-2017) (Percentage of people)

Year	Agriculture		Manufacturing		Commerce and services	
	Hocabá	*Sahcabá*	*Hocabá*	*Sahcabá*	*Hocabá*	*Sahcabá*
1990	56.9	80.4	19	10.6	20	8.4
2000	26.3	33.9	39.1	50.9	33	14.6
2017	14	7	39.8	61.3	46.2	31.5

Source: INEGI (1990) *Censo de Población y Vivienda 1990*. Mexico. INEGI (2000) *Censo de Población y Vivienda 2000*. Mexico. Author's survey data (December 2016-April 2017).

5.1.2 Milpa region: Yaxcabá (semi-rural) and Kancabdzonot (rural)

Yaxcabá is located in the so-called *milpa* or maize-growing region, where traditional activities (*milpa* + homegarden + forest management) still represent the primary livelihood strategies of local people (Fenzi *et al.*, 2015). Yaxcabá was founded in pre-Hispanic times and it is located close to the capital of one of the main Postclassical settlements of the Mayan civilisation, Chichén Itzá (36.5 Km from Kancabdzonot and 47 Km from Yaxcabá, the municipality seat) (Alvarado Sosa, 2016). This region was the last of the Mayan city-states to be conquered by the Spaniards, and was not formally annexed until 1696 (The Mesoamerican Research Center, 2010).

The first half of the nineteenth century was a period of unrest in the Yucatán Peninsula. During these decades, Yucatán was twice declared an independent republic from Mexico and it was involved in an armed conflict between the elites of the cities of Mérida and Campeche, which ended with the separation of Campeche as an independent state in 1857 (Caso Barrera and Aliphat Fernández, 2016). Poor Mayans were involved in these armed conflicts in exchange of offers of reductions in civil and ecclesiastic taxes and of access to agricultural land; promises which were not fulfilled (Gabbert, 2004; Caso Barrera and Aliphat Fernández, 2016). Some of these Mayan groups did not return their guns after these conflicts and started what was called the Caste War (1847-1901) (Gabbert, 2004).

During the Caste War, the population of Yaxcabá was evacuated twice and the town was destroyed (Uribe Briceño, 2016). Two years after the war ended, the population went back to the town to rebuild the settlement (Uribe Briceño, 2016). "Demographic collapse in the wake of the fighting, cholera, and famine characterised the latter half of the nineteenth century" (Alexander, 2006, p. 460). Violent events took place again in Yaxcabá during the Mexican Revolution (1910-1917) and during the post-revolutionary liberalist-socialist political disputes (1924) (Alexander, 2006). The population of Yaxcabá began to recover around 1940 and by the 1980s its settlement pattern was again dispersed, reoccupying old settlements and creating new ones (Alexander, 2006).

The traditional ways of living of the predominantly Mayan population of Yaxcabá have attracted several researchers during the last few decades. These have involved historical studies analysing the Caste War to agronomy studies exploring the *milpa* system, including homegardens, from various biological, anthropological, sociological and economic perspectives (c.f. Vara Morán, 1980; Cuanalo de la Cerda *et al.*, 1998; Baños Ramírez, 2001; Alexander, 2003; Gabbert, 2004; Moreno *et al.*, 2006; Velázquez Solís, 2012; Fenzi *et al.*, 2015).

In contrast with the abandonment of agriculture observed in the communities of the sisal region, livelihoods in the *milpa* region still depend mainly on agriculture. From 1990 to 2017, a reduction in the people working in the primary sector was observed, but it was not as deep or fast as that found in the sisal region, as Table 5.2 shows. Moreover, during the period 1990-2000, Kancabdzonot (rural, *milpa* region) did not show a significant change in the occupational profiles; but during the period 2000-2017 there was a decrease by -27.5% in the proportion of people working in agriculture in this rural community. The main driver of this occupational transition has been the increasing involvement of people in

woodcarving of handicrafts targeted at tourists who visit the archaeological site of Chichén Itzá. The differences in pace and quality of disengagement in agriculture between the sisal and the *milpa* regions also explain the disparities observed in homegardening patterns, as I discuss in this and the next two chapters.

Table 5.2 Distribution of workers by economic sector, Yaxcabá and Kancabdzonot (1990-2017)
(Percentage of people)

Year	Agriculture		Manufacturing		Commerce and services	
	Yaxcabá	*Kancabdzonot*	*Yaxcabá*	*Kancabdzonot*	*Yaxcabá*	*Kancabdzonot*
1990	60.4	70.4	16.9	11.6	21.9	13.6
2000	56.4	70.0	20.0	13.8	22.4	13.8
2017	48.5	50.7	21.2	35.8	30.3	13.4

Source: INEGI (1990) *Censo de Población y Vivienda 1990*. Mexico. INEGI (2000) *Censo de Población y Vivienda 2000*. Mexico. Author's survey data (December 2016-April 2017).

5.2 Drivers of long-term transformations and household responses

Based on the literature review presented in chapter 2 and on the life histories collected in the last phase of fieldwork, four main intertwined factors were identified to have shaped the long-term dynamics the role of the Yucatecan homegarden as a livelihood strategy: (i) urbanisation; (ii) the decline of sisal production; (iii) climate shocks; and (iv) government interventions. This section explains why and how these factors have influenced homegardening, linking the macro drivers of change to the responses at household level.

5.2.1 Urbanisation

Urbanisation has been the main driver of the transformations of people's livelihoods. As explained in chapter 1, urbanisation can be understood as a demographic, economic, social and cultural transition involving: population growth; off-farm diversification; increasing participation of women in the labour market; intensified connection with urban areas; improvement of social infrastructure and education levels; change of the family structure and 'modernisation' of lifestyles and values (c.f Baños Ramírez, 2001; Satterthwaite and Tacoli, 2003; Zhijun, 2004; Cloke, 2006; Satterthwaite *et al.*, 2010). Urbanisation has shaped homegardening in different ways. Demographic pressure has resulted in land division and thus less space for cultivating plants and raising animals. Moreover, population growth has meant less land for extensive agriculture (*milpa)*, a driver of off-farm diversification.

Lower participation in *milpa* cultivation has also resulted in lower animal diversity in the homegarden. The *milpa* used to be the main source of animal feeding. Today, its role in livelihood security has been undermined by multiple factors, among them: population

growth; changes in weather patterns; use of agrochemicals and the consequent reduction in agrodiversity; lower soil fertility and unaffordable fertilisers (Baños Ramírez, 2001; Sampson, 2015). A male research participant explained about the changes faced in the *milpa*:

> Now you get a lower harvest. In the past, you obtained enough to eat. Sometimes [it was so much that] you did not have to collect all the harvest. You did not have to buy anything. Sacks of beans, wax beans, cowpeas, you could not consume it all […] Before, the forest was high and the soil was fertile. Now the soil lacks 'food' [nutrients]. Even the maize, if you do not fertilise it, you do not get anything. One bag of 50 Kilos costs MXN 700[21] and it is just enough for one hectare. The municipal major gives it [fertiliser] at half price, but before it was for free. Now everyone uses it [fertiliser]. We already knocked down all the forest. Many people [are living] here, we are too many. Before we were just about 40 families. The forest has been disappearing (Male research participant from Kancabdzonot, Yucatán, 12/12/2018).

Nonetheless, in those households where the *milpa* is still cultivated, having maize is an incentive for raising pigs, even in cases where the homegardens have shrunk, as research participants highlighted:

> Wife: He [my husband] does not like having pigs because the pigsty is too close to the kitchen area.
> Husband (*milpero*): Because the plot is small. But we bought two pigs so that we can use the leftovers from tortillas and maize (Research participants from Kancabdzonot, Yucatán, 09/01/2018).

These findings reveal why it is important not to rely on mainstream cost-benefit analysis to study traditional agricultural systems. This type of analyses assigns a market price to animal feeding which otherwise would be wasted. The few studies that have quantified the benefits of the small livestock in homegardens in the region have found negative values (Aké, 1999; Aké *et al.*, 2002; Cuanalo de la Cerda and Guerra Mukul, 2008). However, assigning a positive 'opportunity cost' to an input which otherwise would be wasted generates the wrong impression that rural households make 'irrational' decisions, investing in activities that generate negative economic benefits. The biggest drawback of these studies is that they can lead to policy recommendations that undermine traditional livelihoods. Looking closer, the picture that emerges is a household 'maximising' their (not only economic) benefits with the resources at hand.

Urbanisation and the related improvement of public infrastructure have facilitated work-related movements to urban areas. As a consequence of intensified rural-urban interactions, young adults now have less time for and less interest in homegardening. Those young

[21] GBP 28.5, USD 37.3.

families still interested in homegardening tend to prefer ornamental plants to vegetables and animals. Hernández (2010) called this trend 'gardenisation' of the *solares*. Elderly people have become the main managers of homegardens. The general result of this trend is lower plant and animal diversity than before, and the loss of traditional knowledge. There were also cases where elderly men who cannot keep going to the *milpa* increased their homegarden diversity. Box 5.1 presents some quotes from the life histories interviews, which illustrate the effects of the aging of the main gardeners.

Box 5.1 Homegardeners and ageing

"Because of my feet I cannot walk much, because they hurt. That is why I told him [grandson] I will not do it again, no chicken, no turkey, no anything, because I do not like walking and raising animals anymore." (Female research participant from Hocabá, peri-urban, 67 years old, 30/10/2017).

"We do not have chickens because my mom fell ill and then she died. My dad also died." (Male research participant from Hocabá, peri-urban, 58 years old, 31/10/2017).

"Before she [my mother] did it [homegardening], but now because of her age she falls ill frequently, then she leaves it. And we [the other women living in the house] do not have time. No one can take care of it. Almost all go to work [to Mérida]." (Female research participant from Sahcabá, 44 years old, 14/11/2017).

"When [my husband] was alive, he worked here. He planted the lemon trees, he watered them. If there was not water, he managed to solve it […]. When I have many vegetables I sell them, but now I find difficult to cultivate because my legs hurt a lot. I cannot be standing for a long period of time. The doctor said it [the pain] is because of wearing down of the bones." (Female research participant from Yaxcabá, 66 years old, 05/12/2017).

"Now that I am older, I can only do some firewood cutting, because my sight is not very clear. That is why I cannot go to work in the *milpa*" (Male research participant from Kancabdzonot, 77 years old, 12/12/2017).

An increased connection with urban areas has altered people behaviours. One main change mentioned by research participants was the monetisation of exchanges: "now everything is sale, people want to sell everything, the maize, the *atole nuevo*[22], plums […]" (Female research participant from Kancabdzonot, 05/12/2017). Another research participant mentioned: "there used to be a school allotment and the school expenses were covered with the harvest, now people prefer to pay [with money]" (Male research participant from Kancabdzonot, 05/12/2017). This monetisation of exchanges has made people prioritise animals over plants in the homegarden, because they perceive animal raising as less uncertain and more profitable than cultivating plants: "animals are more expensive, it is

[22] Traditional sweet drink made of maize.

easier and cheaper to buy radishes or coriander" (Female research participant from Kancabdzonot, 10/01/2018).

In addition, since fewer people have animals, some are getting less tolerant of neighbours' animals, and research participants mentioned that they had stopped having animals in their homegardens to avoid problems with their neighbours. This response was common in the four communities, but more frequent in those more urbanised. Moreover, the construction of roads represents a threat for homegarden animals, since the common practice was to leave them free so that they could feed themselves with the weeds around the town.

Urbanisation has facilitated increased access to fruits and vegetables from markets located in urban areas and intermediate towns, but it has also served as a negative incentive for homegarden cultivation. Lower food self-sufficiency has increased the vulnerability of people to market shocks and intensified their dependence on income-earning livelihoods. Improvement in access to education has also broadened job opportunities, especially for young people who can now decide between uncertain, unmechanised agriculture and precarious low-paid jobs in urban areas.

The literature on homegardens has documented the relationship between the life cycle of the family and homegarden diversity (Guerra Mukul, 2005; Hernández Sánchez, 2010). However, according to my results, this pattern is changing. In the past, having children over 8-10 years old meant more animals and plants because of the extra labour they represented, but this is not the case anymore. Now young families tend to have less homegarden diversity, and the presence of elderly people –in good health- rather than the availability of young labour is influencing the diversity of homegardens. The youngest households tend to own the least diverse homegardens. Women are increasingly participating in the labour market, and this reduces the time available for homegardening. Moreover, with the expansion of public education facilities and the delivery of government cash-transfer programmes, conditional to school attendance, children also have less time to support homegarden management. This finding is further elaborated in chapter 6.

The improvement of infrastructure and broader access to public services has been part of the rural urbanisation faced by the field sites. The introduction of tap water has facilitated the access to water; however, it has also meant the closing of several wells, either because people decided to do it or because the government mandated it. This means that in most of the cases people only rely on tap water for their daily supply. In addition, the supply of water

is not constant, especially during the drought season, and local authorities struggle to afford the maintenance and the electricity bills of water supply infrastructure. Water supply, however, is not equal for all households. In the four field sites, it was observed that those households located at the top of hills faced problems with the water supply, having to depend on neighbours or relatives to obtain water for everyday use. Another problem mentioned by research participants was the amount of chlorine contained in tap water, which was related to damage of plants.

The construction of concrete structures is another significant change observed in the homegardens. These structures reduce the vulnerability of the household in the occurrence of tropical storms and hurricanes and helps to solve other dwelling problems, such as open defecation and overcrowding. However, they also reduce the space available for plants and animals. This replacement of traditional structures with 'modern' constructions reflects both a cultural change in peoples' preferences and higher availability of income. Of the households surveyed, 21% mentioned to have built a room, toilet or kitchen in their homegarden in Hocabá (peri-urban, sisal region), 22% in Sahcabá (semi-rural, sisal region), 21% in Yaxcabá (semi-rural, *milpa* region) and 13% in Kancabdzonot (rural, *milpa* region).

Urban jobs have been the main source of income for building these structures. Government and NGO's have also provided support for the construction of toilets and rooms. Box 5.2 illustrates how urban jobs and development interventions have influenced the construction of concrete structures in the homegardens. Other changes in the structures of homegardens are due to off-farm diversification. Since homegardens are part of the dwelling, they are affected by changes in people's livelihoods. Now bike repair shops, grocery shops and areas for preparation and sale of food have become part of the *solar*, as Figure 5.5 shows. Furthermore, people working in pig farms have had to sell their pigs as part of the requirements for their job, as explained in the life history of the Xiu family (Box 5.3).

Box 5.2 Investment and change in homegardens

"When my husband finished his work in the *milpa* and there was much employment in Cancún, he left for 3 weeks or a month, while the next work in the *milpa* started. Then we bought pigs, raised them and sold them to invest in the house. We even raised cattle, we bought a bull calf. We raised him here in the backyard. We fed him with squash, breadnut tree leaves and grass. I think we raised about 7 big [bull calves]. From that we invested in the house." (Female research participant from Yaxcabá, Yucatán, 60 years old 06/12/2017).

"My daughter built the [concrete] room 8 years ago, when she was working in Mérida. She worked in a house [as housekeeper]. She also bought the refrigerator. She worked for 10 years until she got married." (Female research participant from Kancabdzonot, Yucatán, 64 years old 14/12/2017).

"The floor [of the house] was a gift from the government [support from the federal government]. About 3 years ago we received support from *Antorcha Campesina*[23] to build the house made of blocks. We had to attend meetings and marches and they gave us material to build the house. We also had to pay them MXN 1,500[24]. And the toilet, it was support from the government about one year ago." (Female research participant from Kancabdzonot, Yucatán, 30 years old 13/12/2018).

5.2.2 Decline of sisal production

The boom and later bust of sisal production in the region determined rural-urban interactions in the region and shaped people's livelihoods and labour relations. Hocabá, the peri-urban community, was well connected to Mérida by railway since the beginning of the twentieth century (Ortiz Yam, 2013). With the decline of the sisal production, the railway stopped being in use, but roads were improved and buses increased their frequency. In contrast, in Sahcabá (semi-rural), despite being located in the area of sisal production and just 10 kilometres away from Hocabá, main roads outside the community were paved only 20 years ago.

In the sisal region, farmers combined *milpa* cultivation with paid work on the sisal plantations, which allowed them to be self-sufficient in staples and at the same time earn some income for covering other needs. With the decline of sisal production, people were pushed out of agriculture and many people turned to Mérida looking for paid jobs. The government and other development actors embarked in the promotion of different diversification strategies within the communities, such as fruit and vegetable production, flower production, cattle raising and handicrafts, most of them without much success.

[23] Social and political movement linked to the Institutional Revolutionary Party (PRI).
[24] GBP 61.2; USD 79.9.

The attraction of *maquiladoras*[25] was another economic diversification strategy. This type of factory is mainly owned by foreign capital and provides low paid jobs. In Yucatán, the largest proportions of *maquiladoras* are concentrated in the apparel and jewellery sectors (Baños Ramírez, 2017). In Sahcabá, sisal handcrafting was successfully adopted by the community, especially women, and now represents one of their main livelihood activities. According to the survey data collected, half of the households of Sahcabá are involved in the production and sale of sisal handcrafts.

In the *milpa* region, urbanisation has followed a slower pace than in the sisal region. In the *milpa* region, federal and state government policies focus on social issues rather than on economic promotion. In Yaxcabá (semi-rural, *milpa* region), the main roads connecting the community with Mérida were paved about 60 years ago. In contrast, in Kancabdzonot (rural, *milpa* region), the road that connects the community with Yaxcabá, the municipality seat, was only paved 20 years ago and public transportation is still very limited (Focus discussion groups and interviews). In Kancabdzonot, the rural community, woodcarving has been the main off-farm diversification strategy. According to the research participants, people have engaged in this activity for about 15 years, due to its close location to Chichén-Itzá. From the survey data collected, 36.2% of the households have members involved in woodcarving, most of them men. They started just selling the wood, but they gradually learned woodcarving from the people who bought the timber. "Young men do not work the *milpa* anymore, now most of them go to school and learn to do other things, like woodcarving, because you get more money without working too hard" (Male research participant from Kancabdzonot, 16/01/2018).

5.2.3 Climate shocks and government interventions

Droughts, tropical storms and hurricanes have affected the diversity and structure of the homegardens. During droughts the demand of tap water increases, and since people tend to prioritise other water needs over plant watering, this has resulted in the death of trees, especially citrus. When hurricanes occur, their main effect is felling houses and trees. Nonetheless, since most of the trees were planted by chance, research participants mentioned they did not plant trees again after they fell, as illustrated in the cases presented in Boxes 5.4 and 5.6. In addition, weak housing structures, usually 'Mayan houses', are the

[25] The name of *maquiladoras* comes from an industrial development programme implemented in Mexico since the 1960s. It was designed to attract foreign capital direct investments in exchange of special customs treatment. Most of the companies attracted were labour intensive.

most affected during the occurrence of high intensity hurricanes. Since 1999, the Mexican government has provided concrete one-room houses as part of the main disaster recovery strategy (World Bank, 2016). These houses reduce people vulnerability to hurricanes, but also reduce the space for plants cultivation and animal raising.

Government programmes promoting homegardening have influenced their transformation in recent years. As it has also happened in other contexts, these interventions have followed a narrow approach that undermines traditional knowledge and increase the dependence on external inputs, threatening the ecological and social sustainability of the homegardens (Soemarwoto, 1987; López Barreto, 2017). In the field sites it was observed that people shifted from cultivating in pots or other traditional structures to lines: "Before participating in the homegardens programme I just planted in pots, not in lines". "If you plant in pots you can move the plants and protect them from the rain". "Since there are animals you plant in pots" (Research participants in the public event in Yaxcabá, Yucatán, 17/01/2018).

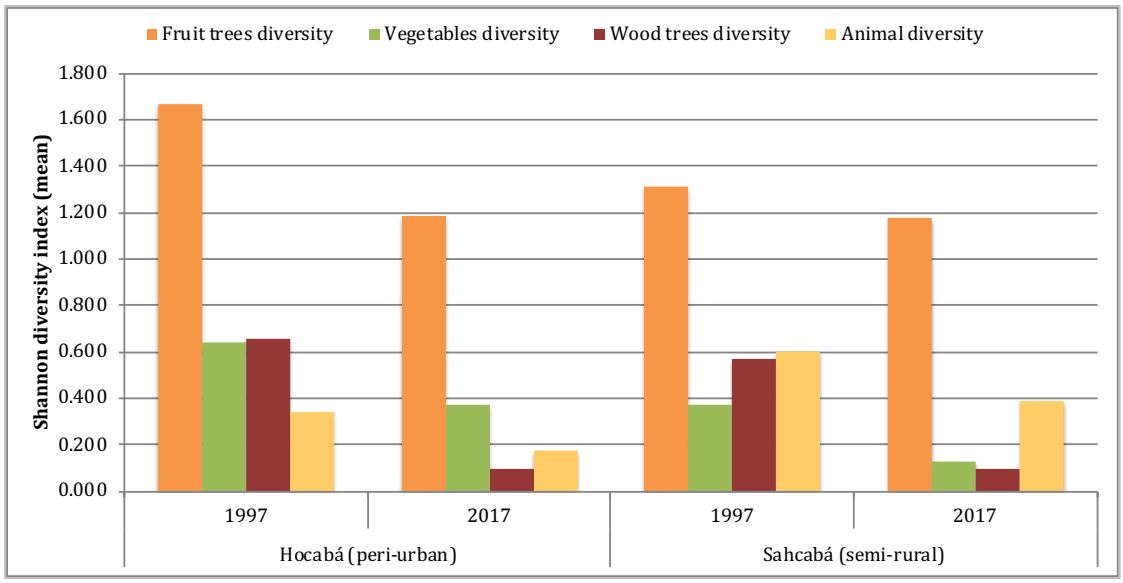
The next section draws on quantitative data to show the differentiated household responses to the drivers of change discussed in this section.

5.3 Homegardening pathways

Drawing on panel data sets, this section discusses differentiated household trajectories in homegarden diversity and livelihood diversification. It focuses on how household characteristics influence these trajectories. Data covers three of the four study sites as explained in chapter 4. The data from the two communities of the sisal region covers the years 1997 and 2016-2017; while the data from Yaxcabá (semi-rural, *milpa* region) covers the years 2004 and 2017.

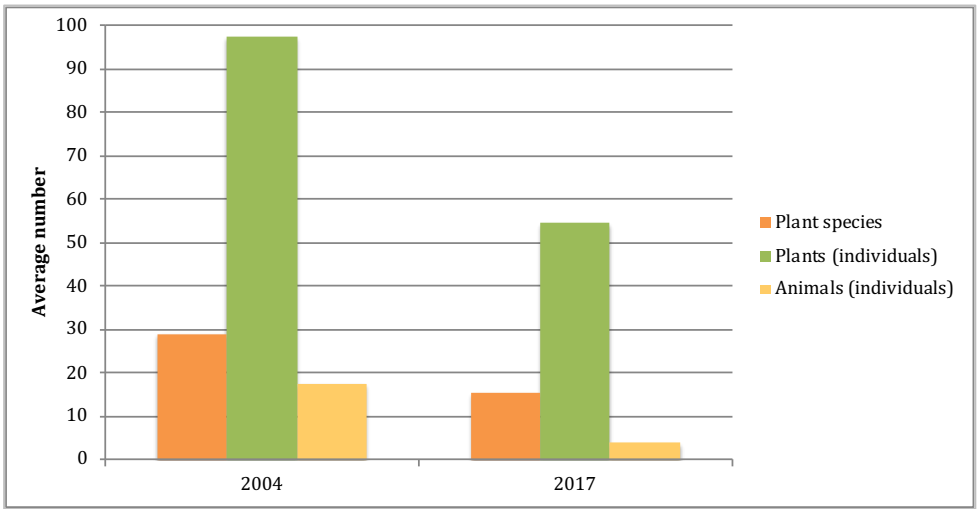
The overall trend observed in the homegardens was a reduction in their diversity, as figures 5.2 and 5.3 show. This biodiversity loss reflects a decreasing dependence on the homegarden in the field sites. In the two communities located in the sisal region, wood trees showed the largest biodiversity reduction (-80%). The second most affected species were animals (-50%) in Hocabá (peri-urban) and vegetables (-66%) in Sahcabá (semi-rural). In all the cases, but vegetables, Hocabá showed larger diversity loss rates than Sahcabá. In the case of Yaxcabá (semi-rural, *milpa* region) the main loss was observed in the number of animals (-78%). The different trend found in Sahcabá (semi-rural, sisal region) is of particular interest. In this community, the largest biodiversity losses were observed in plant species, while in the other two communities the largest losses were in animal species.

Several factors explain the differentiated trend observed in Sahcabá, including lower soil fertility, greater engagement in urban jobs and lower participation in social programmes. The last two factors are further elaborated in Chapter 6.



Source: Author's survey data (December 2016-April 2017); Ortiz Pech (1999).

Figure 5.2 Changes in homegarden diversity in the sisal region, 1997-2017



Source: Author's survey data (December 2016-April 2017); Guerra Mukul (2005).

Figure 5.3 Changes in homegarden diversity in Yaxcabá (semi-rural, *milpa* region), 2004-2017

While the dominant trend was a reduction in homegarden diversity, the households studied followed different trajectories. As described in Chapter 4, homegardens were classified in low and high diverse categories within each temporal subsample. As Table 5.3 shows, four

different diversity transitions were identified from applying these classifications: (i) low-low, (ii) low-high, (iii) high-high, and (iv) high-low.

Diversity transitions differed between the communities studied. The peri-urban community showed the largest proportion of households (50.9%) that moved from a high diversity level to a low one. In contrast, in Sahcabá (semi-rural, sisal region) only 14.3% showed this transition and 26.9% did it in Yaxcabá (semi-rural, *milpa* region). Likewise, the peri-urban community showed the smallest proportion of households (3.8%) that moved from low to high diversity, while about a third of the households of the other two communities were located in this category.

Table 5.3 Transition matrix of homegarden diversity in the field sites

Diversity transitions	Hocabá (peri-urban, sisal region)	Sahcabá (semi-rural, sisal region)	Yaxcabá (semi-rural, *milpa* region)
Low - low	26.4%	38.1%	19.2%
Low - high	3.8%	33.3%	38.5%
High - high	18.9%	14.3%	15.4%
High - low	50.9%	14.3%	26.9%
Total	100.0%	100.0%	100.0%

Note: Hocabá and Sahcabá, 1997-2017; Yaxcabá, 2004-2017. Chi-squared test, p-value= 0.001.
Number of observations: Hocabá, 53; Sahcabá, 21 and Yaxcabá, 26.
Source: Author's survey data (December 2016-April 2017); Guerra Mukul (2005); Ortiz Pech (1999).

Household dynamics, such as off-farm diversification, engagement in jobs outside the community, and intergenerational changes in household head help to explain the different diversity transitions in the homegardens. The small sample size of the panel data sets did not allow me to find statistically significant differences; however, some of the patterns found from the quantitative data were supported by the information captured through life histories.

Table 5.4 shows how those households that transitioned towards off-farm occupations were more likely to present a reduction in their homegarden diversity, whereas those households where the head stayed working in agriculture showed higher probability to keep a high diverse homegarden. On-farm activities were also identified as a relevant factor explaining homegarden diversity from the in-depth interviews conducted, as it is illustrated by the case of the Xiu family below (Box 5.3).

Only 20% of the households that returned to on-farm occupations, that is 'off-farm – on-farm transition', managed to recover from low to high level diversity. Insights gained from the life histories pointed at the family lifecycle as a factor explaining why returning to on-

farm activities may not necessarily be related to higher levels of homegarden diversity. Those households where the household head returned to on-farm activities after being employed in off-farm activities tended to have young adult members engaged in paid jobs, reducing the need to depend on the homegarden as a livelihood. This is illustrated by the case of the Itzáes family (Box 5.5).

Table 5.4 Transition matrix of homegarden diversity and household head main occupation in the field sites

Diversity transitions	Occupational transitions (Main occupation of the household head)			
	Farm - farm	Farm -off-farm	Off farm - off-farm	Off-farm - farm
Low - low	15.4%	36.7%	25.6%	40.0%
Low - high	38.5%	10.0%	12.8%	20.0%
High - high	23.1%	16.7%	15.4%	0.0%
High - low	23.1%	36.7%	46.2%	40.0%
Total	100.0%	100.0%	100.0%	100.0%
Occupational transitions	**Diversity transitions**			
	Low - low	Low - high	High - high	High - low
Farm - farm	14.8%	52.6%	35.3%	16.2%
Farm -off-farm	40.7%	15.8%	29.4%	29.7%
Off farm - off-farm	37.0%	26.3%	35.3%	48.6%
Off-farm - farm	7.4%	5.3%	0.0%	5.4%
Total	100.0%	100.0%	100.0%	100.0%

Note: Hocabá and Sahcabá, 1997-2017; Yaxcabá, 2004-2017. Chi-squared test, p-value= 0.135
Source: Author's survey data (December 2016-April 2017); Guerra Mukul (2005); Ortiz Pech (1999).

From the 'high-high' diversity transitions, it was noticed that 'farm-farm' households represented the same proportion as 'off-farm-off-farm' households. A question that emerged from this finding was, how different were those households that had managed to keep highly diverse homegardens despite being engaged in off-farm activities? Tables 5.5 and 5.6 present some answers to this question.

From Table 5.5, the 'off-farm–off-farm' households that kept highly diverse homegardens - 'low-high' and 'high-high' diversity transitions - seemed to count with better endowments: that is, they had a higher level of education, more household members, more assets and better income. However, the differences were not statistically significant. Nonetheless, when analysed in pairs, significant differences were found in the mean income between 'high-high' and 'high-low' diversity transition households (0.05 significance level); and in the mean number of household members between 'low-low' and 'low-high' diversity transition households (0.05 significance level). These results are likely indicating that better-off and larger households have managed to diversify their livelihoods without undermining their homegarden diversity.

Life histories also shed light to how off-farm occupations within the communities differ from urban jobs. Although off-farm occupations within the communities were associated to lower incomes, they also seemed to allow households to better diversified their livelihoods, as the case of the Cocom´s family illustrates (Box 5.4). This case also shows the complex interactions between different household characteristics, such as: household size, preferences, cultural attachment and engagement in off-farm occupations.

Household preferences and cultural attachment were found to contribute to explain the different trajectories in homegarden diversity. In the households that reported 'low-high' and 'high-high' diversity transitions all the household heads spoke Spanish and Maya. Their interest in learning and practicing the Mayan language may be interpreted as a sign of attachment to the 'traditional' culture and thus, greater valuing of homegarden diversity than those household heads who only spoke Spanish. The differences in the proportions of household heads by language spoken between the four diversity transition categories were statistically significant at 0.10 significance level. This cultural attachment, captured through the spoken language, also emerged as a relevant explanatory factor from the life histories.

Table 5.5 Household characteristics of 'off-farm-off-farm' households by homegarden diversity transition, 2016-2017

Household characteristics	Statistic	Low-low	Low-high	High-high	High-low	Anova / Kruskal-Wallis H / Chi-squared *(p value)*
Average education of the adult members of the household (mean, years)	*Mean*	6.13	7.15	7.49	6.25	0.787
	Median	6.00	7.50	6.75	6.50	0.653
Age of the household head (mean, years)	*Mean*	61.56	63.20	61.83	59.89	0.975
	Median	65.00	63.00	63.00	60.50	0.967
Household size (mean, number of members)	*Mean*	4.40	9.00	6.33	5.00	0.105
	Median	4.00	8.00	4.00	4.50	0.153
Youth dependency ratio (Ratio of the children under 15 years old divided by the number of adults in the household)	*Mean*	0.44	0.57	0.28	0.62	0.802
	Median	0.00	0.67	0.00	0.00	0.554
Household head speaks Spanish and Maya	*Proportion*	66.67	100.00	100.00	94.44	0.081
Household head only speaks Spanish	*Proportion*	33.30	0.00	0.00	5.56	0.081
Wealth index (0-1, 5 assets)	*Mean*	0.28	0.30	0.47	0.37	0.578
	Median	0.21	0.37	0.37	0.37	0.457
Household income, adult scale equivalent (MXN) (GBP/USD)	*Mean*	1486.86 (60.63/79.17)	2152.31 (87.77/114.61)	2153.65 (114.68/87.83)	1204.87 (64.16/49.13)	0.244
	Median	1052.90 (42.94/56.06)	1750.47 (71.38/93.2)	1563.52 (63.76/83.25)	1388.06 (56.60/73.91)	0.142

Note: Hocabá and Sahcabá, 1997-2017; Yaxcabá, 2004-2017.
Source: Author's survey data (December 2016-April 2017); Guerra Mukul (2005); Ortiz Pech (1999).

Table 5.6 shows selected household characteristics by occupational transition. The households that shifted into or stayed in off-farm occupations reported higher education level ('pull-factor') and higher dependency ratio ('push-factor'). These characteristics are

likely indicating a generational transition in these households. In contrast, the 'farm-farm' households reported the lowest level of education, the smallest household size and the lowest youth dependency ratio; characteristics that indicate these households belonged to elderly people (Chactemal family's case, Box 5.6). The 'off-farm-farm' occupational trajectory is of particular interest since it represents an alternative to the dominant pathway towards off-farm occupations. These households reported lower education level and lower youth dependency ratio than the 'off-farm' households. Moreover, they reported the largest proportion of household members working in urban jobs and the highest household income. This means that even if the household head returned to work in agriculture, the children were likely working in urban jobs and contributing to the household income, as it was discussed above. The Itzaes' case presented in Box 5.5 illustrates this pattern.

Chapters 6 and 7 elaborate on how education and the life cycle of the household explain both their engagement in off-farm occupations and their patterns of homegardening.

Table 5.6 Household characteristics by occupational transition

Household characteristics	Statistic	Farm – farm	Farm– off-farm	Off farm – off-farm	Off-farm – farm	Anova / Kruskal-Wallis H / Chi-squared *(p value)*
Average education of the adult members of the household (mean, years)	*Mean*	4.47	5.92	6.54	4.50	0.095
	Median	4.75	6.28	6.45	4.50	0.092
Age of the household head (mean, years)	*Mean*	66.24	65.50	61.03	64.80	0.408
	Median	66.00	65.50	63.00	70.00	0.488
Household size (mean, number of members)	*Mean*	3.90	6.93	5.61	6.60	0.073
	Median	3.00	6.00	5.00	3.00	0.046
Youth dependency ratio (Ratio of the children under 15 years old divided by the number of adults in the household)	*Mean*	0.07	0.47	0.52	0.17	0.027
	Median	0.00	0.37	0.00	0.00	0.131
Household head only speaks Maya	*Proportion*	9.52	3.57	0.00	0.00	0.447
Household head speaks Spanish and Maya	*Proportion*	85.71	92.86	89.47	100.00	0.447
Household head only speaks Spanish	*Proportion*	4.76	3.57	10.53	0.00	0.447
Percentage of household members working in urban jobs	*Mean*	0.18	0.28	0.31	0.46	0.043
	Median	0.00	0.33	0.33	0.50	0.060
Wealth index (0-1, 5 assets)	*Mean*	0.32	0.34	0.36	0.34	0.961
	Median	0.22	0.37	0.37	0.37	0.917
Household income, adult scale equivalent (MXN) (GBP/USD)	*Mean*	1,426.01 (58.15 / 75.93)	1,545.19 (63.01/82.28)	1,546.13 (63.05/82.32)	1,879.15 (76.63/100.06)	0.864
	Median	1,232.26 (50.25/65.12)	1,493.12 (60.89/79.51)	1,431.82 (58.39/76.24)	1,501.68 (61.24/79.96)	0.761

Note: Hocabá and Sahcabá, 1997-2017; Yaxcabá, 2004-2017.
Source: Author's survey data (December 2016-April 2017); Guerra Mukul (2005); Ortiz Pech (1999).

The next section presents four case studies that illustrate some of the drivers of the transitions in homegarden diversity and household occupations, discussed in section 5.2, and the interactions between these two types of transitions.

5.4 From statistics to people's stories

The following boxes present four cases of the 24 life histories collected during fieldwork. These cases aim to illustrate diverse factors that influence homegardens transformations. Research participants' names were substituted by names of Mayan noble families to protect their identities, but otherwise the descriptions are accurate representations of these households. The first two cases, drawn from interviews with members of the Xiu and Cocom families, represent high-high homegarden diversity transitions, but different occupational transitions and different locations that have led to very dissimilar homegarden structures. The last two cases, involving the Itzáes and Chactemal families, represent high-low diversity transitions, both located in the sisal region, but in different communities and showing distinct occupational transitions.

The case of the Xiu family (Box 5.3), located in the semi-rural community of the *milpa* region, illustrates the characteristics of a household that has managed to keep a high level of homegarden diversity. This is a 'high-high' diversity and 'farm-farm' occupational transition household. The engagement in *milpa* cultivation and an attachment to the Mayan culture have contributed to keep the interest of Mrs and Mr Xiu in homegardening. However, the case also shows how even in this traditional maize growing region livelihoods are changing and their children are less likely to engage in homegardening. The aging of Mr and Mrs Xiu also emerged as a factor that has contributed to a reduction in homegarden diversity. From the quantitative data, aging was not found a significant factor explaining diversity trajectories; however, the life histories discussed in this and section 5.2 provide qualitative evidence of the relevance of this factor. Although major hurricanes have not affected the community in the last few decades, the homegarden of the Xiu family has served to smooth the losses faced in *milpa* production due to increasing variability in weather patterns.

Box 5.3 Life history of the Xiu family

Diversity transition: high – high	*Location: Yaxcabá (semi-rural, milpa region)*
Occupational transition: farm-farm	*Homegarden size: 600 m²*

This family is formed by four adults. Mr Tutul Xiu, the household head, is over 70 years old, just like his spouse. He speaks both Mayan and Spanish, while his spouse only speaks Mayan. They had 10 children, but only seven survived. The two children who live with them are in their twenties and speak both Mayan and Spanish. The other five children are already married and have formed their own homes. Three established in Yaxcabá and the other two live in Mérida and Kanasín[26]. I interviewed the male household head, Mr Tutul Xiu.

Mr Tutul Xiu is illiterate. He lost his parents when he was a child and his uncle took care of him, but with some limitations. For example, his uncle did not send him to school, despite sending his own children to school. Mr Xiu has always depended on the *milpa* as his main livelihood, while his spouse works as a fulltime housewife. However, recently things have changed at home, as their adult children were hired as labourers by a middle size pig farm. "Since they [children] get their fortnightly pay, they tell me that they can buy maize, but I like it [to cultivate the *milpa*]."

They have chickens, but do not keep pigs. They had to sell them as required by the pig farm where their children work. "They may lose their job, as [keeping pigs at home] is forbidden".

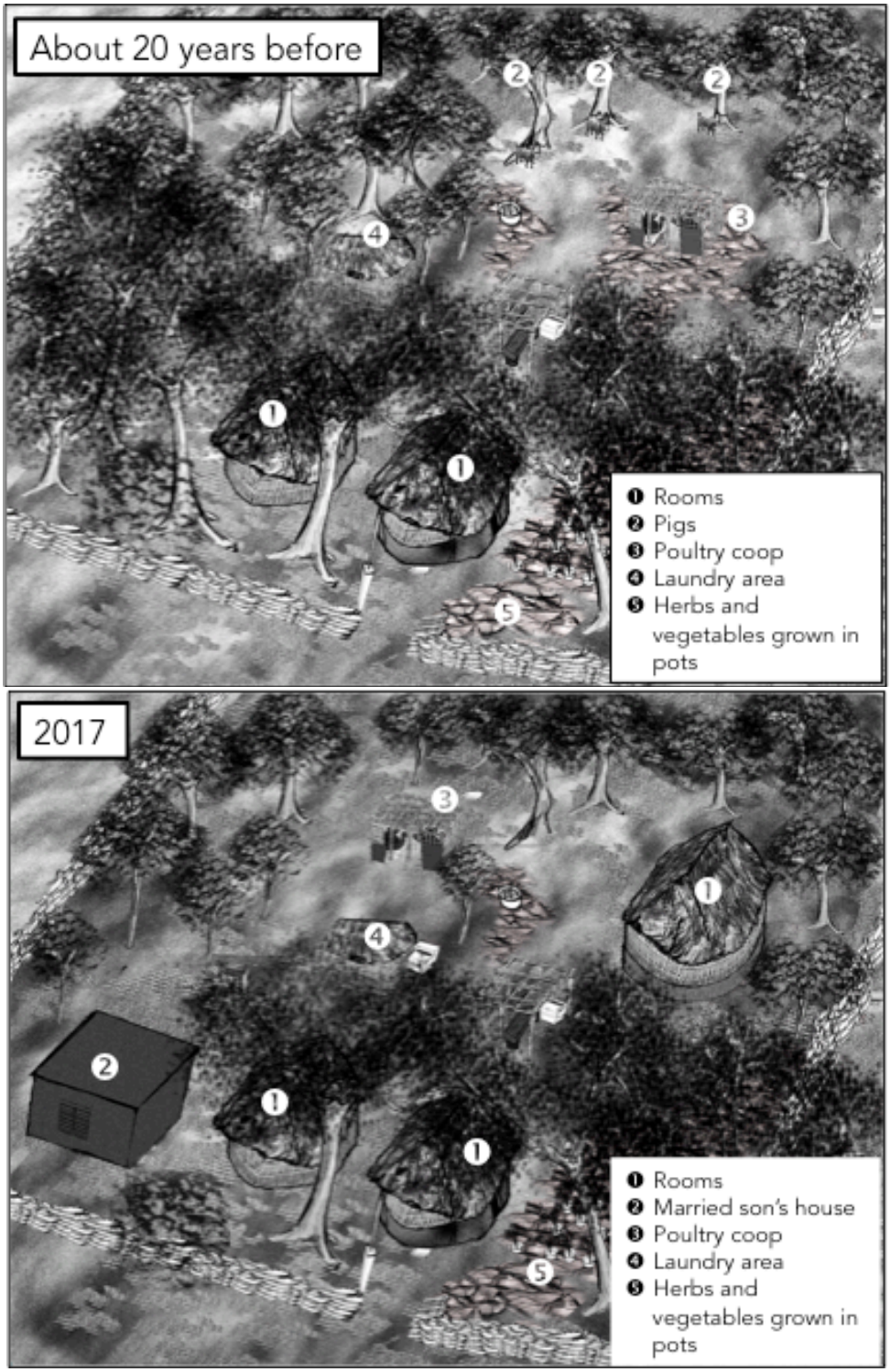
> They [children] are happy because they get money fortnightly. Because in Mérida it is the same, you have to pay rent, electricity and water bills; it is hard [to afford all the bills]. Here it is not. Here is better, because I have my *chan*[27] *milpa*, my *chan* maize, they do not have to buy anything. If they earn money, it is for buying their own stuff, their clothes.

The male children learned how to cultivate the *milpa*, but they do not do it anymore. Mr and Mrs Xiu have lived in the same plot for 38 years. They used to have more animals. They did not plant any of the trees they have: "some were already there and other grew by themselves." Some hurricanes have affected their homegarden, but not significantly:

> [the Hurricane] Gilbert [1988] almost did not drop any trees, but it damaged the maize [from the *milpa*]. The animals [from the homegarden] did not die, but we had to sell them to buy maize.

Figure 5.4 depicts the transformations of the Xiu's homegarden in the last 20 years. The expansion of the family has meant the construction of more rooms and thus less space for homegardening. The figure also shows the disappearance of pigs from the homegarden because of the work in the pig farm of Mr. Xiu's children.

[26] Municipality located in the metropolitan area of Mérida, the capital city.
[27] Mayan word for small.



Drawings by Eric Alonso Méndez Salazar

Figure 5.4 Evolution of the homegarden of the Xiu family

The case of the Cocom family (Box 5.4) illustrates the heterogeneity of the peri-urban community and the uniqueness of the homegardens. This is a 'high-high' diversity and 'farm-off-farm' occupational transition household. Despite being exposed to more intense rural-urban interactions than the Xiu family, the Cocom family has managed to keep a highly

diverse homegarden. The Cocom family case shows how off-farm livelihoods within the communities allow households to keep their homegarden diversity, shedding light to more factors that explain how 'off-farm' households can keep highly diverse homegardens. It also exemplifies how the 'living space' represented by the homegarden evolves along with the changes in people's livelihoods. Other factors that emerged from this case as explanations of the transformations in the homegardens were family life cycle, hurricanes and the engagement in the *milpa*.

Box 5.4 Life history of the Cocom family

Diversity transition: high – high	*Location: Hocabá (peri-urban, sisal region)*
Occupational transition: farm- off-farm	*Homegarden size: 1,300m²*

This family is formed by three adults and two children. Mrs Nicté Ha Cocom, the household head, is over 60 years old and speaks Mayan and Spanish. She had three children, but one has died. Her daughter is 40 years old and her son is 37 years old, both are single. Her daughter speaks Mayan and Spanish and her son only speaks Spanish. Her daughter has two sons who live in the house, the oldest is 16 years old and the youngest is 4 years old. None of them speak Mayan. I interviewed Mrs Nicté Ha Cocom.

Mrs Cocom's father worked cultivating sisal. When Mrs Cocom was 14 years old she started to commute to work in Mérida. She worked as housekeeper in the same house for 7 years. Then she went back to Hocabá and got married with Mr Cocom. They moved to this plot 41 years ago. The plot was a present from her mother-in-law.

Mrs Cocom is now a widow; her deceased husband worked in agriculture. After her husband passed away she became the household head. About her homegarden, she mentioned: "I like having plants, flowers, animals. My grandson also likes it, he started to raise animals again."

> Now is when we have more plants, because before, when I got married, I did not have [plants] because I had children. Now I have more plants because my daughter likes them. We have medicinal plants, such as basil, epazote, mint, peppermint. We have the chickens locked because they eat the plants.

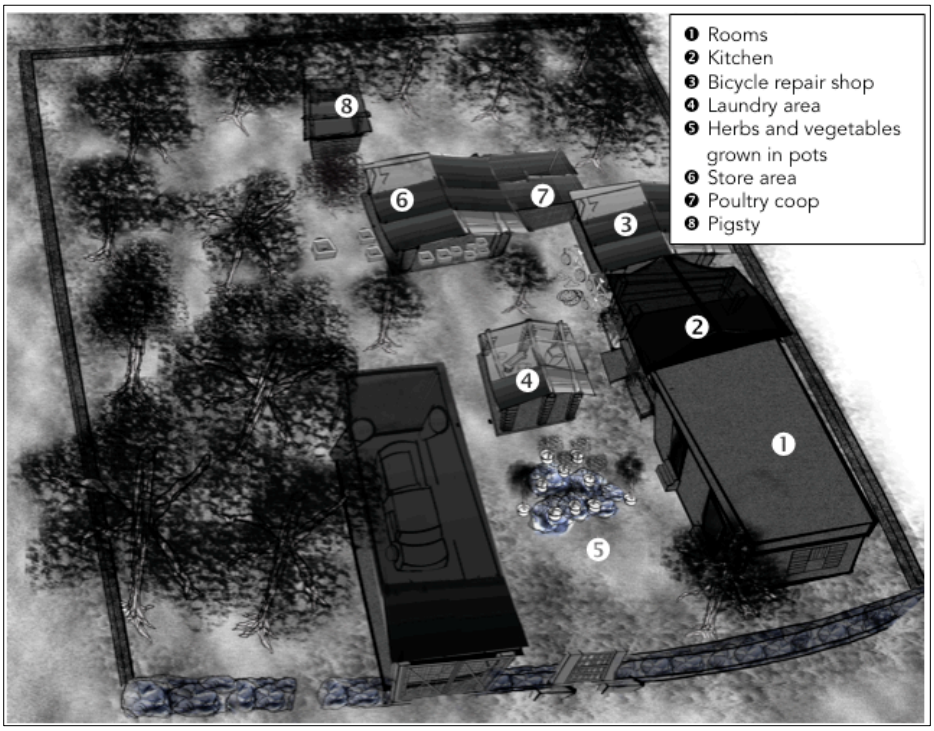
Mrs Cocom and her daughter work selling food at their house. "We stay here to make a living." About how life has changed she explained:

> Now everything is expensive. Before it was cheap, because the maize was cultivated by the *milperos*. Everything came from the *milpa*, wax beans, black beans, squash, watermelon, tannia. There was harvest, there was food. People had tomatoes, radish, coriander in their homegardens. Now there is so much laziness and since you can buy it, people do not grow it anymore. There are people who still grow plants, because they like to eat fresh and better, but there are fewer (…) Now people use too many chemicals for growing the crops faster and that harms us. That is how they feed animals. Before, there were not chemicals. You raised the pig only with things from the *milpa*, with the squash, the breadnut tree and the maize.

The Hurricane Isidore (2002) felled several trees, but not her house, since it was already made of concrete. "Isidore was stronger than Gilbert [1988]". They did not plant trees again after the hurricane dropped them. "We do not plant them, they grow by themselves and since they did not grow we just stayed like this."

They cut down several trees to build the bicycle repair shop where her grandson works. His grandson learned the trade from Mr Cocom. However, her son did not learn the trade. When her son was 18 years old he started to commute to Umán[28] to work as labourer. "Since he is not married, he comes every weekend to visit me and to bring his clothes so that I can wash them".

Figure 5.5 depicts the homegarden of the Cocom family. Despite being classified as highly diverse, like the one of the Xiu family (Figure 5.4), these two homegardens look very different. The Xiu's homegarden shows a more traditional structure, still conserving traditional Mayan houses and using wood in the poultry pen. In contrast, Cocom's homegarden shows rooms made of concrete; the use of blocks and wire net in the construction of the poultry pen and the pigsty; and even a bicycle repair shop. The Cocom's homegarden exemplify how homegardens can be adapted to more urbanised lifestyles without sacrificing their diversity.



Drawing by Eric Alonso Méndez Salazar

Figure 5.5 Homegarden of the Cocom family, 2017

The Itzáes family (Box 5.5) is a 'high-low' diversity, 'off-farm-farm' occupational transition household. This household is located in the peri-urban community and exemplifies the division of the land as a consequence of population growth. It describes how this division relates to the high-low diversity transition in their homegarden, but also how they have

[28] Municipality located in the metropolitan area of Mérida, the capital city.

managed to compensate this with planting in other available plots. Moreover, this case illustrates the relationship between family life cycle and the engagement in urban jobs, describing the less common 'off-farm-farm' occupational transition.

Box 5.5 Life history of the Itzáes family

Diversity transition: high – low	*Location: Hocabá (peri-urban, sisal region)*
Occupational transition: off-farm-farm	*Homegarden size: 600m²*

This family is formed by 3 adults. Mrs Sac Nicté Itzáes, 45 years old; her husband, 46 years old; and their daughter, 23 years old. All of them speak Mayan and Spanish. Mr Itzáes' parents also lived with them, but they passed away a few years ago. I interviewed Mrs Sac Nicté.

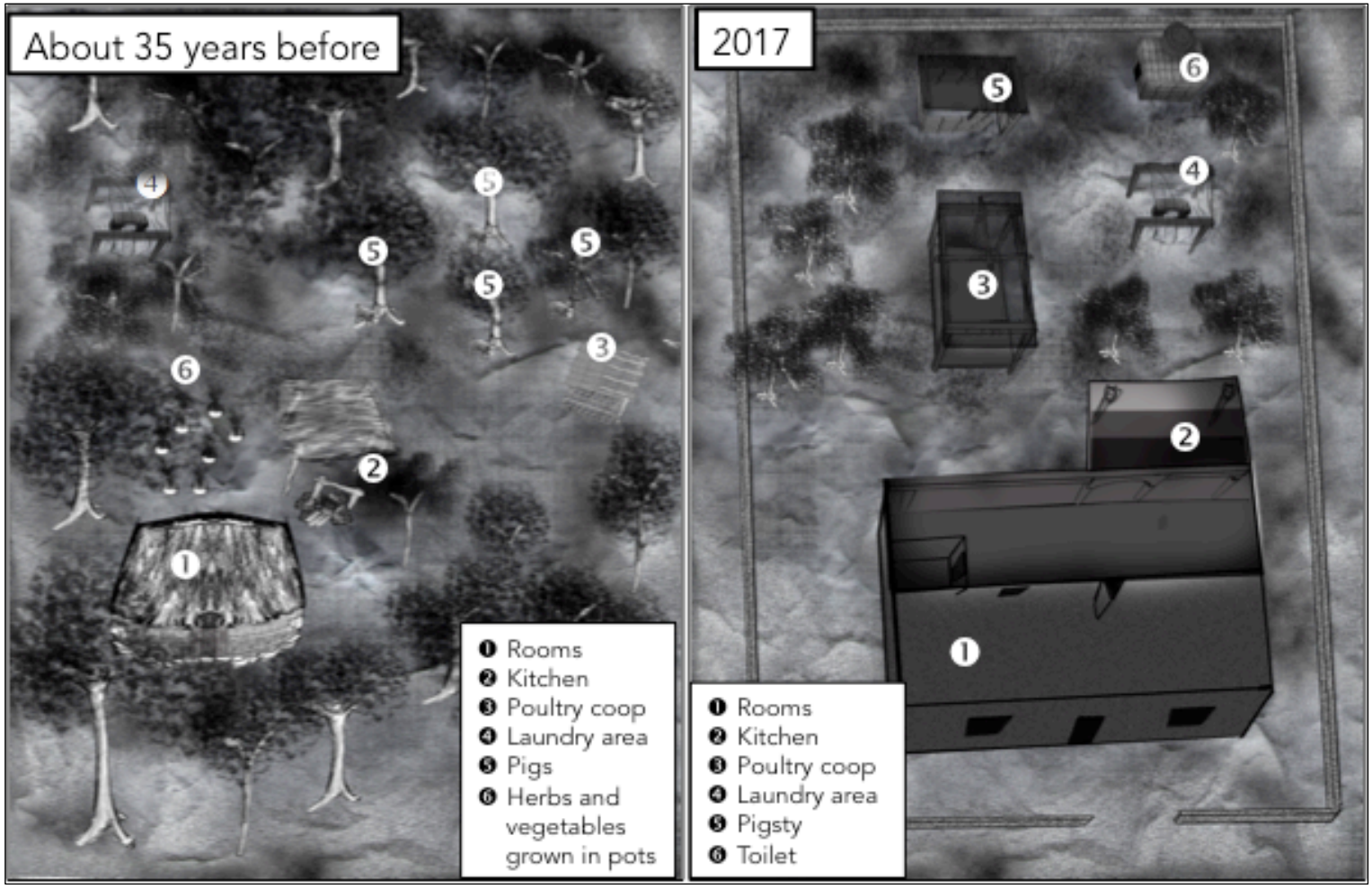
Mrs Sac Nicté explained that she moved to this plot to live with her husband and parents-in-law when she got married. They used to have more plants and animals in their homegarden. "We used to plant coriander, radish and beetroot. Now I only have my orange trees. We also used to have more pigs, but the plot got small." Nonetheless, Mrs Sac Nicté still plants herbs and vegetables in another plot she has.

Mrs Itzáes' brother-in-law stepped into the conversation. He explained how the plot of his parents was evenly divided between the three children when they got married. "That is why it [the plot] got small." He explained that they used to have turkeys, chickens and even some cattle.

Mr Itzáes started working in the *milpa* with his brother and father at a young age. When he was about 20 years old he began to work in Mérida as a loader in a factory. Then he found a job in a hotel. It was around that time when he met Sac Nicté and got married. Now Mr Itzáes works in the *milpa*, he cultivates a non-mechanised hectare for the consumption of his nuclear family. He grows maize, wax beans, black beans, cowpeas, squash, cucumber and watermelon. His brother explained how they are also involved in producing charcol with the wood they obtain from clearing the space for the *milpa*. "Now just a few work in the *milpa*."

Mrs Itzáes' daughter completed an undergraduate degree and recently found a job. Mrs Itzáes explained: "Since she [daughter] completed her studies, her dad does not think that much on it [working in the city]. We helped her as far as we could."

Figure 5.6 depicts the evolution of the Itzáes' homegarden over the last 35 years. The first panel shows how the homegarden looked like when Mr. Itzáes was a child. They used to live in a 'traditional' Mayan house and had more animals and plants. The second panel shows the plot where Mr. Itzáes now lives with his wife and daughter. Their plot is a third of the size of the plot of Mr. Itzáes' parents. They live in a house made of concrete and at the back of the plot they built an English toilet. They continue to raise pigs and keep them in a pigsty made of concrete blocks instead of tethered to trees in the garden.



Drawings by Eric Alonso Méndez Salazar

Figure 5.6 Evolution of the homegarden of the Itzáes family

Finally, Box 5.6 presents the case of the Chactemal family located in Sahcabá, the semi-rural community of the sisal region. This case is a 'high-low', 'farm-off-farm (retired)' household. It illustrates how the construction of concrete structures is related to the income obtained from paid employment outside the community and describes how these structures reduce the space available for homegardening. The extended Chactemal family still produces most of the food they consume. However, the aging of the household members is undermining the diversity and functions of their homegarden.

Box 5.6 Life history of the Chactemal family

Diversity transition: high – low	*Location: Sahcabá (semi-rural, sisal region)*
Occupational transition: farm-off-farm (retired)	*Homegarden size: 1,200 m²*

This family is formed by four adults. The household head is 80 years old, his son and daughter are in their forties and his grandson is 19 years old. All speak Mayan and Spanish, with the exception of the daughter of the household head, Zazil Há, who only speaks Mayan. I interviewed Zazil Há with the help of a translator.

Before Zazil Há was born her father migrated to work in the United States. Then he returned to Sahcabá and worked cultivating sisal and the *milpa*. Thanks to the money her father made in the United States, they managed to build their first room, made of stones. Her three brothers learned how to cultivate the sisal and the *milpa* and two of them still keep cultivating the *milpa*. Even in the present, they obtain enough maize so that they do not have to get it from the market. They only buy meat. The two brothers who keep cultivating the *milpa* do not live in the same house anymore, but they share their *milpa* production with their father and siblings.

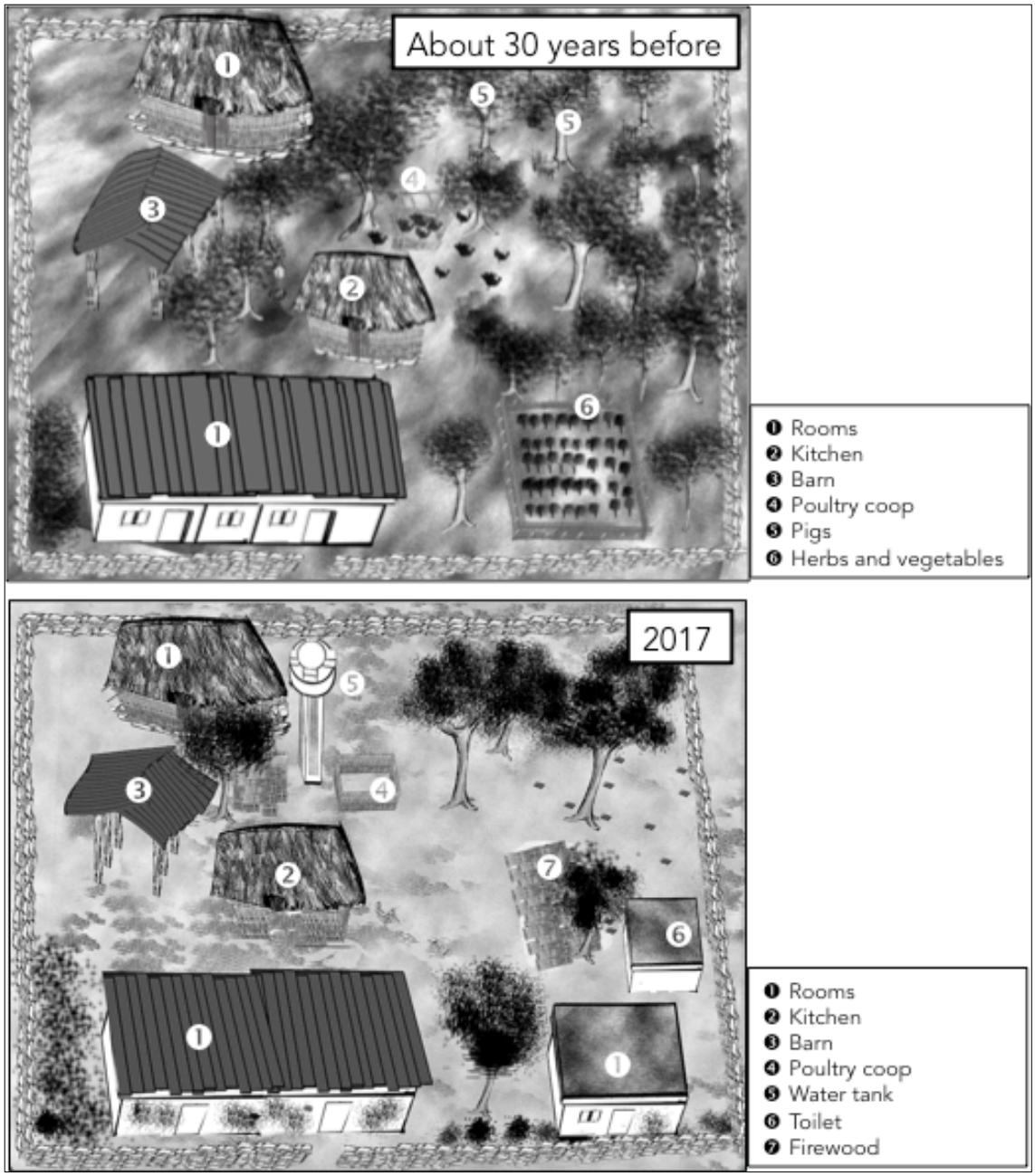
The family gets some income from the pension of the household head and from the paid job of his son who work in Mérida as construction worker. He started to work in Mérida after the decline of sisal production.

> I wanted to go [to work in Mérida], but my mom did not allow me because we were too many. So, I had to stay to help her. We were two daughters, but my sister ran away and I was not allowed to leave.

Zazil Há's mother planted the trees they have, but when they started building new rooms they cut some trees down. Her brother built a concrete room with the money he earned from his job as construction worker. Mrs Zazil Há remembered that Gilbert (1988) was the hurricane that affected the most their homegarden, dropping some trees. She also explained that they did not plant the trees again after the hurricane dropped them. "We were afraid that the trees would fall on the house".

When her mother was alive they had more plants and animals. They stopped having homegarden animals a few years ago, after her mother passed away. Her father got upset because the poultry used to go to the neighbours' plot and the neighbours did not want to return the animals. When they had pigs they fed them with maize from the *milpa*. Zazil Há explained she could not keep raising pigs because her father is ill, and she has to take care of him.

Figure 5.7 shows the evolution of the Chactemal's homegarden in the last 30 years. The main transformations are the construction of more structures made of concrete, a room and an English toilet; the introduction of a water tank as part of government support; the reduction in the number of plants; and the disappearance of homegarden animals.



Drawings by Eric Alonso Méndez Salazar and Fernando Ismael Álvarez Frausto

Figure 5.7 Evolution of the homegarden of the Chactemal family

5.5 Conclusions

This chapter aimed to answer the first research sub-question: ***How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?*** The dominant trend found was a lower dependence on the homegarden with the consequent biodiversity reduction. Urbanisation has meant less land and less interest in agriculture, but also more off-farm livelihood opportunities and better access to infrastructure, public services and urban markets. These findings confirm the first research hypothesis: ***Urbanisation of rural communities has reduced the importance of homegardening as livelihood strategy through opening up off-farm job opportunities and triggering social and cultural changes***.

In the past, rural households depended on the *milpa* as their main livelihood, and the homegarden was part of this broader agricultural system. However, different factors have disincentivised many people's engagement in the *milpa* system. This, in turn, has affected homegarden diversity, although it was observed that the abandonment of the *milpa* has not necessarily led to the abandonment of the homegardens, as previous studies have also noted (Greenberg, 2003). Men may work in urban jobs while their wives or mothers would keep homegardening.

In other contexts, better communications infrastructure has meant broader participation of homegardeners in local markets, as it has been documented for Indonesia (Soemarwoto, 1987; Kumar and Nair, 2004; Abdoellah *et al.*, 2006). However, this was not found to be the case in the research sites. Instead, access to markets has reduced the incentive of many households to produce their own food. Two likely explanations for this different pattern are the smaller size of the Yucatecan homegardens in comparison with other contexts, which constrains the generation of enough surpluses to afford transportation costs; and the preference of some households for other livelihoods to earn an income. Correa (1997) documented two decades ago the presence of 'commercial' homegardens in the sisal region. Nonetheless, broader access to off-farm livelihoods appears to have reduced the relevance of homegardens as means to earn an income for many.

As it is discussed in this chapter, although urbanisation processes have permeated across the peri-urban – rural spectrum, the pace and intensity of this transition has differed between and within the two regions studied. Since the beginning of the nineteenth century, the sisal and the *milpa* regions have shown different patterns of production. Households in the sisal region have focused on cattle raising and the commercial production of maize,

while those in the *milpa* region have focused more on subsistence agriculture. The Caste War and the boom of sisal production exacerbated the differences between these two regions.

People from the sisal region became used to receiving a salary in exchange of sisal cultivation. This early engagement in the labour market is one of the main differences with respect to the *milpa* region and it was the seed of an accelerated process of off-farm diversification after the debacle of sisal production. Nonetheless, this transition also showed differences between the two communities of the sisal region. The peri-urban community was well connected to urban areas since the beginning of the twentieth century and this was reflected in a longer tradition of people commuting for paid jobs. In contrast, in the semi-rural community the involvement in rural-urban interactions was forced by the decline of sisal production.

Urbanisation has also transformed people's lives in the *milpa* region; however, their relative isolation and the extensive coverage of social programmes has allowed households to face a smoother transition without an abrupt abandonment of traditional livelihoods. These differences are likely explaining why in Sahcabá, the semi-rural community of the sisal region, people still show a high dependence on homegarden animals as a way to complement their low incomes and to smooth labour and food market shocks. I elaborate this argument further in the next two chapters.

Although rural urbanisation emerged as the most powerful driver of the transformations in the role of the Yucatecan homegarden as a livelihood strategy, other factors were also found to influence this relationship. The literature on the Yucatecan homegardens recognises the negative impact of droughts and hurricanes on homegarden diversity; however, no previous study was identified to describe or explain the recovery process after these events. As it was illustrated in this chapter, trees usually grow randomly and after they fall it is not likely that new trees will be planted, unless this happens by chance. Moreover, government interventions under a 'agricultural modernisation' agenda and a neoliberal rationale tend to have a narrow understanding of the homegardens, which usually undermines traditional knowledge and ignores some of the key components of this multifunctional agroforestry system.

At household level, it was observed that off-farm diversification and generational transitions have been influencing reductions in homegarden diversity. Participation in off-

farm occupations reduces the time available for homegardening, particularly in the case of urban jobs. Moreover, elderly people are becoming the main gardeners, while less time for and less interest in traditional livelihoods have distanced younger generations from homegardening, causing the loss of traditional knowledge and practices. Nonetheless, alternative pathways to this dominant trend were also identified, confirming the second research hypothesis – *alternative pathways to this dominant trend, where homegardening is still a relevant livelihood strategy, are also observed* –. It was found that better-off and larger households managed to diversify their livelihoods without undermining their homegarden diversity. Better-off households managed to invest more in their homegardens, particularly in their livestock component, using them as a savings repository. Larger households are likely benefiting not only from a larger workforce, but also from stronger mutual support, characteristic of extended families. This means that some members are able to work in the city, while others stay at home to take care of the children and manage the homegardens and the *milpa*. Furthermore, a household head who speaks Mayan, which reflects cultural attachment with traditional practices, was found to contribute to maintaining greater homegarden diversity. The life histories also shed light on how off-farm livelihoods within the communities allow households to keep high levels of homegarden diversity, as illustrated by the Cocom family.

In responding to the first research question – *How has rural urbanisation transformed the role of homegardening as a livelihood strategy in Yucatán, Mexico since the 1980s?* – the chapter contributes to filling the gap on long-term dynamics discussed in Chapter 2. Although the findings do not differ with the main drivers of change found in the literature on homegardens, the approach followed allowed me to analyse the conditions under which different trajectories of homegarden diversity are more likely to occur. The findings uncovered how households exposed to increasing urban interactions can still maintain the diversity of their homegardens and how urbanisation pressures can lead some households to prioritise animals over plants in those systems.

The next two chapters address the second and third research gaps: (i) the interrelationships between homegardens, households and community characteristics; and (ii) the contribution of the homegardens to household food security.

Chapter 6. Homegardening patterns across the peri-urban – rural spectrum

Introduction

In chapter 5, I provided a picture of how the role of homegardening as a livelihood strategy has evolved over the last decades as a result of rural urbanisation, among other factors. In order to get a better understanding on how rural urbanisation influences homegardening, this chapter addresses how homegardening patterns and the benefits people derive from them vary across the peri-urban –rural spectrum. The aim of this chapter is to disentangle how community and household characteristics interact in determining different patterns of homegardening, as highlighted in the second research gap described in chapter 2. The chapter responds to my second research sub-question: ***How and why do homegardening patterns vary across the peri-urban – rural spectrum in Yucatán, Mexico?***

This chapter is divided into four sections. The first section provides an overview of how homegardening fits into a diversified portfolio of livelihood strategies, including on-farm and off-farm activities, as well as participation in social programmes. The second section addresses how homegardening patterns vary across the peri-urban –rural spectrum. The analysis is performed at community level. In it I describe the species diversity and the entitlements people derive from the homegardens surveyed, examining the differences and commonalities between the four field sites. The third section centres the analysis at the household level. A typology of the homegardens studied is presented, examining how these homegarden categories relate to household characteristics. The analysis focuses on five interrelated household characteristics: i) household structure and life cycle; ii) ethnicity; iii) rural-urban interactions; iv) wealth; and v) development interventions. The chapter concludes by summarising the findings in relation to the research sub-question.

6.1 Homegardening and livelihood diversification

As discussed in Chapter 3, homegardening is part of a *bricolage* of livelihood strategies. Over 30% of the adults surveyed mentioned having more than one occupation. However, this figure may be underestimating the relevance of livelihood diversification since some occupations, such as housemaker and farmer, involve several activities not always explicitly recognised by the respondents. Livelihood diversification varied across the peri-urban – rural spectrum, with households located rural communities showing greater diversification. In Hocabá, the peri-urban community, the percentage of adults performing more than one occupation was below 30%, while in Kancabdzonot, the rural community, the percentage was slightly over 40%.

As it was discussed in chapter 5, occupation profiles differed across the peri-urban – rural spectrum. Hocabá (peri-urban, sisal region) and Sahcabá (semi-rural, sisal region) showed a more urban occupational profile, with fewer men involved in agriculture (~10%) and more women working outside their home (~15%). In these communities, the main occupation performed by men was as construction workers (19-34%). By contrast, in Yaxcabá (semi-rural, milpa region) and Kancabdzonot (rural, milpa region) more than 40% of the men still work exclusively in agriculture, while fewer women work outside their home (~5%). The main occupation among women in the four communities was 'ama de casa' or homemaker (55-85%), which usually involves several crucial reproductive and productive activities, including homegardening.

Handicraft making was the second most common occupation in Sahcabá (semi-rural, sisal region) and Kancabdzonot (rural, milpa region), both among men and women. In Sahcabá the handicrafts were made of sisal fibre, while in Kancabdzonot was mainly woodcarving and elaboration of traditional clothing. In Hocabá (peri-urban, sisal region) and Yaxcabá (semi-rural, milpa region) the second main occupation among women was 'housekeeper', performed mainly in houses located in Mérida, the capital city. Among men, 'labourer' was the second main occupation in Hocabá (peri-urban, sisal region), as was 'construction' in Yaxcabá (semi-rural, milpa region). Moreover, a significant percentage (7.23%) of men were retired in Hocabá (peri-urban, sisal region). This pattern is related to the sisal production. Since the farmers involved in sisal production were considered as State employees, many of them are entitled to a monthly pension.

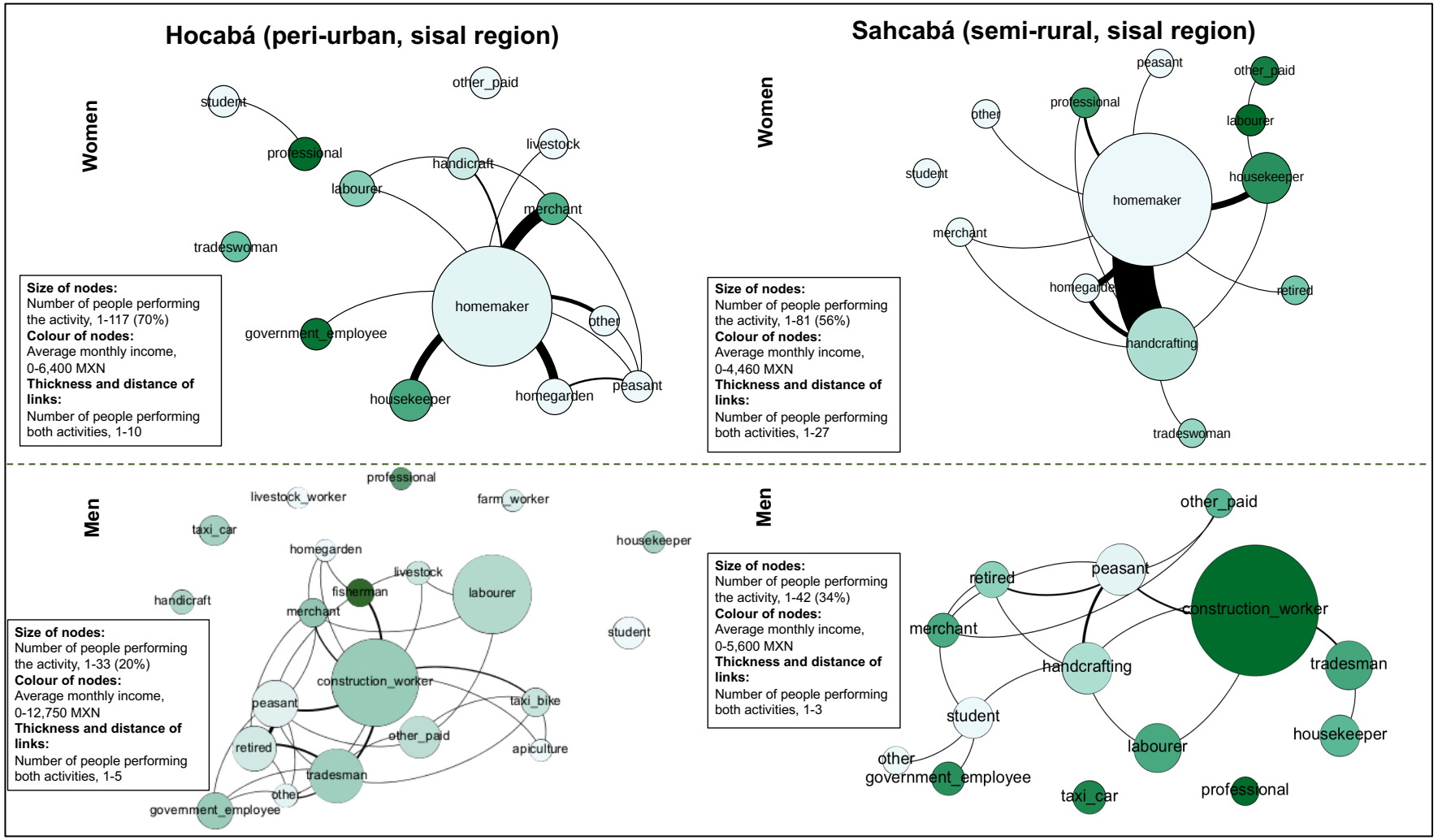
Figures 6.1 and 6.2 present network-type diagrams depicting peoples' livelihoods portfolios. The size of the nodes represents the number of people performing the activity;

the colour of the nodes represents the income earned from the specific activity, the darker the higher; and the thickness and closeness of the links represent the number of people performing both activities. Off-farm occupations, the most profitable (darker nodes), were mainly performed in the more urbanised communities, while on-farm occupations were more relevant in those more ruralised.

The diagrams represent the interaction between the different livelihood activities. In the case of women, in addition to being housemakers, they worked as housekeepers and making handicrafts; the importance of each activity depended on their location. In the case of men, those who worked in agriculture as main occupation were more likely to be involved in other occupations, as the thickness of the links connecting the 'peasant' (*campesino*)[29] node with other occupations nodes shows. Men tended to complement their work in agriculture with jobs in construction, apiculture, working as labourers and elaborating handicrafts.

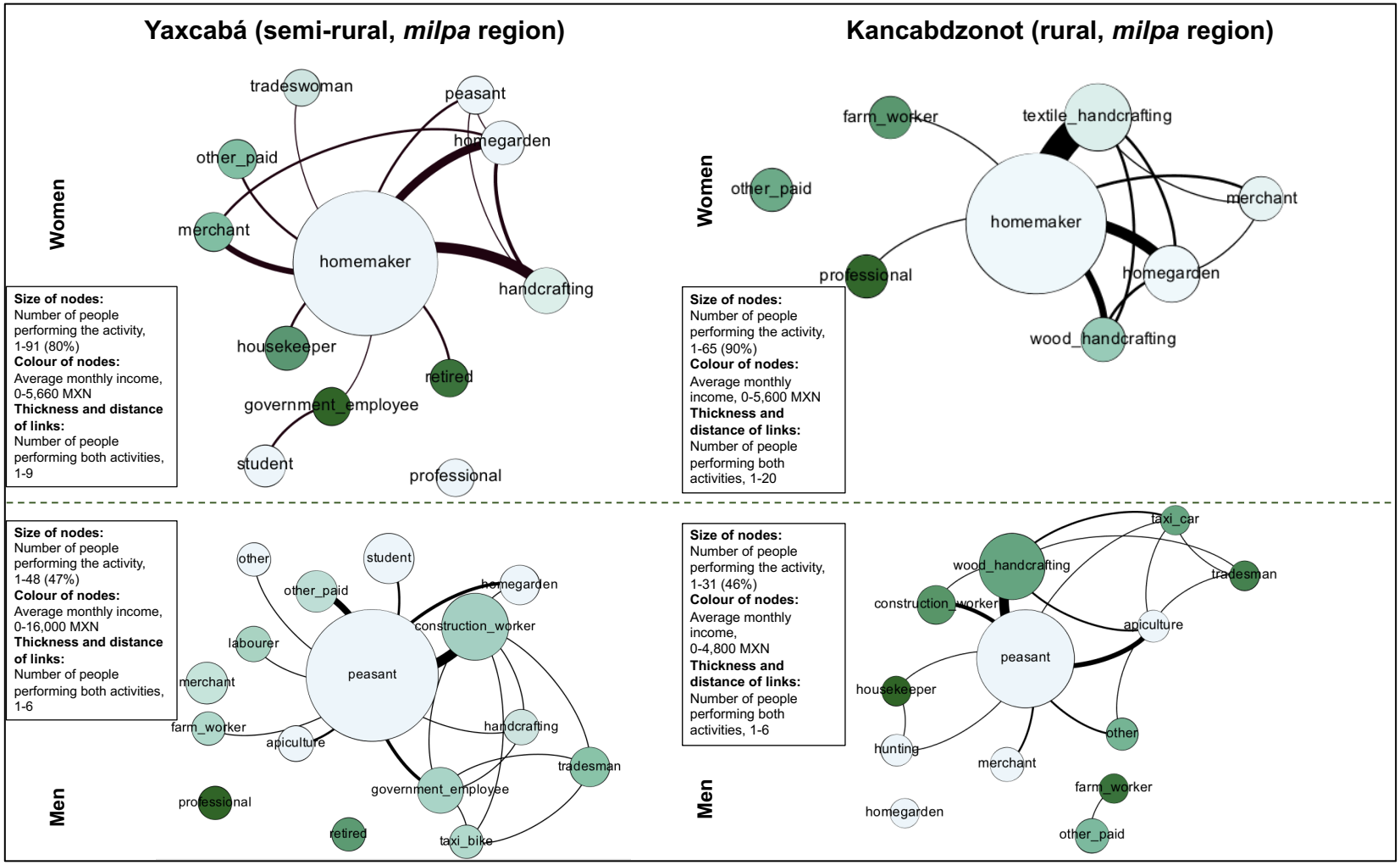
Homegardening emerged mainly as a female occupation, frequently included as the duties involved in being as a homemaker. Nonetheless, elderly men also mentioned being involved in homegardening.

[29] Term used by respondents when referring to agriculture-related activities.



Source: Survey data (December 2016-April 2017).

Figure 6.1 Livelihood diversification in the sisal region by gender



Source: Survey data (December 2016-April 2017).

Figure 6.2 Livelihood diversification in the *milpa* region

6.1.1 Development interventions

Development interventions, particularly government-led cash-transfers, were found to play a crucial role in people's livelihood security. Over ten development interventions were identified in the research sites. Interventions included cash-transfers (e.g. *Prospera and 65 and over*), technical assistance (*PST, the man on the Earth*[30]), provision of agricultural inputs (e.g. *Proagro, PST*) and provision of goods such as toilets, cement floor, concrete rooms and digital televisions.

As Table 6.1 shows, differences in programmes coverage were observed across the peri-urban – rural spectrum, particularly between the sisal and the *milpa* regions. The most extended subsidy in the four communities was the government's conditional cash-transfer programme *Prospera*. In the communities of the *milpa* region, the most rural, nearly all the households received this cash-transfer.

The social inclusion programme *Prospera* is the main poverty reduction strategy in Mexico. In 2016, 6.1 million households received this subsidy (Gobierno de la República Mexicana, 2016). *Prospera* provides a bimonthly cash-transfer conditional on school attendance of children and young people; family health checks; participation in meetings and informative talks; and attendance to literacy and further adult education. The amount of the cash-transfers depends on the number of children and young people (less than 22 years old) attending school and the number of elders in the household (Gobierno de la República Mexicana, 2016). The rules of *Prospera* impose a maximum bimonthly amount of 2,945 MXN (GBP 120; USD 120.1) per family.

As a reflection of the livelihood differences between the two regions studied, in the communities located in the *milpa* region, the second most important subsidy was the agricultural programme *Proagro;* whereas in the communities of the sisal region, the second most important subsidy was the pension programme for elderly people *'65 and over'* (65+). Through *Proagro,* the federal government pays once a year a fixed amount of money per cultivated hectare of the *milpa*[31]. *65 and over* on its part is a cash-transfer programme targeted at people 65 years old and over, who were born in Mexico and do not receive a pension higher than 1,092 MXN (GBP 44.5; USD 58.15). Beneficiaries of this programme receive 1,160 MXN (GBP 47.3; USD 61.77) every two months.

[30] The name of an NGO that provides technical assistance and supplies for livelihood diversification.
[31] MXN1,500 (USD 79.9; GBP 61.2) per hectare for plots up to 3 hectares of rain-fed farming and up to 0.2 hectares of irrigation farming; MXN1300 (USD 69.2 ; GBP 53) per hectare for plots of more than 3 and up to 5 hectares of rain-fed farming and up to 0.2 hectares of irrigation farming; MXN750(USD 39.9; GBP 30.6) per hectare for plots of more than 5 and less than 20 hectares of rain-fed farming and up to 5 hectares of irrigation farming; MXN450 (USD 39.9; GBP18.4) per hectare for plots of 20-50 hectares of rain-fed farming and up to 12.5 hectares of irrigation farming; MXN180 (USD 9.58; GBP7.3) per hectare for plots of more than 50 hectares of rain-fed farming and more than 12.5 hectares of irrigation farming (SAGARPA, 2016).

Table 6.1 Development interventions in the field sites
(Percentage of households)

Programmes	Hocabá (Peri-urban)	Sahcabá (Semi-rural)	Yaxcabá (Semi-rural)	Kancabdzonot (Rural)
Prospera	17.3%	46.9%	95.2%	84.9%
Proagro	2.0%	1.2%	36.9%	45.3%
65 and over	8.2%	8.6%	28.6%	13.2%
Backyard social production (PST)[1/]	-	-	7.1%	9.4%
The man on the Earth[2/]	-	-	-	5.7%
National System for the Integral Development of the Family[3/]	-	-	1.2%	5.7%
Toilet	-	6.2%	-	1.9%
Room / house	4.1%	-	1.2%	-
Scholarship	4.1%	-	-	-
Mover a México (TV)[4/]	3.1%	-	-	-
Piso firme[5/]	-	4.9%	-	-
Others	7.1%	-	7.1%	5.7%

[1/] Producción Social de Traspatio. [2/] El Hombre Sobre la Tierra, NGO. [3/] Sistema Nacional para el Desarrollo Integral de la Familia, DIF. [4/]Programme for the transition to the digital TV. [5/] Cement floor.
Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53 (households).

Source: Survey data (December 2016-April 2017).

Six programmes promoting homegardening were identified in the field sites (see Appendix H for details). Boxes 6.1 and 6.2 describe the two largest, the Backyard Social Production programme (PST) and the Backyard Poultry Production programme (PPT), and discuss particular areas identified for improvement for each programme. The PST, in its second phase, provides inputs and technical assistance for vegetable production, while the PPT provides 10 chickens, 5 females and 5 males. Despite both the PST and the PPT aim to promote homegardening, they are managed by different regional government ministries (Ministry of Social Development and Ministry of Rural Development) and there is no apparent coordination between them (Interviews with government officials; 11/04/2017, 21/04/2017). Another downside consists in the lack of systematic monitoring or assessment, aside from the informal feedback personnel obtaining from participants and the evaluation of a broader policy that involves both programmes but only assesses inputs delivery.

Although these programmes were of relatively recent creation, similar interventions have been delivered by previous administrations. There is a tendency of using these type of programmes, with large geographical coverage, to increase the popularity of politicians. For example, the former Minister of Social Development who led several PST events, later ran as candidate for the Yucatan Gubernatorial elections. The clientelist use of social policy in Mexico and how it influences votes in rural areas has been broadly studied elsewhere (Fox, 1994; Lazos Chavero, 1995; Schedler and Manríquez, 2004; Hevia de La Jara, 2010; Freidenberg, 2017; Gómez Oliver and Tacuba Santos, 2017).

Box 6.1 Backyard Social Production Programme (PST)

The Producción Social de Traspatio programme (Backyard Social Production, PST by its Spanish acronym) was the most important homegarden support programme operating in Yucatán, in terms of geographical coverage. By April 2017, PST had covered 10 thousand homegardens in 254 localities in 50 different municipalities in Yucatán.

According to its operating rules, this programme prioritises communities with less than five thousand inhabitants who are considered highly or very highly marginalised, based on indicators from the National Council of Population. From the field sites, the PST only covers the communities of the *milpa* region: Kancabdzonot (rural) and Yaxcabá (semi-rural).

The PST was designed to operate over three different phases:

- The first phase included the provision of ten chickens, 5 male and 5 female.
- The second and current phase involves the provision of tools, a basic irrigation system, seeds, wire net, biological fertiliser and organic pesticide. After they provide this 'technological package', they keep providing seeds and biological fertiliser twice a year.
- The third phase will involve the provision of one small livestock species or a credit. However, this phase has not started yet and it is uncertain if the programme will continue since there was a change of political party in the regional government in October 2018.

The people in charge of the operation of the PST are agronomists and biologists. The PST personnel visit each homegarden at least twice a year. This is the main monitoring system the programme follows. The operation of the PST has been adjusted to the needs of the particular communities, however these adjustments are not reflected in the written operation rules. This represents a high risk of losing all the know-how that has been accumulated by the PST staff (ecological practices and inputs, seasonal delivery, best providers, seeds preferred, best size of the seeds sachets, etc.) especially since the regional government administration terminated in October 2018.

Although the provision of inputs seems to incentivise homegardening, PST operation rules follow a constrained and uncontextualised vision and definition of the homegarden. The PST personnel only focus on the vegetable component, including some herbs, but ignoring the trees and the animals around it. Personnel help to control the pests and diseases affecting vegetables, but they do not advise on tree or animal pests or diseases. Moreover, the PST personnel ask people to grow vegetables in lines on the ground, ignoring traditional practices involving growing vegetables and herbs in pots. Research participants explained that using pots prevent animals eating the vegetables and allow them to move the plants to protect them either from the sun or heavy rain.

Some areas identified for improvement include: (i) incorporate traditional knowledge and practices; (ii) promote events for sharing knowledge and practices; (iii) adopt a broader and contextualised understanding of the homegardening and reflect this in the assistance provided; (iv) promote the use of inputs available in the communities, e.g. wood-made fences rather than wire-net; (v) adopt a monitoring and evaluation system.

Source: Gobierno del Estado de Yucatán (2014, 2016); Interviews with government officials; interviews and focus group discussions with participants from the *milpa* region; López Barreto (2017).

Box 6.2 Backyard Poultry Production (PPT)

The Producción Pecuaria de Traspatio (Backyard Poultry Production, PPT by its Spanish acronym) is the second most important, state-led, agricultural support programme after the PST. The subsidy provided by the PPT consists of the provision of 10 chickens, 5 females and 5 males, to every household in the communities covered by the PPT. The chickens are between three and five weeks old and are vaccinated.

The PPT prioritises municipalities with medium, high and very high levels of marginalisation. They deliver the chickens every two years. The rules of operation require a minimum available space of 3 m^2 for the chickens and that the household has not received a similar support in the last two years. However, this is a *de facto* universal programme. Every Wednesday, PPT personnel visit a community and provide vouchers to each household. With this voucher and copies of their official ID and evidence of their place of residence, people are able to collect their allotted chickens on Friday of the same week at an official public event. These activities are organised in coordination with the local authorities.

In contrast with the PST, the PPT is managed by personnel with a background unrelated to the aim of the programme and this limits their capability to adjust the programme to the needs of the participants. To illustrate this, when I asked why they followed the 50% male/50% female chickens rule the answer I obtained was: "because it is written in the operation rules". However, research participants explained that a 20-30% male/80%-70% female rule would make more sense, since the male chicken tend to fight with each other. Furthermore, the most recent rules of operation do not mention the 50%/50% proportion, but the personnel are not aware of that.

In Hocabá (peri-urban, sisal region) and Sahcabá (semi-rural, sisal region) people received the chickens during the last days I was conducting the household survey in those communities (January 2017). When I returned to conduct in-depth interviews later that year (November 2017) and asked research participants about their experiences with the chickens, many mentioned that they received mainly cockerels and had eaten most or all of them:

> *Most of the chickens were male, we already ate them all. Since they were 'país' chickens, it was difficult to raise them. I gave them [poultry] feed, tortilla and bread. My mother-in-law got more female chickens, but she also ate all of them already. 'País' chickens cannot be locked; they have to be free, so that they can keep eating herbs. (…) A neighbour, in addition to her chickens got the chickens of her daughters, but since they were too many chickens, they stepped on each other and many of them died.*
>
> (Female research participant from Hocabá, 25 years old, 25/10/2017)
> (Peri-urban, sisal region)

Some areas identified for improvement include: (i) design a targeting criterium and ensure its implementation; (ii) provide training to programme managers or involve personal with relevant background; (iii) improve the organisation of delivery events to reduce mistakes in the number of female/male chickens provided; (iv) adopt a long-term approach to sustain poultry production and reduce the dependency on the programme; (v) adopt a monitoring and evaluation system.

Source: Gobierno del Estado de Yucatán (2016); Interviews with government officials; interviews and focus group discussions with participants from the sisal region.

From field observations, interviews with key government officials and review of official documents, it was noted that government programmes tend to be targeted using national statistics at the municipality level. It was also noted that local authorities tend to prioritise municipality seats over the rest of the communities. Among the four field sites, these practices seemed to favour Yaxcabá (semi-rural, municipality seat, *milpa* region) and to work to the detriment of Sahcabá (semi-rural, sisal region) as the figures of programme beneficiaries presented in Table 6.1 show. The National Council of Population computes a marginalisation index based on census data on housing characteristics and illiteracy rates. According to the 2010 version of this index, Yaxcabá as a municipality, reported a very-high marginalisation level; whereas Hocabá (the municipality where Sahcabá is located) reported an intermediate marginalisation level. However, when looking at the locality level, both Yaxcabá and Sahcabá show high marginalisation levels (Consejo Nacional de Población, 2010).

6.2 Homegardening patterns over the peri-urban – rural spectrum

As discussed in the previous section, livelihood strategies, including access to social programmes, differed across the peri-urban – rural spectrum, with the most striking differences occurring between the communities of the sisal and the *milpa* region. In the homegardens literature, urbanisation has been found to be a factor influencing the type of plant species people grow and the benefits derived from them. Urbanisation and proximity to markets tend to increase the number of ornamental species, fruit trees and commercial crops (Rico-Gray *et al.*, 1990; Kehlenbeck *et al.*, 2007; Novelo Chan, 2007; Bernholt *et al.*, 2009; Molebatsi *et al.*, 2010; Clarke *et al.*, 2014; Mosina *et al.*, 2014; Poot-Pool *et al.*, 2015; Salazar-Barrientos and Magaña-Magaña, 2016). In contrast, homegardens located in distant villages tend to have more edible and medicinal plants (Jeske, 1998; Kehlenbeck *et al.*, 2007; Novelo Chan, 2007; Molebatsi *et al.*, 2010; Clarke *et al.*, 2014; Mosina *et al.*, 2014; Poot-Pool *et al.*, 2015; Peroni *et al.*, 2016).

However, the literature on homegardens is not conclusive on whether homegarden diversity increases across the peri-urban – rural spectrum. Peroni *et al.* (2016) and Mendoza García *et al.* (2011) found decreasing homegarden diversity with the level of urbanisation in Santa Catarina, Brazil and in Veracruz, Mexico; whereas Drescher (1998 in Bernholt *et al.*, 2009) and Perrault and Coomes (2008) found the opposite pattern in Zambia and the Peruvian Amazon. In addition, several studies on the topic have found non-significant differences in the level of diversity, some of these: Kehlenbeck *et al.* (2007) in Central Sulawesi, Indonesia; Molebatsi *et al.* (2010) in North-West Province, South Africa;

Poot Pool *et al.* (2015) in the Yucatán Peninsula, Mexico; and Vieira *et al*. (2017) in Santa Catarina, Brazil.

6.2.1 Homegarden diversity

A total number of 212 plant species were recorded in the 316 homegardens surveyed. Of these, 115 were herbs, 29 were shrubs and 68 were trees (See Appendix D for the complete list of species)[32]. The references in the literature differ widely in the number of plant species found in homegardens in the Yucatán Peninsula, from 19 to 500 (Smith and Cameron, 1977; Cahuich Campos, 2012; Castañeda-Navarrete *et al.*, 2018). This variation can be partly explained by the different seasons when the data were collected; the different length and variability in the methods of data collection, including purposive sampling; the different sample sizes; and different types of species recorded (Castañeda-Navarrete *et al.*, 2018; Lope-Alzina and Howard, 2012).

As I explained in Chapter 2, species diversity contributes to the different functions homegardens perform and the benefits people derive from them. An increasing peri-urban – rural gradient was observed in the diversity of plants and food animals, with the exception of Sahcabá (semi-rural, sisal region) (Table 6.2). Despite being considered as semi-rural, this community showed the lowest diversity of plants among the four field sites. The relatively less fertile soil of Sahcabá (semi-rural, sisal region), as described in Chapter 4, partially explains this finding. Higher participation in urban jobs also contributes to explain this counterintuitive finding.

Contrasting differences were found in the biodiversity data by type of plant according to their height: herb, shrub or tree. The largest differences were found in the herb species, particularly those used for food purposes, such as: onions, tomatoes, chillies and chives. The mean number of herbs used for food purposes in Kancabdzonot (rural, *milpa* region) was about three times higher than the number of herbs used for this purpose in Hocabá (peri-urban, sisal region) and Sahcabá (semi-rural, sisal region). This finding indicates a greater abundance of edible plants in the most rural communities, as expected from the literature review.

[32] Plants are classified as herbs, shrubs or trees according to their height. The classification followed here is based on Chi Quej (2009) and Flores *et al*. (2013) (See Appendix F).

Table 6.2 Biodiversity indicators of the homegardens by field site

Variable	Statistic	Hocabá *(Peri-urban, sisal region)* (1)	Sahcabá *(Semi-rural, sisal region)* (2)	Yaxcabá *(Semi-rural, milpa region)* (3)	Kancabdzonot *(Rural, milpa region)* (4)	ANOVA / Kruskal-Wallis H *p* values	T-test / Wilcoxon rank-sum (1)(2) *p* values	T-test / Wilcoxon rank-sum (3)(4) *p* values
Number of plants	*Mean*	27.3	20.0	42.0	62.9	<0.001	0.128	0.112
	Median	18.0	15.0	32.0	40.0	<0.001	0.093	0.097
Shannon diversity index (plants)	*Mean*	1.73	1.56	1.91	2.08	<0.001	0.100	0.109
	Median	1.92	1.63	2.04	2.24	<0.001	0.054	0.050
Number of animals	*Mean*	8.8	10.0	9.5	15.6	0.011	0.574	0.003
	Median	3.0	6.0	6.5	12.0	<0.001	0.033	0.003
Number of food animals	*Mean*	5.0	6.9	6.9	12.3	<0.001	0.201	0.003
	Median	0.0	2.0	3.0	8.0	<0.001	0.021	0.004
Shannon diversity index (food animals)	*Mean*	0.14	0.27	0.30	0.47	<0.001	0.019	0.018
	Median	0.00	0.00	0.00	0.45	<0.001	0.015	0.019
Number of species of shrubs	*Mean*	0.4	0.2	0.8	0.9	<0.001	0.010	0.427
	Median	0.0	0.0	1.0	1.0	<0.001	0.018	0.633
Number of species of herbs	*Mean*	2.5	1.5	4.0	5.0	<0.001	0.008	0.132
	Median	2.0	1.0	3.0	4.0	<0.001	0.031	0.175
Number of species of food herbs	*Mean*	1.5	0.9	2.8	4.3	<0.001	0.019	0.007
	Median	1.0	1.0	2.0	3.0	<0.001	0.046	0.025
Number of species of trees	*Mean*	5.8	5.3	6.8	7.7	<0.001	0.273	0.152
	Median	5.0	5.0	7.0	8.0	<0.001	0.338	0.091

Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017)

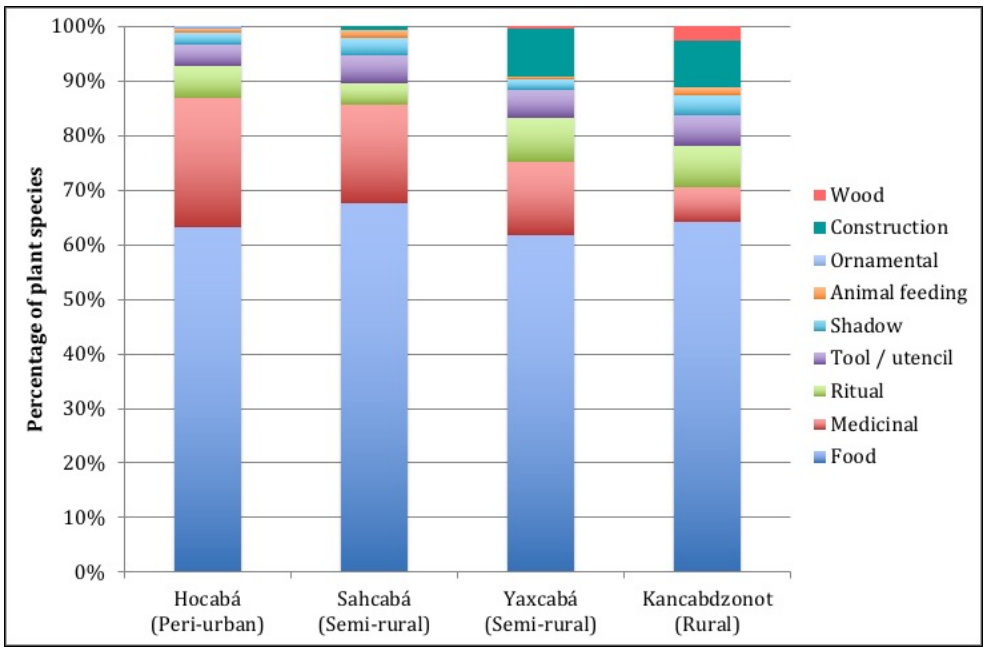
6.2.2 Homegarden functions and entitlements

Through my mixed methods, multi-phase research, I discovered that homegardens in the research sites were mainly valued as source of food. Over 60% of the survey respondents mentioned food consumption as the main reason for homegardening. However, homegardens also provide other materials that contribute to people's livelihood security, including fodder, medicinal plants, timber and other construction inputs. In addition, the homegardens surveyed were identified to perform ecological, economic, social and cultural functions. In the sisal region, besides food consumption, common reasons mentioned for homegardening were income from sales, saving, ornamental and shade; while in the *milpa* region common reasons mentioned were preferences ("because I enjoy it") and income from sales. Following the classification provided in Chapter 2, key functions performed by the homegarden studied include:

i) *Material provisioning.* Non-staple crops, animal protein, fodder, medicinal plants, timber, and other construction material.
ii) *Ecological.* Shade, nutrient cycling, biodiversity conservation.
iii) *Economic.* Savings repository, source of income and safety net.
iv) *Social and cultural.* Enhancement of social networks through sharing, aesthetic and ritual.

As discussed in Chapters 2 and 3, the ecological and economic functions also contribute indirectly to food security, through sustaining soil fertility and productivity; providing access to food from markets; and smoothing weather, health and market shocks.

The relevance of these functions varied across the peri-urban – rural spectrum. The households located in the most rural communities had more uses for their homegarden plants, including: as food, ornament, shade, animal feeding, medicine, tool, for rituals, construction and as timber (Figure 6.3). In addition, the ornamental role of homegardens was found to increase in importance along with urbanisation, as previous studies have found in Mexico (Rico-Gray *et al.*, 1990; García de Miguel, 2000; Novelo Chan, 2007; Poot-Pool *et al.*, 2015; Salazar-Barrientos and Magaña-Magaña, 2016), China (Clarke *et al.*, 2014), Indonesia (Jeske, 1998) and South Africa (Molebatsi *et al.*, 2010; Mosina *et al.*, 2014).



Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017)

Figure 6.3 Distribution of the number of plants by use and field site

Plants and animals were more extensively sold in the most rural communities. The percentage of households selling homegarden plants was: 28.9% in Hocabá (peri-urban, sisal region), 14.1% in Sahcabá (semi-rural, sisal region), 58.3% in Yaxcabá (semi-rural, *milpa* region) and 55.6% in Kancabdzonot (rural, *milpa* region). Previous studies analysing the relationship between the commercial use of homegardens and urbanisation differ in their findings. Some have found that the commercial use increases with urbanisation (Rico-Gray *et al.*, 1990; Bernholt *et al.*, 2009), whereas others have found the opposite pattern (García de Miguel, 2000).

In the field sites the common practice was to sell homegarden products from their homes, rather than selling them in markets or other public areas. The main plant species sold were

the breadnut tree (*Brosimum alicastrum*), the Spanish cedar (*Cedrela odorata*) and citrus, especially the lime (*Citrus aurantiaca* and *Citrus aurantifolia*). In Yaxcabá and Kancabdzonot, the most rural communities, located in the *milpa* region, vegetables were also frequently sold, such as: chives (*Allium schoenoprasum*), coriander (*Coriandum sativum*) and chillies (*Capsicum chinese*). The leaves of the breadnut were sold yearly or occasionally (less than once a year), while the Spanish cedar was sold occasionally. The leaves of a breadnut tree were sold for between 50-150 MXN (2-6 GBP / 2.7-8 USD)[33], while a Spanish cedar was sold for between 50-500 MXN (2-20 GBP / 2.7-26.6 USD). Citrus and vegetables were sold more frequently (twice a week – monthly), though the income flows from these sales were smaller.

Animal sales provided higher income flows than plants sales, though they were less frequent. The communities of the *milpa* region, the least urban, reported the largest proportion of households selling homegarden animals, 48.8% in Yaxcabá (semi-rural) and 28.3% in Kancabdzonot (rural); while in the communities of the sisal region the proportions were 27.5% in Hocabá (peri-urban) and 19.8% in Sahcabá (semi-rural). Within each region, the most urban communities presented the largest proportion of households selling homegarden animals. A likely explanation for this is that households located in the municipality seats, such as Yaxcabá and Hocabá, tend to be wealthier than those in the other communities in the municipality. Differences were significant at p-value<0.01.

Pigs and chickens were the most frequently sold animals in all study communities except Hocabá, the peri-urban community, where turkeys were more frequently sold than pigs. Pig sales represented the largest income flow. They were mainly sold once or twice a year. The price range was 50-80 MXN (2-3 GBP / 2.7-4.3 USD) per kilo and 210-3000 (8.5-122 GBP / 11- 160 USD) per animal. Research participants mentioned how animals raised in homegardens are slaughtered for special occasions, such as *Janal Pixan* (Day of the Dead), Christmas Eve, New Year's Eve or birthdays: "We wanted them [homegarden animals] for a purpose, to celebrate her [daughter's] graduation from kindergarten. We killed them, we killed chickens, we killed turkeys" (Female research participant from Hocabá, 25 years old, 9/11/2017). Animals are also raised and later sold to purchase consumer durables, to invest in the house, or to be used as safety nets against health, weather and labour market shocks. The case of the Xiu family presented in Chapter 5 (Box 5.3) illustrates how

[33] Banco de México, exchange rate of April 2017.

homegarden animals were sold to protect the family from the loss in the *milpa* caused by the Hurricane Gilbert in 1988.

Interviews with research participants highlighted the social and the economic roles of the homegardens. When respondents were asked which plants they sold, a common answer was "*no lo vendo, lo regalo" ("I do not sell it, I give it"*). Nonetheless, this role was found to be undermined by the level of urbanisation, affecting particularly the peri-urban community. With the exception of Hocabá (42.9%), the peri-urban community, most of the households in the field sites mentioned gifting homegarden products, especially plants (Sahcabá 95%, Yaxcabá 82.3% and Kancabdzonot 84.9%). This practice is a way to strengthen relationships between family, friends and neighbours, as Howard (2006) found in a review of studies on Latin-American homegardens. Seasonal products were common unexpected rewards that the research team received from several research participants.

The differences observed across the peri-urban – rural spectrum, both in homegarden diversity and the benefits people derive from it, are explained by the distinct access to off-farm livelihoods and markets, and by different lifestyles. As discussed in section 6.1, in the most rural communities, households depend more on agriculture as the main source of livelihood. Rural households tend to have less access to off-farm livelihoods and to markets. They are not only more distant from markets, but they also have lower incomes that constrain their purchasing power and their affordability of transportation.

The relative remoteness of rural communities has allowed some traditional livelihoods and practices to survive, which further influence the preference for agriculture over other livelihood alternatives. In this case, the homegarden plays a significant role in providing food, fodder, medicinal plants, construction materials, pocket money, etc. In the most urban communities, in contrast, households have more livelihood options at hand, most of which are off-farm, resulting in less time to allocate to homegardening, but also less need to depend on it. Moreover, these households show higher exposure to urban centres, which is likely influencing their preference for flowers, as a way to imitate the ornamental gardens they observe in the city.

This section described the differences between homegardens at the community level, depending on their level of urbanisation. The next section centres the analysis at the household level, providing evidence on how homegardening patterns differ according to

household characteristics, including their location (rural-urban) and participation in urban jobs.

6.3 Unpacking diversity and complexity: a typology of homegardens

One of the main research gaps in the literature is the social and economic determinants of different patterns of homegardening. However, simplifying the diversity and complexity of homegardens in order to first uncover the different patterns of engagement in this activity, and then identifying the related determinants, are not easy tasks. Furthermore, since homegardens are a context-specific phenomenon, transposing classifications or typologies used in other geographical spaces is not a viable option (Kumar and Nair, 2004). This section introduces a typology of the homegardens surveyed, which I found useful in explaining the different patterns of homegardening, using the demographic and socioeconomic features of the households.

6.3.1 A typology of homegardens

As I explained in Chapter 4, this research applied principal components analysis and cluster analysis, together with field-based qualitative observations in order to obtain a typology of the homegardens surveyed. The main differences observed in the characteristics of the homegardens across the peri-urban – rural spectrum were the diversity, type and use of plants and animals. Accordingly, and after running different quantitative tests, the variables selected to obtain the homegarden typology were: diversity of trees; diversity of food herbs; proportion of ornamental plants; and the diversity of animals used for food purposes, e.g., chickens, pigs, turkeys, etc. These diversity measures helped to identify distinct homegarden categories according to the functions they performed and the benefits households derived from them. Four main categories were identified:

1. *Kitchen gardens.* This category represented 51% (161) of the households surveyed, reflecting how about a half of the homegardens showed similar characteristics. These homegardens prioritised the material provisioning function, preferring plants over animals, particularly food plants. They showed an intermediate level of tree and food herb diversity, and they reported the smallest proportion of ornamental plants and low animal diversity. Many of these were relatively old homegardens, with over half being more than 50 years old.

2. *Multifunctional homegardens*. This category represented 29% (93) of the households surveyed. This group showed the greatest diversity of trees, food herbs

and animals. About half of their owners reported that they sold their plants, the largest proportion among the four categories and more than twice the proportion reported by ornamental homegardens. These characteristics reflected the fact that the homegardens were performing 'multiple' functions: material provisioning and various ecological, economic, social and cultural services. These homegardens were the largest and were relatively young homegardens, with over half being less than 51 years old.

3. *Ornamental gardens*. They represented 12% (38) of the households surveyed. They prioritised the aesthetic function of the garden, showing the greatest proportion of ornamental plants among the four categories. These homegardens reported a zero value in animal diversity. It does not necessarily mean they did not have any animals for food purposes, but if they had animals, all were from the same species, for example, all chickens. Among those homegardeners who raised animals it was observed that they did it as a way of investment. Though ornamental gardens showed the lowest animal diversity, more than 40% of the owners mentioned that they sold animals raised in their gardens, the largest proportion among the four categories. Moreover, they reported the largest expense in animal feeding, though the differences were not statistically significant, as reported in Table 6.3. Ornamental gardens were the smallest among the four categories. They were relatively young, with over half of them being less than 51 years old.

4. *Savings repository homegarden*. This category represented 8% (24) of the homegardens surveyed. This group prioritised animals and food herbs over other components, as a strategy to take the most advantage of their small plot size. They reported the second smallest average size among the four categories. The economic function was the most important performed by this category of homegardens, using the small livestock as savings repository. Food animals were consumed or sold for celebrations or to smooth market and health-related shocks. Nonetheless, food provision, nutrient cycling and the aesthetic role of the homegarden were also important. This group of homegardens showed the lowest monthly expenditure in animal feeding, reflecting the use of resources from the *milpa* and the homegarden for this purpose. They also reported the second largest proportion of ornamental plants. These homegardens were the oldest among the four categories, with over 70% being more than 51 years old.

Table 6.3 summarises the characteristics of the homegardens, providing statistical significance values of the differences between the four categories. The relation between the size and the diversity of the homegardens is still a puzzle. Common sense indicates that larger homegardens are more diverse and in fact, there is evidence of this direct relationship (Rico-Gray *et al.*, 1990; Caballero, 1992; García de Miguel, 2000; Quiroz *et al.*, 2002; Kehlenbeck and Maass, 2004; Guerra Mukul, 2005; Perrault-Archambault and Coomes, 2008; Bernholt *et al.*, 2009). Nonetheless, there are also scholars that have found not significant relationship between these two variables, such as Abdoellah *et al.* (2006) in Java, Indonesia; Aguilar- Støen *et al.* (2009) in Oaxaca, Mexico; and Gbedomon *et al.* (2015) in Benin. In this research it was found that larger homegardens, such as those labelled as multifunctional, showed higher diversity than those smaller, such as the ornamental gardens. Nonetheless, savings repository gardens despite being larger than those ornamental, reported lower plant diversity. A likely explanation for this counterintuitive finding is that the owners of savings repository gardens were sacrificing tree diversity in exchange of food animals.

Table 6.3 Characteristics of the homegardens by category

Homegarden characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental garden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Plant diversity (Shannon index)	*Mean*	1.66	2.18	1.61	1.41	<0.01
	Median	1.81	2.24	1.77	1.39	<0.01
Trees diversity (Shannon index)	*Mean*	1.39	1.83	1.16	0.906	<0.01
	Median	1.49	1.84	1.13	1.05	<0.01
Food herbs diversity (Shannon index)	*Mean*	0.375	0.756	0.26	0.416	<0.01
	Median	0	0.687	0	0	<0.01
Proportion of ornamental plants	*Mean*	0.078	0.117	0.637	0.157	<0.01
	Median	0	0.035	0.544	0.04	<0.01
Food animals diversity (Shannon index)	*Mean*	0.0018	0.74	0	0.71	<0.01
	Median	0	0.69	0	0.661	<0.01
Land *(solar)* size (mean, squared metres)	*Mean*	1145.21	1433.38	829.31	850.09	0.043
	Median	800.00	930.00	600.00	800.00	0.040
Solar 15 or less years old	*Proportion*	7.45	10.75	15.79	0.00	0.014
Solar 16-50 years old	*Proportion*	31.68	49.96	42.11	25.00	0.014
Solar 51-99 years old	*Proportion*	27.95	13.98	15.79	37.50	0.014
Solar 100 or more years old	*Proportion*	32.92	25.81	26.32	37.50	0.014
Sale of plants (0,1)	*Proportion*	35.40	51.61	21.05	37.50	<0.01
Sale of animals (0,1)	*Proportion*	26.71	34.41	42.11	33.33	0.250
Monthly expense in feeding by animal, mean MXN (GBP / USD)	*Mean*	91.01 (3.71/4.85)	38.43 (1.57/2.05)	106.00 (4.32/5.64)	25.38 (1.04/1.35)	0.244
	Median	20.31 (0.83 / 1.08)	17.78 (0.73 / 0.95)	17.78 (0.73 / 0.95)	5.70 (0.23 / 0.30)	0.533

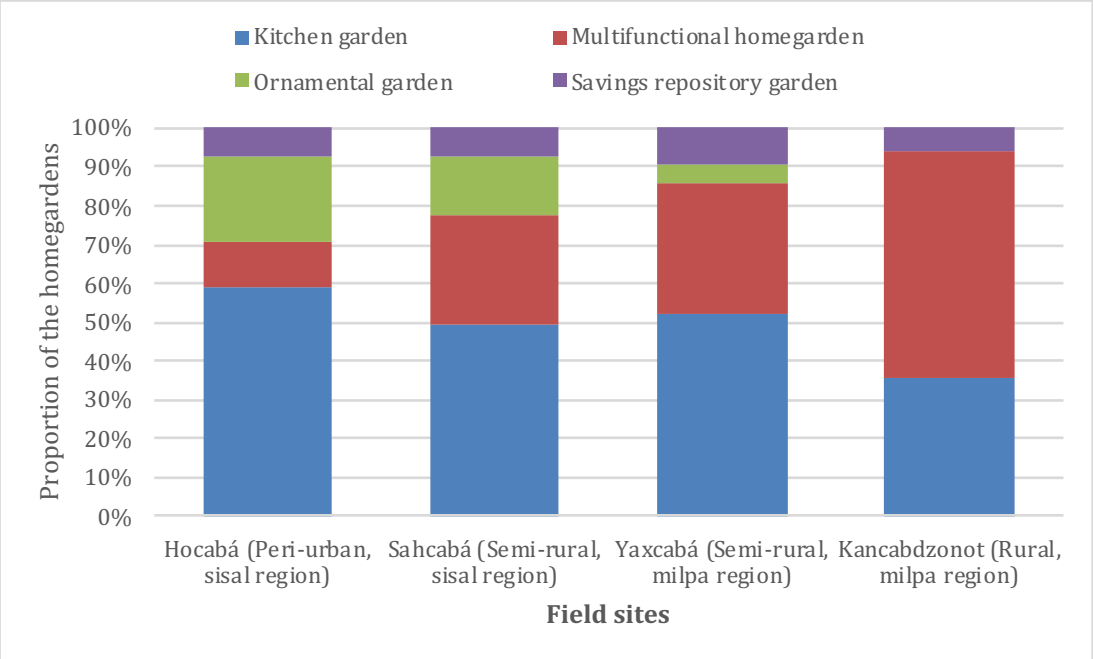
Observations: 316.

Source: Survey data (December 2016-April 2017).

The evidence in the literature on the relationship between the age and the diversity of the homegarden is not conclusive either (Caballero, 1992; Xuluc Tolosa, 1995; Aké, 1999; Quiroz *et al.*, 2002; Kehlenbeck *et al.*, 2007; Aguilar-Støen *et al.*, 2009). This is likely reflecting the complexity of factors interacting in shaping the relationship between homegardening and livelihood security. As an illustration of this, Gbedomon *et al.* (2015)

found in Benin a positive relationship between the age and the diversity of the homegarden but mediated by the age of the gardener. Older homegardens showed greater diversity if owned by the elderly, whereas the opposite pattern was observed among young homegardeners. The next sub-section discusses how household characteristics interact in determining the composition and diversity of the homegardens.

The different types of homegardens are geographically clustered. As Figure 6.4 illustrates, kitchen gardens were mainly located in the peri-urban and semi-rural communities. Multifunctional homegardens showed an increasing peri-urban – rural gradient, with more than half of them located in the rural community. In contrast, ornamental gardens showed a decreasing peri-urban – rural gradient, with no presence in the rural community. This distribution of the homegardens by category across the peri-urban – rural spectrum coincides with the findings discussed in the previous section. The more urban the homegarden, the less diversity and fewer functions are performed, and its ornamental role increases. Finally, the savings repository gardens were mainly present in Yaxcabá (semi-rural, *milpa* region). Chapter 7 discusses further how homegardens are helping households to smooth market shocks in the semi-rural communities studied.



Observations: 316.

Source: Survey data (December 2016-April 2017).

Figure 6.4 Distribution of the homegardens by category and field site

6.3.2 Unpacking the determinants of homegardening patterns

The typology obtained was used to analyse the relationships between the different patterns of homegardening and the demographic and socio-economic characteristics of the households. As explained in the Endowments-based Livelihoods Framework (ELF) and the related theory of change presented in Chapter 3, household characteristics do not only influence homegardening through determining access to resources and shaping preferences, but also through enabling or constraining the access to other livelihood activities and thus, reducing or increasing the need to depend on homegardening as a livelihood strategy.

Qualitative insights from life histories, the analysis of the survey data collected, together with the review of the literature on homegardens, led to the identification of five relevant groups of household characteristics: (i) the household structure and life cycle; (ii) ethnicity; (iii) rural-urban interactions; (iv) wealth; and (v) government-led development interventions. Following the ELF, these characteristics represent endowments (wealth, labour, income from cash-transfers, traditional knowledge), conversion factors (age, gender, ethnicity, social status) and other livelihood strategies (rural-urban interactions, government-led development interventions). This section shows how in the particular context studied, resources and conversion factors interact, constraining and influencing how households decide their livelihood strategies, including homegardening.

Descriptive statistics of the characteristics of the households by homegarden category were analysed, testing the statistical significance of the differences observed. Moreover, a multinomial logistical model was computed to analyse the significance of each factor in predicting homegarden categories, while controlling for the rest of the household characteristics. The results are discussed below, and the output table of the multinomial model is presented at the end of this section, Table 6.16. The discussion focuses on the differences between the four homegarden categories and is organised in terms of the five relevant groups of household characteristics identified.

Figure 6.5 summarises the relationships between the characteristics of the homegardens and the households by homegarden category. It depicts the significant differences found from the statistical analysis, either from descriptive statistics, the regression model (Table 6.16) or both. As shown, significant differences were observed between the homegarden categories for the variables of homegarden diversity, homegarden size, urbanisation, receipt of government support and household wealth. Here the level of urbanisation does

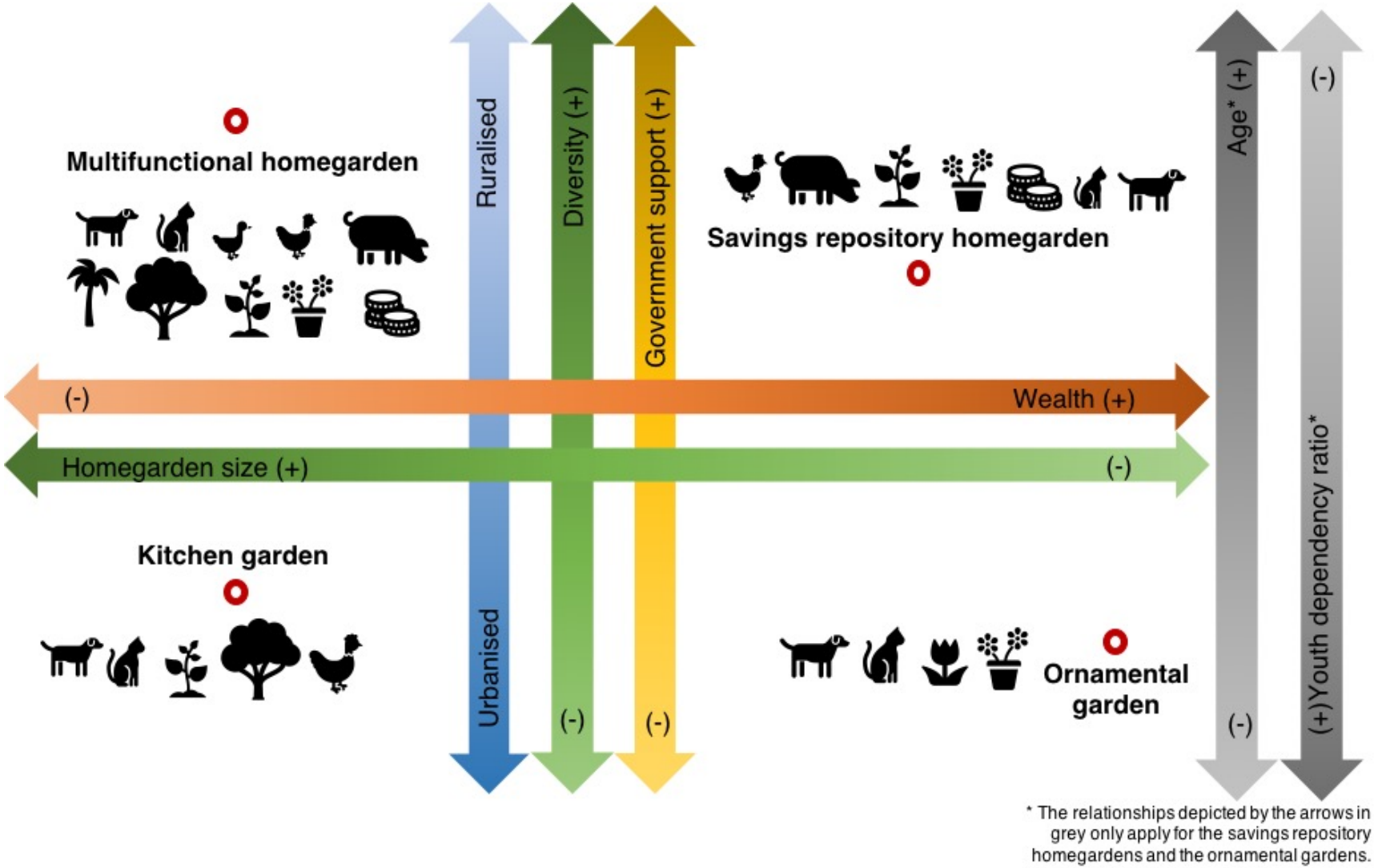
not only refer to the location of the household, but also to the level of engagement in urban jobs and the attachment to traditional livelihoods and traditional cultural practices. In the case of savings repository homegardens and ornamental gardens, additional differences were observed in the age of the household head, the average age of the household members and the youth dependency ratio. These relationships are depicted by the arrows in grey on the right side of the diagram.

The savings repository homegarden category is used as example to illustrate how to interpret the diagram. Households that own savings repository homegardens tend to be more 'rural' (blue arrow): located in the most rural communities, engaged in on-farm livelihoods and speaking the Mayan language. These households are more likely to receive government support than other categories (yellow arrow) and are wealthier than other rural households (orange arrow). These homegardens are diverse (green, vertical arrow), despite being of small size (green, horizontal arrow). In comparison with the households that own ornamental gardens, which are also better off and show a small plot, the tenders of savings repository homegardens are older and have less children (grey arrows). The icons depict savings repository homegardens as being formed by animals and small plants and representing a source of income.

6.3.2.1 Household structure and life cycle

Households distribute their time in different productive and reproductive activities, depending on their size, structure and life cycle (Voydanoff, 1988). Guerra Mukul (2005) in his research on the homegardens of Yaxcabá, Yucatán, Mexico, found that the presence of small children (12 years old or younger) intensified the participation of the household head in paid work, usually outside the community, whilst reducing the number of homegarden components.[34] Moreover, he found that when young people started contributing to the household income, the household head usually returned to the community and reduced the time invested in paid work while investing more time on the preferred traditional livelihoods, such as *milpa* cultivation.

[34] Fruit trees, vegetables, ornamental plants, poultry, pigs, cows and rabbits.



Source: Own elaboration, based on survey data (December 2016-April 2017).

Figure 6.5 Homegarden categories by physical and household characteristics

The relationship between the age of the main gardener and the diversity of the homegarden has been analysed in other contexts. Perrault-Archambault and Coomes (2008) in the Peruvian Amazon, and Quiroz *et al*. (2002) in Venezuela found a positive and significant relationship. In addition, Gbedomon *et al.* (2015) found a positive relationship between the age of the homegarden owner and homegarden ownership in Benin. Aguilar-Støen *et al.* (2009) explain that the more frequent exchange of plant material among older gardeners contributes to explain the relationship between the age of the gardener and their homegarden diversity.

The number of household members and number of adults have been found to affect positively the diversity of the homegardens, since it represents more labour resources (Quiroz *et al.*, 2002; Perrault-Archambault and Coomes, 2008; Bernholt *et al.*, 2009). The gender of the gardener can also influence the diversity of the homegarden. Perrault-Archambault and Coomes (2008) found that female gardeners had more diverse gardens in the Peruvian Amazon; whereas Bernholt *et. al.* (2009) observed greater richness in the homegardens managed by men in Niamey, Niger; meanwhile Kehlenbeck *et. al.* (2007) found no significant relationship between gender and garden diversity in Central Sulawesi, Indonesia.

The life histories presented in Chapter 5 showed how the life cycle of the household influenced homegarden characteristics and the selection of livelihood strategies. The Cocom and Itzáes cases illustrate this. In the Cocom case, the daughter and the grandchildren of the household head were now the main gardeners. In the Itzáes case, Mr. Itzáes returned to work on-farm since his daughter completed her studies and she recently found a paid job in the capital city. Section 5.2.1 also discussed how the age of the gardeners was impacting negatively the diversity of the homegardens.

As Table 6.4 shows, from the survey data, the biggest differences in the structure and life cycle of the households were found between the households owning ornamental and savings repository homegardens. Ornamental homegardens were owned by young couples or young female heads with children and teenagers. These households were the youngest, and differences were statistically significant (p-value<0.10). They reported the largest mean number of household members and the highest values for the youth dependency ratio[35] (p-value<0.05). On the other hand, savings repository gardens were owned by

[35] Ratio of children under 15 years old divided by the number of adults in the household.

households at the opposite stage in the family life cycle. They were owned by the elderly, either a couple or males without a partner. These households reported the oldest heads and the highest average age of the adult members (p-value<0.10). They also showed the smallest number of household members and the lowest youth dependency ratio (p-value<0.05), presumably because their children had moved out to form their own homes. One of the research participants that had an ornamental homegarden spoke about their homegarden preferences: 'Elderly people like to raise animals, but I think it is too much work. I prefer plants' (Female research participant from Hocabá, 50 years old, 05/01/2017).

From the regression model presented at the end of this section (Table 6.16), it was found that a household that is 10 years older increased the probability of owning a savings repository homegarden by 3%, on average; whereas an increase of 0.5 in the youth dependency ratio increased the probability of having an ornamental homegarden by 0.8%. Multifunctional homegardens showed significant marginal effects for the average age of the household (-) and youth dependency ratio (+), indicating that younger households with more children are also likely to own very diverse homegardens, once other household characteristics, such as the size of the plot and the engagement of household members in extensive farming, are accounted for.

Qualitative insights from Chapter 5 together with the quantitative findings discussed in this section suggested an inverted U shape in the relationship between the age of the household members and homegarden diversity. This distribution was tested using the same regressors as in the multinomial model, but also including the age of the main gardener as a quadratic term. The dependent variable in this model was the diversity of the homegarden, measured in two separate regressions by the Shannon diversity indices of the plant and animal components. The coefficients obtained from these regressions confirmed the inverted U shape, estimating a positive coefficient for the linear term of age and a negative coefficient for the quadratic term; however, the coefficients were too small and not statistically significant, with the exception of the quadratic term in the animal diversity regression. The coefficients and standard errors from these regressions are presented in Appendix I.

Significant differences were also observed for the proportion of households headed by males without a partner (mainly widowers). Most of these households owned a kitchen garden and none of them had an ornamental garden (p-value<0.01), reflecting both age and gender differences in the management of homegardens, since most of them were widowers.

In the case of female-headed households (without a partner), the highest proportion was reported as having ornamental gardens; however, the differences were not statistically significant. These findings were held once controlling for other household characteristics and significant differences also emerged in the ownership of multifunctional homegardens by males without a partner. From the regression model, households headed by males without a partner reported a positive probability of having a kitchen garden (37.8%) and negative probabilities of having an ornamental homegarden (-12.6%) or a multifunctional homegarden (-23.4%).

These results were similar to that found in the literature review, with younger households and male gardeners reporting lower homegarden diversity. It was also observed that though widowers may cultivate the homegarden instead of the *milpa* because of aging and health issues, their homegardens tended to be less diverse than their female counterparts. This reflects how the homegarden is perceived as a female space, a characteristic highlighted in previous studies on homegardens in Latin America, as discussed in Chapter 2 (Ángel Pérez and Martín Alfonso, 2004; Howard, 2006; Lope-Alzina, 2007; Dietrich, 2011).

The size of the household was found to interact with other household characteristics, such as age and youth dependency ratio, so that in this research, the households with the largest number of household members and largest dependency ratio owned ornamental gardens and were the least diverse. However, household characteristics also interacted with community characteristics. Young households with children were likely to have either ornamental or multifunctional homegardens, but the final diversity outcome was found to be controlled by the location and other characteristics of the household, such as the size of the plot and the engagement of household members in extensive farming. It is likely the case that in the communities located in the *milpa* region, extended, rather than nuclear, households are still the norm, allowing young couples to rely on their relatives for childcare and homegarden management. This assumption is supported by Baños (2001) who found that nuclear families were less frequent in the *milpa* region in comparison with the sisal, southern and coastal regions. These findings thus provide evidence of how formal and informal institutions shape the way household characteristics interact in determining homegardening patterns, as the capabilities-based livelihoods framework depicted in Chapter 3.

Table 6.4 Household demographics by type of homegarden

Household characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental homegarden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Average age of household adult members (years)	*Mean*	46.1	45.4	40.9	49.9	0.054
	Median	44.0	42.5	38.0	50.0	0.056
Age of household head (years)	*Mean*	55.7	55.5	48.2	55.9	0.059
	Median	55.0	54.0	49.0	54.0	0.078
Average household education (years)	*Mean*	6.4	6.3	7.0	6.1	0.692
	Median	6.0	6.5	7.4	6.3	0.833
Number of household members	*Mean*	5.1	5.3	6.7	4.1	0.038
	Median	4.5	4.0	6.0	3.5	0.022
Youth dependency ratio (Ratio of the children under 15 years old divided by the number of adults in the household)	*Mean*	0.6	0.5	0.9	0.4	0.032
	Median	0.3	0.3	0.7	0.0	0.038
Female head without partner	*Proportion*	12.4	12.9	18.4	12.5	0.802
Male head without partner	*Proportion*	10.6	1.1	0.0	4.2	0.006

Observations: 316

Source: Survey data (December 2016-April 2017).

6.3.2.2 Ethnicity

As biocultural systems, homegardens are highly affected by the ethnic and cultural background of the gardeners. Previous studies in numerous contexts have found significant differences in the diversity, structure and management of the homegardens related to ethnicity, including: Tuz Poot (2001) and Neulinger *et al*. (2013) in Campeche, Mexico; Shrestha *et al.* (2002) in Nepal; Vogl *et al.* (2002) in Chiapas, Mexico; Trinh *et al.* (2003) in Vietnam; Kehlenbeck *et al.* (2007) in Central Sulawesi, Indonesia; Bernholt *et al.* (2009) in Niamey, Niger; and Perrault-Archambault and Coomes (2008) in the Peruvian Amazon. Differences in wealth, education, access to markets, knowledge on local natural resources, management knowledge, ritual practices and livelihood preferences are all factors that explain this relationship between homegarden characteristics and ethnicity.

In the literature on homegardens of Mexico, the use of the terms 'Mayan homegardens' or 'traditional Mayan homegarden' is recurrent when studying the homegardens of the Yucatán Peninsula (Rico-Gray *et al.*, 1990; Caballero, 1992; De Clerck and Negreros-Castillo, 2000; Jiménez-Osornio *et al.*, 2003; Arias Reyes, 2012; Mariaca Méndez, 2012). As described in Chapter 4, Mayan people represent over half of the Yucatecan population. Indigenous ethnicity is recognised in the Mexican official records through the speaking of an indigenous language (Instituto Nacional de Estadística y Geografía, 2010). This research followed this approach, considering the ease of collecting this type of information. Nonetheless, I recognise that the spoken language may reflect more of a cultural than an ethnic ascription (Baños Ramírez, 2001; Gabbert, 2004).

As Table 6.5 shows, significant differences were found between homegarden categories in the percentage of households where the household head only speaks Spanish. The households with ornamental homegardens, the least diverse, showed the largest percentages (31.58%); while the savings repository (0%) and the multifunctional (2.15%), the most diverse homegardens, showed the lowest percentages (p-value<0.01). Moreover, as shown in the regression model presented at the end of the section (Table 6.16), a household headed by a person who only speaks Maya observed a negative probability (-9.7%) of owning an ornamental homegarden, in comparison with a head who speaks Maya and Spanish. Likewise, a head who only speaks Spanish increased the probability of having an ornamental homegarden by 25.2% and decreased the probability of having a savings repository homegarden by -8.5%.

Table 6.5 Household ethnicity by type of homegarden

Household characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental homegarden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Household head speaks Maya	*Proportion*	5.0	10.8	7.9	8.3	0.392
Household head speaks Spanish and Maya	*Proportion*	81.1	86.0	71.1	87.5	0.200
Household head speaks Spanish	*Proportion*	9.3	2.2	31.6	0.0	<0.001

Observations: 316

Source: Survey data (December 2016-April 2017).

The language spoken by the household head is likely to reflect cultural differences. Households where Mayan is still spoken are more likely to preserve traditional knowledge on homegardening and prefer on-farm livelihoods which are strongly linked to the Mayan cosmovision (Mariaca Méndez, 2012; López Barreto, 2017). Besides these cultural differences, other household characteristics are likely to interact with language in shaping homegardening patterns, such as wealth, occupation of the household members and rural-urban interactions. As Table 6.6 reports, as a result of historical discrimination, 'Mayan' households tend to be poorer, with less formal education and engaged in traditional on-farm livelihoods rather than in urban jobs. As these findings show, and following the framework presented in Chapter 3, the attachment to the Mayan culture is a powerful conversion factor that not only shapes homegardening preferences, but given the prevailing formal and informal institutions, also constrains access to different resources and livelihood strategies

Table 6.6 Selected household characteristics by the language spoken by the household head

Household characteristics		Language spoken by the household head			
	Statistic	**Only Maya**	**Spanish and Maya**	**Only Spanish**	**Anova / Kruskal-Wallis H / Chi-squared (*p* value)**
Wealth index (0-1, 5 assets)	*Mean*	0.27	0.35	0.43	0.164
	Median	0.22	0.37	0.37	0.073
Average years of education	*Mean*	3.36	6.40	8.28	<0.001
	Median	2.50	6.40	8.67	<0.001
Household with adults working in agriculture	*Proportion*	69.23	39.34	10.34	0.001
Urban jobs (% of household members working in urban jobs)	*Mean*	0.14	0.24	0.35	0.028
	Median	0.00	0.25	0.33	0.057

Number of observations: 314.

Source: Survey data (December 2016-April 2017).

6.3.2.3 Rural-urban interactions

The intensity and quality of rural-urban interactions shape the structure and functions of the homegardens in different ways. For example, migration of household members can lead to the introduction of new species and techniques as well as to the loss of biodiversity and traditional knowledge (De Haan, 1999; Guerrero Peñuelas, 2007; Cano-Ramírez *et al.*, 2012; Lope-Alzina and Howard, 2012). Furthermore, Guerra Mukul (2005) observed in Yaxcabá, Mexico, that the engagement of the household head in urban paid jobs caused a reduction in *milpa* production; the loss of knowledge transmission between fathers and children; and the deterioration of the homegarden facilities, such as fences, pigsties and poultry pens. The author argued that all these factors interact, reinforcing one another while undermining the food self-sufficiency of the household.

As Table 6.7 shows, the main differences in the engagement of the household members in job-related movements to urban areas were observed between ornamental and savings repository homegardens. These differences can be explained by the dissimilarities in household characteristics. The owners of ornamental gardens, mainly young couples with small children, and those with household heads who speak Spanish, are more likely to commute to the cities for work. In contrast, the owners of savings repository homegardens, typically elderly people who only speak Mayan and who grew up with limited access to formal education, are more likely to stay in their communities and work in traditional livelihoods.

Households involved in extensive farming and in off-farm occupations within the community were more likely to own multifunctional and savings repository gardens than

kitchen or ornamental gardens. This is explained by the higher availability of time, homegarden expertise and inputs that these activities provide in comparison with urban jobs, as Guerra Mukul (2005) also found in Yaxcabá, Mexico. Wiersum (2006) arrived at similar conclusions on the relationship between ornamental plants and off-farm jobs from a review of studies on Indonesian homegardens. He found that when alternative income opportunities emerged, households tended to increase the production of ornamental plants in their homegardens.

Table 6.7 Household rural-urban interactions by type of homegarden

Household characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental homegarden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Household with adults working in agriculture	*Proportion*	26.9	57.0	13.2	50.0	<0.001
Off-farm diversification within the community (1,0)	*Proportion*	10.0	19.4	10.5	20.8	0.125
Urban jobs (% of household members working in urban jobs)	*Mean*	0.3	0.2	0.3	0.2	0.090
	Median	0.3	0.0	0.3	0.0	0.072

Number of observations: 314.
Source: Survey data (December 2016-April 2017).

From the multinomial regression model presented at the end of the section (Table 6.16), it was found that, once controlling for other household characteristics, households with adults participating in extensive farming activities were more likely to own a multifunctional homegarden (25%) and less likely to own a kitchen garden (-28.2%). Furthermore, having household members working in urban jobs increased the probability of having a kitchen garden (20.6%); whereas off-farm diversification within the community decreased the probability of having a kitchen garden (-25%) and increased the probability of having either a multifunctional (16.8%) or an ornamental garden (10.4%). These findings imply that participation in either rural or urban livelihoods was more relevant in defining whether a household had a kitchen or a multifunctional homegarden; whereas the differences in rural/urban livelihoods between ornamental and savings repository gardens were the result of other household characteristics.

6.3.2.4 Wealth

In the literature on homegardens, better-off households have been found to own larger and more diverse homegardens, particularly high-valued cash crops, fruit trees and ornamental plants (Soemarwoto, 1987; Wiersum, 2006; Kehlenbeck *et al.*, 2007; Perrault-Archambault and Coomes, 2008; Poot-Pool *et al.*, 2012). Meanwhile, poorer households have been found

to use the space more intensively, not only for food species, but also for other uses such as fodder, timber and medicinal plants (Soemarwoto, 1987; Poot-Pool *et al.*, 2012).

In this research, the better-off households owned ornamental homegardens, the least diverse among the four categories. These households reported the highest mean and median values of the wealth index (p-value<0.05), as presented in Table 6.8. It was observed that better-off households tended to depend more on urban livelihoods. As mentioned earlier, these results are likely explained by the time constraint that urban jobs impose on homegardening. Moreover, the incomes from urban jobs allow these households to depend less on agricultural livelihoods. In addition, since they have higher exposure to urban areas, they are likely imitating the ornamental gardens observed in the cities, where flowers are predominant. Households with kitchen gardens were also highly engaged in urban jobs, but showed lower mean income than the households owning ornamental gardens, and the lowest wealth index values among the four categories of homegardens. It is therefore likely the case that not all the households are benefiting in the same way from urban jobs. For households owning an ornamental homegarden, urban jobs were an accumulation strategy; whereas for those owning kitchen gardens, urban jobs were more likely to represent only a survival strategy.

Table 6.8 Household wealth by type of homegarden

Household characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental homegarden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Household income, mean, adult scale equivalent MXN (GBP/USD)	*Mean*	1511.3 (61.6 / 80.5)	1430.4 (58.3 / 76.2)	1771.8 (72.3 / 94.4)	1370.7 (55.9 / 73.0)	0.466
	Median	1379.6 (56.3 / 73.5)	1232.3 (50.3 / 65.6)	1501.5 (61.2 / 80.0)	1186.6 (48.4 / 63.2)	0.447
Wealth index (0-1, 5 assets)	*Mean*	0.3	0.3	0.4	0.4	0.026
	Median	0.2	0.4	0.4	0.4	0.035

Number of observations: 314.

Source: Survey data (December 2016-April 2017).

From the regression model presented in Table 6.16, a rise in 30% over the mean value of the wealth index increased the probability of owning an ornamental garden by 0.8% and a savings repository garden by 0.7%; while decreased the probability of having a kitchen garden by -1.7%. The positive relation between the wealth index and having a savings repository homegarden is explained by the investment required to purchase food animals, the main component of these gardens. The relationship between off-farm jobs, wealth and investment in homegarden animals was also discussed in Chapter 5 (Box 5.2).

6.3.2.5 Development interventions

Development interventions impact homegardening, both through direct initiatives promoting specific species and management practices, and indirectly, through cash-transfers and programmes promoting other farm and off-farm livelihoods. Homegardens have been promoted worldwide by international aid agencies, governments, academics and non-government organisations (NGOs) as a way to enhance food security and nutrition (Soemarwoto, 1987; Berti *et al.*, 2004; Montagnini, 2006; Cano Contreras and Moreno Uribe, 2012; Masset *et al.*, 2012; Boone and Taylor, 2016; López Barreto, 2017; Kumar *et al.*, 2018). However, most of these projects only target a few homegarden functions, usually nutrition and income generation, failing to understand the homegarden as complex biocultural system (Soemarwoto, 1987; Soemarwoto and Conway, 1992; Cano Contreras and Moreno Uribe, 2012; López Barreto, 2017). Soemarwoto (1987) explains at this respect:

> Paying attention solely to the tangible economic and nutritional gains of homegardens, and agroforestry in general, runs the risk of sacrificing the intangible ecological and social values. For example, when market demand and price offered for a certain plant product becomes high, the cultivation of that species will spread, often replacing those species and varieties which are of little or no immediate economic value. This causes a reduction in the complexity of the homegarden and degeneration of its forest-like structure. In such processes of commercialisation, the highly nutritious, yet commercially less valuable local vegetables are usually the first ones to go. It is not easy to achieve homegarden development with both nutritional and economic advantages (Soemarwoto, 1987, p. 166).

In the Mexican context, López Barreto (2017) found that the PST, discussed in section 6.1, was undermining traditional knowledge and creating dependence on external inputs. Furthermore, in the Brazilian context, it has been found that cash-transfers can discourage homegarden production, freeing income flows to purchase food from the local markets (Alves *et al*., 2011 in Vieira *et al.,* 2017).

As it was discussed in section 6.1, the main government transfers received in the field sites were *Prospera*, *Proagro* and the pension scheme 'Sixty-five and over' (65+). The main programme specifically addressing homegardens production was the Backyard Social Production Programme (PST, by its Spanish acronym), which only operates in two of the four field sites, Yaxcabá (semi-rural, *milpa* region) and Kancabdzonot (rural, *milpa* region). The largest differences observed in the percentage of households receiving government support were between the multifunctional and the ornamental gardens (p-value<0.01). The households with multifunctional homegardens showed the largest proportion of beneficiaries of the three cash-transfer programmes, as Table 6.9 shows. The second largest values were reported by the savings repository gardens.

Table 6.9 Social programmes beneficiaries by type of homegarden

Household characteristics	Statistic	Kitchen garden	Multifunctional homegarden	Ornamental homegarden	Savings repository garden	Anova / Kruskal-Wallis H / Chi-squared (*p* value)
Prospera beneficiary	*Proportion*	40.0	69.9	26.3	50.0	<0.001
Proagro beneficiary	*Proportion*	14.4	30.1	2.6	16.7	0.001
Sixty five and over beneficiary	*Proportion*	8.1	21.5	2.6	8.3	0.003
Backyard social production beneficiary	*Proportion*	1.9	8.6	0.0	0.0	0.014

Number of observations: 314.
Source: Survey data (December 2016-April 2017).

From the regression model (Table 6.16), households receiving *Prospera* (-6.2%) or *Proagro* (-7.4%) were less likely to have an ornamental garden. On the other hand, households receiving the programme 65+ were more likely to have a multifunctional homegarden (26.9%) and less likely to have a kitchen garden (-17.8%) or a savings repository garden (-3.9%). In the case of the PST, it was only received by households with kitchen and multifunctional homegardens, the multifunctional reporting the largest percentage (p-value<0.05).

Households owning multifunctional homegardens, the most diverse, were disproportionally represented among the beneficiaries of government programmes. However, from this analysis it was not clear how the relationship between receiving government subsidies and homegarden diversity operated[36]. Was it only the case that poorer households - which happened to have more diverse homegardens - were more likely to receive government subsidies? Or were government subsidies playing a role in homegardening? If the second was true, it was likely the case that households receiving *Prospera* had less incentives to look for an urban job, since the cash-transfer compensates the additional income (after deducting transportation and other expenses incurred because of commuting). In addition, people receiving the pension 65+ might be constrained by their age, language and education from commuting to the city for a livelihood. Thus, receiving the pension was likely alleviating their cash needs to invest in the homegarden.

In order to test these hypotheses, a propensity-score matching approach was followed to control for household characteristics that affected the probability of participation in the programmes and were also correlated with homegarden diversity (selection bias), as explained in Chapter 4. The effects on both, animal and plant diversity were tested.

[36] Receiving government subsidies was found to be correlated with the occupation of the household and thus, increased the standard errors computed from the regression model.

Robustness of the matching method was tested and sensitivity analysis on unobserved variables was also performed (Appendix G). The analysis only included the programmes *Prospera*, *Proagro*, *65 and over* and *PST*, since these were the main interventions captured from the household survey. The relationship between *PPT* and homegarden diversity was not analysed because the households surveyed received the chickens at the end of the data collection (only sisal region) and as it was explained in the previous section, all the households received the chickens. This means that a counterfactual group could not be identified.

Being a beneficiary of *Prospera*, *65 and over* or *Proagro* was found to have positive and significant effects on homegarden diversity, after controlling for selection bias. Being a beneficiary of *Prospera* was found to have positive and significant effects on the abundance of food animals. As shown in Table 6.10, the households receiving *Prospera* reported three more food animals on average than those not receiving the programme, and the effect was statistically significant at p-value<0.05.

Table 6.10 Effect of Prospera on the number of homegarden food animals

Sample	Treated	Controls	Difference	Standard errors	T-stat
Unmatched	9.497	5.135	4.362	1.136	3.84 ***
Average Treatment Effect on the Treated (ATT)	9.497	6.363	3.134	1.513	2.07 **

Observations on common support: 314

Control variables: age of the household head, female (single) headed household, youth dependency ratio, language spoken by the household head, wealth index, proportion of household members working in urban jobs, community.

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

In the case of the programme *65 and over*, significant and positive effects were found on both, animal abundance and animal diversity. As Table 6.11 shows, households where the elderly members received *65 and over* reported seven more animals on average than those not receiving the pension programme, a substantial number for a smallholding, and the effect was statistically significant at p-value<0.01. Table 6.12 shows the positive effect of receiving *65 and over* on animal diversity. The total average effect was equal to 97.2% of the mean value of the Shannon diversity index and with a significance level at p-value<0.01.

Table 6.11 Effect of Sixty-five and over on the number of homegarden food animals

Sample	Treated	Controls	Difference	Standard errors	T-stat
Unmatched	13.028	6.482	6.546	1.785	3.67 ***
Average Treatment Effect on the Treated (ATT)	13.028	6.066	6.962	2.691	2.59 ***

Observations on common support: 314

Control variables: age of the household head, female (single) headed household, male (single) headed household, wealth index, proportion of household members working in urban jobs, community.

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

Table 6.12 Effect of Sixty-five and over on the diversity of homegarden food animals

Sample	Treated	Controls	Difference	Standard errors	T-stat
Unmatched	0.475	0.249	0.226	0.067	3.38 ***
Average Treatment Effect on the Treated (ATT)	0.475	0.210	0.264	0.086	3.06 **

Observations on common support: 314

Control variables: age of the household head, female (single) headed household, male (single) headed household, wealth index, proportion of household members working in urban jobs, community.

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

Finally, as shown in Table 6.13, receiving *Proagro* was found to increase homegarden plant diversity in 29.6% of the mean value of the Shannon diversity index. This effect was significant at p-value <0.05.

Table 6.13 Effect of Proagro on the diversity of homegarden plants

Sample	Treated	Controls	Difference	Standard errors	T-stat
Unmatched	2.241	1.706	0.535	0.091	5.88 ***
Average Treatment Effect on the Treated (ATT)	2.241	1.711	0.529	0.113	4.69 **

Observations on common support: 314

Control variables: age of the household head, average education, peasant household member, proportion of household members working in urban jobs.

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

These findings support the hypothesis on the positive effect of cash-transfers on homegarden diversity. However, the analysis performed also indicated that this effect may not be sufficient to retain people in the community, but it is providing additional income to households to invest in their homegardens, especially since the main impacts observed were in the number and diversity of animals. Propensity score matching was applied to verify this. The effect of receiving *Prospera* on the proportion of household members working outside the community was assessed, but no significant differences were found, as reported in Table 6.14. In the case of *Proagro*, it is likely working as an incentive to keep cultivating the *milpa* and thus the homegarden, as a component of the *milpa* system.

Table 6.14 Effect of Prospera on working in urban jobs

Sample	Treated	Controls	Difference	Standard errors	T-stat
Unmatched	0.200	0.270	-0.069	0.029	-2.42 **
Average Treatment Effect on the Treated (ATT)	0.200	0.205	-0.005	0.042	-0.11

Observations on common support: 314

Control variables: age of the household head, female (single) headed household, male (single) headed household, youth dependency ratio, wealth index, community.

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

The effects of PST on the diversity of vegetables and herbs were also analysed. However, given the small number of treatment observations in the sample (11) and the discretional targeting of the programme, the probability model of the treatment assignment reported no significant values in goodness-of-fit measures. Table 6.15 shows how PST beneficiaries reported a higher diversity of vegetables and herbs (the focus of the programme), but these households also reported higher tree and animal diversity. Thus, it was not clear if the higher diversity was due to the programme or to specific household characteristics.

Table 6.15 Homegarden diversity by PST beneficiary status

Diversity indicators	Statistic	Beneficiary	Non-beneficiary	T-test / Wilcoxon rank-sum *p-values*
Shannon diversity index (trees)	*Mean*	1.825	1.509	0.074
	Median	2.053	1.627	0.016
Shannon diversity index (vegetables and herbs)	*Mean*	1.699	0.653	<0.001
	Median	1.736	0.636	<0.001
Shannon diversity index (animals)	*Mean*	0.634	0.344	0.020
	Median	0.802	0	0.014

Observations: 137.

Source: Survey data (December 2016-April 2017).

Table 6.16 presents the results from the multinomial logistic model assessing the determinants of homegardening patterns, discussed in detail in the previous sub-sections.

Table 6.16 Determinants of homegardening patterns

Independent variables / Dependent variable (4 outcomes)	Kitchen gardens *(base outcome)*		Multifunctional homegardens				Ornamental gardens				Savings repository gardens			
	Marginal effect	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Solar size (thousand m^2)	0.001	0.014	0.262 **	0.126	0.058 **	0.027	-0.272 *	0.146	-0.026 *	0.015	-0.425 **	0.216	-0.033 **	0.013
Average age	0.003	0.005	-0.027	0.025	-0.005 **	0.002	-0.014	0.033	-0.001	0.002	0.027	0.024	0.003 **	0.001
Average education (years)	0.009	0.009	-0.039	0.072	-0.005	0.010	-0.105 **	0.046	-0.008 **	0.004	0.036	0.034	0.004	0.003
Youth dependency ratio	-0.047	0.031	0.362 ***	0.106	0.057 **	0.026	0.267 ***	0.063	0.016 ***	0.004	-0.235	0.703	-0.026	0.046
Language spoken by the household head (Base category: Spanish and Maya)														
Maya	-0.145	0.126	1.125	0.717	0.220	0.148	-13.954 ***	1.174	-0.097 ***	0.013	0.641	1.409	0.023	0.131
Spanish	-0.015	0.049	-0.887	0.998	-0.152	0.120	1.522 ***	0.294	0.252 ***	0.090	-15.427 ***	0.703	-0.085 ***	0.005
Female head (alone)	-0.130	0.117	0.794	0.742	0.111	0.101	0.508	0.528	0.021	0.029	0.338	0.274	-0.001	0.012
Male head (alone)	0.378 ***	0.073	-2.422 *	1.321	-0.234 ***	0.054	-15.391 ***	0.835	-0.126 ***	0.018	-0.932	1.093	-0.017	0.059
Wealth (index)	-0.161 *	0.089	0.428	0.527	0.012	0.076	1.043 **	0.416	0.069 **	0.029	1.424 ***	0.403	0.079 ***	0.024
Farming household	-0.282 ***	0.079	1.802 ***	0.509	0.250 ***	0.068	0.771 **	0.376	0.018	0.020	0.879 ***	0.316	0.014	0.019
Rural-urban interactions														
Urban jobs	0.206 *	0.122	-0.913	0.823	-0.096	0.146	-1.093	0.956	-0.065	0.089	-1.082	1.487	-0.045	0.096
Off-farm diversification	-0.250 **	0.098	1.323 **	0.586	0.168 *	0.089	1.586 ***	0.597	0.104 **	0.048	0.295	0.873	-0.021	0.041
Subsidies														
Sixty five and over	-0.178 *	0.104	1.434 ***	0.456	0.269 ***	0.072	-0.195	1.389	-0.052	0.074	-0.117	0.713	-0.039 *	0.023
Prospera	-0.043	0.068	0.524	0.446	0.093	0.073	-0.559 **	0.225	-0.062 ***	0.010	0.278	0.484	0.012	0.032
Proagro	0.070	0.081	-0.009	0.555	0.032	0.084	-1.164 *	0.680	-0.074 **	0.034	-0.551	0.578	-0.028	0.030
Constant			-1.649	1.219			-1.525	1.509			-3.849 **	1.574		

*** p-value<0.01, ** p-value<0.05 and * p-value<0.1.

Number of observations: 291. Pseudo R^2 =0.1871.

Source: Survey data (December 2016-April 2017).

6.4 Conclusions

The aim of this chapter was to contribute to the understanding of how community and household characteristics interact in determining different patterns of homegardening. The chapter addressed the research question: ***How and why do homegardening patterns vary across the peri-urban – rural spectrum?*** Significant differences in homegardening patterns were found across the peri-urban – rural spectrum. The level of urbanisation of a community was found to diminish the diversity of the homegarden and the benefits people derive from this, confirming the third research hypothesis: ***Homegarden diversity shows and increasing peri-urban – rural gradient.*** Homegardens located in more urban communities tended to be less diverse. These homegardens reported mainly ornamental plants; fruit trees; and small food animals, such as chickens. In contrast, homegardens located in the most rural communities tended to be more diverse and provide more entitlements. These homegardens reported greater abundance of vegetables and other plants for uses different to food. They also reported larger food animals, such as pigs. Sales and sharing of homegarden products were also more common in the most rural communities. As suggested in this chapter, differences in homegardening patterns reflect a heterogeneous access to off-farm livelihoods and markets across the peri-urban – rural spectrum and between households.

The mixed methods approach I followed, allowed the development of a typology of homegardens that also reflected differences in household characteristics. Four main categories of homegardens were identified: (i) kitchen gardens; (ii) multifunctional homegardens; (iii) ornamental gardens; and (iv) savings repository homegardens. Kitchen gardens prioritise the material provision function, showing high diversity of plants used as food. Multifunctional homegardens perform 'multiple' functions, material provisioning and various ecological, economic, social and cultural services, showing the greatest diversity of plants and animals. Ornamental gardens prioritise the aesthetic function of the garden, showing the greatest proportion of ornamental plants among the four categories. Finally, the savings repository homegardens prioritise the material provisioning and the economic functions, showing high diversity of animals used for food purposes that contribute both to food consumption and to smooth market and health-related shocks. Multifunctional and savings repository homegardens, the most diverse categories, were more abundant in the most rural communities; whereas kitchen and ornamental gardens, the least diverse, were more common in the most urban communities.

The analysis at the household level shed light on how household characteristics interact with rural urbanisation in explaining differentiated homegardening patterns, confirming the fourth research hypothesis: ***Household characteristics interact with the location of the household in defining homegardening patterns.*** This is one of the main contributions of this research, since studies analysing the differences in the homegardens depending on their level of urbanisation generally fail to explain the reasons for these differences, besides market proximity.

Some of the most significant household characteristics influencing differentiated homegardening patterns were: family life cycle, rural-urban interactions, ethnicity, wealth and government support. Following the ELF and the related theory of change presented in chapter 3, it was discussed that the selection of livelihood strategies is mediated by conversion factors, such as age, gender and ethnicity; and by formal and informal institutions. The least diverse homegardens were owned by young families with young children, Spanish speakers, engaged in urban jobs and less likely to receive government support. These households were more frequent in the peri-urban and semi-rural communities. In contrast, the most diverse homegardens were owned by either elderly people with small households, or young/middle-age couples. The common characteristics of these households were: having Mayan speaking household heads, participating in extensive agriculture (*milpa*) and being beneficiaries of government support. These types of households were more frequent in the rural and the semi-rural communities, particularly in the *milpa* region. The differences between the sisal and the *milpa* region were already discussed in chapter 5.

Differences in homegardening patterns were not only observed between the communities, but also within communities. For example, in the peri-urban community, it is possible to find both an ornamental homegarden owned by a young couple where the head is working in an urban job, and a multifunctional homegarden owned by people engaged in traditional livelihoods.

Government cash-transfers were found to have a positive relationship with the diversity of the homegarden, likely freeing resources to invest in it. In the case of the Proagro programme, which provides an annual stipend conditional to the cultivation of the *milpa*, it was found to work as an incentive to also maintain the homegarden, which is part of the

broader traditional agricultural system. The location of the household was found to not only determine the access to infrastructure and markets, but also the access to government agricultural support programmes.

Government programmes addressing homegardens have adopted a narrow and uncontextualised approach, which constrain the scope of their efforts and limit their impact. Policy design has followed a top-down, bureaucratic approach that does not incorporate traditional agricultural knowledge and practices, which are already being lost among the younger generations. The PST and the PPT programmes analysed in this chapter focus on specific components of the homegarden, without recognising or taking advantage of the interrelationship between the different components and, in some cases, even undermine them. These programmes could enhance their results by increase the collaboration between the two ministries that manage them to improve policy alignment and technical support. The PPT, in particular, could improve its impact with a more careful and targeted delivery of poultry, and by including other small livestock into its design, which local people would value. Unfortunately, since social programmes tend to be used as patronage systems to gain votes during electoral cycles, rather than as a means of strengthening local capacities and knowledge and increasing synergies among stakeholders to enhance the homegardens. A disempowering effect of these state-driven initiatives was perceived in the field sites, as they are creating dependence on external resources and actors, instead of helping people become their own drivers of development.

This chapter examined how household characteristics interact with rural urbanisation in determining different homegardening patterns. It was shown that although people derive several entitlements from homegardening, one of the most valued is food provision. Moreover, it was discussed how households participating in 'traditional' on-farm livelihoods were more likely to have high diverse homegardens; while the more 'urbanised' households were more likely to have low diverse homegardens. The next chapter analyses how homegarden diversity interacts with other livelihood strategies, household wealth and rural-urban location in determining the contribution of homegardening to food security. The trade-offs and complementarities in these interactions are also examined.

Chapter 7. Homegardens and food security across the peri-urban – rural spectrum

Introduction

Chapter 6 discussed how homegardening patterns varied between and within field sites across the peri-urban –rural spectrum. This chapter goes a step further, aiming to uncover how the differences in homegarden diversity influence the contribution of homegardens to food security. Thus, the chapter answers the third research sub-question: ***How does homegardening contributes to food security across the peri-urban – rural spectrum in Yucatán, Mexico****?*

As examined in chapter 6, homegardens contribute to different dimensions of livelihood security. Out of these dimensions, this chapter centres the analysis on food security at the household level. The chapter is divided into six sections. The first section explains how food security fits into the understandings of wellbeing in the research sites and defines how food security is understood. Section two assesses food security in the research sites. Section three examines the contribution of homegarden diversity to food security. Wealth and urban jobs were found to mediate the relationship between homegarden diversity and household food security. Sections four and five discuss how these variables interact with homegarden diversity and influence food security outcomes. Section four examines whether homegarden diversity plays a significant role in moving households with similar socioeconomic status out of food insecurity; while section five describes who participates in urban jobs and analyses whether the income contribution of urban jobs compensates the loss of food from the homegarden. The chapter concludes by summarising the findings and discussing their implications.

7.1 Wellbeing meanings and food security

Information on the perceived local meanings of wellbeing was collected both from focus group discussions and from the household survey. This information was used to identify how people prioritised different dimensions of livelihood security and how these were related to homegardening. As it was discussed in chapter 6, provision of food was the most valuable contribution of the homegardens to livelihood security. Moreover, food access, food quality and food self-sufficiency were among the 10 most frequently mentioned definitions of wellbeing by the research participants, as presented in Table 7.1. These results show how relevant was food security as a dimension of wellbeing in the research

sites. Wellbeing meanings were similar across the four field sites; however, Sahcabá (semi-rural, sisal region) showed larger percentages in 'access to food' and 'having money' and the differences were statistically significant (Chi-squared, *p-value*<0.05). Differences in how people defined a 'good life' in this community can be explained by the larger proportion of households facing food insecurity and engaged in urban jobs in comparison with the other three communities, as it is discussed in the next sections. The following quotes illustrate the most frequent responses on how the research participants defined a 'good life':

> 'To have a job in Hocabá'; 'a fair payment for your work'; 'to have a good wage' (Research participants from Hocabá, household survey, December, 2016).
> 'Not to get sick, so that one can work' (Research participants from Sahcabá, FDG, 29/09/2016).
> 'To consume something harvested in your own house and fresh off the tree'; 'a good harvest'; 'to have animals'; 'a good life is to work, to harvest and consume what we grow' (Research participants from Yaxcabá, FDG, 13/10/2016).
> 'Harvest to eat' (Research participant from Kancabdzonot, household survey, 11/03/2017, 2017).

Table 7.1 Wellbeing meanings by field site

Wellbeing meanings	Hocabá (Peri-urban, sisal region)	Sahcabá (Semi-rural, sisal region)	Yaxcabá (Semi-rural, *milpa* region)	Kancabdzonot (Rural, *milpa* region)
Being healthy	44.9%	54.9%	52.9%	62.3%
Having a job	38.8%	47.6%	43.5%	37.7%
Access to food	27.6%	58.5%	27.1%	17.0%
Good social life	20.4%	8.5%	11.8%	15.1%
Having a house	13.3%	12.2%	9.4%	15.1%
Having no worries	11.2%	6.1%	8.2%	7.5%
Having money	10.2%	19.5%	3.5%	5.7%
Food quality	7.1%	1.2%	3.5%	1.9%
Food self-sufficiency	4.1%	0.0%	7.1%	3.8%
Being educated (school)	4.1%	6.1%	1.2%	3.8%
Public services (e.g. tap water, electricity, health services)	4.1%	2.4%	1.2%	0.0%
Fair/good salary	3.1%	1.2%	3.5%	0.0%
Having a job in the community	1.0%	0.0%	0.0%	0.0%
Transportation	1.0%	3.7%	0.0%	0.0%
Subsidies	0.0%	1.2%	0.0%	1.9%
God's blessing	0.0%	0.0%	1.2%	0.0%
Being free to go out	0.0%	0.0%	1.2%	0.0%
Having wood for handicrafts	0.0%	0.0%	0.0%	1.9%

Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53. The percentages sum more than 100% since more than one answer was given by some of the households.
Source: Survey data (December 2016-April 2017).

In this research I have adopted the 1996 World Food Summit definition of food security: "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2008, p. 1). This definition implies four dimensions of food security: (i) physical *availability*, which is determined by the level of food production, stock

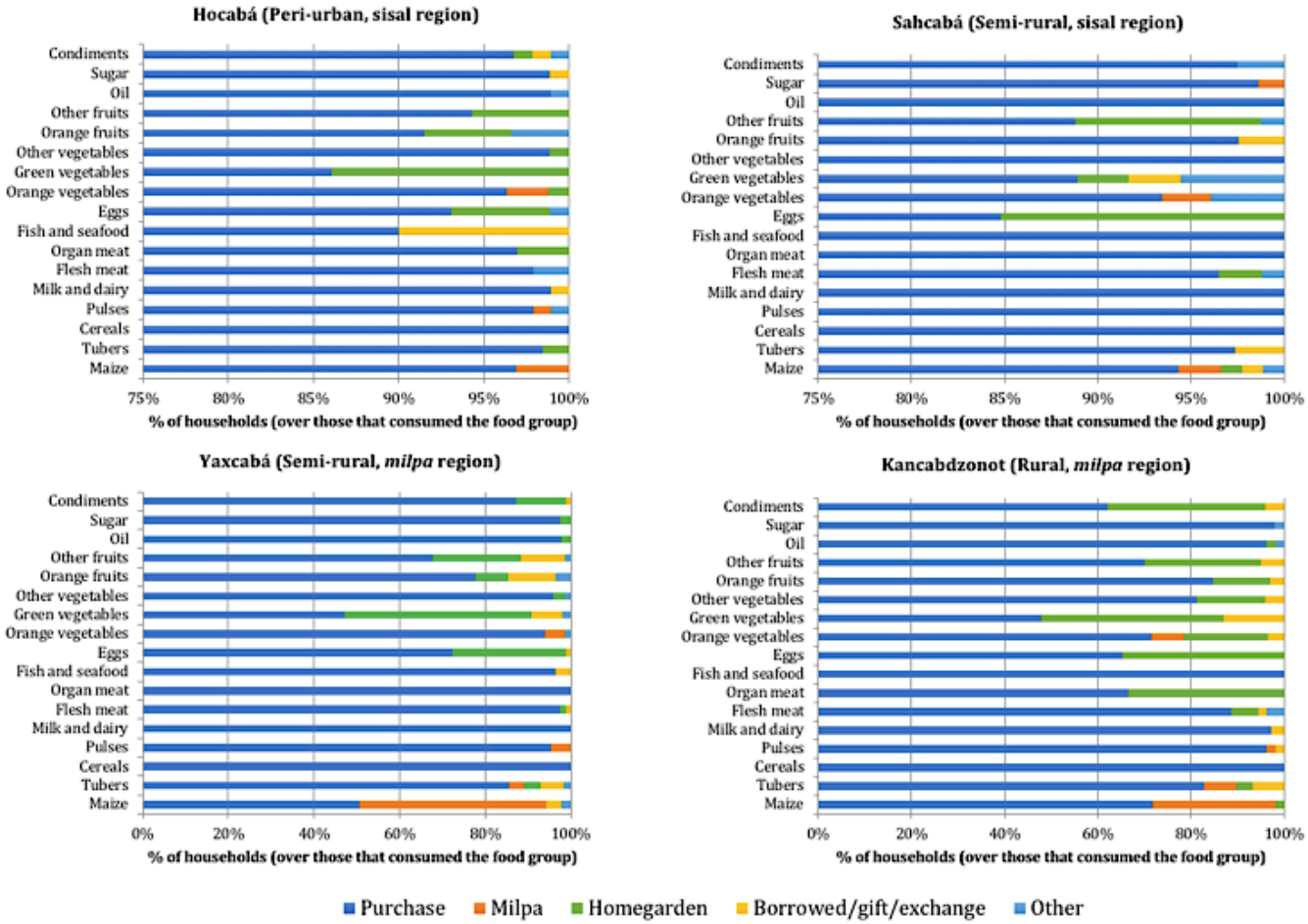
levels and net trade; (ii) economic and physical *access* to food at the household level; (iii) food *utilisation*, understood as "the way the body makes the most of various nutrients"; and (iv) *stability* of the other three dimensions over time (FAO, 2008, p. 1). Given the focus of this research on household dynamics and the constrained time frame, the analysis focused mainly on two of the four dimensions of food security: food access and food utilisation.

7.2 Food security in the research sites

This section describes the main sources of food in the research sites, discussing differences and similarities between communities. Food security patterns are also examined through the analysis of food and micronutrient consumption.

7.2.1 Where does the food come from?

The main source of food in the field sites was the market, although the homegarden, the *milpa,* other plots, gifts and hunting were also mentioned as primary and secondary sources of food. The commodisation of food in the Yucatán Peninsula has been documented elsewhere (Leatherman and Goodman, 2005a; Pérez Izquierdo *et al.*, 2012). The dependence on the homegarden as a source of food showed an increasing peri-urban – rural gradient. In the more urban communities of the sisal region, less than 30% of the households surveyed obtained at least one food group from the homegarden; while in the communities of the *milpa* region, the proportion of households was above 70%. The differences were statistically significant at p-value<0.01. Figure 7.1 presents the primary sources of the different food groups by field site. The main food groups obtained from the homegarden (in green) were: green vegetables, eggs, fruit, condiments and meat, which are source of important nutrients, as it is examined in section 7.3.2. The figure also shows the relevance of the exchange of food (in yellow) and the role of the *milpa* (in orange) in providing maize in the communities of the *milpa* region.



Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017).

Figure 7.1 Primary sources of food groups by field site, 2016-2017

Small shops selling fruit and vegetables showed differentiated characteristics between the sisal and the *milpa* region, particularly in the ownership of the shops and the source of the products. In the sisal region, most of the fruit and vegetables available from the petty shops come from the main wholesale market located in Mérida, the capital city (*central de abastos*). In Hocabá (peri-urban, sisal region) people from Mérida owned the main fruit and vegetables shop. The owners visit their shop weekly and they hired local people to look after their business (Personal communication). In Sahcabá (semi-rural, sisal region), the main seller was a petty trader from a neighbouring community. He visits Sahcabá three times a week (Personal communication). Figures 7.2 and 7.3 present pictures of the main shops of fruits and vegetables identified in the research sites of the sisal region.

Figure 7.2 Fruit and vegetables shop in Hocabá (peri-urban, sisal region)

Figure 7.3 Fruit and vegetables petty trader in Sahcabá (semi-rural, sisal region)

While in the communities of the sisal region there was only one 'specialised' trader of fruit and vegetables, in the *milpa* region there were several and they were all owned by people living in the community. Some of the vegetables and fruits sold in the *milpa* region come from Mérida, however, petty traders also buy from other sources, such as: the wholesale market located in Oxkutzcab[37], middlemen who visit the communities every week, local small-scale producers, and from their own production. It is likely the case that the proximity to markets and the greater mobility of people in the sisal region inhibit the production and trade of fruits and vegetables within the communities. Figures 7.4 and 7.5 present pictures of the main shops of fruit and vegetables identified in the research sites of the *milpa* region.

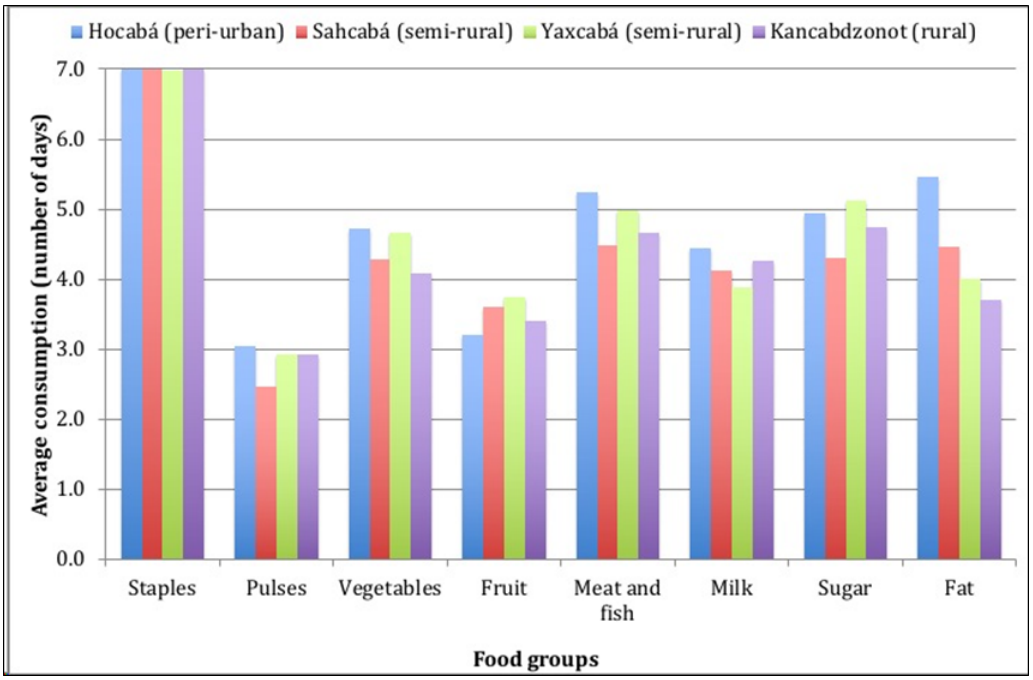
Figure 7.4 Fruit and vegetables shops in Yaxcabá (semi-rural, *milpa* region)

[37] Oxkutzcab is a medium size community located in Southern Yucatán. It is known because of its citrus production, but it is also a distribution centre of fruits and vegetables.

Figure 7.5 Fruit and vegetables shops in Kancabdzonot (rural, *milpa* region)

7.2.2 Food access

The consumption of food groups was similar between the four communities, with staples (maize) as the most frequently consumed food, eaten every day, and pulses the lowest frequently consumed food group, eaten three days a week on average. Figure 7.6 depicts the consumption frequency of the main food groups by study community.



Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017).

Figure 7.6 Consumption frequency of main food groups

The low consumption of pulses was an unexpected finding, since traditionally the Mexican diet has been based on maize, beans and chillies. Beans used to be the second most common food consumed by rural households in Yucatán, as found by Bonfil Batalla (1962) and Stuart

(1993). More recent studies have reported how the consumption of pulses, cereals, fruit and vegetables have decreased in recent years, while the consumption of sugar, fat and meat have increased (Balam Pereira *et al.*, 2004; Leatherman and Goodman, 2005; Pérez Izquierdo *et al.*, 2012). Some reasons for the changes in the diet are the decrease in *milpa* production; broader and more diverse access to purchased food from the markets; higher income flows from off-farm jobs, remittances, and government cash transfers; and changes in people's food preferences (Leatherman and Goodman, 2005a; Pérez Izquierdo *et al.*, 2012). Box 7.1 illustrates these factors from the view of the research participants.

Box 7.1 What happened to the beans?

Young people's preferences
'Small children do not eat like we used to eat in the past, the harvest from the milpa, cowpeas, beans, butter beans. The youth now do not eat it, they mainly eat meat. They do not like it [pulses], they prefer meat.'
(Female research participant from Hocabá, 45 years old, 31/10/2017)

Livelihood changes
'It is difficult to find beans. Before it was easy, because people worked in the milpa'
(Male research participant from Sahcabá, 52 years old, 31/01/2018)

Low soil fertility
- Research participant: *I did not plant beans [because] there are not seeds.*
- Researcher: *Why there are not seeds?*
- Research participant: *I do not know, the forest is low, before it was high forest. That is why I rather buy beans (…) besides you have to do it by yourself [not hiring other people to do it]. You have to be careful that the liquid [herbicide] does not touch the beans.*
(Male research participant from Yaxcabá, 73 years old, 05/12/2018)

Young people's preferences and low soil fertility
'Young people do not eat food from the milpa, they ask for meat. Besides if you do not use fertilisers you do not get many beans.'
(Male research participant from Kancabdzonot, over 70 years old, 14/12/2018)

Food Consumption Scores (FCS) were computed to assess food security status at household level, as explained in chapter 4. The FCS is a composite score that captures dietary diversity, food frequency, and relative nutritional importance of different food groups (World Food Programme, 2008). Cluster analysis was performed to define context specific thresholds that accounted for the high consumption of sugar and fat in the field sites, as suggested in the methodology developed by the World Food Programme. Significant differences were observed among the field sites. Hocabá (peri-urban, sisal region) showed the highest proportion of households with borderline and acceptable food consumption, while Sahcabá (semi-rural, sisal region) showed the lowest proportion of households in these categories (p-value<0.10) (Table 7.2).

Table 7.2 Proportion of households by food consumption score by field site

Food consumption score	Hocabá (Peri-urban, sisal region)	Sahcabá (Semi-rural, sisal region)	Yaxcabá (Semi-rural, *milpa* region)	Kancabdzonot (Rural, *milpa* region)
0-51.5 (Poor)	9.18	24.69	13.1	22.64
52-76 (Borderline)	42.86	38.27	47.62	32.08
>77 (Acceptable)	47.96	37.04	39.29	45.28

Pearson Chi-squared: 12.004, p-value: 0.062

Source: Survey data (December 2016-April 2017).

Although research participants of the sisal region recognised that there have been improvements in the availability and diversity of food products, it was also found that not all the households were equally able to purchase food from the market. Contrasting views were shared by the research participants of Sahcabá, the semi-rural community located in the sisal region, where the highest percentages of food insecure households were found:

> [Life in the community] - it has changed a lot, because nowadays we have a little money to buy things. Before it was not like that, we only ate chives with orange, squash seeds, we ground the seeds. Now we can buy a little meat (Female research participant form Sahcabá, 61 years old, 15/11/2017).

> I cannot work the *milpa* anymore because I am ill. Before, you earned a little, but things were cheap. Now everything is expensive (...) It is hard [to cover their living expenses] because I am old. You have to buy everything (Male research participant from Sahcabá, 67 years old, 16/11/2017).

Leatherman and Goodman (2005) arrived to similar findings in an earlier study of households in the Yucatán Peninsula. These scholars found that a greater variety of foods were available in rural communities, but only those with access to steady employment managed to purchase enough foods year-round. A quote from a resident of one of the communities they studied resembles the views of some of the research participants of the present study: ‘‘there are more foods available now, but no money to buy them’’ (Leatherman and Goodman, 2005, p. 841).

7.2.3 Food utilisation

Food consumption score nutrition quality analysis (FCS-N) was used to assess food utilisation in the households studied. FCS-N focuses on three key micronutrients: protein, vitamin A and iron (hem iron), as it was explained in chapter 4. As Table 7.3 shows, the differences observed in food consumption between communities also held for nutrient consumption. Hocabá (peri-urban, sisal region) reported the most frequent consumption of nutrients, with significant differences in the consumption of protein (p-value<0.05) and hem iron rich foods (p-value<0.01). In contrast, Sahcabá (semi-rural, sisal region) showed the least frequent consumption of these nutrients.

Table 7.3 Food consumption score nutrition quality analysis by field site

Nutrients	Consumption frequency	Hocabá (Peri-urban, sisal region)	Sahcabá (Semi-rural, sisal region)	Yaxcabá (Semi-rural, *milpa* region)	Kancabdzonot (Rural, *milpa* region)	Chi-squared *(p-value)*
	0 days	0	1.23	0	0	
Vitamin A	1-6days	17.35	23.46	23.81	24.53	0.589
	7 days	82.65	75.31	76.19	75.47	
	0 days	0	0	0	0	
Protein	1-6days	5.1	18.52	7.14	11.32	0.020
	7 days	94.9	81.48	92.86	88.68	
	0 days	1.02	1.23	3.57	0	
Hem iron	1-6days	77.55	97.53	89.29	98.11	<0.001
	7 days	21.43	1.23	7.14	1.89	

Observations: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017).

7.3 The contribution of homegardening to food security

There is significant evidence linking homegardening to improvements in food security and micronutrient intakes. Examples of countries and studies where positive impacts have been found include: Bangladesh, where a project promoting low-cost vegetable gardens combined with nutrition education increased household consumption of vegetables (Marsh, 1998); the Philippines, where children from households with homegardens were found to have higher dietary diversity scores (Cabalda *et al.*, 2011); Indonesia, where Javanese homegardens were found to provide 18 per cent of the calories and 14 per cent of the proteins consumed by the households studied (Soemarwoto *et al.*, 1985); Mexico, where homegardens were found to provide significant contributions to nutrients intakes, such as 10 per cent of protein, 55 per cent of vitamin A and 73 per cent of vitamin C (Stuart, 1993); and Zambia, where positive associations were found between production diversity and children dietary diversity and nutrition status (Kumar *et al.*, 2015).

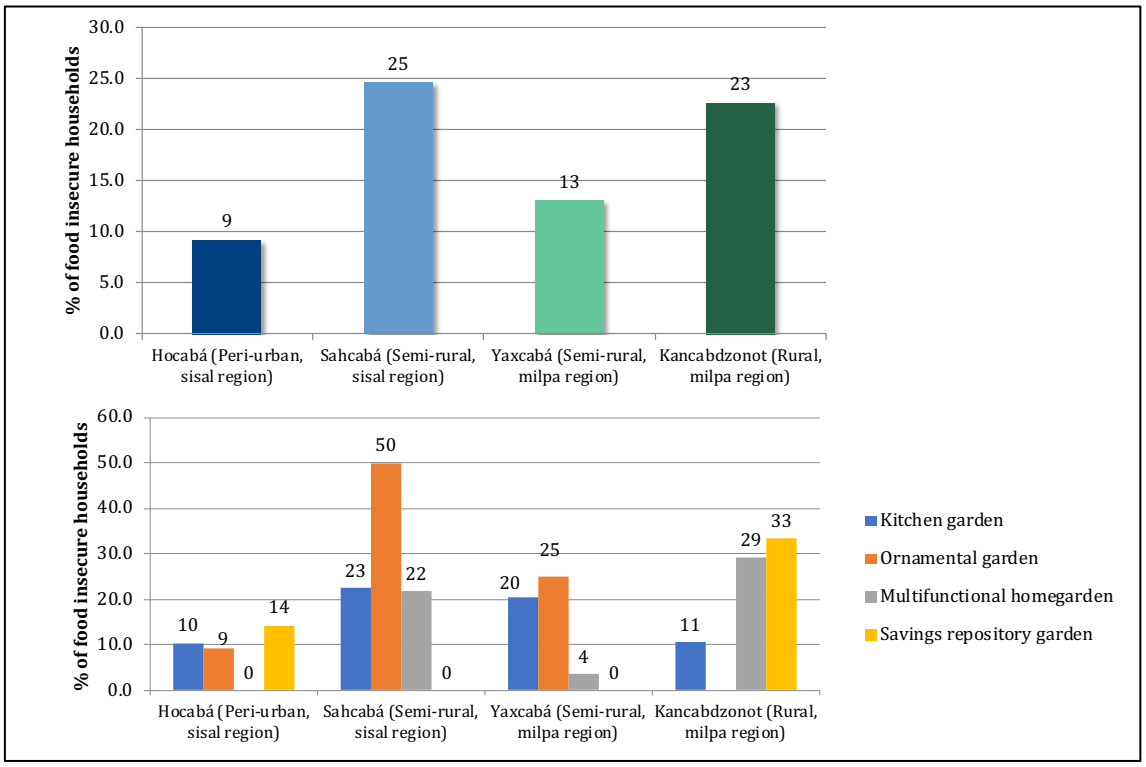
As it was discussed in Chapter 2, despite this evidence, there is little information in the literature on how household and context characteristics and agrobiodiversity mediate the impact of homegardens on food security. This gap is addressed in this section through the analysis of the relationship between homegarden diversity and consumption patterns of food and micronutrients at household level.

7.3.1 Food access

The relationship between food insecurity, measured through food consumption, and homegarden category varied between field sites. As Figure 7.7 shows, in the peri-urban and the rural communities, those households with a savings repository homegarden were the most likely to be food insecure. As it was discussed in chapter 6, the owners of savings repository homegardens tended to be elderly people. Age and health status are likely restricting their access to food. In contrast, in the semi-rural communities, households with a savings repository garden were the least likely to be food insecure, whereas those with an ornamental garden were the most likely to be food insecure. The owners of ornamental gardens are highly engaged in urban jobs and it is likely the case that they are not managing to compensate the loss of their own production of food with their wages from the urban jobs (This is further explored in Section 7.5). In the rural community the opposite situation was observed, as households with a kitchen garden were the least likely to be food insecure. These households reported the greatest engagement in urban jobs and in contrast with that observed in the semi-rural communities, they compensated the loss from their own production of food in their homegardens.

Splitting the data by both the community type and homegarden category left few observations in each group, making it challenging to find statistically significant differences (lower panel of the Figure 7.7). Nonetheless, significant differences were observed within Sahcabá (semi-rural, sisal region), particularly between the food security outcomes of the households owning savings repository and ornamental gardens. The differences found in the incidence of food insecurity by community and homegarden category are likely reflecting the outcomes of the interactions between homegardening, the life cycle of the household and the engagement in other livelihoods. These patterns also shed light to the different roles homegardens perform depending on the location of the household. In the semi-rural communities, savings repository homegardens emerged as the most important in contributing to food security. As reported in chapter 6, savings repository homegardens

were performing economic (savings repository), food provision, nutrient cycling and aesthetic functions.



Notes: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017).

Figure 7.7 Food insecurity by field site and homegarden category

Probit regression models were estimated to analyse the relationship between homegarden diversity and access to food, controlling for household and community characteristics as explained in chapter 4. Appendix J presents the complete output tables of these regression models. Plant and animal diversity were found to be positively associated with food security; however, the magnitude and significance of these effects differed between communities and types of homegardens. Plant diversity had the greatest effect on the food security of households located in the peri-urban community and those owning a kitchen or an ornamental garden. An increase in one unit in the Shannon diversity index of plants would increase the probabilities of being food secure by 11.5% in Hocabá and by 8.8% in households with kitchen or ornamental gardens. Furthermore, the abundance (number) and diversity of animals had the greatest effect on the food security of households located in Yaxcabá (semi-rural, *milpa* region) and those owning a multifunctional or a savings repository homegarden. An increase in one unit in the Shannon diversity index of food animals was found to increase the probabilities of being food secure by 27.8% in Yaxcabá and by 34% in households with multifunctional and safety net gardens.

Other factors that were found relevant in explaining household food security status were average education of the household, wealth, urban jobs and being a beneficiary of the government cash-transfer programme *Prospera*, all showing positive effects. Depending on the regression, some of these variables were found to have an even larger effect than homegarden diversity. Furthermore, the regression analysis confirmed the significance of location in explaining the food security status of a household. Households located in more rural communities showed negative and significant probability of being food secure, in comparison with households located in Hocabá. From the plant diversity regression: Kancabdzonot, -15.4%; Sahcabá, -12.1%; and Yaxcabá, -6.8%. Tables 7.4 and 7.5 summarise the marginal effects and significance level of these relationships. The complete output tables from these regressions are presented in Appendix J.

Table 7.4 Plant diversity and household food security (selected regressors)

Dependent variable: food security (1,0)	*Marginal effect*		
	Four field sites	**Hocabá (Peri-urban, sisal region)**	**Kitchen and ornamental gardens**
Shannon diversity index (plants)	0.056 **	0.115 **	0.088 **
Average education (years)	0.018 **	0.012	0.025 **
Wealth (index)	0.137 ***	0.069	0.196
Urban jobs	0.178 ***	0.099	0.230 *
Community (Base category: Hocabá, peri-urban)			
Sahcabá (semi-rural)	-0.121 ***		-0.117 *
Yaxcabá (semi-rural)	-0.068 ***		-0.110
Kancabdzonot (rural)	-0.154 ***		0.052
Pseudo R^2	0.162	0.230	0.240
Number of observations	313	89	196

The complete output tables from these regressions are presented in Appendix J.
***p-value<0.01, ** p-value<0.05, * p-value<0.01.
Source: Survey data (December 2016-April 2017).

Table 7.5 Animal diversity and household food security (selected regressors)

Dependent variable: food security (1,0)	*Marginal effect*		
	Four field sites	**Yaxcabá (Semi-rural, *milpa* region)**	**Multifunctional and savings repository gardens**
Shannon diversity index (animals)	0.086	0.278 **	0.340 **
Number of food animals[1/]	0.005 **	0.018 *	0.010 ***
Youth dependency ratio	-0.028 *	-0.056	0.009
Average education (years)	0.016 *	0.037 **	0.025
Wealth (index)	0.145 ***	0.146	0.145
Urban jobs	0.185 ***	0.085	0.122
Prospera	0.048	-0.125	0.184 ***
Community (Base category: Hocabá, peri-urban)			
Sahcabá (semi-rural)	-0.140 ***		-0.083
Yaxcabá (semi-rural)	-0.061 ***		0.032
Kancabdzonot (rural)	-0.159 ***		-0.248 *
Pseudo R^2	0.158	0.323	0.341
Number of observations	313	79	115

1/ Marginal effect from a separate regression that excluded the Shannon diversity index of food animals. The results of the rest of regressors were omitted, since the values obtained were very similar to those from the specification presented in this table.
The complete output tables from these regressions are presented in Appendix J.
***p-value<0.01, ** p-value<0.05, * p-value<0.01.
Source: Survey data (December 2016-April 2017).

This analysis contributes to a better understanding of how homegardening patterns, and household and community characteristics interact in shaping this relationship. The different levels of plant and animal diversity explain the variance in the effects on food security. Plants were the main component of kitchen and ornamental gardens, and of the homegardens located in the peri-urban community. Thus, it was expected that the contribution of homegardening to food security were mainly through plant diversity. In contrast, multifunctional and savings repository homegardens showed both, plant and animal diversity, but differences in the abundance and diversity of animals were found to influence food security outcomes. These results provide evidence on how in the most diverse homegardens greater effects on food security can be achieved through the animal component; and that even in the less diverse homegardens, plant diversity can still contribute to household food security.

7.3.2 Food utilisation

Relations between the frequency in the consumption of nutrients and homegarden characteristics were also explored, finding significant differences in the consumption of protein rich foods. In Sahcabá and Yaxcabá, the semi-rural communities, households with more frequent consumption of protein rich foods showed greater abundance and diversity of homegarden animals. Related to this finding, in these communities, households with multifunctional and savings repository homegardens, the most diverse, showed more

frequent consumption of protein than households with kitchen and ornamental gardens, as shown in Table 7.6.

Table 7.6 Homegarden characteristics by consumption of protein rich foods and field site

Variable	Statistic	Hocabá (Peri-urban, sisal region)		Sahcabá (Semi-rural, sisal region)		Yaxcabá (Semi-rural, *milpa* region)		Kancabdzonot (Rural, *milpa* region)	
		1-6 days	*7 days*	*1-6 days*	*7 days*	*1-6 days*	*7 days*	*1-6 days*	*7 days*
Shannon diversity index (plants)	*Mean*	1.211*	1.754*	1.335	1.615	1.910	1.842	2.136	2.071
	Median	1.33	1.925	1.465	1.636	1.897	2.04	2.135	2.312
Shannon diversity index (food animals)	*Mean*	0.000	0.151	0.063**	0.3159**	0.000**	0.328**	0.683	0.440
	Median	0.000	0.000	0.000**	0.000**	0.000**	0.000**	0.692	0.451
Number of food animals	*Mean*	1.4	5.2	2.7*	7.8*	1.0*	7.3*	11.3	8.0
	Median	0.0	0.0	0.0**	4.5**	0.0*	5.0*	9.0	12.4
Kitchen and ornamental gardens	*Proportion*	6.3	93.8	25.0**	75.0**	12.5**	87.5**	5.3	94.7
Multifunctional and safety net gardens	*Proportion*	0.0	100.0	6.9**	93.1**	0.0**	100.0**	14.7	85.3

** p-value<0.05 and * p-value<0.1 (T-test for mean values; Wilcoxon rank-sum test for median values and Chi-squared test for proportions).
Observations: Hocabá, n=98; Sahcabá, n=81; Yaxcabá, n=84; Kancabdzonot=53.
Source: Survey data (December 2016-April 2017).

Probit models were estimated to analyse this relationship, controlling for household characteristics. From the Sahcabá (semi-rural, sisal region) specific regression, having one more animal – for food purposes, such as chickens or pigs – was found to decrease the probability of a low consumption of protein rich foods (less than 7 days a week) by -1.4%. Animal diversity also reported a negative and significant effect. Other factors that were found significant in reducing the probability of a low consumption of protein were: wealth, urban jobs and being a *Prospera* beneficiary, as shown in Table 7.7.

Wealth and rural-urban interactions were found to be significant in explaining household food security outcomes. Sections 7.4 and 7.5 analyse whether and how these variables mediate the relationship between homegardening and food security.

Table 7.7 Determinants of protein consumption (Food animal diversity and number of food animals)

Dependent variable: frequency of protein consumption (0,1) Base outcome: 7days	Four field sites				Sahcabá (semi-rural, sisal region)			
	Coeff.	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Homegarden characteristics								
Shannon diversity index (animals)	-0.560	0.683	-0.076	0.093	-2.045 **	1.029	-0.397 **	0.186
Number of food animals[1/]	-0.030	0.022	-0.004	0.003	-0.071 *	0.038	-0.014 **	0.007
Age of the household head	-0.001	0.006	0.000	0.001	-0.010	0.018	-0.002	0.003
Youth dependency ratio	0.056	0.060	0.008	0.008	-0.051	0.301	-0.010	0.058
Average education (years)	-0.034	0.047	-0.005	0.006	-0.106	0.098	-0.021	0.019
Language spoken by the household head (Base category: Spanish and Maya)								
Maya	-0.116	0.157	-0.015	0.019	-0.330	1.497	-0.056	0.225
Spanish	0.094	0.448	0.013	0.067	1.216	1.093	0.288	0.275
Female head (alone)	0.304	0.285	0.041	0.038	-0.036	1.042	-0.007	0.202
Male head (alone)	0.258	0.656	0.035	0.089	-0.874	0.954	-0.170	0.181
Wealth (index)	-0.943 *	0.518	-0.129 *	0.066	-0.083	0.846	-0.016	0.164
Rural-urban interactions								
Urban jobs	-1.518 ***	0.403	-0.207 ***	0.058	-2.815 **	1.282	-0.546 **	0.225
Off-farm diversification	-0.586	0.517	-0.080	0.069	0.408	0.788	0.079	0.152
Subsidies								
Sixty five and over	-0.127	0.428	-0.017	0.058				
Prospera	-0.383 *	0.212	-0.052 *	0.030	-0.597	0.617	-0.116	0.117
Community (Base category: Hocabá, peri-urban)								
Sahcabá (semi-rural)	1.023 ***	0.018	0.148 ***	0.011				
Yaxcabá (semi-rural)	0.322 ***	0.119	0.030 ***	0.011				
Kancabdzonot (rural)	0.690 ***	0.193	0.082 ***	0.026				
Constant	-0.628	0.657			1.624	1.310		
Pseudo R^2	0.210				0.291			
Number of observations	313				73			

*** p-value<0.01, ** p-value<0.05 and * p-value<0.1.
Source: Survey data (December 2016-April 2017).

7.4 Wealth, homegardening and food security

Households were divided into four categories according to their poverty and food security status. This approach was followed in order to determine whether homegarden diversity played a significant role in moving households, with similar socioeconomic status, out of food insecurity. Poverty groups were defined using context-specific income and assets poverty lines, using the two lowest quantiles of the income and of the wealth index distributions[38]. Appendix F presents details of how the wealth index was computed. The analysis focused on the differences between food secure and food insecure households with the same poverty status. Differences in plant and animal diversity were analysed, finding significant differences only in the levels of plant diversity. The non-significant results of animal diversity are likely explained by the relationship between animal ownership and wealth. Descriptive statistics are presented in Appendix K.

For non-poor households, food insecurity can be understood as a manifestation of short-term spells of poverty or an income-food trade-off. Within the (income) non-poor, plant diversity was found to be significant in reducing the probabilities of a household being food insecure. The results from the probit regressions are presented in Table 7.8. An increase in one unit in the Shannon diversity index was found to reduce the probability of being food insecure by -6.9%. However, no significant effect of plant diversity was found from the assets poverty regression. Education and urban jobs were found to play a significant role in preventing households falling into food insecurity. Food insecure households reported lower education levels than food secure households. An increase of three years in the average education of the household, would decrease the probabilities of a household being food insecure by -7.2%. Food secure households also reported a larger proportion of household members working in urban jobs. In a household where all the adult members work in the community, if all of them suddenly were employed in urban jobs, it would decrease the probabilities of the household of being food insecure by -23.1%. The relationship between wealth, education and urban jobs is further examined in the next section.

[38] Household income was computed by applying the per adult equivalent scales used to compute national poverty measures (Coneval, 2010).

Table 7.8 Determinants of food security by poverty status (non-poor households)

Dependent variable: non-poor & food secure (0), non-poor & food insecure (1)	Income				Assets			
	Coeff.	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Homegarden characteristics								
Shannon diversity index (plants)	-0.452 ***	0.124	-0.069 ***	0.019	0.052	0.302	0.008	0.046
Average age	-0.009	0.014	-0.001	0.002	-0.006	0.020	-0.001	0.003
Youth dependency ratio	0.252	0.248	0.039	0.037	-0.016	0.184	-0.002	0.028
Average education (years)	-0.157 ***	0.023	-0.024 ***	0.003	-0.151 **	0.075	-0.023 **	0.011
Language spoken by the household head (Base category: Spanish and Maya)								
Maya[1/]								
Spanish	0.081	0.168	0.013	0.027	-0.023	0.636	-0.003	0.094
Female head (alone)	0.352	0.693	0.054	0.104	-0.096	0.574	-0.015	0.087
Male head (alone)	0.455	0.562	0.070	0.086	0.117	0.811	0.018	0.122
Rural-urban interactions								
Urban jobs (proportion of adult members)	-1.262	0.858	-0.193	0.125	-1.533 **	0.767	-0.231 **	0.117
Off-farm diversification (inside the community)	-0.187	0.521	-0.029	0.086	-0.015	0.396	-0.002	0.060
Subsidies								
Sixty five and over	-0.518	0.702	-0.079	0.107	-0.404	0.602	-0.061	0.091
Prospera	-0.101	0.266	-0.015	0.040	-0.239	0.342	-0.036	0.051
Community (Base category: Hocabá, peri-urban)								
Sahcabá (semi-rural)	0.650 ***	0.160	0.095 ***	0.025	0.715	0.472	0.117	0.080
Yaxcabá (semi-rural)	0.590 ***	0.170	0.084 ***	0.025	0.042	0.504	0.005	0.055
Kancabdzonot (rural)	0.280	0.240	0.033	0.031	0.492	0.571	0.071	0.091
Constant	0.778	0.549			0.095	1.502		
Pseudo R^2	0.202				0.161			
Number of observations	179				171			

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

For poor households, plant diversity showed a larger and more significant effect than for non-poor households, particularly for assets-poor households, which can be considered as chronically poor. This larger effect can be explained by the fewer livelihood options poor households have in comparison with the better-off. The results from the probit regressions are presented in Table 7.9. An increase in one unit in the Shannon diversity index was found to reduce the probability of a household being food insecure by -12.7%. Poor, food insecure households reported significantly lower income and wealth than the food secure households. Thus, food insecurity is likely explained by the severity of their poverty. Education and urban jobs were also significant factors in explaining food security status. Three more years of education on average reduces the probability of being food insecure by -9.0%, while having all the adults of the household working in an urban job reduces the probability of being food insecure by -18.3%. Moreover, households located in more rural communities were more likely to be food insecure, as was also found from the regression analyses discussed in earlier sections.

The results presented in this section showed that *no matter the poverty status of a household, greater plant diversity in the homegarden contributes to food security.* Nonetheless, the analysis also provided evidence on the importance of wealth (income and assets), education and urban jobs in preventing food insecurity. Homegarden diversity had a lower or even no significant effect on the food security of the wealthiest households, which are likely compensating for the losses of food from the homegarden with the income flows from other livelihood strategies. Previous studies have also found a positive impact of wealth, education and rural-urban interactions on food security. For example, Regmi and Paudel (2016) found significant effects of remittances, literacy and household income in reducing the probabilities of being food insecure in Bangladesh. Hasanah *et al*. (2017) observed significant and positive effects of migration on food security in Indonesia. Finally, Tsiboe *et al.* (2016) reported positive effects of non-farm work on nutrient availability in Ghana, noting that households that combined non-farm business with farming showed the greatest food nutrient availability.

Table 7.9 Determinants of food security by poverty status (poor households)

Dependent variable: poor & food secure (0), poor & food insecure (1)	Income				Assets			
	Coeff.	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Homegarden characteristics								
Shannon diversity index (plants)	-0.254	0.245	-0.069	0.065	-0.478 **	0.207	-0.127 **	0.052
Average age	-0.010	0.007	-0.003	0.002	0.002	0.015	0.001	0.004
Youth dependency ratio	-0.114	0.144	-0.031	0.039	0.324	0.230	0.086	0.060
Average education (years)	-0.111 **	0.055	-0.030 **	0.015	-0.109 *	0.063	-0.029 *	0.016
Language spoken by the household head (Base category: Spanish and Maya)								
Maya[1/]	-0.211	0.326	-0.054	0.077	0.141	0.546	0.039	0.156
Spanish	-0.204	0.462	-0.052	0.109	0.055	0.582	0.015	0.159
Female head (alone)	0.508	0.545	0.137	0.146	0.418	0.369	0.111	0.096
Male head (alone)	0.471	0.589	0.127	0.160	0.413	0.444	0.110	0.117
Rural-urban interactions								
Urban jobs (proportion of adult members)	-0.679 **	0.327	-0.183 **	0.085	-0.386	0.802	-0.102	0.213
Off-farm diversification (inside the community)	0.474	0.573	0.128	0.154	-0.035	0.421	-0.009	0.112
Subsidies								
Sixty five and over	0.235	0.606	0.064	0.163	-0.128	0.400	-0.034	0.106
Prospera	-0.299	0.584	-0.081	0.157	-0.118	0.334	-0.031	0.088
Community (Base category: Hocabá, peri-urban)								
Sahcabá (semi-rural)	0.562 ***	0.163	0.129 ***	0.042	0.606	0.393	0.130	0.083
Yaxcabá (semi-rural)	0.389 ***	0.136	0.083 ***	0.025	0.794 *	0.457	0.183 *	0.100
Kancabdzonot (rural)	0.944 ***	0.278	0.249 ***	0.068	1.008 *	0.522	0.249 **	0.124
Constant	0.370	0.752			-0.210	1.073		
Pseudo R^2	0.103				0.136			
Number of observations	126				136			

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

7.5 Urban jobs, homegardening and food security

Rural-urban interactions, and particularly urban jobs, emerged as significant factors explaining both homegardening patterns and food security outcomes. Households with the largest proportion of adults working in urban jobs reported less diverse homegardens but were found to be better-off. This section describes the rural-urban interactions observed in the four field sites, discussing the characteristics of the people engaged in these interactions and the effects on homegardening and on food security.

The main interactions between the field sites and the urban centres were through urban jobs, off-farm diversification and migration. Between 70-80% of the adults with jobs outside their communities worked in large and medium-size cities, such as Mérida, the capital city of Yucatán, or neighbour cities, such as Cancún, Playa del Carmen and Campeche. Depending on the distance to their workplaces, people travelled every day, weekly, fortnightly or even every two months. Everyday commutes were more common in Hocabá, the peri-urban community (73.7%); while weekly and less frequent commutes were more common in the rest of the field sites: Sahcabá (semi-rural, sisal region), 45.7%; Yaxcabá (semi-rural, *milpa* region), 91.7%; and Kancabdzonot (rural, *milpa* region), 90.9%. Permanent migration was mostly internal (rural-urban) and it was less common than the work-related commuting and off-farm diversification. Moreover, only a few of the households with migrant members received remittances. The main reason for this was low salaries which do not allow the migrants to cover their expenses and also send some money back to their families, especially when young migrants get married and have their own offspring.

Table 7.10 presents the descriptive statistics of the main rural-urban interactions observed in the field sites at the household level and the significance levels of the differences observed between them. As discussed in chapter 4, at the community level, Hocabá appeared as the most urbanised community, located closer to the capital city and showing better infrastructure. However, at the household level, Sahcabá (semi-rural, sisal region) reported the largest percentage of people engaged in urban jobs and the highest mean of remittances flows. Moreover, Yaxcabá (semi-rural, *milpa* region) showed the largest figures of households with migrant members. These findings reflect the scarcity of paid jobs in the semi-rural communities. In contrast, off-farm occupations inside the community were more relevant in the most rural of the study communities, particularly those located in the *milpa* region.

Table 7.10 Rural-urban interactions in the field sites, 2016-2017

Rural-urban interactions	Hocabá (Peri-urban, sisal region)	Sahcabá (Semi-rural, sisal region)	Yaxcabá (Semi-rural, *milpa* region)	Kancabdzonot (Rural, *milpa* region)	Statistic Test	*p*-value
Adults working or studying outside the community (%)	35.08	39.33	21.03	8.51	Chi-squared	<0.0001
Adults working in off-farm occupations (%)	54.90	67.41	42.67	49.31	Chi-squared	<0.0001
Proportion of households with migrant members	27.55	25.93	41.67	24.53	Chi-squared	0.5790
Proportion of households that received remittances	2.04	2.47	9.52	9.62	Chi-squared	0.0890
Average monthly remittances (received), adult equivalent scale, MXN (USD and GBP)	n.a.	906.29 (48.3/37.0)	436.19 (23.2/17.8)	80.25 (4.3/3.3)	Anova	0.0323

n.a. Data not available, from a migrant member living in the US. The research participant who answered the survey preferred not to disclose the amount of remittances they received.
Individuals observations: Hocabá 337, Sahcabá 270, Yaxcabá 225, Kancabdzonot 144.
Household observations: Hocabá 98, Sahcabá 81, Yaxcabá 84, Kancabdzonot 53.
Source: Survey data (December 2016-April 2017).

The next sub-section discusses the differences in the characteristics of the individuals engaged in off-farm occupations within their communities, compared with those participating in urban jobs, which explain why off-farm diversification is more common in the most rural communities.

7.5.1 Who moves to the city?

Rural-urban interactions, such as urban jobs and off-farm occupations, varied not only between the four field sites, but also within them. As presented in Table 7.11, young adults, men, more educated people and Spanish speakers were more likely to participate in urban jobs. In contrast, off-farm occupations within the communities were more accessible livelihood strategies for elderly people, women and Mayan speakers. These differences are likely due to the higher education and Spanish speaking requirements of urban jobs in comparison with off-farm occupations inside the communities. Furthermore, given the patriarchal nature of Mexican society, occupations are more socially acceptable for women if they are located within their own communities than if they are based in urban areas. Moreover, these occupations allow women to spend more time in their communities, taking care of their multiple house chores.

The decision to work inside or outside the community and between on-farm and off-farm occupations has important implications for the mean wage individuals can aspire to earn. As Table 7.11 shows, individuals working inside their communities reported an average monthly wage of MXN 990.6 (GBP 40.4; USD 52.7), while those working outside their

communities reported an average wage more than four times larger, which is still low in comparison with national standards. The national average wage of formal employees in 2017 was MXN 9,990 (GBP 407.4; USD 531.9) (IMSS, 2020), more than twice of the mean wage earned by those working outside their communities. On-farm and off-farm wages also reported a gap. People working in on-farm occupations earned an average monthly salary of MXN 933.7 (GBP 38.1; USD 49.7), while those working off-farm received almost twice as much money. A statement from a study conducted in Yucatán two decades ago still holds true: *"What differentiates the very poorest from the poor households is the lack of income from employment"* (Poole, *et al.*, 2007, p. 326).

Table 7.11 Characteristics of working adults by type and location of occupation, 2016-2017

Characteristics	Outside the community	Inside the community	T-test/Chi-squared *p*-value	Off-farm	On-farm	T-test/Chi-squared *p*-value
Mean age	34.38	47.14	<0.001	46.20	55.89	<0.001
Mean years of education	8.71	6.02	<0.001	6.57	4.84	<0.001
Proportion of women	14.84	85.16	<0.001	97.37	2.63	<0.001
Proportion of men	44.74	55.26	<0.001	16.34	83.66	<0.001
Proportion of Maya speakers	6.38	93.62	<0.001	42.86	57.14	0.042
Proportion of Maya and Spanish	27.9	72.1	<0.001	40.72	59.28	0.042
Proportion of Spanish speakers	41.14	58.86	<0.001	70.00	30.00	0.042
Mean monthly wage, MXN (GBP/USD)	4,358.23 (177.73/232.07)	990.63 (40.40/52.75)	<0.001	1,821.36 (74.27/96.98)	933.73 (38.08/49.72)	0.049

Observations: Hocabá 337, Sahcabá 270, Yaxcabá 225, Kancabdzonot 144.
Source: Survey data (December 2016-April 2017).

Previous studies have arrived at similar findings on how the access to non-agricultural occupations is constrained by context-specific formal and informal institutions, which are based on political power, political affiliation, religion, income, ethnicity, gender, generation, etc. (Ellis, 1998; Bah *et al.*, 2003; Becker, 2013; Tacoli and Mabala, 2010; FAO, 2018). For example, gender and generational differences in access to and control over resources are a 'push' migration factor for women and young people in Sub-Saharan Africa (Bah *et al.*, 2003; Tacoli, 2003). Moreover, it has been observed in different developing countries across Asia (Hoang *et al.*, 2008; Rungmanee, 2014; FAO, 2018), Africa (Adusah-Karikari, 2015; FAO, 2018) and Latin America (Bravo-Ureta *et al.*, 1996; Guerrero Peñuelas, 2007), that young and better-educated family members are more likely to migrate and to take advantage of non-farm job opportunities. Box 7.2 presents the research participants' rationale for working outside or inside their communities.

Box 7.2 To leave or not to leave?

It is almost the same… if you find a job at home

'I started going to work [as a construction worker] to Mérida when I was 30 years old, but I have also worked here in Hocabá. It is almost the same if you do the math, and here [in Hocabá] you can wake up later. For working in Mérida you have to leave between 5 and 6 in the morning. [When I worked in Mérida] I commuted every day. Well, it depends on where you work, sometimes there is a place where you can stay, but I mostly commuted every day.'

(Male research participant from Hocabá, 58 years old, 31/10/2017)
(Peri-urban, sisal region)

To leave if…

You have children

'My grandson is nine years old and still drinks milk every day and sometimes more than once a day. He does not like the chocomilk [chocolate powder brand] with water (…) so my son tells me, you see mom this is the reason why I have to earn money, how can I buy milk if I do not work [off-farm]?'

(Female research participant from Sahcabá, 29/09/2016)
(Semi-rural, sisal region)

You want to make better money

Here [Yaxcabá] is getting larger and there are not enough jobs, well there are, but only in the milpa. And from the milpa you do not make a good money. For one mecate[1] of knocking down trees you can make 60 pesos[2], the maximum. And just one [mecate] you are going to work, you cannot work two because you get tired (…). That is why many young men go to work to Cancún and to Mérida, because there they make better money.'

(Research participant from Yaxcabá, 66 years old, 05/12/2017)
(Semi-rural, *milpa* region)

There are not handicraft sales or the harvest was lost

'My husband works in woodcarving and in the milpa (…) These days, if there is not handicraft there is not life (…) Every time more people learn it [woodcarving], my son has 16 years old and he already learned it. When there are not sells, my husband goes to work to Cancún, he then travels every week. He works as peón [helper of construction worker].'

(Female research participant from Kancabdzonot, 32 years old, 14/12/2017)
(Rural, *milpa* region)

_____

[1] 400m^2.
[2] USD 3.2; GBP 2.5.

7.5.2 Is there an income-food trade-off?

I have shown in this chapter and the previous one how urban jobs had a positive effect on food security, but a negative effect on homegarden diversity. In chapter 6 it was discussed that better off households, which tended to participate more in urban jobs, had less diverse homegardens. And in Sections 7.3 and 7.4 it was shown that both, urban jobs and homegarden diversity, were contributing to food security. From these findings a question

emerged: *Is the income effect from urban jobs able to compensate the loss of food from the homegarden?* In order to answer this question, mediation analysis was performed.

As it was explained in chapter 4, mediation analysis decomposes the total effect of a variable *X* -here urban jobs- on a dependent variable *Y* -here food security- into its direct and indirect effects. The indirect effect refers to the influence of *X* on *Y* through an intervening or mediator variable *Z* -here homegarden diversity- (Buis, 2010). Figure 7.8 depicts this decomposition.

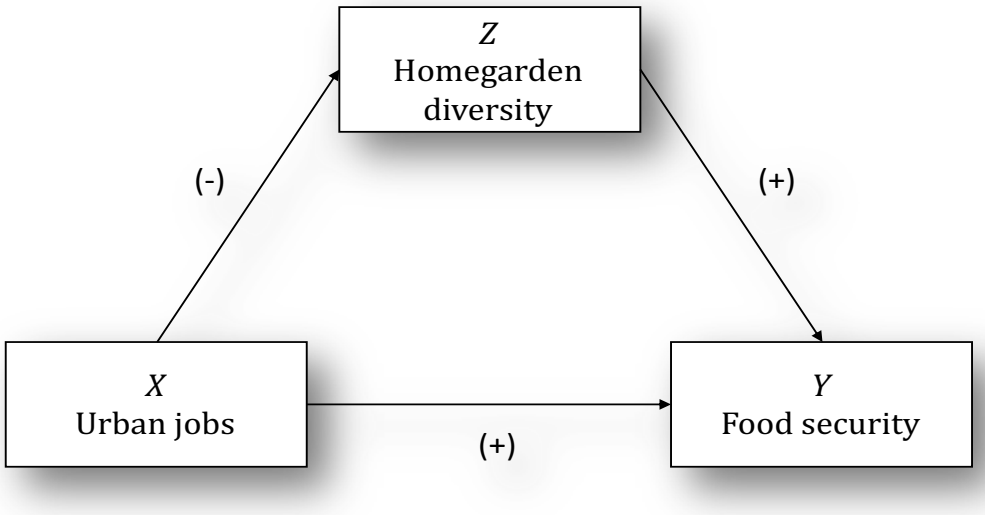


Figure 7.8 Mediation analysis

The results obtained from the mediation analysis were statistically significant only in the pooled regression of the four field sites, both for plant and animal diversity; and in the specific regression of the households located in Yaxcabá (semi-rural, *milpa* region), using animal diversity as intervening variable. As Tables 7.12 and 7.13 show, on overall, the positive effect of urban jobs on food security compensates the loss of plant and animal diversity from the homegarden. Nonetheless, as reported in Table 7.13, in Yaxcabá, the semi-rural community located in the *milpa* region, the participation of at least one household member in urban jobs had a negative indirect effect on food security through the reduction of food animal diversity. This effect was larger than the direct effect of urban jobs on food security and was significant at p-value<0.05. This means that households participating in urban jobs would increase their probability of being food secure by increasing the animal diversity of their homegarden at levels similar to those presented by households who do not participate in urban jobs. These results imply that the income obtained from urban jobs is not compensating the loss of food from the homegarden in this semi-rural community.

Table 7.12 Mediation analysis: urban jobs – plant diversity – food security

Dependent variable: food security (1,0)	Four field sites	Hocabá (peri-urban, sisal region)	Sahcabá (semi-rural, sisal region)	Yaxcabá (semi-rural, *milpa* region)
	Coefficient (Log odds ratio)	*Coefficient (Log odds ratio)*	*Coefficient (Log odds ratio)*	*Coefficient (Log odds ratio)*
Total	0.704 **	0.810	1.057	-0.062
Method 1				
Indirect=ln(Odds_ij/Odds_jj)	0.003	0.338	0.083	-0.015
Direct= ln(Odds_ii/Odds_ij)	0.701 **	0.472	0.974	-0.047
Method 2				
Indirect= ln(Odds_ii/Odds_ji)	0.004	0.333	0.084	-0.015
Direct= ln(Odds_ji/Odds_jj)	0.700 **	0.477	0.972	-0.047
Number of observations	313	98	79	83
Treatment' variable: Household member with an urban job.				
Mediator variable: Plant diversity (Shannon index).				
Control variables: age of the household head, youth dependency ratio, average education of the household, language spoken by the household head, gender of the household head and household wealth				

Note: The two methods differ in the group used to compute the factual and counterfactual probabilities: households with adults participating in urban jobs and households without adults participating in urban jobs.
For Kancabdzonot, the rural community, the model could not be computed because the number of observations was too small to allow the model to converge.
*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

Table 7.13 Mediation analysis: urban jobs – diversity of food animals – food security

Dependent variable: food security (1,0)	**Four field sites**	**Hocabá (peri-urban, sisal region)**	**Sahcabá (semi-rural, sisal region)**	**Yaxcabá (semi-rural, *milpa* region)**
	Coefficient (Log odds ratio)	*Coefficient (Log odds ratio)*	*Coefficient (Log odds ratio)*	*Coefficient (Log odds ratio)*
Total	0.698 **	1.141	1.044	-0.086
Method 1				
Indirect=ln(Odds_ij/Odds_jj)	-0.044	0.063	0.038	-0.287 **
Direct= ln(Odds_ii/Odds_ij)	0.742 **	1.078	1.006	0.201
Method 2				
Indirect= ln(Odds_ii/Odds_ji)	-0.043	0.060	0.029	-0.284 **
Direct= ln(Odds_ji/Odds_jj)	0.742 **	1.080	1.015	0.198
Number of observations	313	98	79	83
Treatment' variable: Household member with an urban job.				
Mediator variable: Food animals (Shannon index).				
Control variables: age of the household head, youth dependency ratio, average education of the household, language spoken by the household head, gender of the household head and household wealth				

Note: The two methods differ in the group used to compute the factual and counterfactual probabilities: households with adults participating in urban jobs and households without adults participating in urban jobs.
For Kancabdzonot, the rural community, the model could not be computed because the number of observations was too small to allow the model to converge.
*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1

Source: Survey data (December 2016-April 2017).

Access to education from primary to upper secondary level has improved in the field sites. While elders only had the chance to complete a few years of primary education, their grandchildren now have access to upper secondary schools in their communities, in addition to scholarships, which form part of the cash-transfer programme *Prospera*. This broader access to education also forced new generations to learn Spanish, since teachers usually only speak Spanish. This, however, has contributed to the erosion of the transmission of the Mayan language. On the economic side, being more educated and speaking Spanish has allowed new generations to have more livelihood alternatives, besides agriculture. Urban jobs are providing a significant contribution to livelihood security; however, most of these jobs are low paid positions as discussed in section 7.5. Furthermore, rising living costs, stagnant salaries and the augmented violence in urban centres[39] raise doubts about the long-term sustainability of urban jobs as livelihood strategies, as illustrated in box 7.3.

Box 7.3 Returning home

I was born here [in Yaxcabá]. I have been living in this plot for ten years. Before we lived in Cancún. When I got married I moved to Cancún, but when my children were six years old and were about to start primary school we moved back to Yaxcabá.

The school from the city charged a fee and we were paying rent, so we could not afford it. Here we do not have to pay school fees; besides, here you get school supplies for free [from the regional government]. Here we managed it [to make a livelihood].

In the city the house was much smaller. We are fine here, it is safer, because in the city there are many thieves.

(Female research participant from Yaxcabá, 43 years old, 05/12/2017)

[39] Data from the National Survey of Victimisation and Perception of Public Security (INEGI, 2018) helps to illustrate the recent patterns and trends in violence. In Yucatán, 37% of the resident adults surveyed perceived public insecurity in 2018. In contrast, in the metropolitan zone of Cancun, 84.4% of the respondents perceived insecurity. That is, more than twice the percentage of adults that perceived insecurity in Yucatán. In 2014, when urban-specific data on perception of public security were collected for the first time, the percentage of adults that perceived insecurity in the metropolitan zone of Cancun was 74.8%. This means an increase by 13% in the perception of public insecurity during the last four years.

7.6 Conclusions

This chapter addressed the third research sub-question: ***How does homegardening contribute to food security across the peri-urban – rural spectrum in Yucatán, Mexico?*** Plant and animal diversity from the homegarden were found to be positively associated with household food security, confirming the fifth research hypothesis: ***Homegarden diversity is positively associated with household food security***. Plant diversity was found more relevant for food security in the less diverse homegardens, whereas the abundance and diversity of animals was found to have more significant effects on food security in the most diverse homegardens and those located in the semi-rural communities. These findings provide evidence on how homegardens can contribute to food security even with low levels of diversity; and on the relevance of the animal component to food security.

The positive effect of homegardening on food security is not a novel finding. Nonetheless, this chapter contributes to filling a gap in the understanding on how homegardening diversity and community and household characteristics mediate this relationship. The relationship between homegarden diversity and food security was found to depend on a number of key factors: the location (rural-urban) of the household; household wealth; and participation in other livelihood activities, such as urban jobs and social programmes.

The dependence on the homegarden as source of food showed an increasing peri-urban – rural gradient, a pattern already discussed in chapter 6 and explained by the different availability of and preferences for livelihoods across that spectrum.

Education, wealth and urban jobs were all found to have a positive impact on food security. Moreover, it was observed that these three variables were interconnected. Individuals working in urban jobs tended to be wealthier and to report higher levels of formal education. Plant diversity was found to have a positive effect on the food security of both poor and non-poor households, but the effects were greater in the poor households. These findings shed light on how homegardens perform different roles depending on the wealth of the household. In poorer households, homegardens play a crucial role in fulfilling basic needs, such as food security, whereas in the better-off households, homegardening is a complementary livelihood activity, performing mainly aesthetic and accumulation roles.

Working in urban areas was the main alternative to agricultural livelihoods, especially among young people living in the most urbanised communities. Urban jobs were found to have a positive effect on food security - even higher than homegarden diversity -, but a

negative effect on homegarden diversity. The directions of the interactions between homegardening and urban jobs were found to vary between communities. In the peri-urban and the rural communities, the households with the least diverse homegardens were found to compensate for the loss of food from the homegarden with the incomes obtained from urban jobs. In contrast, in the semi-rural communities, urban jobs were found to have a negative effect on homegarden diversity and thus an indirect negative effect on food security.

Differences between communities can be explained by the differential access to other livelihoods and transportation across the peri-urban – rural spectrum. In the peri-urban community, it is easier to access urban jobs, thus the opportunity cost of neglecting the homegarden is lower. In the rural community the same outcome occurs, but for different reasons. Given the low availability of off-farm livelihoods, aside from woodcarving, the best chance for obtaining a stable income is to look for a job in urban areas. In the semi-rural communities, most households manage to cover their needs through a *bricolage* of on-farm and off-farm livelihoods. Thus, leaving the community for an urban job means neglecting on-farm livelihoods, homegardening being one of them; and the findings show this trade-off is not always paying off.

This analysis has provided evidence on the contribution of homegarden diversity to food security. Moreover, it shed light on the complex interactions that occur in this relationship with other household characteristics, such as education, wealth and urban jobs, confirming the sixth and last research hypothesis: ***Household and community characteristics mediate how homegarden diversity contributes to food security***.

Homegardens represent an important safety net that help communities facing urban transitions to smooth the market and health shocks they face, such as the semi-rural communities studied in this research. Nonetheless, as I showed in this chapter, homegardens are not a magic bullet. Urban jobs, overall, are providing a larger contribution to livelihood security than homegardens.

Chapter 8. Conclusions

8.1 Synthesis: Rural urbanisation, homegardening and livelihood security

This thesis aimed to contribute to the understanding of how rural urbanisation influences the role of homegardening as a livelihood strategy. The research built on elements of the Sustainable Livelihoods Framework and the Capability Approach, to create a hybrid 'Endowments-based Livelihoods Framework' (ELF) that helped to frame the relationship between homegarden diversity, rural urbanisation and livelihood security. I applied this framework to analyse how people converted their resources and rights into wellbeing achievements, through the selection of a *bricolage* of livelihood strategies, including homegardening.

For analytical purposes, rural urbanisation was studied in terms of its temporal and spatial dimensions. Accordingly, in chapter 5 I examined longitudinal data to address the temporal dimension of rural urbanisation; and in chapters 6 and 7 I examined cross-sectional data to account for the spatial dimension. This chapter aims to synthesise the findings from both dimensions in order to provide a unified answer to the overarching research question: ***How does rural urbanisation influence the contribution of homegardening to livelihood security in Yucatán, Mexico?***

Rural urbanisation, understood as a heterogeneous transformation involving not only a demographic transition, but also structural economic, political, social and cultural changes, was found to be a powerful driver of the transformations faced by homegardens, as I showed in chapters 2 and 5. Rural urbanisation is a phenomenon that can be observed over both time and space. Rural communities in the Yucatán Peninsula, which used to be relatively isolated, are now interlinked with intermediate towns and urban centres through improved roads and telecommunications and broader access to education and the media. Moreover, at this point in time, it is possible to observe communities showing different levels of urbanisation within a region.

In order to capture the temporal and spatial dimensions of rural urbanisation, I adopted a multi-case study design and a mixed methods approach. The selection of four communities with different levels of urbanisation and the integration of qualitative and quantitative, and longitudinal and cross-sectional methods of enquiry helped me to analyse the

transformations over time and the differences across the peri-urban – rural spectrum of the role of homegardening as a livelihood strategy.

The homegardens studied perform four key functions: (i) material provisioning; (ii) ecological; (iii) economic; and (iv) social and cultural. Rural urbanisation was found to reduce the diversity of the homegardens and thus undermine and change their functions. As urbanisation increases, so do ornamental plants and fruit trees; whereas vegetables, timber trees, palms and pigs disappear. Urbanisation was also found to reduce the commercial and non-commercial exchange of homegarden products. The social and cultural effects of urbanisation were observed in the ageing of the main gardeners; the related lower interest among younger generations in managing the homegarden; the loss of traditional knowledge; and changes in diets.

The cross-sectional information collected allowed me to develop and test a typology of homegardens, as described in chapter 4. I identified four main categories of homegardens: (i) multifunctional gardens; (ii) savings repository homegardens; (iii) kitchen gardens; and (iv) ornamental gardens. In chapter 6 I explained that these categories differed in the types and levels of diversity and thus, in the entitlements people derive from them. This typology was also useful in explaining these four common types of homegardens in terms of the demographic and socioeconomic characteristics of the households, and the location of the communities across the peri-urban – rural spectrum.

Following the ELF presented in chapter 3, I found that the contribution of homegardens to livelihood security was mediated by access to and control of resources, such as land, labour and wealth; conversion factors, such as age, gender and ethnicity; and by formal and informal institutions, captured through the community and regional context.

Multifunctional and savings repository homegardens, the most diverse categories, are owned by either elderly people with small households or young/middle-age couples. The common characteristics of these households are: having Mayan speaking household heads; participating in *milpa* cultivation; and being beneficiaries of government support programmes. This type of household is more common in the rural and the semi-rural communities, particularly those located in the *milpa* region. In these households the most significant contribution of the homegardens to food security was through food animals, particularly poultry and pigs. In contrast, kitchen and ornamental gardens, the least diverse, are owned by young families with young children, who tended to be Spanish speakers,

engaged in urban jobs and were less likely to receive government support. These households were more common in the peri-urban and semi-rural communities. In these households, homegardens were contributing to food security through their plant diversity.

These findings, presented in chapters 6 and 7, reflect how the interaction between community and household characteristics determine heterogenous access to off-farm livelihoods. Young people, who are predominantly Spanish speakers and live in the more urbanised areas, have more opportunities to engage in off-farm jobs, either in their communities or in urban areas. They are not only physically closer to the cities, for them transportation is cheaper and more frequent than for those living in more distant villages. Speaking Spanish facilitates their communication and reduces their chances of being discriminated against. However, these advantages are not without a cost, as spending more time travelling to and working in the cities leaves less time to engage in agriculture and other traditional livelihoods in their communities. This appears to be eroding the traditional knowledge and social capital of the communities and shifting younger people's preferences towards more urbanised lifestyles.

I found in this thesis that the prominent role of homegardening as a livelihood strategy decreased over time, although the pace of lessening varied across the peri-urban – rural spectrum. Moreover, alternative pathways were identified to this dominant trend, where some households managed to maintain highly diverse homegardens. From both the longitudinal and the cross-sectional analyses, I identified five key interrelated factors mediating the relationship between homegardening and livelihood security: (i) participation in urban jobs; (ii) wealth; (iii) ethnicity; (iv) rural-urban location; and (v) being a recipient of social programmes. In order to understand these interactions better, the analysis in Chapter 7 focused on the contribution of homegardening to food security.

The findings showed that *participation in urban jobs* reduces homegarden diversity. Nonetheless, urban jobs have a positive impact on food security through their income effect. This contribution to food security is even larger than that provided by homegardening, as the analysis presented in chapter 7 revealed. On average, households engaged in urban jobs appear to compensate the loss of food from the homegarden with incomes that allow them to purchase food from the market. However, in the semi-rural communities this does not occur. It is likely that in these communities, households manage to cover their needs through a *bricolage* of on-farm and off-farm livelihoods. Thus, leaving the community for an

urban job means neglecting on-farm livelihoods – homegardening being one of them – with negative net effects in their food security.

Wealth also differentially mediates the relationship between homegardening and livelihood security in the short and in the long term. Findings from chapter 7 revealed that in the short term, the contribution of homegarden diversity to food security is larger in the poorest households. However, over time, the better-off households are more likely to be able to diversify their livelihoods towards off-farm occupations without making large sacrifices in homegarden diversity, as the findings from chapter 5 showed. This reflects how livelihood diversification means a survival strategy for the poorest households, representing larger trade-offs for them; whereas for the richest households it is an accumulation strategy, and thus the trade-offs they face are smaller.

In chapters 5 and 6, I provided evidence on how households with Mayan speakers as heads manage to maintain high levels of diversity over time and across the peri-urban – rural spectrum. Speaking the Mayan language reflects a cultural attachment to the Mayan culture, which involves traditional knowledge and practices, such as homegardening. Following the ELF presented in chapter 3, the attachment to the Mayan culture (*ethnicity*) was seen as an important conversion factor that not only determines different patterns of homegardening, but - given the prevailing formal and informal institutions - also constrains access to different resources and livelihood strategies. In chapter 6 the analysis showed how Mayan households have less endowments (physical assets and education) and lower participation in urban jobs.

I showed how although urbanisation permeated the peri-urban – rural spectrum in chapter 5 and revealed how the pace and intensity of this transition differed between and within the two areas studied (*rural-urban location*): the sisal region and the *milpa* region. The relative isolation of the *milpa* region and the extensive coverage of social programmes has allowed households located there to face a smoother transition, without the abrupt abandonment of traditional livelihoods observed in the sisal region. Nonetheless, households located in the peri-urban community showed higher chances of being food secure than those located in the semi-rural and rural communities.

In chapter 6, I examined how cash-transfers have a positive effect on homegarden diversity, likely freeing resources to invest in the garden. The rural-urban location of the household was found to not only determine the access to infrastructure and markets, but also the

access to government agricultural support programmes. The effects of location on the interaction between homegarden diversity, *social programmes* and food security become apparent when comparing the semi-rural communities located in the two different regions. In Yaxcabá, the semi-rural community located in the *milpa* region, people's livelihoods can still depend on agriculture, and there are several development interventions promoting it in addition to social cash-transfer programmes. At the same time, access to upper-secondary education in the community and the growth of nearby cities are also facilitating the transition into alternative livelihoods, not without trade-offs. In contrast, Sahcabá, the semi-rural community located in the sisal region, emerged as a more vulnerable community, trapped in an urban transition, with lower access to social programmes, that has pushed people to depend mainly on low-paid jobs in urban areas, undermining their food security.

The next section summarises the main contributions identified from this thesis, while section 8.3 describes the limitations and areas for future research and section 8.4 presents final reflections.

8.2 Thesis contributions

In this thesis, I have sought to make a number of unique contributions to the academic literature on homegardens and livelihood security. These take the form of theoretical, methodological, empirical and policy contributions, each of which is briefly outlined below.

8.2.1 Theoretical contribution

This thesis makes two main theoretical contributions. In chapter 2, I advanced the understanding of the functions and dynamics of homegardens by synthesising previous literature on these topics and integrating elements from the Millennium Ecosystem Assessment framework (2005), economics of biodiversity and from agrarian change studies. Furthermore, in chapter 3, I introduced a framework for studying how households and individuals select their livelihoods and convert their endowments into livelihood outcomes. The Endowments-based Livelihoods Framework built on elements of the Sustainable Livelihoods Framework and the Capability Approach. Chapters 4 to 7 showed how this framework can be applied from both qualitative and quantitative perspectives, accounting for, among other things: the research context; individual and household characteristics; and people's meanings of wellbeing.

8.2.2 Methodological contribution

From a methodological point of view, this research contributed to the literature on mixed methods, navigating between critical realist and positivist paradigms. The way qualitative and quantitative methods were connected and integrated allowed the generation of hypotheses from the literature and field data and the later testing of these hypotheses in an iterative process. Although quantitative methods are usually regarded as less powerful in explaining complexity, the mixed methods approach enabled me to apply quantitative methods to analyse and understand complexity and diversity of the homegardens, through the identification and application of a typology for categorising their functions. Moreover, this thesis provided evidence of the importance of using qualitative methods to inform quantitative analysis, both to select relevant variables and to explain the results from these analyses. The understanding of dynamic phenomena, such as rural urbanisation, requires the combination of longitudinal and cross-sectional methods. Although resource-intensive, this approach proved to be useful for gaining a deeper understanding of the differences between and within the field sites.

8.2.3 Empirical contribution

As explained in chapter 2, in this thesis I aimed to narrow three research gaps in the literature on homegardens: (i) long-term dynamics; (ii) interrelationships between homegardens, households and community characteristics; and (iii) how homegardening contributes to food security. The longitudinal dimension of this research helped to gain qualitative and quantitative insights of how homegardens evolved in the last decades. In particular, a novelty of this thesis was to track the same households over time, both surveying households studied years ago by local scholars and conducting in-depth life histories in a sub-sample of these households. This allowed me the identification of different trajectories in their homegarden diversity and to relate these to demographic and livelihood dynamics of the households, as I explained in chapter 5. The second and third research gaps addressed were interconnected. A better understanding of the determinants of homegardening enhanced the analysis of how the relationship between homegardening and livelihood security, in general, and its contribution to food security, in particular, worked in different settings and for different types of households.

The homegardens typology I presented in chapter 6 is another empirical contribution that emerged through the application of my mixed methods research approach. To my knowledge, this is one of the few successful attempts to explain homegarden differences in terms of household characteristics. In addition, the typology developed in this study

facilitated the understanding of how the contribution of homegardening to food security depended on different patterns of homegarden diversity and interactions with community and household characteristics, which I presented in chapter 7.

This research shed light to the heterogeneity of households within communities, showing how the rural-urban location of the homegardens interacted with other household characteristics, such as family life-cycle, wealth, recipient of government subsidies and participation in urban jobs. I examined these relationships in chapters 6 and 7. This approach helped me to uncover different factors that were mediating the contribution of homegardening to livelihood security.

Te impact of urbanisation on homegardening was not only analysed in terms of the location of the household, which is the common practice, but in terms of the engagement of household members in off-farm livelihood activities. This approach allowed me to explain counterintuitive findings in the semi-rural community located in the sisal region, which reported higher participation in urban jobs than the peri-urban community.

Furthermore, while most of the literature on homegardens has focused on plant diversity, this study contributed to identifying and understanding the interactions and trade-offs between the plant and the animal components and how animal diversity and its contribution to livelihood security varies across the peri-urban – rural spectrum.

Although homegardening is a context-specific phenomenon, the findings presented in this thesis can be generalised to contexts with similar characteristics and immersed in similar rural urbanisation transitions.

8.2.4 Policy implications

As shown in this research, homegardens are particularly relevant for the food security of the poorest households and for those that depend on off-farm and on-farm livelihoods, such as those located in the semi-rural communities studied here. Besides programmes targeted at homegardening, my findings provide evidence on how social protection programmes can free resources to allow poor households to invest in homegardening and how programmes promoting extensive agriculture can also provide incentives to maintaining high levels of homegarden diversity. The findings also proved how the attachment to the Mayan culture contributes to higher levels of homegarden diversity. Thus, it can be concluded that promoting an institutional environment that allows people to freely express and embrace

their ethnicity without the risk of being discriminated against would contribute to preserving the biocultural richness of their homegardens.

This study has also revealed that the main government programmes promoting homegardening have adopted a narrow and decontextualised approach, which constrains the scope of their efforts and their impacts. These programmes tend to focus on specific components of the homegarden without appreciating or taking advantage of their dynamic interrelationships. The findings also showed how as plant diversity increases, the animal component of the homegarden also increases its contribution to food security. State-led policy design, which has followed a top-down approach, has failed to recognise these synergistic interactions or draw on traditional knowledge and practices on which they are built. Moreover, focusing only on the nutrition and income generation functions of the homegarden can undermine other important functions, such as the role of reciprocal exchange in building social relations.

The findings of this research also supported the relevance of urban jobs in the food security of the communities studied. Although participation in urban jobs tend to have a negative effect on homegarden food production, its income effect is usually larger, allowing households to compensate the loss from the homegarden with food purchased in the market. Nonetheless, low-skilled urban jobs are usually part of a broader *bricolage* of livelihood strategies, involving other on- and off-farm activities. Households tend to rely on 'rural' resources and depend on family and communal support. Survey data and the in-depth interviews collected in this research also provided evidence of the limited capacity of urban jobs to move people out of poverty, particularly in the semi-rural and rural communities. From these findings, it can be concluded that more opportunities to earn an income in their communities or in intermediate towns, would contribute to improve people's wellbeing, saving the time and money they spend in commuting to the urban areas.

Furthermore, as the findings of this thesis showed, even in the most rural communities, people's livelihood strategies and aspirations are shifting towards urban lifestyles. These transformations are opening opportunities to participate in off-farm livelihoods; however, they also represent a risk which could threaten future livelihood options. In the research sites, the main resources of the households are labour and land. As people become older, their chances to participate in urban jobs are reduced. In a precarious economic environment, it is unlikely that many will have gainful, formal employment or receive a

pension on retirement. Thus, if they lose their interest in and knowledge of agriculture, they are also risking the long-term wellbeing of their households and communities.

8.3 Limitations and future research

Given the diversity in the characteristics of the homegardens and the households investigated in this study, one of the main limitations of this research was the relatively small sample size. A larger data set, comprising more communities along the rural-urban spectrum and more sample households in each site, would have enabled a breakdown of the data into more within-groups, allowing me to conduct a deeper analysis of the interactions of the key factors influencing the relationship between homegardens and food security. Resources beyond those available for this doctoral research, may enable to conduct deeper analysis using larger sample sizes in the future.

Another limitation was the timeframe of the data collected. Even if some seasonal variations were captured during the different phases of my fieldwork activities, a comprehensive understanding of the role of homegardens in livelihood security would have required a follow up of the same households across different seasons of the year. Future research addressing this seasonal dimension of people's livelihoods would contribute to a more thorough understanding of the role of homegardening as a livelihood strategy. This is particular relevant for those more 'ruralised' households that still show a high dependence on on-farm activities and their livelihoods are thus more vulnerable to seasonal variations.

Participation of researchers from other disciplines, such as Agronomy, Veterinary Science, Social Anthropology, Rural Sociology and Human Nutrition, would have allowed for a more interdisciplinary approach and a deeper understanding of the relationship between homegardening and livelihood security in the field sites. Questions on plant pests and diseases, soil management and animal diseases were asked frequently by the research participants, but I was not in a position to offer them sound technical advice. Research on homegardens in Yucatán is an interdisciplinary field where scholars from fields as diverse as Anthropology, Human Nutrition, Economics, Botany, Agronomy, to mention some, have collaborated to gain a better understanding of this complex and dynamic system. Although I was in constant communication with several of these scholars, while conducting this doctoral research, I am looking forward to collaborate in interdisciplinary research projects with them and other researchers in the future.

This research studied the contribution of homegardening to livelihood security, revealing different pathways through which homegardens contribute to peoples' livelihoods. However, detailed analysis of the linkages between homegarden diversity and livelihood outcomes was only focused on food security. Further research is needed to improve the understanding of the contribution of homegardening to other dimensions of wellbeing, particularly to those non-tangibles. For example, the exchanges of homegarden products were found to occur mainly outside the market, which contributed to strengthening social relations. However, the scope of this research was not broad enough to capture qualitative information on the relationship between homegardens and social relations and on how intensified rural-urban interactions are shaping them. The loss of traditional knowledge on homegardening was another related research gap identified which I was not able to address in detail in this thesis.

Access to financial services is limited in the field sites. For example, of the four communities, only the peri-urban one has an automated teller machine. The homegarden animals work as a 'savings repository' and people usually sell them to pay medical bills or to make housing improvements, or people slaughter them for important celebrations. A more detailed collection of data on income flows, savings and debt management behaviour would have facilitated a more thorough understanding of the role of homegardens as savings repositories.

Intra-household dynamics is a topic that was not explored in this research, since the analysis was conducted at household and community level. However, from the analysis of the participation of people in different livelihood activities, it became apparent how young men were better positioned to take advantage of urban jobs and other off-farm activities than women and the elderly. Furthermore, the study of the effect of rural-urban interactions on homegardening could have been enriched with a more detailed analysis of the different exchanges between rural and urban areas, beyond job-related commuting and a comparison of on- and off-farm income sources.

Another area identified for future research is the understanding of the influence of returning internal migrants. In the regions where this research took place, job related movements are mainly within the Yucatán Peninsula. In Yaxcabá, the semi-rural community located in the *milpa* region, young families who had migrated to Cancún were found to be returning to the same area. The main causes people mentioned for these movements were increasing living costs and urban insecurity. This is a recent phenomenon that, to my knowledge, has not yet been studied in the region, but which may mark at least a partial shift from the current rural-to-urban transition to a reverse urban-to-rural movement.

8.4 Final reflections

This thesis aimed to contribute to the understanding of how rural urbanisation influences the role of homegardening as a livelihood strategy. To achieve this, the effects of rural urbanisation were examined in terms of the changes observed over time and the differences captured across the space. Moreover, a hybrid 'Endowments-based Livelihoods Framework' (ELF) was developed to analyse how household and community characteristics were mediating the relationship between homegarden diversity, rural urbanisation and livelihood security.

In the past, homegardens were intimately connected with the *milpa* system, but as *milpa* production has declined, homegardens are now interacting with more 'urbanised' livelihood activities. Throughout this thesis I showed how rural urbanisation is associated to reductions in homegarden diversity, undermining and changing the functions performed by the homegardens. However, alternative pathways were identified in addition to this dominant trend, where some households managed to maintain highly diverse homegardens.

Food security was identified as the main contribution of homegardening to livelihood security. The relationship between homegardening and household food security was observed to depend on homegarden diversity and its interaction with other livelihood sources, particularly social programmes and urban jobs, and household characteristics, such as wealth and education. The rural-urban location of the household was also found to mediate these interactions.

These research findings shed light on how the relationship between homegardening and livelihood security works in an increasingly urbanised context, on how household characteristics mediate this relationship, and on the complementarities and trade-offs in the interactions between homegardening and other livelihood strategies.

Ultimately, this thesis aimed to inform policies targeted at improving people's livelihoods. Policies that would account for the complexity of livelihood diversification, as well as for context and household specificities. Policies that in the long-term, would enable Yucatecan young people, such as Lool-be, the fictional character that introduced this thesis, to have access to livelihood strategies beyond migration and precarious jobs.

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Appendices

Appendix A. Rural-urban classification of municipalities

The National Institute for the Federalism and the Municipal Development (INAFED by its Spanish acronym) uses the following rural-urban classification of municipalities:

- Metropolitan: more than 50% of the population lives in localities of more than one million inhabitants.
- Large urban: more than 50% of the population lives in localities between 100 thousand and one million inhabitants.
- Medium urban: more than 50% of the population lives in localities between 15 thousand and less than 100 thousand inhabitants.
- Semi-urban: more than 50% of the population lives in localities between 2,500 and less than 15 thousand inhabitants.
- Rural: more than 50% of the population lives in localities with less than 2,500 inhabitants.
- Mixt: The population is distributed in the above categories, but in a proportion lower than 50%.

Appendix B. Participatory research techniques

B.1 Community mapping

Participatory mapping has been used to learn from local people on topics such as wealth, resources management, health and education (Mascarenhas and Kumar, 1991). Group sizes and materials vary depending on the topic and context. The recommended group size is between 8 and 10 participants, but this technique has been applied in groups as big as 50 participants (Jones, 1996). Participatory maps have been constructed on the ground, paper or using existent maps (Mascarenhas and Kumar, 1991; Jones, 1996). An essential part of community mapping is to "interview the map", that is to discuss issues emerged from the mapping exercise (Jones, 1996).

In this research, participatory mapping was used in the exploratory phase of fieldwork to gain general knowledge on the main places and everyday practices in the four communities. Research participants were mainly women and the size of the groups was of between 6 and 15 participants. Research participants were asked to highlight or draw, on printed maps, the most important places in the communities. They highlighted: main roads, schools, health clinics, shops, maize grinders, butcher shop, water wells, tap water tanks, churches, midwives' houses, sport fields, *milpa* plots, local authorities' offices, cultural/handicraft house, small shops and the graveyard. After they finished drawing on the maps, we discussed together why these places were important to them. Since most of the participants were women, they usually mentioned how men would have highlighted other places, such as beer shops. Figure B.1 shows maps drew by participants of Sahcabá (semi-rural, sisal region) and Kancabdzonot (rural, *milpa* region).

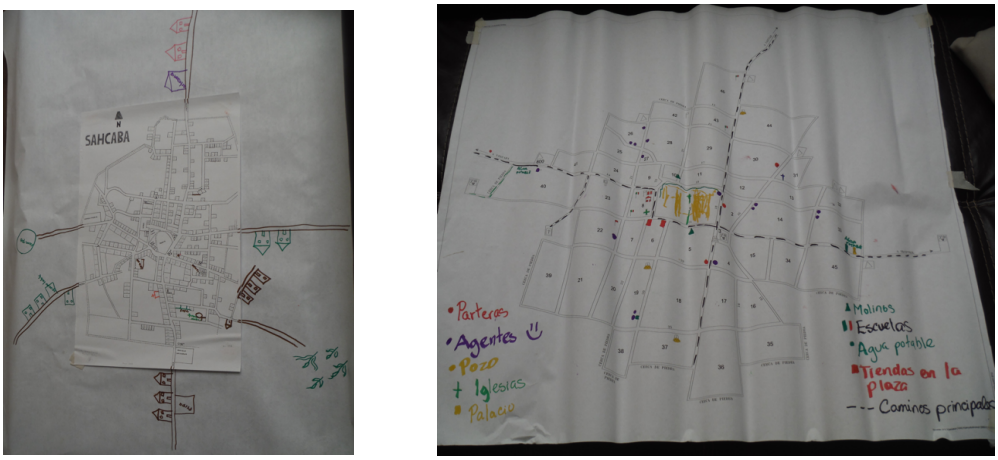

Figure B.1 Maps drew by research participants in Sahcabá (semi-rural, sisal region) (left) and Kancabdzonot (rural, *milpa* region) (right)

B.2 Preference matrices and free lists

Preference matrices and free lists were used to elicit information on the main plants managed in the homegardens and their uses. Preference matrices are used to explore people´s preferences and priorities for a set of items and to understand their choices (Pretty *et al.,* 1995). This technique has been used in a wide range of topics, such as: varieties of cereal, types of fertiliser, homegarden crops, fodder plants, etc. (Pretty, 1990). In this research, participants of the sisal region were asked to select between four and five main plants that they had in their homegarden and to list them in the first column of the matrix. Between 4 and 6 items are recommended for this exercise (Pretty, 1990). Then participants selected four criteria to characterise these plants according to their preferences. In Sahcabá and Hocabá (sisal region) the criteria selected were: if the plants were used as food; if they were sold; if they contributed to their health; and if they were easy to cultivate (Figure B.2). The next step was to assign a score from 1 to 5 to each plant per criterium. This scoring exercise did not work well in all the sub-groups, but when the participants did not score the plants, they explained why the plants were important for them. At the end of the exercise the matrices were "interviewed", as it is the general practice for preference matrices and other visual participatory techniques (Pretty, 1990).

Since I realised preference matrices limited the number of plants to be discussed and given the diversity of the homegardens of the research sites, in the communities of the *milpa* region I applied free lists instead of preference matrices. Free listing involves asking the participants to create an inventory of all the items they know within a given category (Quinlan, 2005). Free listing is an ethnographic research method based on three assumptions: (i) people tend to list terms in order of familiarity; (ii) people with more knowledge list more items than people with less knowledge; and (iii) people's lists reflect locally prominent items (Ibid.). Free listing has been previously used in ethnobotany studies to identify the most culturally salient plants and their uses (Quinlan, 2005; Rivera *et al*., 2007; Powell *et al*., 2014).

In Yaxcabá (semi-rural, milpa region), since there were over 20 participants, sub-groups were formed according to categories of plants suggested by them: fruit trees; non-fruit trees; vegetables; aromatic and medicinal plants; and ornamentals. Then plants were listed and the whole group discussed the different uses and who were involved in their management. In Kancabdzonot (rural, milpa region), where the group was formed by 16,

they asked to work all together and thus, all the plants were listed together. Figure B.2 presents some pictures of preference matrices and free lists.

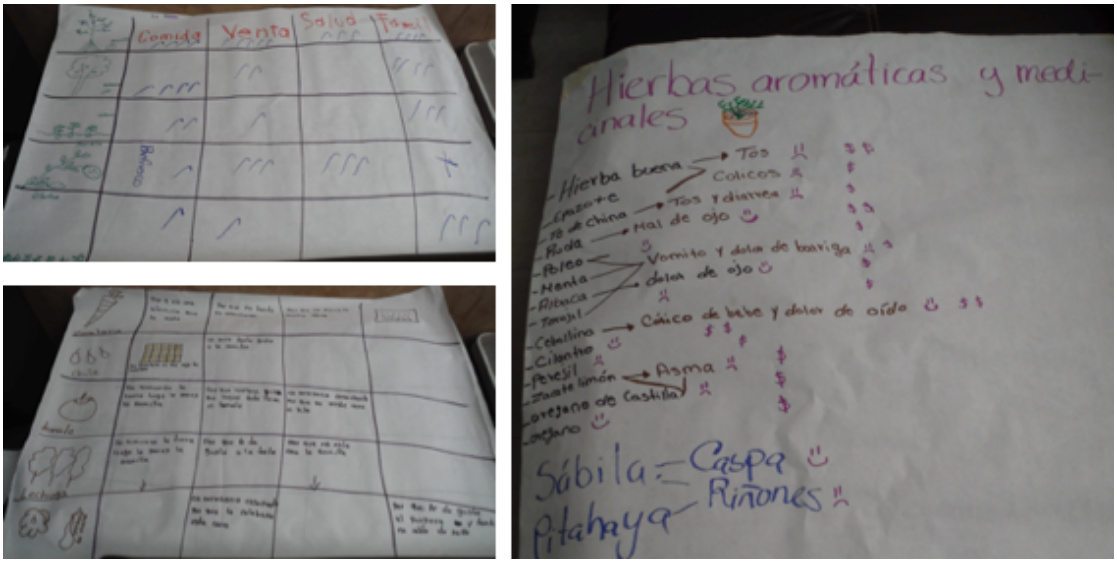

Figure B.2 On the left, preference matrices (Sahcabá, semi-rural, sisal region) and on the right, a list of the main plants grown in the homegardens (Yaxcabá, semi-rural, *milpa* region)

B.3 Seasonal calendars

Seasonal calendars are used to understand the changes in people's livelihoods over the year (Pretty, 1990). They can represent patterns of rainfall, water use, diseases, crop sequences, labour demand, pests, migration, and so on (Pretty, 1990; Laderchi, 2001). Research participants were asked to develop seasonal calendars depicting the variability in food availability, rain fall, diseases and workloads in the homegarden and in the *milpa*. For each category research participants assigned a score between zero and five depending on how much it usually affects their lives in each of the 12 months of the year. Since the general practice is to not necessarily begin the calendar in January (Pretty, 1990), research participants decided which month would the calendar begin in. Figure B.3 presents pictures of two seasonal calendars developed by research participants in Sahcabá (semi-rural, sisal region) and Kancabdzonot (rural, *milpa* region).

Figure B.3 Seasonal calendars from Sahcabá (semi-rural, sisal region) and Kancabdzonot (rural, *milpa* region)

B.4 Other drawing and diagramming activities

Drawing is regarded as a powerful participatory technique to express person's views (Chambers, 2012). In addition to the topics already mentioned, drawing and diagramming were used to elicit information on three topics: the meanings of a 'good life'; the main livelihoods of the people living in the field sites; and the main rural-urban and rural-rural interactions.

I asked research participants to draw what was to have a 'good life', *buena vida* in Spanish and *ma'alob kuxtal* in Maya. At the end of the exercise the drawings were discussed, either in small groups or with the larger group, as requested by research participants. The strategy I followed when collecting information on the main livelihoods and interactions with other communities varied depending on the community. In Sahcabá (semi-rural, sisal region) participants drew and wrote down the main livelihoods of men and women. In the communities of the *milpa* region participants preferred to discuss these topics all together and asked me to draw the diagram while they were commenting on it. Once we obtained a first version of the diagram I asked again if something was missing or wrong and I changed or complemented the diagram as they guided me. In Hocabá I was not able to conduct this activity since research participants of this community showed lower availability than those in the other three communities. Differences on the livelihoods between men and women were discussed at the end of each exercise. Figure B.4 shows drawings and diagrams developed in Yaxcabá.

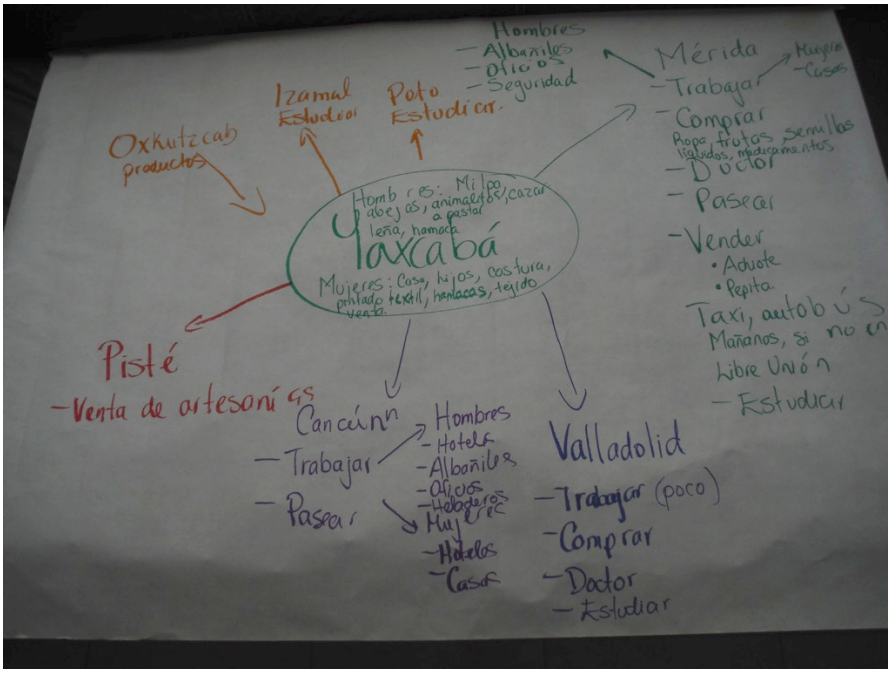

Figure B.4 Drawings on a 'good life' and interactions with other communities from Yaxcabá (semi-rural, *milpa* region)

Appendix C. Household survey questionnaire

Introduction and asking for consent
1. Household ID
2. Date
3. Name of the interviewer
4. Municipality
5. Community
4. Household address
5.Is the house inhabited?

Yes ☐ No ☐

6.Respondant's name
7.Was this household surveyed in 1997?

Yes ☐ No ☐

If it was not Who is now living in the house? _____

I. HOMEGARDEN CHARACTERISTICS

8. Solar size (square meters)
9. Homegarden age

☐ 15 or less
☐ Between 16 and 50
☐ Between 51 and 100
☐ More than 100

10. What is(are) the source(s) of the water used for watering the homegarden?
Code: 1=well, 2=tap water, 3=rain water, 4=none.
11. What vegetal species do you grow in your homegarden?

Species name	Number	Main uses	Gift or exchange (Yes / No)	Sale (Yes / No)	Where do you sale it?	If other community, specify the name	Price (Mexican pesos)	Unit of measurement	How often do you sale it?

Codes
Main uses: 1=eating fresh, 2=condiment, 3=cooking, 4=drinking, 5=ornamental, 6=medicinal, 7=construction, 8=animal feeding, 9=fodder, 10=fertilizer, 11=shadow, 12=tool / utensil, 13=wood, 14=insecticide, 15=ritual, 16=to attract bees / birds, 17=other.
Sale: 0= Not for sale, 1= Sold fresh, 2=Sold cooked.
Where: Butcher shop, market, mill, groceries shop, house, street_sale, other community.
Frequency: Weekly, monthly, yearly, occasionally, seasonal, other

12. Is there any fruit or crop loss?

Yes ☐ No ☐

If yes

12a. Which species? _____

12b. Why is it wasted? (no_time, no_help, do_not_like, lowprices, plague, other) _____

13. Do you grow crops or fruit trees in another plot (different from the homegarden and the milpa)?

Yes ☐ No ☐

If yes

13a. Main use

Consumption ☐ Sale ☐

14. What animals do you rise in your homegarden?

Species name	Number	Main uses	Gift or exchange (Yes / No)	Sale (Yes / No)	Where do you sale it?	If other community, specify the name	Price (Mexican pesos)	Unit of measurement	How often do you sale it?

Codes

Main uses: 1=food, 2=ritual, 3=sale, 4=fertilizer, 5=pet, 6=hunting, 7=protection.

Sale: 0= Not for sale, 1= Sold alive, 2=Sold processed.

Frequency: Weekly, monthly, yearly, occasionally, seasonal, other

Where: Butcher shop, market, mill, groceries shop, house, street_sale, other community.

15. Do you use any of these inputs in your homegarden?

Input	Yes/No	Source	Where	Community name	Amount spent	How often do you buy it?
Seeds						
Earth						
Fertilizer						
Herbicide						
Pesticide						
Animal feeding						
Animal medicines / veterinary services						

Codes:

Source: 1=do it by a family member, 2=gift/exchange, 3=government, 4=university, 5=NGO, 5=bought.

Where: 1=inside the comunity, 2=outside the community

Frequency: Weekly, monthly, yearly, occasionally, seasonal, other

16. What are the main differences between this homegarden and the homegarden you had as a child?

II. FOOD SECURITY

17. I would like to ask you about all the different foods that your household members have eaten in the last 7 days. Could you please tell me how many days in the past week your household has eaten the following foods?
(for each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any)

	Number of days (0-7)	Primary source	Secondary source
Maize: Maize, pozol, tortilla, pimitos, tamales or any other meal made of maize			
Tubers: Tannia, potato, cassava, kohlrabi, etc.			
Bread / wheat: Rice, bread, pasta, oat or breakfast cereal.			
Pulses and groundnuts: Beans, lentils, peanuts, wax beans, slender green beans, broad beans or nuts.			
Milk and dairy products: Milk, cheese, cream or yogurth			
Meat: Pork, beef, chicken, etc. (Do not include organs of these animals)			
Organ meat: Liver, kidney, heart or other organs.			
Fish and seafood			
Eggs			
Orange vegetables: Squash, carrot, sweet potato or red pepper			
Dark green vegetables: Chaya, spinach, amaranth, chard or broccoli.			
Other vegetables: cucumber, tomato, cabbage, etc. (Do not include condiments)			
Orange fruits: Mango, papaya, melon.			
Other fruits: Citrus, banana, plum, watermelon, pitahaya, anonas, cocoyol, etc.			
Fat: Oil, animal fat or butter			
Sugar: Sweets, cakes, biscuits, mermelade or soft drinks			
Condiments: Small amounts of chilli, onion, coriander, tomato, sugar, coffee			

Codes
Sources: 1=hunting, 2=buy, 3=milpa, 4=forest, 5=gift, borrowing or exchange, 6=homegarden, 7=other plot, 8=other (specify)

18. Have you or any of the household members skipped a meal because of the lack of food or money? (In the last three months)

Yes ☐ No ☐

19a. If yes, who? _____

19b. If yes, Why did you face lack of food or money? _____

III. HOUSEHOLD CHARACTERISTICS

20. What type of toilet facilities are available? (1= flush toilet, 2=letrine, 3=outdoors)

21. Which of these services, appliances or equipment do you have?

	No=0, Yes=1
Tap water	
Electricity	
Refrigerator	
TV	
Radio	
Mobile	
Fan	
Bicycle	
Motorcycle	
Car	

22. How many families live in the household? _____

23. How many adults live in the household? _____

25. How many children and young people below 18 years old? _____

26. Household members characteristics

Member ID (1 head, 2 spouse)	First name	First surname	Second surname	Relationship to household head	Sex	Age	Marital status	Language	Education
1									
2									
3									
4									
5									
6									
7									

Codes:
Relationship: 1=spouse, 2=son/daughter, 3=parents, 4=grandparents, 5=grandchild, 6=daughter/son in law, 7=other relative, 8=non relative.
Sex= 0=male, 1=female.
Marital status: 1=single, 2=married, 3=cohabitating, 4=divorced, 5=widow/er.
Language: 0=Spanish, 1=Maya, 3=Maya and Spanish, 4=Other.
Education: Number of years, 0 = illiterate people.

27. Household members health status

Member ID (1 head, 2 spouse)	Chronic diseases	Infectious diseases	Other health conditions	Access to health services
1				
2				
3				
4				
5				
6				
7				

Codes:
Chronic disease: 0=none, 1=heart disease, 2=diabetes, 3=asthma, 4= hypertension, 5=arthritis, 6=stroke, 7=cancer, 8=other.
Infectious disease: 0=none, 1=respiratory, 2=gastro-intestinal, 3=dengue, 4=zika, 5=chikungunya, 6=other.
Access to health services: 0=none, 1=seguro popular, 2=servicios de salud (SSA), 3=IMSS, 4=ISSSTE, 5=private, 6=other.

IV. LIVELIHOODS AND RURAL-URBAN LINKS

28. What are the occupations of the household members?

Member ID (1 head, 2 spouse)	Main occupation	Other occupations	Where do you perform these activities?	If outside the community. Where?	How often do you commute back to the community?	How much do you spend in transportation?	How often do you spend this amount?	Do you receive any income from this occupation? (No=0, Yes=1)	How often do you receive this income?	How much do you receive?
1										
2										
3										
4										
5										
6										
7										

Codes
Occupations: 1=agriculture (milpa or plot), 2=apiculture, 3=livestock, 4=homegarden, 5=hunting, 6=wood cutting, 7=fisher, 8=housewife, 9= student, 10=clothes making, 11=other handicraft, 12=taxi (bike or motorcycle), 13=taxi (car), 14=merchant, 15=trade, 16=housekeeper, 17=construction worker, 18=labourer, 19=professional, 20=government employee,
Where: 0=within the community, 1=outside the community.
Frequency= 1=everyday, 2=twice or three times a week, 3=weekely, 4=every 15 days, 5=monthly, 6=once the work is finished, 7=other(specify).

28a. If the milpa was cultivated in the household What was the area cultivated in 2016?
28b. What crops did you cultivate?

29. Did you receive any support (subsidy or funding) from the government / university or NGO in the last year?

Type of support	Source	Source name (Programme and/or	Amount or support details	How often do you receive this support?

Codes
Type: 1=in kind, 2=money, 3=technical assistance, 4=products commercialization, 5=other(specify).
Source: 1=government, 2=university, 3=NGO, 4=other.
How often= 1=weekely, 2=every 15 days, 3=monthly, 4=every two months, 5=every six months, 6=yearly.

30. Have any of the household members receive or send remittances?

Member ID (1 head, 2 spouse)	Receive (0=No, 1=Yes)	How much?	How often?	From who?	Where does this person live?
1					
2					
3					
4					
5					
6					
7					

Codes
How often= 1=weekely, 2=every 15 days, 3=monthly, 4=every two months, 5=every six months, 6=yearly.
Who: 1=family, 2=friends, 3=other (specify)

Member ID (1 head, 2 spouse)	Send (0=No, 1=Yes)	How much?	How often?	Whom?	Where does this person live?
1					
2					
3					
4					
5					
6					
7					

Codes
How often= 1=weekely, 2=every 15 days, 3=monthly, 4=every two months, 5=every six months, 6=yearly.
Whom: 1=family, 2=friends, 3=other (specify).

31. Is there any family member who used to live in the house but migrated to another community?

Yes ☐ No ☐

31a. How many former household members? _____

31b.Where do they live? _____

V. PERCEPTIONS AND OPINIONS

32. What are the main changes the community has faced in the last 10 years?

_____

_____

33. What do you think is to have a 'good life' in the community?

☐	Attending to school
☐	Good social relationships
☐	Food sovereignty
☐	Food quality
☐	Having no worries
☐	Health
☐	Food (access)
☐	Job
☐	Shelter / House
☐	Other _____

34. Would you like to have more plants or animals in you homegarden?

Yes ☐ No ☐

Which species? Why?

_____ _____

Why?

_____

_____

Thank you very much for your time. May I take a picture of your homegarden?
I brought you these seeds (radish and coriander) as a way to thank for your time and knowledge.

General comments.

Appendix D. List of plant species

Family	Scientific name	Spanish name	Mayan name	Type of plant
Acanthaceae	Justicia spicigera Schltdl.		Ts'i'its	Shrub
Acanthaceae	Dicliptera assurgens Juss	Pensamiento		Herb
Acanthaceae	Justicia carthagenensis Jcq.		Ak'ab xiw	Shrub
Acanthaceae	Ruellia nudiflora (Engelm. & Gray) Urban.	Maravilla	Kabal ya'ax niik	Herb
Acanthaceae	Ruellia tuberosa L.	Hierba de la calentura	Kabal ya'ax niik	Herb
Adoxaceae	Sambucus mexicana C. Presl ex DC.	Ramo de novia		Herb
Agavaceae	Yucca elephantipes Regel Isote	Pata de elefante	Tuk	Herb
Agavaceae	Agave americana L.	Maguey		Herb
Agavaceae	Agave fourcroydes Lem.	Henequén		Herb
Agavaceae	Agave sisalana Perrine	Agave	Bab kij	Herb
Agavaceae	Agave tequilana F.A.C. Weber	Agave azul tequilero		Herb
Amaranthaceae	Amaranthus spinosus L.	Quelite blanco	Xtees	Herb
Amaranthaceae	Celosia argentea L.	Cresta de gallo	Sabakpox	Herb
Amaranthaceae	Celosia virgata Jacq.	Zorrillo negro		Herb
Amaranthaceae	Spinacia oleracea L.	Espinaca		Herb
Amaryllidaceae	Hippeastrum striatum (Lam.) H.E. Moore	Lirio		Herb
Amaryllidaceae	Allium schoenoprasum L.	Cebollina		Herb
Amaryllidaceae	Crinum amabile Donn ex Ker Gawl.	Lirio Jacinto		Herb
Amaryllidaceae	Polianthes tuberosa L.	Azucena		Herb
Amaryllidaceae	Zephyranthes carinata (L.) Herb.	Brujita		Herb
Anacardiaceae	Spondias mombin L.	Ciruela	Ju'ujub - Jobo	Tree
Anacardiaceae	Anacardium occidentale L.	Marañón		Tree
Anacardiaceae	Astronium graveolens Jacq.		K'ulinché	Tree
Anacardiaceae	Mangifera indica L.	Mango		Tree
Anacardiaceae	Spondias lutea L.	Ciruela amarilla		Tree
Anacardiaceae	Spondias purpurea L.	Ciruela campechana	Chi'abal	Tree
Anacardiaceae	Metopium brownei (Jacq.) Urban		Cheechem	Tree
Annonaceae	Annona muricata L.	Guanábana	Tak'ob	Tree
Annonaceae	Annona squamosa L.	Saramuyo	Ts'almuy	Tree
Annonaceae	Mosannona depressa (Baill.) Chatrou		E'ele'muy	Tree
Annonaceae	Sapranthus campechianus (Kunth) Standl.	Manchado		Tree
Annonaceae	Annona cherimola Miller	Chirimoya	Ek'mul	Tree
Annonaceae	Annona purpurea Moc. &Sessé ex Dunal	Anona morada	Chak oop	Tree
Annonaceae	Annona reticulata L.	Anona		Tree
Apiaceae	Coriandrum sativum L.	Cilantro		Herb
Apiaceae	Petroselinum crispum (Mill.)	Perejil		Herb
Apiaceae	Pimpinella anisum L.	Anís		Herb
Apocynaceae	Allamanda blanchetti A.DC.	Amallanda		Herb
Apocynaceae	Allamanda cathartica L.	Enredadera flores amarillas		Herb
Apocynaceae	Cascabelagaumeri (Hemsl.) Lippold	Campanilla	Aki'its	Herb
Apocynaceae	Tabernaemontana amygdalifolia Jacq.	Jazmín de perro	Utsun pek'	Tree
Apocynaceae	Tabernaemontana divaricata (L.)	Clavel		Herb
Apocynaceae	Catharanthus roseus (L.) G.	Vicaria		Herb
Apocynaceae	Echites tuxtlensis Standl.		I'ibin kaan	Herb
Apocynaceae	Mandevilla hirsuta (Rich.) K. Schum		sak away	Herb
Apocynaceae	Nerium oleander L.	Narciso		Shrub
Apocynaceae	Plumeria obtusa L.		Nicte' ch'oom	Tree

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Apocynaceae	Plumeria rubra L.	Flor de Mayo	Chaknikte'	Tree
Apocynaceae	Stapelia atropupurea Salm-Dyck	Estrella		Herb
Apocynaceae	Tabernaemontana coronaria (Jacq.) Willd.	Clavel de la india		Herb
Apocynaceae	Thevetia ahouai (L.) A. DC.	Huevos de toro	Sutum pek	Shrub
Apocynaceae	Thevetia peruviana (Pers.) Schum.	Campanilla de oro	Ajkits	Tree
Araceae	Aglaonema commutatum Schott.	Hoja pinta	Ye patié	Herb
Araceae	Alocasia plumbea Van Houtte	Oreja		Herb
Araceae	Anthurium schlechtendalii Kunth.	Pata de gallo	Bobtun	Herb
Araceae	Caladium bicolor Vent.	Corazón de cristo		Herb
Araceae	Epipremnum pinnatum var. aureum Nicolson	Teléfono		Herb
Araceae	Syngonium podophyllum Schott.	Motusai	Oochil	Herb
Araceae	Xanthosoma yucatanense Engl.		Makal	Herb
Araliaceae	Dendropanax arboreus (L.) Decne. & Planch		Sak chakaj	Tree
Araliaceae	Polyscias balfouriana (André) L.H. Bailey	Cola de mono		Tree
Arecaceae	Pseudophoenix sargentii H. Wendl. Ex Sarg.		Kuká	Tree
Arecaceae	Acrocomia mexicana Karw. Ex Wart.	Cocoyol	Itsuk	Tree
Arecaceae	Chamaedora oblongata Mart.	Palma ornato		Tree
Arecaceae	Cocos nucifera L.	Coco		Tree
Arecaceae	Cryosophila stauracantha (Heynh.) R. Evans	Escoba		Tree
Arecaceae	Dypsis lutescens (H. Wendl.) Beentje & J. Dransf.	Palma de oro areca		Tree
Arecaceae	Roystonea regia (Kunth) O.F. Cook	Palma real		Tree
Arecaceae	Sabal mexicana Mart.	Guano	Xa'an	Tree
Arecaceae c	Chameadora seifrizii Burret	Palmita	Xiat	Tree
Aristolochiaceae	Aristolochia maxima Swartz	Guaco	Xaakak'	Herb
Asclepiadaceae	Huernia schneideriana Berger	Cuernito		Herb
Asclepiadaceae	Asclepias curassavica L	Rompe muelas	Anal, analk'ak	Herb
Asparagaceae	Asparagus densiflorus (Kunth) Jessop	Jardinera		Herb
Asparagaceae	Asparagus setaceus (Kunth) Jessop	Espárrago		Herb
Asparagaceae	Chlorophytum comosum (Thunb.) Jacques	Mala madre		Herb
Asparagaceae	Sansevieria hyacinthoides (L.) Druce	Lengua de vieja		Herb
Asparagaceae	Sansevieria zeylanica Willd.	Lengua de vaca		Herb
Asphodelaceae	Aloe vera (L.) Burm f.	Sábila		Herb
Asteraceae	Calea urticifolia (Miller) DC.	Hierba de la paloma	Xikin	Herb
Asteraceae	Helianthus annuus L.	Girasol		Herb
Asteraceae	Lactuca sativa L.	Lechuga		Herb
Asteraceae	Zinnia violacea Cav.	Virginia		Herb
Asteraceae	Artemisia mexicana Gray Willd. & Spreng.	Estafiate	Tsi'tsim	Herb
Asteraceae	Aster novi-belgii L.	Margarita		Herb
Asteraceae	Dahlia pinnata var. coccinea (Cav.) Voss	Pon pón		Herb
Asteraceae	Montanoa grandifolia DC.	Teresita		Herb
Asteraceae	Tagestes erecta L.	Flor de Muerto	Xpuhuk	Herb
Asteraceae	Tagetes lucida Cav.	Pericón		Herb
Asteraceae	Tithonia diversifolia (Hamsley) A. Gray	Árnica		Shrub
Balsaminaceae	Impatiens balsamina L.	Miramelindo		Herb
Begoniaceae	Arrabidaea floribunda (Kunth) Loes		Aanil kaab	Herb
Begoniaceae	Begonia lindleyana Walp.	Begonia		Herb
Begoniaceae	Begonia rex Putz.	Mano de León		Herb
Bignoniaceae	Crescentia cujete L.	Jícara	Was	Tree
Bignoniaceae	Parmentiera aculeata (Kunth) Seem.	Pepino kat		Tree

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Bignoniaceae	Tabebuia rosea (Bertol.) DC.	Makulis	Sak bek	Tree
Bixaceae	Bixa orellana L.	Achiote		
Bombacaceae	Ceiba petandra (L.) Gaertn	Ceiba	Yaxche'	Tree
Bombacaceae	Ceiba schottii Britton & Baker	Pochote	Pi'im	Tree
Bombacaceae	Pachira aquatica Aubl.	Zapote de agua	K'uy che'	Tree
Boraginaceae	Cordia dodecandra A D.C.	Ciricote	K'oopte'	Tree
Boraginaceae	Cordia gerascanthus L.	Bojom	K'oopte'	Tree
Boraginaceae	Ehretia tinifolia L.	Roble	Bek	Tree
Brassicaceae	Brassica juncea (L.) Czern.	Mostaza		Herb
Brassicaceae	Brassica oleracea L.	Col		Herb
Brassicaceae	Raphanus sativus L.	Rábano		Herb
Bromeliaceae	Ananas comosus (L.) Merr.	Piña		Herb
Bromeliaceae	Tillandsia bulbosa Hooker	Bromelia	Jolul siijal	Herb
Bromeliaceae	Bromelia pinguin L.	Piñuela	Tsalbay	Herb
Burseraceae	Bursera simaruba (L.) Sarg.	Palo mulato	Chakah	Tree
Cactaceae	Opuntia ficus indica (L.) Miller	Nopal		Herb
Cactaceae	Hylocerus undatus (Howorth) Britt. & Rose	Pitaya	Chakam	Herb
Cactaceae	Opuntia ficus-indica (L.) Mill	Tuna		Herb
Cannaceae	Canna glauca L.	Bandera	Ix pujúc	Herb
Capparaceae	Forchhammeria trifoliata Radlk.	Tres marías	K'olok'ma'ax	Herb
Caprifoliaceae	Sambucus mexicana Presl.	Ramo de novia		Herb
Caricaceae	Carica mexicana (A. DC.) L.D. Williams	Papaya de monte	chich puut	Shrub
Caricaceae	Carica papaya L.	Papaya	puut	Herb
Chenopodiaceae	Chenopodium abrosioides L.	Epazote, apazote		Herb
Combretaceae	Terminalia catappa L.	Almendro		Tree
Convolvulaceae	Ipomoea carnea Jacq.	Campanilla		Herb
Convolvulaceae	Ipomoea batatas (L.) Poir	Camote	Is	Herb
Crassulaceae	Kalanchoe blossfeldiana Poe.	Tres hermanos		Herb
Crassulaceae	Kalanchoe daigremontiana Raym.-Hamlet & H. Perrier	Belladona		Herb
Cucurbitaceae	Cucumis sativus L.	Sakpepino	Sakpepino	Herb
Cucurbitaceae	Cucurbita mixta Pang.	Calabaza	Xka', xtoop	Herb
Cucurbitaceae	Cucurbita moschata Duch.	Calabaza larga	K'uum, ts'ol	Herb
Cucurbitaceae	Cucurbita pepo L.	Calabaza pequeña	Mehen-k'um	Herb
Cucurbitaceae	Sechium edule (Jacq.) Swartz	Chayote	K'uum	Herb
Cucurbitaceae	Citrullus lanatus (Thunb.) Matsumara & Nakai	Sandía		Herb
Cucurbitaceae	Cucumis melo L.	Melón		Herb
Cucurbitaceae	Cucumis sativus L.	Pepino		Herb
Cucurbitaceae	Momordica charantia L.	Cundeamor	Yakunah-ak'	Herb
Cuppressaceae	Thuja orientalis L.	Pinito		Shrub
Cyclanthaceae	Carludovica palmata Ruiz & Pav	Jiji japa		Herb
Dryopteridaceae	Nephrolepis ribularis (Vahl) Mett. Ex. Krug	Helecho		Herb
Ebenaceae	Diospyros digyna Jacq.	Zapote negro	Tauch	Shrub
Euphorbiaceae	Acalypha alopecuroides Jacq.	Cola de zorrillo		Herb
Euphorbiaceae	Acalypha leptopoda Muell. Arg.	Manto de Cristo	Ya'ax ch'ilib tux	Herb
Euphorbiaceae	Euphorbia pulcherrima Willd.	Flor de Noche Buena	Xela te'	Shrub
Euphorbiaceae	Phyllanthus acidus (L.) Skeels	Grosella		Shrub
Euphorbiaceae	Cnidoscolus chayamansa Mc Vough	Chaya		Shrub
Euphorbiaceae	Croton chichenensis Lundell	Palo de quina	Eek' balam	Herb
Euphorbiaceae	Croton peraeruginosus Croizat	Oreja de burro	Eh balam	Herb
Euphorbiaceae	Euphorbia marginata Pursh	Flor blanca		Herb

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Euphorbiaceae	Euphorbia milii Des Moul.	Corona de Cristo		Herb
Euphorbiaceae	Euphorbia trigona Haw.	Abrázame si puedes		Shrub
Euphorbiaceae	Jatropha curcas L.	Piñón	Piij	Shrub
Euphorbiaceae	Jatropha gaumeri Grenm.	Piñón	Pomol che'	Shrub
Euphorbiaceae	Manihot esculenta Crantz	Yuca	Ts'iim	Shrub
Euphorbiaceae	Ricinus cuminis L.	Higuerilla	K'o'och	Shrub
Euphorbiaceae	Sebastiana confusa Lundell	Chechén blanco		Tree
Fabaceae	Galactia striata (Jacq.) Urban	Bejuco		Herb
Fabaceae	Senna alata (L.) Roxb.	Coqueta		Shrub
Fabaceae	Sesbania grandiflora (L.) Pers.	Flamboyán		Tree
Fabaceae	Tamarindus indica L.	Tamarindo	Pahch'uhuk	Tree
Fabaceae	Acacia angustissima (Miller) Blake		K'aantemo'	Shrub
Fabaceae	Acacia collinsi Safford	Cornezuelo	Subin che	Tree
Fabaceae	Bauhinia divaricata L.	Pata de vaca, pata de cabra	Ts'uru' took'	Shrub
Fabaceae	Caesalpinia pulcherrima L. Swartz	Camaroncito	Chaksik'in	Shrub
Fabaceae	Caesalpinia violacea (Miller) Standley		Chakte'	Tree
Fabaceae	Caesalpinia yucatanensis Greenm.	Cocoite negro	Taak'inche'	Tree
Fabaceae	Calliandra houstoniana (Miller) Standley	Cola de faisán	K'analsin	Shrub
Fabaceae	Canavalia ensiformis (L.) DC.	Habas, frijol blanco		Herb
Fabaceae	Cassia fistula L.	Lluvia de oro		Tree
Fabaceae	Cassia grandis L.	Fístula, palo verde	Yax tié	Tree
Fabaceae	Centrosema virginianum (L.) Benth.	Patito	K'antin	Herb
Fabaceae	Erythrina standleyana Krukoff	Colorín	Chakmolche	Tree
Fabaceae	Gliricidia sepium (Jacq.) Steud.	Cocoite	Sak ya'ab	Tree
Fabaceae	Inga paterno Harms	Caguama		Tree
Fabaceae	Inga vera subs. spuria (Willd) J.	León	Xeret	Tree
Fabaceae	Leucaena leucocephala (Lam.) de Witt.	Guaje	Uaxim	Tree
Fabaceae	Lonchocarpus castilloi Standl.	Machiche		Shrub
Fabaceae	Lysiloma latisiliquum (L.) Benth.	Tsalam	Tsalam	Tree
Fabaceae	Mucuna deeringiana Bort Merr.	Nescafé	Spiika bu'ul	Herb
Fabaceae	Peltophorum inerme (Rox.)	Naves Paraíso		Tree
Fabaceae	Phaseolus lunatus L.	Ibes		Herb
Fabaceae	Phaseolus vulgaris L.	Frijól	bu'ul	Herb
Fabaceae	Piscidia piscipula Sarg.	Jabín		Tree
Fabaceae	Senna pendula (Willd.) Irwin & Barneby	Cachimbo		Shrub
Fabaceae	Senna racemosa (Mill.) Irwin & Barneby		Kanlol, kanjabin	Tree
Heliconiaceae	Heliconia collinsiana Griggs.	Platanillo	Bijai	Herb
Heliconiaceae	Heliconia latispatha Benth	Platanillo		Herb
Lamiaceae	Ocimum micranthum Willd.	Albahaca de monte	Kakaltuun	Herb
Lamiaceae	Coleus amboinicus Lour.	Orégano grueso		Herb
Lamiaceae	Melissa officinalis L.	Toronjil		Herb
Lamiaceae	Mentha citrata Ehrh.	Yerbabuena	Xak'ilxiw	Herb
Lamiaceae	Mentha piperita L.	Menta		Herb
Lamiaceae	Ocimum basilicum L.	Albahaca	X-kakaltun	Herb
Lauraceae	Sassafras albidum (Nutt.) Nees.	Salsafrás		Shrub
Lauraceae	Nectandra salicifolia (H.B.& K.) Nees	Aguacatillo		Tree
Lauraceae	Persea americana Miller	Aguacate	Oon	Tree
Liliaceae	Allium cepa L.	Cebolla	Xku	Herb
Liliaceae	Cordyline terminalis (L.) Kunth	Muñeca, tepejilote		Herb
Liliaceae	Dracaena americana Donn. Smith	Despeinada		Shrub

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Liliaceae	Echeandia paniculata Rose	Vara de San Juan		Herb
Liliaceae	Allium sativum L.	Ajo	Kukut	Herb
Liliaceae	Aloe vera L.	Sábila	Hunpets'k'inki	Herb
Liliaceae	Dracaena deremensis Engl.	Don Julio		Herb
Liliaceae	Sansevieria trifasciata Prain.	Lengua de vaca		Herb
Lythraceae	Lagerstroemia indica L.	Astromelia		Shrub
Lythraceae	Lawsonia inermis L.	Residan		Shrub
Malpighiaceae	Byrsonima crassifolia (L.) HBK.	Nance	Chi'	Tree
Malvaceae	Hibiscus mutabilis L.	Malva roda		Shrub
Malvaceae	Malva alcea L.	Malva		Herb
Malvaceae	Gossypium hirsutum L.	Algodón	Pits'	Shrub
Malvaceae	Hibiscus rosa-sinensis L.	Tulipán		Shrub
Malvaceae	Hibiscus sabdariffa L.	Jamaica		Shrub
Marantaceae	Maranta arundinacea L.		Chaak	Herb
Martyniaceae	Martynia annua L.	Uña de gato	Chuc chich	Herb
Meliaceae	Melia azedarach L.	Paraíso	K'aankab	Tree
Meliaceae	Azadirachta indica A. Juss	Nim, neem		Tree
Meliaceae	Cedrela odorata L.	Cedro	K'uj che'	Tree
Meliaceae	Swietenia macrophylla King	Caoba	Punab	Tree
Moraceae	Artocarpus communis J.R. & G. Forster	Árbol de pan		Tree
Moraceae	Dorstenia contrajerva L.	Pluma de gallo	kabalhaw	Herb
Moraceae	Ficus carica L.	Higo		Tree
Moraceae	Brosimum alicastrum Swartz	Ramón	Ox	Tree
Moraceae	Chlorophora tinctoria (L.) Gaud.	Moral, palo mora	Chak ox	Tree
Moraceae	Ficus lyrata Warb.	Ficus		Tree
Moringaceae	Moringa oleifea Lam.	Moringa, paraíso blanco		Tree
Musaceae	Musa paradisiaca L.	Plátano		Herb
Musaceae	Musa sapientum L.	Plátano macho		Herb
Musaceae	Musa sapientum L. Var champa Baker	Plátano manzano		Herb
Myrtaceae	Pimenta dioica (L.) Merill.	Pimienta	Nukuch pool	Tree
Myrtaceae	Psidium guajava L.	Guayaba	Pichi	Tree
Nyctaginaceae	Bougainvillae glabra Choisy	Bugambilia		Shrub
Onagraceae	Oenothera stricta Ledeb	Flor San José		Herb
Orchidaceae	Encyclia belizensis (Rchb. f.) Schltr.	Orquídea		Herb
Papaveraceae	Argemone mexicana L.	Cardosanto	Ixk'anlol	Herb
Passifloraceae	Passiflora edulis Sims	Maracuyá		Shrub
Phytolaccaceae	Petiveria alliacea L.	Zorrillo	Paay che'	Herb
Piperaceae	Piper auritum H.B. & K.	Hierba santa, momo	Xmak'olan	Shrub
Poaceae	Digitaria insularis (L.) Fedde	Zacate taiwan		Herb
Poaceae	Panicum maximum Jacq.	Zacate guinea		Herb
Poaceae	Saccharum officinarum L.	Caña		Herb
Poaceae	Bouteloua disticha H.B. & K.		K'u'su'uk	Herb
Poaceae	Cymbopogon citratus (DC) Staff.	Zacate limón		Herb
Poaceae	Zea mays L.	Maíz	Nal	Herb
Polygonaceae	Coccoloba cozumelensis Hemsley		Ch'iich'bob	Tree
Polygonaceae	Coccoloba acapulcensis Standl.	Uvero	Xtohyub	Tree
Polygonaceae	Coccoloba spicata Ludell		Boob	Tree
Polygonaceae	Coccoloba uvifera (L.) L.	Uva de mar		Tree
Polygonaceae	Gymnopodium floribundum Rolfe	Palo cuerudo	Ts'its'ilche'	Tree
Pontederiaceae	Eichhornia crassipes (Mart.) Solms-Lamb	Lirio acuático, jacinto		Herb
Portulacaceae	Portulaca pilosa L.	Mañanita	Ts'ayoch	Herb
Portulacaceae	Portulaca oleracea L.	Verdolaga	Kabalchunup	Herb

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Punicaceae	Punica granatum L.	Granada		Shrub
Rhamnaceae	Colubrina greggi S. Watson var. Yucatanensis M. C. Johnst.	Pimienta che'		Tree
Rosaceae	Bouvardia longiflora (Cav.) Kunth	Rosa de San Juan		Herb
Rosaceae	Rosa chinensis Jacq.	Rosa		Herb
Rosaceae	Rosa gallica L.	Rosa de Castilla		Herb
Rubiaceae	Alseis yucatanensis	Standley Papelillo	Kakaw che'	Tree
Rubiaceae	Coffea arabica L.	Café		Tree
Rubiaceae	Ixora coccinea L.	Cocinera		Shrub
Rubiaceae	Morinda citrifolia (L.)	Noni		Shrub
Rubiaceae	Psychotria microdon (DC.) Urban	Cancerillo	Bakel-ak	Shrub
Rutaceae	Citrus aurantium (L.)	Naranja agria	Suuts'pak'aal	Tree
Rutaceae	Citrus reticulata Blanco	Mandarina		Tree
Rutaceae	Fortunella japonica L.	Naranjilla		Tree
Rutaceae	Citrus aurantiaca Swingle	Limón indio		Tree
Rutaceae	Citrus aurantifolia (Christh.) Swingle	Limón, limón persa		Tree
Rutaceae	Citrus deliciosa Ten.	Tangerina		Tree
Rutaceae	Citrus limetta Risso	Lima dulce		Tree
Rutaceae	Citrus limon (L.) Burm. f.	Limón real	Mulix pakal	Tree
Rutaceae	Citrus medica L.	China lima, cidra		Tree
Rutaceae	Citrus paradisi Max.	Toronja		Tree
Rutaceae	Citrus sinensis (L.) Osbek	Naranja dulce	Pak'aal	Tree
Rutaceae	Citrus sp.	Cajera		Tree
Rutaceae	Murraya paniculata (L.) Jacq.	Limonaria		Tree
Rutaceae	Ruta chalapensis L.	Ruda		Herb
Rutaceae	Zanthoxylum caribaeum Lam.		Sinanché	Tree
Sapindaceae	Nephelium lappaceum L.	Rambután		Shrub
Sapindaceae	Sapindus saponaria L.	Jaboncillo		Tree
Sapindaceae	Melicocus bijugatus HBK	Guaya cubana		Tree
Sapindaceae	Talisia olivaeformis (H.B. & K.) Raldlk.	Guaya india	Uayam	Tree
Sapotaceae	Chrysophyllum cainito L.	Caimito	Chi'keejil	Tree
Sapotaceae	Pouteria campechiana (H.B. & K.) Baehni.	Zapote amarillo	Kanisté	Tree
Sapotaceae	Pouteria glomerata (Miquel) Radlk.		Choch	Tree
Sapotaceae	Pouteria reticulata (Engl.) Eyma	Zapotillo	Ch'iich'ya'	Tree
Sapotaceae	Pouteria sapota (Jacq.)H.E. Moore & Stearn	Mamey	Chakal jass	Tree
Sapotaceae	Manilkara zapota (L.) P. Royen	Zapote	Chak yah	Tree
Simaroubaceae	Alvaradoa amorphoides Liebm.	Palo de hormiga	Belsinikche'	Tree
Simaroubaceae	Simarouba glauca DC.	Pistache	Pa'sak'	Tree
Solanaceae	Brugmansia x candida Pers.	Flor campana		Shrub
Solanaceae	Capsicum annuum L.	Chile Xkat	Xkat-ik	Herb
Solanaceae	Capsicum annuum var. aviculare D'Arcy & Eshbaugh	Chile piquín	X-max ik	Herb
Solanaceae	Capsicum frutescens L.	Chile de monte	Chile max	Herb
Solanaceae	Cestrum nocturnum L.	Dama de noche	Ak'ab yon	Shrub
Solanaceae	Datura inoxia Miller	Toloache	Chaniko	Herb
Solanaceae	Lycopersicum esculentum Miller	Tomate	P'ak	Herb
Solanaceae	Nicotiana tabacum L.	Tabaco	Kuts	Shrub
Solanaceae	Physalis arborescens L.	Tomatito		Shrub
Solanaceae	Physalis cinerascens (Dunal) Hitchc.	Tomatillo		Herb
Solanaceae	Solanum nigrescens M. Martens & Galeotii	Hierba mora		Herb
Solanaceae	Capsicum chinense Jacq.	Chile habanero	Chak-ik	Herb
Sterculiaceae	Guazuma ulmifolia Lam.	Guácimo	Pixoy	Tree

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Turneraceae	Turnera ulmifolia L.	Plumina de oro		Herb
Ulmaceae	Trema micrantha (L.) Blume		Sak piixoy	Tree
Urticaceae	Cecropia peltata L.		Kololché	Tree
Urticaceae	Pilea microphylla (L.) Liebm.	Frescura		Herb
Urticaceae	Pilea nummulariifolia (Sw.) Wedd.	Centavito		Herb
Urticaceae	Urera caracasana (Jacq.) Griseb	Ortiga	Lal	Shrub
Verbenaceae	Clerodendrum speciosissimum Van Geert	Flor roja		Herb
Verbenaceae	Cornutia pyramidata L.	Bastón de vieja	Xoolte'	Herb
Verbenaceae	Lippia graveolens Kunth.	Orégano	Xaak'che'	Shrub
Verbenaceae	Petrea volubilis L.	Enredadera		Herb
Verbenaceae	Vitex gaumeri Greenm.	Carrete	Ya'axnik	Tree
Vitaceae	Vitis vinifera L.	Uva		Shrub
Zingiberaceae	Alpinia purpurata (Viellard) Schumann	Alpinia roja		Herb
Zingiberaceae	Hedychium coronarium J. Korig	Mariposa		Herb
Zingiberaceae	Zingiber officinale Roscoe	Gengibre		Herb
Zygophyllaceae	Guaiacum sanctum L.	Guayacán	Chunchintok'	Tree

Source: Chi Quej (2009); Flores *et al.* (2013).

Appendix E. Classifications and typologies found in the literature on homegardens

Geographical area	Methodology	Sample size	Criteria	Categories	Source
Latin America, North America, Asia and Africa	Literature review	NAp	Degrees of dependence on homegardening.	Two categories: subsistence and budget gardens.	Niñez (1985)
Java, Indonesia	NA	NA	Plant species and main function.	Two classifications: - Fruit, vegetable, or flower species - Subsistence, kitchen, market, plant nursery and aesthetic.	Christanty, 1990 in Wiersum (2006)
Yucatán Peninsula, Mexico	Principal components analysis	60	Relative abundance of the plant species.	Three categories with different species dominance: - *Citrus spp*. and *Byrsonima crassifolia*; - *Sabal mexicana* and *Brosimum alicastrum*; - *Annona squamosa* and *Brosimum alicastrum.*	Caballero (1992)
Tetiz, Yucatán, Mexico	Indicators and thresholds determined by the author	77	Productive specialisation, economic orientation and income level.	Three different classifications: - Specialised, transitional and diversified; - Commercial, semi-commercial and consumption; - Surplus, subsistence and infrasubsistence.	Correa Navarro (1997)
Cameroon	Cluster analysis	150	Types of species (biological cycle and uses).	Three categories: - Maize gardens; - Staples and vegetables gardens and - Perennial species gardens (fruit trees and other trees).	Tchatat *et al.* (1996)
Yucatán Peninsula, Mexico	Principal components analysis and cluster analysis	300	Abundance of species.	Two categories with different species dominance: - Orange (*Citrus sinensis*) and banana (*Musa spp*.);	García de Miguel (2000)

Geographical area	Methodology	Sample size	Criteria	Categories	Source
				- Breadnut tree (*Brosimum alicastrum*), Unspined salt palm (*Sabal spp*.) and Spanish cedar (*Cedrela Mexicana*).	
San Juan de Oriente, Masaya, Nicaragua	Cluster analysis	20	Number of management zones, number of plant uses, number of plant species and total homegarden area.	Six categories: - Ornamental; - Handcrafting; - Subsistence; - Handcrafting and mixed production; - Mixed production and - Minimal management.	Méndez *et al.* (2001)
Andean and Central regions, Venezuela	Cluster analysis	36	Number of species.	Four categories related to four different ecozones.	Quiroz *et al*. (2002)
Vietnam	Literature review	NAp	Primary production systems, crop composition and structure.	Four categories: - Homegardens with fruit trees; - Homegardens with pond and covered livestock areas; - Homegardens with vegetables; - Homegardens with forest trees.	Trinh *et al.* (2003)
Central Sulawesi, Indonesia	Cluster analysis	30	Crop species (presence or absence).	Four categories: - Small, moderately old, species- and tree-poor spice gardens; - Medium-sized, old, species-rich fruit tree gardens; - Large, rather young, species- and tree-poor gardens of transmigrant families; - Diverse assemblage of rather old, individual gardens with a very high crop diversity	Kehlenbeck and Maass (2004)
Kerala, India	Cluster analysis	30	Structure, functions, management and dynamics.	Four categories: Traditional, adapted traditional, incipient modern and modern.	Peyre *et al*. (2006)
Niamey, Niger	Cluster analysis	51	Plant species composition.	Five categories: - Small, subsistence; - Large, commercial;	Bernholt *et al.* (2009)

Geographical area	Methodology	Sample size	Criteria	Categories	Source
				- Small and species poor; - Small and intermediate diversity; commercial and intermediate size gardens	
Campeche, Mexico	Cluster analysis	66	Species richness by botanical family.	Four categories (no further information).	Chi Quej (2009)
Africa, Asia and Latin America	Literature Review	NAp	Size, structure, components, functions and location.	Four categories: - Kitchen garden; - Traditional mixed gardens; - Market gardens and - Nursery gardens.	Landon-Lane (2011)
Benin	Cluster analysis and principal components analysis	235	Size, plant diversity (species richness), richness of crop wild relatives and prevailing plant group.	Three categories: - Herb-based; - Herbs and shrubs/trees-based and - Palm and liana-based homegardens.	Gbedomon *et al*. (2015)
Greater Bushenyi, Uganda	Cluster analysis	102	Plant species density.	Four categories: - Diverse tree gardens; - Small forest-edge gardens; - Large, old, species-rich gardens and - Large, annual-dominated herb gardens.	Whitney *et al.* (2018)

NAp: Not applicable; NA: Not available.

Appendix F. Wealth index computation

I constructed a wealth index, using five asset variables, following the main literature on wealth indices (Filmer and Pritchett, 2001; Vyas and Kumaranayake, 2006; Kolenikov and Angeles, 2009; Filmer and Scott, 2012; Dutta and Kumar, 2013; Johnston and Abreu, 2013; Neuman *et al.*, 2013; Smits and Steendijk, 2015) and after performing sensitive analysis using different combinations of assets. I applied an extension of Principal Components Analysis, using a tetrachoric correlation, which accounts to the discrete nature of the variables. For this purpose, I used the polychoricpca command in the software Stata 14. I found that the first component of the index explained 57.7% of the variation in the data. This percentage was higher than those found in the literature, which tend to be close to 30%, supporting the explanatory power of the index (Smits and Steendijk, 2015). The coefficients obtained from the fist component were used as weights (Table D.1) and multiplied by 1 if the household owned the asset or by 0 if the household did not own the asset. Then the results were summed up and the index was rescaled to values from 0 to 1. The weighting and summing up process is expressed by the following equation, where *WI* is the raw wealth index, w_i is the estimated weight of the *i* asset and x_i is the indicator variable of the *I* asset.

$$WI = \sum_{i=1}^{n} w_i * x_i$$

Table F.1 Scoring coefficients

Asset variable	Coefficients first component (weights)
Refrigerator	0.217485
Mobile	0.235588
Television	0.083953
Automobile	0.696346
Motorcycle	0.638414

The index was standardised and five quantiles were computed to define socio-economic groups. The common practice is to define the lowest 20-40% of the distribution as poor and the highest 20% as rich (Filmer and Pritchett, 2001; Smits and Steendijk, 2015). Quantiles were used to verify what is called 'internal coherence' in the literature. This refers to the analysis of asset ownership by socio-economic groups. Table D.2 shows the wealth index in comparison with household income.

Table F.2 Adult-equivalent monthly income by wealth quantile

Wealth quantiles	**Index 2** *(mean income, MXN)*
I	902.47
II	1272.03
III	1456.31
IV	1855.83
V	1885.04

Appendix G. PSM robustness of the matching method and sensitivity analysis

G.1 Prospera programme

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	163	163
Treated	151	151
Total	314	314

```
. pstest
```

Variable	Mean Treated	Mean Control	%bias	t-test t	t-test p>|t|	V(T)/ V(C)
age	54.848	54.726	0.8	0.07	0.946	0.68*
youthdepratio	.43247	.4068	3.2	0.37	0.709	0.70*
femaleh_alone	.11921	.11815	0.3	0.03	0.977	.
1.language_recoded	.07285	.04458	14.1	1.04	0.298	.
2.language_recoded	.03974	.0545	-5.2	-0.60	0.546	.
wealthindex_dsd	.31887	.33638	-7.1	-0.65	0.514	0.80
urbanjobs_p	.20042	.21735	-6.7	-0.58	0.561	0.85
2.community	.21854	.22561	-1.6	-0.15	0.883	.
3.community	.37748	.4033	-6.0	-0.46	0.647	.
4.community	.29139	.26846	6.4	0.44	0.658	.

* if variance ratio outside [0.73; 1.38]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.006	2.56	0.990	5.1	5.6	18.4	0.83	50

* if B>25%, R outside [0.5; 2]

```
. rbounds number_foodanimals, gamma(1 (.5) 5)

Rosenbaum bounds for number_foodanimals (N = 316 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
-------------------------------------------------------------------------
    1              0         0       5.5       5.5         4       6.5
  1.5              0         0       3.5         7       2.5       8.5
    2              0         0       2.5       8.5       1.5        10
  2.5              0         0         2        10         1      11.5
    3        1.3e-14         0         1        11        .5      12.5
  3.5        8.5e-13         0        .5      11.5  -4.3e-07      13.5
    4        2.0e-11         0        .5      12.5  -4.3e-07        15
  4.5        2.4e-10         0        .5        13  -4.3e-07      15.5
    5        1.8e-09         0  -4.3e-07        14  -4.3e-07        16

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)
```

G.2 Sixty-five and over programme

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	278	278
Treated	36	36
Total	314	314

```
. pstest
```

Variable	Mean Treated	Mean Control	%bias	t-test t	t-test p>|t|	V(T)/ V(C)
age	70.278	70.216	0.5	0.02	0.981	0.73
femaleh_alone	.25	.2431	1.8	0.07	0.947	.
maleh_alone	.08333	.08358	-0.1	-0.00	0.997	.
wealthindex_dsd	.25557	.24301	5.6	0.27	0.791	0.79
urbanjobs_p	.15456	.14771	2.8	0.13	0.896	1.13
2.community	.16667	.20046	-8.2	-0.37	0.716	.
3.community	.5	.46626	7.2	0.28	0.778	.
4.community	.13889	.12418	4.0	0.18	0.856	.

* if variance ratio outside [0.51; 1.96]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.005	0.47	1.000	3.8	3.4	15.9	0.77	0

* if B>25%, R outside [0.5; 2]

```
. rbounds number_foodanimals, gamma(1 (.5) 5)

Rosenbaum bounds for number_foodanimals (N = 316 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
----------------------------------------------------------------------
    1              0         0       5.5       5.5         4       6.5
  1.5              0         0       3.5         7       2.5       8.5
    2              0         0       2.5       8.5       1.5        10
  2.5              0         0         2        10         1      11.5
    3        1.3e-14         0         1        11        .5      12.5
  3.5        8.5e-13         0        .5      11.5  -4.3e-07      13.5
    4        2.0e-11         0        .5      12.5  -4.3e-07        15
  4.5        2.4e-10         0        .5        13  -4.3e-07      15.5
    5        1.8e-09         0  -4.3e-07        14  -4.3e-07        16

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)

. rbounds shannon_animals, gamma(1 (.5) 5)

Rosenbaum bounds for shannon_animals (N = 316 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
----------------------------------------------------------------------
    1              0         0   .270102   .270102   .225281   .318257
  1.5              0         0   .135594   .330781  -2.6e-07   .350927
    2        1.0e-14         0  -2.6e-07   .366531  -2.6e-07   .446944
  2.5        4.0e-12         0  -2.6e-07   .433782  -2.6e-07   .471674
    3        2.2e-10         0  -2.6e-07   .455509  -2.6e-07   .502693
  3.5        3.7e-09         0  -2.6e-07   .474623  -2.6e-07   .529739
    4        3.2e-08         0  -2.6e-07   .497224  -2.6e-07   .543538
  4.5        1.7e-07         0  -2.6e-07   .514826  -2.6e-07   .590516
    5        6.6e-07         0  -2.6e-07   .529739  -2.6e-07   .611984

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)
```

G.3 Proagro programme

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	258	258
Treated	56	56
Total	314	314

Variable	Mean Treated	Mean Control	%bias	t-test t	t-test p>|t|	V(T)/ V(C)
age	60.25	60.107	1.0	0.06	0.950	0.68
peasant	.89286	.89286	0.0	-0.00	1.000	.
aveducation	5.4123	5.0788	10.9	0.56	0.575	0.66
urbanjobs_p	.07968	.09054	-5.1	-0.36	0.723	0.82

* if variance ratio outside [0.59; 1.71]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.005	0.74	0.946	4.2	3.1	16.2	0.76	0

* if B>25%, R outside [0.5; 2]

```
. rbounds totalshanon, gamma(1 (.5) 5)

Rosenbaum bounds for totalshanon (N = 316 matched pairs)

Gamma           sig+      sig-    t-hat+    t-hat-       CI+       CI-
---------------------------------------------------------------------
    1              0         0   1.83847   1.83847   1.75973    1.9113
  1.5              0         0   1.71329   1.95357   1.63221   2.02569
    2              0         0   1.62734   2.03092   1.53932   2.10547
  2.5              0         0   1.55692   2.08949   1.45872    2.1598
    3              0         0   1.49944   2.13292   1.39439   2.20328
  3.5        1.1e-16         0   1.44768    2.1683   1.33728   2.24048
    4        7.1e-15         0   1.40404   2.19739   1.29547   2.27045
  4.5        2.0e-13         0   1.36471   2.22182   1.25276   2.29561
    5        3.0e-12         0   1.33166   2.24512    1.2154   2.31968

* gamma  - log odds of differential assignment due to unobserved factors
  sig+   - upper bound significance level
  sig-   - lower bound significance level
  t-hat+ - upper bound Hodges-Lehmann point estimate
  t-hat- - lower bound Hodges-Lehmann point estimate
  CI+    - upper bound confidence interval (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)
```

Appendix H. Government programmes supporting homegardening

Table H.1 Government programmes supporting homegardening

Organisation / Programme	Type of support	Field sites benefited	Number of beneficiaries
Ministry of Social Development (Backyard social production, PST)	Chickens (2013). Tools, a basic irrigation system, seeds, wire net, biological fertiliser and organic pesticide (2014-2016). Seeds and biological fertiliser (2014).	Yaxcabá (semi-rural) Kancabdzonot (rural)	Yaxcabá: 100 (2017). Kancabdzonot: 128 (2014).
Ministry of Rural Development (Backyard Livestock Production, PPT)	Chickens.	Hocabá (peri-urban) Sahcabá (semi-rural) Yaxcabá (semi-rural) Kancabdzonot (rural)	Hocabá: All the households (2014 and 2017) Sahcabá: All the households (2014 and 2017). Yaxcabá: All the households (2014 and expected in 2017) Kancabdzonot: All the households (2014 and expected in 2017).
Ministry of Rural Development (Strategic Project for Food Security, PESA)	Money for buying inputs and training. Projects supported on raising pigs and chickens, production of organic fertiliser and irrigation infrastructure for the production of maize and vegetables.	Sahcabá (semi-rural) Kancabdzonot (rural)	Sahcabá: 2 projects in 2014 and 4 projects in 2015. Kancabdzonot: 2 projects in 2015 and 1 project (one family) in 2016-2017 (16,311 GBP).
National Commission for the Development of Indigenous Peoples, CDI (Programme for the improvement of the indigenous production and productivity)	Money for buying inputs for vegetables cultivation.	Hocabá (peri-urban)	1 project, about 20 beneficiaries (2016).
Ministry of Environment and Natural Resources (Temporal Employment Programme)	Seeds, tools and money.	Hocabá (peri-urban)	30 families.
National System for the Integral Development of the Family, DIF (Programme of Community Development 'Different Community')	Seeds, tools, training and an irrigation system.	Sahcabá (semi-rural)	1 project, about 20 beneficiaries.

Source: Interviews with government officials and local authorities and official records.

Appendix I. Homegarden diversity and age of the main gardener

Table G.1 Plant diversity and age of the main gardener

Dependent variable	Plant diversity (Shannon diversity index)		
Average age of the household	**Coefficient**	**Standard error**	**P-value**
Linear term	0.01093	0.11727	0.420
Quadratic term	-0.00013	0.00008	0.209

Number of observations: 314.

Source: Survey data (December 2016-April 2017).

Table G.2 Animal diversity and age of the main gardener

Dependent variable	Animal diversity (Shannon diversity index)		
Average age of the household	**Coefficient**	**Standard error**	**P-value**
Linear term	0.00654	0.00309	0.124
Quadratic term	-0.00007	0.00002	0.050

Number of observations: 314.

Source: Survey data (December 2016-April 2017).

Appendix J. Determinants of food security

Table J.1 Determinants of food security (Plant diversity)

Dependent variable: food security (1,0)	Four field sites				Hocabá				Kitchen and ornamental gardens			
	Coeff.	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Homegarden characteristics												
Shannon diversity index (plants)	0.276 **	0.135	0.056 **	0.028	0.843 **	0.428	0.115 **	0.056	0.468 **	0.210	0.088 **	0.038
Age of the household head	-0.003	0.006	-0.001	0.001	0.002	0.020	0.000	0.003	0.000	0.015	0.000	0.003
Youth dependency ratio	-0.147	0.105	-0.030	0.021	0.254	0.422	0.035	0.057	-0.213	0.186	-0.040	0.035
Average education (years)	0.086 **	0.042	0.018 **	0.008	0.087	0.085	0.012	0.011	0.135 **	0.058	0.025 **	0.011
Language spoken by the household head (Base category: Spanish and Maya)												
Maya	0.220	0.240	0.040	0.040					0.310	0.926	0.051	0.135
Spanish	-0.106	0.174	-0.022	0.038	0.077	0.689	0.010	0.090	-0.153	0.427	-0.030	0.086
Female head (alone)	-0.190	0.293	-0.038	0.059	-0.688	0.571	-0.094	0.078	-0.496	0.374	-0.093	0.069
Male head (alone)	-0.333	0.386	-0.067	0.078	-0.236	0.756	-0.032	0.103	-0.211	0.442	-0.040	0.083
Wealth (index)	0.678 ***	0.185	0.137 ***	0.037	0.507	0.688	0.069	0.094	1.043	0.709	0.196	0.132
Rural-urban interactions												
Urban jobs	0.881 ***	0.296	0.178 ***	0.060	0.726	0.949	0.099	0.130	1.227 *	0.644	0.230 *	0.117
Off-farm diversification	0.021	0.244	0.004	0.049					-0.127	0.402	-0.024	0.076
Subsidies												
Sixty five and over	0.200	0.269	0.040	0.054	0.172	0.810	0.024	0.111	0.437	0.506	0.082	0.094
Prospera	0.210	0.312	0.043	0.063	-0.166	0.641	-0.023	0.088	-0.323	0.309	-0.061	0.058
Community (Base category: Hocabá, peri-urban)												
Sahcabá (semi-rural)	-0.650 ***	0.141	-0.121 ***	0.025					-0.603 *	0.342	-0.117 *	0.067
Yaxcabá (semi-rural)	-0.409 ***	0.103	-0.068 ***	0.015					-0.574	0.379	-0.110	0.074
Kancabdzonot (rural)	-0.776 ***	0.152	-0.154 ***	0.031					0.419	0.630	0.052	0.070
Constant	0.144	0.583			-1.076	1.734			-0.492	1.046		
Pseudo R^2	0.162				0.230				0.240			
Number of observations	313				89				196			

*** p-value<0.01, ** p-value<0.05 and * p-value<0.1.

Source: Survey data (December 2016-April 2017).

Table J.2 Determinants of food security (Food animals, diversity and number)

Dependent variable: food security (1,0)	Four field sites				Yaxcabá				Multifunctional and safety net gardens			
	Coeff.	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*	*Coeff.*	*Standard error*	*Marginal effect*	*Standard error*
Homegarden characteristics												
Shannon diversity index (animals)	0.394	1.070	0.086	0.079	1.864 *	0.975	0.278 **	0.138	2.232 **	0.991	0.340 **	0.138
Number of food animals[1/]	0.026 *	0.014	0.005 **	0.003	0.128 *	0.076	0.018 *	0.010	0.066 **	0.027	0.010 ***	0.004
Age of the household head	-0.003	0.007	-0.001	0.001	0.021	0.024	0.003	0.004	0.033	0.026	0.005	0.004
Youth dependency ratio	-0.138	0.087	-0.028 *	0.017	-0.376	0.466	-0.056	0.069	0.057	0.238	0.009	0.036
Average education (years)	0.078 *	0.042	0.016 *	0.008	0.246 **	0.119	0.037 **	0.016	0.166	0.124	0.025	0.018
Language spoken by the household head (Base category: Spanish and Maya)												
Maya	0.255	0.207	0.047	0.034					0.625	0.993	0.077	0.094
Spanish	-0.072	0.198	-0.015	0.042	0.011	1.064	0.002	0.158				
Female head (alone)	-0.184	0.272	-0.038	0.056	-0.187	0.678	-0.028	0.101	0.653	0.701	0.099	0.105
Male head (alone)	-0.268	0.377	-0.055	0.077	-0.484	1.240	-0.072	0.184	-1.842	1.537	-0.280	0.229
Wealth (index)	0.708 ***	0.149	0.145 ***	0.031	0.981	1.032	0.146	0.152	0.954	0.950	0.145	0.143
Rural-urban interactions												
Urban jobs	0.908 ***	0.259	0.185 ***	0.051	0.573	1.335	0.085	0.198	0.801	1.071	0.122	0.162
Off-farm diversification	0.001	0.206	0.000	0.042	-0.009	0.622	-0.001	0.093	0.417	0.515	0.063	0.077
Subsidies												
Sixty five and over	0.092	0.261	0.019	0.053	-0.356	0.704	-0.053	0.104	-0.816	0.628	-0.124	0.092
Prospera	0.233	0.314	0.048	0.065	-0.839	0.621	-0.125	0.090	1.209 **	0.490	0.184 ***	0.068
Community (Base category: Hocabá, peri-urban)												
Sahcabá (semi-rural)	-0.726 ***	0.101	-0.140 ***	0.020					-0.647	0.688	-0.083	0.080
Yaxcabá (semi-rural)	-0.375 ***	0.121	-0.061 ***	0.019					0.448	0.977	0.032	0.073
Kancabdzonot (rural)	-0.799 ***	0.088	-0.159 ***	0.015					-1.407 *	0.848	-0.248 *	0.118
Constant	0.538	0.497			-1.539	1.853			-3.427 *	2.052		
Pseudo R^2	0.158				0.323				0.341			
Number of observations	313				79				115			

*** p-value<0.01, ** p-value<0.05 and * p-value<0.1.

1/ Coefficients, marginal effects and standard errors from a separate regression that excluded the Shannon diversity index of food animals. The results of the rest of regressors were omitted, since the values obtained were very similar to those from the specification presented in this table.

Source: Survey data (December 2016-April 2017).

Appendix K. Homegarden and household characteristics by poverty and food security status

Table K.1 Descriptive statistics of the homegardens and households by poverty and food security status

Variable	Statistic	Income poverty				Assets poverty			
		Non-poor & food secure (1)	Non-poor & food insecure (2)	Poor & food secure (3)	Poor & food insecure (4)	Non-poor & food secure (1)	Non-poor & food insecure (2)	Poor & food secure (3)	Poor & food insecure (4)
Shannon diversity index (plants)	*Mean*	1.869**	1.576**	1.752	1.632	1.849	1.920	1.789**	1.466**
	Median	1.973**	1.751**	1.900	1.768	1.973	1.895	1.934**	1.432**
Shannon diversity index (food animals)	*Mean*	0.268	0.183	0.326	0.223	0.300	0.267	0.266	0.173
	Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of food animals	*Mean*	7.3	4.3	8.6	5.0	8.1	5.8	7.1	4.1
	Median	2.0	2.0	2.5	3.0	3.0	6.0	2.0	2.0
Proportion of adults working in urban jobs	*Mean*	0.350	0.258	0.107	0.046	0.306*	0.177*	0.179	0.109
	Median	0.375	0.292	0.000	0.000	0.333*	0.000*	0.000	0.000
Off-farm occupations (inside the community)	*Proportion*	17.18	15.00	8.16	13.33	14.37	17.65	12.50	11.76
Average age	*Mean*	42.2	46.0	48.6	52.7	42.9	47.2	47.5	51.5
	Median	40.0	40.3	47.0	52.5	39.4	43.5	46.1	50.0
Youth dependency ratio	*Mean*	0.577	0.690	0.628	0.494	0.691	0.659	0.441	0.525
	Median	0.400	0.000	0.333	0.000	0.400	0.000	0.000	0.000
Average education	*Mean*	7.1***	4.8***	6.1*	4.8*	7.5***	5.5**	5.7*	4.5*
	Median	7.0***	4.5***	6.0*	4.8*	7.5***	4.5***	6.0*	4.7*
Household head only speaks Maya	*Proportion*	2.5	0.0	6.2	10.0	3.8	0.0	3.9	8.8
Monthly income, adult equivalent scale, MXN (USD / GBP)	*Mean*	2244.78 (119.53 / 91.55)	1829.02 (97.39 / 74.59)	562.37** (29.95 / 22.94)	408.99** (21.78 / 16.68)	1783.01 (94.94 / 72.72)	1424.07 (75.83 / 58.08)	1352.39*** (72.01 / 55.15)	756.40*** (40.28 / 30.85)
	Median	1973.68 (105.09 / 80.49)	1697.09 (90.37 / 69.21)	583.96** (31.09 / 23.82)	389.45** (20.74 / 15.88)	1614.12 (85.95 / 65.83)	1689.94 (89.99 / 68.92)	1147.09*** (61.08 / 46.78)	585.18*** (31.16 / 23.87)
Wealth index	*Mean*	0.398	0.328	0.351***	0.160***	0.524	0.441	0.158**	0.125**
	Median	0.366	0.366	0.218***	0.148***	0.366	0.366	0.205	0.148

*** p-value<0.01, ** p-value<0.05 and, * p-value<0.1 (T-test for mean values; Wilcoxon rank-sum test for median values and Chi-squared test for proportions). Differences between groups 1 and 2; and 3 and 4 were tested.

Source: Survey data (December 2016-April 2017).