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ORIGINAL RESEARCH ARTICLE

Family agriculture for inclusive rural development

Laksmi Reddiar Krishnamurthy[1,*], Sumithra Krishnamurthy[2], Indumathi Rajagopal[1], Arturo Peralta Solares[1]

[1] *Agroforestry Center for Sustainable Development, Autonomous University of Chapingo, 56230 Chapingo, Mexico*

[2] *University of Sussex, Sussex House, Falmer Brighton, BN1 9RH, United Kingdom*

*** Corresponding authors:** Laksmi Reddiar Krishnamurthy, uach1854@gmail.com

ABSTRACT

The indigenous Mayan populations of the Yucatan Peninsula of Mexico have practiced the ancient traditions of family farming, especially home gardens, to ensure their food security. With the objective of improving traditional practice with modern science, data were collected on the structural complexity and functional diversity of 20 home gardens selected at random in each of the following five communities: X-Maben, X-Pichil, X-Yatil, San José II, and Melchor Ocampo. In addition, group discussions were organized to elucidate the management strategy practiced by the indigenous people. The results show that home gardens are managed mainly by women. The main purpose of growing and maintaining home gardens is to guarantee the production of nutritious food year round. Finally, the home gardens also serve secondary purposes, such as the provision of products and services for traditional medicine. This study suggests that home gardens should be promoted and invested in to improve inclusive development strategies for contexts with similar socio-cultural and biophysical circumstances.

Keywords: food security; home gardens; species diversity; sustainable development

1. Introduction

Home gardens embody an ancient and common practice among indigenous population groups around the world[1]. Home gardens generally integrate multiple crops and serve several purposes[2], which include food and economic security, but also knowledge sharing and community cohesion. Although there are various definitions of "home gardens"[3,4], for the purpose of this paper, home gardens are considered farming systems that combine different physical, social, and economic functions in the plot area around the family house.

The practice of home gardens is considered one of the oldest land use activities; it has evolved through generations with a progressive intensification of land use[5]. The concept of the operational basis of home gardens is in the close combinations of trees, shrubs and annual crops, sometimes associated with domestic animals around the home[5,6–9]. Home gardens, although practiced in different socioeconomic sectors, are predominantly adopted by subsistence farmers and are widespread, mainly in tropical climates in rural settings[2], usually managed by the mother of the family[10]. Due to these considerations, home gardens have represented a dimension in the type of actions that represent inclusive development, which can be understood as a series of activities in which poverty is reduced while the different groups of each society are involved in the decision-making and participation process[11]. A distinctive feature of home gardens is the presence of a

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great diversity of species from different functional groups such as vegetables, fruit trees, medicinal plants, spices and condiments, beverages, ornamental plants, as well as domestic and wild animals.

Several studies on home gardens have focused on their structural complexity[9,12–14], function[8], biodiversity, food security and nutrient management[15,16], economic gains[17,18], and sustainability issues[3,19]. Despite receiving high ratings for productive and service functions, home gardens have not been given importance as an inclusive development strategy. Home gardens have come to the fore as mere practices to ensure food security in marginal areas and communities.

Home gardens play a crucial role in ensuring household food security for indigenous populations. Globally, home gardens are of strategic importance for the achievement of the Millennium Development Goals and the subsequent Sustainable Development Goals, where ending food poverty and creating successful access to nutritious food are priorities. Food security and food sovereignty can be understood as two complementary parts of a common goal. Food security, on the one hand, refers to the condition where "at all times, all people have physical, social and economic access to sufficient, safe and nutritious food that can meet their dietary needs and food preferences for an active and healthy life"[20]. Food sovereignty, on the other hand, is the right to access healthy and culturally appropriate food produced through ecologically sensitive and sustainable methods, as well as the right to define one's own agricultural and food systems[21].

In this context, the incorporation of the food security perspective into the international development agenda has had a transformative effect on home garden research, especially since 2000, when the Millennium Development Goals were agreed upon, where home garden research has been oriented towards the inclusion of sustainability and resilience issues. Resilience, the capacity of a system to withstand social, political and environmental change, is achieved through the availability of additional sources of food and income outside traditional employment[20]. Sustainability, the quality of a practice that is not harmful to the environment, both socially and ecologically[22,23], is also a key component of home garden practices since their ecological footprint is typically very low[2].

The CONEVAL report[24] estimates that 25% of Mexico's population lives in conditions of food poverty; therefore, the Government launched the Crusade against Hunger, which aims to achieve national food security while maintaining environmental sustainability. In this context, home gardens can play a significant role, as they can facilitate food security results without jeopardizing environmental conditions.

In Mexico, in order to understand the incorporation of home gardens, it is important to consider the role that home gardens have played historically. In fact, home gardens played an important role for pre-colonial societies, such as the Maya, Aztecs and Totonacs[10]. Through these systems, populations were able to develop settlements with sustained annual food production[25]. Moreover, communities were able to establish relationships with nearby communities through trade, and these practices continued during and after colonial times[10]. In this sense, home gardens have allowed the creation of living conditions through resilience, food, and economic and social security. Currently, the combination of these aspects through home gardens represents a form of inclusive development as a practice by which the most vulnerable population is equitably included in national and international development processes[26], which are widely practiced in some of the poorest areas of Mexico[27].

This study examines: 1) the role of home gardens for rural development, with a specific focus on their contribution to food security in the context of Mayan indigenous populations of the Yucatan Peninsula, Mexico and 2) the structural complexity, functional diversity and management strategy of Mayan home gardens. As well as the role that home gardens could play as a viable strategy for inclusive development, especially in marginal areas that are left out of the benefits of production technologies promoted during the last decades.

2. Materials and methods

2.1. Study site

The research was carried out in the municipality of Felipe Carrillo Puerto in the state of Quintana Roo, in southeastern Mexico (19°03' N and 20°25' N; 87°25' W and 88°43' W; altitude of 0–100 m; annual rainfall of 1250 mm); warm climate (tropical dry Köppen: DBCity[28]) and humid with Leptosols réndzico soils in greater predominance[29]. The population of the area is of Mayan descent, and their activities include the practice of home gardens. In the state of Quintana Roo, 44.4% of the population is indigenous[30] and 95% are Mayan speakers[31].

2.2. Sampling and data collection

Data on the productive components of the home gardens, including both vegetation and animal components, structural complexity, functional diversity, and management strategies that point to family farming management systems in the gardens, were obtained from 100 households. These households were selected by random sampling to obtain representative data. Twenty households were selected from each of the following five communities (20 in each community, 100 total): X-Maben (19°80' N; 88°17' W; Tageo[32]), X-Pichil (19°68' N; 88°42' W; Tageo[33]), X-Yatil (19°66' N; 88°44' W), San José II (19°97' N; 88°23' N), and Melchor Ocampo (20°03' N; 88°28' W; Dices[34]).

Data collection consisted of a combination of qualitative field observations, quantitative surveys, and focus group discussions. The quantitative surveys were based on the collection of data on the structural complexity of the gardens, which can be understood as the dimensions, or layering, of the crops in the gardens and their vertical or horizontal management for land use. They were conducted on the basis of field observations in conjunction with comments on the management of the gardens by household members. The field observations were collected by the researchers and involved randomly selected households (because 100% of the households in the communities have some type of home garden, ranging from a few plants to a complex system), with families willing to participate in the research. These field observations were used mainly for the purpose of collating quantitative data such as the structural complexity of the home gardens (vertical, horizontal, mixed, individual, communal, mixed soil management, etc.) and their yield (production m^{-2}, etc.).

Focus groups, or the set of people who participated in surveys and collective discussions, corroborated the data collected through field observations with information on indigenous knowledge related to functional diversity and the management strategies used to maintain their own home gardens. Focus groups were chosen for two reasons: 1) to allow communication among participants for data collection[35]; and 2) to allow an understanding of common management strategies and knowledge based on communal consensus. Focus groups are used to generate data on sustainable natural resource management, as the approach allows for a better understanding of how communities manage their own resources[26,36,37]. Through the focus groups, it was possible to explore issues of social well-being and relationships within the community to understand the impact of home gardens on positive social conditions with respect to increased well-being and development processes that families have access to. The focus groups consisted of 15 to 25 members of both sexes, with the occasional participation of children. This was repeated in each of the five communities, which allowed for a more representative understanding of social practices and knowledge of the different levels of garden production and management (stratification of activities based on gender and age), as well as the different strategies to take advantage of the land based on complex structures (multifunctionality based on seed diversification, use of land to grow interwoven structures, etc.), which in turn provided information on the social function of home gardens through community building and networks. Participants came from randomly selected households and

joined voluntarily. The community leader was also informed of the goals and objectives of the focus groups prior to the research.

The research involved the participation of translators (from Mayan to Spanish), since the participants in the focus groups were of Mayan origin and their level of Spanish was very limited. The translators consisted of a group of students from the University of Felipe Carrillo Puerto who are fluent in both Spanish and Mayan.

3. Results

3.1. Production components and structural complexity

The results reported were obtained in five indigenous communities in the state of Quintana Roo. Some of the results may be similar to those reported by other authors who have also studied similar socio-cultural environments, indicating that the Mayan population has turned home gardens into a cultural heritage. Generation after generation, they have designed and managed similar multi-functional home gardens, so that from them they can achieve their objectives. This is why their cultural heritage results in similar data.

The data collected on the production components, the various strata, and plant diversity in the home gardens showed two key results. First, it was observed that there are an average of 4–5 strata in each of the sites visited, as shown in **Figure 1**, where in the lower stratum 0–1 m there is the greatest presence of ornamental, aromatic, vegetable, and medicinal species, which in most cases are located near the sides of the house; in the second 1–2 m stratum there is the presence of mostly grasses (corn) and various species of fruit trees in growth; in the third stratum of 2–5 m there is the presence of species such as banana, palms, and fruit species, among others; and the stratum greater than 5 m is composed of mature species of fruit trees, palms, and timber, and a diversity of herbaceous, shrub, and woody plants (**Table 1**). Second, more than 95% of the households studied have both domestic and wild animals. Together, these components of both plant and animal production serve a variety of purposes, including the provision of food, fodder, medicines, and many others (**Table 2**).

Figure 1. Strata of a home garden in the community of X-Maben, Quintana Roo.

Table 1. Most common plant species found in the home gardens of X-Maben, X-Pichil, X-Yatil, San José II and Melchor Ocampo in Felipe Carrillo Puerto, Quintana Roo.

Vertical organization with regional and scientific plant name			
Presence by height ranges 2-5			
0–1	**0–2**	**2–5**	**5+**
Habanero chili	Papaya	Banana	Chique
(*Capsicum chinensis*)	(*Carica papaya*)	(*Musa* sp.)	(Unidentified)
Pumpkin	Grenada	Nance	Coco
(*Cucurbita mixta*)	(*Punica granatum*)	(*Byrsonima crassifolia*)	(*Cocos nucifera*)
Sweet potato	Tulip	Naranjo	Guarumbo
(*Ipomoea batatas*)	(*Malvaviscus arboreus*)	(*Citrus sinesis, C. Aurantium*)	(*Cecropia peltata* sin. *C. obtusifolia*)
Ruda	Nettle	Guaje	Guano
(*Chalpensis route*)	(*Urtica dioica*)	(*Leucaena leucocephala*)	(*Sabal yapa, S. Mexicana*)
Peppermint	Dalia	Holy leaf	Cedar
(*Mentha piperita*)	(*Dahlia* sp.)	(*Piper auritum*)	(*Cedrela odorata*)
Epazote	Tobacco	Plum	Sabin
(*Chenopodium ambrosoides*)	(*Nicotiana tabacum*)	(*Spondias mombin*)	(Unidentified)
Cilantro	Wonder	Chaya	Kaska'at
(*Coriandrum sativum*)	(*Calendula officinalis* L.)	(*Cnidoscolus chayamansa*)	(*Luehea speciosa*)
Rosa	Cana de aztcar	Bougainvillea	Pinch
(*Rosa gallica*)	(*Saccharum officinarum*)	(*Bougainvillea glabra*)	(Unidentified)
Bean	Corn	Xiyiat	Anona
(*Phaseolus* sp.)	(*Zea mays*)	(Unidentified)	(*Annona squamosa, A. reticulata*)
Basil	Bird of paradise	Mandarin	Handle
(*Ocimum bailicum*)	(*Strelitzia reginae*)	(*Citrus reticulata*)	(*Mangifera* sp.)
		Smells at night	Mamey sapote
		(*Cestrum nocturnum* L.)	(*Pouteria sapota, P. mammosa*)
		Palm	Ramon
		(*Veitchia merillii*)	(*Brosimum alicastrum*)
			Avocado (*Persea americana*)

Table 2. Some of the plants and animals found in home gardens in the communities: X-Maben, X-Pichil, X-Yatil, San José II and Melchor Ocampo in Felipe Carrillo, Quintana Roo, Mexico, and their uses.

Plant species			
Local name	**Scientific name**	**Family**	**Uses**
Chincuya	*Annona purpurea*	Anonaceae	Food, aromatic, handicrafts, housing construction, firewood and timber
Achiote	*Bixa orellana*	Bixaceae	Food, aromatic, ceremonial, coloring, condiments, industrial, firewood and medicinal
Chaka	*Bursera simarouba*	Burseraceae	Crafts, hedgerow, ceremonial, ground support, tools, firewood, timber, medicinal, tannins, etc.
Nance	*Byrsonima crassifolia*	Malpighiaceae	Food, handicrafts, ceremonial, dyes, construction, fodder, soil subjection, firewood, timber, medicinal, ornamental, etc.
Papaya	*Carica papaya*	Caricaceae	Food, beverages, industrial, medicinal, ornamentals

Table 2. (*Continued*).

Plant species			
Local name	**Scientific name**	**Family**	**Uses**
Cedar	*Cedrela odorata*	Meliaceae	Handicrafts, wood, ground support, firewood, repellents, ornamentals
Sweet lemon	*Citrus limonia*	Rutaceae	Food, aromatic, beverages, condiments, firewood, medicinal, ornamentals
Pajarito	*Cordia alliodora*	Boraginaceae	Crafts, tools, firewood, wood, medicinal, ornamental, etc.
Jicara	*Crescentia cujete*	Bignoniaceae	Food, construction material, ceremonial, household utensils, medical, honey production, etc.
Cocoite	*Gliricidia sepium*	Fabaceae	Fodder, handicrafts, hedgerows, colorants, nitrogen fixation, firewood, medicinal, repellents, shade, tannins, ornamentals
Avocado	*Persea americana*	Lauraceae	Food, cosmetics, seasonings, industrial, medicinal, wood
Animal species			
Local name	**Scientific name**	**Household use categories**	
Dog	*Cannis familiaris*	Protection, pet	
Chicken	*Gallus gallus*	Food, sale	
Pig	*Sus scrofa*	Food, sale	
Turkey	*Melleagris gallopavo*	Food, sale	
Duck	*Anas* sp.	Food, sale	
Borrego	*Ovis aries*	Food, sale	
Cat	*Felis silvestris catus*	Protection, pet	
Horse	*Equus caballus*	Job	
Cattle	*Bos indicus, B.taurus*	Food, work	
Donkey	*Equus asinus*	Job	
Rabbit	*Sylvilagus* sp.	Food, sale, pet	
Mule	*E. caballu x asinus*	Job	
Goose	*Anser anser*	Protection, ornamental	
Poultry	*Numida meleagris*	Ornamental	
Aquijones	*Melipona* sp.	Honey as food and medicine	

Home gardens also contain vertically stratified plant species, with each stratum containing plants belonging to a specific life form. This tendency is recognized in home gardens in other regions[38].

The households studied showed diverse production foci: some households specialize in animal production (about 82%, as animals are the main source of protein; goats, sheep, pigs, chickens and wild animals), while others specialize in traditional medicine (about 90%, in order to reduce the cost of medical care and provide immediate relief) and still others specialize in food production (100%, divided between vegetables and fruit trees) (**Table 3**, **Figure 2**). Therefore, Mayan home gardens consist of complex interactions between species and are diversified with flexible management strategies and minimal external labor input since most of the activities are carried out with family labor[10].

Table 3. Number of useful plant species, by category, present in the home gardens of the communities of X-Maben, X-Pichil, X-Yatil, San José II and Melchor Ocampo, in the municipality of Felipe Carrillo Puerto.

Category of use	X-Maben		X-Pichil		X-Yatil		San José II		Melchor Ocampo	
	No.	%	No.	%	No.	%	No.	%	No.	%
Medicines	78	28.5	59	23.9	108	34.6	144	41.0	96	35.5
Food	99	36.2	86	34.9	94	30.1	102	29.0	71	26.3
Construction	9	3.3	13	5.3	21	6.7	18	5.12	11	4.0
Handicrafts	8	2.9	14	5.7	9	2.9	15	4.3	8	3.0
Ornamentals	13	4.76	16	6.5	11	3.5	10	2.8	9	3.3
Timbers	9	3.3	11	4.4	10	3.2	15	4.3	12	4.4
Forages	19	6.9	12	4.8	13	4.2	10	2.8	15	5.5
Tools	9	3.3	7	2.8	11	3.5	8	2.2	10	3.7
Fuels	18	6.6	19	7.7	22	7.0	19	5.4	23	8.5
Household goods	11	4.0	9	3.6	13	4.2	10	2.8	15	5.5
Total	273	99.76	246	100	312	99.9	351	99.72	270	99.7

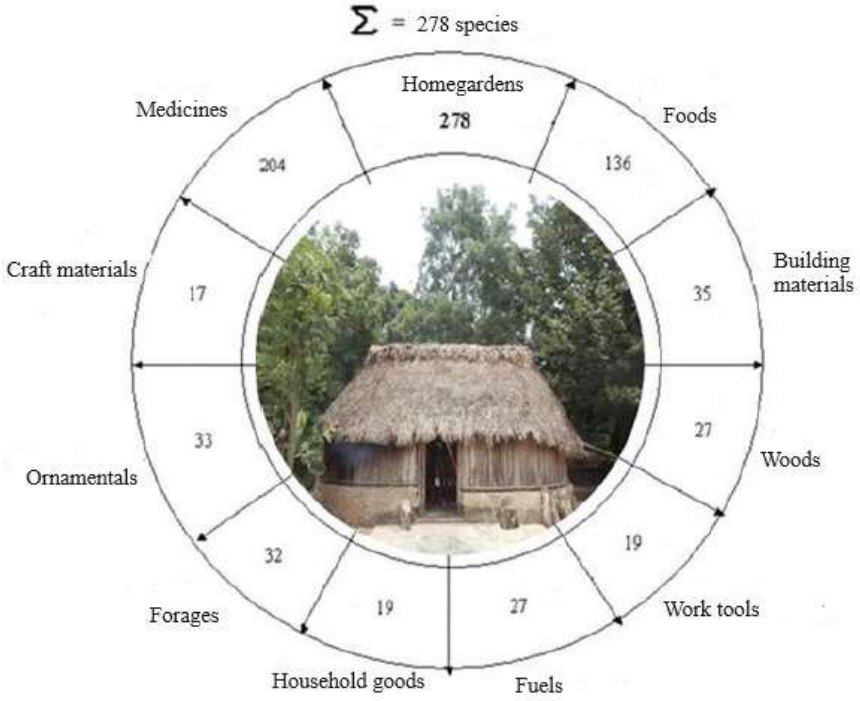

Figure 2. Number of species and multiple products that can be obtained from traditional Mayan orchards in the communities studied in the municipality of Felipe Carrillo Puerto, Quintana Roo[39].

3.2. Profits obtained from traditional home gardens

One of the main outcomes of the focus group discussions was the unanimous recognition of the role of women in managing the productive components of home gardens. Men and other household members are in charge of management tasks, including tree pruning, construction, and small-scale sales to create disposable income. This suggests that the management strategy of home gardens is flexible and generally managed within the household through family labor.

As for the products obtained from the home gardens themselves, most of the food products are used for family consumption. Only a small proportion of the surplus is sold, being shared from time to time with

neighbors and other community members. This is a common Mayan tradition whereby households are expected to share their horticultural produce for religious festivals. This serves to preserve culture, identity, and tradition while fostering social cohesion and social reproduction. Focus group discussions suggest that members see the varied services and functions of home gardens as affecting communities in a positive way, so it is possible to justify the practice of home gardens as much more than just the need for food. This was another important consideration discussed in the focus groups.

The role of home gardens in creating social networks, cohesion, and community building was considered important during the focus group discussions. Participants highlighted the importance of home gardens in everyday activities as well as a starting point for creating a good relationship between people within each community to relate to each other. This is an important finding, as the main international policy agendas, such as Agenda 21, the Millennium Development Goals, and more recently, the Sustainable Development Goals, promoted by the United Nations, neglect the different ways in which social cohesion can be built through home gardens. Although there is recognition of the exchange of ideas and traditional knowledge that is taking place, notions such as food sovereignty, identity, relationships, and community building are often seen as the result of the positive accumulation of food and economic security rather than a parallel consequence of the practice of home gardening.

In this sense, the focus groups are aware of the uses and functions of home gardens, which can be considered under the spectrum of security, including financial, nutritional, social, and sanitary, highlighting for them the following: (1) food or provisions; (2) medicines (for humans and domestic animals); (3) fodder; (4) aromatics (condiments, perfumes, etc.); (5) sweeteners; (6) alcoholic or non-alcoholic beverages; (7) spices; (8) stimulants; (9) ceremonials (amulets, magic, rituals); (10) drugs (hallucinogens, narcotics, tranquilizers); (11) resins; (12) honey; (13) oil (edible and industrial); (14) fences; (15) windbreaks; (16) tools for agriculture, hunting, and fishing; (17) fibers (textiles, ropes, and basketry); (18) construction (furniture or houses); (19) handicrafts; (20) musical instruments; (21) waxes; (22) dyes; (23) biological control (insecticides, fungicides, herbicides); (24) cosmetics; (25) household use (cooking, packaging, drying adhesives, etc.); (26) bioenergy (charcoal, firewood, oil); (27) soil erosion control; (28) rubber and latex; (29) ornamental or aesthetic; (30) tannins; (31) toxic (poisonous to man and domestic animals); (32) bee stings for medical purposes; and (33) green manure.

3.3. Functional services of the family gardens

Based on the Millennium Ecosystem Assessment 2001[40] four-fold classification criteria, the focus groups, in addition to identifying the various uses of the products grown, were also able to envision a number of other services of the home gardens as units in their own right. These would include (1) provisioning services: products obtained from the system; (2) regulating services: the benefits of regulating the system include improved air quality, climate regulation, and reduced susceptibility to natural disasters; (3) cultural services: non-material services harvested from the system: non-material services collected from spiritual enrichment, social status, recreation, entertainment, mindfulness, social relationships, and social networks; and (4) supporting services: services considered important for other ecosystem functions, such as soil conservation, photosynthesis, and nutrient cycling.

4. Discussion

Home gardens are complex systems. They are time-tested resilient strategies[2] and consist of flexible management strategies at the household level[10]. The home gardens studied are of a very specific type[41]. It is because home gardens in indigenous communities include a large number of wild and cultivated plant species that are structured in different vertical layers and are managed with the objective of transmitting knowledge in

an inter-generational manner. Moreover[42], the intricate combination of plant species is arranged horizontally, which takes into consideration specific soil types and nutrient cycles for the best production throughout the year. What makes the combination of these factors so striking in the Maya context is that communities do not consider these aspects as separate units of analysis but as a whole, where political, economic, cultural, and social factors are linked together and related to biological, agricultural, and ecological factors. Leclerc and Thuillet[42] observed similar patterns of family farming in different parts of the world.

Although focus groups are becoming increasingly important in the study of social views, in using them, individual perceptions are discarded in favor of communal ones. The problem with focus groups is that certain voices and discourses may be ignored, as not all members feel comfortable speaking in a group setting. Perhaps there might even be local hierarchies that researchers are unaware of, including hierarchies based on gender or social status. To avoid this, the research could have been conducted through semi-structured individual interviews. Another alternative could have been to divide the focus groups based on gender. This would have allowed for a better understanding of home gardens as a space for social welfare, but in addition, and even more importantly, it would have produced gender-disaggregated data on management practices. This is important when considering the fact that home gardens, in most cases, are usually managed by the female head of household[10]. Because of this, it can be argued that women are better equipped and prepared for the issues of management and functional diversity. They also spend more time in home gardens compared to men and tend to be in charge of deciding how to use the products for household consumption[15]. Not only this, but a gender perspective could also have shed light on the ways in which subsections of society relate to each other. For example, women's relationships, knowledge sharing, and well-being are more intrinsically related to home gardens than men's relationships, partly because men also have their own work spaces to discuss among themselves.

Apart from the addition of a gendered understanding of home garden practices and their social importance, selective rather than random sampling could have improved the study. Given the randomized nature of the study, it can be argued that certain aspects of home gardens were ignored. These include proximity to other social spaces, roads, and cities, which could have an effect on home garden practices, opinions, and relationships.

Finally, it is important to recognize the limitations of using translators. Although, in this case, there was little or no alternative, translators have embedded biases in their own understanding of the communities and participants involved. This probably influenced the translations of the focus group discussions. On the other hand, for the participants, the use of these translators may have had consequences overlooked by the researchers. These included issues such as wanting to look a certain way to the translators and therefore changing their responses. Although there was no alternative, it is crucial to keep these potential limitations in mind when considering the results and conclusions.

The diversity of the functions of home gardens reveals three main findings. First, home gardens play an important role in creating economic and food security, which in turn facilitates livelihood security. Second, home gardens have a presence and influence on day-to-day relationships and activities at the household, fraternal, and community levels. Third, within the multiplicity of the functions of home gardens, it is possible to see that they support the creation and recreation of both ecosystems for food production as well as social relationships in a sustainable and interrelated manner.

Considering that food security encompasses notions of availability, accessibility, utilization, and stability, it is possible to understand the ways in which this research corroborates the dominant discourse on home

gardens: that the main and most important reason for the practice and maintenance of home gardens is for the continued production of varied food sources for consumption at the household level[10,20].

In addition to the recognition of home gardens as a source of food, it is also important to consider their social functions. Home gardens represent an example of bottom-up development because the communities initiated the practice themselves. This implies that home gardens are a practice and an approach that allow local communities and actors to express their concerns and knowledge to define development pathways[2]. An example of this is the active participation in the management of home gardens by different family members. Focus group discussions about different management methods demonstrated how home gardens are key to enabling communities to become agents of their own change. Communities have control over their food, economy, livelihood, and social security and are flexible and adaptable to changing conditions. The role of home gardens is different depending on whether they are analyzed holistically or through an analysis of their various components and functions. The home garden, as a unit, has important social meanings, and its symbolic use is essential in creating conversations, relationships, and shared notions of identity. When considering crops individually, by contrast, one of the key roles of home gardens is the production of crops to mitigate social inequalities and poverty by providing food, medicine, and ornaments. Home gardens can be classified not only in terms of soil, produce, size, and yield but also in terms of the management methods used. This in turn emphasizes the identity and diversity of home gardens in different regions of the world.

The fact that home gardens and their purposes and functions can be understood in this way suggests that home gardens play a role in indigenous realities and lives in a variety of ways. This is a key consideration because, in the study of home gardens, a range of lifestyles and realities are also being considered. More importantly, however, consideration of the diverse functions of home gardens defines indigenous communities as agents of their own well-being and security.

It is also important to note the limitations of home garden practices in the Mayan context. First, there is no body such as a cooperative to which communities can sell their surplus production. For this, perhaps the establishment of an association or community body can improve access to markets and other public institutions and reduce the costs associated with selling their produce. This could also make it easier to find new demand opportunities, as well as to obtain training and technical knowledge and expertise from external bodies such as government agencies, which in turn could help increase yield and production. Cooperatives could also improve the relationship and communication between communities and the state, mitigating a number of problems in the communities that are not necessarily associated with home gardens, such as infrastructure, information sharing, and modernization of the area through new methods and enterprises, becoming marketable activities that allow them to insert themselves into the global economy. While doing this could lose the essence of the "family" of the home gardens studied, what is proposed is a synergy between the modes of production in the gardens and the systems of demand and supply in the communities. The purpose of this would not be to maximize economies of scale but to use the available markets as sources of modern income to improve the management of the home gardens. It is also worth mentioning that in the school of inclusive development, the potential of home garden producers to sell their excess in markets to generate additional income on the one hand and food security on the other is discussed[43].

Finally, it is important to remember that home gardens allow for flexibility, culture, identity, and resilience. In this sense, government agencies should consider the different types of family farming practices involved in home garden management to create policies that fit the multidimensional realities of indigenous experiences and at the same time help economic, commercial, and public development.

5. Conclusions

Home gardens play a crucial role for the Mayan communities of X-Maben, X-Pichil, X-Yatil, San Jose II, and Melchor Ocampo in the state of Quintana Roo because they serve to provide food, economic, and social security. This is because they offer a diversity of crops, high yields, and year-round production, but they also imply a flexible space for the production of nutritious and varied foods. In fact, they consist of a great diversity of species, complex structures, minimal external input, and flexible management systems to combine agricultural, forestry, and animal components. Home gardens also serve communities through plant-based traditional medicine care that helps cope with unforeseen crises, as well as cost-effective and immediate self-sufficient relief. Perhaps most notably, the research shows that home gardens enable social resilience and community building through the provision of spaces for the exchange of knowledge and goods. This, in turn, allows for the modernization and rapid diversification of isolated communities, which has implications for bottom-up rural approaches to development. The research also shows that most of the daily personal and communal activities take place around the home garden, allowing it to play the role of an entity and a space for development. In this sense, it is possible to argue that home gardens touch on each of the three recognized spheres of development: social, economic, and environmental, suggesting that the literature on home gardens therefore needs to consider a more precise understanding of the role they play at the grassroots level, where communities and individuals use home gardens to empower themselves as drivers and agents of their own change.

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Conflict of interest

The authors declare no conflict of interest.

References

1. Eyzaguirre PB, Linares OF. *Home Gardens and Agrobiodiversity*. Smithsonian Institution Press; 2004.
2. Galhena DH, Freed R, Maredia KM. Home gardens: A promising approach to enhance household food security and wellbeing. *Agriculture & Food Security* 2013; 2: 8. doi: 10.1186/2048-7010-2-8
3. Torquebiau E. Are tropical agroforestry home gardens sustainable? *Agriculture, Ecosystems & Environment* 1992; 41(2): 189–207. doi: 10.1016/0167-8809(92)90109-O
4. Méndez VE, Lok R, Somarriba E. Interdisciplinary analysis of homegardens in Nicaragua: Micro-zonation, plant use and socioeconomic importance. *Agroforestry Systems* 2001; 51: 85–96. doi: 10.1023/A:1010622430223
5. Kumar BM, Nair PKR. The enigma of tropical homegardens. In: *New Vistas in Agroforestry*. Springer Netherlands; 2004. pp. 135–152. doi: 10.1007/978-94-017-2424-1_10
6. Weersum KF. Tree gardening and taungya on Java: Examples of agroforestry techniques in the humid tropics. *Agroforestry Systems* 1982; 1(1): 53–70. doi: 10.1007/bf00044329
7. Brownrigg LA. *Home Gardening in International Development: What the Literature Shows, Including an Anannotated Bibliography, and Inventories of International Organizations Involved in Home Gardening and Their Projects*. League for International Food Education; 1985.
8. Fernandes ECM, Nair PKR. An evaluation of the structure and function of tropical homegardens. *Agricultural Systems* 1986; 21(4): 279–310. doi: 10.1016/0308-521X(86)90104-6
9. Soemarwoto O. Homegardens: A traditional agroforestry system with a promising future. In: Steppler HA, Nair PKR (editors). *Agroforestry: A Decade of Development*. ICRAF; 1987. pp. 157–170.
10. Caballero J. Maya homegardens: Past, present and future. *Etnoecológica* 1992; 1(1): 35–54.
11. UNDP. Inclusive development (Spanish). Available online: https://www.undp.org/es/el-salvador/desarrollo-

inclusivo (accessed on 28 October, 2016).
12. Arias L. The current Mayan-Yucatec family or solar garden (Spanish). In: Mariaca Méndez R (editor). *The Family Garden of the Mexican Southeast* (Spanish). ECOSUR; 2012. pp. 111–130.
13. Flores Guido JS. Floristic diversity, uses and origin of genetic material of species from home gardens of the Yucatan Peninsula (Spanish). In: Mariaca Méndez R (editor). *The Family Garden of the Mexican Southeast* (Spanish). ECOSUR; 2012. pp. 149–175.
14. Mariaca Méndez R. *The Family Garden of the Mexican Southeast* (Spanish). ECOSUR; 2012.
15. Montagnini F. Homegardens of Mesoamerica: Biodiversity, food security, and nutrient management. In: *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry*. Springer Netherlands; 2006. pp. 61–84. doi: 10.1007/978-1-4020-4948-4_5
16. Cahuich-Campos D. The Mayan garden and the daily diet of the peasant families of X-Mejía, Hopelchén, Campeche. In: Mariaca Méndez R (editor). *The Family Garden of the Mexican Southeast* (Spanish). ECOSUR; 2012. pp. 197–229.
17. Mohan S, Alavalapati JRR, Nair PKR. Financial analysis of homegardens: A case study from Kerala state, India (Spanish). In: *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry*. Springer Netherlands; 2006. pp. 283–296. doi: 10.1007/978-1-4020-4948-4_16
18. Cámara-Córdova J. Contribution of the family garden to the rural economy, adaptation to climate change and productive conversion in Tabasco, Mexico (Spanish). In: Mariaca Méndez R (editor). *The Family Garden of the Mexican Southeast* (Spanish). ECOSUR; 2012. pp. 372–390.
19. Torquebiau E, Penot E. Ecology versus economics in tropical multistrata agroforests. In: *Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry*. Springer Netherlands; 2006. pp. 269–282. doi: 10.1007/978-1-4020-4948-4_15
20. Food and Agriculture Organization (FAO). World food summit. Available online: https://www.fao.org/3/w3548e/w3548e00.htm (accessed on 8 August 2015).
21. Vía Campesina. World food summit. Available online: https://viacampesina.org/en/index.php/organisation-mainmenu-44 (accessed on 18 September 2016).
22. United Nations. Millennium development goals and beyond 2015. Available online: http://www.un.org/millenniumgoals/poverty.shtml (accessed on 25 August 2015).
23. Food and Agriculture Organization (FAO). *State of Food and Agriculture. Food System for Better Nutrition*. FAO; 2013.
24. National Council for Evaluation of Social Development Policy (CONEVAL). *Poverty Report in Mexico, 2012*. CONEVAL; 2013.
25. Angel-Pérez AL. Homegardens and the dynamics of Totonac domestic groups in Veracruz, Mexico. *Anthropological Notebooks* 2013; 19: 5–22.
26. United Nations Environment Programme (UNEP). Consideration of initial elements: Recognizing indigenous and local knowledge and building synergies with science. Available online: http://www.ipbes.net/plenary/ipbes-1.html (accessed on 4 December 2015).
27. Rebollar-Domínguez S, Santos-Jiménez VJ, Tapia-Torres NA, et al. Family gardens, an experience in Chancah Veracruz, Quintana Roo (Spanish). *Polibotánica* 2008; 25: 135–154.
28. DBCity. Felipe Carrillo Puerto. Available online: http://es.db-city.com/M%C3%A9xico-Quintana-Roo-Felipe-Carrillo-Puerto (accessed on 18 September 2016).
29. Bautista F, Palma-López D, Huchin-Malta W. Update of the soil classification of the state of Yucatán (Spanish). In: Bautista F, Palacio G (editors). *Characterization and Management of Soils in the Yucatan Peninsula: Agricultural, Forestry and Environmental Implications* (Spanish). National Institute of Ecology; 2005. pp. 105–122.
30. National Institute of Statistics and Geography (INEGI). Available online: http://sipse.com/novedades/quintana-roopoblacion-indigena-encuesta-intercensal-2015-inegi-lenguamaya-184159.html (accessed on 18 September 2016).
31. National Institute of Statistics and Geography (INEGI). Available online: http://www.cuentame.inegi.org.mx/monograf ias/informacion/qroo/poblacion/diversidad.aspx?tema=me&e=23 (accessed on 18 September 2016).
32. Tageo. Melchor Ocampo, Quintana Roo. Available online: http://www.tageo.com/index-e-mx-v-23-d-m2398966.htm (accessed on 28 October 2016).
33. Tageo. X-Pichil, Quintana Roo. Available online: http://www.tageo.com/index-e-mx-v-23-d-m2399119.htm (accessed on 28 October 2016).
34. Dices. Melchor Ocampo, Quintana Roo, Felipe Carrillo Puerto, Chetumal. Available online: http://www.dices.net/mapas/mexico/mapa.php?nombre=Melchor-Ocampo&id=110414 (accessed on 29 October 2016).
35. Kitzinger J. Qualitative research. Introducing focus groups. *BMJ* 1995; 311: 299–302. doi: 10.1136/bmj.311.7000.299

36. Raymond CM, Fazey I, Reed MS, et al. Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management* 2010; 91(8): 1766–1777. doi: 10.1016/j.jenvman.2010.03.023
37. Convention of Biological Diversity (CBD). *The Tkarihwaié: RI code of Ethical Conduct to Ensure Respect for the Cultural and Intellectual Heritage of Indigenous and Local Communities Relevant to the Conservation and Sustainable Use of Biological Diversity*. CBD; 2011.
38. De Clerck FAJ, Negreros-Castillo P. Plant species of traditional Mayan homegardens of Mexico as analogs for multistrata agroforests. *Agroforestry Systems* 2000; 48: 303–317. doi: 10.1023/A:1006322612362
39. Toledo VM. Indigenous peoples, strategic actors for the Mesoamerican Biological Corridor (Spanish). *Biodiversitas* 2003; 47: 8–15.
40. Millennium Ecosystem Assessment (MEA). *Ecosystems and Human Well-Being: Synthesis*. Island Press; 2005.
41. Lope-Alzina DG, Howard PL. The structure, composition, and functions of homegardens: Focus on the Yucatán Peninsula. *Revista Etnoecologica* 2012; 9(1): 17–41.
42. Leclerc C, Thuillet AC. Wild and cultivated biodiversity and natural resource management. *Montpellier, France. Agrop. Int* 2014; 19: 35–47.
43. Gupta J, Vegelin C. Sustainable development goals and inclusive development. *International Environmental Agreements: Politics, Law and Economics* 2016; 16: 433–448.