Social perceptions of urban agriculture in Latin America: A case study in Mexican social housing.

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Abstract

The topic of food security has a critical place in the government agendas of developing countries. In Latin America, urban agriculture (UA) offers an interesting alternative to ensuring a sufficient, safe and nutritious food supply for urban populations. However, Latin American urban contexts have been subject to radical transformations in the last decades, most apparently through the expansion of social housing. The main objective of this research is to analyze the social perceptions and feasibility of UA in Mexican social housing neighborhoods.

The city of Mérida was used as a representative case study. Structured interviews were given to 65 key stakeholders across different categories (residents, urban government officials and technical experts). The results indicate a nonexistent perception of UA in Merida, despite the secular agriculture tradition of the Yucatan region. Nevertheless, respondents agreed in their interest in potentially developing UA activities to improve diets, increase green areas, support local economies, and reduce CO_2 emissions. The main perceived barriers for UA are the prevalent model of housing that has a very limited floor area and the current approach to urban planning, which lacks non-built-up areas. Significantly, large artificialized zones create suitable areas to implement UA on extended rooftops.

Finally, stakeholders demand the intervention of authorities at different levels (Federal [national], State [regional] and local) as a requirement to develop UA properly. The main pathways for this support should be to prepare new urban and housing policies and introduce economic incentives.

Keywords: food security, green rooftop, stakeholders survey, urban planning, Mérida, Yucatán.

Abbreviations:
DIF System for Integral Family Development of Mexico
ECLAC Economic Commission for Latin America and the Caribbean
FAO Food and Agricultural Organization
LAC, Latin America and the Caribbean
RTG rooftop greenhouse
SAGARPA Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico
SEDESOL Social Development Secretary of Mexico
SEMARNAT Secretary of Environment and Natural Resources of Mexico
UA urban agriculture
UN United Nations

1. Introduction

More than 50% of the world population lives in urban settings (United Nations, 2014). The problem of urban food security, especially in developing economies that cannot cope with rising food prices, is exacerbated in growing cities dependent on food supplies from rural areas (Wadel et al., 2010). According to the Food and Agriculture Organization of the United Nations (FAO, 2014), many urban residents face difficulties accessing the food they need.

Limitations to food access in cities are both physical and economic. Long-distance transportation between agricultural areas and urban markets lead to 10-30% losses in product. Food prices and household income are major constraints (FAO et al., 2015). In Latin America and the Caribbean (LAC), the inflation of food prices affect the ability of the most vulnerable households to purchase healthy food. In LAC, poor urban households spend 60-85% of their income on food (Ilbery, 2010; Mougeot, 2005). For the poor in developing countries in particular, the relative welfare impact of changing food prices or decreasing income is more significant than for poor people in developed countries (Prakash, 2011).

In face of this situation, urban agriculture (UA) offers innovative solutions to safeguard the environment and economic sustainability of food supplies within urban settings and encourage healthier diets (Nadal et al., 2017). While UA in developing countries is a historical reality (Dubbeling et al., 2010; Renting, 2013), it has been poorly analyzed, particularly in regards to social perceptions,

84 opportunities and barriers (De Bon et al., 2010; Orsini et al., 2013; Poulsen et al., 2015; Ruel et al.,
85 1998; Warren et al., 2015).
86
87 There are no studies analyzing the relationship between UA and the city development in the context
88 of Latin America's rapid urban transformations, described in further detail below. For these reasons,
89 a better understanding of UA, its perception among public and private actors and its potential for
90 further development in cities is urgent.

91 With this in mind, this study examines the social perception of UA in a Mexican "social housing"
92 neighborhood in Mérida, Yucatán, as an example of the typology of housing built throughout the
93 country. Specifically, the aim is to identify and understand the relationship between the role of UA
94 in Mexican "social housing" neighborhoods and stakeholder perceptions about current and future UA
95 development. Two specific objectives guide the study. The first objective is to expose the perceptions
96 and motivations for UA, as well as the barriers, benefits and relationships that urban agriculture
97 presents in built environments. The second one is to identify the main trends in feeding and logistics
98 and health related to vegetable consumption.

99 Four "social housing" neighborhoods of Mérida (Yucatán, México) were chosen as representative
100 cases of Mexican urban developments during the last 10 years, using criteria such as location, housing
101 typology, urban plan and neighborhood design and year of construction. We combine quantitative
102 and qualitative research methods involving different stakeholder groups (residents, government
103 officials and technical experts) that have the greater potential to be involved in UA developments.

104 After this introduction, a background section outlines the state of UA, particularly in Latin American
105 and Mexican contexts. After that, the study area and the quantitative and qualitative methodology
106 used in the study are presented, followed by the results and discussion of the structured interviews,
107 divided into four sections. Finally, we present the conclusions and future perspectives regarding the
108 social perception of UA in the social housing neighborhoods of Mexico.
109

110 **1.1 Background. Urban agriculture and changing Mexican cities**

111 UA comprises growing food plants and raising livestock within and around cities (FAO, 2011). The
112 variety of UA forms can be classified in various ways, depending on its actors, purpose, land use,
113 scale, location, property, technology and production system (Fig 1). As UA is easily adaptable to built
114 environments, it is an essential ally in cities' quests to secure adequate food. UA may manifest

through different typologies (such as green walls, urban orchards, green roofs, rooftop greenhouses, facades, balconies, backyards, basements), scales, orientations and purposes (Nadal et al., 2015).

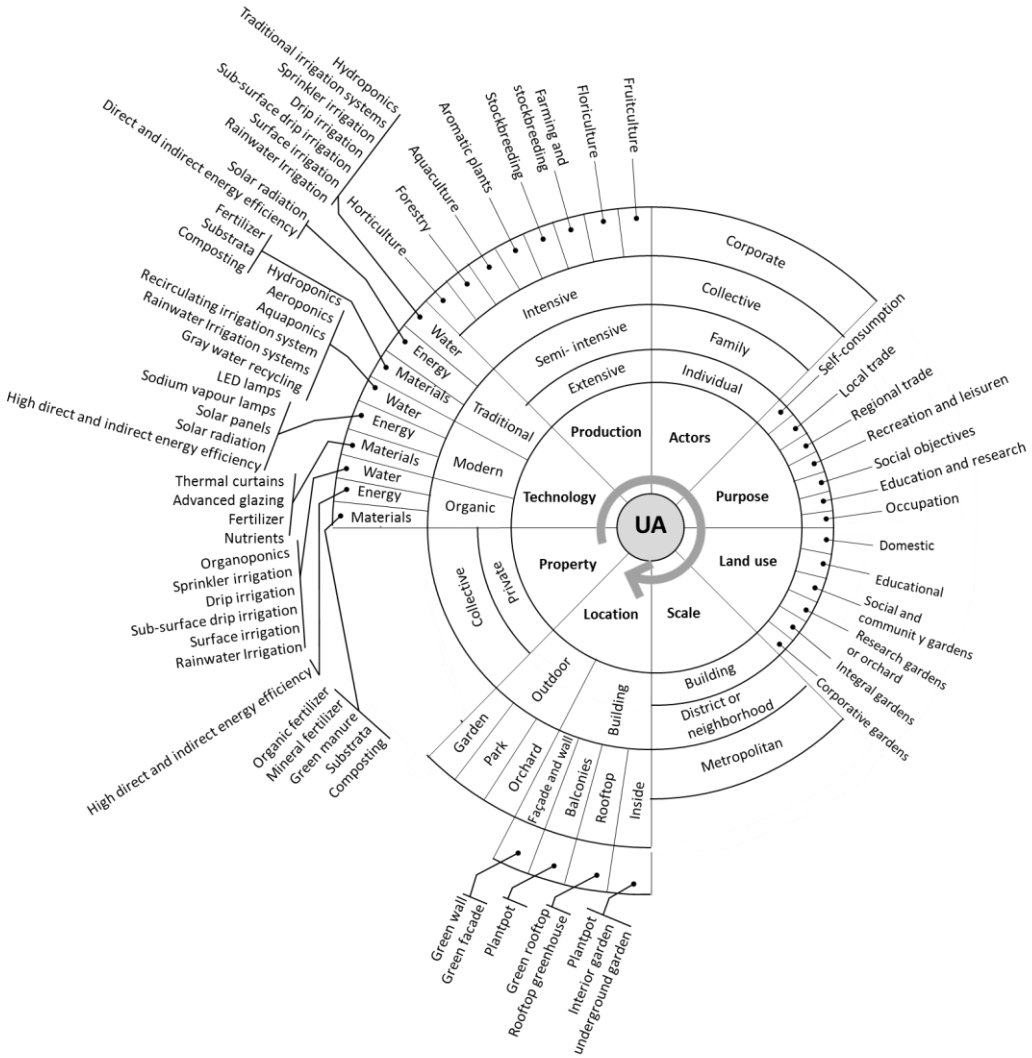


Fig 1 Classification of UA, based on Nadal et al. (2015).

The multiple benefits of UA (Table 1) include the following: tackling food production constraints; providing direct access to of nutritionally richer and more varied diets according to local culture and food preferences; increasing the stability of household food consumption; and generating revenues through the sale of production surplus (Armar-Klemesu, 2000; FAO, 2011; Zezza and Tasciotti, 2010).

126

Table 1 Primary benefits of UA

Area	Benefits	Authors
Social	Food security	(Barthel and Isendahl, 2013), (Kirwan and Maye, 2012), (Carney, 2012), (Maxwell et al., 1998), (Moustier and Danso, 2006)
	Social cohesion	(Sanyé-Mengual et al., 2016), (FAO et al., 2015), (Novo and Murphy, 2001), (Smit and Bailkey, 2006), (Orsini et al., 2009), (Díaz-Albertini, 1991), (Oths, 1998), (FAO, 2016)
	Food justice	(Alkon and Mares, 2012), (Block et al., 2012)
	Human right to food	(Moustier and Danso, 2006)
	Healthier diet	(Gockowski et al., 2003), (Smith and Eyzaguirre, 2007)
	Environmental and nutritional education	(Mezzetti et al., 2010), (FAO, 2005), (Smit and Bailkey, 2006)
Economic	Local production	(Mok et al., 2014), (Zezza and Tasciotti, 2010)
	Job opportunities	(Agbonlahor et al., 2007), (IIED, 2011)
	Economic savings	(Moustier and Danso, 2006)
	Affordable food	(Kirwan and Maye, 2012)
	Food sovereignty	(Moustier and Danso, 2006)
Environmental	Urban biodiversity	(Konijnendijk and Gauthier, 2006), (McClintock, 2010)
	Less food transportation impacts	(Cerón-Palma et al., 2012a), (Arosemena, 2012),(Jones, 2002), (Sanyé-Mengual et al., 2014)
	Less emissions	(Cerón-Palma et al., 2012a), (Arosemena, 2012),(Jones, 2002), (Sanyé-Mengual et al., 2014)(Harris and Manning, 2010)
	More sustainability	(Pearson et al., 2010), (Holdsworth, 2005), (Smit and Nasr, 1992), (La Rosa et al., 2014)
	Closed cycles in urban food flows	(Cerón-Palma et al., 2012a), (Coffey and Coad, 2010)
	Urban multi-functionality	(Arosemena, 2012), (Aubry et al., 2012), (Zasada, 2011)

127

128 Worldwide interest in self-growing vegetables is increasing, and 25–30% of urban dwellers are
129 involved in the agri-food sector (Orsini et al., 2013). However, research and information regarding
130 the role of UA in developing countries are limited (Orsini et al., 2013; Poulsen et al., 2015; Warren
131 et al., 2015).

132 The past three decades ago in Latin America have seen a tendency toward the segregation and division
133 of urban structures with a diffuse or extensive form called a "city of islands" or "urban archipelago".
134 This new structure inherits some classic characteristics of Latin cities, combined with the following
135 four new areas: *islands of wealth* (gated communities for the upper and middle classes), *islands of*
136 *production* (industrial production in suburban areas located in peripheral industrial parks), *islands of*

consumption (construction of numerous malls) and *islands of precariousness* (social housing neighborhoods and informal settlements located on the edge of the city). These trends erode social cohesion and lead to an increase in instability, violence and insecurity (Janoschka and Glasze, 2003).

In Mexico, this structure is partly the result of the current housing policy, encompassing "social housing" for lower-income populations. The Mexican Federal Government promotes housing of reduced dimensions on the city outskirts comprised of three types of social housing: *economical* (with a cost of up to 118 times the monthly minimum wage (mmw) in Mexico City), *popular* (from 118.1 to 200 mmw) and *traditional* (from 201 to 350 mmw). The main difference between these types is the size of the dwelling in square meters (m^2) (Cerón-Palma et al., 2013; SHF, 2015), which varies from 30 to 62.5 m^2 (CONAVI, 2010) in plots with dimensions of 8x20 m, 10x20 m or 10x25 m (Romero, 2007). Construction materials are conventional, e.g., beam and vault slabs, concrete, and either hollow block walls, concrete walls or clay bricks (Cerón-Palma et al., 2013).

Direct subsidy funding programs in support of this housing require a down payment of approximately 15% and 25% of household incomes. Affordable home ownership plans (e.g., reduced deposits) have led to more widespread home ownership and a massive expansion of social housing, which now represents 34.7% of the total housing stock in Mexico. The target buyers are workers with individual or family income of 1-3.9 times the mmw (González, 2006; SHF, 2015).

However, the 'Satisfaction index of Mexican housing', which evaluates physical, spatial, functional and environmental adaptations and transformations of housing characteristics, and the 'Satisfaction index of complex housing and Mexican cities', which evaluates the location, perception, equipment and services in the housing complex and the city, were both unsatisfactory in 2014 (SHF, 2015). This leads residents to remodel and extend their homes to fit their needs

Based on own observations and other references (García-Huidobro et al., 2011), we identified a pattern in the trend of modifying the original typologies of social housing in Latin America. The original or basic social housing model, with its small size and limited number of rooms, undergoes an architectural transformation that typically includes the following three states:

a) Establishment: the family makes minor modifications to ensure the safety of the property and provide individuality to the image of the house.

b) Densification: the family grows and incorporates new spaces, demanding the greatest constructive effort; mainly bedrooms and bathrooms are built. The process of change is mainly self-engineered and depends directly on the family's funds.

c) Consolidation and diversification: family housing becomes a conglomerate of aggregate functions and social values.

From the construction perspective, these changes occur progressively along four steps (Fig 2). These were identified through an on-site tour of the neighborhoods to document the structures, their specific locations and constructive and formal characteristics. Reference data for areas obtained by Cerón-Palma et al. (2013) were used to generate the plot area, constructed area, available plot area and roof area of each step, also indicated in Fig. 2 as follows:

1. Original configuration, without modification or change.
2. Construction of a front or backyard annex. This is usually a two-car garage that covers the entire facade of the house and means the loss of space from the front garden. This annex involves the construction of a roof (approximately 43 m^2). A backyard annex usually consists of the construction of a new bedroom and/or porch. The covered area of the house increases and limits the backyard space. This annex involves the construction of a roof (approximately 37 m^2).
3. The housing has a bedroom and a porch built in the backyard, which further limits the free space on the ground.
4. Construction of spaces on the second level of the house. Usually, no buildings of three or more levels are implemented.

Steps 3 and 4 of this process result in the initial available land area of the house (104 m^2) shrinking to approximately 20-24 m^2. The remaining space is usually used for air-drying clothes on clotheslines or drying racks. At the same time, rooftop areas expand.

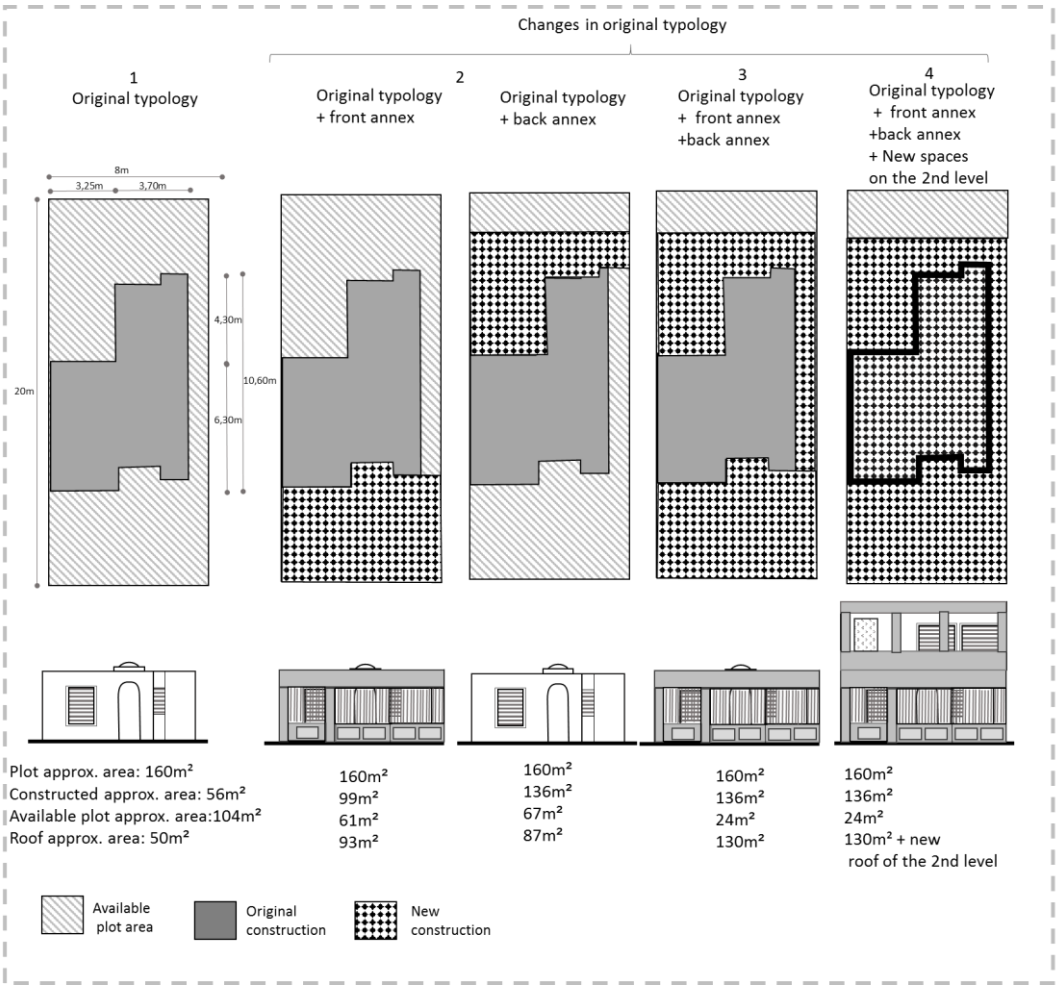


Fig 2 Evolution of social housing in "social housing" neighborhoods of Mérida in a densification state.

According to the National Institute of Statistics and Geography of Mexico (INEGI), 78% of the 119.5 million inhabitants of Mexico lived in urban areas in 2015. This corresponds to 31.3 million households with an average of 4 members (INEGI, 2015). The need for housing increases as the population grows. This causes a decrease in green areas as the percentage of surfaces covered with pavement, houses, parking areas and roads increases (Grimmond, 2007). The development of UA in Mexico is bounded by this context, which is largely shared with the entire Latin American region.

In addition to the benefits already mentioned, UA provides a strategy for combatting obesity, another major concern. As the urban area expands, traditional diets tend to become "more urban" (i.e., based on food with high sugar, salt and fat contents). This increases the incidence of chronic degenerative diseases (overweight, obesity and diabetes) (Perez-Izquierdo et al., 2012). In Mexico, almost 50% of household purchases are processed foods. The consumption of fruits and vegetables fell by almost 30% between 1984 and 1998, while the consumption of refined carbohydrates and sodas rose by

nearly 8% and 35%, respectively, (NU-CEPAL, 2013). According to data from the 2012 National Survey of Health and Nutrition, 34% of the urban population is obese (INSP, 2012). More than 70% of the adult population was overweight (FAO, 2013).

In this context, between 2007 and 2012, 15,700 inhabitants of México city received US $24.6 million in public investments for horticulture, floriculture and crop and livestock production, and US $37 million for the conservation and sustainable use of natural resources in primary production (FAO, 2014). However, the conditions for the development of UA are unfavorable. For instance, the Mexican National Development Plan (2013-2018) does not include or promote UA as a strategy for improving health, urban planning and family economy (SEGOB, 2013).

Despite the novelty of this topic, there is limited literature on agriculture UA in Mérida and the classification of vegetable species in orchards in peri-urban or rural areas: J. S. Flores and Ek (1983), Jiménez-Osornio et al. (1999), Domínguez Santos et al. (2011), A. González (2012), Mariaca (2012). Agriculture in the urban environment and within the social field, specifically regarding the perception of residents of the city, remains neglected as a research area. The present paper fills this gap, helping to expand the scientific literature on UA in Latin America.

2. Study area and methods

Fig 3 summarizes the methodological procedures in this paper, outlining the research stages and associated approaches and tools. They will be explained in detail in the following sections.

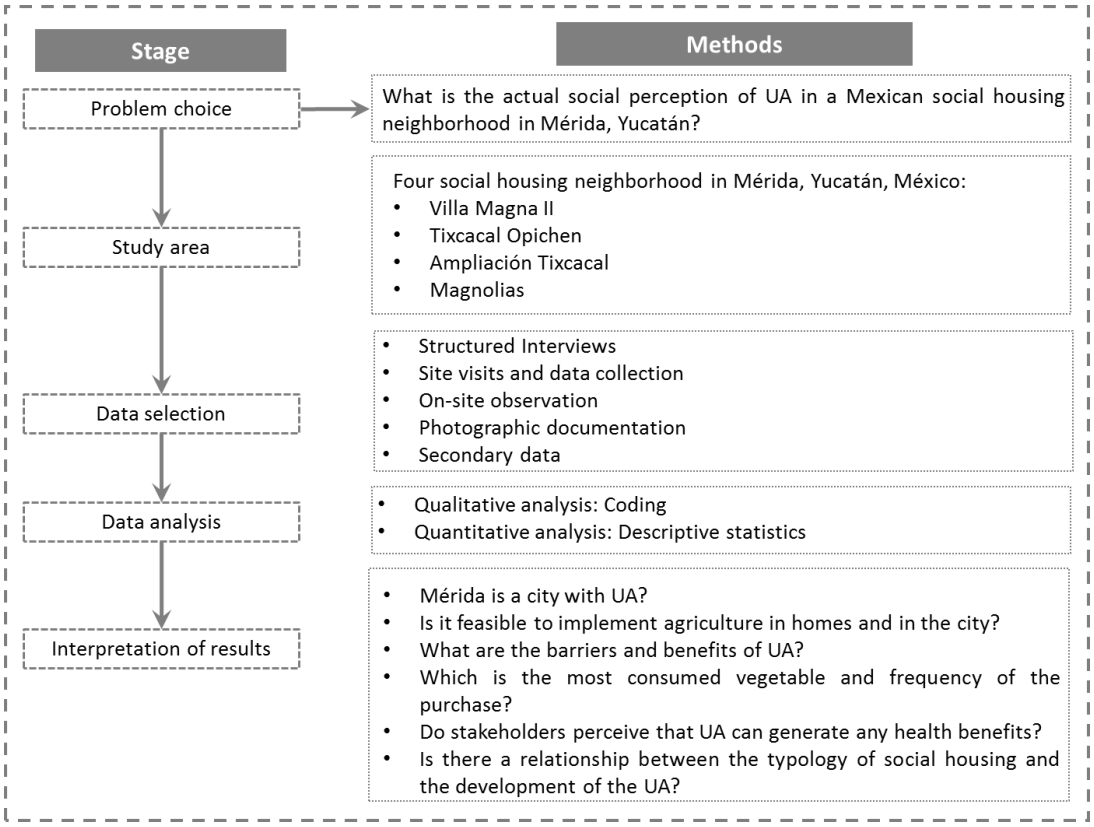


Fig 3 General methodology.

Case study selection: Social neighborhoods in Mérida, México.

The case study was conducted in Mérida, the capital city of Yucatán province, in southeast México. In line with the objectives and the reviewed literature, the criteria used to select the case included the following: presence of consolidated areas of social housing with a high percentage of artificiality; loss of the traditional diet; adequate climatic conditions for the development of UA; culturally rich agricultural heritage; and high incidence of chronic food-related diseases. Due to the reasons that follow, Merida fits the following requirements perfectly:

a) Merida is a large city with residential segregation (García et al., 2012), reflecting the current model of a "city of islands" common in Latin America (Castañeda, 2007; Janoschka and Glasze, 2003; Rodríguez and Arriagada, 2004).

b) Many areas of social housing built during the last 10 years may or may not have implemented UA. There is limited information on how plots in social housing have been used for food production.

c) The sunny weather and year-round warmth provides a strong potential to develop UA through collective gardens, commercial installations, small private gardens or vertical gardens. The climate in Merida is warm and humid, typical of the tropical regions, with rain in the summer, an average annual temperature between 24.5 and 27 °C, annual rainfall of 805.4 to 1120.5 mm and an average global solar radiation of 5.0 kWh/m^2/day (García, 2004; UADY, 2016).

d) The city has a pre-Hispanic history and a heritage of growing fruits and vegetables. Yucatecan people have an extensive agricultural background. Traditionally, the vernacular dwellings have a garden in which vegetables and fruits are grown. Home gardens (Mayan solar in Spanish or "Ich-tankaab" in the Mayan language) (J. Flores and Ek, 1983; Gómez-Pompa, 1987) are a key point of livelihood for the Yucatán population during times of crisis, as they provide the minimum inputs necessary for a family's survival (Jiménez-Osornio et al., 1999).

e) Mérida is an example of the chronic degenerative disease crisis currently present in Mexico. In 2013, the prevalence of diabetes was 9.2%. 35.5% of the population was overweight and 44.8% obese (IDF, 2013).

Mérida is a dense and expansive city with a population of 830,732 inhabitants in 2010 (INEGI, 2010), representing 42.5% of the total population of the state of Yucatan. It is spread over an area of 883.40 km2, equivalent to 2.19% of the state (SEDUMA, 2006). It has experienced great spatial growth in the last 50 years.

Like most Latin American cities, this growth is characterized by a tendency to concentrate economic activities such as trade, infrastructure, education and health services (Bolio, 2007a, 2007b, 2006; García et al., 2012). This occurs especially to the north and west of the city, generating significant changes in the spatial organization.

The city expansion is mainly based on the construction of economical housing in succession with traditional buildings. A total of 229,635 new private housing units were built in 2010, the equivalent of 45.3% of the total housing in Yucatán (INEGI, 2010). Nevertheless, 8% of the total population (72,019) lived in homes with poor quality materials and inadequate spaces in 2015. Additionally, 10.6% lived in homes without basic services, which means that housing conditions are not adequate for 95,093 people. Moreover, 18% (161,189 people) had problems with access to food (SEDESOL, 2015).

Four social neighborhoods are used here as a sample as follows: Villa Magna II, Tixcacal Opichen, Ampliación Tixcacal and Las Magnolias (Fig 4 and Table 2). These four neighborhoods are representative of the "social housing" neighborhoods in Mérida in 2010 (a total of 209), as they have

the most important characteristics of housing typology and urban planning. Specifically, they were chosen because of the following characteristics:

a) Location: they are situated in the north and west axes, following the current trend of increased urban growth of Mérida.
b) Housing typology: they have common features relating to the type or housing design, house size and socioeconomic status. Generally, the houses have a similar spatial distribution and number of spaces, built area and average household of 3.6 people.
c) Urban plan and neighborhood design: these "social housing" neighborhoods were built by construction companies (not by the owners). Generally, the blocks have an orthogonal trace of 150 x 40 m, with 38 houses each.
d) Year of construction: all neighborhoods were built between the years 2000-2010; thus, they have been occupied for at least 5 years, which is enough time for residents to have completed the appropriation stage. Therefore, it is possible to evaluate the evolution of the uses of housing spaces, built or otherwise.

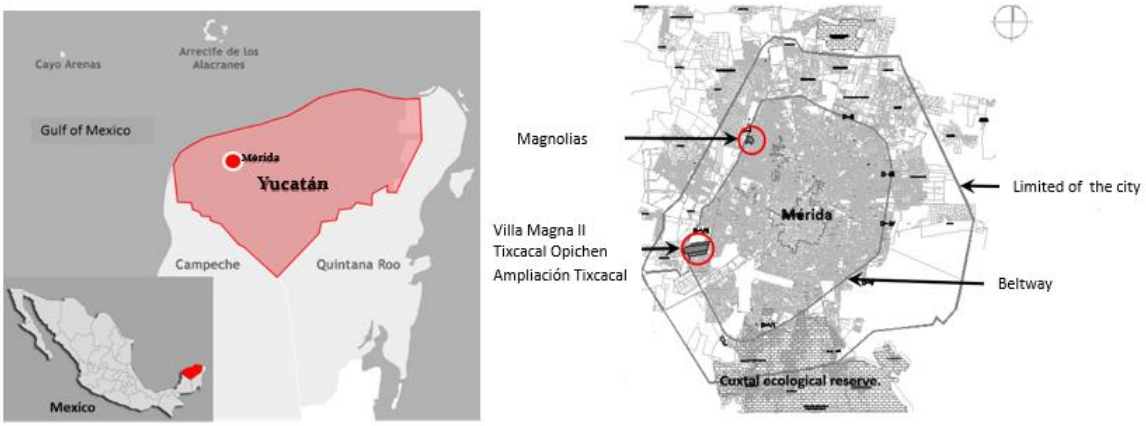


Fig 4 Location of Mérida, delimitation of the city and location of the four "social housing" neighborhoods of the sample.

Table 2 Characteristics of the social neighborhoods.

Name	Year of construction	Location	Total area (ha)	Housing per block	AVG Housing area (m^2) [a]	Total housing	Housing typology	Average household size
Villa Magna II	2007	West	18	38	56	825	Social housing	3.6 people
Tixcacal Opichen	2004	West	62	38		1944		
Ampliación Tixcacal	2007	West	30	38		332		
Las Magnolias	2005	North	20	34		569		

[a] Constructed area of the original typology

The four neighborhoods all have basic infrastructure (electricity, potable water, sanitary drainage, sewage system, paving, sidewalks, etc.) and three types of roads (avenues or primary streets, collectors or secondary streets and local or tertiary streets). For urban equipment, the neighborhoods have elementary schools, urban parks, sports fields and shops.

The original or basic housing model (Fig 5) is similar in each of the four neighborhoods. Each house has a plot area of 160 m^2 with 56 m^2 of construction on one floor. The basic housing model has a usable flat floor of 50 m^2. Additionally, 72.8 m^2 of the plot area is used for green space, and the rest is comprised of the house entrance, paths, etc. (Cerón-Palma et al., 2013). The single family home has one bathroom, two bedrooms, and a living room with a kitchen and is usually occupied by young families (Cerón-Palma et al., 2013; Gil et al., 2012).

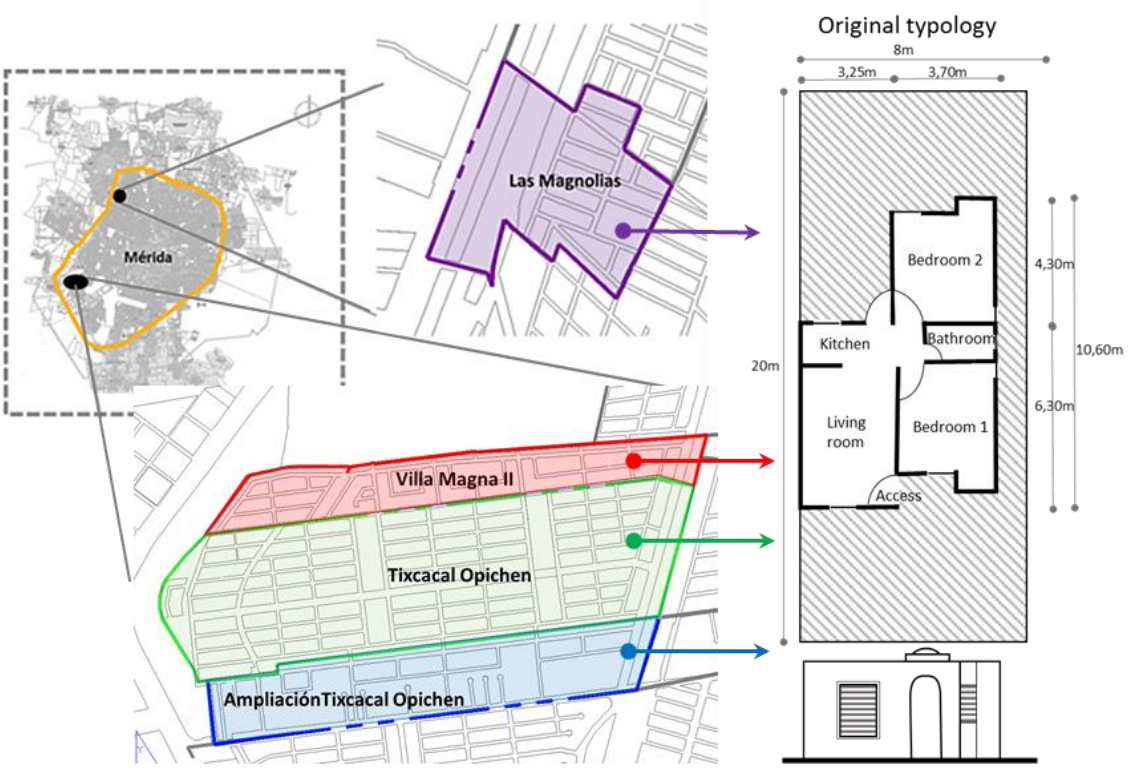


Fig 5 Urban plan of the four sample neighborhoods and dimensions and distribution of "social housing".

The construction system consists of a stone foundation, walls made of concrete blocks reinforced with steel casing armed at the corners, a concrete roof with a joist and beam and a compression layer of concrete. All "social housing" has a flat rooftop with a minimum load resistance of 200 kg/m^2, which usually has no use.

Stakeholders in Mérida

The identification of stakeholder categories who may play a prominent role in the implementation of UA in Mérida was based in the study of Sanyé-Mengual et al. (2016). The selection was carried out using our knowledge of current UA experiences in México and brainstorming with initial key stakeholders.

The actors involved in UA in Mérida will be characterized with respect to their role in promoting UA at the local level. The analysis will consider the basic steps of UA (design, construction, production and consumption) and areas of change in the city (design, construction, use and management). In this respect, UA plays an important role in bringing different actors and areas of implementation together. The resulting map (Fig 6) focuses on the following key actors and groups relating to UA:

- Urban government officials: employees of government institutions related to the urban development of the city
- Technical experts: professionals with expertise in various disciplines that complement the development of agriculture in the city
- Residents: people living in social housing neighborhoods that make up the sample.

The government is related to design by regulating the activities and efforts of the city. Technical experts influence design and construction areas, and residents are the users of the city. Finally, all actors are connected to the common good of the city. In addition, these actors are classified according to their degree of commitment to addressing AU. Within this classification, we have the following two types of actors:

- Direct (Residents): this group has an important role in the process, as they can help strengthen UA in Mérida on a large scale in a short time. They are the ones who develop the activity.
- Indirect (Technical experts, organizations and persons who maintain specific links with UA): they support programs, projects or policies. Urban government officials include government institutions related to the development of UA through an institutional mandate and skills.

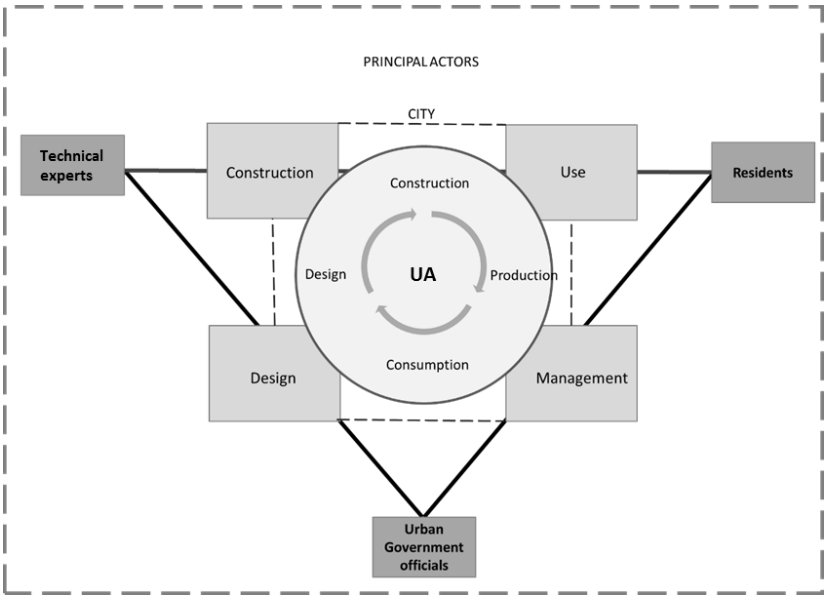


Fig 6 Map of potential stakeholders involved in the different steps of implementation of UA and urban changes in the city.

Data collection

For this study, we used quantitative and qualitative research through a multilevel concurrent nested design, which provides a broad overview of the research problem and a thorough exploration of various types of data (Hernández Sampieri et al., 2006). For the collection of information, we conducted structured interviews with 65 participants.

The interviewing process was conceived as an exploratory study. Standardized questions indicate the magnitude of the different processes under analysis rather than seeking statistical significance. At the same time, open-ended questions provide qualitative information that supplements the narrative and was subsequently coded.

Interviewees were distributed as follows: 5 residents (local people) from each of the 4 neighborhoods, 20 urban government officials and 25 urban planning, environment, construction and health technical experts (Table 3). These groups provided information about aspects of UA, social perceptions, urban planning, housing, and food health. We chose multidisciplinary groups and city dwellers in order to gain insight on their views and experiences concerning UA, their expectations about its benefits, problems facing the development of UA and their opinion about actual feeding habits.

Table 3. Stakeholders, group, number of respondents and main relationship to UA in Mérida

Stakeholders	Group	No	Total
Residents	Villa Magna II neighborhood	5	20
	Tixcacal Opichen neighborhood	5	
	Ampliación Tixcacal neighborhood	5	
	Magnolias neighborhood	5	
Urban Government Officials	Urban planning	6	20
	Architecture	9	
	Construction	5	
Technical experts	Urban planning	7	25
	Environment	7	
	Construction	6	
	Health	5	
	Total		65

The interviews were organized around the following two topics: perceptions of and motivations for UA, and logistics and feeding. Each interview lasted approximately 30 minutes and was conducted in January 2016, including a pilot interview with a technical expert in agronomy. The questions posed

358 to urban government officials (urban planning, architecture and construction) and technical experts
359 (urban planning, environment, construction and health) were adapted for local non-experts with
360 barriers to technical or specific vocabulary that limited understanding of the issues. In the case of the
361 neighborhood resident, we interviewed people older than 18 years with a minimum of 5 years living
362 in the neighborhood. Moreover, interviews were restricted to homes located in the middle of blocks
363 (lots located in the corners have greater dimensions).

364 All interviews had the same structure (Fig 7). The first part dealt with general perceptions of UA, its
365 meanings and definitions of its concept, practice, technology, typology and development. The specific
366 topics of UA technology and typology were discussed only with technical experts. Other topics were
367 related to urban planning and housing, the potential for urban public gardens, home gardens and
368 places inside the houses where UA could be implemented. There is also a focus on the benefits and
369 barriers facing the development of UA in Mérida.

370 The second part discussed the frequency, place, distance and means of transport used to acquire
371 vegetables. This part focused on current eating habits in urban Mérida, e.g., variety and daily amount
372 of vegetables consumed, and variety of crops that residents would like to cultivate. For health
373 perceptions, we focused on the health benefits derived from vegetables and the reasons why growing
374 vegetables can improve consumers' quality of life.

375

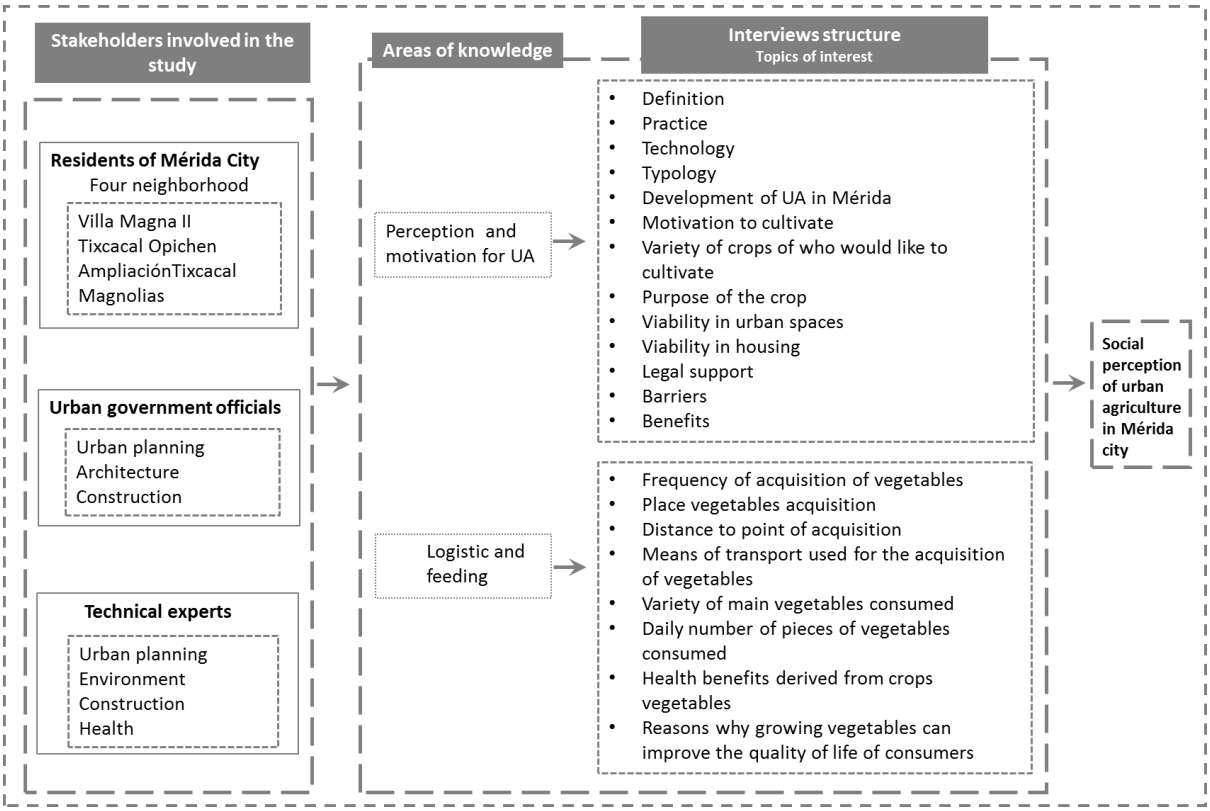


Fig 7. Structure of the interviews in the study.

Analyzing the influence of "social housing" in urban agriculture

In analyzing the data, we tried to identify new categories of variables for future studies. Directly comparing results from quantitative data collection with results from qualitative data collection, we formed new variables or datasets (Hernández Sampieri et al., 2006). Data collection and analysis was complemented with secondary data collection.

Given the background information on the characteristics and evolution of social housing in Merida, an argumentation is made about the potential development of urban agriculture in Mérida. This is presented and considered in the discussion section.

3. Results

The results are presented in the following four sections: general perceptions of UA; urban planning and housing; eating habits and health perceptions; and benefits and barriers.

Perceptions and motivation for urban agriculture

We examined whether stakeholders know and can define the concept of UA (Table 4). Generalized awareness of UA is limited to groups of government officials and technical experts. In contrast, only

5% of residents reported awareness of UA. In trying to define UA, stakeholders generally focus on urban space (86%), while only 14% consider the peri-urban space. Poultry, livestock and fish were mentioned by 10% of the interviewees. The remaining definitions were restricted to growing fruits, vegetables and fruit trees.

Table 4 Results of general perceptions of Urban Agriculture in Mérida, according to the different stakeholder groups

Urban Agriculture	Details[a]	Stakeholders		
		% of respondents within each category		
		Residents	**Urban government officials**	**Technical experts**
Concept definition	Known	5	**100**	**100**
	Unknown	**95**	0	0
Practice	Practice	5	20	40
	Not practice	95	**80**	**60**
Typologies	Private gardens	[b]	25	12
	Collective gardens	[b]	25	12
	Green roofs	[b]	10	12
	Edible landscaping	[b]	0	4
	Pots	[b]	25	4
	Do not know the topic	[b]	**35**	**56**
Technology Concepts	Hydroponics systems	[b]	25	8
	Sprinkler irrigation technologies	[b]	25	**44**
	Aquaponics systems	[b]	15	0
	Leeds	[b]	0	4
	Compost	[b]	0	4
	Do not know the topic	[b]	**35**	40

[a] Categories were indicated by stakeholders
[b] This category was not surveyed in this group of stakeholders

As for the social character of UA, 8% of all respondents recognized that UA is an activity that should be performed in conjunction with neighbors and not individually. Some professional stakeholders, including urban government officials, defined UA as follows:

It is a necessary discipline for the reintegration of subsistence food sources, given the loss of natural agricultural production capacities (Urban government official).

Urban agriculture is a practice [that is] *part of the cities and […] peripheries, […] a good exercise for generating healthier food for urban populations […] especially in those neighborhoods where urban agriculture is not performed individually […] there is no space (Health specialist).*

Growing plants and raising animals inside and around cities provides us with different types of food products, such as poultry, livestock and non-food products (ornamental plants, aromatic and medicinal plants) (Environment specialist).

The practice of UA reported by the residents is irrelevant or residual (only 5%) compared to the perception of the implementation level by urban government officials (20%) and technical experts (40%). For the types of UA, the five forms identified with the greatest potential for implementation are private gardens, collective gardens, green roofs, edible landscaping and pots.

Although all urban government officials and technical experts know the concept, 35% of urban government officials and 56% of technical experts could not identify any form of UA. Among urban government officials, private and collective gardens are the most popular forms, with 25% of respondents indicating each. In the group of specialists, 44% reported knowing a typology of UA in which private gardens, collective gardens and green roofs together represent 36%.

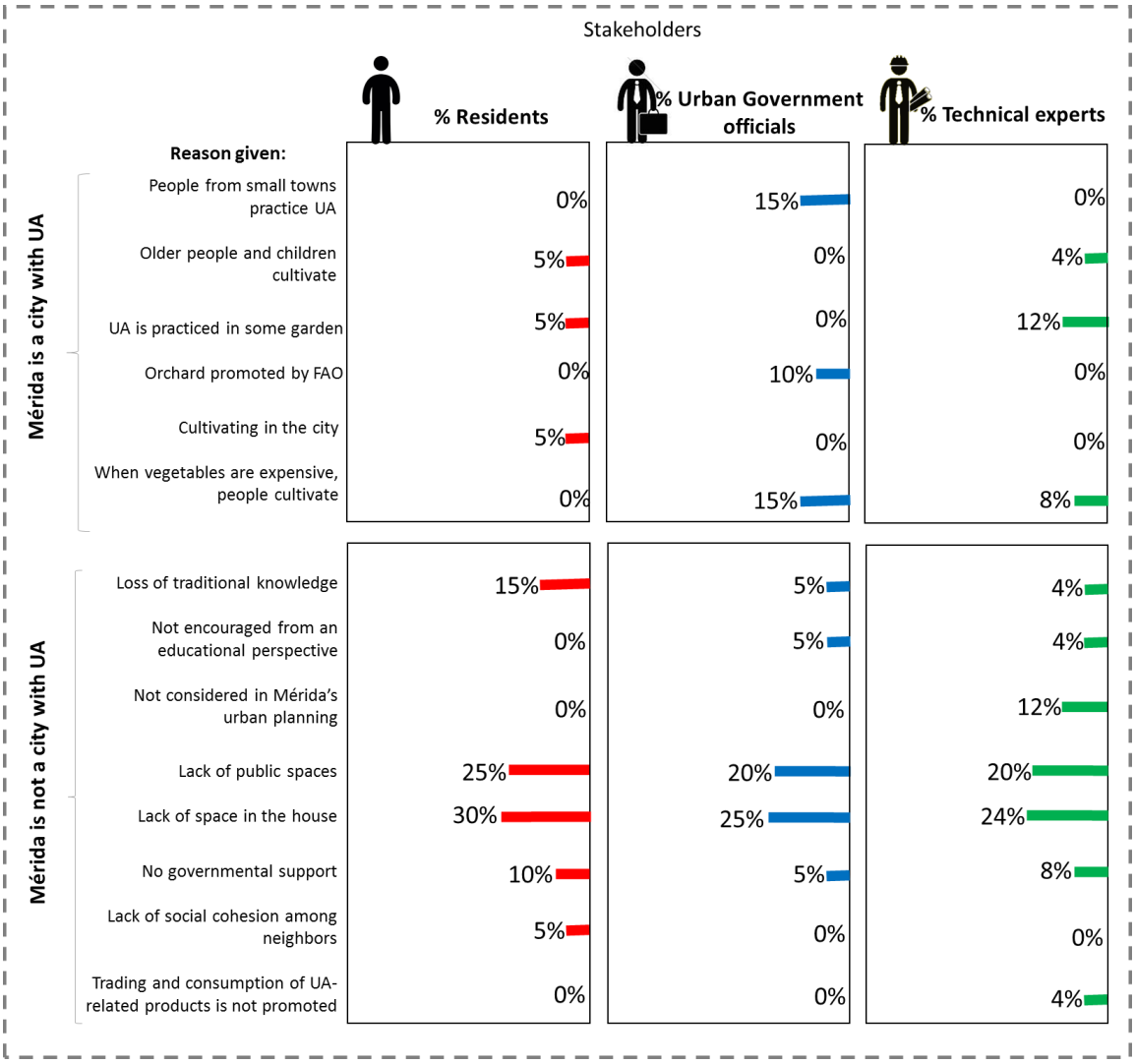
Similar to what we observed with UA typologies, 35% of urban government officials and 40% of technical experts reported having no knowledge of the cultivation technologies in urban areas. The rest identified the following five types of technologies of UA: hydroponics systems, sprinkler irrigation technologies, aquaponics systems, lees and compost. The sprinkler irrigation technology was best known (24% of all respondents). Within the group of government officials, hydroponics systems and sprinkler irrigation technologies are the main technologies, with 25% each. For specialists, sprinkler irrigation is the most known technology with 44%. In sum, the knowledge of UA technologies and typologies is limited. Most people still believe that agriculture must be done in the traditional way but are aware of the limitations currently facing its implementation and are open to accepting other forms of UA.

The next block of responses was related to the question, 'Is today's Mérida a city with UA? (Fig. 8). Most stakeholders (residents 85%, urban government officials 60% and technical experts 76%) consider Mérida to be a city without UA development. The explanations for this perception include the following: loss or lack of traditional agricultural knowledge (social approach), lack of public and

housing spaces (environmental approach) and a lack of government support (economic approach). These results coincide with the high percentages presented in Table 3 concerning the number of people who do not develop any UA activity.

Urban government officials are more optimistic and supportive of the development of UA in Mérida (40%), followed by technical experts (24%) and residents (only 15%). Generally, the reasons identified by stakeholders are older people and children cultivate (social approach), crops are grown in some gardens (environmental approach), and when a vegetable is expensive, people cultivate it (economic approach).

All stakeholders agree that the lack of space in houses and public spaces is the main constraint for the development of UA in Merida. Meanwhile, the fraction of stakeholders who consider Merida a city with UA does not agree on a particular set of reasons to support their view.



445 **Fig. 8** Results of the general perception about the topic, "Is today's Merida a city with Urban Agriculture?

446

447 Regarding the motivation to practice UA in Mérida (Fig. 9), urban government officials and technical
448 seem the most committed (100% and 96%, respectively), but only 55% of residents expressed interest.
449 All stakeholders agree that parks are the most viable option (80-82%) for collective forms of UA, but
450 they also see potential in the vacant land (18-20%). Backyards seem the preferred location for
451 individual forms of UA (residents 65%, urban official government 60%, technical experts 84%),
452 followed by front gardens (residents 10%, urban official government 40%, technical experts 12%).
453 25% of residents reported their preference for potential cultivation on the roof due to the lack of a
454 better space.

455 In the legal sphere, there is ignorance relating to the laws and regulations in support of UA, with only
456 14% of technical experts reporting to know them. Despite the benefits UA can bring to cities, current
457 urban policies in Mérida do not offer feasible options to support it. UA is not considered in the
458 Mexican National Development Plan 2013-2018, the State Development Plan of Yucatán 2012-2018
459 or the Municipal Development Plan of Mérida 2015-2018.

460 There are no official statistics on existing urban gardens', their production, performance or
461 contribution to family income. Practitioners of urban gardening do not receive support from the
462 government through the relevant secretariats: Secretary of Agriculture, Livestock, Rural
463 Development, Fisheries and Food (SAGARPA); Secretary of Environment and Natural Resources
464 (SEMARNAT); and Social Development Secretary (SEDESOL). Only in some cases does the System
465 for Integral Family Development (DIF) donate seeds or poultry, but they do not deal deeply with the
466 issue (Mariaca, 2012).

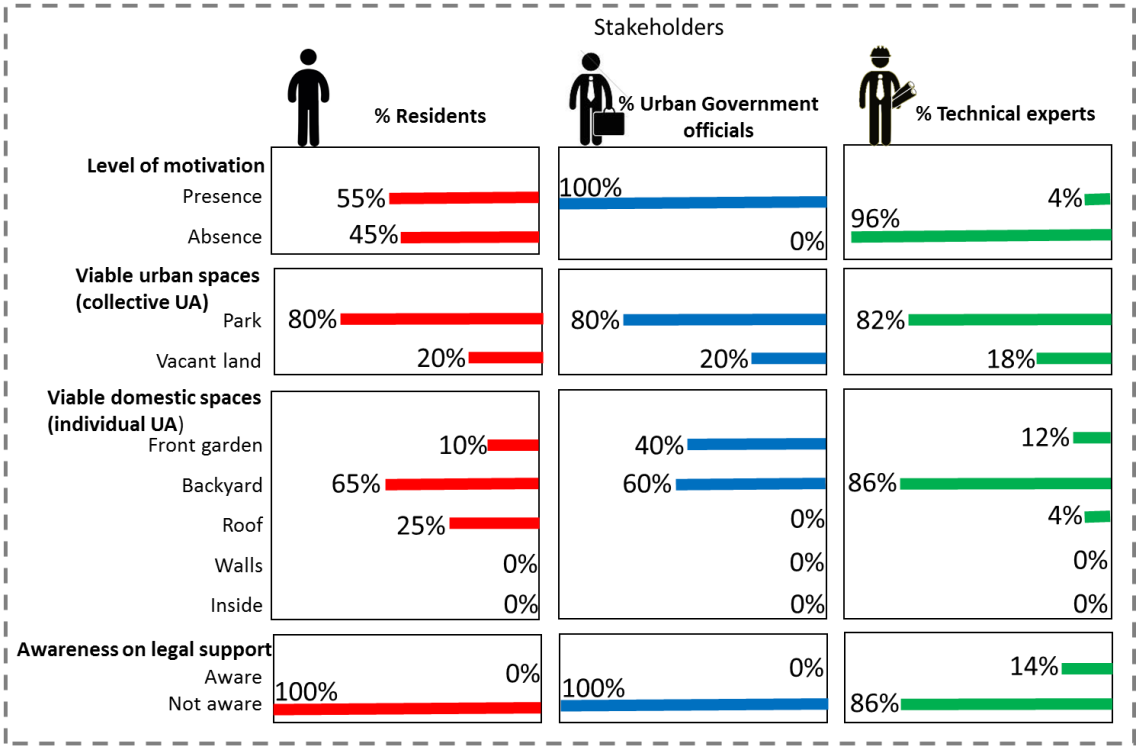


Fig. 9 On the motivation of people to practice UA in Mérida.

The main perceived barriers to the development and implementation of UA in "social housing" neighborhoods of Mérida (Table 5) are the lack of time, public spaces, housing spaces and government support. The perceived benefits are numerous and include support of food security, improvement of the quality of food, preservation of traditional knowledge, personal satisfaction, increasing green areas and cost savings.

"Lack of time" was detected as a cultural barrier for the maintenance of urban or family orchards. However, the perception of social benefits overcomes this barrier: support of food security, the quality of food, rescue of traditional knowledge and staff satisfaction. Through information provided by stakeholders, it may be noted that the benefit of preserving traditions related to Mayan solar knowledge is perhaps the most important to the development of UA in the city. In the economic field, the direct benefits of UA would be for the family and local economy: cost savings, supporting local economies and product exchange. However, there is a fear of a lack of financial support from the government because the costs of housing, food and transportation are continuous and wages are insufficient. Therefore, stakeholders perceive government financial support to be necessary for developing vegetable farming because their wages are not sufficient to cover the costs of implementing and maintaining a private or community garden.

Importantly, stakeholders perceived more benefits than barriers, coinciding with the highest percentage of motivation for cultivation in the three stakeholder groups.

Table 5. Benefits and barriers of implementing UA in "social housing" neighborhoods of Mérida

Topic	Approach	Details	Stakeholders		
			Residents[a]	Urban government officials[a]	Technical experts[a]
Barriers	Social	Lack of time	X	X	X
		Lack of knowledge of agriculture		X	X
		Mentality: "It is easier to buy"	X	X	X
		Lack of social cohesion			X
		Vandalism in neighborhoods			X
		It is not promoted in the development plan of the city			X
	Environment	Lack of public spaces	X	X	X
		Lack of housing spaces	X	X	X
		Introduction of exotic species			X
		Increased vermin			X
		Limited variety of crops			X
	Economic	Lack of government support	X	X	X
		Cost of implementation	X		X
		Maintenance cost			X
Benefits	Social	Support for environmental education		X	X
		Fosters social cohesion		X	X
		Supports food security	X	X	X
		Improves the quality of food	X	X	X
		Support for self-consumption			X
		Rescue of traditional knowledge	X	X	X
		Helps with relaxation			X
		Promotes physical activity			X
		Helps reduce obesity			X
		Personal satisfaction	X	X	X
		Increases the quality of life	X		X

	Environment	Soil enrichment			X
		Reduces CO_2 emissions			X
		Increases green areas	X	X	X
		Reduces heat islands			X
		Reuse of vacant lots	X		X
		Optimization of public space		X	X
	Economic	Cost savings	X	X	X
		Supports the local economy		X	X
		Product Exchange	X		X
		Source of employment	X		
[a] Only the source of the contribution is indicated, not the percentage.					

488

489 *Logistics and feeding*

490 For a better understanding of the results (Fig 10), they are divided into two categories: actual
491 acquisition of vegetables (transportation from outside of the city) and improved acquisition of
492 vegetables (through UA with less transportation). The first shows the information concerning
493 frequency, location, distance and transportation used for the acquisition of vegetables. Improved
494 acquisition is made through UA, revealing information about motivation, viability in the city, viability
495 in housing and legal support.

496 In the area of real acquisition of vegetables, weekly is the most referenced category (residents 70%,
497 urban government officials 80%, technical experts 76%), followed by daily (residents 20%, urban
498 government officials 20%, technical experts 12%). Urban government officials and specialists use
499 more car and public transportation for short distances to procure vegetables. Specifically, 60% of
500 urban government officials and 68% of technical experts use a car to travel distances between 500
501 meters and 5 kilometers, while 40% of residents only used the car and public transport to travel
502 distances between 500 meters and 10 km. The continued use of fossil fuel transportation generates
503 large amounts of CO_2 and promotes a sedentary lifestyle; this lack of physical activity also promotes
504 obesity. Only 32% of technical experts and 40% of government officials walk distances between 100
505 and 500 meters to acquire vegetables. Regarding the residents, 55% walk distances between 50 and
506 500 meters. This means that, in the four social neighborhoods studied, there are several points to
507 purchase vegetables.

In summary, vegetables are generally acquired weekly within a radius of 1 km and large areas, such as supermarkets, causing a considerable emissions impact from the use of cars, as a considerable portion of interested groups use them for movement. Local trade in vegetables occurs through greengrocers that are usually owned by a resident of the neighborhood.

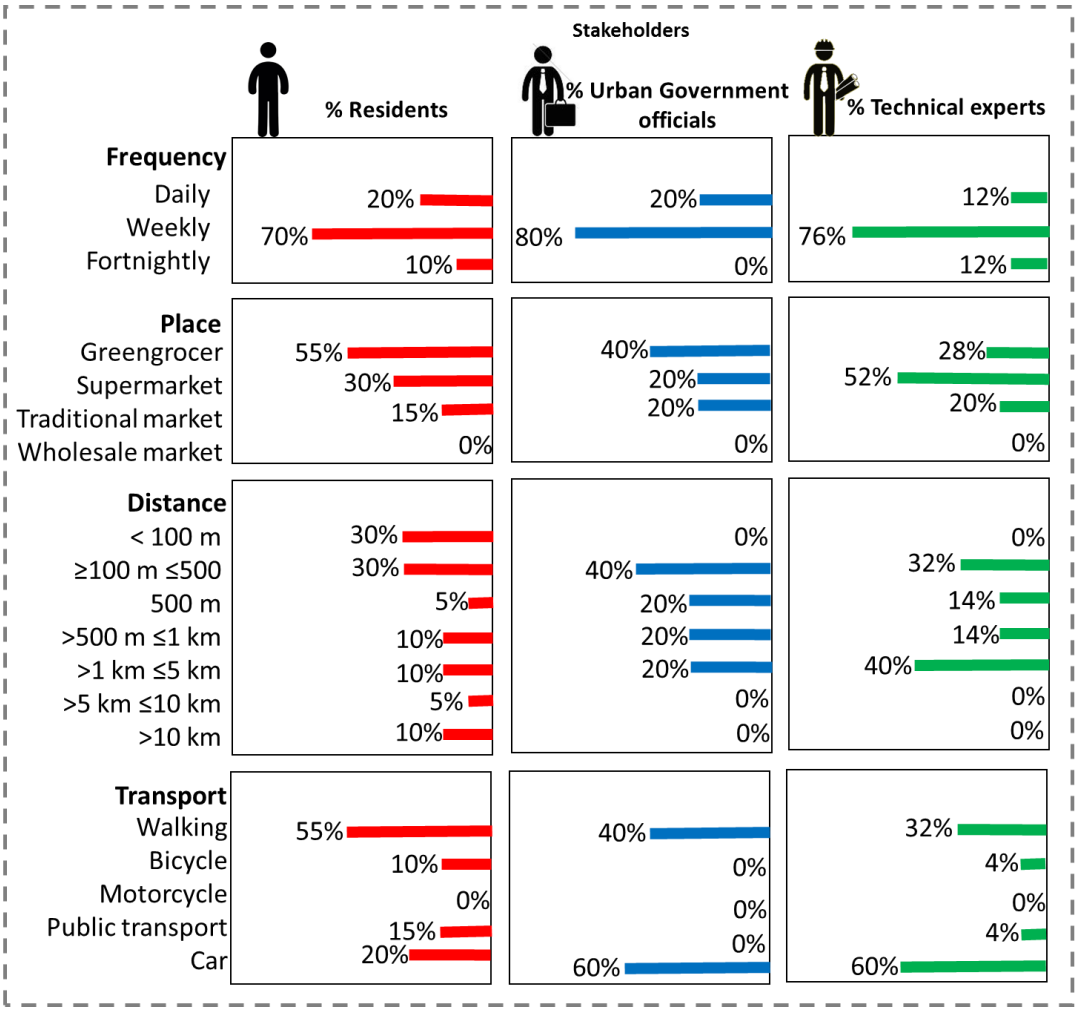


Fig 10. Logistic for vegetables acquisition in the study area.

To present the results concerning healthy food and eating habits (Table 6), the process is divided into three main areas: a) real consumption of vegetables, b) improved consumption of vegetables (through UA) and c) perceived health.

In terms of current real consumption of vegetables, the five most frequently consumed vegetables are tomato, lettuce, carrot, onion and orange. Stakeholders noted that, on average, 3 pieces of vegetables are consumed per day per person. If stakeholders' consumption data are analyzed, residents have the highest intake of vegetables (95% claimed to consume 3 to 5 or more vegetables per day). In contrast,

only 68% of technical experts achieve that amount of vegetable consumption. Despite the daily intake of vegetables by stakeholders, consumption is low and does not meet the minimum set by the FAO of 5 parts or 400 grams per day. Only 25% of residents, 20% of urban government officials and 20% of technical experts consume the minimum recommended intake of vegetables per day.

On the topic of improved vegetable consumption, the three groups of stakeholders agree on their preference of fruits and vegetables they would like to cultivate: tomato, lemon, onion, lettuce, pepper and coriander. Tomato was considered the basic plant for the development of UA. The main reason for the implementation of UA in social housing neighborhoods is consumption. The sale of crops was reported by only 15% of residents. In the case of both activities, there is an interest by 30% of residents, 20% of urban government officials and 20% of specialists, and sales would only apply to excess production.

On the topic of perceived health, all stakeholders recognize that growing their own vegetables would provide health benefits, as the products would be free from pesticides and the number and frequency of vegetable consumption would increase. Only 15% of residents foresaw no perceived benefit because they believe the vegetables they eat today provide the same benefits.

Table 6. Main results of the actual and improved consumption of vegetables in "social housing" neighborhoods of Mérida and their influence on perceived health.

Stage	Topic	Details	Stakeholders		
			% of respondents within each category		
			Residents	**Urban Government officials**	**Technical experts**
Actual consumption of vegetables	Variety of main vegetables consumed (ordered by preference)	5 main crops [a]	**Tomato**	**Tomato**	**Tomato**
			Onion	Lettuce	Orange
			Pepper	Carrot	Lettuce
			Banana	Lemon	Banana
			Potato	Pumpkin	Potato
	Daily number of vegetables consumed	1	0	0	8
		2	5	20	24
		3	**45**	**60**	**44**
		4	25	0	4

		5	10	0	4
		>5	15	20	16
Improved consumption of vegetables (through UA)	Variety of crops you would like to cultivate	5 main crops [b]	**Tomato**	**Tomato**	**Tomato**
			Onion	Lemon	Lettuce
			Lemon	Lettuce	Lemon
			Lettuce	Pepper	Pepper
			Pepper	Coriander	Onion
	Purpose of the crop	Consumption	**55**	**80**	**82**
		Sale	15	0	0
		Both	30	20	18
Health Perceived	Will growing your own vegetables improve your health?	Yes	**85**	**100**	**100**
		No	15	0	0
	Why will growing your own vegetables improve your health?	Pesticide-free crops [c]	**60**	**100**	**60**
		Crops with more nutrients [c]	15	0	12
		Increasing amount and frequency of consumption of vegetables [c]	25	0	24
		Increased physical activity [c]	0	0	4

[a] Categories were indicated by stakeholders and ordered by preference
[b] Ordered by preference
[c] Categories were indicated by stakeholders

4. Discussion

The results presented above led to two main interconnected findings, namely the current panorama of urban agriculture and development possibilities of urban agriculture in Mérida, which are representative for other similar urban developments in México and other Latin-America countries. They will be discussed in the following sections in the light of existing literature.

Current panorama of urban agriculture in Mérida

Although each day sees further promotion of UA by international institutions such as the FAO, Economic Commission for Latin America and the Caribbean (ECLAC), and United Nations (UN), this study posits that their message does not reach the entire population, but rather only groups of government workers and specialists, at least initially. This is shown in the fact that most residents are unfamiliar with UA, compared to the high percentage of familiarity among urban government officials and technical experts. Perhaps it is a matter of time before the message reaches residents. This creates a new aspect for analysis related to the lack of knowledge about UA; this includes not only a lack of knowledge of the theoretical concept but also a lack of knowledge regarding the practice of agriculture in general. Perhaps this ignorance about UA exists due to a lack of practice and development of UA in the city. It also highlights the need to develop programs that promote UA, as the initiative will be very difficult to develop otherwise.

In Mérida, we observed divergent stakeholder opinions (residents, urban government officials and technical experts) regarding the different attributes given to UA, specifically "physical limits" or geographical limits. Most stakeholder opinions show a marked penchant for considering only what develops within the city limits as UA. This trend may be attributed in part to the values, training or interests of each interviewee and the current weak link between the city and UA. This coincides with a report by Sanyé-Mengual et al. (2016) in Barcelona (Spain), where the conceptualization of UA is built on what stakeholders see as a distant relationship between agriculture and cities. Nevertheless, this constant relationship with the "physical limit" is a normal trend reported by other authors (Gumbo and Ndiripo, 1996; Maxwell, 2000; Maxwell et al., 1998; Mbiba, 1994) and is even present in the FAO's official definition of UA (FAO, 2011).

The lack of an official definition of UA in Mérida creates an unstable starting point for its development, as evidenced by the low prevalence of UA practice (5% residents, 20% urban government officials and 40% technical experts) and most stakeholders' failure to consider that Merida is a city in which agriculture is currently being developed (85% residents, 60% urban government officials and 76% technical experts). In this case, it is necessary to issue a formal, common definition approved by the different actors who make up Mexican society in general. This definition could provide a starting point to promote activities related to UA in which all interested parties can support its development, whether across the country or specifically in Mérida.

Knowledge about technologies and types of UA remains limited. Most stakeholders still believe that agriculture must be done in the traditional way with irrigation systems. Still, they are aware of that system's limitations and are open to accepting other forms of UA, including vertical agriculture (green roofs and walls). In some way, this mental openness to experimentation with different types

577 of UA is a sign of strong interest by stakeholders to develop some of the modalities of agriculture
578 (55% residents, 100% urban government officials and 96% specialists) and cultivate traditional crops,
579 such as tomatoes, onion, orange, peppers and lettuce. Thus, they can acquire vegetables in a more
580 sustainable way within the same neighborhood (or in an area not exceeding 500 m), avoiding excess
581 CO_2 emissions generated by the use of cars for transport. This method will also help to revive
582 ancestral knowledge about agriculture, strengthening the identity of the people and improving their
583 current food and health conditions.

584 *Development possibilities of urban agriculture in Mérida*

585 This study found Merida to have high motivation and potential for the development of UA in the
586 technical field. However, important limitations of a legal and political character exist. Today, we
587 cannot consider UA to be present in Mérida, largely due to limitations in urban planning and housing
588 characteristics that hinder its development, as reported in this study. It should be noted that the current
589 trend in Mérida's urban planning policy, in which urban settlements are located on the periphery due
590 to insufficient resources for the city to grow by buying cheap land without infrastructure located in
591 the external areas of the city. These results coincide with the statement by Aravena (2011) about
592 social housing policy in Chile and Latin America, where there are two trends in current urban
593 planning and housing growth, namely reducing and displacing: reducing the size of housing and
594 moving urban settlements to the periphery. The present study affirms the existence both tendencies.
595 The current design of social housing is inadequate for the proper development of a family, both in
596 size and number of spaces. This is reflected in the tendency to annex new areas to meet the space
597 needs of families. Reinforcing this idea, residents think the dimensions of the plot area and housing
598 promoted by the government are insufficient for developing an orchard. This also coincides with the
599 views expressed by Aguilar (2012) and González (2012), who note that the current urbanization of
600 the country has greatly influenced the decline in urban orchards. The construction of settlements on
601 the periphery of Mérida is exposed through the construction of huge garages in social housing. This
602 is a reflection of the neighborhoods' bad location, which has consequences related to displacement
603 and lack of efficient transportation systems. Users are thus forced to have a car to meet those needs.

604 As a way to summarize this argumentation, an outline of the potential development for UA is
605 proposed in Fig. 11. Based on the results presented above, this figure presents a synthetic view of
606 changing stages in the typology of "social housing" in the study area and the applicable typology of
607 UA.

608 The initial typology of social housing provides support for a new image and new uses for UA. The
609 importance of the elements' arrangement (rehabilitation or modification) in the original design
610 determines the possibilities for adaptation and the spatial conditions that families might generate.

611 In the initial typology of social housing, UA can be implemented in the modalities of the front-
612 traditional garden, back-traditional garden, green roofs, green walls, pots inside and pots outside. As
613 the artificialized (built) surface increases in housing, the implementation of UA becomes less
614 traditional. Although there are different alternatives for the implementation of agriculture in housing,
615 stakeholders have a predilection for traditional forms of agriculture. However, they are interested in
616 green roofs for UA implementation in housing with a high level of built surfaces. Perhaps, the lack
617 of examples of innovative forms of UA in the city conditions their predilection for traditional
618 agriculture. They are, however, aware of the physical or space limitations of modified social housing
619 in the implementation of UA. In this moment, the weight of traditional forms of agriculture is an
620 important barrier for the development of UA in the city.

621 In this situation, we can say that renovations to housing reflect the limitations of the original design,
622 which is not always suitable to users' cultural and environmental needs and do not support the
623 model of a sustainable city. Despite the above, social housing and social neighborhoods in Mérida
624 have a high potential for implementing UA in the most innovative modalities.

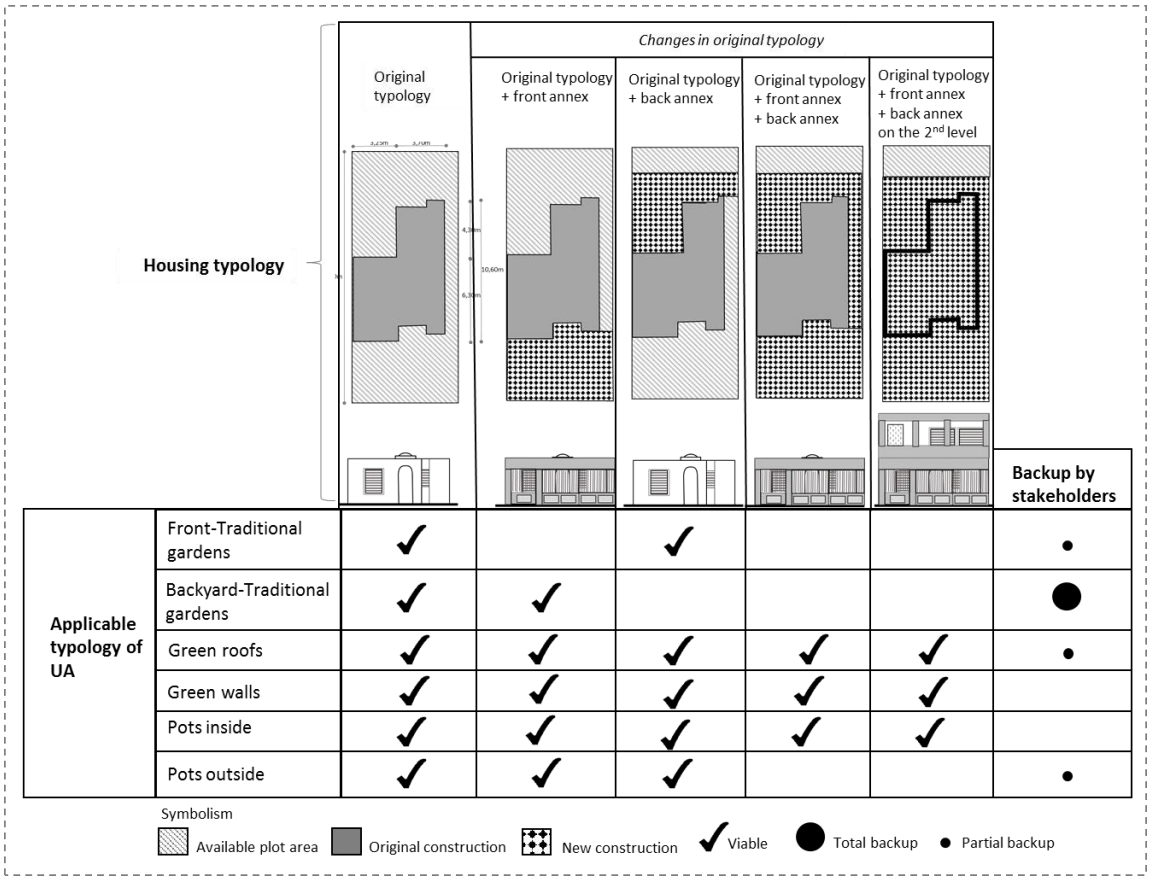


Fig. 11 Architectural feasibility of implementing UA in social housing in Mérida.

Considering the amount of constructed area and the constant addition of spaces to housing, vertical farming is a viable option. The development of rooftop gardens, green rooftops and green walls can be a solution for those homes without ground space for UA. Specifically, the development of UA on roofs can revalue unproductive spaces by giving them a new use. In the case of "social housing" in Merida, the implementation of UA would be feasible and fast, as the houses have adequate characteristics: minimum resistance of 200 kg/m^2, flat roofs, high solar radiation, minimum roof area of 50 m^2 and drains to capture water for irrigation. This brings benefits to both the neighborhood and the city, as noted by Cerón-Palma et al. (2012b), Specht et al. (2013), Specht et al. (2015) and Sanyé-Mengual et al. (2016): reducing food transportation miles and emissions; naturalizing the city; increasing habitability of the buildings; improving community food security; providing education on food production; encouraging local development; and more.

Government support through urban and legal facilities is basic to UA development because most stakeholders in the present study showed a marked interest in the support of government before venturing into UA. To some extent, the lack of legal knowledge of all stakeholders is a clear reflection

641 of the minimal importance that the current government gives to the issue. Therefore, it is necessary
642 to make changes to current legislation in Mérida and Mexico. If a sustainable city and country are to
643 face the challenges of the future, they must have a legal framework that promotes activities supporting
644 food security and food sovereignty to the benefit of the population. In general, any interest or
645 openness to the adoption of new activities for the sustainability of the city and healthier diets must be
646 supported in Mexico and Latin America (and other world regions), especially for residents who are
647 the basis for change in the current system. Among urban government officials and specialists, UA
648 presents ongoing challenges to working together to achieve a multidisciplinary vision that can benefit
649 the city and its population.

650 **5. Conclusions and future perspectives**

651 This study is the first to address the topic of urban agriculture in Yucatán. It reveals through first-
652 hand accounts the current situation of UA in social housing neighborhoods in Mérida. We have
653 observed that the stakeholders (residents, urban government officials and technical experts) consider
654 agriculture to be undeveloped in the city, mainly due to a lack of adequate space both in homes and
655 neighborhoods and a lack of promotion by government institutions.

656 This lack of development of UA is reflected by the limited consumption of vegetables and partial
657 ignorance of the concept of UA, which breeds the mentality of "it is easier to buy than grow."
658 However, urban government officials, technical experts, and half of residents are motivated to begin
659 implementing urban agriculture.

660 The basic typology of social housing in Mérida tends to be constantly modified and thus does not
661 seem to meet the needs of its users. Specifically, the high percentage of constructed areas (in housing
662 and neighborhoods), in extreme cases artificializing 100% of the surface of the lot, is inconvenient
663 for developing urban agriculture in its traditional form. Nevertheless, it presents an opportunity for
664 UA in the form of green roofs, green walls and rooftop greenhouses (RTG). "Social housing"
665 neighborhoods in Mérida have characteristics suitable for the development of UA. Mérida has all of
666 the technical characteristics for vertical implementation: there is cultural knowledge of cultivation
667 methods, motivation, and understanding that traditional crops should be developed (tomato, lettuce,
668 onion, pepper, among others). Stakeholders uniformly believe that UA can improve the quality of
669 their food, improve food security, revive traditional agricultural knowledge, generate personal
670 satisfaction, increase green areas in neighborhoods and allow economic savings in homes.

671 However, for this to occur, UA must first have an official definition. The lack of clarity around the
672 concept makes UA a topic with important subjective nuances that can limit and/or condition its

development. To strengthen and support its development, UA should be included as one of the priority issues on the agendas and development plans of governments (national, state and municipal) and in real estate development in the state of Yucatán.

Finally, the results of this study demonstrate that more research is necessary to address UA in areas of social housing in different cities of Mexico, Latin America and other world areas. Given the gap in the literature, it is imperative to have support to guide the changes needed. In the case of Mérida specifically, it is desirable to quantify the different types of agriculture that could be developed inside housing and plot areas, but these figures have not been reported. It is also important to investigate in depth the influence of cases of housing modification as an opportunity or hindrance for the development of UA. Similarly, it would be interesting to expand the study of social and intergenerational aspects of the transmission of traditional knowledge of Mayan agriculture from the perspective of the stakeholders.

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References

Agbonlahor, M.U., Momoh, S., Dipeolu, A.O., 2007. Urban vegetable crop production and production efficiency. Int. J. Veg. Sci. 13, 63–72. doi:10.1300/J512v13n02_06

Aguilar, W., 2012. Percepción Social sobre la influencia de la ciudad de Mérida en la ... y manejo de los solares en la comisaría de Dzununcán, Mérida, Yucatán, México. Huertos Fam. la Península Yucatán 535–565.

706 Alkon, A.H., Mares, T.M., 2012. Food sovereignty in US food movements: Radical visions and
707 neoliberal constraints. Agric. Human Values 29, 347–359. doi:10.1007/s10460-012-9356-z

708 Aravena, A., 2011. Elemental: A do tank. Archit. Des. 81, 32–37. doi:10.1002/ad.1235

709 Armar-Klemesu, M., 2000. Urban agriculture and food security, nutrition and health, in: Growing
710 Cities, Growing Food: Urban Agriculture on the Policy Agenda. A Reader on Urban
711 Agriculture. pp. 99–117.

712 Arosemena, G., 2012. Urban agriculture: spaces of cultivation for a sustainable city. Gustavo Gili.

713 Aubry, C., Ramamonjisoa, J., Dabat, M.H., Rakotoarisoa, J., Rakotondraibe, J., Rabeharisoa, L.,
714 2012. Urban agriculture and land use in cities: An approach with the multi-functionality and
715 sustainability concepts in the case of Antananarivo (Madagascar). Land use policy 29, 429–
716 439. doi:10.1016/j.landusepol.2011.08.009

717 Barthel, S., Isendahl, C., 2013. Urban gardens, Agriculture, And water management: Sources of
718 resilience for long-term food security in cities. Ecol. Econ. 86, 224–234.
719 doi:10.1016/j.ecolecon.2012.06.018

720 Block, D.R., Chávez, N., Allen, E., Ramirez, D., 2012. Food sovereignty, urban food access, and
721 food activism: Contemplating the connections through examples from Chicago. Agric. Human
722 Values 29, 203–215. doi:10.1007/s10460-011-9336-8

723 Bolio, J., 2007a. Mérida y su zona metropolitana; vivienda, mercado inmobiliario y los impactos de
724 la actividad petrolera en el mediano y largo plazos, in: Ramírez Carrillo, L.A. (Ed.), La Ruta
725 Del Petróleo. Impactos de Una Eventual Explotación Petrolera En Yucatán. Mérida, Yucatán,
726 pp. 193–268.

727 Bolio, J., 2007b. Escenario habitacional en la zona metropolitana de la ciudad de Mérida, in:
728 Ramírez Carrillo, L.A. (Ed.), La Ruta Del Petróleo. Impactos de Una Eventual Explotación
729 Petrolera En Yucatán. Mérida, Yucatán, pp. 119–193.

730 Bolio, J., 2006. Políticas públicas y privatización ejidal. Nuevas modalidades de expansión urbana
731 en Mérida, in: Ramírez Carrillo, L.A. (Ed.), Perder El Paraíso, Globalización Espacio Urbano
732 Y Empresariado En Mérida. Mérida, Yucatán.

733 Carney, M., 2012. Compounding crises of economic recession and food insecurity: A comparative
734 study of three low-income communities in Santa Barbara County. Agric. Human Values 29,
735 185–201. doi:10.1007/s10460-011-9333-y

736 Castañeda, M., 2007. Apuntes sobre la situación de pobreza y marginación en el municipio de
737 Torreón. Buenaval 88–103.

738 Cerón-Palma, I., Sanyé-Mengual, E., Oliver-Solà, J., Montero, J.-I., Rieradevall, J., 2012a. Barriers
739 and opportunities regarding the implementation of Rooftop Eco.Greenhouses (RTEG) in
740 Mediterranean cities of Europe. J. Urban Technol. doi:10.1080/10630732.2012.717685

741 Cerón-Palma, I., Sanyé-Mengual, E., Oliver-Solà, J., Montero, J.-I., Rieradevall, J., 2012b. Barriers
742 and opportunities regarding the implementation of Rooftop Eco.Greenhouses (RTEG) in
743 Mediterranean cities of Europe. J. Urban Technol. 19, 1–17.
744 doi:10.1080/10630732.2012.717685

745 Cerón-Palma, I., Sanyé-Mengual, E., Oliver-Solà, J., Montero, J.I., Ponce-Caballero, C.,
746 Rieradevall, J., 2013. Towards a green sustainable strategy for social neighbourhoods in Latin
747 America: Case from social housing in Merida, Yucatan, Mexico. Habitat Int. 38, 47–56.

748 doi:10.1016/j.habitatint.2012.09.008

749 Coffey, M., Coad, A., 2010. Collection of municipal solid waste in developing countries, UN
750 Habitat. doi:10.1080/00207233.2013.853407

751 CONAVI, 2010. Código de Edificación de Vivienda. Ciudad de México.

752 De Bon, H., Parrot, L., Moustier, P., 2010. Review article Sustainable urban agriculture in
753 developing countries . A review. Agron. Sustain. Dev. 30, 21–32. doi:10.1051/agro

754 Díaz-Albertini, J., 1991. Non-government development organisations and the grassroots in Peru.
755 Voluntas 2, 26–57. doi:10.1007/BF01398528

756 Domínguez Santos, R., Chablé Santos, J., Flores Guido, J.S., 2011. Aves y huertos familiares en la
757 zona periurbana de la ciudad de Mérida, Yucatán, in: XI Congreso Para El Estudio Y
758 Conservación de Las Aves En México (CECAM).

759 Dubbeling, M., Zeeuw, H., Veenhuizen, R., 2010. Cities, poverty and food: multi-stakeholder
760 policy and planning in urban agriculture. Cities poverty food multistakeholder policy Plan.
761 urban Agric. 192.

762 FAO, 2016. FAO Gender [WWW Document]. URL http://www.fao.org/gender/en/ (accessed
763 6.7.16).

764 FAO, 2014. Growing greener cities in Latin America and the Caribbean. Rome, Italy.

765 FAO, 2013. The state of food and agriculture, 2013., Lancet. doi:ISBN: 978-92-5-107671-2 I

766 FAO, 2011. Food , Agriculture and Cities. Challenges of food and nutrition security, agriculture and
767 ecosystem management in an urbanizing world. FAO, Rome, Ital. 48.

768 FAO, 2005. Setting up and running a school garden. Manual for teachers, parents and communities.

769 FAO, IFAD, WFP, 2015. The State of Food Insecurity in the World: Meeting the 2015 international
770 hunger targets: taking stock of uneven progress, FAO, IFAD and WFP. doi:I4646E/1/05.15

771 Flores, J., Ek, E., 1983. Nombres usados por los mayas para designar a la vegetación.

772 Flores, J.S., Ek, E.U., 1983. Nombres usados por los mayas para designar a la vegetaci{ó}n,
773 Cuadernos de divulgaci{ó}n. Instituto Nacional de Investigaciones sobre Recursos Bi{ó}ticos.

774 García-Huidobro, F., Torriti, D.T., Tugas, N., 2011. The experimental housing project (PREVI),
775 Lima: The making of a neighbourhood. Archit. Des. 81, 26–31. doi:10.1002/ad.1234

776 García, E., 2004. Modificaciones al sistema de clasificación climática de Koeppen, 5ta ed. Ciudad
777 de México.

778 García, G., Oliva, Y., Ortiz, R., 2012. Distribución espacial de la marginación urbana en la ciudad
779 de Mérida, Yucatán, México. Investig. Geográficas, Boletín del Inst. Geogr. 89–106.

780 Gil, G.G.., Pena, Y.O.., Pech, R.O.., 2012. Spatial distribution of the urban exclusion in the city of
781 mérida, yucatán, Mexico [Distribución espacial de la marginación urbana en la ciudad de
782 mérida, yucatán, México]. Investig. Geogr. 77, 89–106.

783 Gockowski, J., Mbazo'o, J., Mbah, G., Fouda Moulende, T., 2003. African traditional leafy
784 vegetables and the urban and peri-urban poor. Food Policy 28, 221–235. doi:10.1016/S0306-
785 9192(03)00029-0

Gómez-Pompa, A., 1987. On Maya Silviculture. Mex. Stud. 3, 1–17. doi:10.2307/4617029

González, A., 2012. Del huerto a los jardines y vecindades: procesos de cambio en un agroecosistema de origen antiguo, in: Méndez, R.M. (Ed.), El Huerto Familiar Del Sureste de México. p. 487–520 1st Alba González Jácome 12 · Universidad.

González, L., 2006. Política de subsidios, política de vales de despensa. En economía y política de la vivienda en México. UAB.

Grimmond, S., 2007. Urbanization and global environmental change: local effects of urban warming. Geogr. J. 173, 83–88. doi:10.1111/j.1475-4959.2007.232_3.x

Gumbo, D.J., Ndiripo, T.W., 1996. Open Space Cultivation in Zimbabwe: A Case Study of Greater Harare, Zimbabwe. Afr. Urban Q. 11, 210–216.

Harris, T.B., Manning, W.J., 2010. Nitrogen dioxide and ozone levels in urban tree canopies. Environ. Pollut. 158, 2384–2386. doi:10.1016/j.envpol.2010.04.007

Hernández Sampieri, R., Fernández Collado, C., Baptista Lucio, P., 2006. Metodología de la investigación, Metodologia de la investigacion. doi:- ISBN 978-92-75-32913-9

Holdsworth, B., 2005. Continuous Productive Urban Landscapes: designing urban agriculture for sustainable cities. Refocus 6, 13. doi:10.1016/S1471-0846(05)70421-2

IDF, 2013. Global Diabetes Scorecard Taking Progress For Action. Int. Diabetes Fed. 53, 1689–1699. doi:10.1017/CBO9781107415324.004

IIED, 2011. The Human Settlements Programme [WWW Document]. URL http://www.iied.org/. (accessed 6.7.16).

Ilbery, B., 2010. Agriculture in Urban Planning: Generating Livelihoods and Food Security – Edited by Mark Redwood. Geogr. J. 176, 184. doi:10.1111/j.1475-4959.2010.00360_9.x

INEGI, 2015. Encuesta intercensal. Principales resultados de la Encuesta Intercensal 2015: Estados Unidos Mexicanos. Ciudad de México.

INEGI, 2010. Censo de Población y Vivienda 2010. Inst. Nac. Estadística y Geogr. 105.

INSP, 2012. Encuesta Nacional de Salud y Nutrición 2012. Resultados Nacionales, ENSANUT. Ciudad de México.

Janoschka, M., Glasze, G., 2003. Urbanizaciones cerradas: un modelo analítico. Ciudades 59, 9–20.

Jiménez-Osornio, J., Ruenes, M., Montañez, P., 1999. Agrodiversidad de los solares de la península de Yucatán. Red, Gestión Recur. Nat. 14, 30–40.

Jones, A., 2002. An environmental assessment of food supply chains: A case study on dessert apples. Environ. Manage. 30, 560–576. doi:10.1007/s00267-002-2383-6

Kirwan, J., Maye, D., 2012. Food security framings within the UK and the integration of local food systems. J. Rural Stud. 1–10. doi:10.1016/j.jrurstud.2012.03.002

Konijnendijk, C., Gauthier, M., 2006. Urban forestry for multifunctional urban land use. Cities farming Futur. urban Agric. green Product. cities 413–442.

La Rosa, D., Barbarossa, L., Privitera, R., Martinico, F., 2014. Agriculture and the city: A method for sustainable planning of new forms of agriculture in urban contexts. Land use policy 41, 290–303. doi:10.1016/j.landusepol.2014.06.014

825 Mariaca, R., 2012. La complejidad del huerto familiar maya del sureste de México, in: El Huerto
826 Familiar Del Sureste de Mexico. pp. 7–97.

827 Maxwell, D., 2000. Urban livelihoods and food and nutrition security in Greater Accra, Ghana,
828 Research Report 112. Washington, D.C.: International Food Policy Research Institute in
829 collaboration with Noguchi Memorial Institute for Medical Research and the World Health
830 Organization, 2000, pp. xiv, 172.

831 Maxwell, D., Levin, C., Csete, J., 1998. Does urban agriculture help prevent malnutrition? Evidence
832 from Kampala. Food Policy 23, 411–424. doi:10.1016/S0306-9192(98)00047-5

833 Mbiba, B., 1994. Institutional responses to uncontrolled urban cultivation in Harare: prohibitive or
834 accommodative? Environ. Urban. 6, 188–202. doi:doi: 10.1177/095624789400600116

835 McClintock, N., 2010. Why farm the city? Theorizing urban agriculture through a lens of metabolic
836 rift. Cambridge J. Reg. Econ. Soc. 3, 191–207. doi:10.1093/cjres/rsq005

837 Mezzetti, M., Orsini, F., Fecondini, M., Michelon, N., Gianquinto, G., 2010. WOMEN AND
838 SIMPLIFIED HYDROPONICS: COMMUNITY GARDENING AS A WAY OF
839 EMANCIPATION IN TRUJILLO, PERU, in: Acta Horticulturae. International Society for
840 Horticultural Science (ISHS), Leuven, Belgium, pp. 169–172.
841 doi:10.17660/ActaHortic.2010.881.20

842 Mok, H.F., Williamson, V.G., Grove, J.R., Burry, K., Barker, S.F., Hamilton, A.J., 2014.
843 Strawberry fields forever? Urban agriculture in developed countries: A review. Agron.
844 Sustain. Dev. doi:10.1007/s13593-013-0156-7

845 Mougeot, L.J.A., 2005. Agropolis: The Social, Political and Environmental Dimensions of Urban
846 Agriculture, Agriculture. doi:10.1016/j.agee.2006.12.021

847 Moustier, P., Danso, G., 2006. Local economic development and marketing of urban produced
848 food. Cities farming Futur. Urban Agric. Sustain. cities 171–206.

849 Nadal, A., Cerón, I., Cuerva, E., Gabarrell, X., Josa, A., Pons, O., Sanyé, E., Rieradevall, J., 2015.
850 Urban Agriculture in the Framework of Sustainable Urbanism. Temes de disseny 0, 92–103.

851 Nadal, A., Llorach-Massana, P., Cuerva, E., López-Capel, E., Montero, J.I., Josa, A., Rieradevall,
852 J., Royapoor, M., 2017. Building-integrated rooftop greenhouses: An energy and
853 environmental assessment in the mediterranean context. Appl. Energy 187, 338–351.
854 doi:10.1016/j.apenergy.2016.11.051

855 Novo, M.G., Murphy, C., 2001. Urban Agriculture in the City of Havana: A Popular Response to a
856 Crisis. Grow. Cities, Grow. Food Urban Agric. Policy Agenda 329–347.

857 NU-CEPAL, 2013. Agricultura familiar y circuitos cortos: Nuevos esquemas de producción,
858 comercialización y nutrición. Memoria del seminario sobre circuitos cortos realizado el 2 y 3
859 de septiembre de 2013.

860 Orsini, F., Kahane, R., Nono-Womdim, R., Gianquinto, G., 2013. Urban agriculture in the
861 developing world: A review. Agron. Sustain. Dev. doi:10.1007/s13593-013-0143-z

862 Orsini, Michelon, N., Scocozza, F., Gianquinto, G., 2009. Farmers-to-consumers: An example of
863 sustainable soilless horticulture in Urban and Peri-Urban areas. Acta Hortic. 809, 209–220.

864 Oths, K.S., 1998. Assessing variation in health status in the Andes: A biocultural model, in: Social
865 Science and Medicine. pp. 1017–1030. doi:10.1016/S0277-9536(98)00161-0

866 Pearson, L.J., Pearson, L., Pearson, C.J., 2010. Sustainable urban agriculture: stocktake and
867 opportunities. Int. J. Agric. Sustain. 8, 7–19. doi:10.3763/ijas.2009.0468

868 Perez-Izquierdo, O., Beutelspacher, A., Izaba, B., Romo, S., Rodríguez, L., Burguette, M., Mendez,
869 R., Teresa, M., 2012. Frecuencia del consumo de alimentos industrializados modernos en la
870 dieta habitual de comunidades mayas de Yucatán , México. Estud. Soc. 20, 155–184.

871 Poulsen, M.N., McNab, P.R., Clayton, M.L., Neff, R.A., 2015. A systematic review of urban
872 agriculture and food security impacts in low-income countries. Food Policy 55, 131–146.
873 doi:http://dx.doi.org/10.1016/j.foodpol.2015.07.002

874 Prakash, A., 2011. Safeguarding food security in volatile global markets, Organization.

875 Renting, H., 2013. Learning from best practices in the Global South for sustainable (peri)urban food
876 systems in Europe. Urban Agric. Mag. 11–12.

877 Rodríguez, J., Arriagada, C., 2004. Segregación residencial en la ciudad latinoamericana. Eure 30,
878 5–24. doi:10.4067/S0250-71612004008900001

879 Romero, R., 2007. Informe técnico del proyecto "Confort térmico y ahorro de energía en la vivienda
880 económica en México: Regiones de clima cálido húmedo y seco.

881 Ruel, M.T., Garrett, J.L., Morris, S.S., Maxwell, D., Oshaug, A., Engle, P., Menon, P., Slack, A.,
882 Haddad, L., 1998. Urban Challenges to food and nutrition security: A review of food security,
883 health, and caragiving in the cities. FCND Discuss. Pap. 129.

884 Sanyé-Mengual, E., Anguelovski, I., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2016. Resolving
885 differing stakeholder perceptions of urban rooftop farming in Mediterranean cities: promoting
886 food production as a driver for innovative forms of urban agriculture. Agric. Human Values
887 33, 101–120. doi:10.1007/s10460-015-9594-y

888 Sanyé-Mengual, E., Romanos, H., Molina, C., Oliver, M.A., Ruiz, N., Pérez, M., Carreras, D.,
889 Boada, M., Garcia-Orellana, J., Duch, J., Rieradevall, J., 2014. Environmental and self-
890 sufficiency assessment of the energy metabolism of tourist hubs on Mediterranean Islands:
891 The case of menorca (Spain). Energy Policy 65, 377–387. doi:10.1016/j.enpol.2013.10.011

892 SEDESOL, 2015. Informe Anual Sobre La Situación de Pobreza y Rezago Social Informe Anual
893 Sobre La Situación de Pobreza y Rezago Social 2015, Mérida, Yucatán.

894 SEDUMA, 2006. Programa de Ordenamiento Ecológico Territorial de Yucatán.

895 SEGOB, 2013. Plan Nacional de Desarrollo de México 2013 - 2018, Diario Oficial de la
896 Federación.

897 SHF, 2015. Estado actual de la vivienda en México 2015. Ciudad de México.

898 Smit, J., Bailkey, M., 2006. Urban Agriculture and the Building of Communities, in: Cities Farming
899 for the Future. Urban Agriculture for Sustainable Cities. pp. 145–170.

900 Smit, J., Nasr, J., 1992. Urban agriculture for sustainable cities: using wastes and idle land and
901 water bodies as resources. Environ. Urban. 4, 141–152. doi:10.1177/095624789200400214

902 Smith, F.I., Eyzaguirre, P., 2007. African Leafy Vegetables: Their Role in the World Health
903 Organization's Global Fruit and Vegetables Initiative. African J. Food, Agric. Nutr. Dev. 7, 1–
904 17.

905 Specht, K., Siebert, R., Hartmann, I., Freisinger, U.B., Sawicka, M., Werner, A., Thomaier, S.,

906 Henckel, D., Walk, H., Dierich, A., 2013. Urban agriculture of the future: an overview of
907 sustainability aspects of food production in and on buildings. Agric. Human Values 1–19.
908 doi:10.1007/s10460-013-9448-4

909 Specht, K., Siebert, R., Thomaier, S., Freisinger, U.B., Sawicka, M., Dierich, A., Henckel, D.,
910 Busse, M., 2015. Zero-Acreage farming in the city of Berlin: An aggregated stakeholder
911 perspective on potential benefits and challenges. Sustain. 7, 4511–4523.
912 doi:10.3390/su7044511

913 UADY, 2016. Centro meteriológico, Campus de ciencias exactas e ingenieríaas de la Universidad
914 Autónoma de Yucatán [WWW Document]. URL
915 http://www.estacionclimatologica.ingenieria.uady.mx (accessed 5.4.16).

916 United Nations, 2014. World Urbanization Prospects: The 2014 Revision, Highlights
917 (ST/ESA/SER.A/352), New York, United. doi:10.4054/DemRes.2005.12.9

918 Wadel, G., Avellaneda, A., Cuchí, A., 2010. Sustainability in industrialised architecture: Closing
919 the materials cycle [La sostenibilidad en la arquitectura industrializada: Cerrando el ciclo de
920 los materiales]. Inf. la Constr. 62, 37–51. doi:10.3989/ic.09.067

921 Warren, E., Hawkesworth, S., Knai, C., 2015. Investigating the association between urban
922 agriculture and food security, dietary diversity, and nutritional status: A systematic literature
923 review. Food Policy. doi:10.1016/j.foodpol.2015.03.004

924 Zasada, I., 2011. Multifunctional peri-urban agriculture-A review of societal demands and the
925 provision of goods and services by farming. Land use policy.
926 doi:10.1016/j.landusepol.2011.01.008

927 Zezza, A., Tasciotti, L., 2010. Urban agriculture, poverty, and food security: Empirical evidence
928 from a sample of developing countries. Food Policy 35, 265–273.
929 doi:10.1016/j.foodpol.2010.04.007

930

931

932

933

934

935