Urban agriculture in the framework of sustainable urbanism

Ana Nadal

Doctoral thesis

Supervisors: Dr. Joan Rieradevall Pons (UAB)
Dr. Alejandro Josa Garcia-Tornel (UPC)
Dra. Eva Cuerva Contreras (UPC)

Academic tutor: Dr. Joan Rieradevall Pons (UAB)

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Sostenipra research group
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Chapter 10

Social perception of urban agriculture in Latin-America. A case study in Mexican social housing

CHAPTER 10 - Social perceptions of urban agriculture in Latin America: A case study in Mexican social housing.

This chapter is based on the following journal paper:

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Abstract

Food security is at the heart of governmental 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 cities 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 Mérida city 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 Mérida, despite the secular agricultural 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 CO2 emissions. The main perceived barriers for UA are the prevalent model of housing, with 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.

Chapter 11

Social -housing model influence in social perception of urban agriculture in México

CHAPTER 11 - Social -housing model influence in social perception of urban agriculture in México

From this chapter, a paper has been extracted and submitted in a peer-review indexed journal and had the following collaborators:

Ana Nadal, Beatriz Rodríguez-Labajos, Eva Cuerva, Alejandro Josa, Joan Rieradevall

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Abstract

The number of megacities around the world increased from 17 to 29 and is projected to reach 41 by 2030. Cities are still spaces of inequality with disparate access to quality public services and high degrees of socioeconomic and residential segregation. Latin America and the Caribbean exhibit the highest levels of inequality compared to international standards that are reflected in social problems. This region has had an urbanization with a strong tendency to generate urban problems, and resulted in widespread processes of urban land loss and increasing built urban area.

In this context, this research focuses on urban systems and the socioeconomic and environmental dynamics of medium-sized cities in Latin America and the Caribbean (Mérida, Mexico as an example). Two objectives guide this study to expose the relationship between population patterns and the characteristics of social housing with respect to the developed urban agriculture: To analyze how naturalization (agriculture) and artificialization (architecture) compete in the process of urban transformation in different social areas in medium-sizedcities of Latin America. And to understand how the notion of artificialization in housing is associated with social-environmental factors in households. The sample included two social neighborhoods: Ampliación Tixcacal and Las Magnolias, and four housing typologies (small house, big house, small house, modified big house). We used quantitative and qualitative research methods, 157 surveys were applicated. The results indicated that artificialization process occurs gradually and from the outside to the inside of the housing. And, the housing typology defines the area or magnitude of UA. Finally, this constant struggle between artificialization (increase in impermeable surface) and the need to cultivate in housing (naturalization) results in a considerable limitation to achieving urban sustainability in Mexico.

Keywords

Social housing, urban agriculture, impervious surface, artificialization, naturalization

11.1.Introduction

Historically, cities have driven societal development and their expansion has resulted in complex urban systems. Globally, urbanization is closely related to a country's economic and social development, i.e., a greater development is a synonym of a greater urbanization (CEPAL, 2017). Currently, cities are the main sites for the distribution of the world population, which results in cultural dynamics of change with relevance for research.

Between 2000 and 2015 the number of megacities around the world (population of 10 million people or more) increased from 17 to 29 and is projected to reach 41 by 2030. In the case of cities with 5 to 10 million and 1 to 5 million inhabitants, a strong expansion was also recorded, totaling 63 and 558 cities, respectively (United Nations, 2014b). This growing trend aligns with current interurban migration patterns, as the urban demographic expansion has been stronger at the upper and intermediate levels (megacities and intermediate cities), whereas while small cities remain relatively stable (United Nations, 2012). In parallel, low urban fringes are known "expellers" of people to big cities, while intermediate fringes tend to be attractive and the superior fringe presents internal diversity. It can be considered that small cities generally have lower living standards, which leads people to emigrate to higher levels of the city system, but not to the rural area (CEPAL, 2017).

Nevertheless, cities are still spaces of inequality with disparate access to quality public services and high degrees of socioeconomic and residential segregation, which have negative effects on social vulnerability and sustainable economic development. (CEPAL, 2017). Among the negative effects arising from high urbanization rates, food deserts stand out, i.e., populated urban areas where residents do not have access to an affordable and healthy diet (Cummins and Macintyre, 2002, 1999; Pearson et al., 2005). In the case of Latin America and the Caribbean region, the double burden of malnutrition is a problem characterized by a high prevalence of low height-for-age and high weight-height ratios, both being anthropometric indicators of malnutrition and overweight (Altamirano Laura et al., 2014; FAO, 2013b; Levy et al., 2015; UNICEF, 2013).

In a context of high urban dynamism, peripheral development poses serious limitations to achieving a more inclusive and spatially balanced urbanization. Latin America and the Caribbean exhibit the highest levels of inequality compared to international standards that are reflected in social problems: residential segregation, gentrification, mobility gaps, insecurity, heat islands and environmental impacts, among others (Barcenas, 2017; CEPAL, 2017; ONU-Habitat and CAF Banco de Desarrollo de América Latina, 2014; UN, 2016). Hence, this region has had an urbanization with a strong tendency to generate urban problems, which together with the political and technical inability to anticipate and manage these issues, and the dynamic shortcomings in productive and labor matters, haa resulted in a more precarious and informal urbanization and massive and expansive urbanization models (Banco Mundial, 2009; Glaeser and Henderson, 2017; Hertwich and Peters, 2000). This resulted in widespread processes of urban land loss and increasing built urban area.

In this context, this research focuses on urban systems and the socioeconomic and environmental dynamics of medium-sized cities in Latin America and the Caribbean (Mérida, Mexico as an example). In particular, we address these issues at at the neighborhood scale, which is a partial expression of the production, distribution and consumption structures and development style of the region. Two objectives guide this study to expose the relationship between population patterns and the characteristics of social housing with respect to the developed urban agriculture (UA) models.. The first one is to analyze how naturalization (agriculture) and artificialization (architecture) compete in the process of urban transformation in different social areas in medium-sizedcities of Latin America. The second is to understand how the notion of artificialization in housing is associated with social-environmental factors in households.

Two social housing neighborhoods were selected in Mérida (Yucatán, México) as representative cases of Mexican urban complexes, using criteria such as location, housing typology, urban planning and neighborhood design, and year of construction. Both cases are interesting because in spite of having the same architectural characteristics, they represent low and medium-high socio-economic levels due to the expansion of the urban sprawl.

The background section describes the influence of social housing in the development of Latin American and Mexican cities in order to understand its relationship with impervious areas and the potential for urban agriculture in the framework of the sustainable urban development.

11.1.1.Background. Social housing in Latin America

Parallel to Latin American large cities, medium-sized cities are rapidly expanding, which increases the demand for built space and urban infrastructure. Currently, there are 188 medium-sized cities that represent almost a third of the region's gross domestic product (GDP) and are expected to generate 40% of the region's GDP growth by 2025 (Cadena et al., 2011). In general, urban growth is occurring in a disorganized and unplanned manner, consuming large amounts of land to be transformed into artificial zones. On average, cities expand three times than their populations and generate considerable environmental impacts (Angel et al., 2016).

The social housing sector and its associated services incorporate new residential land into the urban footprint, generating large impacts. During the last three decades, urban expansion processes have created cities without defined borders, with irregular densities and dispersed neighborhoods with homogeneous land use, i.e., mainly residential. In addition, these settlements coexist with fragmented open spaces and have limited connectivity with each other. Residential districts mainly consist of social housing for the working class that usually provide basic and limited service infrastructure in the urban periphery (CEPAL, 2017).

The economic implications of the housing sector are complex and extensive. These involve incentives promoted byhousing markets, policies and public housing programs to expand and des-densify the cities of the region (Rojas, 2016). These subsidies have fostered a movement that seeks to reduce costs and maximize rents through the purchase and subdivision of land in the urban periphery, where the price of land is lower and its urbanization easier and cheaper (CEPAL, 2017). This trend transforms the periphery into urban areas and increases the rent of free land that remains between the neighborhoods of new construction (Cobos, 2014; Duhau, 2003).

Mexico is a good example of these phenomena, although these processes are commonplace in almost all the countries of the region (Calderón, 2015; Rodríguez and Rodríguez, n.d.; Ziccardi and Alicia, 2016). The metropolitan areas of Mexico present a new spatial architecture. From an economic and functional viewpoint, the largest cities have developed a polycentric structure organized into nodes or islands with deconcentrated activities, and services scattered over an extensive territory of mixed urban, rural and environmental uses. The widespread use of automobiles, industrial relocation processes, the lack of urban regulation and the housing policy developed during the last years are the factors that have made this model feasible (Ziccardi and Alicia, 2016).

The features of housing complexes are very similar in all of Mexico's cities: they are large groups of housing blocks consisting of small single-family houses of one or two floors with low quality building materials, lack of basic services (e.g., education, culture and health) and in most cases with recreational places (Cobos, 2014; Duhau, 2003; Eibenschutz and Goya, 2009; Pírez, 2014). In all the medium and large-size Mexican cities, the mega-complexes of social housing have been built at a great distance from the center of the cities to take advantage of economical land.

In the case of Mexico, 78% of 119.5 million inhabitants lived in urban areas with 27.74 million private social housing units, which represented 66% of the total private housing market in the country (35.6 million) in 2015 (INEGI, 2015). This is reflected in the fact that 75% of land use in Mexico corresponds to the residential use (Ponce, 2011). Hence, housing is considered a national problem due to its amplitude and quantity. This situation limits the development of green areas in Mexico, which is very similar in the entire Latin American region. In light of this situation, urban agriculture (UA) is an option for supporting urban sustainability and food safety within urban settings and encouraging healthier diets (Ana Nadal et al., 2017b). UA also plays a key role in the objectives of the cities of the future because of its impact on society, environmental harmonization and economically sustainable development (Berger, 2013; Nadal et al., 2015): UA increases biodiversity, contributes to an efficient use of resources, guarantees affordable food, saves money on food, promotes job creation and environmental and nutritional education and sensitization, improves health and quality of life, and upgrades deteriorated and abandoned urban spaces, among others.

UA has been widely studied in developed (De Bon et al., 2010; Orsini et al., 2013; Poulsen et al., 2015; Ruel et al., 1998; Warren et al., 2015), but, in the case of Latin America, there are no studies about the relationship between UA and city development in the context of rapid urban transformations related to the construction of social housing. Therefore, it is interesting to analyze this topic to understand the implications that both phenomena have within the cities. Looking at the case of Mérida, this topics remains unexplored; current literature only explores 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)).

11.1.2.From the gray city to the gray house

Cities comprise a mosaic of diverse land uses and covers that shape the urban context through sealed surfaces and green areas (Gill et al., 2008). This mosaic arises from the spatial complexity and heterogeneity found in cities (Pickett et al., 2011). But, nowadays, urban agglomerations are characterized by a high degree of impervious surfaces (European Commission, 2011); thus, the imperviousness of urban soils (e.g. asphalt, buildings and concrete) is one of the main global challenges in sustainable urban development (Artmann, 2016). Soil sealing is the result of transforming natural and semi-natural areas into human settlements and mobility zones (European Commission, 2012).

In this sense, the ground is sealed by "impervious surfaces", which are defined as human-made land covers through which water cannot penetrate (including driveways, parking lots, sidewalks, rooftops and roads) (RIDD, 1995; Weng, 2012). impervious surfaces result in interconnected spatial procedures within multifaceted ecological impacts such as on climatic change (Buyantuyev and Wu, 2010), loss of biodiversity (Ortega-Álvarez and MacGregor-Fors, 2009), heat islands (Haselbach et al., 2011; Pauleit and Duhme, 2000; Weng et al., 2004) and water runoff generation (Angrill et al., 2017; Sjöman and Gill, 2014). Impervious surface goes beyond a purely superficial aspect and has two dimensions: quantitative and qualitative. Basically, the quantitative dimension refers to the physical properties of the artificial surface. The qualitative dimension is interlinked with the requirement to support compact cities as a sustainable urban form to decrease urban sprawl and the consumption of natural resources (European

Commission, 2011).This dimension also includes the complexity of human relations among people, governments and enterprises influencing land use and land cover (Liu et al., 2014).

Existing international policies target soil protection against degradation and the cessation of land sealing. For example, the United Nations Convention to Combat Desertification (UNCCD) recommends a Sustainable Development Goal for Rio+20 in which net land take is reduced to zero (the Zero Net Land Degradation) by 2030 (Ashton, 2012). The year 2015 was declared the International Year of Soils by the 68th UN General Assembly with the objective to foster effective strategies for soil protection, its sustainable management, awareness-raising and monitoring (FAO, 2015e). However, Latin America housing policies continue to be developed beyond the limits of cities and considerably increase the impervious surface.

Despite its importance, this subject is only studied without considering its close relationship with the processes involved in the building and housing evolution, which significantly influence the increase in impervious surfaces in Latin American cities. Additionally, the social, family and cultural aspects defining the basic housing unit were not considered, although these can influence the creation of impervious surfaces and the decrease in green areas. That is why Latin American urban planners, architects, and decision makers are currently facing conflicting interests such as protecting urban land and supporting green areas or gaining economic profits by building impervious surfaces on large tracts of land mainly for social housing.

Based on aforementioned discussion, the complexity of urban soil management must be considered a priority to solve current urban and to be able to develop instruments adapted to the needs of each city. TO do so, it is necessary to analyze the impervious surfaces that are gradually and progressively generated throughout the useful life of social housing and improve and update the urban guidelines related to soil use (e.g., soil absorption, soil occupancy, and land utilization coefficients) that are often debated to define the value of land and real estate income.

Considering the increasing complexity in urban planning and resource constraints (Dalal-Clayton and Bass, 2002), this study argues that there is a need to study in detail the relationship that exists between the patterns of impervious surface and green spaces. Specifically, we study the case of urban agriculture as a strategy for sustainability and how it develops within social housing areas in medium-sized cities; this we call “the process of social housing artificialization”. Our goal is to provide firsthand information that facilitates the cooperation between urban social actors and decisionmakers when developing housing strategies and urban planning to shape dynamic and sustainable cities through urban agriculture. This should help achieve goal 11 “Make cities inclusive, safe, resilient and sustainable” of the Sustainable development goals promoted by the United Nations. Additionally,, this paper helps to expand the scientific literature on UA and impervious surfaces by focusing on the main problem in Mexico and Latin America, i.e., social housing,.

11.2.Study area and methods

Figure 11.1 summarizes the methodology applied in this paper, outlining the research stages and their associated approaches described in the following sections.

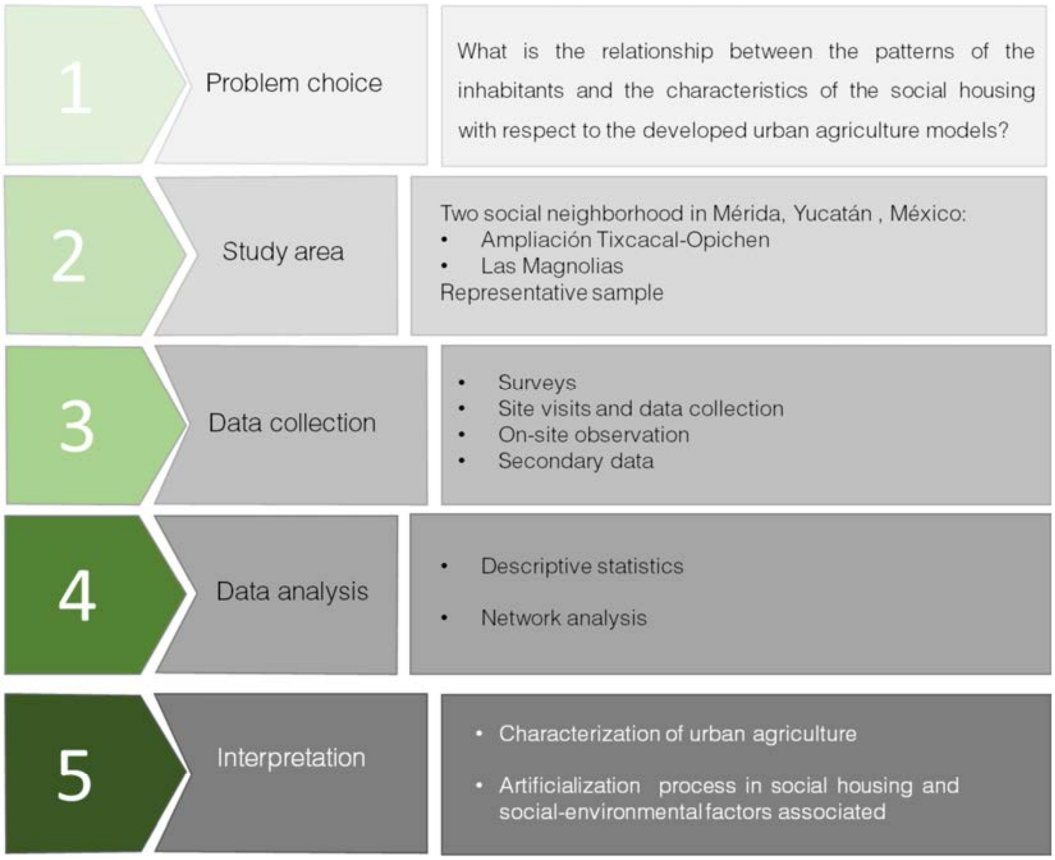

Figure 11.1 General methodology

11.2.1.Case study selection: Two emblematic social neighborhoods in Mérida, México

The study was conducted in Mérida, the capital city of Yucatán state (southeast México). Based on 2010 census, Mérida has 830,732 inhabitants (42.5% of the total population of Yucatán) and 12,000 housing units (45.3% of the housing stock of Yucatán) (INEGI, 2010). With an area of 883.40 km^2 (2.19% of the state) (SEDUMA, 2006), it has rapidly grown during the last 50 years and almost 3 thousand homes were built in 2015. Following the criteria defined by Nadal (2018), Mérida was selected because it is a good example of a medium-sized Latin-American city with residential segregation (García et al., 2012), consolidated areas of social housing with a high percentage of impervious surfaces and adequate climatic conditions for the development of UA, i.e., average annual temperature between 24.5 and 27 °C, annual rainfall of 805.4 to 1120.5 mm and average global solar radiation of 5.0 kWh/m^2/day (García, 2004; UADY, 2016). In addition, Mérida has both a rich pre-Hispanic history and heritage of growing fruits and vegetables in home gardens (Mayan solar in Spanish or "Ich-tankaab" in the Mayan language) (J. Flores and Ek, 1983; Gómez-Pompa, 1987) and presents the most common degenerative diseases related to diet problems in Mexico and Latin America (Prevalence of diabetes of 9.2%, overweight 35.5% and 44.8% obese in the population)(IDF, 2013).

The sample included two social neighborhoods: Ampliación Tixcacal and Las Magnolias (Figure 11.2 and Table 11.1). Both are representative of the 209 existing social housing neighborhoods built up until 2010 in Mérida and have the most important characteristics of this housing typology (Nadal 2018), i.e., common housing design, location, house size and socioeconomic status, as well as a similar spatial distribution, number of spaces and built area.

Figure 11.2 Location of Mérida, delimitation of the city and location of the two social housing neighborhoods of the sample.

Table 11.1Urban and architectural characteristics of the social neighborhoods considered in the study sample

Name	Ampliación Tixcacal-Opichen	Las Magnolias
Year of construction	2007	2005
Location	West	North
Context typology	low socioeconomic level	medium-high socioeconomic level
Total area (ha)	30	20
Housing per block	38	34
AVG Housing area (m^2) [a]	56 (big house model) 46 (small house model)	56 (big house model)
Total housing	332	568
Housing typology	Social housing	Social housing
Average household size	3.6 people	3.6 people

[a] Constructed area of the original typology

These two neighborhoods were built with blocks of orthogonal trace of 150 x 40 m, with an average of 38 houses each and access to basic infrastructure and services (e.g., electricity, drinking water, sanitary drainage, paving, sidewalks, etc). The sample has two basic or original housing typologies (Figure 11.3): small house model (I) and big house model (II). The big house model is similar in both neighborhoods and has a plot area of 160 m^2 with 56 m^2 of construction on one floor, with usable flat floor of 50 m^2. The useful plot area for green spaces is 70% of the available plot (72.8 m^2), since the remaining surface is used for green spaces, and the rest comprises the house entrance, paths, etc. (Cerón-Palma et al., 2013). The single family home has a bathroom, two bedrooms, and a living room with a kitchen and usually hosts young families (Cerón-Palma et al., 2013; Gil et al., 2012). The small house model has the same plot area with 40 m^2 of construction on one floor and 37 m^2 of usable flat floor. This model has a bedroom and the same spaces of the big house model. This model was only found in Ampliación Tixcacal-Opichen neighborhood.

Usually many of the residents tend to extend or remodel their homes to meet their needs, so the original or basic social housing model typologies undergo an architectural transformation that changes the use and surfaces of the lot. This generated two additional housing models, which we called Modified small house model (III) and modified big house model (IV). In most cases these changes happen in the second stage (densification) of the economical housing consolidation (García-Huidobro et al., 2011). Nadal 2018 focus on the construction perspective and expose that these changes occur progressively along four steps in which new spaces are gradually added (garage, bedrooms and bathrooms) , including new impervious surfaces that generate a loss of green areas (originally intended for recreation and gardening). In general, the house's construction system consists of a stone foundation, walls made of concrete blocks reinforced with steel rebar structure at the corners, flat forged joists and slabs with a minimum load resistance of 200 kg/m^2.

Figure 11.3 Urban plan of the two sample neighborhoods and dimensions and distribution of the two original typologies of social housing.

11.2.2.Data collection

- Sample design

We used quantitative and qualitative research methods through a stratified random sampling design, which provides a broad overview of the research problem (Hernández Sampieri et al., 2006). With a sample universe of 900 houses, with a maximum admitted error of 10% and a confidence interval of 95%, we estimated that a total of 157 houses make up the sample of the present study; 82 houses in Ampliación Tixcacal-Opichen neighborhood and 75 houses in Las Magnolias (Table 11.2).

Table 11.2 Delimitation of the sample

Neighborhood	Ampliación Tixcacal-Opichen	Las Magnolias
Population size	568	332
Maximum error admitted	10%	10%
Confidence interval	95%	95%
Total	82	75

Table 11.3 defines each cluster of the sample that corresponds to a category of social housing typology, as well as the quantity and distribution of houses that integrate them.

Table 11.3 Breakdown of surveys by conglomerates (number of questionnaires)

Neighborhood	Ampliación Tixcacal-Opichen		Las Magnolias	
	Cases	Sample	Cases	Sample
Original small house model	242	35		
Modified small house model	15	2		
Original big house model	116	17	44	10
Modified big house model	195	28	288	65
Total	568	82	332	75

- Survey design

We designed a survey drawing on the information about the results of social perception of UA in social housing by Nadal 2018. To test the questionnaire, we undertook 20 pilot surveys. The interviews revolved around two topics: social housing and UA. The surveys were carried out in January 2017 by some of the authors as face-to-face survey.

For the collection of information, we conducted surveys in the neighborhoods with standardized and open-ended questions. The former provide quantitative information of statistical significance and the latter, qualitative information that supplements the narrative. A total of 46 questions were considered in the survey, of which 10 were open-ended questions. Each survey took approximately 15 to 25 minutes. We interviewed people of all ages without a minimum of years living in the neighborhoods. Those under the age of 18 were asked for consent from their parents or guardians.

Appendix 11.1 describes the survey's structure, which has three main parts and an additional module only for urban farmers or UA practitioners. The first part was meant to collect general information of the interviewee, i.e., age, education level, work, income, weekly spending on food, among others. The second part focused on specific topics of the housing typology, i.e., years of residence, inhabitants, number of spaces, use of spaces, construction order, housing extensions and others. The third part covered the questions related to interest in and knowledge of urban agriculture and its viability in social housing. Questions included whether residents cultivate in their home or not, what spaces are used to do so or what the characteristics of the ideal cultivation plot would be, among others. The additional module for urban farmers addressed specific questions about the variety of crops, destination of production, irrigation system, problems of the productive system and others.

11.2.3.Data gathering

Our data collection system was an exploratory, probability sampling survey. It is thus considered to be statistically and demographically representative of the residents of Mérida's social neighborhoods. This exploratory approach is suitable because it offers preliminary insights into a previously unexplored issue. Each of the houses was assigned a color and number code based on their type of home (modified or not) and the neighborhood. For the application of the surveys, the houses were randomly selected by generating random numbers in Excel software using the number codes assigned to each house.

The housings at the corners of the blocks were discarded because they have lots with dimensions greater than the standard. The sampling unit is the house; hence, we conducted a survey per house. We first asked the potential participants of selected houses if they were willing to participate in the survey. In the case of a negative response, we chose to survey the adjacent house on our right side.

11.2.4.Data organization and analysis

The information obtained through the surveys was stored in a database in Excel. The data was organized into three broad categories: urban agriculture, housing, and social aspects. The category of urban agriculture includes topics related to the development of UA, development of spaces, variety of crops, problems and strengths of crops. The category of housing includes the changes in the type of social housing, the order of construction of the spaces annexed to the houses, and the main problems of housing for the development of the UA. The social aspects refer to various issues that may be related to the relationship between UA and housing: origin, sex, age, salary, spending on food.

The information was coded in quantitative terms for the analysis. The information corresponding to open questions was also coded. The answers to ordinal and nominal questions were analyzed with descriptive statistics, using Microsoft Excel and IBM SPSS Statistics (Statistical Package for the Social Sciences) (IBM, 2013)for Windows (version 22.0). Descriptive statistics methods were used to analyze the frequencies and the concurrence of the different types of codes. Descriptive numerical information was generated for the characterization of urban agriculture developed in the dwellings. We used a non-parametric test (Kendall's Tau) to establish the correlations between aspects related to housing and social aspects that can influence the development of UA.

A network analysis was also carried out to study the evolution in the changes in social housing typology using Gephi 0.9.2. software (Gephi.org, 2018) for Windows.

11.3.Results

The results are presented in three sections: Characterization of urban agriculture; socio-environmental factors associated with artificialization and artificialization process in social housing.

11.3.1.Characterization of urban agriculture

UA is developed in 60% (94 units) of social houses analyzed. The forms of UA identified were five: Pot (23%); front garden (16%), backyard garden (40%); front garden or backyard plus pot (9%) and front garden plus backyard garden (12%).

The production focuses on the cultivation of tropical fruits of the region and aromatic plants used in traditional food preparation. 99% of the production is for self-consumption and the breeding of farmyard animals does not develop. Regarding the diversity of cultivated plants, 20 different crops were listed, among them: Papaya (Carica papaya); Soursop (Annona muricata); Nance (Byrsonima crassifolia); Guava (Psidium guajava); Sugar-Apple (Annona squamosa); Chi'aval plum (Spondias purpurea); Lemon (Citrus × lemon), Maax'ik pepper (Capsicum annuum); Mint (Mentha spicata); Epazote (Dysphania ambrosioides) Coriander (Coriandrum sativum). Most crops usually include at least one variety of fruit, vegetable or aromatic plant, leading to multi-crops.

In general terms, the production does not require many external inputs, since residents usually used their property's land for cultivation and their own seeds, exchanged or donated plants between relatives and used domestic organic waste as organic fertilizers. Only 3% of the crops used chemical fertilizers and 10% used chemical components for pest control. 100% of the crops are irrigated in a traditional way with water from the municipal system. Unfortunately, 33% of crops have problems, which are mainly related to the lack of space (25%), problems with neighbors (25%) and pests. To a lesser extent, residents mentioned the lack of water (10%), vandalism (6%), excess of sun (3%) and others (6%). Despite the present problems, various aspectsare also visualized for the strengthening and improvement of agricultural activity in social housing: plant donations (40%), government support (25%), agricultural training (15%), access to financial support (10%), urban spaces for cultivation (5%), spaces for the exchange and sale of products 83%) and the development of seed fairs (2%).

The characteristics of the households interviewed that develop the UA reflect a predominantly urban origin (80%), with a high level of property ownership (97%), a family farming tradition (63%) and a residence period equal to or greater than 10 years (56%). Usually, the households are integrated by three people. The predominant age range of the interviewees is between 35-40 years (32%) and 53% are women. 48% of households own their own cars. The average salary could not be estimated since 30% of the sample did not answer this question. However, they did agree to give information regarding the weekly food expenditure, with 84% of the interviewees spending 500-thousand Mexican pesos. In addition, 70% of the interviewees consider that the main limitation for the development of UA is the lack of space at home and in the lot.

In this sense, Figure 11.4 illustrates the most relevant information on the characterization of UA in social housing at a general level.

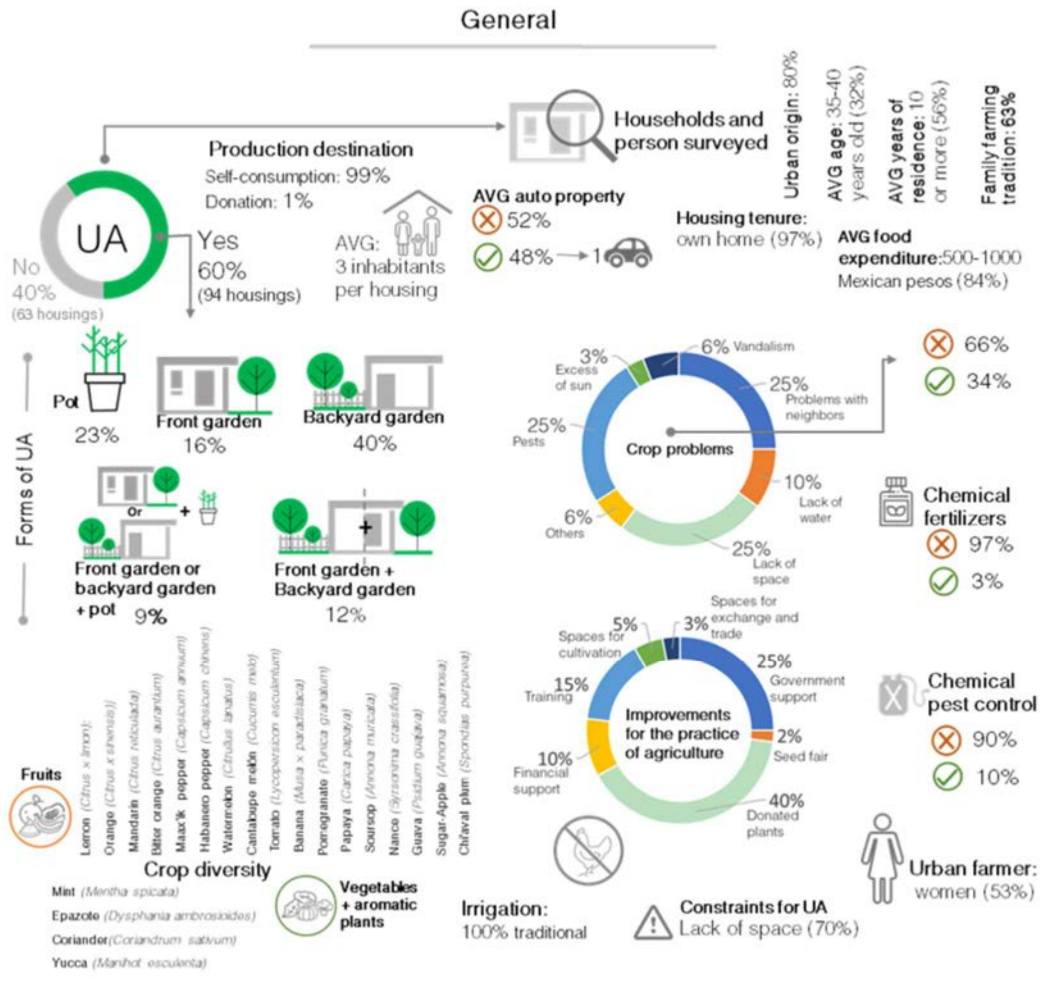

Figure 11.4 Characterization of the UA in social housing based on the main results of surveys

Within the neighborhoods analyzed (Figure 11.5), the results indicate that 79% of the housing of Ampliación Tixcacal-Opiuchen practice the UA. In the four typologies of housing at least 70% of the cases developed UA. The typology of housing with greater UA development is the small house modified with 100%, followed by the original small (86%), big original (76%) and big modified (71%) houses. The backyard garden form is the most developed (45%), whereas the front garden plus backyard garden is the least developed (9%).

In the case of Las Magnolias, the percentage of development of the UA is considerably lower than that of Ampliación Tixcacal-Opichen, as only 39% of the interviewees practiced UA. The two typologies of housing present development of the UA, but in unequal percentages; the big original house shows 90% of the UA development and the big modified house only 31%. Only three forms of UA are developed: Pot, backyard garden, and front garden plus backyard garden. Contrary to the case of Ampliación Tixcacal-Opichen, the form of pot represents 52% of the UA development and the backyard garden, 31%.

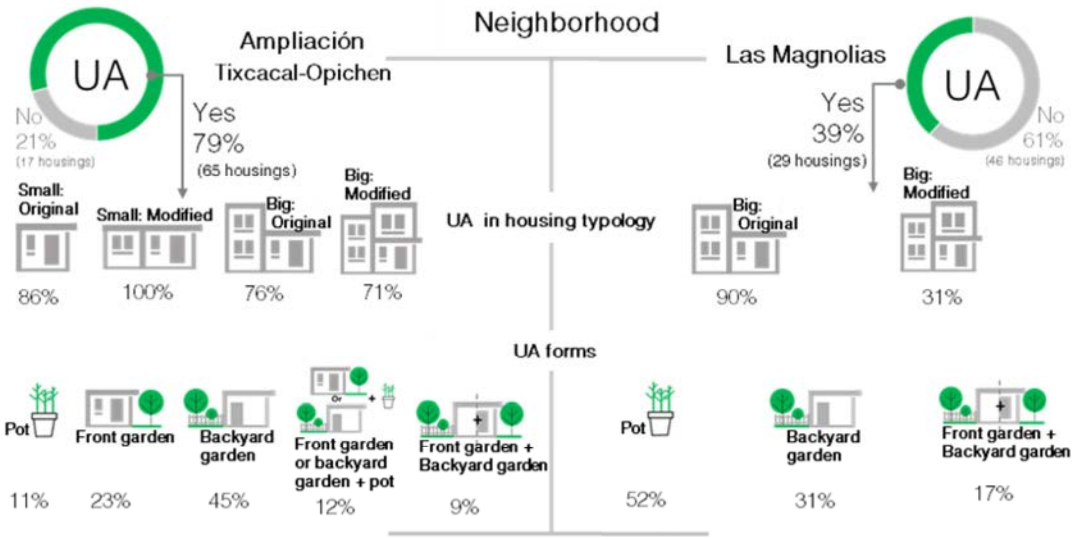

Figure 11.5 Characterization of the UA in social housing at a neighborhood level

If the results are analyzed from the perspective of the four typologies of housing identified in the general sample (both neighborhoods) with UA (Figure 11.6), in the original small housing typology, the most developed form of UA is the backyard garden with 53% of the houses. With 7%, the front garden or backyard garden plus pot shape is the least developed. 100% of the modified small housing typology developed UA in the form of a backyard garden. As in the original small house typology, in the original big housing typology the backyard garden form is the most common with 41%. And in the case of modified big houses, pot is the most practiced form of UA with 43%.

In terms of production, two trends were present: the typologies of small housings (original and modified) focus their cultivation on fruits (70%), of which 76% correspond to different varieties of citrus fruits; the second trend indicates that the cultivation of aromatic and vegetable plants represents more than 60% of the cultivation of the typologies of big housings (original and modified).

Considering 0.13m^2 as the area of an average pot of aromatic plant (Figueroa-Pérez et al., 2018; Figueroa Pérez et al., 2014; Rojas-Valencia et al., 2011) and 0.25 m^2 the average area for a citrus tree (R Almenares Garlobo et al., 2015) the average indexes of UA/m^2 (pot + tree), pot/m^2 and tree/m^2 were obtained. The results indicate a maximum of 0.95m^2 of UA/m^2 in the typology of original small housing and a minimum of 0.33m^2 of UA in the modified big housing. The typologies of small housing (original and modified) have the highest index tree/m^2. The typology of modified small housing has 0.88 tree/m^2 and the modified big housing only has 0.13 tree/m^2. In three of the housing typologies (original small, modified small and original big) the pot index per m^2 is lower compared to the index of the tree. The highest rate of pot/m^2 is found in the original small housing (0.27m^2). The highest rate of pot/m^2 represents 30% of the highest index of tree/m^2; that is, the largest area of UA/m^2 is constituted by trees.

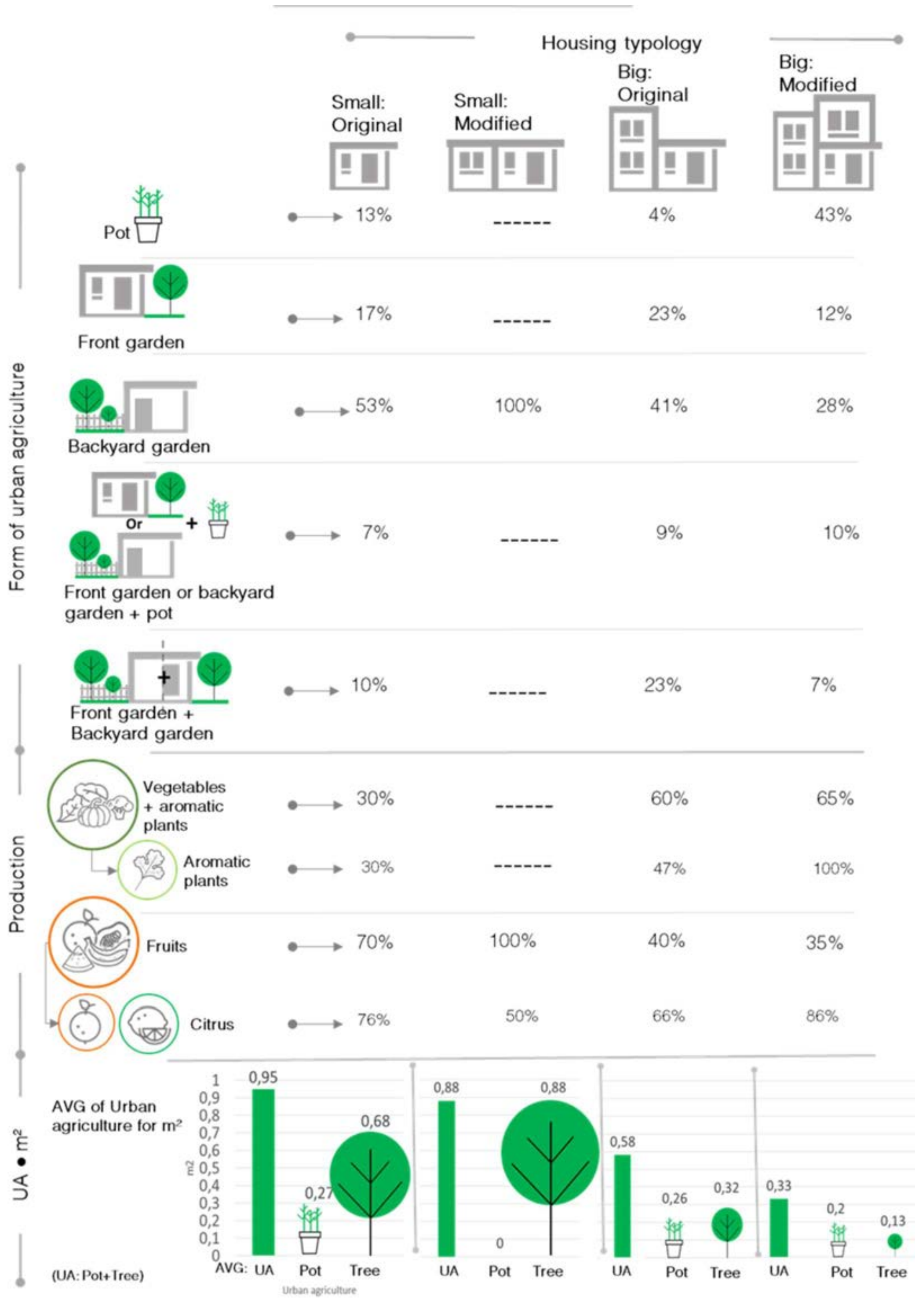

Figure 11.6 Development of urban agriculture in the four typologies of social housing

11.3.2.Housing R&E factors allocated with the practice of UA

The Kendall's Tau nonparametric correlation test (Table 11.4) showed that the area of development of UA and the neighborhood have a negative correlation (τb = -0.426, p = 0.000) and there is also a negative association with the housing typology (τb = - 0.397, p = 0.000). Regarding weekly spending on food, there is a negative association with the practice of UA (τb = -0.247, p = 0.002). Likewise, the area in which UA is developed is negatively associated with the typology of social housing (τb = -0.513, p = 0.000) and the neighborhood (τb = -0.348, p = 0.000). Regarding social aspects, when the area of UA development is related to the weekly spending on food, a negative correlation is presented (τb = -0.235, p = 0.001). Likewise, there is a negative correlation with the number of inhabitants (τb = -0.148, p = 0.022). Obviously, there is a moderate and positive association with the developed UA form (τb = 0.741, p = 0.000).

In this sense, the test also indicated that the neighborhood influences the practice of UA, so that in economically higher contexts the practice of UA decreases. That is, the neighborhood influences more than the type of housing in the practice or development of UA. But when UA is developed, the type of housing is associated with the area or magnitude in which it develops.

There is also no clear relationship between social factors (sex, origin and salary) and UA and its area of development. However, the association with the weekly spending on food (as a factor close to salary) is existent but weak; hence, the greater the spending on food, the less developed is UA. Thus, UA turns out to be an activity that supports small households at risk of marginalization or exclusion. However, UA does not produce enough to reduce the spending on food. It is necessary to point out that the origin factor does not seem to be associated with any of the UA variables.

Table 11.4Summary of results from the correlation tests (Kendall's Tau)

Correlations

			UAP	AreaUA	Ngbhd	TH	Sex	Origin	InHabt	Salary	FoodExpense
Kendall's tau_b	UAP	Correlation Coefficient	1,000	,741**	-,426**	-,397**	-,071	-,001	-,067	-,044	-,247**
		Sig. (2-tailed)	.	,000	,000	,000	,376	,986	,361	,617	,002
		N	157	157	157	157	157	157	157	105	155
	AreaUA	Correlation Coefficient	,741**	1,000	-,348**	-,513**	-,052	,021	-,148*	-,049	-,235**
		Sig. (2-tailed)	,000	.	,000	,000	,458	,765	,022	,523	,001
		N	157	157	157	157	157	157	157	105	155
	Ngbhd	Correlation Coefficient	-,426**	-,348**	1,000	,548**	-,024	-,054	,004	,083	,256**
		Sig. (2-tailed)	,000	,000	.	,000	,769	,498	,962	,340	,001
		N	157	157	157	157	157	157	157	105	155
	TH	Correlation Coefficient	-,397**	-,513**	,548**	1,000	-,015	-,004	,227**	-,071	,327**
		Sig. (2-tailed)	,000	,000	,000	.	,845	,957	,001	,397	,000
		N	157	157	157	157	157	157	157	105	155
	Sex	Correlation Coefficient	-,071	-,052	-,024	-,015	1,000	,037	,096	-,104	-,148
		Sig. (2-tailed)	,376	,458	,769	,845	.	,640	,194	,234	,059
		N	157	157	157	157	157	157	157	105	155
	Origin	Correlation Coefficient	-,001	,021	-,054	-,004	,037	1,000	,027	-,069	,157*
		Sig. (2-tailed)	,986	,765	,498	,957	,640	.	,713	,430	,046
		N	157	157	157	157	157	157	157	105	155
	InHabt	Correlation Coefficient	-,067	-,148*	,004	,227**	,096	,027	1,000	-,112	,189**
		Sig. (2-tailed)	,361	,022	,962	,001	,194	,713	.	,161	,009
		N	157	157	157	157	157	157	157	105	155
	Salary	Correlation Coefficient	-,044	-,049	,083	-,071	-,104	-,069	-,112	1,000	,031
		Sig. (2-tailed)	,617	,523	,340	,397	,234	,430	,161	.	,713
		N	105	105	105	105	105	105	105	105	105
	FoodExpense	Correlation Coefficient	-,247**	-,235**	,256**	,327**	-,148	,157*	,189**	,031	1,000
		Sig. (2-tailed)	,002	,001	,001	,000	,059	,046	,009	,713	.
		N	155	155	155	155	155	155	155	105	155

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 11.7 shows specifically the relationship between the area of UA development and the neighborhood context. Ampliación Tixcacal-Opichen presents on average a greater presence of UA (more than 0.50 / m^2). Due to the economic characteristics of the neighborhood, this indicates that in a limited economic context there will be a greater practice of UA. It can also be seen that the area of UA development has greater range in the original typologies of social housing (small and big), and on average small housings (original and modified) had more m^2 of UA.

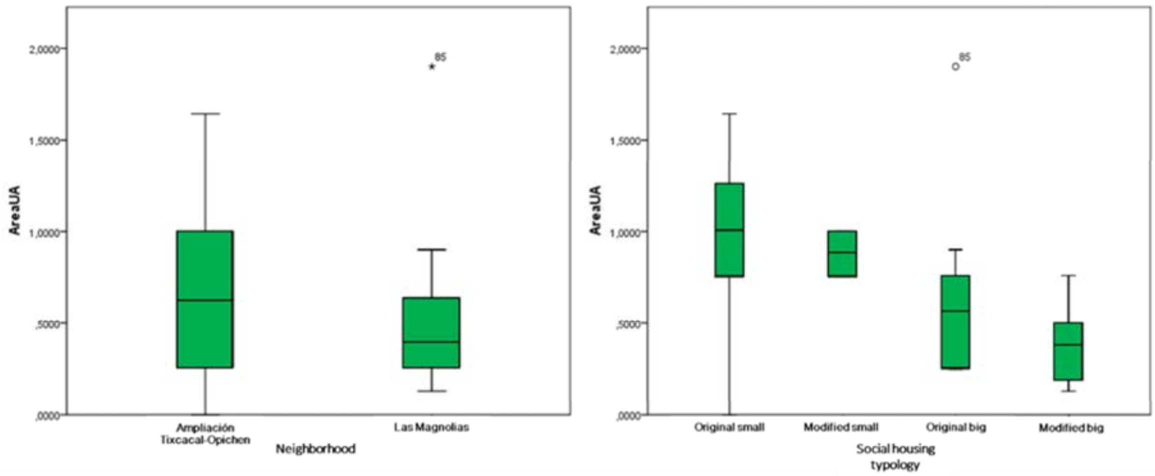

Figure 11..7 Relation between the urban agriculture area, neighborhood and social housing typology

11.3.3.Artificialization process in social housing

Figure 11.8 illustrates the evolution in the change or modification of social housing. The circles (nodes) indicate the housing spaces identified through the surveys. The size of the node specifies the frequency of appearance, the width of the arrow indicates the frequency of the connection, and the proximity between nodes indicates more frequent relations. Seven spaces are usually modified or incorporated into the functional and aesthetic structure of the social housing (small and big): garage, bedroom, perimeter wall, bathroom, corridor, kitchen and façade. The most frequent tendency to modify the original typology is constructing the garage, corridor, and façade. The second trend consists of constructing the bedroom, garage or corridor and façade. Less frequently, the process started with the perimeter wall, continuing with the garage or the corridor and finally the façade. The bathroom is usually built after the bedroom or garage. The kitchen and facade are the last spaces incorporated into the housing.

In line with (Nadal et al., 2018), the process of modifying the social housing, and thus the artificialization of the free surface, is developed in four steps: 1st, it starts from the original typology; 2nd, construction of the garage, bedroom and perimeter wall; 3rd, building the corridor and bathroom, and 4th, the construction or modification of the kitchen and the facade. In turn, these steps are included in the stages of evolution of social housing: establishment, densification and consolidation and/or diversification.

Specifically, the process of housing artificialization aligns with the status of the modification of the house. During the establishment stage, the impervious surface is limited in both types of social housing (40 and 56 m^2) and corresponds to the surface occupied by the house. In the densification, the housing artificialization increases, as does the impervious floor surface, doubling or tripling its magnitude, reaching approximately 117 for the small house and 123 m^2 for the big house. In the third stage (consolidation and diversification), the expansion of the impermeable surface is less than in the densification, but it's more significant. This is because in this state all the available plot for UA can be lost, leading to a complete artificialization of the lot (160m^2).

In both types of housing the process of artificialization occurs in the same way, but with differences in impervious areas. Therefore, the change in the typology of UA and in the area for its development presents great modifications depending on the development step that the house is going through.

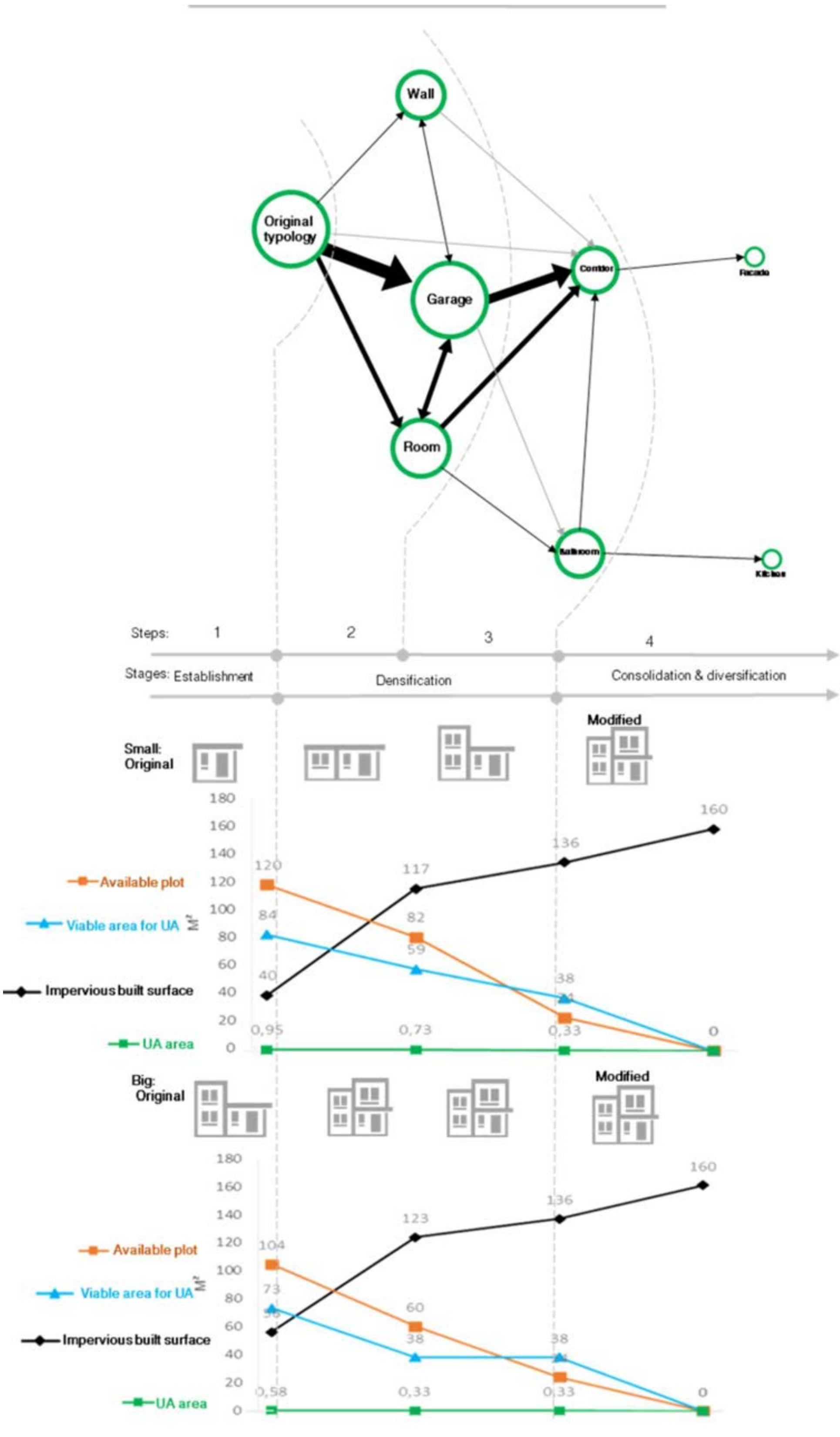

Figure 11.8 Artificialization process in social housing and its relationship with urban agriculture

11.4.Discussion

The paradigm of modernization in Latin America and the world led UA to disparage its importance for urban sustainability (Cortes Rojas, 2009), causing a considerable increase in impervious surface and urban temperature (Barrandas, 2013; Correa et al., 2003). Despite the limitations of the "modernization" of the Latin American city and globalization (de Mattos, 2002), UA developed in social housing neighborhoods. The diversity of crops found in the two neighborhoods analyzed in Mérida, Mexico, responds to the ability to adapt to the built urban environment, but is limited or encapsulated within the lot and housing. This condition is different to European practices, where UA is developed in community urban spaces such as parks and and vacant lots (Arosemena, 2012; Aubry et al., 2012; Mougeot, 2006, 2000; Quon, 1999). Cultivating within the boundaries of the land or inside the house diminishes theinteraction with neighbors and can be a limiting factor to social cohesion in the medium-sized cities of Mexico and Latin America.

The crops developed in the social housing analyzed focus primarily on tropical fruits, specifically citrus fruits and represent 70% of production, which is a clear example of the agricultural tradition of the region, since Mexico is the world's leading exporter of lemon and Yucatán is one of the most productive states of this crop (SAGARPA, 2016). Despite the variety of fruit crops, production is low and does not represent a saving in food expenditure. As Calderón Cisneros (2016) points out, urban agriculture systems in medium-sized cities in Mexico are largely supported by personal and cultural motivations, and not by of its productivity.

According to the interviewees, the lack of space in households is the main limiting factor for the development of UA. In this sense, and after statistically analyzing the results of the surveys, the factor that is most correlated with the development of UA in social housing are the neighborhood conditions. The housing typology defines the area or magnitude in which it is developed. Likewise, no strong relationship was found between social factors (sex, origin and inhabitants) and the development of UA.

Focusing on the relationship between artificialization and UA development, we observed that gradually viable surface is lost for the crop and therefore a change in the forms of UA practiced is generated. That is, in the original typology of social housing it is possible to grow in the traditional form, but gradually the viable surface for the UA becomes impervious and the residents switch from traditional UA to pot plantations. This process of modifying housing and increasing the impervious surface highlights a complex and ancient problem of social housing in Mexico: social housing is not adapted to the current needs of the inhabitants.

Villavicencio Blanco & Durán Contreras (2003) point out that the social housing promoted by Mexico's national housing policy does not consider in its design the true social, demographic and cultural characteristics that the population demands. Therefore, the promoted housing typology does not meet the basic needs of Mexican families (Galindo et al., 2004; Leal, 2012; Leal et al., 2013; López Estrada and Leal Iga, 2012; Pírez, 2014),which in turn requires a transformation process. This process occurs gradually and from the outside (garage) to the inside of the housing (bedrooms, backyard corridor). Otherwise, the process ends with the consolidation of the exterior space through the aesthetic modification of the façade.

This constant struggle between artificialization (increase in impermeable surface) and the need to cultivate in housing (naturalization) results in a considerable limitation to achieving urban sustainability in Mexico. Therefore, it is necessary to review and modify the national social housing policy of Mexico in such a way that UA is supported and promoted as an integral part of sustainability and the circular urban metabolism.

11.5.Conclusions

The present study helps in identifying the factors that determine the development of UA in social housing and its modification process. The neighborhood is the factor that presents the most significant correlation with the development of UA. The housing typology defines the area in which UA is developed. Likewise, social factors (sex, origin and inhabitants) do not have a strong relationship with the development of UA in social housing.

The artificialization process is developed by states and steps, in which new spaces in the house are being built. Usually, the process occurs from the outside to the inside of the housing: garage, room and bathroom. This modification process generates an increase in impervious surfaces and limits the development of UA in the traditional form. Hence, the residents need to adapting the form of UA they develop accordingly. The original typologies of social housing (small and big) have the highest UA ranges compared to the modified housing; however, the small housing (original and modified) has the highest UA average per m^2.

Currently, UA is developed in the traditional form in the backyard in original small housing, modified small and original big housing. However, in the big housing typology, the crop is usually grown in pots. Most crops focus on fruits (70%) and some aromatic species. Citrus fruits are the most cultivated fruits, perhaps because their maintenance does not require special care. Identifying the factors involved in the development of UA, and the way artificialization is developed has shown the current panorama of UA in social housing. This can be useful to professionals working on urban development to modify and promote new policies that integrate UA as a fundamental element to achieve sustainable development.

Finally, the results obtained in the present study highlight the need to develop research that will evaluate in depth the current status of UA in social housing in Mexico. This will help to generate an updated and reliable database that can be used to redesign the social housing typologies, so that these can meet the current needs of the inhabitants.