Chapter 4
Urban Agriculture—More Than Food Production

Martina Artmann and Jürgen Breuste

Abstract Urban agriculture describes the growing of plants and animals in and around cities and it involves activities such as production, processing, delivery, and marketing of agricultural products. Urban fabrics can be composed of manifold urban and peri-urban agriculture depending on spatiality (e.g., rooftop gardens and indoor farming), the actors involved (e.g., family farms and community-supported agriculture), and the organizational perspective (e.g., market orientation including urban farming or subsistence activities such as urban gardening). This chapter aims to contribute to an increased understanding about the impacts and framework conditions for the implementation of urban agriculture taking into account various types of urban food production such as allotment gardens (Breuste and Artmann), community gardens (Liu), community-supported agriculture (La Rosa), home gardens (Dissanayake and Dilini), and the edible city concept (Artmann and Sartison). Thereby, the case studies used cover a wide range of geographical backgrounds from the Global South and North such as Pakistan (Waseem and Breuste), Sri Lanka (Dissanayake and Dilini), China (Liu), Spain (Breuste and Hufnagl), Italy (La Rosa), Austria (Breuste and Artmann), and Germany (Artmann and Sartison). This chapter aims at the development of a comprehensive understanding of urban agriculture and the challenges and changes in food production in cities.

Keywords Urban agriculture · Peri-urban agriculture · Urban gardening · Food production · Allotment gardens · Garden forms

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Introduction

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The current global food system is criticized for the major negative impacts it has on nature and humans and it can be considered a crucial driving force of exceeded planetary boundaries (Meier 2017). In particular, through rapid worldwide urbanization, a pressing need for the sustainable transformation of both our food system and agricultural practices has developed (Gonzalez 2011). Within the fields of research and planning, the implementation of urban agriculture has gained increasing attention since the last decade (Artmann and Sartison 2018). Urban agriculture can also incorporate a more technological system (e.g., vertical farming) as well as simulate natural ecosystems for holistic food production (e.g., permaculture).

Depending on the perspectives and production forms of urban agriculture, it can contribute to a range of benefits (Breuste and Artmann 2015; Langemeyer et al. 2016). For instance, urban agriculture can provide positive ecological and environmental impacts and can reduce urban heat islands depending on garden management (Lin et al. 2015). In this regard, trade-offs between food supply and climate regulation can occur when trees (which are important for climate regulation) are removed to provide space for food production (Taylor et al. 2017). However, urban agriculture can also benefit from the urban heat island phenomenon by taking advantage of the potential to grow warmer-climate crops (Waffle et al. 2017). Furthermore, social benefits can be obtained from urban agriculture, particularly for residents involved in urban gardening activities such as allotment care and community gardening. Gardeners can gain health benefits related to social interaction (Soga et al. 2017) and physical activities (Hale et al. 2011).

Urban gardens are also important educational settings for cross-generational learning about nature (Breuste and Artmann 2015). They are the most intensively used recreation sites within cities and are well investigated throughout Europe, yet they have been only marginally explored worldwide (Bell et al. 2016).

In economic terms, urban agriculture projects merge fiscal activities with ecological and social objectives and are generally accepted by residents compared to technology-based agriculture (Specht et al. 2016). Cities can act as living labs for innovative forms of urban agriculture such as ZFarming (Zero-Acreage Farming) (Corcoran et al. 2017) and aquaponics (Laidlaw and Magee 2014). However, to secure multidimensional benefits provided by urban agriculture, it requires careful management to avoid high energy demand (Goldstein et al. 2016a) and excessive irrigation (Garcia et al. 2015) as well as to minimize the risks for human health (e.g., through soil contamination) (Sharma et al. 2015).

It is crucial to make the multidimensional benefits provided by urban agriculture visible in order to highlight the value of food production in cities. Areas used for urban farming are especially under threat in situations of land consumption for residential and commercial development (Artmann 2013). Urban gardening

practices are suffering from ongoing urbanization and are often limited by temporary land access (Mikulec et al. 2015). In general, the successful implementation of urban agriculture can vary depending on the system involved. For instance, urban residents need to be accepting of the establishment of vertical farming (Specht et al. 2016) and strong cooperation between civic populations and public sectors can aid the effective running of community gardens (Fox-Kämper et al. 2018). In general, a mix between bottom-up and top-down approaches can be considered supportive of the secure implementation of urban agriculture through broad civic participation and city administration (Artmann and Sartison 2018). Residents who value the quality of local and organic food are often engaged in urban agriculture by way of resistance against the conventional agri-food system (Orlando 2011). Although some analyses show that there is potential for cities to become entirely food self-sufficient, the main driver of urban agriculture should be its multidimensionality as an urban-nature-based solution (Artmann and Sartison 2018).

4.1 Allotment Gardens Contribute to Urban Ecosystem Service: Case Study Salzburg, Austria[1]

Jürgen Breuste and Martina Artmann

4.1.1 Introduction

4.1.1.1 Allotment Gardens

An allotment garden (UK), community garden (North America), allotment plot or simply "allotment" is a plot or parcel of urban or suburban land made available for individual, noncommercial gardening. Anywhere from a few to several hundred individually cultivated allotment plots used by individuals or families make up an allotment site. In Austria, individual gardeners at an allotment site are usually organized in an allotment association. The latter lease the land from an owner, who usually stipulates that it be only used for gardening (i.e., growing vegetables, fruits, and flowers) and not for residential purposes. This is also usually a requirement of the federal Allotment Garden Law (Bundes-Kleingartengesetz). Within this framework, gardeners are free to create an individualized natural space, according to their own wishes, with their own intentions and for their own use.

Allotments are an important feature in urban landscapes. They combine utility, social meaning, beauty, and ecosystem services (ES). Allotment gardens are deeply

[1]Based on Breuste and Artmann (2015).

embedded within the cultural landscape and, in Britain for instance, they have been a familiar feature for almost 200 years (Crouch 2003).

The history of allotments is one of conflict, contestation, and vulnerability. Allotment gardens have been located on marginal and redundant land and at the margins of governmental discourse (De Silvey 2003). In research, the subject of allotments has suffered neglect too (Buchardt 2002). Yet the desire to have a plot continues to remain significant as an increasingly intricate and dynamic element of contemporary urban life (Crouch 2003). In many European countries, there is a great and rising interest in allotment gardening. The occasional prediction of the demise of the allotment movement was never realized (Crouch 1997).

There have been six larger empirical surveys over the last 20 years focused on investigating utilization and behavioristic aspects of allotment gardeners in Central European cities. These were conducted in Salzburg, Austria and the German cities of Darmstadt, Halle/Saale, Berlin, Regensburg, and Osnabruck (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). They show

- The reduction of fruit and vegetable production as the main objective of gardeners;
- The rise of recreational aspects in the utilization of the plots;
- The change of plot structure from vegetation production to lawns and marginal flower beds; and
- The high intensity of recreational use by frequency and duration of stay on the plots.

Ecological aspects of behavior or ES were not investigated by these studies. Only the study by Breuste and Breuste (1994a) included soil pollution by heavy metals.

4.1.1.2 Allotment Gardens Provide Ecosystem Services

Ecosystem services (ES) are the benefits people obtain from ecosystems (MEAB 2005). Four categories of ES can be defined according to the Millennium Ecosystem Assessment Board (MEAB) (2005) and Costanza et al. (1997): (1) provisioning services (food and timber production, water supply, etc.); (2) regulating services (regulation of climate extremes such as heavy rainfall and heat waves, regulation of floods and diseases, etc.); (3) cultural services (recreation and tourism, provision of aesthetic features, etc.); and (4) habitat and supporting services (soil formation and processes, pollination or energy, etc.).

The ES concept has already been integrated into ES of cities and towns, where urban green and blue areas are the main providers of ES (Bolund and Hunhammar 1999; Chiesura 2004; Niemelä et al. 2010). Besides several studies on ES at the city level, there are only a few studies at the site or local level in urban areas. The latter

have focused on selected urban green space types, most on public spaces (Niemelä et al. 2010; Qureshi et al. 2010; Breuste et al. 2013a, b).

4.1.1.3 Aim

This paper investigates the ways in which urban allotment gardens contribute to ES. Not least, the services selected were recreation, food production, and experiencing nature (learning and teaching); as these are crucial services provided by allotments for urban dwellers. Additionally, the ecological behavior and gardening of the allotment holders were included in the survey to study how they can contribute to ES supply in cities.

4.1.2 Methodology

4.1.2.1 Study Area

Salzburg has about 147,000 inhabitants and a development history as a cultural and administrative center, with marginal industrial activity. Due to this fact, the city of Salzburg has much fewer allotment gardens than cities such as Linz or Vienna, with a denser built-up residential area and an industrial history.

The first allotment site was founded in 1940 ("Dauerkleingartenverein Thumegg"). In 1958, the State Allotment Gardeners Association (Landesverband der Kleingärtner Salzburg) was founded. Eight allotment sites in Salzburg belong to the association. From the eight allotment sites of the Salzburg Allotment Gardeners Association, four were selected for the survey (Table 4.1 and Fig. 4.1). Since 1960, 48.2% (23.1 ha) of the allotment garden areas have been replaced primarily by residential buildings. However, since 1988, the area of allotment gardens has only been reduced by 5.6 ha, resulting in 243 allotments lost. The current 649 Salzburg allotment gardens cover an area of 28.3 ha.

Table 4.1 Surveyed allotment sites (author's illustration)

Allotment site	No. of allotments	Year of foundation	Location
Liefering-Herrenau (LH)	125	1982	Fringe
Thumegg (TH)	68	1940	Inner city
Leopoldskron (LK)	54	1956	Inner city
Pulvermacherweg	37	1991	Fringe
Total number of allotment gardens	284		

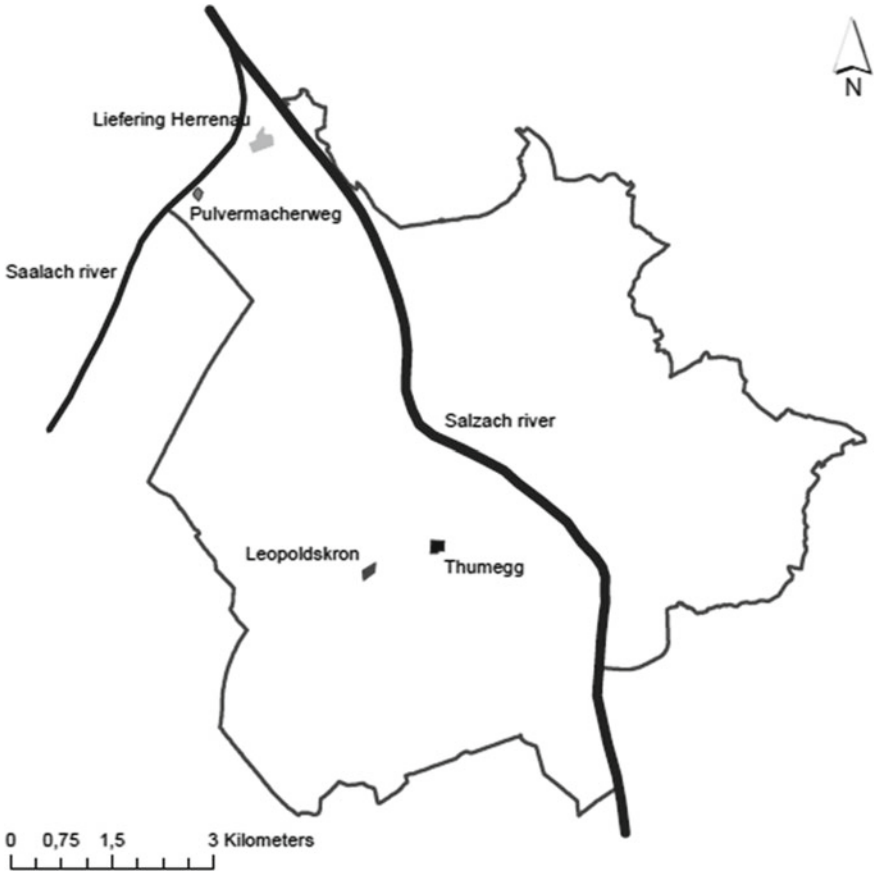

Fig. 4.1 Location of the four investigated allotment sites in Salzburg, Austria (design: D. Wurster)

4.1.2.2 Questioning of Allotment Holders

To reach the target of the investigation, allotment gardeners were interviewed.

A questionnaire was developed to that end, which was divided into five sections: (1) the utilization of the allotments; (2) the ecologically relevant behavior; (3) food production; (4) nature experience and learning about nature; and (5) environmental consciousness. With regard to the utilization of the allotments, gardeners were asked about the size of their allotment and their motivations for choosing it (such as recreation and recovery, space for children to play, quiet, and place for retreat). Other questions targeted information about (1) the duration of stay; (2) the activities undertaken; (3) travel time to the allotment garden and mode of transportation; (4) comparison to the use of other public green spaces in the city; (5) the partitioning of the allotment (area used for cultivation of fruits/vegetables, lawn, terrace,

etc.); (6) the know-how in gardening and utilization strategies; (7) improvements and changes they had made in their gardens (amelioration, construction of cabins, planting of trees and bushes); (8) the use of insecticides and pesticides; and (9) the use and consumption of their own fruits and vegetables. The interview concluded with some sociodemographic data about the interviewee (age group, education, engagement, and living situation). All in all, 156 persons were interviewed in four different allotment sites. The questionnaires were given to all the directors of the allotment associations, who distributed them to the gardeners. We received 65 questionnaires from the allotment site LH, 32 questionnaires from TH, 26 questionnaires from PW, and 33 questionnaires from LK. Interviews were conducted on the allotment sites from September to November 2012.

4.1.3 Results

4.1.3.1 The Allotment Gardeners

Most of the questioned persons (60–75%) are over 60 and retired, and mostly started gardening shortly before retirement, over the age of 50. Younger family members (children and grandchildren) are involved as well, but mostly as non-association members. Normally, an older couple or a single older person is responsible for the site, doing most of the management and spending most of the leisure time on the plot. The younger family members are frequent users and profit in some way from the provided ES. The majority (more than two-thirds) of the questioned persons were males.

4.1.3.2 Where the Gardeners Come from

About 50% or more of the gardeners are not residents of the nearby neighborhoods. Originally embedded allotment sites in residential neighborhoods are declining to become recreational sites for people from the whole city as well as the surrounding areas. The growing distances can be compensated by available and faster means of transport compared to the past (private cars).

4.1.3.3 Reasons for Allotment Gardening

For approximately 80% of the gardeners, allotment gardening is for relaxation and recreation. Allotment gardening is the main hobby for the majority (66–93%). Connectivity to "nature" is the main reason for gardening for 65% of the gardeners. Other reasons, such as (1) to have a quiet place for retreat (57%), (2) to balance out the stress of work (47%), and (3) to self-supply with fruits and vegetables (46%),

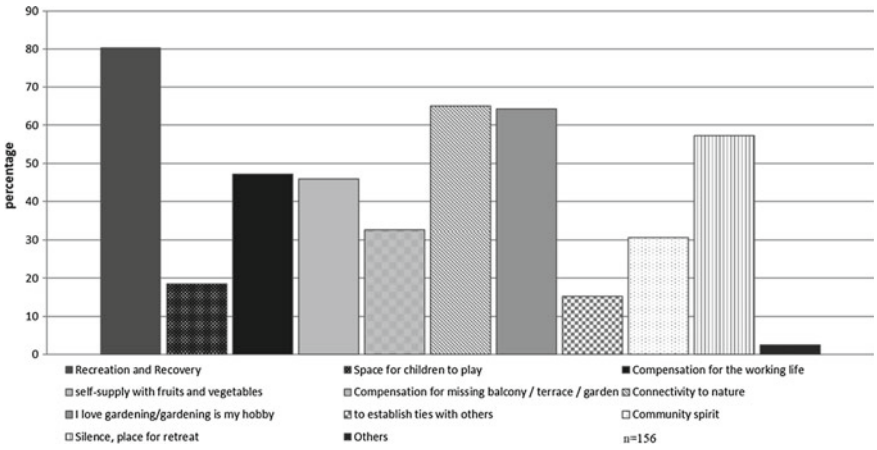

Fig. 4.2 Reasons to use an allotment garden

are also important. Much less important are reasons like (1) compensation for absent private green (32%) or (2) community spirit (31%) (Fig. 4.2).

The allotment gardeners are very much satisfied with their gardens, and the majority (68%) does not feel disturbed by anything. Even the strict regulations, restricting them in some activities, disturb only 10% of the questioned persons.

4.1.3.4 Utilization of the Allotment Plot and Public Green Spaces

In summer, majority of the allotment gardeners use the plot several times a week (59%) or even daily (36%) (see Fig. 4.3). Even in winter, 22% use the garden several times a week and only 29% use it seldom. On a working day in summer, the majority spend 4-6 hours on the plot for gardening as recreation (32%). The summer weekend day is, for the majority, mostly spent fully in the allotment garden (more than 6 or even more than 8 hours). Also, 31% spend their summer holidays predominantly on the allotment plot. Most of the leisure time of allotment gardeners is thus spent on the allotment plot.

The interviewed allotment gardeners are infrequent users of public urban green spaces. More than two-thirds—68% in summer and 71% in winter—express that they use them fewer than only several times a month.

4.1.3.5 Partitioning of the Allotment Gardens

The structure of the allotment gardens mirrors the utilization structure:

- A majority of gardeners (45%) use only 10–20% of the space for the cultivation of fruits and vegetables (see Fig. 4.4).

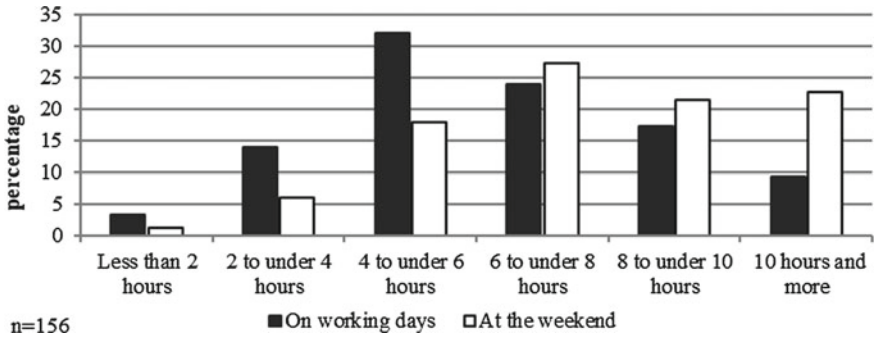

Fig. 4.3 Leisure time spent in the allotment

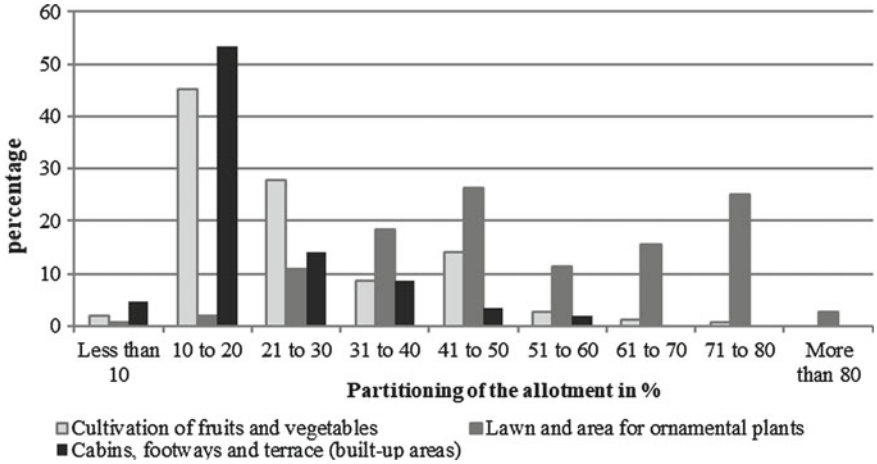

Fig. 4.4 Partitioning of the allotment gardens

- Twenty-six percent of the gardeners use 40–50% of the allotment for lawns and another 25% of the gardeners use as much as 70–80% of the allotment for lawns.

4.1.3.6 Changes Undertaken in the Gardens

Many of the allotment gardeners have changed their garden structure from food production (fruit and vegetable beds) to relaxation (lawns). They reduced their management intensity and spend more time on relaxation than in the past. Other changes include 41% of interviewees enlarging the flowerbeds, and 28% enlarging the leisure areas (terrace, pergola, barbecue place, etc.). Only 17% report that they have not changed uses in their gardens.

4.1.3.7 Food Production

Most of the allotment gardeners have improved the allotment garden in general since they started working on the plots. This includes the improvement of soils by (1) self-produced organic fertilizer (85%); (2) planting of trees (54%) and shrubs (82%); and (3) cultivating fruits and vegetables (76%). Almost half of the questioned persons (44%) never use chemical fertilizers while the others (54%) rarely use them. The soil and plant management practices aim to improve the fertility of the allotment gardens.

The produced food is used fresh and seasonally, mostly by allotment gardeners (71%) and their families (45%) (more than one answer was possible) (see Fig. 4.5). The majority of gardeners (52%) produce only up to 10% of their overall fruit consumption on their allotment gardens. The reasons for producing one's own food are (1) healthier production (47%) and (2) better quality and taste (41%).

4.1.3.8 Experiencing Nature (Learning and Teaching About Nature)

A majority of gardeners (66%) increased their knowledge of nature through allotment gardening. 31% percent learned about the general relation to nature and ecological behavior, and 28% about horticulture and garden management. Seventy-eight percent of the questioned persons valued the allotment garden as an important or even a very important place for learning about nature for the younger generation.

The allotment garden is a place for nature observation. Birds, small mammals, and amphibians are frequently observed (see Fig. 4.6). The majority of the gardeners (74%) call the attention of the younger generation to observe animals. If the

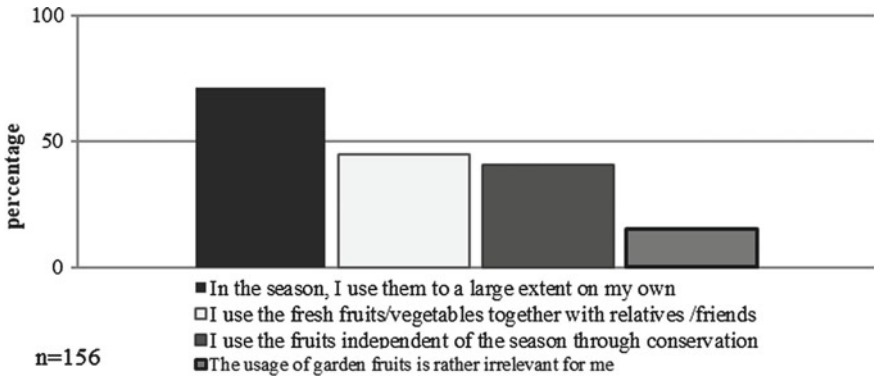

Fig. 4.5 Consumption of garden fruits and vegetables

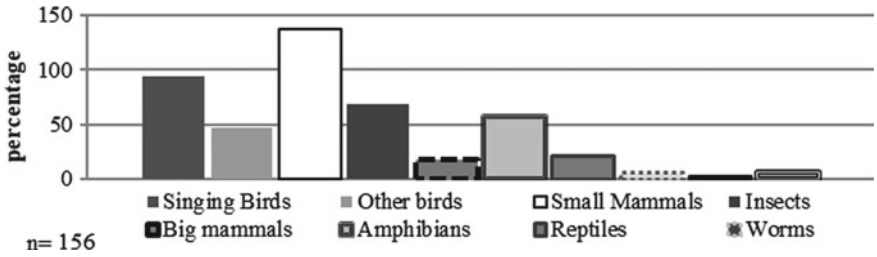

Fig. 4.6 Observed animal groups in allotments

allotment gardeners compare where they make most of their animal observations, it is 80% of the time on the allotment plot, followed by 34% in forests and only 9% in urban public green spaces.

4.1.3.9 Ecological Gardening and Environmental Behavior

Between 60 and 79% of the allotment gardeners express that they behave, for the most part, sustainably. More than two-thirds and up to 85% of the questioned persons connect this with the consumption of ecologically produced fruits and vegetables. This is, of course, not only based on their own ecologically produced food, but also includes a more sensitive consumption of organic food in general, as most of the fruit and vegetable consumption does not come from their own garden. About one-third (30–57%) prefer to use the public transportation network to reach their gardens rather than a private car. Up to one-third of the people also often use a bike. Other aspects of ecological behavior are seldom expressed.

The allotment gardeners express that their gardens are already sustainable (54%). Only 21% express that they are open for a change in management to a more sustainable garden. Only 18% have no interest in the ecological garden idea.

4.1.4 Discussion

4.1.4.1 Comparing Recreation in Allotments and Urban Parks by Frequency and Activities

The survey shows a very intensive usage of the allotment gardens based on frequency and duration of stay. A comparison of the utilization intensity of these privately used green areas with public urban green appears to be a meaningful approach for revealing different utilization patterns based on green space type.

Park usage and physical activity research as well as the theory of urban park geography are still in their infancy (Brown 2008; Hamilton 2011). Sasidharan et al.

(2005) showed important cultural differences in urban recreation patterns and in park usage and activity participation. Hamilton (2011) recorded 1,098 park users. The overall park usage patterns revealed that the most prevalent park users were female (52%). Adults (aged 18–65) were the most prevalent age group (47%). Physical activity recordings showed that 45% of users were sedentary, 40% were walking (moderate physical activity), and 15% were engaged in vigorous activity. This shows that physical activities were mostly sitting and walking.

Park activities are not comparable to those in allotment gardens. In parks, activities are mostly contemplative, whereas in allotment gardens they are physically active and involve active engagement with nature. This means allotment gardens allow many different activities and recreation opportunities than parks. They are an alternative for a more active and individually shaped recreation.

The duration of stay and frequency of visits is different in all public parks but extends from the majority of weekly visitors (more than 50%) to daily (more than 60%) (Veal 2006). Visits mostly last less than 2 h (Breuste et al. 2013a, b).

A comparison to allotments shows a much higher frequency and duration of stay in the latter. Allotments are much more intensively used urban green spaces than parks. The high degree of usage is also supported by several allotment garden studies in Central Europe (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005).

With a long-lasting rental—often more than 20 years—allotment gardeners create a very individual and personal relation to a small part of "semiprivate" urban green. This may be one of the reasons for the more than 150 years' success in allotment gardening in Central Europe. The other reason is the limited self-determination in designing one's own nature spaces by individual gardening activities. After the apartment, the allotment garden is the second center of life for the allotment gardeners. They spend most of their leisure time there, often even the holidays, and reduce other open space activities, even visits to public urban parks.

Allotment gardens can be reached mostly within 30 min from home, in longer distances often by car or bicycle (see e.g., Breuste and Breuste 1994a, b). The most harmonious usage of the allotment gardens indicates a high degree of sufficiency with this part of the urban green—much more than with most of the public urban green (Breuste 2007).

4.1.4.2 Can Allotments Be a Good Place to Experience Nature?

Cities are the most important places to learn about nature for the majority of people. In Central European cities, there have been many activities to teach about nature on public ground (Schemel 1998). Forests, public parks, wetlands, and other natural areas in cities have been identified for their potential for nature experiences and learning opportunities. The UK was a forerunner in Europe for experiencing nature in cities (e.g., Johnston 1990), including parks, forests, and succession land, but not including allotment gardens and other forms of gardening. The individual learning

by doing and the social learning of connected generations have been surprisingly underestimated or even excluded from concepts of learning about nature in cities (Register 2006).

The perspective of nature must, therefore, be broader and include all forms. Allotment gardens should also now be seen as places to learn about nature. They are a means to (1) learn and understand nature and its processes; (2) change behavior through this knowledge; and (3) teach experiences to the younger generations. The results in Salzburg show the key role that allotments can play in the process of learning about nature: two-thirds of the interviewees learned about nature through gardening and more than three-quarters value the allotment as an important place for the new generations to learn about nature.

4.1.4.3 Changes in Allotment Structure and Management—Change of ES?

The allotment gardens have tremendously changed in structure over the last 50 years. There is a shift from food production to beauty and recreation. This has an important influence on the ES provided by them. Allotment gardens have become a leisure ground with interactive learning and nature experiencing function. This is also supported by the results of comparable studies on the subject (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a, 2000; Breuste et al. 1996; Atzensberger 2005).

Gardeners do not want to invest as much time as in the past for garden management, including vegetable beds. The reduction of time for these activities is linked to spending more time on physical recreation. It should not be forgotten, however, that physical work in lesser proportions is still an important part of gardening in the understanding of most of the gardeners. The equipment of gardens with leisure facilities has increased significantly over the last several decades. Amenities of the allotment like garden houses, terraces, barbeques, and playgrounds for children, even movable swimming pools, now have a greater share of the plot.

4.1.4.4 Healthy Food Production by Allotment Gardening

Food production is not the main service of allotments in Salzburg and Germany (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). This is perhaps different from other countries (Kingsley et al. 2009; Leake et al. 2009; Turner 2011), especially the United Kingdom (Degnen 2009). The Royal Horticultural Society (2013) lists eight reasons to get an allotment. Three of the first reasons are related to food production (fruits and vegetables).

For nearly half of the allotment gardeners, the actual production of fruits and vegetables covers only up to 10% of their overall consumption. All allotment gardeners produce food because of the better health and taste argument. The fact

that 44% never use chemical fertilizers shows that healthy production of food is important for them. As health (Dixon et al. 2009; Kingsley et al. 2009; Leake et al. 2009; Schoneboom 2010; De Vries 2012; Ferres and Townshend 2012) and food security (Deppe 2010) in urban societies become rising issues, it can be expected that the food production service of allotments will increase in the future. The allotments and the allotment holders are prepared for this. Activities like planting trees and shrubs and organic fertilization of soils are already activities carried out by most of the allotment gardeners. McCormack et al. (2010) already show an increase in the consumption of fresh fruit and vegetables in American community gardens.

4.1.5 Conclusions

Allotment gardens are part of the urban fabric and a lesser-known part of the urban green. It can be expected that their importance as green spaces will not decline. Privately used urban green seems to be an important part of the urban green infrastructure, providing important ES, as this and other studies show. The different ES public and private urban green can provide should be recognized and actively included in urban planning, targeting the improvement or at least securement of ES by all parts of the urban green infrastructure. This consists not only of public urban green. In many cities, the majority is private green. This should be included in research, planning, and management of urban green and its ES.

Traditional food production is no longer the main service of the allotment gardens. Recreation, gardening as a basic human activity, and contact with and learning about nature are becoming more and more important. The trend to reduce the intensity of land use in the allotment gardens also means a chance to further develop other ES like habitat provision and biodiversity.

The attractiveness of allotment gardening is undiminished in many European countries. It is surprising that having these potentials, allotment gardens are less privileged urban green structures in comparison to others, and are very often shrinking due to development decisions.

There is an especially strong need to secure allotment garden sites that are being absorbed into the urban fabric, mostly not only for recreation but also for other ES and biodiversity. The demand to produce healthy food by allotment gardeners will develop. Allotment gardens can be a social and ecological stabilizing factor for urban societies.

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4.2 Community Garden Practices in High-Density High-Rise Urban Areas in Shanghai, China

Yuelai Liu

4.2.1 Introduction

4.2.1.1 Community Gardens in Shanghai

In light of the increased development of agglomerated cities in China, these ever-growing metropolises are increasingly confronted with a string of issues related to land, energy, transportation, and environmental protection due to the high density of population and the rapid expansion of urban construction (Min and Changdong 2015).

Shanghai, as an important example of China's high-density cities, is focusing on the exploration of sustainable urban development despite tight resources and a significant decrease in downtown open green spaces. The outline of the 13th Five-Year Plan for National Economic and Social Development in Shanghai states that by the end of the 13th five-year period, the city will have no more than 3,185 km^2 of land available for construction. However, in 2015 the entire city had 3,145 km^2 of land available for building, leaving only an additional 40 km^2 of land available for the current five-year plan. The outline states that efforts will be made to ensure that the new land is available for infrastructure and projects that strengthen people's livelihoods and benefit the public. Currently, the main task of urban spatial planning is to enhance the quality of public space, strengthen the compound use of land, and motivate community residents to participate in designing, maintaining, and managing the land.

Although "community gardens" originated in the West, the idea has become increasingly popular in China in recent years. In this approach to the utilization of green spaces, idle land is divided into small pieces and cheaply leased or assigned to individuals and families for gardening or agronomy (Jing 2011). In the context of China's public ownership of land, this model attaches more importance to space for gardening activities for all community residents. Instead of restricting the use of land, community gardens facilitate the pursuit of a wider range of social benefits, in which gardening serves as the promoter and the gardens as the space carrier.

The emergence of community gardens has brought a good solution to issues such as environmental pollution, decrease of green spaces, and also relationships in the community. Community gardens in high-density urban areas can provide spaces with complex functions and complementary forms that meet diverse needs for activities and experiences. Introducing pastoral elements to urban landscapes also helps to release the full potential of the land. It not only brings economic and social value, but also reduces possible negative effects brought about by high-density commercial development (Chong 2011).

Although community gardens are not zoned and have posed problems to the city's management of green space, they complement other forms of green spaces and also provide some dynamic and customized ways of urban development.

4.2.1.2 Aim

Comparative research was conducted to analyze the different features of community gardens in public and private urban spaces in terms of participants, involvement, and applicable conditions. The research is designed to explore the strategy for creating community gardens in current high-density downtown areas in China and to provide references for inclusive participation and sustainable development of community gardens.

4.2.2 Methodology

4.2.2.1 Study Area

The city of Shanghai is situated at the middle part of the north–south coastline in China and accommodates over 24 million inhabitants in a territory of 6833 km^2. In recent years, some social organizations have emerged in Shanghai, engaged in the creation of community gardens. They actively lobby urban policy-making bodies to grant permission and support for agricultural projects that educate citizens about the natural world in urban spaces. Moreover, they are self-governing and utilize diverse landscaping approaches as they see fit.

They do not advocate a one-size-fits-all mass production model for commercial purposes; rather, they more often begin by responding to the needs of the city residents and create community gardens based on the specific features of the space available. They also consolidate the resources of multiple parties to involve urban residents in the development and maintenance of the gardens.

At present, there are nearly 20 community gardens built or being built in the neighborhoods, communities, schools, and parks in Shanghai (Fig. 4.7). Based on 2 years of practice, two typical cases in Yangpu District, Shanghai were selected. They are "Knowledge and Innovation Community Garden", a public neighborhood garden supported by private enterprise and "Baicao Garden", a community-governed supported by the government.

Baicao Garden

The Baicao Garden project is located in the Central Square of the Third Neighborhood of Anshan Fourth Village, Yangpu District, Shanghai (Fig. 4.8). It is a community garden that has drawn on multiple disciplines including landscape studies, ecology, and sociology and explores community-led participatory landscaping models for well-established residential communities.

Fig. 4.7 Map of Shanghai community gardens
1 Jing'an Yucai Middle School; 2 Camellia Garden; 3 Jing'an Youth Activity Center; 4 Guangling Second Road Street; 5 Knowledge and Innovation Roof; 6 Mi Garden; 7 Fushan Road Runway Garden; 8 Yangshuo Street; 9 Jinwei Community.
A Hongmei Community (the design forms a "new landscape in old community" with the residents' participation); **B** Jiading Tongji University Affiliated Primary School, Edible Campus (the project is an attempt to promote edible landscape on campus); **C** Yikangyuan Community (it actively promotes the residents to participate in the design); **D** Caoyang Middle School (the ecological wetland of Caoyang Middle School symbolizes the possibility of the river clearing); **E** 190 Yuqing Road Kindergarten (the project is trying to integrate the edible landscape into the children's playground); **F** Train Garden (the site was originally an urban wasteland. Through rainwater harvesting and purification, wildflower weeds and crop planting have been formed); **G** 363 Lane Fang Garden (as a pilot project of "Hemei Street District", it formed a reproducible remediation method system); **H** Knowledge and Innovation Community Garden (it aims to bring the concept of Permacultural sustainable design and care for the earth into the community); **I** Shanghai Pingliang Neighborhood Center (it enhances the public landscape space with elements such as edible landscapes, herb gardens, and roof gardens); **J** Healing Garden (it belongs to the mutual help version of the "urban Permaculture" community); **K** Nine Village Plum Garden (with the concept of "Permaculture sustainable", spots have been created such as "One Meter Vegetable Garden", "Mini Orchard", and "Energy Square"); **L** Century Park (Century Park carried out the practice of the first Edible Garden in Shanghai City Park); **M** Hundred-Grass Garden (the design creates a new vitality through the community creation to revitalize the degraded central green space); **N** Zhengtong Xinyuan (activates the blue-green symphony of the community's self-governing energy); **O** Lujiazui Shuangyong Square (the landscape of the square is enhanced through landscape replanning); **P** Three Hang Community (the small garden adds elements such as edible garden, spiral garden and herb garden); **Q** Qianxiaoju Farm (it integrates agricultural production elements into the landscape); **R** Herb Garden in Tongji University (it uses half-roof space to create an ecological microenvironment); **S** Biyun International Community (it shows the natural circulation and four-time changes of ecological farming and breeding) (elaborated and translated into English by Yuelai Liu and Ruiming Ma, respectively)

Fig. 4.8 Bird's eye view of Baicao garden (elaborated by Yuelai Liu)

This project is designed to transform a dull central green space in this old neighborhood into a shared "living room" for social interactions revolving around the plants and the strengthening of neighborhood connections. At the same time, community gardens are also supposed to enhance residents' overall management capacity, increase the awareness of community ownership, and promote residents' self-governance. This community was selected for the following reasons:

- Lack of public space: The community is located in a dense residential area built in the 1970s. In 2014, the average public green space among Shanghai residents was 13.38 m^2 per capita. The 2011 statistic for the Yangpu District was 4.26 m^2. However, the number for this particular community was only 2.23 m^2, far lower than the average level of the city and the district. Additionally, the available space was of too poor quality to meet the residents' needs for public activities and social interactions. Moreover, due to the lack of public management awareness, residents have ceded the management of community gardens to the property management company with the lowest cost. "Collectively owned" has turned into "privately operated" (Yuelai 2016). As the quality of living rises, residents' lifestyles have changed and these central green spaces are in urgent need of improvement and upgrade.
- High proportion of elderly residents: The community has 6,800 residents, 23.5% of whom are over 60 years old. While there are many renters, the population in this neighborhood is generally quite stable. Neighbors get along well with each

other and there is a relatively slow pace of life. On the balconies and in the green spaces around the homes there are many traces of traditional agriculture and gardening arts, which gave the design team confidence for establishing the garden in this area. Exploratory visits to the neighborhood revealed the existence of a basic self-governing social organization, the Fangling Flower Club. This resident-organized club consists of gardening enthusiasts who wish to share their experience in tending gardens with one another.

- Support from subdistrict and nongovernmental organizations: Existing grassroots neighborhood municipal systems hinder communication between citizens and governments. One subdistrict is in charge of several neighborhoods and one neighborhood contains several residence communities. In light of the intense workload of government officials, landscape renewal and public participation are rarely prioritized. Last year, the Tongji University and Siping Subdistrict chose the Baicao Garden as a demonstration site for community empowerment and introduced a nongovernmental organization, the Clove Nature School, to take part in community empowerment activities.

The Baicao Garden explores ways of improving spaces within older residential communities in Shanghai in order to provide new thinking and management models for similar communities with a high population density, aging residents, and other barriers for landscape improvements.

Knowledge and Innovation Community Garden (KICG)

Located in Knowledge and Innovation Community (KIC) Park in Wujiaochang Street, Yangpu District, Shanghai, the 2200 m^2 Knowledge and Innovation Community Garden (KICG) is adjacent to Wujiaochang Business District, one of the subcenters of Shanghai (Figs. 4.9 and 4.10). The KIC park was jointly built by

Fig. 4.9 Location of KICG (elaborated by Yuelai Liu)

Fig. 4.10 Bird's eye view of KICG (Picture: Yuelai Liu)

the government of the Yangpu District and Shui On Land Limited, Hong Kong with a total investment of 10 billion RMB. It is a high-tech industry cluster with information industry as its core and covers a total construction area of one million m^2.

In 2015, the government of Yangpu District proposed an idea to expand and promote KIC Park into a "Greater KIC Zone" in the context of the innovation and entrepreneurship campaign to better advance common development with surrounding areas. The plot of land where KICG stands was thus incorporated into the key "green axis". KICG is on the east of Jiangwan Regency (residential area) with the boundary wall to the old district of Shanghai University of Finance and Economics on the west. To its south, there are the fashionable Daxue Road and the dual-use commercial/residential SOHO Community KIC Area. To the north of KICG, the School of Management, Fudan University, is being built. The surroundings are rich in commercial and demographic diversity. This plot used to be the auxiliary green land of Jiangwan Regency but was not put into full use due to some important municipal pipelines underground. It was later used for temporary housing for construction workers or stayed idle. In 2016, the Shanghai Yangpu Science and Technology Innovation Group Co., Ltd. (STI) and the Shui On Group seized the opportunity of "Greater KIC Zone" development to put this plot of land into better use and positioned it as "community interaction space". They chose Clover Nature School, which holds a similar philosophy regarding landscape transformation and community building, to run the KICG. Thus, KICG became the first community garden placed in an open neighborhood in Shanghai (Yuelai et al. 2017).

4.2.2.2 Analytical Methods

A descriptive analysis is presented in this paper, based on 2 years of explorative practice. This paper shows how different strategies of approach target a variety of groups during different phases of building and managing community gardens.

4.2.3 Results

4.2.3.1 Baicao Garden: Residents' Self-governance

Promote Consulting with Residents to Improve Landscape Space

Learning that the community lacked platforms for democratic discussion, local government departments and the residents' committee joined the process and launched an internal consultation mechanism. They held meetings at every level from subdistrict office to residents and children, breaking down barriers of communication among residents themselves and between residents and decision-makers. They also went on neighborhood visits and listened to the opinions of large numbers of residents. While creating the landscape improvement plan, the design team took a creative on-site approach and held an art event with some so-called "Future Local Landscape Architects", i.e., local students. The event allowed the children to exercise their right to make requests and expressed their hope to have a part of the garden reserved for them. Using their extensive local surveys and professional skills, the team strengthened communication with resident committee members and local enthusiasts and adjusted the plan for the garden. Finally, the garden was designed as a space to meet the needs of residents for leisure activities, parent–child interaction, and nature education.

Once the initial draft had been completed, the design team solicited the opinions of the residents for improvement. Firstly, the wooden floor featured in the design was opposed by the residents.

There is only a small amount of space between the buildings and there were concerns that the sound created by the floor would disturb nearby residents. Secondly, the residents suggested that the natural water pots next to the spiral-shaped garden might pose a safety hazard and requested adjustments. After further discussions, it became clear to the design team that community gardens should not add additional pressure to the residents.

As the high-density environment already takes a psychological toll on the people that live there, the landscaping improvements should start small and focus on personalizing the space and relating it to the residents' lives, giving the residents more ownership of the space and keeping an option to change the space in the future. The network of residents in such old, high-density residential communities is complex, and the rights of residents in the public space are exercised sincerely and strongly. The current state of the cramped space was the result of a compromise

between competing interests, and the landscape improvements also brought these conflicts to light. The design team had to have the confidence and patience to look at the garden from the residents' standpoint and communicate more with residents to find a plan that would best aid and satisfy residents.

The design team's selection of the central green space, which had an area of 200 m^2, was the final solution. The poorly maintained grass would be changed into a children's activity area, a herb garden, and a public garden that would together make up Baicao Garden. The garden's name means to collect flowers from all to build a garden for all.

Multi-strength and Public Participation

The design team broke the landscaping work into a number of steps that could be completed separately, such as shaping the earth, preparing the soil, laying turf, planting plants and seeds, paving, and covering the beds. Each step in the process was turned into a public class for the residents so that they could learn while carrying out the work. The Fangling Flower Club began to play an active role in the process at this point. The club president created a list of members, recorded the free time of each member, and developed a work schedule based on each member's areas of expertise and the main skills needed for each step in the process. The president also established a watering and fertilization team, a litter-picking team, and a gardening team. The work on the garden and the recruitment of flower club members encouraged even more children and adults to get involved. The residents, who had almost no prior experience in landscaping, rebuilt Baicao Garden in less than 1 week.

Foster Interest Groups to Strengthen Community Empowerment

Public space is a way of fostering public life. Integrating the hobbies of community residents into the maintenance of the public space, organizing events around nature education or community-building, and reorganizing and retraining community residents can help unearth local talents, establish a local talents database, and encourage residents to take the lead (Jiayan et al. 2017).

At the same time, building a community space is also a matter of building community cohesion. Through multiple well-organized, content- rich theme events, a child volunteer team was assembled. A public WeChat (messaging app) group was established to talk about shifts at the garden, conflicts over square dancing space, dog walking, and other issues related to community life. These discussions outside of the gardens' scope deepened the children's understanding of people's responsibilities to their community and society. The child volunteer team currently has more than 40 members, and the group is able to support activities such as watering, planting, and fertilizing. The children have also organized community events including a Mid-Autumn Day lantern riddle party and have become a dynamic force for community-building and garden management. In addition, Baicao Garden also worked with Dahushan Road Primary School as its nature education base, and shared resources with Fangcao Gardens at Anshan 363 Alley, bringing neighboring groups closer together (Fig. 4.11).

Fig. 4.11 24 solar terms nature class (Picture: Yuelai Liu)

By holding such events, the child volunteers learned basic gardening skills and eventually the kids and the adults launched and actively participated in a management mechanism for space by themselves. The original goal of the community garden was exactly to establish this kind of shared learning mechanism and to turn the garden into a "learning garden". The program encouraged the residents to start with small actions and gradually transformed them from consumers into active participants and producers.

Develop Community Organizations and Focus on Institutional Norms

A mark of maturity for a self-governing community garden is whether or not it has a public organization capable of managing the space independently. The greater the number of clubs and content-rich events, and the more standardized the management systems are, the more inclusivity and greater levels of resident engagement a garden enjoys. At present, Baicao Garden has two self-governing organizations that are gradually standardizing their policy systems. However, more time is needed to explore issues around establishing community and resident discussion mechanisms, policies on oversight and implementation, and the formulation of standards for evaluating results.

4.2.3.2 Knowledge and Innovation Community Garden (KICG): A Collaborative Effort

Build Communication Platform to Address Community Pain Points

The design team conducted basic research on the KIC area and prepared materials on the status of the local community culture, population, and facilities as a basis for the design of the garden. At the same time, with the design team at the helm, the community was fully motivated and involved. In neighborhoods with relatively complex environments, people were classified based on land usage. Among them, an active group was selected to set up a platform connecting the design team and community residents so that professional knowledge and localized life experience can complement each other.

The KIC was already a complex high-tech community, but it lacked public space and areas for nature education. In light of this, the design team divided KICG into several parts including a facility and a service zone, a public activity zone, a permaculture garden, square-meter vegetable gardens, and an interactive gardening zone (Fig. 4.12). In order to meet the community needs for public exchange activities, indoor and outdoor community living rooms, a community square, and children's sandpit were set up. Practices and popular science on sustainable concept and energy recycling were also integrated into every corner of the garden, such as garbage sorting bins and a rainwater collection system. The public farm provided a place for nature education encouraging urban residents to come to the land for observation and practice. The square-meter gardens were designed to cater to urban residents' enthusiasm for planting and to explore new management models of public space through the conversion of money, time, and labor.

Fig. 4.12 Humulus garden in KICG (Picture: Yuelai Liu)

Bring in More Active Participants with Better Services

There are three types of services involved in the operation and maintenance of KICG. Daily management and services (including adopting-and-fostering management and guest/tourist reception): KICG opens on a daily basis and garden management rules, activity organization and management rules, and other regulations have been developed for administration purposes.

Over the 6 months since its opening, KICG has received 20 groups of VIP visitors. Residents come here every day for social communication. Science education: teachers of nature science are hired and theme activities are organized at least once a week, covering multiple aspects such as farming activities, children's nature education, food and beverage, as well as arts. Community consolidation initiatives: interactive platforms are established to bridge colleges and universities, enterprises, the government, and local residents through the topic of public relations to enable information and resources sharing. Within KICG, social responsibility departments of large enterprises and the self-governance office of the neighborhood responsible for promoting social construction and community governance offered great help in the early stages of operation. They also strengthened exchanges and cooperation regarding space sharing and resource complementarity. The government and enterprises have provided key support to KICG's regular activities including an interdisciplinary lecture salon, a farmers' market featuring organic food for urban–rural mutual assistance, public welfare programs jointly sponsored by the government and enterprises,[2] as well as activities for Party building and League building.

Promote Multiparty Dialogue to Strengthen Community Self-governance

Though KICG has taken the first step toward participatory landscape development, more efforts are required for further exploration of such issues as expanding services to neighborhood communities, motivating the public, and standardizing management regulations. Given the large area of KICG, the complex management contents and the fact that no community self-governance has been formed so far, participants' awareness of self-governance still has to be cultivated through a sound operating mechanism and long-term practice. For community gardens built in open blocks, the conflict of interest appears more noticeable due to the much more diversified population mix around them. To address this issue, the key is encouraging dialogue among stakeholders, which lays a foundation for cooperation by establishing a platform that involves government agencies, businesses, colleges and universities, social organizations, and local residents. Tongji University's

[2]In the "Love for Children of the Stars" initiative co-organized by the office of Shanghai Landscaping Committee and Green Shanghai Special Fund of China Green Foundation, autistic kids, accompanied by their parents, are guided by KICG employees to identify vanilla and participate in an experiment of fostering aquatic plants. The organizers have tried to understand the world from the kids' perspectives yet also have left some space for them to think and explore, expecting that their inner potential could be unleashed.

"landscape of joint governance" workshop takes KICG as the core topic to explore the mechanism for sustainable development of social public space. Through student's role-playing debates and discussions, in which actual representatives from four parties participated as what would happen in reality, the workshop seeks to inject more thinking and strength into the future development of KICG.

4.2.4 Discussion and Conclusions

Community gardens play a positive role in addressing many issues in the development of high-density cities, including limited available resources and environment, sustainable development, community–building, and nature education. In China, the development of community gardens is still relatively one-sided. For example, usually relying on the form of tourist agriculture park in the suburbs, community gardens are often seen as only a new attraction of suburban tourism, without much actual participation of the public (Xiaojie and Guotai 2014).

For example, as they usually rely on the form of tourist agriculture parks, community gardens are often seen as simply a new attraction of suburban tourism, without much actual participation of the public/residents (Xiaojie and Guotai 2014).

In addition to bridging producers and consumers, more efforts should be made to cultivate people's ability of self-governance in production and foster proper public communication habits in public green spaces to promote community communication and enhance neighborhood vitality.

At the same time, people of all ages and from all occupations benefit from the opportunities for nature education provided by community gardens, especially children. Therefore, they play a positive role in cultivating their awareness for sustainable development and ecological protection as well as maintaining urban biodiversity (Clarke and Jenerette 2015).

Based on the two representative projects completed in recent years—Baicao Garden and KICG—the case expounds main characteristics and corresponding strategies of community garden-building from the two perspectives of "public" and "private". Practice indicates that the degree of participation is lower at the beginning in communities with more vague boundaries, a more complex population mix, and richer contents of community gardens. Residents in closer relationships fully participate in the building of community gardens under the guidance of a professional design team. Residents in lack of such relationships may have to build a garden space by more heavily relying on a design team. Trust and closer relationships should be established through long-term community exchanges and activities by the operation team so that residents' participation can be enhanced regarding future management, maintenance, and even spatial updating. In fact, either way will lead to the set destination. Strategies in the early stage of building and operation should give consideration to the characteristics of different communities. Solutions should also vary in different stages as well. In fact, despite their differences, both types of community gardens aim to encourage more residents to

pay attention to the surrounding environment and properly participate in public affairs with will and ability. In the process of public participation, a self-governance organization should be formed to help build a sustainable development mechanism for public space.

The rapid development of metropolises in China brings many challenges. This requires solutions based on profound interdisciplinary discussions. As a space for residents to participate in gardening activities through joint construction and sharing, Shanghai's community gardens focused on landscape design to deal with human–environment relationships by combining ideas from sociology, education, and other sciences. Community gardens are a scientific attempt to realize sustainable ecosystems, harmonious neighborhood relations, and nature education activities in a densely populated metropolis like Shanghai. From a nonacademic point of view, the essence of space is people; not just children and the elderly, but also young people. The idea of community gardens is all about taking the position of the users, paying attention to their concerns and arranging activities that meet their pursuit of value, promoting the interconnection between people, coordinating the contradictions of all parties, and enhancing people's attachment to space.

4.3 Urban Gardening and Environmental Behavior of Urban Gardeners in Different Garden Forms in Barcelona, Spain

Jürgen Breuste and Andreas Hufnagl

4.3.1 Introduction

4.3.1.1 Urban Gardening

Urban ecosystems such as parks, cemeteries, green roofs, forests, and gardens are identified as "green infrastructure" (Galster et al. 2001; Rusche et al. 2015; Artmann et al. 2019), a metaphor to underline the role of green spaces in the built environment as providers of ecosystem services (ES) (Bolund and Hunhammar 1999; Gómez-Baggethun et al. 2013). Urban ES directly or indirectly support human well-being (MEAB 2005; TEEB 2010).

One element of urban green infrastructure that has attracted growing attention in the literature in recent years are urban gardens (Breuste 2010). Urban gardens are spaces of nonprofit and non-subsistence activities, connected with the maintenance of ornamental nature, or the growing of fruits and/or vegetables. They are managed individually, in families or in social groups, either in separated plots or allotments, or in commonly used spaces. All these are horticultural activities but differ from urban agriculture practices. Gardens may cover a broad range of forms, including

school gardens, therapeutic gardens, allotment gardens, home gardens, and community gardens (Larson 2012). The importance of urban gardens has been emphasized on the basis of (1) their social functionality and high intensity of use (Breuste 2010, p. 464); (2) their role in building resilience (Barthel et al. 2013); and (3) their contributions to human well-being through the delivery of ES (Breuste and Artmann 2015; Langemeyer et al. 2016).

Many studies have focused on examples of cases in Central, Western, or Northern European countries. They mainly deal with the utilization and social behavior of urban gardeners (e.g., Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005), and recently with the benefits from or the provision of ES by urban gardens. ES are broadly investigated in many case studies. It is known that (1) urban gardens provide them; and (2) urban gardeners and even the neighborhoods or the city benefit from them. The ecological aspects of behavior were but not investigated by most of the studies. Only the study by Breuste and Breuste (1994a) included soil pollution by heavy metals. The Central European studies show

- The reduction of fruit and vegetable production as the main objective of gardeners;
- The rise of recreational aspects in the utilization of the plots;
- The change of plot structure from vegetation production to lawns and marginal flower beds; and
- The high intensity of recreational use by frequency and duration of stay on the plots (Breuste and Artmann 2015).

Numerous studies deal with urban allotment gardens, a traditional but specific form of urban gardening. It can be expected that new forms of urban gardening such as community gardens, guerilla gardens, and intercultural gardens are related to different gardening targets and attract different social groups. This renewal of urban gardening is still not much investigated. Not much is known about differences in the ES provided by (1) different urban garden forms; (2) different benefit groups; and (3) different motivations of urban gardeners, especially beside food production, which is often argued to be the core of urban gardening.

Over the last 20 years, several empirical surveys focused on investigating utilization and behavior aspects of allotment gardeners in Central European cities (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). Questioning of urban gardeners and participatory observations, methods of social sciences were frequently used. Many studies had different objectives, using the different methods, sample sizes, or interview strategies. Research targets were mostly on utilization, gardening activities, and ES. There are still open questions concerning the provision of ES like

- Why is urban gardening so attractive?
- Which are the motivations to become an urban gardener?
- Is food production the main target of gardening?
- Which role can urban gardens play as part of the urban green?

4.3.1.2 Urban Gardening in Spain

The first urban gardens in Spain were established in the 1980s. Urban gardening activates were led by neighborhood movements and promoted by local governments. They were part of an urban regeneration process, solving the shortage of public facilities and urban green spaces in often peripheral social housing neighborhoods. Illegal vegetable gardens were developed in the peri-urban areas of Spanish cities, also in Barcelona. Mostly retired, unemployed people and migrants from rural areas tried to overcome the economic crises with urban gardening. In 1988, the Allotment Gardens Program of San Fernando de Henares, an organic agriculture project, was launched in the Madrid metropolitan area. In 1997, also Barcelona started with the "Barcelona Urban Gardens Network", a municipal program aimed at retired people (Keshavarz and Bell 2016, p. 27).

A study was executed by Camps-Calvet et al. in 2014 on urban gardening in Barcelona. Data were collected on 27 initiatives, including 13 community gardens and 14 municipal gardens. 201 persons in Barcelona were questioned (Camps-Calvet et al. 2016). It was uncovered that (1) community gardens have become a form of resistance to the privatization of public urban space; and (2) this has offered opportunities to experiment with new models of urban lifestyles (Camps-Calvet et al. 2015). Twenty ES, ranging from food production over pollination to social cohesion and environmental learning could be identified. Among them, cultural ES (nonmaterial benefits people derive from their interaction with nature) were the most widely perceived and the most highly valued. The main beneficiaries of ES from urban gardens are the elderly, low–middle income, and migrant people. The analysis showed the relation of urban gardening to critical policy challenges, such as the promotion of societal cohesion and healthy lifestyles (Camps-Calvet et al. 2016).

However, there is still a shortage of information on urban gardening in Southern European countries. The gardening tradition in Southern Europe is younger than in the north of Europe. No southern country is among the "14 pioneer countries" in urban gardening, where these activities started by different reasons already before World War II (Keshavarz and Bell 2016, p. 13). A shorter gardening history and the concurrence of dynamic urbanization, especially during the last 50 years, underlie the specific characteristics of urban gardening in the European south. Keshavarz and Bell (2016, p. 26) claimed that urban gardening is a new phenomenon in Southern European countries:

> … Allotment and community gardening is (there) a recent phenomenon that started in the late twentieth and early twenty-first centuries mainly for financial and social cohesion reasons, as well as a means to use green areas which the city cannot afford to maintain, while legalizing squatter-type gardens.

4.3.1.3 Aim

This survey extends former studies on ES of urban gardens (Calvet-Mir et al. 2012, 2016; Camps-Calvet et al. 2016), includes the new garden forms (the Pla Buits gardens), and focuses on environmental behavior. The aim is to perform a comparative assessment on the ES provided by the distinct urban garden forms existent in a Southern European example (Barcelona). Not least, it has been investigated (1) who the gardeners are; (2) in which way urban gardeners use the gardens; (3) what their motivations for gardening are; (4) how they perform "ecological" behavior; and (5) how they develop and transfer environmental knowledge. The study is based on Hufnagl 2016 (unpublished). It was expected that gardeners in different urban garden forms differ in motivation or behavior and that food production is an important reason for gardening.

4.3.2 Methods

4.3.2.1 Study Area

Barcelona is Spain's second largest city by population and one of the most densely populated cities in Europe (over 16,000 inhabitants/km^2). Urban gardens had a long tradition in Barcelona until the 1980s (Mubvami et al. 2006). Over recent decades, however, the city has been subject to large development pressures, which have resulted in a large decline of green and agricultural lands. The number of urban gardens decreased strongly with the fast urban renewal and urban extension connected to the Olympic Games in 1992, which entailed almost their disappearance from the core city (Roca 2000; Huertas and Huertas 2004).

Connected with the global financial crises in 2008, however, urban community gardens have multiplied in many Southern European cities (Keshavarz and Bell 2016). Barcelona became a city with very recent and fast-growing urban gardening activities. The actual urban garden estates have an urban gardening tradition of less than 20 years. Barcelona has currently 35 urban garden estates. The first were two municipal gardens established in 1986 and 1997, but urban gardening started on a broader scale in 2001. Thirty of the 35 garden estates are younger than 10 years.

The Barcelona City Council supports public gardens since 1997 as municipal gardens. Urban gardens are recognized as important components of urban green infrastructure in "Barcelona's Green Infrastructure and Biodiversity Plan" (Barcelona City Council 2011, pp. 71 and 80). Bottom-up gardening initiatives, self-governed by neighborhood associations and political activists, have multiplied in the city (Calvet-Mir et al. 2012, 2016; Camps-Calvet et al. 2015). The Barcelona City Council also put into place the initiative "Pla Buits" (Empty-Spaces Plan) in 2013, to promote gardening on vacant public lots (Barcelona City Council 2015;

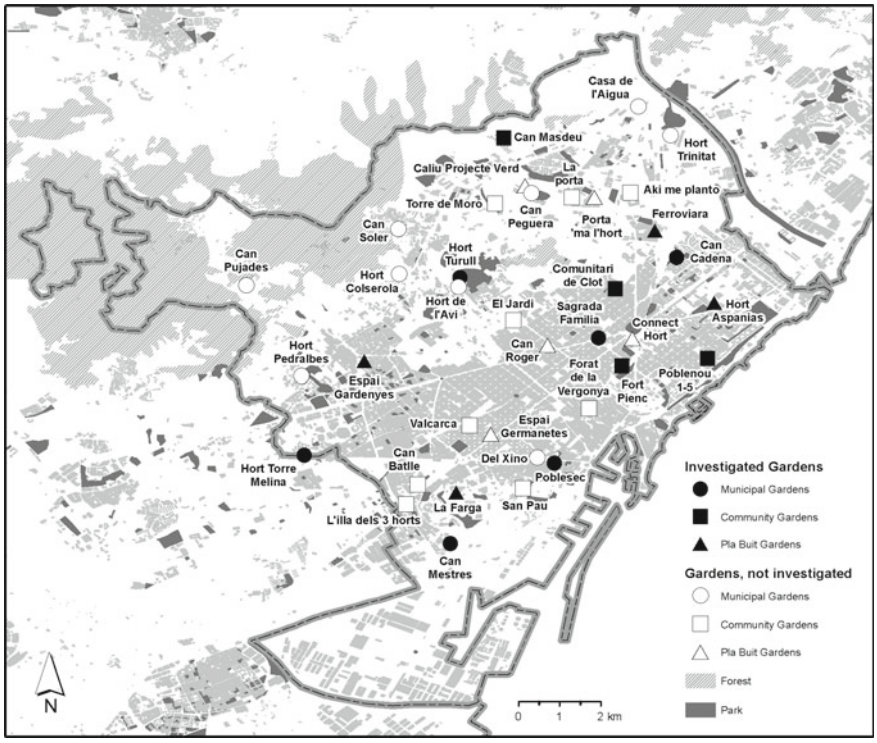

Fig. 4.13 Types of urban garden in Barcelona, Spain (*cartography*: Breuste and Gruber)

Camps-Calvet et al. 2016). Nowadays, there are three main garden types in Barcelona, mostly all younger than 15 years (Camps-Calvet et al. 2014, 2015, 2016) (Figs. 4.13 and 4.14).

M = Municipal gardens (**Xarxa d'horts municipal**) These are formally regulated allotment gardens (Camps-Calvet et al. 2016). Initiatives of the town council of Barcelona were launched for the first time in 1997 though they trace back to one earlier example in 1986. Barcelona has 15 municipal garden estates, 13 of which were established between 2001 and 2015.

C = Community gardens (**Xarxa d'horts communitaris**) These are self-governed community gardens (Camps-Calvet et al. 2016) and public gardens (Camps-Calvet et al. 2015). They correspond to informal gardens established through bottom-up process, mostly by squatting processes by different social movements and associations of Barcelona. In some cases, agreements were reached with the landowners. Barcelona has 11 community gardens, established between 2002 and 2015 (Calvet-Mir et al. 2012, 2016).

PB = Pla Buits gardens (**Gardens in the context of the Empty Urban Plots Plan**) These are "collective gardens" (Camps-Calvet et al. 2016) on empty plots, for temporally free lease to not-for-profit public and private associations. Barcelona has

Fig. 4.14 Hort (garden) Torre Melina (Andreas Hufnagl, picture taken in 2015)

9 Pla Buits gardens, all established in 2013. With the Pla Buits gardens, the Barcelona City Council is currently experimenting to promote urban green space in vacant areas based on civic engagement.

4.3.2.2 Questioning of Urban Gardeners

Ninety-three urban gardeners were interviewed on their behavior and attitudes when gardening. This enabled to qualify and quantify activities related to

- Recreation;
- Food production;
- Experiencing nature (learning and teaching about nature); and
- Ecological gardening and environmental behavior.

A questionnaire consisting of 27 questions was developed to address these specific research agendas. Most of the questions were closed questions with given answer options to select. Only three questions were open questions. The questionnaire was divided into four sections.

Section I dealt with the utilization of the gardens. Gardeners were asked about (1) the motivations for gardening (for example, recreation and recovery, space for children to play, quiet, and place for retreat); (2) the duration of stay; (3) the activities undertaken; (4) the travel time to the gardens and mode of transportation; and (5) the use of other public green spaces in the city.

Section II dealt with ecologically relevant behavior and environmental awareness. This included (1) the utilization and consumption of fruits and vegetables; (2) the motivations for food production; (3) ecological food production; (4) learning about gardening and from gardening; (5) the methods used to improve gardening; (6) the gardeners' know-how in gardening and utilization strategies; (7) of cabins, planting of trees and bushes; and (8) the use of insecticides and pesticides.

Section III dealt with urban gardens as environmental learning places and with the transference of ecological knowledge. The interview concluded in Section IV, with 11 questions on sociodemographic data about the interviewee (age group, education, engagement, and living situation). All data remained anonymous.

All in all, 93 persons were interviewed in 14 different urban garden estates, representing the three urban garden forms. The questioning was performed in 6 of the 15 municipal gardens (Xarxa d'horts municipal; in 40% of all these garden estates; 33 persons), in 4 of the 11 community gardens (Xarxa d'horts communitaris; in 38% of all these garden estates; 30 persons) and in 4 of the 9 Pla Buits gardens.

4.3.3 Results

4.3.3.1 Who Are the Gardeners?

The majority of gardeners in all garden forms are elderly persons over 65 years (M-gardens 100%, C-gardens 36.7%, PB-gardens = 46.7%). Among C- and PB-gardeners, there are additionally persons aged between 25 and 65. Among C-gardeners, 46.7% are employed gardens, while among PB-gardens, 43.4% (see Fig. 4.13). Among the questioned gardeners, there are no unemployed persons and only one student.

In all garden forms, most urban gardeners are (1) male (M-gardens 91%, C-gardens 63.3%, PB-gardens 86.7%); and (2) active in horticulture since five or less. A high number of persons are migrants from other regions. In M-gardens, two-thirds of the gardeners are not from Catalonia. Most of the non-Catalans are from Andalusia (17–21% in all garden forms).

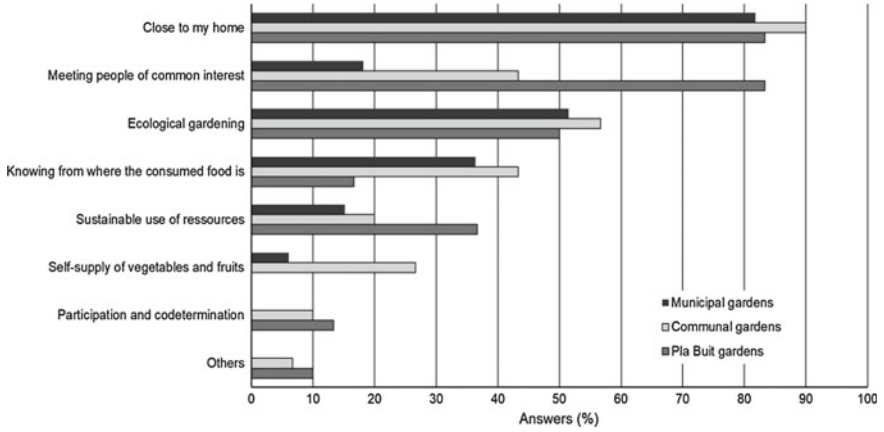

Fig. 4.15 Reasons for gardening

4.3.3.2 Where the Gardeners Live and Why They Are on this Gardening Site

The big majority of gardeners (89–93%) lives in nearby neighborhoods and can reach the garden in less than 10 min (43.3–57.6%) from their apartment. Garden sites are embedded in residential neighborhoods. This is highly valued by the gardeners. The most important reason to choose the used site in all garden forms is the location close to the homes of the gardeners (81.8–90%) (see Fig. 4.15). Most of the gardeners can reach the gardens on foot.

Most urban gardeners live in apartments (53–83%) and do not have access to alternative garden forms, such as house gardens. The garden is an important alternative for outdoor recreation, besides public urban green spaces. Ecological gardening and controlling own food production are also reasons for gardening. Only the PB-gardeners profile as a community (83.3%. The self-supply with fruit and vegetables and governance do not really play a role (10 or less percent expressed this).

4.3.3.3 Motivation for Gardening

In all garden forms, relaxation and recreation are a significant end to do gardening. All other motivations differ among garden forms:

- Gardening as a hobby: it is often the second most important motive of gardeners, but it is only selected by 43.3% of the gardeners in the case of PB-gardens.
- Establishing new contacts: it is the most important motivation only in PB-gardens (86.7%) and does not play an important role in other garden forms (e.g., M-gardens only 21.2%).

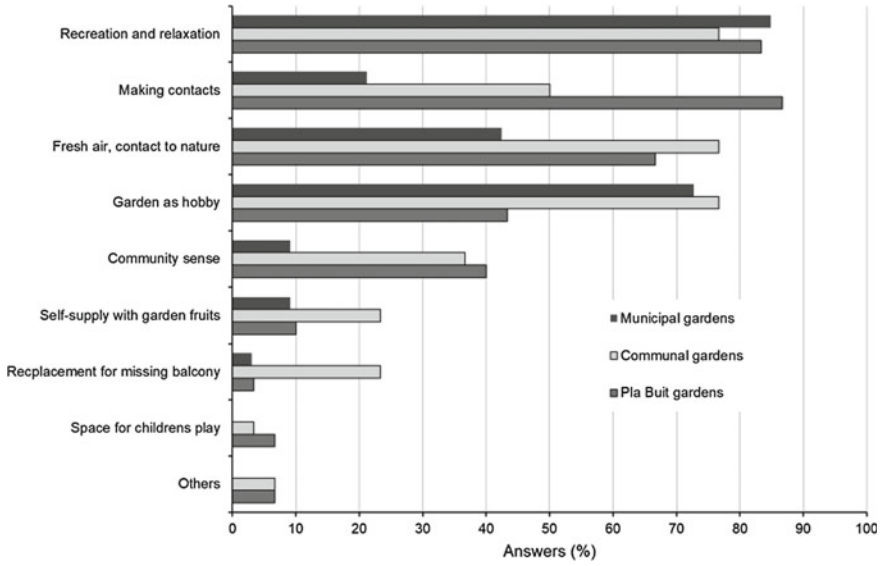

Fig. 4.16 Motivation for gardening

- Enjoying fresh air and being in contact with nature: this is, to varying degrees, an important motivation in all garden forms.
- Producing food (fruits and vegetables) for self-supply: none of the participants mentioned this as an important motivation (9.1–23.3%).
- Developing a community spirit: it/this ranks only among 9.1% and 40% and differs between the garden forms (see Fig. 4.16).

In M-(100%) and C-(80%) gardens, gardening is an individual activity, whereas in PB-gardens (80%) it is a clear community activity. The allotment gardeners are very satisfied with their gardens, and a two-third majority (68%) does not feel disturbed by anything. Even the strict regulations, binding them in some activities, disturb only 10% of the questioned persons.

4.3.3.4 Utilization of the Garden Plots and Public Green Spaces

Two-thirds of the gardeners use the plot in summer several times per week (63.4%) or even daily (28%). However, this differs between the garden forms. M-gardeners are the most intensive garden users in summer (daily 42.4%; several times per week 54.6%). PB-gardeners do gardening several times per week (73.3%), while they rarely use the plots daily (13.3%). Even in winter, 46.2% use the garden several times a week and 25.8% use it only on weekends (average).

Again, this differs between the garden forms. PB-gardeners are the most intensive users in winter (53.3% several times per week and 23.3% on weekends).

Public urban green spaces are an alternative to urban gardening as outdoor activity spaces. The interviewed gardeners are also frequent users of these spaces. The utilization intensity is less significant than in urban gardens, but still remarkable. Public green spaces are used on a daily basis by 34.5% in summer and 29% in winter. Differences among M-gardeners and C-gardeners are not big (e.g., daily use in summer of public urban green spaces equal to 39.4% and 43.3%, respectively), but PB-gardeners are rarely using urban green spaces (daily use in summer: 23.3%; several times per week: 30%).

4.3.3.5 Food Production and Consumption

Food production is a less-important motivation for gardening. Mainly vegetables are produced in the plots. These are tomatoes (90.2%), lettuce (88%), onions (66.3%), broad beans (53.3%), bell peppers (44.6%), garlic (35.9%), potatoes (35.9%), beans (22.8%), carrots (13%), and beetroot (13%). All other vegetables are planted by only 10% of the questioned gardeners. Fruits (e.g., lime) or ornamental plants (e.g., flowers) are very rare, especially bushes and trees. The gardens are mainly "kitchen gardens". The selected vegetables depend on the season and personal preferences (PB-gardeners rate this the highest, with 36.7% of the gardeners expressing this idea). Soil conditions, irrigation, diversity, rotation or productivity do not play an important role.

The produced food is used fresh during the season mostly by gardeners (92%), their families and friends (86%) (more than one answer was possible). Only a few gardeners (22.6%) conserve vegetables for consumption in winter. The differences among garden forms are marginal.

The majority of gardeners have replaced bought vegetables by homegrown ones (M-gardeners: 78.8%; G-gardeners: 56.7%; and PB-gardeners: 63.3%). The reasons are (1) taste and quality (48.5–73.3%) and (2) healthier food (20–40%). The reduction of costs is less important (M-gardeners: 6.1%; G-gardeners: 26.7%; and PB-gardeners: 10%). The majority of gardeners (59.1%) have reduced the purchase of vegetables in supermarkets and increased their consumption of local products (74.2%). Only 11,8% say that their food consumption has not been influenced by gardening (see Fig. 4.17).

4.3.3.6 Ecological Gardening and Environmental Behavior

Allotment gardeners state that their gardens are already sustainable (54%). Only (1) 21% say that they are open for a change toward a more sustainable management and (2) 18% have no access to the ecological garden idea. Nearly 100% of the gardeners in all garden forms assess their gardening as "ecological". However, most of the gardeners have no clear idea of "ecological gardening". In 75.3% of the

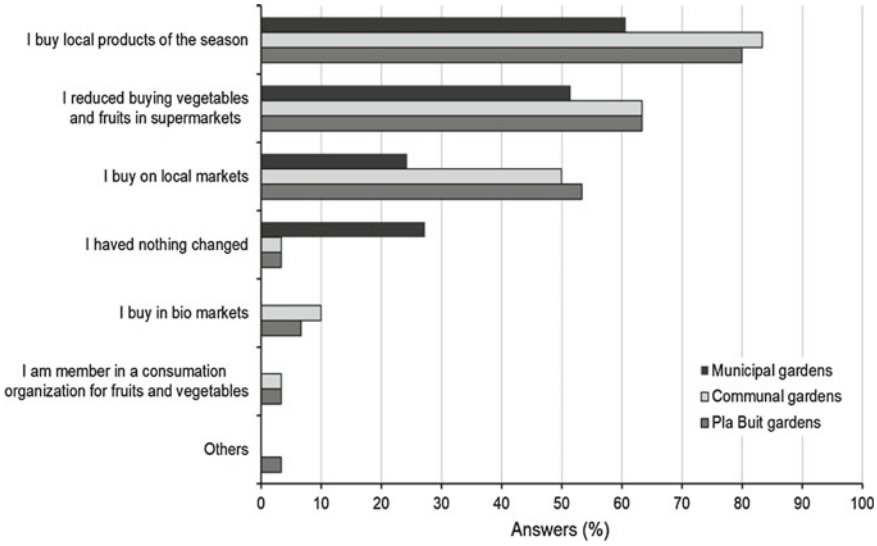

Fig. 4.17 Origins of the consumed fruits and vegetables

cases, gardening is influenced by ecological management and by examples from other gardens (37.6%).

In all garden forms, gardeners state that gardening has supported their perception of the environment and nature. This mainly includes (1) a better understanding of nature and their processes (M: 36.4%; C: 66.7%; and PB: 80%); (2) an increase in environmental awareness (M-gardeners: 33.3%; C-gardeners: 76.7%; and PB-gardeners: 66.7%); (3) a change to an ecological management of gardens (M-gardeners: 27.3%; C-gardeners: 46.7%; and PB-gardeners: 46.7%); and (4) supported personal recovery and recreation (M-gardeners: 42.4%; C-gardeners: 40%; and P-gardeners: 43.3). This last statement applies for all garden forms while the others differ among garden forms. Gardeners use tube water for irrigation. Only a minority uses rainwater from collecting containers. PB-gardeners do not use rainwater at all.

Besides gardening, gardeners express that they often behave sustainably (30.3–56.7%) or even have an ecological lifestyle (23.3–42.4%). Most of the questioned persons connect this with (1) the composting of organic garden waste (79–90%); (2) the consumption of biologically produced food (80–85%); and (3) the usage of public transport instead of cars (48.5–60%).

4.3.3.7 Changes Undertaken in the Gardens

Many of the gardeners have changed their garden structure in the last years.

They extended their management intensity (40%) and the garden size (21.5%) and included also ornamental plants (10.8%). Most changes happened in C- and

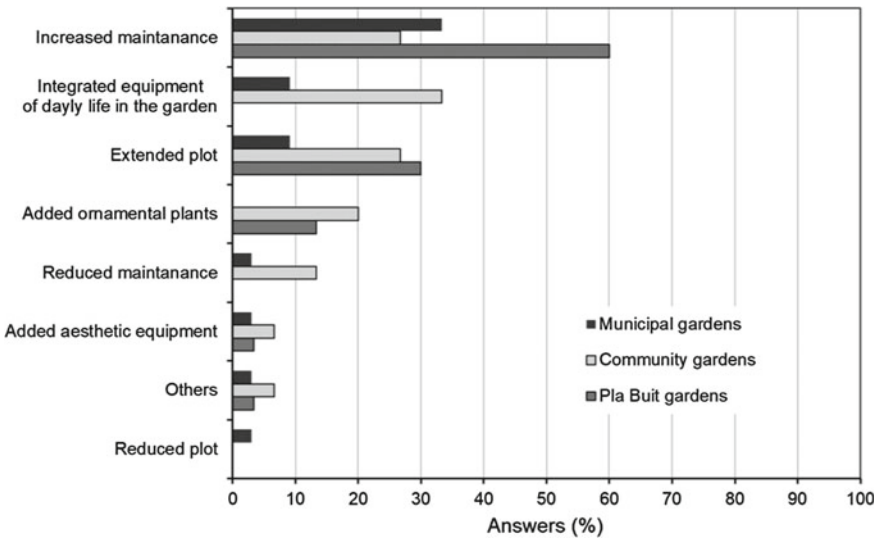

Fig. 4.18 Changes in gardens during the last years

PB-gardens (see Fig. 4.18). Most of the gardeners have improved the garden since they started gardening on the plots. This includes the improvement of soils by self-produced organic fertilizer. Ninety-seven percent of the questioned persons use it. Between 24.2% and 73.3% additionally use turf as fertilizer. None of the gardeners use chemical fertilizers. There are no big differences between garden forms.

4.3.3.8 Experiencing Nature (Learning and Teaching About Nature)

A majority of gardeners in all garden forms agrees that gardening is a very good (60.2%) or good (31.2%) possibility to learn about nature. They (1) improved their environmental awareness (84.9%); (2) gathered new knowledge about horticulture (90.3%) and about conservation and utilization of vegetables (47.3%); and (3) came in close contact to nature (plants and soil).

The horticultural knowledge of the gardeners has different sources. M-gardeners learned it mostly from the elder generation and family (45.5%), while C-gardeners and PB-gardeners learned from other gardeners (63.3% and 50%, respectively) and individual learning by doing (63.3% and 73.3%, respectively). Gardeners learned about gardening from scratch. There was only little preexisting horticultural knowledge from former agricultural work (M-gardeners: 24.2%; C-gardeners: 16.7%; and PB-gardeners: 6.7%). Additionally, other sources of knowledge are media like TV and books, but not the Internet. This applies to all garden forms (26.9%). Urban gardens are clearly learning places about dealing with nature and nature processes.

4.3.4 Discussion

4.3.4.1 Urban Gardening: Beyond Food Production?

Urban and peri-urban agriculture is often seen with a special focus on food production:

> Urban and peri-urban agriculture (UPA) contributes to food availability, particularly of fresh produce, provides employment and income, and can contribute to the food security and nutrition of urban dwellers (FAO 2018).

In many countries, especially developing countries, this seems to be the case, but in Europeans countries several studies do not reveal this to be the focal issue (Mougeot 2006; Swinton et al. 2007; ZALF 2013). Artmann and Sartison (2018) showed in a review of 166 urban and peri-urban agriculture studies that this activity can contribute to overcoming several challenges of urbanization like climatic change, health alterations, resource efficiency, ecosystem services provision, and biodiversity loss, etc. In one-third of the studies, recreation is the steering motivation of urban gardening. There are, indeed, several reasons for urban gardening (Müller 2011). In 2013, the Royal Horticultural Society of the UK listed the following:

- Get the freshest produce: the flavor and freshness of food straight from the plot are streets ahead of most supermarket produce.
- Save money: a bag of salad costs as much as a packet of rocket seed, and sometimes a lot more. One packet of seed will give you dozens of bags worth of tasty salads.
- Get some exercise in your own "green gym": Getting outside in the garden is a proven winner for health and stress relief. "Allotments are the ultimate stress-buster."
- Avoid additives: if you care about what goes into and onto your food, growing your own organically is the best way of taking control. You can avoid chemical additives that are sometimes found in shop-bought food.
- Get to know neighbors: having an allotment is one of the best ways of getting to know people in your local area. "Allotment communities are genuine communities, with people from all sorts of backgrounds and ages."
- Save food miles: think of the carbon saved by growing your own; a smaller distance from "plot to plate" also means tastier, fresher food.
- Grow the food you enjoy: the number of varieties of fruit and vegetables available to home gardeners is huge compared to the number available in shops.
- A great escape: sometimes it is just great to get away from the house, and normal day-to-day chores. For many, allotments are a perfect stressbuster (Royal Horticultural Society 2013).

This investigation shows that the reasons for gardening in Barcelona are neither mainly economic nor related to food self-sufficiency. Thus, gardening might not

have been primarily driven by the economic crisis. However, food production, especially of vegetables, is the main reason for these types of gardens in Barcelona. They are mainly "kitchen gardens" and the produced vegetables are mostly freshly consumed by the gardeners and their families. A wide range of vegetables (from tomatoes to beetroot) is produced, by employing intensive or even very intensive management practices. The invested time by gardeners in the production of crops is larger than the actual value that products have. This is explained by the high value attributed to these vegetables, which are appreciated more than vegetables bought in a supermarket. The reasons given include (1) a better taste; (2) a perception of own-grown food as healthier; and (3) the producer's proudness to have harvested their own vegetables. This is comparable to results in other studies.

Urban gardening in Barcelona is, compared to several studies in Central Europe, an activity to produce own vegetables, even if it cannot satisfy the entire demand for vegetables, and to participate actively in the production process. In Central Europe, contemplative recreation as an important aspect of urban gardening is growing; however, it does not play any role in the urban gardening in Barcelona. Also, the garden structure represents this. The extended lawns and the garden houses of Central European gardens do not exist here (e.g., Breuste 2010; Breuste and Artmann 2015). In the present study, gardening is an activity of recreation and relaxation for more than 70% of the gardeners. The majority of gardeners are elderly men, notwithstanding this is changing and slowly other members of society are engaging in urban gardening. Having time available is the main factor for gardening which is why it is difficult for actors who are not retired to engage in gardening. This has already been shown in several studies in Europe (e.g., Bargmann et al. 1989; Breuste and Breuste 1994a; Breuste 2010; Breuste and Artmann 2015).

Gardening is a healthy, physical, emotional, and learning activity which can be undertaken all year round, also outside the vegetation period. Gardeners use "their" individual green space much more intensively and frequently than any other urban green spaces like parks. They are creative in the management of nature, something they can never do in other green spaces. This makes urban gardens extraordinary places for learning by doing and nature observation. This has already been widely recognized (Eisel 2012; Freitag 2002; Hoffmann 2002):

- Gardeners learn by doing and from each other.
- Gardening results in a better understanding of nature.
- Gardens are learning places on nature and horticulture.
- Gardeners generally have a higher level of environmental awareness than most people in society and act in accordance also outside gardens.

Several studies report a reduction of physical gardening activities during the last 20 years, especially in Central Europe (e.g., Breuste and Artmann 2015). The results of the present study are different. The gardeners in Barcelona increased their garden management by 40% during the last 15 years and even increased the garden sizes. Ornamental plants, which play a big role in other European gardens (Breuste 2010), are only starting to become implemented in Barcelona.

4.3.4.2 Divergences Among Urban Garden Forms

In C- and PB-gardens, gardeners are more community-oriented than M-gardeners, who are more individualistic, less cooperative, and less interested in social networking. Social interaction is a steering reason for gardening only in the Pla Buits gardens. This is also reported in other studies (Rosol 2006; Larson 2012). Differences between the distinct garden forms are marginal when most other behavior traits are considered. This speaks for a broader consensus on gardening as an activity in the society of Barcelona.

Urban gardens in Barcelona are mostly reachable within 15 min either on foot or by bike. Barcelona gardening is a neighborhood activity, which can be done nearly every day or several times a week within a short distance from home. This is not the case anymore in many other European cities. The formerly integrated garden estates of the neighborhood are often pushed from attractive sites in the cities to the fringe areas or remaining unattractive places (near railways, wastelands, etc.) (e.g., Breuste and Breuste 1994a).

In municipal gardens, gardeners learn about traditional gardening, either by themselves or through family or friends who have partly worked in agriculture before. In contrast, community and Pla Buits gardeners learn by themselves and from other gardeners. Media plays a role for all of them. Learning about gardening seems to change the gardeners' environmental behavior. Both community and Pla Buits gardeners claim for themselves a better understanding of the environment and environmental awareness. In general, Barcelona gardeners understand themselves as behaving "ecological", as ecological actors, even when their understanding and awareness of "ecological gardening" is marginal. This makes urban gardeners at least more open to the idea of sustainable behavior in general and protecting nature.

Urban gardening can play a key role in reconnecting urban residents with the nature of different forms in a creative and self-learning format:

> 'Urban gardening' is a term that encompasses many forms of gardening in urban areas. The woman who grows herbs on her window sill is as much a part of the urban gardening movement as the man who has tomatoes on his balcony or the collective who have turned an abandoned lot into a thriving community vegetable garden, though collective projects make up the majority of the people who currently identify with the label (Stewart 2018).

4.3.5 Conclusions

Urban gardening exists in many forms and varieties. In Barcelona it has been in practice for less than 20 years. It is a recent activity which already is of interest to many residents and is supported by the municipality. The interest of the municipality is to make use of unused land and to increase the attractiveness of residential areas, especially those of lower social standards. The results show that this support successfully links to the additional new forms of urban green in the urban green infrastructure. The location integrated or in the vicinity of big housing estates,

something which is already lost in other European countries, makes the garden land especially attractive for the residents. Like in Central Europe elderly people represent the majority among the gardeners, they integrate their families into this activity, making the urban gardening a part of normal urban life, improving their health by physical activities and producing vegetables themselves in a healthy way. This shows that urban gardening is a valuable part of urban gardening and cannot be replaced by any other part of green infrastructure because only this supports active dealing with nature where people live. It is recommended to extend and enlarge urban gardens in Barcelona. It is indeed a green success story.

4.4 Investigations on Water Utilization and Water Management Practices in Urban/Peri-Urban Agriculture of Bahawalpur, Pakistan

Liaqat Ali Waseem and Jürgen Breuste

4.4.1 Introduction

4.4.1.1 Water Utilization and Water Management Practices in Urban/Peri-Urban Agriculture

Water is a scarce commodity and a fundamental source of agriculture in arid and semiarid regions of Pakistan (Ahmad et al. 2019). Agriculture is the largest single user of water and uses 65–75% of freshwater for irrigation (Bennett 2000; Prathapar 2000) and in some cases up to 90% of the total freshwater. Water consumption is more alarming in urban areas due to demographic shifts in developing countries. The world urban population increased from 750 million in 1950 to 2.9 billion in 2000 and equaled rural population in 2007 (Celio et al. 2010). These drastic changes in urban demographics result in a growing demand for drinking water. With constant water resources, agriculture is using intensive water to meet the rising demand for food supply in the urban areas (Celio et al. 2010). The urban population needs sustainable urban and peri-urban agriculture (UPA) to achieve food security. The Food and Agriculture Organisation (FAO) introduced the acronym UPA considering "urban agriculture" as the agriculture practices within the built-up city and "peri-urban agriculture" as the agriculture practices in the surrounding areas of cities (Nugent 2000). However, the leading feature of UPA that distinguishes it from the rural agriculture is its integration with the urban entity, limited land resources, urban economic, and ecological systems (Dhakal et al. 2015; Pearson et al. 2010; Mougeot 1999). The systematic evaluation of UPA aspects is lacking (Zezza and Tasciotti 2010; Hamilton et al. 2014), though the recent studies from 15 developing countries found the partition at a country level ranging 11–69%.

UPA has contributed a great deal in the livelihood strategies of the urban household in developing countries in the context of the economy, food security, water conservation, and combating urban problems (Bryld 2002). Water is a key source of agricultural production. Water scarcity in the case of crop production can cut production and adversely impact food security. Frequent increase in demand for irrigation water over many years caused the changes in water flows and water quality. Thus, to address these issues and fulfill domestic and industrial water demand will require dynamic and modern ways of irrigation (Hanjra and Qureshi 2010). Lofty investments in irrigation technologies, infrastructure, and improved water management strategies can minimize the impacts of water scarcity and partially fulfill the water demands for food production (Falkenmark and Molden 2008). According to the United Nations Development Programme (UNDP 1996) estimates, approximately 800 million urban dwellers were involved in agricultural production in the mid-1990s, on both commercial and subsistence levels. Since then, it continues to grow (UNDP 1996; Borgue 2000) to accomplish the urban needs. Drastic population boom and uneven spatial distribution of water resources in the semiarid regions are worsening the water crises due to overexploitation of aquifers (Qasimpour and Abbasi 2019), especially generating more burden in arid and semiarid urban areas (Hoekstra and Chapagain 2008). The situation is causing serious threats to the city dwellers globally, due to great water competition between various sectors (agricultural, industrial, and domestic consumption) including the disposal of wastewater (Knight and Riggs 2010).

4.4.1.2 Aim

Keeping in view these aspects, the study was launched in arid/semiarid area of Bahawalpur based on the scarcity of water and misuse of water. The aim of this investigation is to elucidate and document the difference between UPA from rural agriculture. The aim of the study is to investigate UPA water resources utilization and water management practices. This includes investigating qualitative, quantitative, and distributional aspects of groundwater and surface water. Another aim is to study irrigation water conveyance, delivery infrastructure, and cropping pattern.

4.4.2 Methodology

4.4.2.1 Study Area

Study area is Tehsil Bahawalpur city, located on the southern bank of river Sutlej and Cholestane desert in the east, at the latitude: 29° 24′ N and longitude: 71° 47′ E. Total area of Tehsil Bahawalpur is 2372 km^2. The population of Tehsil Bahawalpur is almost 700,000. (Pakistan Bureau of Statistics 2017). Climatic conditions are hot and dry with scanty rainfall averaging only 143 mm annually (PMD 2019). The economy of Bahawalpur depends upon agriculture. Water resources of Bahawalpur

include surface water and groundwater. Agriculture is the mainstay of the economy and is considered as the wheat and cotton belt of Punjab, Pakistan.

The factors affecting the availability of a sufficient amount of freshwater in this area include a shortage of water due to its geographical location in the arid/semiarid region of Pakistan where rainfall is very low. Groundwater use is not feasible due to technical reasons, especially due to salinity. Agriculture as a big user of water forces to think about sustainable manners of the water utility, irrigation systems to maintain water conveyance and delivery infrastructure. The abovementioned factors are the measures of productivity of water. Orientation with farmers of case study area revealed that they were using water unwisely. They have traditional irrigation systems wasting water during conveyance. The structural investments in the Middle Eastern countries improved the irrigation efficiency from 40–50% to 60–70% (Playán and Mateos 2006). The survey conducted in arid areas of Bahawalpur and Moro Sindh revealed 40–50% losses during poor conveyance and delivery system of canal irrigation (WAPDA and CSU 1978). Another survey in central Punjab revealed 64–68% water losses due to unlined channels (Arshad et al. 2009). During direct flooding to the field, a lot of water is evaporated and rest is wasted as runoff. It creates adverse environmental impacts on ground and surface water by contaminating it with chemical fertilizers and pesticide residuals. These losses can be reduced. The experiments in Northeastern Spain revealed efficiencies close to 50% with traditional surface irrigation systems (Playán et al. 2000; Lecina et al. 2005), and enhanced to 90% with properly designed and managed pressurized systems (Dechmi et al. 2003a, b).

4.4.2.2 Methodological Steps

The methodology comprised of different steps to collect the information. In the first step, the peri-urban boundary was marked to distinguish UPA from general agriculture. The second step was to create zoning on the basis of proximity in qualitative, quantitative and distributional aspects of water, soil conditions, and cropping pattern. In these zones, sample sites were selected for baseline survey to collect the required information. The methodological steps are described below.

Step 1. Demarcation of Peri-Urban Boundary

Peri-urban boundary was separated from the countryside. The investigation was based on finding the close connection between urban centers and vicinities, as peri-urban areas exhibit both urban and rural characteristics. This connection was determined by frequent circulation of community and commodities between the urban centers and vicinities and farmers landholding size. The task was accomplished by taking the information about the connection between the urban centers and vicinities from Tehsil Municipal Administration (TMA) officials. The spatial pattern of landholding size was collected from the Agriculture Extension Department Bahawalpur (AE). The information was confirmed by field visits and personal observation accompanied by officials from concerned departments.

Step 2. Zoning and Selection of Sample Sites

Zoning was organized within the premises of UPA, based on qualitative, quantitative and distributional aspects of water, soil conditions, and cropping patterns. In particular, zoning procedure is explained on the basis of groundwater quality and soil conditions, availability of canal and sewage water for irrigation and cropping pattern of UPA as shown in Table 4.2. Categorized zones are shown in Fig. 4.19. Groundwater and soil samples were collected to analyze their quality and were tested in Soil and Water Testing Laboratory (S&WTL), Bahawalpur. Groundwater conditions were categorized as fit water (F), marginally fit water (MF), and unfit water for agriculture (UF). Supplementary information about water, soil, and cropping pattern was collected by further consultation with Water Management Department (WM), S&WTL, TMA Bahawalpur, and Canal Department (CD) officials with the help of a location map of Bahawalpur provided by TMA.

Cropping pattern information for zoning was acquired from AE officials and focal persons of the area as preliminary information, which was quantified as a result in the baseline survey. The areas were identified for data collection to investigate the research subjects. At the end of the process, four zones were identified, named A, B, C, and D. Eight sample sights were selected from every zone for information collection.

Table 4.2 Procedure of zone generating criteria of UPA Bahawalpur

Sr. No.	Zone category	Zone name (based on) Groundwater quality and soil type	Fraction of canal water perennial/ non-perennial	Fraction of sewage water optimum/ minimum	Cropping pattern
1	A	Fit water zone with loamy soil	Perennial	Optimum	Wheat, cotton, fodder, sugarcane, and vegetables
2	B	Marginally fit and fit water zone with loamy and sodic soil	Perennial	Not available	Wheat, cotton, fodder, sugarcane, and tunnel vegetables
3	C	Brackish and marginally fit water zone with loamy soil	Non-perennial	Minimum	Wheat, cotton, fodder, vegetables, tunnel vegetables, sugarcane, rice, and fruits
4	D	Brackish water zone with sandy loam soil	Perrenial/ non-perennial	Minimum	Wheat cotton, fodder, vegetables, pulses, and fruits

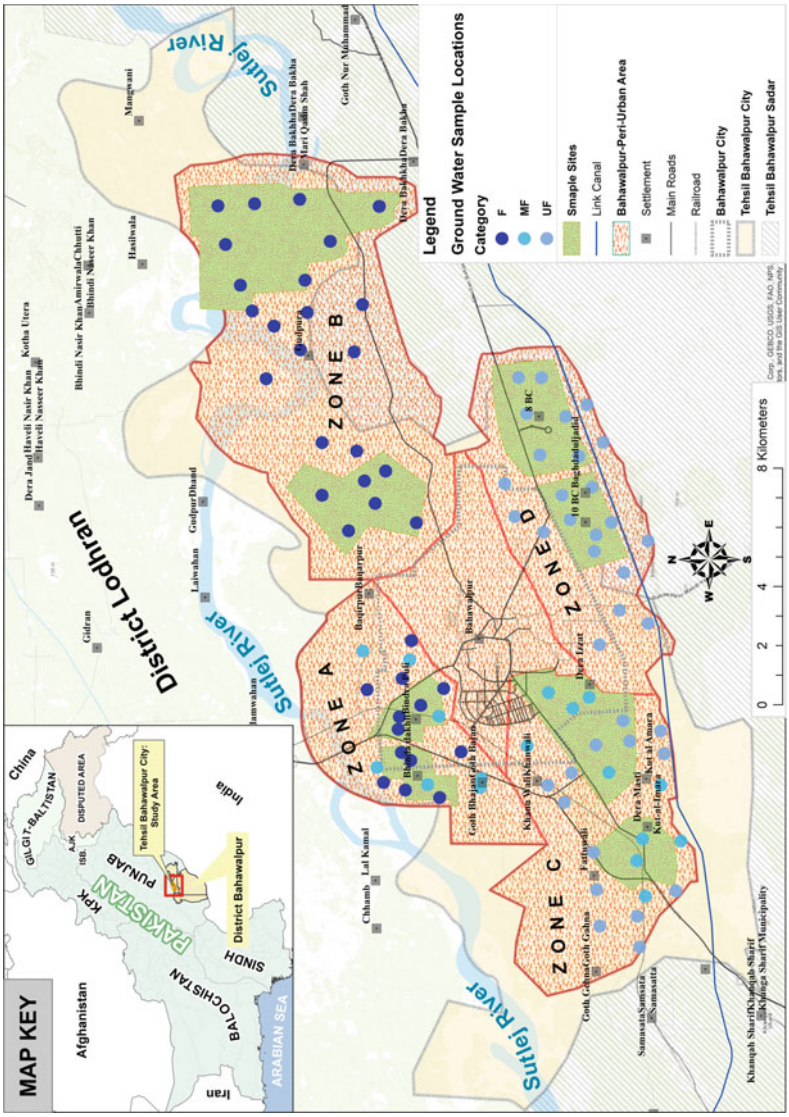

Fig. 4.19 Map showing the methodological procedure *Source* Authors (F = fit, MF = marginally fit, UF = unfit)

Step 3. Information Collection

In each sample site, information was collected on available water resources, crop water utilization, and their management practices employed in the UPA Bahawalpur. Baseline survey with UPA farmers was conducted with structured and semi-structured questionnaire in order to obtain these data. Sixty farmers households were selected from each sample site, which means that 120 questionnaires from each zone and a total of 480 questionnaires from all zones were obtained. The task was accomplished with the help of four research assistants and one field assistant of AE. Water resources were scrutinized with reference to the quality of groundwater, quantitative and distributional aspects of surface water. Irrigation systems and infrastructure (conveyance and delivery) were also investigated. The crop choices and copping pattern in each zone were also investigated. These aspects were also investigated with in-depth interviews, focal person interviews, personal observation, and participatory methods. The AE, CD, Irrigation Department (ID), S&WTL and TMA Bahawalpur, Federal Bureau of Statistics (FBS), Punjab Bureau of Statistics (PBS), and Agriculture Census Organization Pakistan (ACO) including multidisciplinary journals, conference proceedings, and books relevant to research were main sources of secondary information.

4.4.3 Results

4.4.3.1 Quality, Distribution, and Availability of Groundwater and Surface Water

The groundwater is mostly saline. The unbalanced concentration of different salt ratios makes it unfeasible for use for crops and livestock. Fit water is concentrated only in a specific portion of UPA Bahawalpur with very limited surface water supply. The surface water resources like canal water and sewage water lower the detrimental intensity of brackish groundwater to accomplish the irrigation needs. However, the surface water resources are very limited. These aspects including some sociocultural aspects create some specific cropping patterns in all zones.

4.4.3.2 Cropping Pattern and Landholdings

The cropping pattern was categorized into two categories (1) agronomic crops/cash crops and (2) horticultural crops (perishable products). Agronomic crops/cash crops comprised wheat, cotton, fodder, sugarcane, and rice. Horticultural crops consisted of vegetables, fruits, and pulses. Results are on Fig. 4.20. Landholding size results revealed that only agronomic crop cultivation is dominant over a combination of agricultural and horticultural crops. The tenants were always growing both agricultural and horticultural crops. Horticultural crops were only more common at

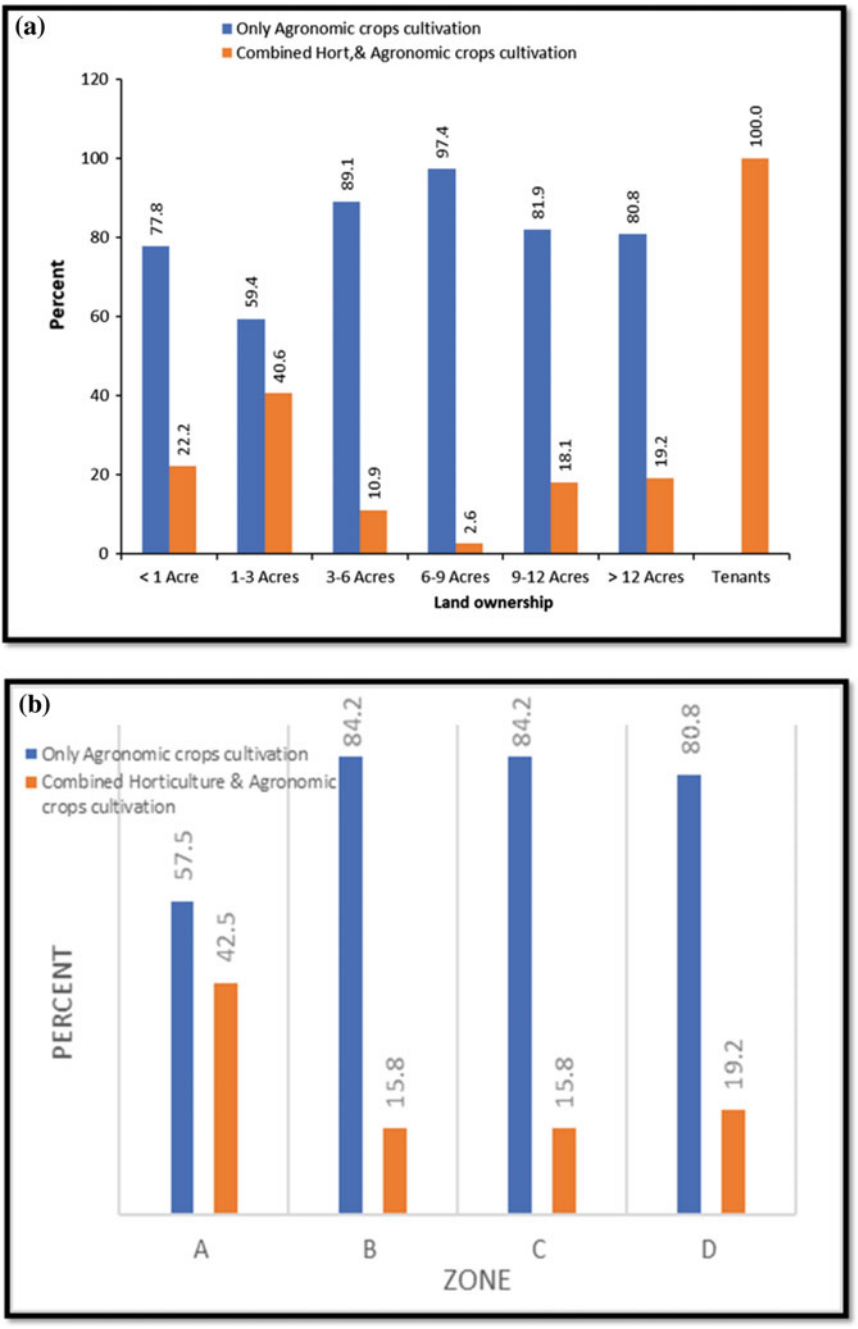

Fig. 4.20 **a** Landholdings and **b** spatial cropping pattern

small landholders (size 0.4–1.2 ha) and were combined with agronomic crops. Regarding the spatial distribution, agronomic crops were dominant in all zones. However, a combination of horticultural and agricultural crops in zone A was more common than in other zones.

Mostly agronomic crops are cultivated because of the legacy of traditional trends. The sociocultural aspect of crop legacy is that vegetables are cultivated mostly by the farmers who were brought from India and settled here by Nawab (Prince) of Bahawalpur. This project of the settlement was launched in 1925 with the name Sutlej Valley Project. Later, after the partition of subcontinent Pakistan immigrants from Indian Punjab were also brought there to cultivate the vacant lands. These farmers have more tendencies to cultivate vegetables besides agronomic crops. The vegetable cultivation is taboo for native farmers of Bahawalpur. Native farmers cultivate only agronomic crops and fruit gardens. The vegetables were mostly cultivated in zone A because of the availability of sewage water in a reasonable amount. It was almost free. The use of sewage water also prevents farmers from extra expenditure on fertilizers. Vegetables were also grown in zone B, mostly in protected farms (tunnels). The groundwater conditions were fit for irrigation and lofty investments on tunnels to cultivate all season vegetables. In zone C and D, vegetables were cultivated in small amounts. In zone C and D there was a trend toward mangoes, citrus, and guava gardens. The farmers of all zones cultivate fodder on a small scale for the domestic purpose of livestock feeding.

4.4.3.3 Water Resources and Delivery Infrastructure

There were three main water resources in UPA Bahawalpur. Their spatial distribution and delivery infrastructure are described below.

Canal Water and Tube Well Water

Two main canals irrigate UPA Bahawalpur, Bahawalpur Distributary Canal, and Ahmadpur Canal Branch (desert branch). Bahawalpur Distributary Canal (Disty) water was available in zone A and B for irrigation. It is a perennial canal. Ahmadpur Canal branch (desert branch) irrigates zone C and zone D. It is a non-perennial canal. Half of the zone D is irrigated by Bahawal Distributary. The study area is a mostly canal tail area. The water delivery from the canal to the fields is conducted through the outlets and channels. The number of main official channels are the same as the number of outlets. The tube well water (groundwater) is a major supplementary source of irrigation used by mixing with canal water in all zones as shown in Figs. 4.20 and 4.21.

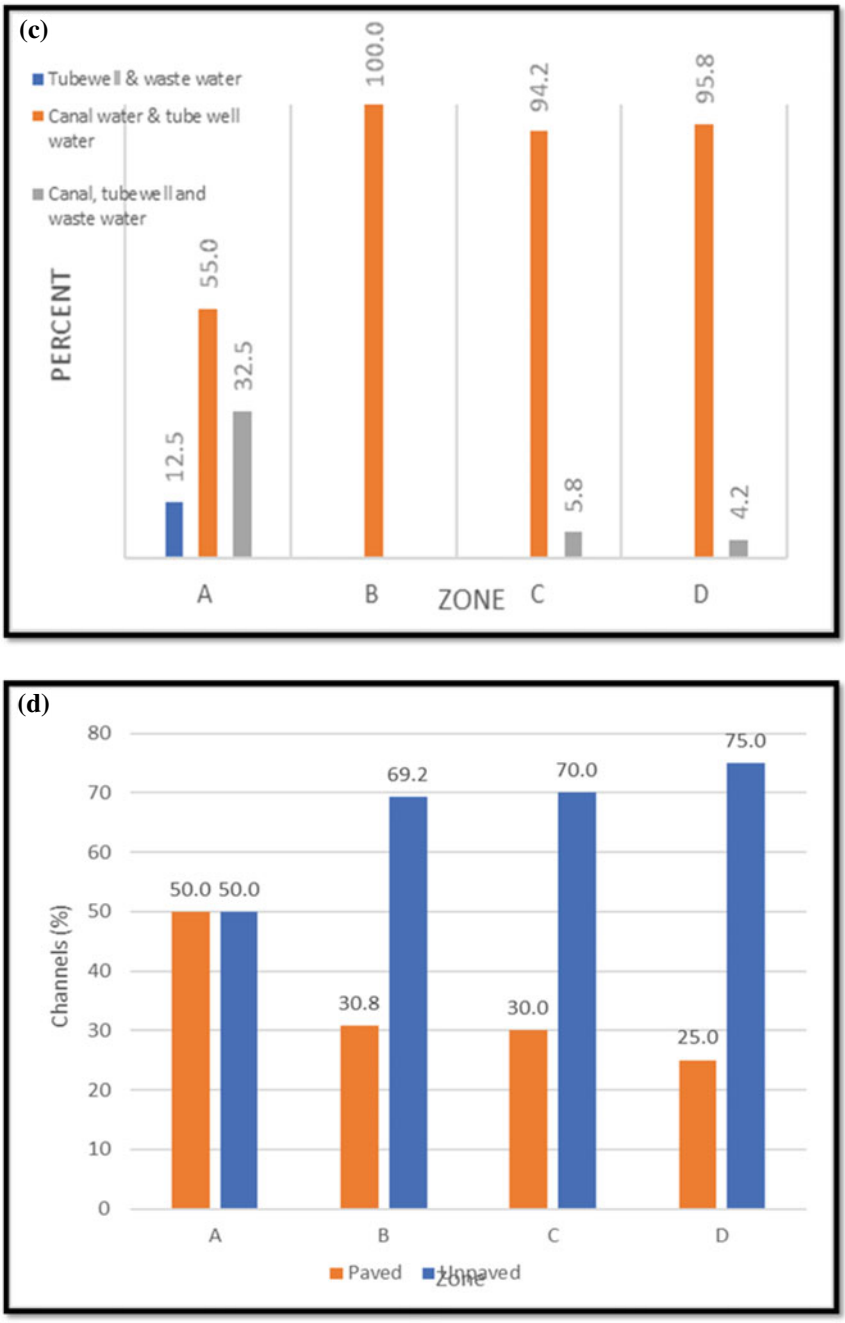

Fig. 4.21 **c** Water resources spatial distribution and **d** delivery channels infrastructure characteristics

Canal Water Conveyance and Delivery Infrastructure

The tube well and wastewater channels are totally unpaved. The canal freshwater conveyance and delivery channel infrastructure were also mostly unpaved in all zones. Paved channels made one-fourth to one-third of all channels, only in zone A it was one-half. From these channels, the water is delivered to the fields by the local field channels.

These are totally unpaved channels, prepared by the farmers according to the demand of crops. The percentage of paved and unpaved channels are shown in Fig. 4.21.

Wastewater

Wastewater was used for irrigation in zone A. In zone C and D, it was available in little amount for irrigation near the city core vicinities. There is no use of wastewater in zone B as shown in Fig. 4.21. It was used for irrigation through the open discharge of semiorganized channels. The sewerage tube wells were not used in these areas to irrigate the crops.

Usage of the Water Resources and Delivery Infrastructure

In all zones, the water quality was focused on groundwater and the quantity was focused on canal and sewage water. Due to the variability and unreliability of canal water (Kuper and Malaterre 1994), the farmers mostly rely on groundwater. Sugarcane and rice were the high-water delta crops with immense use of ground and canal water in all zones. However, dominantly cultivated in zone A and B with fit water conditions. Canal water is very limited due to lower flow and limited time schedule for irrigation. Therefore, all crops rely on groundwater. In agronomic crops delta of water rise from wheat, cotton, fodder to sugarcane and rice, respectively. Farmers use all types of available water for fodder irrigation. In horticultural crops, vegetables used all three types of water resources, i.e., groundwater, canal water, and wastewater where sewage water is available. Gardens and orchards were irrigated only with ground- and canal water. The groundwater is excessively used for fruits as compared to vegetables. The spatial distribution of irrigation within zones revealed different crop water requirements and the availability of water resources for crops. Water qualitative and quantitative spatial diversification in all zones also creates production constraints and pattern variation in both categories of crops.

The irrigation systems in UPA Bahawalpur are direct field flooding. There were two systems of direct flooding: basin irrigation systems and furrow irrigation system. The majority of the UPA farmers use basin irrigation system in all zones. Furrow irrigation was adopted by vegetable and sugarcane growers mostly in zone A, B, and C with some controlled dikes. This system is more efficient than the basin irrigation system when properly controlled and scheduled. However, the farmers with furrow irrigation did not prepare the dikes properly. Irrigation was uncontrolled and not scheduled. Another important factor of water loss was the duration of irrigation water supply to the fields.

4.4.4 Discussion

The good quality water together with good soil conditions and good water management practices increases productivity. Due to the qualitative and quantitative spatial diversification of ground and surface water as evident from UPA Bahawalpur, it is crucial to know all aspects of water in the arid and semiarid zones to achieve best management practices.

The UPA Bahawalpur is practiced in the canal command area to irrigate the crops. Marginal resources like sewage water are also available to accomplish the irrigation need. Groundwater is used as supplemental water to satisfy the crop water requirement. Due to water shortage in rivers, the water supply is limited in canals including Bahawalpur command area. There are uneven intervals in canal flows. The canal flow rate is slow and thus unable to satisfy the irrigation water needs. Sewage water is concentrated on specific sites and cannot be used over specific limits due to adverse effects on soil and crops. Therefore, irrigation mostly relies on groundwater. There was injudicious use of limited canal and groundwater resources by UPA farmers of Bahawalpur causing heavy water losses. These water resources are limited because groundwater conditions are dominantly unfit for irrigation. Besides these limitations, there is heavy extraction of groundwater by pumping. The unfit water having high electrical conductivity and sodium absorption ratio (SAR) affects both crop and soil (Ghafoor et al. 2001). Despite these limitations, a considerable amount of water is wasted due to centuries-old traditional irrigation, conveyance and delivery systems in the UPA Bahawalpur.

A study from Elephant Butte Irrigation District, New Mexico, USA pointed out the water losses by the improper and long duration of irrigation water supplies to the field (Skaggs and Samani 2005). Other factors include lack of farmer's attention, unlined farm ditches, low water discharge at the farm turnout, and poor water conveyance and delivery infrastructure (Skaggs and Samani 2005). These factors were found in UPA Bahawalpur hindering the water use efficiency and contributing to heavy water losses. Conveyance and delivery infrastructure were poor. The canal delivery channels were partially paved in some zones, mostly in zone A and the majority were unpaved in other zones. Paved and unpaved canal channels lead to total unlined and unpaved small channels through which the water is released to the field for irrigation. All of those aspects are causing heavy water losses in water-scarce UPA Bahawalpur. Water is wasted by evaporation through the surface during conveyance and irrigation, leakage during storage and water application to the field, uncontrolled drainage, and runoff (Qadir et al. 2003). During the process of conventional irrigation, 30% water is wasted during conveyance and storage, and according to 63% of the delivered water is lost as evaporation, drainage and runoff. Only 13–18% of supplied water is used for the transpiration of crops while other is wasted (Qadir et al. 2003). In zone B, a small amount of the farmers uses drip irrigation in the tunnels. This is the best option to save water since it supplies water according to the crop water requirements. However, in UPA Bahawalpur drip irrigation was not in a considerable amount.

Due to limited surface water resources, excessive groundwater use can badly affect the groundwater level due to disturbance in the equilibrium. The attainment and maintenance of a long-term balance between the amount of groundwater discharge and recharge, safe use of groundwater require no more groundwater pump than replenished through the natural recharge via precipitation and surface water seepage (Sophocleous 1997, 2000). In the arid environment of Bahawalpur, due to scanty rainfalls and casual flow of River Sutlej aquifer recharge is very low. Therefore, aquifer overexploitation can significantly impact the groundwater quality. With limited recharging, salts become accumulated on the aquifer and create salinity in the water thus making it unfit for the crops and animals. In UPA Bahawalpur the farmers have installed tube wells with a large diameter in abundance to pull the groundwater. These are closely spaced. It is assumed that closely spaced tube wells cause a very rapid decline in groundwater than the same number of tube wells more widely spaced (Sophocleous 2000). In UPA Bahawalpur, groundwater recharge capacity is different in different zones. Zones A and B lie on the southern bank of River Sutlej; the water table ranges from 60 to 76 m in both zones. Zones C and D are close to the desert and thus the water table is deeper and ranges from 76 to 90 m. The different groundwater table is caused by recharging capacity of the river. Zones A and B are annually recharged by the Sutlej River which flows occasionally. Sometimes, when India releases its flood water, it flows in the Sutlej River and the aquifer of zone A and B are recharged up to some extent. However, this cannot happen in zone C and D. The depletion in groundwater is creating an extension in the desert. The irrigation systems of UPA Bahawalpur are shown in Fig. 4.22. Irrigation conveyance and delivery infrastructure are shown in Fig. 4.22.

4.4.5 Conclusions

Water is scanty in the arid and semiarid region of Bahawalpur, Pakistan. Agriculture is the single largest user of available freshwater. High water delta crops (consuming more water), poor infrastructure of water delivery, and traditional irrigation systems like improper direct flooding result in high amounts of wasted water. Groundwater conditions are dominantly brackish with small packets of freshwater. Surface water resources like canal and sewage water are limited including low rainfall. The high-water delta crops are grown in all zones. There is excessive cultivation of rice and sugarcane in zone A and B, of fit water zones. These are high water delta crops excessively consuming good quality groundwater. Rice and sugarcane are also cultivated in zone C and D at a small scale. Fruit gardens also consume a high amount of water, cultivated on large scale in zone C and D of unfit and marginally fit groundwater zones. A little amount of available canal water is mixed with groundwater and used for garden irrigation to reduce brackish groundwater detrimental effects. As far as water infrastructure is concerned, all three water resources have different infrastructures. Canal water

Fig. 4.22 UPA Bahawalpur water resources and management illustrations (*Source* the author of this paper)

infrastructure is comprised of some proportion of paved channels derived from canal outlets, delivered to the farmer's fields with unlined and unpaved channels. Mostly paved canal channels are in zone A. In the other three zones, the paved and lined channels are in small amounts. Tube well and sewage water delivery are conducted through totally unlined and unpaved channels causing environmental and health risks. On the other hand, irrigation is conducted by direct flooding in the open field's basins. Centuries-old conventional irrigation system and poor water delivery infrastructure are contributing to heavy water losses. The evaporation process is high due to local climate conditions with dry winds and high air temperatures. Due to these aspects, cultivation of high water delta crops like sugarcane and rice in fit water zones A and B are causing overexploitation of good quality groundwater. These practices should be restricted in UPA Bahawalpur. Salt tolerant crops should be promoted in zone C and D. Rice and sugarcane cultivation should be restricted in UPA Bahawalpur. Drip irrigation system is a very good option for gardens, orchards, and vegetable cultivation in open and protected farms, to prevent

heavy water losses of open field flooding. The present water infrastructure of irrigation should be properly paved and lined to prevent conveyance and delivery of water losses. Water conservation is a dire need of time and farmers will have to quit conventional methods of irrigation and adopt modern techniques to save this precious commodity. An integrated awareness program must be launched involving all stakeholders to convince growers for water savings. TV and radio channels should present innovative programs about the endangering water situation. Drip and sprinkler irrigation systems should be introduced through demonstration and installation with the help of subsidies from the government side. Policies formulated for water management should be reasonable and compatible with people's norms and taboos (Montanari et al. 2013; Walker et al. 2015).

4.5 Edible City—A New Approach for Upscaling Local Food Supply? The Case of Andernach, Germany

Martina Artmann and Katharina Sartison

4.5.1 Introduction

4.5.1.1 Urban Food Supply as a Response to Societal Challenges in Our Cities?

Most cities in the world are spatially expanding twice as fast as their urban population (Angel et al. 2011), which results in an ongoing loss of agricultural land in urban and peri-urban areas (Eigenbrod et al. 2011; Wilson and Chakraborty 2013). At the same time, it is necessary to secure the rising demand for food which will increase by 43% by 2030 (Food and Agriculture Organization of the United Nations 2011). Food security is not only at risk in countries of the global south but also, for example, in low-income households of the global north (Mok et al. 2014). Apart from food security, food quality is a major concern in cities of the global north and fresh and local food is increasingly demanded by society (Poulsen 2017; Forster et al. 2015). Industrial agriculture, which is practiced on large a scale, is seen as economically efficient. However, it results in substantial environmental costs, which are not taken into account in food prices, such as erosion, loss of biodiversity, water resource depletion, or pollution of rivers from surface runoff (Knudsen et al. 2006; Nellemann 2009). Furthermore, food producers and consumers are disconnected due to the fact that food travels far distances to nourish our population (Halweil 2002). The continuous reduction of arable land on the one hand, and the increasing demand for locally produced food on the other hand, highlights the urgency to put urban and peri-urban agriculture (UPA) on the political and research agenda. UPA includes various forms of practices ranging, for instance, from community gardens over schoolyards and public parks, to green roofs and peri-urban farming. In this

regard, UPA can be considered as part of urban green infrastructure contributing to urban resilience, ecosystem services and quality of life in cities (Russo et al. 2017; Artmann and Sartison 2018).

In order to upscale local food supply and its related benefits within cities, the concept of edible cities is gaining importance in research and urban planning although there is currently no explicit definition of edible cities. In general, they refer to the use of public urban green spaces for the cost-free provision of food (Kosack 2016). The areas of the edible city can have different functions varying from professional urban farming (e.g., peri-urban agriculture at the urban periphery) to urban gardening as a community-based activity (e.g., integrative, community or therapeutic gardens) (Artmann and Sartison 2018). The term edible city was firstly used in 2007 in Todmorden (UK) when a local initiative introduced "Incredible Edible Todmorden". This project aims to grow food in public places for free consumption, which should result in sustainable local food production (Morley et al. 2017). Currently, various cities worldwide have started to support the concept of the edible city. In a recently started European research program, a network of edible cities will exchange and analyze their knowledge within a living lab supported by different expert groups with representatives ranging from city authorities, research institutes, and NGOs to businesses in Europe, Africa, East Asia, and Central America (European Commission 2018). However, more research is needed to understand how the concept can be implemented and to understand its multidimensional benefits.

4.5.1.2 Aim

The focus of this study is on Andernach, one of the first edible cities in Germany. The aim of this paper is to evaluate how the concept of the edible city was implemented in Andernach and the benefits that can be observed associated with the realization of the edible city concept.

4.5.2 Methodology

4.5.2.1 Study Area

"Help yourself" instead of "do not enter". This is the slogan of the edible city of Andernach. It has a population of about 30,000 inhabitants (state: 2016) (Destatis 2018) and is located in the Rhineland-Palatinate region between the urban agglomeration centers of Cologne and Koblenz in western Germany, with the Rhine river running through the city (City of Andernach 2010) (see Fig. 4.23).

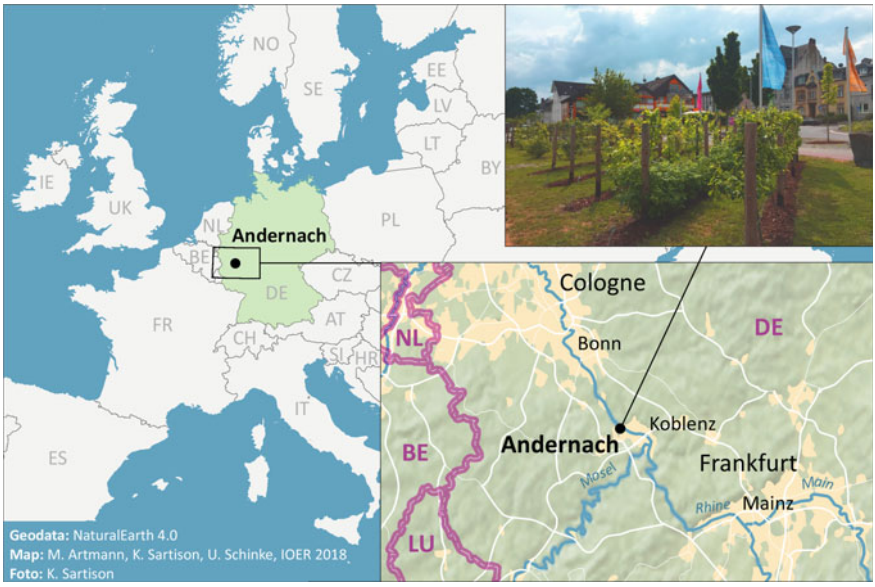

Fig. 4.23 Location of the city of Andernach, including a picture of a public space cultivated with vineyards

A key initiator of the edible city was the local government with the mayor and the heads of the department for green planning and social affairs. With the concept of the edible city, Andernach aims to integrate UPA into local green space planning. The year 2010 was the year of biodiversity. In order to call attention, not only to wild species but also to gene erosion of traditional crop species, the city of Andernach cultivated and signposted 101 tomato varieties along a dry moat, which surrounds the ruins of a medieval castle in the city center. Further attractive vegetables, such as Swiss chard, berry fruits, or kitchen herbs were also cultivated. The residents' acceptance for this project was very high, due to the fact that everyone was allowed to harvest in this public garden.

The area along the moat was perceived in a new light and experienced a revaluation, thanks to the cultivation of edible plants. Due to this success, more areas within the city were cultivated with edible plants, e.g., in raised vegetable beds in front of the town hall or on green patches along the Rhine waterfront. Furthermore, the city of Andernach also promotes peri-urban agriculture and in 2009, a permaculture field encompassing 14 ha, was established in the outskirts of the city. Here, not only plants but also Saddlebag pigs and sheep have been introduced. The agricultural products are sold in a shop in the city and are further processed in a canteen for long-term unemployed people who also build and maintain the edible areas. In this way, all residents can afford local and organic food of high quality (Kosack 2016).

4.5.2.2 Data Collection and Processing

To evaluate how the concept of the edible city was implemented in Andernach and which benefits can be observed, two semi-structured interviews are presented, which were conducted with the main initiators of the concept. These initiators are representatives from the departments of green space planning and social affairs within the city administration. The questions are based on the assessment framework developed by Artmann and Sartison (2018), which aims to evaluate the impact and implementation efficiency of UPA. The interviews took place in May 2018 and were recorded and transcribed using the program F4. The transcripts were then analyzed based on the assessment framework for UPA by Artmann and Sartison (2018) using the text analysis software MAXQDA 10. This paper focuses on the main findings referring to a general understanding of the concept of edible cities, framework conditions referring to the implementation of the edible city and benefits provided by the edible city.

4.5.3 Results

4.5.3.1 What Can We Understand Under the Concept of an Edible City?

In Andernach, a range of sites used for the edible city can be found, such as raised beds in the city center or a permaculture farm at the urban fringe (see also Sect. 4.5.2.1). Each year the city selects a different theme (e.g., strawberries and tomatoes). In 2018, Andernach focused on salads as well as on some other species and lettuce varieties were planted around the medieval city walls in the city center (see Fig. 4.24). In addition to this, residents can also observe chicken and sheep as well as beehives in the center.

The city of Andernach organizes an annual festival called "Andernach tastes good". Here citizens have the opportunity to inform themselves and get involved in the edible city of Andernach.

As stated in Sect. 4.5.1, there is no explicit definition of the edible city, which also became evident in the interviews. One interviewee sees the edible city as one form of urban permaculture. Permaculture can be understood as a design process, which helps to create nature-based circuits that meet human needs while enhancing biodiversity, reducing negative environmental impacts, and fostering social justice (Permaculture Association 2018). The reason for this perception comes from the multifunctional and interdisciplinary character that an edible city can achieve. The interviewees distinguish between urban farming and urban gardening (see Sect. 4.5.1.1), whereby in their city the latter plays the major role. However, it should not solely produce food for city residents, but rather serve as an ecological education program in public spaces, which are open to everyone.

Fig. 4.24 Salad growing along the city's dry moat (*Foto* M. Artmann)

When implemented successfully, the concept can have the potential to introduce a paradigm shift in the community and open up opportunities for further innovative and integrative ideas for a livable city.

4.5.3.2 What Factors Influenced the Implementation of the Edible City Andernach?

The factors influencing the implementation of the edible city in Andernach are very diverse and social, institutional, economic, ecological, and technological ones could be identified in this study. The fact that edible cities stand out for their multifunctional nature was also mentioned by the interviewees as a driver for implementation (see Table 4.3).

The social dimension provides the most driving factors. Both interviewees state that the spirit of the time combined with some good luck helped bring the edible city to Andernach. There is an increasing demand by people to reconnect with nature and to know where the food they consume comes from. Furthermore, food grown in the city looks pleasant and attracts people, who can harvest fresh food for free.

Table 4.3 Drivers and constraints of implementation

Category	Indicator
Multifunctional driver	The edible city as integrative concept to address different urban challenges (e.g., biodiversity, climate change, social cohesion, and food security)
Social drivers	Spirit of the time/good luck Emotional connectivity to urban food supply Aesthetics Access to local food Media attention Educational support Community participation and building
Institutional drivers	Experiential/practical learning Mayor's support Top-down policy-making Public provision of resources for local food supply
Economic drivers	Money savings Competition for innovative ideas
Ecological drivers	Greening the city Favorable location characteristics for urban food supply (e.g., climate, soil, and water)
Technological drivers	Efficient recycling methods
Social constraints	Concerns on health-related impacts Vandalism Constraining food consumption patterns Conflicts and tensions among actors Lack of community support
Institutional constraints	Lack of governmental resources (e.g., staffand money) Competing priorities Bureaucratic/political burdens Concerns on liability in case of damage (e.g., health)
Spatial constraints	Limited space for urban food supply

Another key driver was positive media attention. Andernach participated in a competition by a radio show, where they presented their idea to build the permaculture field at the city outskirts. After they won the competition, the media took a keen interest in Andernach and it accompanied every step in preparing the field. Suddenly, Andernach received an even larger national and international media attention ranging from various newspaper articles to radio and television reports. The city administration's aim to pursue environmental education was also a major driver for implementation. The children should know where their food comes from and become sensitized to regional products as well as fresh and healthy food. This fact goes hand in hand with the potential for community participation and building. Who has the rights to the city? This is a question which arises in the context of an

Fig. 4.25 The permaculture field at the outskirts of Andernach (*Foto* K. Sartison)

edible city. The interviewees aim to foster more community participation. Residents should become designers in their city, for instance, by taking responsibility for certain vegetable beds in the city. While doing so, they may increasingly get in contact with neighbors and exchange information or recipes for the edible plants, which in turn promotes community building.

One major institutional driver for implementing the edible city in Andernach was experiential and practical learning, although without any concrete concept. Two influential local authorities had the idea of the peri-urban permaculture field (see Fig. 4.25) and, based on self-study and knowledge exchange with a permaculture association, presented the idea successfully to the mayor. Consequently, it was implemented without complex planning or communication in the city council since it was seen as the daily business of the green planning department to decide which plants, e.g., Swiss chard instead of roses, should be cultivated.

Public provision of resources was also a major institutional driver for implementation and still is. The resources are provided mainly by the department of social affairs, which pays a local employment association to build and maintain the areas with the help of gardeners and long-term unemployed people.

Financial savings on a broad scale can be considered as an economic driver. When implemented successfully, long-term unemployed people may become employed as qualified gardeners, may have fewer health issues, and can be socially integrated. The competition in the radio show, which was mentioned before, was also an economic

driver for implementation. Ecological motivations included bringing edible plants back to the city, reconnecting people with nature, and elucidating the importance of biodiversity as well as the cooling effect of plants, paired with the option to eat them. Furthermore, Andernach, with annual temperatures over the German average, has a slight Mediterranean climate, which also promotes the growth of more exotic fruits such as peaches, vine fruits, or bananas. A technological driver was the use of efficient recycling methods. Recently, the city installed an aquaponics plant to demonstrate that urban farming is also possible on a small scale with closed resource loops.

Constraints for implementing the edible city are mainly of social, institutional, and spatial nature. Major social constraints for the implementation were the concern regarding health-related impacts by pollutants in air and or soil as well as vandalism. However, once implemented successfully, no one had problems with these issues anymore. Some citizens have other dietary preferences and were rather skeptical or not interested in the topic at all.

A few tensions arose among citizens because some vegetables or fruits were picked too early. Due to the fact that it is a top-down policy approach, community support is still expandable. Even though financial resources are available for implementing the edible city, local authorities have to work for it next to their daily business. The edible city is still seen as a "nice to have" measure, competing with the main basic functions of existence in the city (e.g., education or waste disposal). The initiators of the edible city foresaw bureaucratic and political burdens for implementation, such as complex applications or long discussions. This is why they chose to cultivate edible plants via the daily business of the green planning department. Furthermore, the city government had to deal with concerns regarding liability in case of damage, for example, by dogs urinating on vegetables. A spatial constraint for implementation was the lack of space for urban farming in and around Andernach. This is why the city concentrates, next to their permaculture field, on urban gardening within the town center.

4.5.3.3 How Is Andernach Benefitting from the Edible City?

Andernach benefits from the edible city in various ways. This paper reveals social, economic, and ecological benefits as well as ecosystem services that are inherent to the edible city in Andernach (see Table 4.4). Due to the fact that the interviewees mentioned the multifunctionality of the edible city that addresses different urban challenges such as food security, biodiversity, or social cohesion as a positive impact, we added the multifunctional benefit as a separate impact as well.

Social benefits include positive attention via different media channels. In the beginning, there were many concerns about the implementation of the edible city (see constraints in Sect. 4.5.3.2), but due to its popularity in the media and among citizens, the concept has now been established as a long-term initiative. Furthermore, there is less vandalism because the areas are now aesthetically revaluated. Children and adults become aware of environmental issues such as biodiversity or climate change, which are often seen as complex, by easily tasting,

Table 4.4 Benefits of the edible city

Multifunctional benefits	Edible cities provide multidimensional benefits (e.g., biodiversity, climate change, social cohesion, and food security)
Social benefits	Positive media attention Less/no vandalism Activities for environmental awareness-raising and education Empowerment and practical knowledge gain Appreciation for regional food supply
Economic benefits	Local market benefits Income and job generation Good city image
Ecological benefits	Habitat provision and biodiversity
Provisioning ecosystem services	Local food Medicinal resources
Regulating ecosystem services	Regulation of local climate and air quality pollination
Cultural ecosystem services	Aesthetic appreciation and inspiration Education and learning Sense of place spiritual experience/deceleration Tourism

smelling, and observing the edible plants. Some schools have a school garden and the city organizes annual school tours to the permaculture field, where the children can learn more about urban farming. This point goes hand in hand with practical knowledge gain and empowerment while the latter holds especially true for seniors or long-term unemployed people who have a task to fulfill that is valued by society.

The appreciation for regional food supply is also a social benefit, which in turn results in economic benefits for local retailers who sell regional products from the permaculture field. Jobs and income are generated by employing staff through additional project funding and training of long-term unemployed people.

Both groups are involved in maintaining and further developing the edible city in Andernach. Due to its positive acceptance among citizens and media, the edible city of Andernach promotes a good city image, which is now known even internationally. Through greening the city with edible plants, new habitats, also for endangered species, are provided, which in turn helps to promote biodiversity.

With regard to the potential of ecosystem services present in the edible city of Andernach, a distinction was made between provisioning, regulating, and cultural ecosystem services (Bastian et al. 2013). Provisioning ecosystem services include the provision of local, organic, and fresh food as well as medicinal resources which can be produced with herbs and buds from the plants. With regard to regulating ecosystem services, increased pollination potential and the regulation of local climate and air quality, which contributes to a cooling effect in the city, are inherent in Andernach.

Cultural ecosystem services encompass aesthetic appreciation and new inspiration such as for cooking, education and learning, a new sense of place and

connectivity to the city, deceleration and spiritual experience through human-nature interaction as well as tourism, which is increased through a positive city image generated by the edible city.

4.5.4 Discussion

As seen in Sect. 4.5.3, the edible city has many multifunctional benefits. However, according to the local interviewees, there is a discrepancy between reality and romanticizing the topic, as it has been done in some newspaper articles on the edible city in Andernach. In fact, the current literature also shows that UPA does not only provide benefits to humans and nature but can also be linked to ecosystem disservices and risks such as allergies or jeopardizing public health due to soil contamination (Artmann and Sartison 2018). To avoid such potential risks, it is necessary to conduct detailed risk assessments (Megson 2011) and consumers are requested to clean the food properly before eating. To support ecosystem service supply and multifunctional landscapes through agriculture, natural systems agriculture should be promoted (Eggermont et al. 2015) as it is done through a permaculture approach in the edible city Andernach. By applying the major ethics of permaculture, *care of the earth, care of people, and share surplus resources,* the permaculture approach can function not only as a basis for sustainable UPA but also provides an integrative treatment in approaching sustainable cities (Copeman 2012). In this regard, edible cities can be considered as a continuous productive urban landscape aiming to promote multifunctional open green spaces embedded into the built environment (Bohn and Viljoen 2011).

In the recent literature, it is widely discussed that bottom-up policy is essential for implementing UPA in cities (Fox-Kämper et al. 2018; Olsson et al. 2016). The practical example of Andernach shows the opposite approach. The key initiator of the edible city was the local government with the mayor and the heads of the department for green planning and social affairs. The latter two had the idea to bring permaculture and biodiversity into the city and to raise attention to these topics among citizens in the form of the edible city of Andernach. The edible areas are maintained by a local association, which fosters the employment of long-term unemployed people. These people work together with professional gardeners to cultivate the areas effectively.

Nevertheless, the city aims to foster its citizens' engagement to become active in strengthening the edible city. In such a way, further associations, pensioners, local companies, or students become involved in maintaining the edible areas. Financial sponsorships for single beds are also an option for reducing the maintenance costs for the city in the long run (Kosack 2016). According to the interviewees, all citizens can benefit from the implementation of the edible city. The spectrum of participants ranges from young to old, over people with low or high income, to people who grew up in Andernach or people who immigrated to the city. Today, the tourism agency attracts further tourists by conducting 80-90 guided tours on the

edible city of Andernach annually, which in turn results in higher profits for the local gastronomy and retail sector and the long-term unemployed people, who care for the edible areas and are perceived in a positive light.

As already mentioned in Sect. 4.5.3.2, the media was a key player in raising attention to the edible city of Andernach, even beyond national borders. Funded by the European Commission, Andernach is going to be part of a European research project aiming to develop an international network of edible cities to exchange and further develop new ideas to foster the concept of the edible city. Good practice examples such as Andernach can act as a frontrunner in inspiring further cities to implement the concept of edible cities. However, in each city, the local framework conditions should be considered such as space available for UPA as well as actors and policies motivated to support UPA. Thus, further research is needed to investigate drivers and constraints for implementing the concept of edible cities, taking into account different kinds of municipalities such as big and small, growing and shrinking cities. In this regard, it should be mentioned that this paper provides insights into Andernach by two main actors responsible for promoting the edible concept in Andernach. To get a broader view of the concept, its impacts and framework conditions for implementation, more actors should be taken into account such as NGOs, farmers, and residents.

4.5.5 Conclusions

Urban development is facing a range of societal challenges such as food security, biodiversity loss, social segregation, and climate change. Food supply through sustainable UPA can act as a nature-based solution providing multidimensional benefits to humans and the environment. In this regard, the concept of edible cities gains increasing attention in urban planning and research.

Through upscaling urban food supply by using public green spaces as part of the continuous productive urban landscape, residents get free access to fresh and healthy food, reconnect with nature, and develop a sense of place for their city by actively contributing as prosumers to urban development. Due to the manifold activities and benefits connected with the edible city, an interviewee in Andernach sees the concept as part of the urgently needed societal transformation toward sustainable development. Therefore, further efforts are needed so that UPA and edible cities are not only “nice to have” in urban planning but that strategies for local and organic food supply become a fixed task for city administration and urban policy as part of the public service. Important arguments to strengthen the topic in research and society can be provided by making the multidimensional benefits of UPA and edible cities visible.

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4.6 New Forms of Urban Agriculture in Metropolitan Areas: Examples from Italy

Daniele La Rosa

4.6.1 Introduction

4.6.1.1 The Role of Urban and Peri-urban Agriculture in Contemporary Metropolitan Contexts

For decades in many European countries, the dynamics of urban and economic growth have been separated from the demographic development (Kasanko et al. 2006) and despite the stability or decreasing of population, urban development pressure has been a significant driver of high consumption of land and agricultural resources. Urbanization processes have produced complex landscapes where agricultural, natural, and seminatural spaces have been totally or partially replaced by a highly heterogeneous mix of urban and nonurban uses. As a result of the fragmentation of the number of open spaces, seminatural and natural areas present in urban contexts were dramatically decreasing. These areas include, among others, cultivated land, abandoned farmlands, grassland, woods, and shrubs that are often located at the peri-urban cities' fringes (La Rosa and Privitera 2013).

Within the differentiated picture of these areas, agricultural activities provide a set of fundamental ecosystem services. Specifically, agriculture is able to supply all three major categories of ecosystem services, provisioning, regulating, and cultural services (Swinton et al. 2007). Even if the most tangible services are food, fuel, and fiber, a number of other services are also provided by agriculture, such as the maintenance of soil fertility, the regulation of pollinators, pests, pathogens and wildlife, water quality and supply, greenhouse gas emissions, and carbon sequestration. Other cultural services provided by agricultural landscapes include the benefits coming from open space, rural viewscapes, and the cultural heritage present in rural landscapes. Among managed ecosystems, farmlands offer special potential because of their variety of generated ecosystem services. This potential arises from their broad spatial extent and the human management objectives focused on biotic productivity (Swinton et al. 2007).

Agriculture in metropolitan areas contrasts sharply with its nonurban counterpart. As observed by Heimlich (1989), the longer areas are affected by urban pressures, the greater the adaptation they reflect in certain farm characteristics.

These areas are often included in large metropolitan contexts and thus their services have higher importance due to the number of people that can benefit from them (Swinton et al. 2007). In fact, agriculture both provides and receives services that extend beyond the provision of food, fiber, and fuel so that only in their absence do they become most tangible.

Urban agriculture (UA) practices have been defined as "the growing, processing, and distribution of food and nonfood plant and tree crops in farmlands that are mainly located on the fringe of an urban area" (Zezza and Tasciotti 2010). This type of agriculture meets a local and growing urban demand for food, but it also generates an intensifying conflict between the maintenance of agricultural production and the rapid land transformations by growing urban activities and related infrastructures (Aubry et al. 2012). In China, peri-urban agriculture has also been characterized by the specialization and diversification of traditional agriculture (Yang et al. 2016). In Europe and North America, New forms of Urban Agriculture (NFUA) are emerging in response to low-density urbanization patterns and mainly aim at shortening the food chain and producing local food in order to enhance food security (Benis and Ferrão 2017).

Particularly in Europe, NFUA have gained increasing attention for their multifunctionality and attitude going beyond food production. Current literature is extensively investigating the opportunities of NFUA in developed countries and particularly Europe, with examples from Paris (Aubry and Kebir 2013), Rome (Pulighe and Lupia 2016), Barcelona (Recasens et al. 2016), Gothenburg (Wästfelt and Zhang 2016), Copenhagen (Zasada 2011), and Berlin/Brandenburg (Lange et al. 2013).

Highly differentiated types of NFUA can be found in urban contexts (La Rosa et al. 2014), often characterized by small or medium-sized farms that have to deal with both market globalization and urbanization processes (Clark and Munroe 2013). Urban farms represent a partnership of mutual commitment between farms and communities of users/supporters, which provide a direct and short link between the production of agricultural goods and their consumption (van En 1995). Community-supported agriculture consists of agricultural practices that are economically supported by users and communities that take advantage of local food produced in the supported farms. They can provide environmental benefits due to an environmentally friendly production process as well as reduced "food miles", thanks to the proximity of production and consumption (Bougherara et al. 2009). Allotment gardens are more oriented to generate social values and cultural services, including active participation in the management of green spaces by particular social groups such as children, retired, or un-employed people (Rubino 2007). Finally, agricultural parks are larger agroforestry systems where food production (mainly by private farmers) is promoted and safeguarded along with more general rural and seminatural landscapes (Sorace 2001). They are usually publicly managed areas that protect and support existing agricultural production, wildlife management, and promote the fruition and access of the park, therefore providing important cultural and aesthetics services.

4.6.1.2 Planning New Forms of Urban Agriculture

The integration of urban agriculture into densely populated areas might greatly extend opportunities for mixing food production with social, cultural, and recreational functions of urban green spaces. To be a feasible alternative in cities and cohabit with other urban land uses, urban agriculture should include ecological and cultural functions in addition to the direct benefits of food production (Lovell 2010).

New forms of planning are therefore required to consider the possibilities offered by NFUA to enhance and support the provision of ecosystem services in urban and peri-urban contexts. To this end, a better understanding of the different features of current agricultural landscapes would allow the identification of the possible new land uses that are most suitable to fulfill the multifunctional aims of NFUA (La Rosa et al. 2014). Areas for UA can be planned and designed in different forms and at different scales to provide an extensive set of ecological benefits for urban and peri-urban residents (Deelstra et al. 2001). However, the integration of urban agriculture in land-use planning has seldom been considered in top-down urban planning and urban agriculture practices have often been implemented from the bottom-up and spontaneously (Lovell 2010).

Some attempts at introducing NFUA in planning of urban and metropolitan systems can be found in recent literature. Provè et al. (2016) suggested that a governance strategy that simply stimulates advocacy and institutional support would only minimally benefit NFUA. Adding more specific needs of the urban world (e.g., request for specific goods, or creating local markets) and integrating other functions (e.g., leisure and tourism) can push peri-urban agriculture toward its full potential. Furthermore, NFUA should be included in broader municipal or regional programs and in investments for public greenery and environmental conservation. However, their planning cannot be limited to the administrative boundaries of a single municipality as their extent goes beyond these boundaries.

In a study of the peri-urban agriculture in Beijing, Yang et al. (2016) focused on the importance of multifunctionality and diversity in agricultural development, recognizing the role of municipal government in promoting bottom-up local initiatives for the inclusion of these activities into land-use plans. However, both built-up land and lands needed for peri-urban agriculture activities require collective land with ambiguous property rights (state-owned), which hinders the implementation of UA in larger contexts and discourages long-term investments.

La Rosa et al. (2014) proposed a GIS-based Multi-criteria Planning Model to explore the suitability of land-use transitions of current open spaces (farmlands, abandoned farmlands, and seminatural areas, mainly located in the peripheral areas) to NFUA in southern Italy. This planning model delivered different scenarios of multifunctional land uses that increased the possibilities of food production in urban contexts and the overall access to public green spaces by the transformation of abandoned farmlands or other unused open spaces into urban farms or agricultural parks. As a parallel result, the scenarios are able to protect the existing productive farmlands from further urban development pressures.

4.6.1.3 Aim

In this paper, some examples of urban agriculture implemented in Italy are presented. The aim is to present and learn from current practices put into effect in different contexts throughout Italy.

4.6.2 Methodology

4.6.2.1 Study Area

Italy has an exemplary history of the process of the gradual erosion of peri-urban farmlands, which were often considered as reservoirs of physical space for further urbanization processes. During the 70s and 80s, in spatial planning—especially at the municipal level—farmlands were represented with white or blank patches ("zone bianche"), empty places waiting to be transformed into different types of built-up areas. No consideration of natural resources or services (e.g., soil, water, species, and landscape) was attributed to these areas.

This indifference of urban planning toward agricultural peri-urban areas has been one of the reasons for the contemporary sprawl process. Since the land had no particular inner value, planners and city decision-makers used to design new developments without taking into account the peculiarities and features of peri-urban and agricultural landscapes. The difficult coexistence of developed and agricultural uses has been more common in such a settlement pattern than in the homogeneous suburban contexts. At the same time, this proximity of residential areas with peri-urban farmland offers the possibility to reuse the open spaces between small developments for new forms of agriculture (La Rosa et al. 2014).

Current research is giving growing attention to the role of UA in providing multifunctional services to people, and many examples have started to be implemented in Italian cities. Although not always driven by public initiatives, they express a positive and new sensitivity to people regarding issues of food security and the loss of agricultural land.

4.6.2.2 Analytical Methods

To narrow the possible choice to the most representative case studies among the many initiatives that can be found in Italy, the following criteria were used for the selection:

- The example has been implemented and is currently ongoing.
- The example is representative of different geographical areas (north, center, and south Italy).

- The example is representative of a specific typology of NFUA (see Sect. 4.6.1.2).

Examples are summarized in Table 4.5 and presented in Sect. 4.6.3.

4.6.3 Results

4.6.3.1 Urban Farms in Rome

In the last 10 years, the city of Rome has increasingly attributed a new and alternative role to the numerous public green but unmanaged spaces present in the city.

The most relevant public initiative in the Italian Capital was the approval by the City Council of a municipal regulation to assign urban farms and share orchards to citizens and the launch of a public call to assign land plots to cooperatives or other forms of private associations of citizens. The publicly owned areas where urban farms are to be established are assigned through 6-year loans to private groups or cooperatives that then divide the land and assign plots to private citizens who make a formal request. The management of the urban farms will then be the responsibility of private groups or cooperatives that will divide the areas into smaller plots (down to 60 m^2). Private citizens will be in charge of cultivating the plots and must commit to taking care of the land, including the management of wastes, to choose organic farming, and to not use GMOs. Furthermore, the municipality offers the opportunities to set up specific agreements (in forms of free land loan) with citizens or associations that were already informally using the public areas for urban agriculture.

All the areas have already been selected by the Land Use Plan of Rome and selected as places where new urban farms will be established, based on their physical and ecological characteristics (City of Rome 2015). In this way, the public administration (the municipality in this case) acts as the main promoter of the process aimed at protecting the areas from further urban development, protects urban biodiversity and other ecosystem services, provides new possibility of fruition of open unbuilt spaces, promotes food security issues, and provides some support for poorest people for self-consuming crops.

Another initiative promoted by the Municipality of Rome is the launch of educational gardening in schools, involving school groups, young people within their schools, and extracurricular activities to improve the awareness of issues like food security and nutrition. Some of the schools offer meals specifically prepared with products coming from their local farms.

Even before this important initiative is promoted by the City Council, there has been a significant number of private/bottom-up initiatives of using vacant plots, abandoned farmlands, or other types of open spaces as areas for NFUA, with a total of 409 ha in 2013. Since 2010, a private project is mapping and investigating community and edible gardens in Rome, as a collective action for urban public space appropriation and for the development of environmental, economic, and

Table 4.5 Case studies presented

Name	Type of NFUA	Location	Size	Ownership of the land	Management	Leading actor
Parco Agricolo Sud Milan	Agricultural Park	Metropolitan area of Milano	46000 ha	Mostly private	Public	Metropolitan City of Milan
Orti di Librino	Allotment Gardens	Catania	3 ha	Private/public (land loan from municipality)	Private	Municipality of Catania
Rome Urban Farms	Urban Farms	Rome	/	Private/public (land loan from municipality)	Private	Municipality of Rome/ Cooperatives
Arvaia	Community Supported Agriculture	Bologna	40 ha	Public (land loan from municipality)	Private (social cooperative)	Municipality of Bologna/ Cooperative of Arvaia

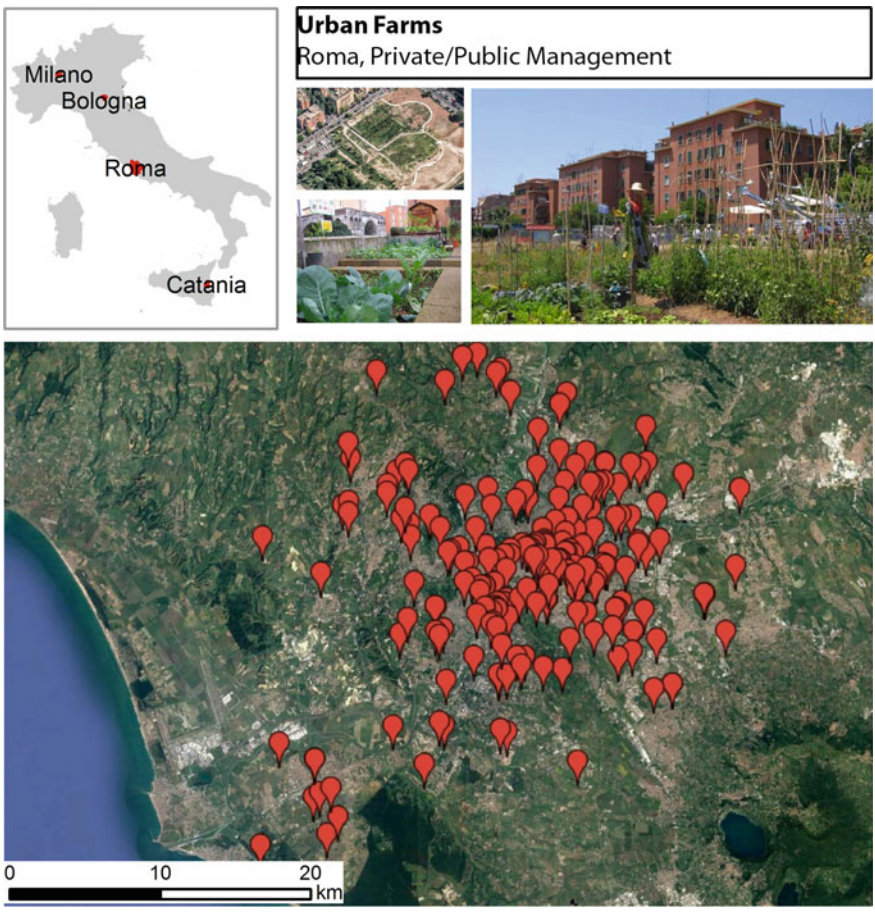

Fig. 4.26 Sites of urban farms in Rome (own elaboration from Zappata Romana (2018), retrieved on June 30, 2018)

social innovative issues (Pulighe and Lupia 2016). The project (Zappata Romana 2018) is based on a Volunteered Geographic Information approach based on the use of Google Maps, allowing users and citizens to locate and update any urban agriculture initiatives. The following categories of urban agriculture have been mapped: small urban gardens and play yards (102 sites), edible gardens (67 sites), and guerrilla gardening actions (31 sites) (Fig. 4.26).

Among these bottom-up initiatives in Rome, there have been other interesting cases of reuse of private vacant lots for UA. Some local cooperatives launched initiatives of social professional farming in Rome using agriculture and food as a tool for building new forms of social cohesion. These projects generated a more sustainable way of food consumption, through a closer relationship among consumers and producers and with a fair economic return for farmers.

4.6.3.2 Allotment Gardens in Catania

In the past few years, the city of Catania, in Sicily, has started a slow and difficult regeneration process of a large public housing district in the periphery, Librino. After more than 40 years since its development, the district presented many symptoms of deprivation and physical degradation and a general lack of public services (i.e., green spaces and infrastructures), therefore hampering aggregation, social interaction, and vibrant life for the inhabitants of the district.

Since the end of the 2000s, many grassroots movements grew in the district, promoting activities such as the reuse of an abandoned municipal sports facility by a local rugby team and the occupation of open unbuilt spaces to establish self-organized gardens for vegetables.

In addition, the City Council started to launch and promote new scenarios for the rehabilitation of the Librino district: taking advantage of the increase of social awareness, the Municipality launched a first call in 2017 for 13 allotment gardens (Fig. 4.27) to be assigned to local residents for a period of 4 years (removable for

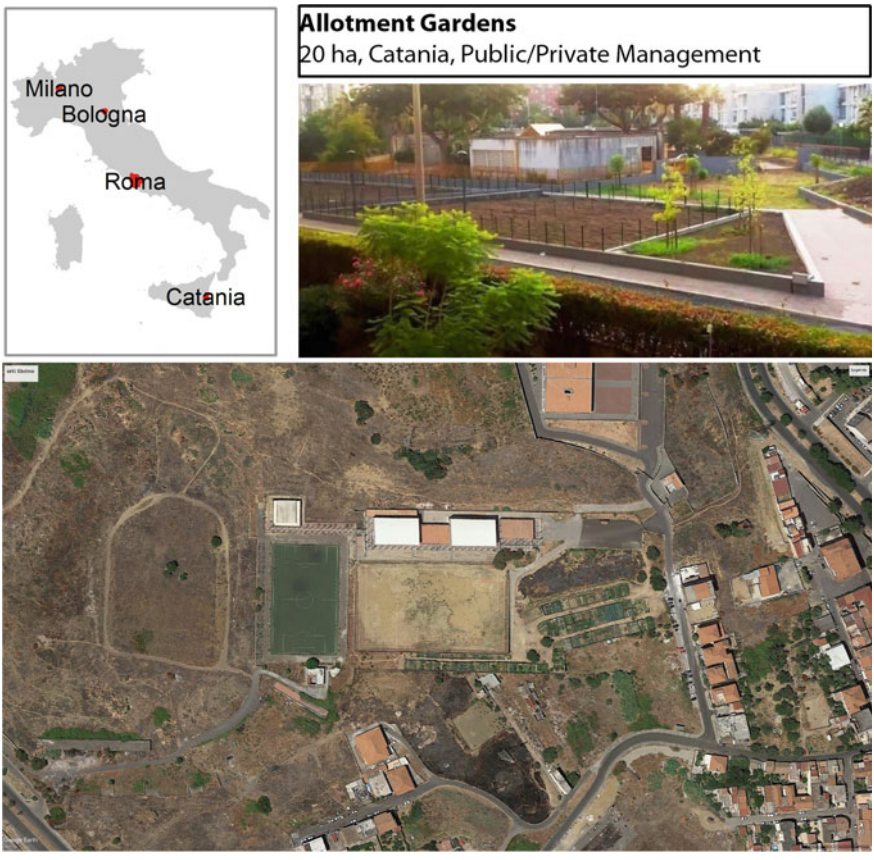

Fig. 4.27 Allotment gardens in Catania (elaborated by Daniele La Rosa)

other 4 years) at a loan fixed by the municipality. Different types of allotment (from 200 to 4000 m^2) could be assigned to specific categories of applicants: allotments for retired people/low-income people, families, condominiums, schools, other associations, or NGOs. These categories demonstrated the importance of the social value of UA for urban regeneration. Every allotment is equipped with water, electricity, a small path, a box for tools, and nearby parking. Beneficiaries had the possibility to buy plants, seed, trees, and organic fertilizer at reduced costs.

The relevance of the project, for the particular conditions of the district, was demonstrated by the participation of the Italian president in the ceremony for the assignments of the first plots at the beginning of 2018. The success and interest in the district of this initiative pushed the municipality to launch a second call in late 2017 in the same district. Allotment gardens will be established in a larger area (about 3 ha for 72 allotments) of abandoned farmlands and bare soil (City of Catania 2017).

Although limited in extent, this initiative demonstrated that also in deprived districts, urban agriculture is highly valued by citizens and can be an effective tool of urban regeneration and a way to protect open spaces from further urban development or abandonment.

4.6.3.3 Community-Supported Agriculture in Bologna

The cooperative Arvaia is the largest agricultural cooperative in Italy supported by a community of private consumers. It is located in a peri-urban area of Bologna and covers a cultivated area of 47 ha (Fig. 4.28). It integrates a heterogeneous group of people with different backgrounds and specializations such as farmers, agronomists, and volunteers, with the common and shared objective to promote the KM 0 philosophy to the majority of citizens in a supportive community of people. At the beginning of its activities, Arvaia was a small cooperative that won a public call launched by the Municipality of Bologna for the management for 25 years of a large agricultural area belonging to the municipality. Since 2016, the cooperative started to cultivate cereals, legumes, and fruits according to three main principles: the use of a strict organic farming; the production reserved for a local community (therefore eliminating all types of intermediation and transport costs); and the inclusion of an open community that is at the base of every choice and decision on the activities of the cooperative (crops to grew, methods of cultivation, prices, …).

Cultivated crops increase every year and include mainly vegetables available only in particular seasons and following natural successions. Today, Arvaia provides an average of almost 500 Kilos of products per year (Arvaia 2018).

Interestingly, the cooperative is also in charge of the management of almost 8 ha of public open spaces that are accessible to all citizens, therefore extending the functions of urban agriculture to fruition. This was possible, thanks to the development of 5 km of bike lanes and pathways and the creation of a didactic farm for schools and other associations.

Fig. 4.28 Community-supported agriculture in Bologna (elaborated by Daniele La Rosa)

4.6.3.4 South Agricultural Park Milan

The Parco Agricolo Sud Milano (Fig. 4.29) is the largest agricultural park in Europe, with 46,300 ha to the south of Milan, covering about the 30% of the entire Metropolitan area of Milano and including a total of 61 municipalities, with 1,400 farms and almost 40,000 ha of utilized agricultural area. It was established by a regional law in 1990 as a regional park, but it is currently managed by the Metropolitan Area of Milano (città metropolitana di Milano, former province of Milano).

The main objective of the park is to safeguard traditional farming activities from the increasing urbanization processes that were very strong due to the proximity with the city of Milano. Other important objectives are the protection of the existing network of natural areas (especially wetlands and residual woodlands), the

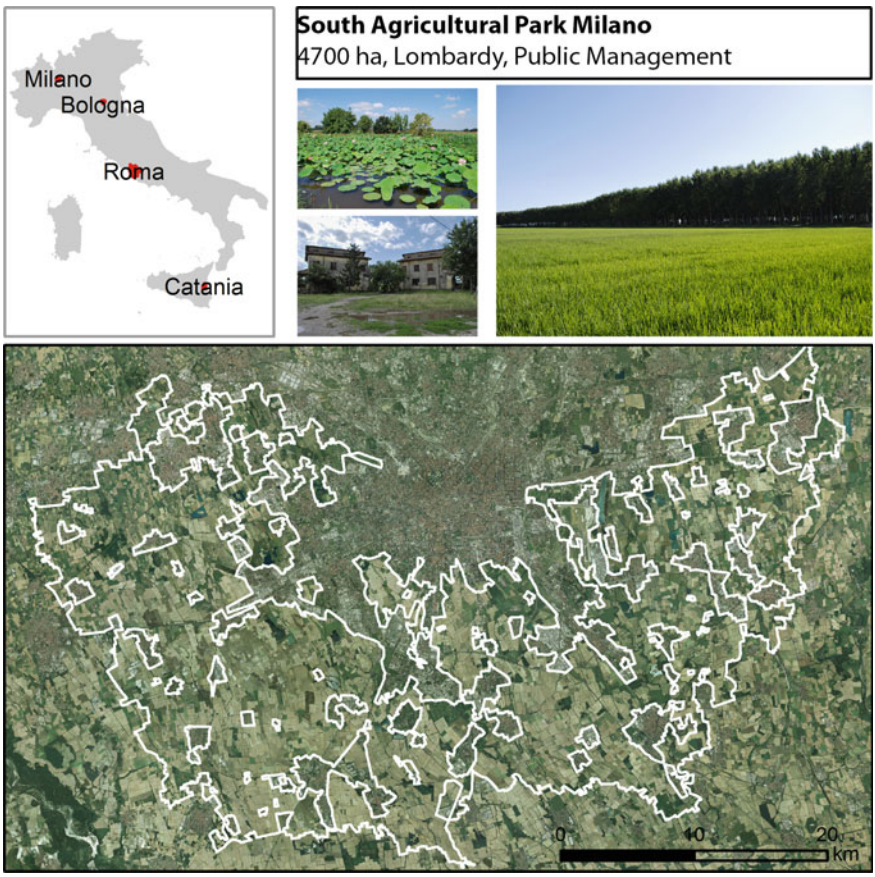

Fig. 4.29 South agricultural park in Milan (elaborated by Daniele La Rosa)

valorization of the historical and architectural heritage with castles, abbeys and traditional rural buildings, and the ecological restoration of particular landscapes that were damaged by anthropic activities.

The park is characterized by cornfields and water meadows. Tree rows mark the borders of the fields and run along the watercourses. Ancient farmsteads and rural towns are scattered throughout the park. The agricultural vocation of the area is related to the rich availability of water, mainly coming from an articulated and widespread network of draining ditches, fed by resurgences and partly encircled by hedgerows. The park also includes more than 100 ha of important regional nature reserves, protected areas which are crucial for the safeguard of its ecosystems and of the flora and fauna that inhabit them, and an extended network of bike and pedestrian pathways.

For almost 40 years since its creation, the park has been successful not only in protecting the extensive farmland landscape of the area but also in generating added

value in the economic dimensions of farms. However, some concerns about the environmental sustainability of the production system have been raised, especially related to rice and horticultural sectors (Migliorini and Scaltriti 2012).

Since its establishment, the park has been a fundamental driver in changing traditional farming into a modern multifunctional activity. The park's agriculture today is much more than this, being a modern multifunctional business, allowing metropolitan citizens to enjoy the area through a wide range of services directly offered by farms, and managing and safeguarding the environment. Farmers' markets bring costumers closer to the rural world, making them experience the origin and characteristics of the products, and organize the most effective distribution of products. Farmers have been increasingly interested in developing qualified and modern productions in order to get the park environmental quality label ("Marchio di Qualità Ambientale"). Farm activities have been diversified and new forms of income have been included, such as holiday farms, which benefit from flows of people living in the large metropolitan area. Other forms of educational services include the dissemination of information about rural customs and traditions through educational farms that have been widely expanding in all of Europe and Italy (Parco Agricolo Sud Milano 2007).

4.6.4 Discussion

From the broad analysis of the case studies presented in Sect. 4.6.3, some initial conclusions can be drawn on the development of Italian UA practices and their achieved results.

First of all, all initiatives confirm the overall interest and increasing awareness of the benefits and potentialities of UA by the two main categories of subjects involved, namely administrators and citizens. This is generally in line with what is happening elsewhere in Europe and confirms how UA experiences are successfully spreading in the global northern context (Pölling et al. 2016). Increasing concerns for food security, supply chains, and local sustainable foods have helped the mushrooming of UA initiatives (Opitz et al. 2016). Case studies reported in Sect. 4.6.3 confirm positive participation of many users to activities related to UA, as demonstrated by the success of the calls for urban farms and allotment gardens launched in Rome and Catania. This is also confirmed by many other similar initiatives in Italian cities of different sizes (Milano, Torino, Vicenza, Reggio Emilia, and Genova).

The second most relevant result achieved by all these initiatives is the successful conservation of the land from further urban development and their reuse for NFUA. Farmlands within or near towns are therefore no longer considered merely as lands for future urbanization. This guarantees not only the provision of ecosystem services by the existing network open spaces but also increases the accessibility of citizens to the agricultural services and their public goods. Some of the areas that are used as NFUA have been often neglected and abandoned, therefore generating,

in some instances, issues of public security (La Rosa et al. 2014). The experience of the South Agricultural Park Milano represents a well-acknowledged and successful case. Indeed, the park has been able to act as a barrier to the urban development process that has been rather intense from the 1980s to the 2000s in the Milano metropolitan area (Pileri and Maggi 2010). To this end, other successful and innovative farmland protection programs include a mix of several strategies involving partnerships between different community groups and private landowners. The main feature of these partnerships is to keep the land in private ownership but at the same time to ensure its protection and satisfy interests of the communities (e.g., food production, leisure, and environmental protection).

An important issue to be considered concerns the legal status of the area to be used for NFUA. Traditionally, UA includes activities which do not have a recognized legal status. In the US, many cities have passed specific ordinances permitting certain commercial, community, or nonprofit agricultural activity in urban and/or periurban areas (Optiz et al. 2016). However, the legal status of UA is still not acknowledged by other forms of urban governances or planning. This condition is also related to the characteristics and property assets of lands where UA is conducted, which are often vacant or abandoned lots belonging either to public administrations or private persons.

Legally binding standards and regulations exist at different levels, from the supranational to the regional, but they often address other fields of businesses (like European or national standards for water quality or amount of pollutants on soils). Correctly including UA in spatial plans at different administrative levels could act as a way to provide UA a legal and recognizable status (La Rosa et al. 2018). On the other hand, spatial plans can include the obligation for farmers to follow specific norms and prescriptions to avoid negative environmental impacts of intensive agriculture and to protect food safety with standards along the whole food chain (Ghaida et al. 2014).

This last point recalls the importance of new planning processes for NFUA. As urban areas are expected to keep growing in the future, planners and political decision-makers have to carefully consider the role of areas used for NFUA in planning scenarios that are aimed at the conservation/increase of ecosystem services. The integration of urban agriculture into densely populated areas might greatly extend opportunities for mixing food production with social, cultural, and recreational functions of urban green spaces (Lovell 2010).

The challenge for including NFUA in spatial planning is to design an urban and peri-urban environment able to include a differentiated range of functions including urban agriculture and other typologies of green spaces for leisure, biodiversity protection, and recreation (La Rosa and Privitera 2013). These possibilities are, in some cases, hindered by existing planning systems that do not provide suitable planning instruments for UA. However, in some of the Italian examples resented, public administrations have tried to include NFUA in specific planning regulations, as in the case of Rome, where all the vacant plots suitable for NFUA that belonged to municipality have been zoned in the binding land-use plan as areas for NFUA.

Another key point deserving more research is related to the dual concept of sustainability of NFUA, both from an ecological (territorial) and economical (internal) point of view (Aubry et al. 2012). The first side of sustainability is related to the ecological performances of UA, with special reference to possible negative ecological effects, i.e., food waste, energy use, and ecological footprint. A recent review by Goldstein et al. (2016b) emphasizes the uncertainties in the environmental performances of different types of UA. Significant differences in the environmental performance of similar UA systems highlighted these uncertainties and where evidence does exist, it has normally been proved for only one type of UA. The author's concern is that:

> If UA is to promote on environmental grounds, then there remain a number of unanswered questions about the environmental performance of individual systems and less certainty regarding how an edible city would perform (Goldstein et al. 2016b).

The second side of the sustainability of NFUA depends largely on the chosen system of production and on the spatial relations between farms and the rest of the urban system, as this latter point can substantially affect commercial relationships, incomes, resource accessibility, and potential market.

4.6.5 Conclusions

Italy is experiencing unprecedented interest in UA, as demonstrated by all the initiatives that are flourishing in a high number of cities of different sizes. Public administrations—especially municipalities—are starting to consider UA as a publicly accepted way to achieve multifunctional benefits and services for the current unused or abandoned open spaces. Although still limited in their spatial extent and with some issues still to be addressed, these examples appear as the first effective attempts in decades to build new sustainable planning scenarios, protect existing productive farmlands from urban development pressures, and contribute toward more sustainable and green cities.

The attribution of a new and multifunctional role to agriculture could be one of the key strategies for spatial planning that aims to reactivate or revitalize farmland that has suffered from economic crisis, abandonment, and pressure from urbanization processes. To this end, areas in between urban nodes should not be considered by planning as a spatial reserve for future urban and infrastructure developments but as the fundamental components of an integrated metropolitan and regional green infrastructure.

4.7 Structure and Processes of Home Gardens in Urban Landscape: The Case of Galle, Kandy, and Jaffna Cities in Sri Lanka

Lalitha Dissanayake and M. M. G. S. Dilini

4.7.1 Introduction

4.7.1.1 Structure and Processes of Home Gardens

A home garden, or domestic garden, can be defined as an area adjacent to a domestic dwelling. The structure, composition, and diversity of home gardens are influenced by socioeconomic and cultural factors as well as the surrounding geographical and ecological conditions. Home gardens can range from multilayered, diverse vegetation to those in the single dimension with different intermediate gradients with respect to the requirements of the dwellers. Individuals modify their immediate environment to either maintain useful plants or introduce external species while eliminating those that are undesirable. Home gardens generally function on provisional, supportive, regulatory, and cultural services. Thus, the home garden can be broadly defined as a farming system that combines a variety of socioeconomic and physical functions on the land near a residence. Being "near" a residence can include roofs, balconies, or window boxes, especially when a dweller has limited space. Additionally, the garden can appear in different forms, such as indoor gardening, water gardening, or container gardening.

Eliminating hunger, achieving food security, and improving nutrition are some of the aims that comprise sustainable development goals. In terms of this concern, home gardens play a key role in household food security. Additionally, tropical home gardens also contribute to the conservation of plant species, carbon sequestration, flooding and temperature mitigation, the enhancement of biodiversity and the aesthetic value of the environment, the provision of fuel, medicinal usage, and the guarantee of a groundwater table while also acting as an alternative to protecting natural forests providing several other timber and non-timber uses.

Based on the factors mentioned above, the structure and processes of home gardens can differ between rural and urban landscapes. They can also differ between a city's center and its periphery. As implied in the study by Drescher et al. (2006), urban gardening involves three basic types of practices: home gardening, allotment gardening, and community gardening.

4.7.1.2 Aim

The current study primarily focuses on urban home gardening and has been conducted within the municipal boundary of three different geographical locations in

Sri Lanka in order to explore human interactions with the environment to assure their requirements. Even though research on home gardens already exists, there are no comparative studies investigating their structural and functional basis in selected regional landscapes, which presents a way in which to identify certain socio-environmental issues despite the focus on three geographical locations (located within defined boundaries of administrative divisions of the country). The identification of spatial patterns in relation to the structure and functions of home gardens can enhance understanding of local situations, revealing the necessary requirements for ensuring a balanced ecosystem.

4.7.2 Methodology

4.7.2.1 Study Area

As indicated in Fig. 4.30, the study was carried out in the Galle, Kandy, and Jaffna municipal council areas in the years 2017 and 2018 in order to represent the different geographical contexts within the country. Jaffna and Galle represent the low-country physiographic region while Kandy belongs to the up-country physiographic region. Furthermore, cultural representation was another considered factor for study site selection. According to the records of the Department of Census and Statistics of Sri Lanka for the year 2012, the majority of Jaffna inhabitants are Tamils (98.95%) while the majority of Galle inhabitants are Sinhalese (94.4%). Moreover, Kandy is more culturally diverse, comprised of Sinhalese (74.55%), Tamils (13.12%), and Moors (10.9%).

4.7.2.2 Sampling and Data Collection

Fifteen sample location data per each study site were collected based on the random sampling technique.

A grid was created for each municipal area to ensure the representativeness of the samples. Each sample was collected within a 3-kilometer buffer zone from the city center concerning air distance. Questionnaire surveys and semi-structured interviews were conducted in order to gauge the size of the land unit, size of the house, reasons behind varying land extent for gardening, fertilization details, and whether the home gardens meet food requirements, are aesthetically beautiful, and provide medicinal services. In addition, field observations and photographs were used to acquire data within the selected sampling locations.

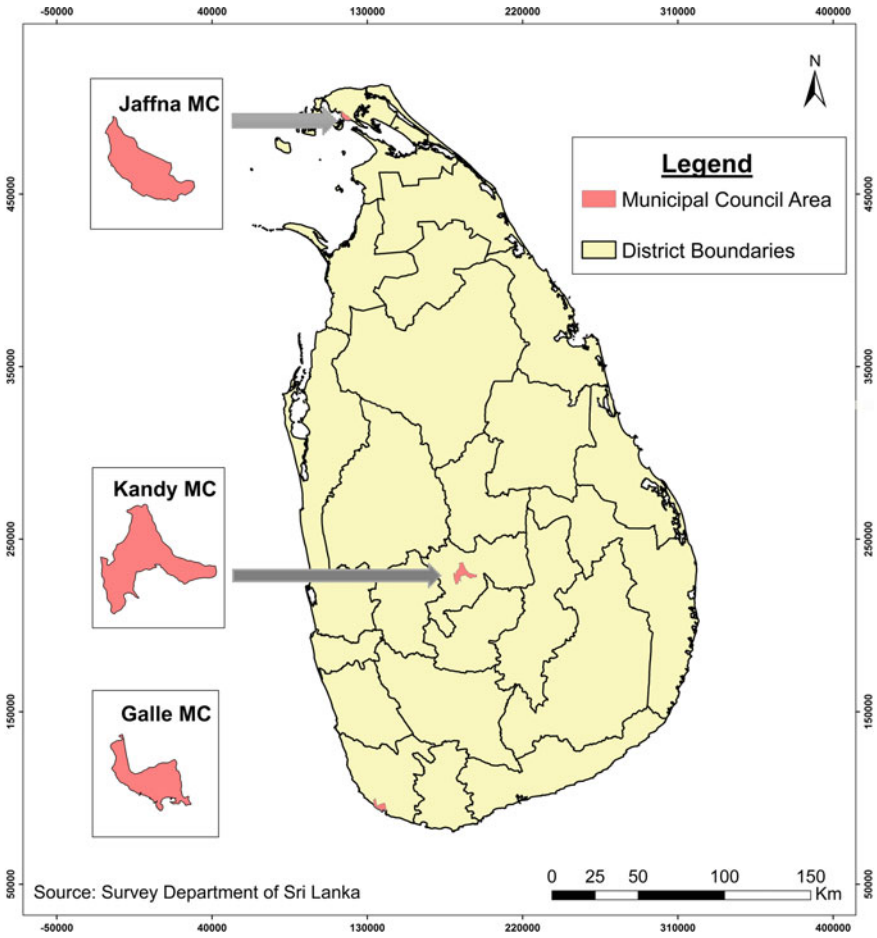

Fig. 4.30 Map of Sri Lanka indicating the Galle, Kandy, and Jaffna municipal areas (design by Lalitha Dissanayake and M. M. G. S. Dilini)

4.7.2.3 Data Analysis

The structure and processes of home gardens can be considered related concepts. Furthermore, there are two major landscape indicators of environmental quality, as indicated in the report "Landscape Patterns Environmental Quality Analysis, 2013": landscape configurations and land cover patterns that uncover biophysical aspects of the land surface. Accordingly, landscape configuration factors such as the size, shape, and spatial pattern of urban home gardens were examined in order to understand their structure. The biophysical aspects of land cover types, species distribution, and diversity were also examined in the present study. The processes

of the urban home gardens were identified through the structural basis and related to land utilization for gardening, distribution, and species diversity. Additionally, results were further clarified through the examination of the questionnaires and semi-structured interviews.

The major techniques used for data analysis are Excel and SPSS for statistical analysis, ArcMap 10.5.1 for mapping, and Simpson's Diversity index. Simpson's Diversity index was used to measure the diversity of home gardens at three study sites. The index value is always within the range of 0-1; here, values closer to 1 signified higher diversity while those closer to 0 signified lower diversity. Simpson's Diversity index is dependent on species richness and evenness. Therefore, the number of species per sample and the relative abundance of each species were also considered. The formula for Simpson's index is shown in Eq. 4.1 below.

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)} \tag{4.1}$$

where n = number of individuals of each species; and N = total number of individuals of all species.

4.7.3 Results and Discussion

4.7.3.1 Structural Patterns of Urban Home Gardens with Respect to Landscape Configuration Indicators

Distinctive landscape configurations such as size, shape, and spatial patterns can be identified based on analysis in order to understand the structure of urban home gardens at the three study sites.

Variations in Total Land Extent per House Unit

The study shows that land area utilized for urban gardening was smaller for locations closer to the city center. The average area of urban home gardens for the distance of 1500 m from the city center was quite similar in both the Kandy and Jaffna municipalities, as shown in Fig. 4.31. The area of urban home gardens within the limit was highest in the municipality of Galle. Moreover, the average land area of urban home gardens significantly increased with the distance from the city center. This was especially true for the Galle and Jaffna municipalities. However, in Kandy, a little variation was observed, as shown in Fig. 4.31, and, therefore, average land extent values were comparatively homogeneous within this municipality.

The data obtained from the Department of Census and Statistics of Sri Lanka (2012) revealed that land per person in each municipality is 1, 2.7, and 2.4 m^2 for Galle, Kandy, and Jaffna, respectively. Even though this data indicates a

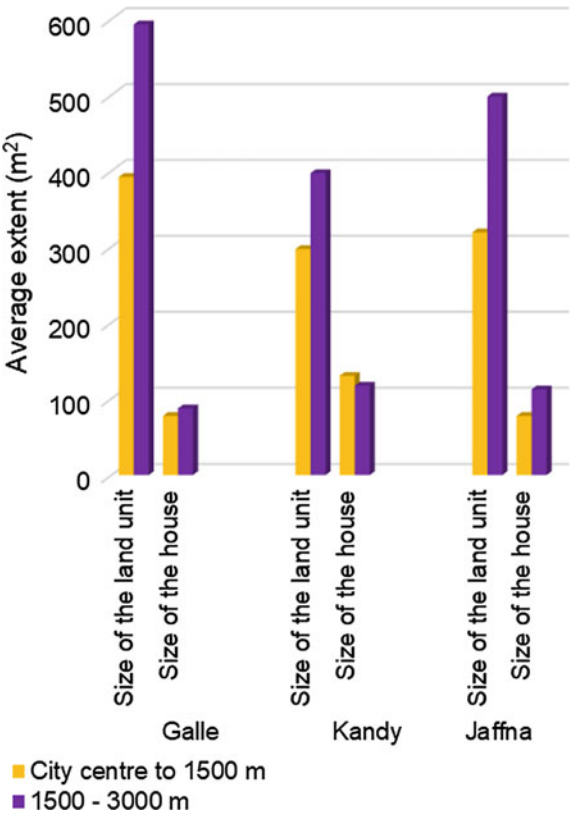

Fig. 4.31 Average land extent and average house size in the Galle, Kandy, and Jaffna municipal areas according to distance from city center

considerable value of land per person within the Kandy municipality, its land pressure could also be higher based on its urbanization when compared to the two other municipalities. The Department of Census and Statistics of Sri Lanka records for the year 2012 showed that the largest urban population is in the Kandy municipality among three study sites. This could also explain why the Kandy municipality displays a lower average area of urban home gardens than Galle and Jaffna.

House size was also an important factor since only the remaining land of a property can be used for gardening. Land allocated for a house was distinctively higher in Kandy. Figure 4.31 indicates the existence of larger houses near the city center in Kandy. However, the situation was different in the other two municipalities, where larger houses are located further from the city center. With respect to the land unit and house size, the area remaining for gardening was comparatively high in both Galle and Jaffna.

Structural Patterns of Paved Areas in Urban Home Gardens

The typical paved areas in the urban home gardens of the three study sites were house path and front yard. In the Kandy municipality, both exhibited an impervious character, as the paths were concrete and the front yards interlocked. On the other hand, Galle and Jaffna displayed natural pervious surfaces. In other words, natural sand, stone, and grass are used to maintain the natural condition of the Galle and Jaffna landscape. The Kandyan landscape experiences land management issues due to intensive soil erosion. Therefore, impervious structures have been implemented to avoid this issue. However, this has negatively influenced the water detention function of the soil, causing urban flooding as well as soil erosion.

Land Utilization for Gardening

It is important to recognize land utilized for gardening since garden size positively correlates with land cover composition. Land utilized for gardening widely varied among the regions of Galle, Kandy, and Jaffna. As shown by Fernandes and Nair (1986), the average size of home gardens in the tropics is significantly less than one hectare. Hence, the size of urban home gardens at present will almost certainly be even smaller in size. The utilized space of Galle and Jaffna home gardens was observed to be much larger than that of the Kandyan urban gardens. The average area utilized for gardening was within a 3-kilometer distance from the city center as 250, 113, and 206 m^2 for the Galle, Kandy, and Jaffna municipalities, respectively.

Figure 4.32 shows how land utilized for gardening increases from the city center to the periphery. In this vein, Galle exhibited an average of approximately 210–280 m^2

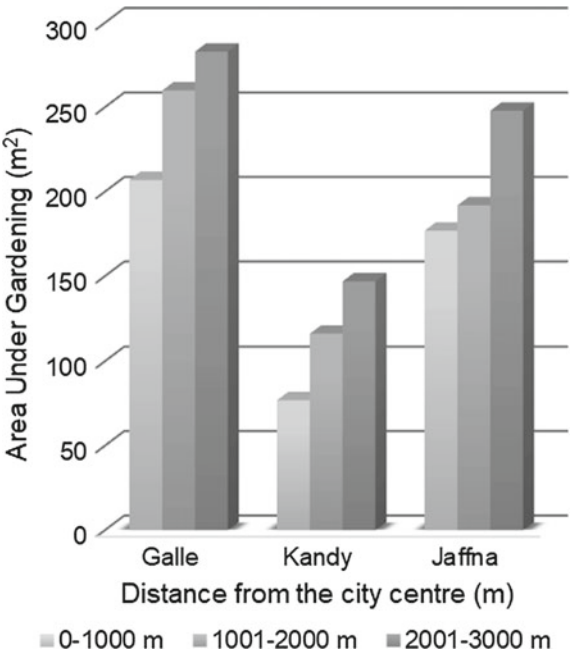

Fig. 4.32 Average area for gardening in respect to distance from city center

and Jaffna exhibited an average of approximately 180–250 m^2. However, Kandy exhibited a distinctively small area utilized for gardening overall, increasing from 80 to 150 m^2 from the city center to the periphery.

According to the Labor Force Survey Annual Report from 2016, the contributing family worker percentage for Galle, Kandy, and Jaffna districts is 6.5%, 5.9%, and 2.9% respectively. Contributing family worker refers to a household member engaging in a family business or farming without receiving any payment. This can be considered an influential factor in gardening in the Galle district. Even though Kandy also has a record of a high contributing family worker percentage, this has no influence on home gardening. This might be due to the high employment percentage in the Kandy city, possibly meaning individuals in Kandy do not have enough time to spend on their gardens, which thus potentially influences the observed small area utilized for gardening in Kandy. The semi-structured interviews helped reveal other reasons for the small area of urban home gardens. Recent animal disturbances were often mentioned in the interviews, especially those of jackanapes, chipmunks, hedgehogs, and wild bores, which have almost destroyed gardening in the area.

This effect was especially dramatic in the Watapuluwa, Pitakandagama, Mapanawathura, Aruppola, and Boowelikada Grama Niladari Divisional areas. This might be due to their close proximity to forested areas since areas are all near the Udawattakele forest reserve. Even though the Dunumadalawa forest reserve is located in the southern region of the municipality, settlement distribution around the Dunumadalawa forest is smaller than that around the Udawattakele forest reserve. Therefore, it can be noted that urban gardening in the northern part of the municipality is most affected by animal disturbances.

The reason has been distinctively influenced to reduce land utilization for gardening in the Kandy municipality simultaneously with space limitations. Increased damage might be caused by the low amount of other green space in urban landscape. This reason has been indicated by Saunders (2016) in regard to bird, bee, and bug disturbances. Similarly, less attention is often paid to gardening in Kandy due to intensified threats from jackanapes. These animal disturbances might arise from the lack of food sources available to animals in the urban landscape.

Garden Structure in Respect to House Location

Areas primarily used for gardening within a land unit were demarcated in respect to the house's location. The results obtained by the study highlighted four major patterns in the three study sites: all four sides, only front; front and back side only; and front, right, and left side only.

According to Table 4.6, garden structure relatedness to house location was practically the same in Galle and Jaffna. Furthermore, the highest percentages were obtained in regard to front and backside gardening in these two regions. However, the highest percentage in Kandy was for front gardens. There was no distinctive amount of land allocated for gardening in backside.

Table 4.6 Gardening in different locations of the land unit in respect to house location in the Galle, Kandy, and Jaffna municipalities

Galle municipality		Kandy municipality		Jaffna municipality	
Gardening in land	%	Gardening in land	%	Gardening in land	%
Front and back side	64	Only front	52	Front and back side	69
All four sides	22	Front, left, and right side	31	All four sides	15
Other	14	Other	17	Other	16

4.7.3.2 Land Cover Pattern in Urban Home Gardens

The biophysical aspects in regard to different land cover types and the distribution and diversity of species in urban home gardens in the study sites were examined.

Species Distribution Pattern of Urban Home Gardens

Fruits, vegetables, spices, ornamental plants, medicinal plants, and timber crops could be identified as prominent species types in all three study sites. However, there is a noticeable spatial variation. According to Fig. 4.33, the highest amount of fruit, vegetable, and timber crops were grown in the Galle urban landscape, as this practice is essential for meeting nutritional food requirements while also saving money. Fruit and medicinal plants covered similar areas in both the Kandy and Jaffna urban landscapes. Kandy displayed the largest area of ornamental and medicinal plants among the study sites, with the amount of ornamentals being particularly high. However, there was noticeably a small amount of vegetables and

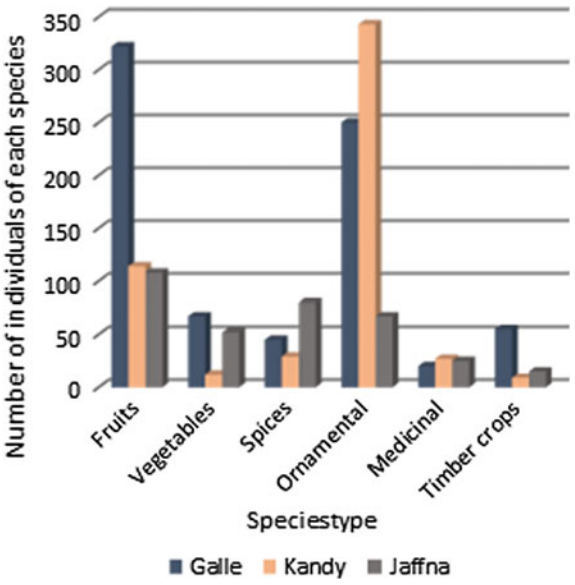

Fig. 4.33 Species distribution pattern of urban home gardens in the Galle, Kandy, and Jaffna municipalities

timber crops in Kandy urban home gardens. There is no doubt that all three urban home gardens have occupied the highest amount of ornamental and fruit species. It is also possible to consist of more ornamental species, as Pushpakumara et al. (2012) indicated that urban home gardens are more aesthetically oriented.

Even though there is no distinctive record of a particular species, Jaffna exhibited an evenly distributed pattern in regard to species type.

The species distribution pattern can be further examined in regard to distance from the city center. Maps created for such a purpose assign numbers 1–15 to locations in each site according to distance from the city center while pie charts show percentage distribution of species relevant to the location.

As shown in Fig. 4.34, even though ornamental and fruit species are homogeneous in Galle urban home gardens, vegetables comprise a major percentage within a one-kilometer buffer zone from the city center. Additionally, other species were not seen to vary with this distance.

Figure 4.34 further indicates that ornamental plants comprised the largest area in Kandy urban gardens. Other species such as fruits, vegetables, spices, medicinal, and timber crops were also present but in much lower amounts. Thus, Kandy exhibited less evenness.

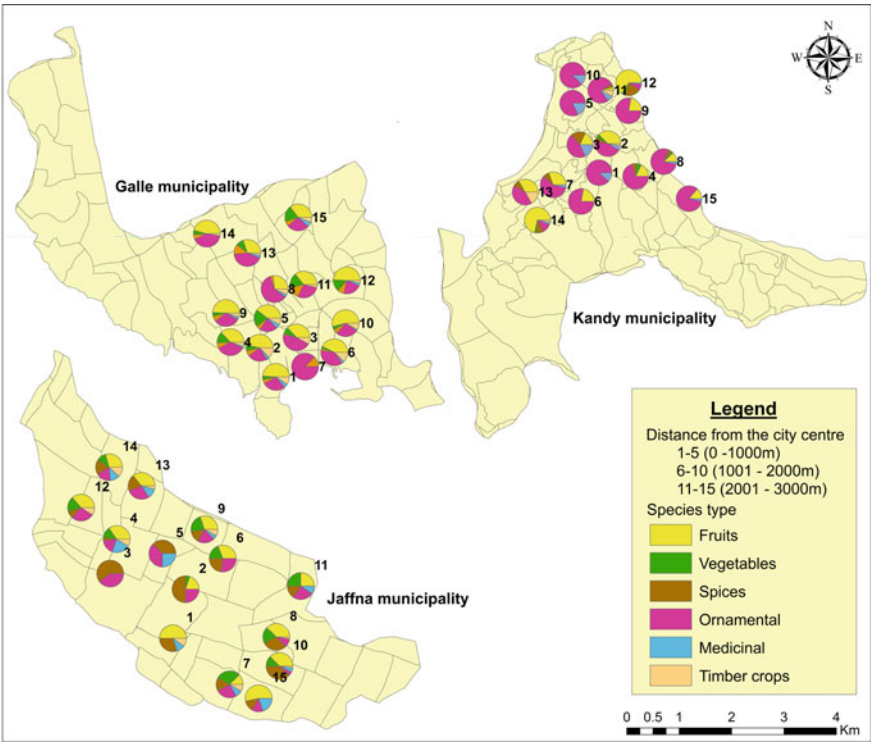

Fig. 4.34 Species distribution pattern in respect to the distance from the city center (Galle, Kandy, and Jaffna municipalities) (design by Lalitha Dissanayake and M. M. G. S. Dilini)

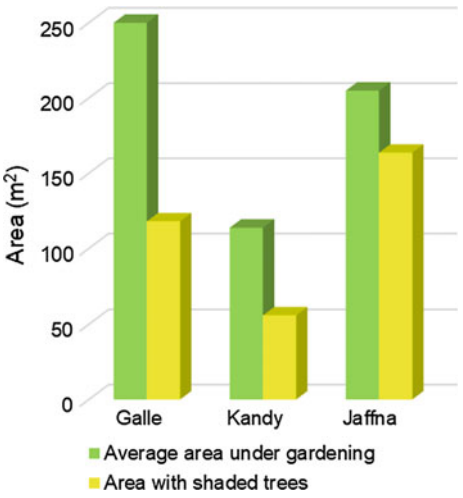

Fig. 4.35 Shaded tree area within urban home gardens in the Galle, Kandy, and Jaffna municipalities

Meanwhile, Jaffna exhibited a considerable percentage of spice, fruit, and ornamental species throughout the city area. The land was also seen to be utilized for other species. Therefore, species distribution evenness in the Jaffna landscape was the highest among the three study sites.

The species distribution pattern of urban home gardens was further identified based on the shaded tree area within the landscape. Shaded trees provide shade to the surrounding environment, spreading a leafy canopy to facilitate protection from sunlight. Also, they help ensure the privacy of the dwellers.

As shown in Fig. 4.35, shaded tree species in Jaffna and Galle were more numerous than in Kandyan urban home gardens. It may be obviously relative to the size of the home garden plot. This lesser distribution of shaded species in Kandyan urban home garden plots may be due to limitations of the urban area, such as coverage problems and root damage to construction foundations. Erythrina and palmyra were the most abundant shade species in Jaffna.

Species Diversity of Urban Home Gardens

Most fruit and ornamental species were common in the three study sites, with banana (*Musa paradisiaca*), mango (*Mangifera indica*), guava (*Psidium guajava*), and lemon (*Citrus limon*) specifically observed. Ornamental species such as hibiscus, rose (*Rosa*), and jasmine (*Jasminum*) were also present. In addition to these common species, there were other predominant species types observed in the three study sites. Coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophylla*), areca nut (*Areca catechu*), papaya (*Carica papaya*), passion fruit (*Passiflora edulis*), drumstick (*Moringa olefera*), ginger (*Zingiber officinable*), and karapincha (*Murraya koenigii*) were the most prominent species types in Galle urban home gardens, while ornamental species such as rose (*Rosa*), hibiscus (*Hibiscus*), croton (*Codiaeum variegatum*), orchid (Orchidaceae), jasmine (*Jasminum*) and spices like

karapincha (*Murraya koenigii*) were distinctive of Kandy urban home gardens. Jaffna exhibited the most diverse varieties, including palmyrah (*Borassus flabellifer*), drumstick (*Moringa oleifera*), sugarcane (*Saccharum officinarum*), pomegranate (*Punica granatum*), passion fruit (*Passiflora edulis*), rose apple (*Syzygium aqueum*), margosa (*Azadirachta indica*), aloe vera, croton (*Codiaeum variegatum*), orchid (Orchidaceae), jasmine (*Jasminum*), rose (*Rosa*), and hibiscus (*Hibiscus*).

Species diversity in the three study sites can be further understood through the measured value. Simpson's index of diversity was calculated to this end, with richness and evenness of species considered to clarify the results. The richness value (e.g., number of species per sample) was the highest in Galle and lower in Kandy and Jaffna. Moreover, the relative abundance of the different species and evenness was the highest in Jaffna and lower in Galle and Kandy. Simpson's index of diversity was 0.69 for Galle, 0.54 for Kandy, and 0.78 for Jaffna. The index ranges from 0 to 1, where 0 signifies low diversity and 1 signifies high diversity. Accordingly, species diversity was the highest in Jaffna urban home gardens despite its low richness value. This could be due to the high evenness of species in this study site. Galle urban gardens exhibited the second highest record, as they also exhibited the highest richness and considerable evenness values. Even though Kandy exhibited greater species richness than Jaffna, it also displayed the lowest index of diversity due to its lowest evenness value among three study sites.

4.7.3.3 Brief Discussion on Processes of Urban Home Gardens

Possible functions of urban home gardens can be understood through the structural and land cover patterns in terms of distribution and diversity of species. In general, food production is a key function of home gardens in addition to balancing socioeconomic needs and ecosystem quality with aesthetic beauty, ensuring biodiversity, and maintaining carbon sequestration via air purification. The recent study of Kunhamu (2013) shows that a typical home garden consists of a multiple output production system, including aesthetic and ecological services. Even though urban home gardens have lower richness of species values compared to their rural counterparts, the functional basis is the same. However, urban home gardens contribute to each function less than their rural counterparts. As the study reveals, Galle and Jaffna landscapes exhibit higher amounts of land utilized for gardening, a better distribution pattern, and greater diversity of species than the urban home gardens in Kandy. Accordingly, functional capacity was also better in Galle and Jaffna than in Kandy.

Furthermore, little attention has been paid to sustainable gardening in terms of species distribution and fertilization. As mentioned in Sect. 4.7.3.2, native species are not often considered. Additionally, organic fertilization was not observed to function well in Kandy urban home gardens. Possible organic fertilizers that can be found in home gardens come from plant or animal waste. As shown in Table 4.7, compost, legume/green manure cover crops, animal manure, and urea are common

Table 4.7 Fertilizer usage of urban home gardens in the Galle, Kandy, and Jaffna municipalities

Type of fertilizer	Usage percentage (%)		
	Galle	Kandy	Jaffna
Compost	20	10	17
Legume/green manure cover crops	8	8	5
Animal manure	3	0	20
Urea	3	0	10
Chemical fertilizer	32	47	20
Foliar fertilizer	20	25	8
No fertilizer use	14	10	20

types of organic fertilizers, with 34% of Galle and 52% of Jaffna urban home gardens implementing these fertilizers and only 18% in Kandy.

Although composting is a commonly used fertilization method, it is used less in the Kandy municipality. There are also no animal manure or urea users for Kandy urban gardens. There are also fewer users in Galle. Despite Jaffna urban dwellers not often engaging in animal husbandry, they have practiced using cow feces and urea for their gardens. Thus, it can be ascertained that Jaffna urban home gardens are heading in the direction of organic gardening.

Furthermore, a difference in benefits obtained from urban home gardens can be identified. Questionnaire analysis and the semi-structured interviews highlighted the major reasons for urban home gardens in Jaffna and Galle: food production. Meanwhile, Kandy was more oriented toward aesthetic beauty, as shown in Table 4.8. A recent study carried out by Legesse et al. (2016) indicates that fruit and vegetable production in the home gardens of urban areas tend to increase household fruit and vegetable consumption. Since individuals living in Galle and Jaffna significantly utilized their home gardens for food production, they also exhibited a higher potential to fulfill their nutritional requirements. Table 4.8 shows that economic purposes are the least frequent reason for gardening, with the highest rates observed in Galle at 7.1%.

Studies carried out by Daily (1997) emphasize that the functional basis of home gardens is both tangible and intangible. Therefore, environmental functions are difficult to measure quantitatively. However, it is relatively evident that considerably contributing to environmental quality are the factors of land area used for gardening, species distribution, and diversity. Galle displayed higher values in terms of land used for gardening and distribution. The second highest land

Table 4.8 Predominant uses of urban home garden products in the Galle, Kandy, and Jaffna municipalities

Major type of use	Galle (%)	Kandy (%)	Jaffna (%)
Food	57.7	29.0	69.1
Aesthetic beauty	32.5	64.2	19.3
Medicinal	2.6	5.0	7.2
Economic	7.1	1.6	4.3

utilization and highest species diversity values were observed in Jaffna. Therefore, the study revealed that Galle and Jaffna urban home gardens might have greater environmental functions than their Kandyan counterparts.

4.7.4 Conclusions

According to the analysis, it can be concluded that the structural and functional aspects of urban home gardens display major spatial variation among the three different study sites (and even within one city area). Land utilized for gardening was significantly higher in Galle and Jaffna while lower in Kandy. The underlying reasons for this could be land pressure in the urban landscape, greater area taken up by the house, individual lifestyles, and animal disturbances in Kandy. Another important factor is the pattern of land utilization for gardening increase with distance from the city center. The structure of the garden with respect to house location was also an observed pattern, as Kandy urban home gardens were mostly located in front of the house while the other two sites utilized the whole surrounding area. Grown plant species were mostly of the fruit and ornamental variety; only the Jaffna urban home gardens were evenly planted with respect to species. Therefore, Jaffna displayed the highest rates of diversity despite the total number of species being low. Furthermore, it was observed that little attention is given to sustainable gardening in terms of species distribution and fertilization in the three study sites. However, the Jaffna urban home gardens were somehow directed toward organic gardening. A distinctive factor is the purpose of the urban home gardens. While the reason for gardening was food production in Jaffna and Galle, it was aesthetic beauty in Kandy. All in all, urban home gardens require diversity in regard to existing weaknesses with respect to their structural and functional aspects to ensure a socioeconomic and environmental balance.

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