



HAL
open science

Home gardening and the social divide of suburban space: Methodological proposal for the spatial analysis of a social practice in the Greater Paris urban area

Sécolène Darly, Thierry Feuillet, Clémence Laforêt

► To cite this version:

Sécolène Darly, Thierry Feuillet, Clémence Laforêt. Home gardening and the social divide of suburban space: Methodological proposal for the spatial analysis of a social practice in the Greater Paris urban area. *Sustainability*, 2021, 13 (6), pp.3243. 10.3390/su13063243. hal-03170442

HAL Id: hal-03170442

<https://hal.science/hal-03170442>

Submitted on 16 Mar 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Article

Home Gardening and the Social Divide of Suburban Space: Methodological Proposal for the Spatial Analysis of a Social Practice in the Greater Paris Urban Area

Ségolène Darly ^{1,*}, Thierry Feuillet ^{1,*}  and Clémence Laforêt ²

¹ Geography Department, UMR 7533 LADYSS Research Unit, Paris 8 Vincennes Saint-Denis University, 93200 Saint-Denis, France

² Geography Department, Cergy-Paris University, 95011 Cergy-Pontoise, France; clemence.laforet@sciencespo.fr

* Correspondence: segolene.darly@univ-paris8.fr (S.D.); thierry.feuillet@univ-paris8.fr (T.F.)

Abstract: This paper explores home gardening geography in metropolitan outskirts, seen as a major asset and challenge of the alternative suburban city model. Studies that estimate the domestic production of backyard gardens are scarce, but they all confirm the persistence of an ancient and “ordinary” phenomenon still firmly rooted in the food landscape of the globalised North cities. To fill a gap in European alternative urban and food systems studies, we focus on the case of two subsectors of the extended suburban belt of greater Paris agglomeration. We designed and performed a spatial analysis protocol that differentiates vegetable garden types to test spatial relationships between environmental and intrinsic factors and assess clustering patterns. We had to overcome several methodological barriers by building an original vegetable gardens database and applying distinct qualitative and quantitative methods. Our results show spatial home gardening patterns differentiation at three intertwined levels: At the micro-level of domestic space (according to the size and share of vegetable plots); at the house block level (according to their socio-economic and built environment profile); and at the level of the housing estates or urban agglomeration (according to the geography of social specialisation).

Keywords: vegetable gardens; home gardening; greater Paris region; point pattern analysis; Ripley’s K-functions



Citation: Darly, S.; Feuillet, T.; Laforêt, C. Home Gardening and the Social Divide of Suburban Space: Methodological Proposal for the Spatial Analysis of a Social Practice in the Greater Paris Urban Area. *Sustainability* **2021**, *13*, 3243. <https://doi.org/10.3390/su13063243>

Academic Editor: Brian Deal

Received: 14 December 2020

Accepted: 9 March 2021

Published: 16 March 2021

Publisher’s Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The contribution of urban agriculture to urban social resilience has been acknowledged in the Global South contexts for several decades [1–3]. More recently, it has also been part of the utopian narratives of the ideal city in Northern countries [4,5]. An abundant scientific and expert literature explored and asserted its potential contribution to improve the urban environment, to enhance social interactions between city dwellers, to secure part of the local and quality food supply, but also to mitigate the effects of social inequalities (see [6]). This literature is now widely used both in planning approaches that are rooted in the “sustainable” urban development schemes [7], but also by part of the social movement fighting for more social, environmental, or food justice [8,9]. In this context, urban and environmental studies are expected to play an important role in assessing the credibility of a “productive city” model that relies on its “green infrastructure” to locally ensure a part of its food supply in good sanitary conditions and for all segments of the population [4,10]. In response, scholars engage in prospective approaches, analysis of available resources [11–16] and expected benefits [17] or inventory approaches, more akin to the diagnosis of existing practices and initiatives [18,19].

As new collective gardening initiatives (neighbourhood-based initiatives led by gardeners or more militant in the struggles of the social movement) and commercial enterprises

are currently burgeoning in the heart of large conurbations, they tend to drive a lot of attention from scholars and planners, especially in prospective approaches [14,15]. In comparison, residential vegetable gardens are often neglected, even though they provide a great proportion of local urban production [20]. Studies aiming to estimate this domestic production are scarce, but they all confirm the persistence of an ancient phenomenon that is still firmly rooted in the food landscape of the cities of the globalised North (studies cited in [13]): In North America, a national study estimated that 25% of resident households in the United States self-produced part of their food [21], while more targeted studies of large cities in the USA [22,23] and Canada [24,25] showed that between 40% and 50% of households surveyed grew a vegetable garden. In Europe, a quantitative questionnaire survey that includes five regions from five countries compared in each case the answers of urban and rural respondents and estimated that the share of urban households engaged in food gardening activities in urban areas varies from 13% (Netherlands) to 49% (Hungary) and also showed that this self-production was strongly correlated with the ownership of a single-family house [26]. In France, a 2008 national survey on household food consumption revealed that nearly 30% of households living in suburban areas, where the single-family house dominates the urban landscape, declared that they self-produced part of their food [27]. Detailed mapping of three medium-sized cities in the western part of France exhibited that between 10% and 17% of the gardens of single-family homes were occupied by a vegetable garden large enough to be detected by the aerial image [28].

In recent years, several research projects have tested methods, combining qualitative and quantitative approaches, to better appreciate the weight of these forms of domestic food production in urban space [29–31], as well as their contribution to the metropolitan food system [28,32]. These results largely confirmed the hypotheses resulting from the census surveys (see above) and revealed, beyond the extent of the phenomenon, its uneven spatial distribution. This heterogeneous distribution revives the debate about urban agriculture by questioning the promise of a significant and “sustainable” contribution of home gardening to the urban system, as it could result in an unbalanced accessibility of ecosystem services and local food sources among city dwellers. It makes necessary to better understand, on the one hand, the variegated motivations that drive (or prevent) households to invest domestic labour for self-producing food, but also, on the other hand, to assess the various place effects that affect this motivation and how it is anchored and reproduced in an urban environment. To focus on the geography of home gardening and its relationship with urban contexts using a quantitative spatial analysis approach might help us to tackle this issue. All the studies related to this field underlined that the main factor determining the investment of domestic labour in food self-production is the ownership of a private garden (adjoining a detached house) [26,29]. This observation explains, for instance, the critical situations observed in the central districts of American metropolises, where the increased land insecurity of poor residents living in single-family homes without owning them reduces the likelihood of investing in a vegetable garden, which is recognised as one of the levers for alleviating the burden of social inequality among these populations.

In the context of the Western European cities, the shift in food-producing efforts that dwellers invest in their home gardens arises less in the central areas of conurbations than in their outskirts. The edges of the central conurbations and the surrounding urban countryside (also called peri-urban or commuting areas depending on the national context) currently host a significant part of the urban population [33], all social classes taken together. While the United Kingdom is certainly one of the Western European countries that first experienced the phenomenon, in France, it is estimated that the share of the population living in a rural municipality under urban influence varies between 23% and 35% (depending on the zoning selected) [34]. The annual population growth rate has been the highest in commuting belts of large urban areas over the last four decades [35]. Formerly industrial and agricultural countryside, part of this urban countryside had first welcomed new local factory workers, which mainly belonged to the social groups of the working-class [36]. Then, according to each city, popular middle-class commuters

started to settle also nearby city centres. They triggered a more general movement of peri-urbanisation that most major (and now even minor) cities have experienced since then [33]. Furthermore, this dynamic, has been fuelled in recent decades by the departure from the city centres of the wealthy middle-classes, and even “rich” households, who were themselves confronted with unprecedented real estate pressure in the historic centres of large cities. Experiences of population containment linked to the COVID-19 health crisis have even led some media [37] to forecast new waves of migration to the countryside and metropolitan commuting belts.

Despite these well-known figures, metropolitan outskirts (suburbs and commuting belts) have been pushed back into the dead angle of the sustainable urban food system studies. This fact is even more manifest in Europe (and especially in France), where single housing developments are blamed for turning the traditional rural landscape into working- and middle-class “unsustainable” commonplaces [38]. Nevertheless, some scholars recently called for more pragmatic research that would consider the alternative practices that unfold in the suburbs and commuting urban belt model [39]. Thus, in this regard and to fill a gap in European alternative urban and food systems studies, we focused on the case of suburban spaces of a major European city (Paris), where the great majority of housing takes the form of the individual house, and whose peripheral location allowed us to be part of a reflection on the sustainability of “ordinary” practices.

Home gardening is a food production activity that strongly relies on time availability and free manual household labour. Most of the work that questioned the evolution of the productive relationship to the gardened space, therefore, focused on the profile and motivations of gardeners to determine their degree of involvement. In these prospects, a high food-producing effort in the garden has long been interpreted as the expression of a *habitus* (a lifestyle transmitted throughout familial, educational or any other long-standing socialization networks [40]) of working-class households linked to subsistence practices constrained by a critically low level of income. Studies of ethnoecology or micro-geography of gardens pointed out that, in reaction to the negative affects associated with manual and subsistence work, households tend to convert the ‘utilitarian’ vegetable garden to ‘ornamental’ lawns and flowerbeds as a way to exhibit an ascending social trajectory [41]. These findings have led to predict the disappearance of vegetable home gardens in countries experiencing an increase in the working-class level of incomes. Scientific literature shows, however, that free goods and financial savings are far from being the only motivations driving gardeners to invest time and energy in food self-production [42–46], even for low-income households: Performing a hobby activity, accessing fresh and healthy food, food sharing, maintaining and transmitting cultural identity (among other) are generally mentioned or experienced by gardeners, with no direct link with the level of incomes. More recently, the analysis of ordinary environmentalism practices supported the hypothesis of a new movement in the “green shift” of domestic labour, largely driven by environmental ethics and expressed by the emergence of new, more “ecological” practices to which households with high cultural capital openly adhere. These practices are widely observed in collective gardening initiatives in gentrified neighbourhoods [47], but can also be found in some individual gardens [48]. The fact that this environmental ethic is more likely to be publicly demonstrated in these cases does not mean that gardening practices in more popular contexts lack ecological care; it is simply less explicitly expressed and more fairly implemented [44]. If the investment of gardeners for the productive act seems nowadays to diversify according to their cultural background and individual motivations, their unequal spatial distribution in the metropolitan space must also be analysed in the light of environmental contexts in which they anchor, particularly those that influence the residential trajectories (i.e., accessibility to space and resources) of peri-urban households.

In this paper, we propose a spatial analysis protocol that differentiates vegetable gardens according to the domestic space allocation made by gardeners, to characterise their spatial distribution and to assess the spatial relationships between the density of garden, their types and some environmental factors. Our objective is to produce knowledge that

can help urban planning to recognise, maintain and support “actually existing sustainability” [49,50]. In this perspective, our contribution is also novel because it tested tools to overcome methodological limits raised in the literature of this field. Qualitative field surveys are generally performed to qualify the complex entanglement of gardeners and their contribution to the production of urban space. However, it presents important biases linked to the socio-cultural profile of the individuals who are most willing to respond. Studies that adopt a more quantitative approach of self-provisioning practices [26,51,52] manage to overcome this bias, but tend to overlook their spatial dimension, especially at the scale of the urban fabric. In this article, we propose a complementary method that relies rather on a micro-geography of vegetable plots to differentiate the profiles of gardeners based on their willingness to allocate domestic space for food growing. We, therefore, draw more attention to the spatial expression of gardeners’ motivations while considering all existing gardens. Regarding the spatial analysis of vegetable garden distribution, this is generally detected by comparing the densities calculated within a continuous grid over the entire study area. This method is well suited to the context of a continuous urbanised fabric, but is not suitable in the discontinuous urban fabric of peri-urban areas, spatially distributed according to the geography of the village nucleus seedling inherited from rural history. We, therefore, propose to adapt the protocol for evaluating the spatial aggregation of vegetable gardens to this particular urban fabric configuration.

2. Materials and Methods

2.1. Study Area

To achieve these objectives, we took as a case study some urban peripheries of the Paris metropolitan area. These areas contain the earliest (in France) phenomenon of industrial settlement, dating back to the end of the 19th/beginning of the 20th century. The successive settlements of the middle-classes, wealthy and high-income households began then as early as the 1960s and continued until recent times.

The Paris region is deeply marked by the polarisation of the economic, administrative and political capital located in its centre. This urban agglomeration brings together more than 10 million people in 2018 and is by far the major centre of settlement in the French and European (alongside London) urban structure. This strong centrality structures the area of influence of this agglomeration (which extends beyond the regional boundaries) into radiocentric density sectors (Figure 1). Despite the high density of the most central parts (over 100 inhab./built ha, over 300 for the core), the edges of the agglomeration and its outer belt contain nearly 43% of the regional population.

The spatial analysis protocol presented in the following sections was tested on two subsectors (Table 1): A northern subsector composed of 44 municipalities located in the north of the Parisian metropolitan agglomeration, around the Roissy airport (North sector/Roissy) and a southern subsector composed of 57 municipalities located around the geographical entity of the Saclay plateau (South/Saclay). These two sectors were chosen because they are representative of the contrasted socio-environmental regional trajectories, characterising the strong social polarisation of this region [53,54]. The North/Roissy sector is still a predominantly popular area (low-incomes and lower-middle-classes with even a few pockets of impoverishment), where households are attracted by the low level of land prices which allow them to access single housing ownership. Conversely, the South/Saclay sector is mostly invested by dwellers from the upper-middle-class, affluent and very high social groups, whose arrival is accompanied by the fairly characteristic effects of rural gentrification, especially in the sectors with the greatest environmental and landscape amenities (especially the wooded valleys that are highly prized for their ecological quality).

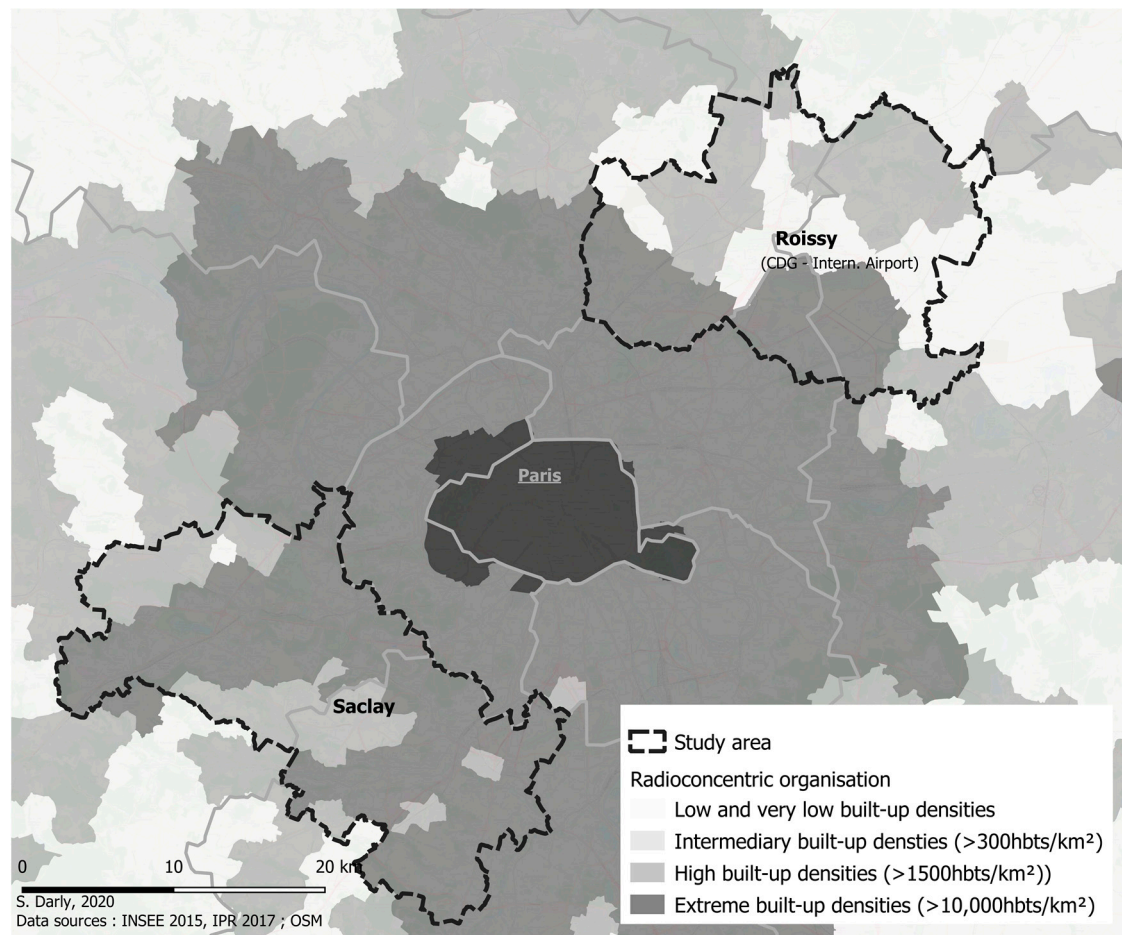


Figure 1. The central area of the Paris Region. The grey colour indicates the built-up density and illustrates the radioconcentric organisation. The two subsectors included in our study area are located in the metropolitan outskirts: Around Roissy in the North, around Saclay in the South (data: National Institute of Statistics and Economic Studies INSEE, 2015).

Table 1. Households repartition between the two subsectors (data: INSEE, 2015).

	Pop. (households)	Single House Households/All Households	House Owners/All Households
Île-de-France region	11,987,500 (4,875,580)	27.90%	47.80%
Roissy subsector	432,769 (143,639)	47.11%	53.40%
Saclay subsector	804,445 (317,265)	34.02%	55.85%

2.2. Mapping Home Kitchen Gardens

We focused on the case of home kitchen gardens (or vegetable home gardens), i.e., vegetable garden grown on the house yard, considering that in most cases, the allocation of space for food growing is directly linked to individuals' decisions, whereas in allotments, gardens and other types of collective gardens, location and spatial design of the plots are framed by more or less formal collective rules. Domestic spaces cultivated by urban gardeners are particularly difficult to map automatically at the scale of urban territories. No tax database lists them. Their small size, their internal heterogeneity and the need to take into account contextual elements to differentiate them, especially when it comes to isolated vegetable gardens, such as those in houses, make them objects that escape automatic classification methods. Several studies have also tested and recognised that, even at the scale of an entire city, it is more appropriate to use manual orthorectified image classification methods [28,29,31]. Manual classification “may be the only suitable

strategy for identifying such a diverse and fine-scale urban land use as urban agriculture, particularly at the scale of the home garden" ([21], p. 59).

In our case study, home gardens were mapped by manual photo-interpretation. The vegetable garden limits were digitalised by vectorisation on a background of 2014 images from the IGN's ORTHO HR (c) database, a database of orthorectified aerial photographs with a resolution of 20 cm, using a GIS software. The vectorised boundaries are those of the outer edges of the cultivated portion of the garden. This cultivated plot was identified by the succession of more or less wide bands, of variable colour and texture, corresponding to different plant varieties and growth stages. Garden sheds, often bordering the cultivated portion of the garden, were not included in the perimeter.

Field surveys (direct observations of 212 vegetable home gardens distributed in 10 municipalities) carried out in 2018 provides a series of matching examples between the real objects that we were trying to map (e.g., crop boards, arrangements) and the shapes and textures observed on the orthophotos (we used a set of 2018 images for this purpose). These surveys were not used to check the accuracy of the database (as changes can occur over the years), but were helpful to find "on the field" gardens that matched the images, and therefore, provide illustrations and criteria to formalise and homogenise the classification choices of the different operators who participated in the several digitisation processes over the two sectors of the study area. Vectorisation was also based on the cadastral boundaries of private properties, by displaying on-screen the PARCELLARY (c) DB of the cadastral parcels (tax plots) provided by the IGN. The polygon vegetable garden layer was then converted into a dot layer based on centroids, leading to a spatial point pattern. Association of each point to tax plots (cadastral parcels) id and intrinsic information (overall area and non-built area of the tax plot) was carried out through a spatial join with the cadastral parcel database (BD PARCELLAIRE (c) of the IGN). This step provided the necessary information to assess the micro-spatial configuration of each garden (e.g., share of vegetable gardening area, total size of the garden).

In order to compare and support discussion on the contribution of home gardening to urban self-provisioning dynamics, a complementary mapping of *spatially bundled* allotment gardens was performed in the case study perimeter: Only the external boundaries of the allotment were digitalised for this purpose (we, therefore, could not evaluate the number of gardeners involved but only the total area).

2.2.1. Spatial Indicator of Food Related Motivations and Residential Profiles of Gardeners

From the map of vegetable garden plots, we calculated the total area of cultivated land within a tax plot, considering that they were cultivated by the same gardener. We retained this area as an indicator of the time, knowledge and energy that gardeners are willing, given his or her set of motivations, to invest in food growing. Based on the scientific literature (see above), we know that gardeners' motivations unfold in many dimensions, each one of them being linked to growing food. We assume here that providing a significant amount of food can still be an important dimension of some specific gardeners' motivations, even if food security is not the main objective anymore. For example, this will be the case when their goal is to significantly improve the freshness and quality of their meals on everyday bases, or when they wish to support an extended network of social relationships by regularly donating or exchanging goods. Gardener's specialised literature and web resources oriented toward French gardeners recommend to consider that 100 m² is the minimum land size necessary for those who attempt to cover the food needs of a household of 3 or 4 persons for a large part of the year. In addition, [55] observes that the surface area of individual plots allocated to a household in allotment gardens (whose vocation is historically food provisioning) is globally higher than 100 m² (oscillates between 100 and 200 m²). This figure is consistent with estimated households' consumption and gardener's productivity values that can be found in the scientific literature: Given the average vegetable crop yields, which can vary between 1.2 kg/m² [28,56] and 2.4 kg/m² [21,57], we can consider that a gardener who grows a 100 m² vegetable garden is able to produce between 120 kg and 240 kg per year,

which is close enough to the estimated value of the French annual consumption of fruits and vegetables of 117 kg/year/person estimated from [58]. Moreover, this 100 m² threshold allows us to relate our data to a recent empirical survey applied in Parisian allotment gardens (therefore, in similar pedo-climatic conditions and plant species availability). In this research, the authors adopted the 100 m² threshold to differentiate “big plots” from the others and showed that despite the yield variability, the highest amount of food is produced on the biggest plots [56].

In addition to the area of the productive vegetable plot, we assumed that the total area of outdoor domestic space (productive vegetable portion and non-productive ornamental portion taken altogether) informs us about the residential standard the household was able to reach (given its preferences and resources). From the tax plot database, we were able to derive the unbuilt area of the tax plot, which we retained as an indicator of the area of outdoor domestic space. As for the sorting of vegetable gardens according to cultivated plot size, the tax plots were divided into two groups according to the value of the non-built area, whether it was higher, or lower than 400 m². In France, the average size of private gardens is estimated at 600 m² [59], but the specific context of Île-de-France, where the cost of land is higher than in other contexts, led us to calculate this value from our field data. The 400 m² value corresponds, therefore, to the median value of the unbuilt area of the tax plots in the individual housing areas of our two study sectors, which we calculated from the official database of cadastral plots (BD PARCELLAIRE (c) of the IGN) and the land use mapping produced in 2012 by the Institut Paris Region (IPR).

2.2.2. Covariates

In this paper, we propose to explore the covariation between the density of vegetable gardens and two variables indicating the spatial and social differentiation of the living environment. Our aim is to bring new empirical elements that help to challenge two common assumptions: (i) The fact that home gardening is more frequent in rural areas (whereas self-provisioning unfolds in urban areas in the form of allotment gardens); and (ii) the fact that self-provisioning is mostly a response to the household financial bankrupt. At the municipality level, we selected the urban fabric density, considered as an indicator of the spatial differentiation of the living environment. The municipality urbanicity profile was determined from a national classification of the population density values of built-up areas performed by the National Institute for Statistics and Economic Studies (INSEE). Following this database, the municipalities were, thus, divided into three groups: Urban, intermediate and rural. The urban profile corresponds to the group of “densely populated municipalities”, the intermediate profile to the group of “intermediate category” municipalities and the rural profile to the group of “low density” and “very low” municipalities (Table 2).

Table 2. Municipalities and households distribution among the two subsectors (data: INSEE, 2015), Pool sample = Roissy sample + Saclay sample.

Urbanicity Profile	Urban (High Built Area Densities)		Intermediate (Interm. Built Area Densities)		Rural (Low Built Area Densities)	
	Municip.	Households	Municip.	Households	Municip.	Households
Pool Sample	51	378,617	33	77,224	17	5063
Roissy subsector	11	98,976	17	39,638	16	5025
Saclay subsector	40	279,641	16	37,586	1	38

At the house block level, we retained the average standard of living of households per census tile as an indicator of the socio-economic profile of the neighbourhood. The census tile is the smallest aggregation grid for the data from the general population census

and the tax data managed and disseminated by the National Institute of Statistics and Economic Studies. The settlement areas are divided by a grid of tiles of 2 ha (200 m by 200 m, about 5 acres), each tile containing the aggregated individual data of at least 11 tax households. By selecting only tiles, including at least one vegetable garden, we had the value of the average standard of living of the households living inside the tile (average disposable income per consumption unit), as well as the urbanicity profile of the municipality in which the tile is located. The average standard of living variable calculated from the tax data was discretised into quartiles to differentiate between four types of neighbourhoods: Low-income (values between Lowest value and first quartile, referred as Low), lower-median-income (values between first quartile and median value, referred as MedianLow), upper-median-income (values between median value and third quartile, referred as MedianHigh) and high-income (values between third quartile and highest value, referred as High). The median standard of living in our study area (all sectors combined) is 27,496 euros (Table 3). This value is higher than the median standard of living for France as a whole, estimated in 2014 at 20,830 euros, and is closer to the upper bound for “upper-middle-class” living standards in the overall classification of living standards. Thus, the Low-class corresponds rather to the income of the social groups known as the “popular middle” social class, the MiddleLow class to those of the “upper-middle” social class, MiddleHigh to those of the “well-off” social class and High to those of the social group known as the “rich” (above a certain threshold of very-high-income).

Table 3. Average standard of living (average incomes per consumption unit) classification thresholds in the pool sample and the two subsectors (data: INSEE, 2015).

Classification Thresholds	Lowest Value	First Quartile	Median Value	Third Quartile	Highest Value
Pool	9806	22,737	27,496	33,256	58,481
Roissy	10,268	19,346	22,620	25,582	44,388
Saclay	9806	25,993	30,570	35,544	58,481

This shift towards higher values for the pool sample is explained by the social particularity of the Ile-de-France region: On the one hand, this region concentrates part of the wealth creation of the French economy and household incomes (as well as the cost of living), on the other hand, the tiles, including vegetable gardens, correspond a priori to urban blocks of privately owned single-family houses that remain unaffordable for the poorest households. This indicator is illustrating the social contrast discriminating our two subsectors, as the incomes distribution in the Roissy subsector is closer to national standards than in the Saclay subsector, where the values are significantly higher (Table 3).

2.3. Data Spatial Analyses

Another way to explore the link between financial or cultural resources and home gardens and their contribution to the production of urban space is to assess if they follow the social divide of suburban housing developments [53]. In order to quantitatively characterise the spatial distribution of home gardens, our objectives were threefold. We wanted to test whether (i) gardens followed a specific spatial distribution responding to any place effects, (ii) there were any spatial relationships between types of gardens (attraction or repulsion) and (iii) the spatial distribution of gardens were associated with spatial covariates, i.e., urbanicity and the socio-economic environment. At a regional scale, gardens can be considered as a point pattern, i.e., geographical points assumed to have been generated by a random process [60]. As such, the set of methods used in point pattern analysis can be relevantly involved to verify our hypotheses.

2.3.1. Exploring the Spatial Patterning of Gardens Using the Ripley’s K-Function

The fact of questioning possible place effects on the development of gardens amounts to asking whether gardens are randomly distributed across space (i.e., generated by a

Poisson process, also called complete spatial randomness—CSR), or whether they tend to spatial clustering (attraction) or spatial dispersion (repulsion). In the case of actual place effects, spatial clustering would be expected. One of the most common methods used to explore such distribution patterns in the occurrence of spatial events is the Ripley's K -function [61]. Briefly, this technique consists of counting the number of neighbouring gardens in circles of various radii (noted r) around each garden, then calculating the average number of gardens for each r , and ultimately comparing these average numbers to those that would have been achieved in the case of a CSR process. Mathematically, the empirical K -function is given by [62]:

$$\hat{K}(r) = \frac{|A|}{n(n-1)} \sum_{i=1}^n \sum_{j=1}^n 1\{d_{ij} \leq r\} w_{ij}(r) \text{ with } j \neq i$$

where $|A|$ being the study area in the observation window, n the number of gardens, d_{ij} is the distance between two gardens in a given buffer of radius r , $1\{d_{ij} \leq r\}$ is an indicator equalling 1 if ' $d_{ij} \leq r$ ' is true and 0 otherwise, and w_{ij} is an edge correction weight. The choice of the observation window is an essential component of point pattern analysis. This window should correspond to the area where gardens could occur, and should, thus, exclude, for instance, water or forest area. Since we focused here on residential gardens, we used observation windows that we crafted by merging the layers "single housing area" and "gardens and parks" extracted from the IPR MOS database (keeping only the portions of polygons overlapping the grid used by INSEE to locate its demographic and socio-economic data). Another crucial point is the application of an edge correction weight. An edge effect occurs when the number of points inside a circle of radius r , centred on the point of the process inside A , is not observable if the circle extends outside A [62]. Here we used a translation correction (see [62] for the mathematical demonstration). The empirical function is then compared to a K -function that would have been generated by a CSR process. An acceptance interval with a significance level 0.05—called envelope—centred around this CSR K -function, allows to easily and visually assess whether the empirical K -function is significantly different from a completely random distribution, at different scales. The envelopes around the theoretical values were obtained by computing 99 Monte Carlo simulations of CSR.

Furthermore, gardens here are categorised in four specific types, so that they can be considered as a marked, or multitype, point pattern. Therefore, empirical K -functions were computed for the pool sample of gardens, but also for each type separately. In addition, cross-type K -functions were computed to explore the relationships between the point patterns of different garden types. This method consists, for each pair of garden type, in counting the expected number of gardens of type j lying within a distance r of a typical point of type i , standardised by dividing by the intensity (i.e., the density, measured in gardens per unit area) of gardens of type j , noted λ [62,63]:

$$\hat{K}_{ij}(r) = \frac{1}{\lambda_j n_i n_j} \sum_{k \in i} \sum_{l \in j} 1\{d_{kl} \leq r\} w_{ij}(r) \text{ with } k \neq l$$

where k indexes the gardens of type i and l the gardens of type j , n_i being the number of gardens of type i and n_j the number of type j .

2.3.2. Modelling the Association between Garden Intensity and Spatial Covariates

In a second step, we aimed to explore the relationships between the garden intensity and two spatial covariates (municipality urbanicity level and average standard of living at the house block level). We first fitted an additive Poisson point process model, where we assumed that the garden intensity is a loglinear function of the two covariates:

$$\lambda(u) = \exp(\beta_0 + \beta_1 R(u) + \beta_2 L(u))$$

where $\lambda(u)$ is the intensity of gardens, $R(u)$ is the level of urbanicity at location u , $L(u)$ the average standard of living at location u , and β_0 , β_1 and β_3 the parameters to be estimated. Standard of living was quantified differently in the pool sample model and in the submodels, because of a strongly varying distribution according to places. In the pool model, the variable was included as a discretised variable derived from the quartile of the raw continuous variable. In each submodel, it was included as a continuous variable. In order to check for spatial dependence issues, the residual K -function was estimated, as considered as the closest analogue of residual spatial autocorrelation (in fitted GLM) for a fitted point process model (A. Baddeley, personal communication, January 19, 2021). The residual K -function computes discrepancies between the observed and predicted numbers of pairs of points along a gradient of distances, in a manner similar to a spatial correlogram. Results (not shown) exhibited positive residuals at various scales, indicating spatial dependence between points, thus, violating a basic regression assumption. Such a residual spatial autocorrelation is often attributable to an unobserved spatially patterned covariate that influences the spatially varying intensity of points. To overcome this issue, we computed a Cox process model (method of minimum contrast), as recommended by Baddeley et al. [62], since such a model includes dependence on covariates and positive correlation between points. Cox (and cluster) process models are defined as Poisson process models with a random intensity function, i.e., with a random effect. This random effect is supposed to capture the unobserved spatial covariate. Note that the estimates of the model coefficients are the same in Poisson and Cox process models. What differs is the uncertainty of the estimates, larger in Cox models. In other words, Cox models have wider confidence intervals, and are, thus, more trustworthy (Baddeley et al. [62], Section 12.4.4). Finally, goodness-of-fit for the fitted Cox models was estimated through Diggle–Cressie–Loosmore–Ford Monte Carlo tests, as recommended by Baddeley et al. [62]. The null hypothesis is that the data point pattern is a realisation of the model, therefore, a p -value > 0.05 indicates no evidence against the fitted model.

Regression coefficients were systematically exponentiated to be interpreted as the odds ratio. All the statistical methods were applied both to the pool sample and to the two study subsectors separately to explore possible territorial heterogeneity, and computing using the spatstat R package [62].

3. Results

3.1. Overall Geographical Description

3.1.1. Micro-Spatial Patterns and Typology

On the two subsectors, we inventoried 7792 tax plots containing one or more vegetable growing areas. This cultivated areas shows a median size of 72 m² for a total area of 81.42 ha, which is almost equivalent to the total area of allotment gardens (see Table 4). In most cases (55%), the vegetable plot is located within large house yards, i.e., >400 m² (the median for all house yards with vegetable plots being 443 m²). If only 32.5% of gardeners cultivate vegetable plots that measure more than 100 m² (indicating strong motivations for food provisioning), the total area represents more than 65% of the total vegetable home gardening (VHG) area of the pool sample. These aggregated values mask a heterogeneity of spatial configurations unveiled by the crossing of the two criteria retained as indicators of the degree of motivation to produce food in quantity and the profile of the owner (large or small) of the gardener. The set of spatial configurations of the vegetable gardens is distributed among the four profiles resulting from this crossing, in unequal, but never negligible, proportions (Table 1)—22.5% vegetable gardens are grown by largeholder food provider gardeners (Type 1), 10% by smallholder food provider gardeners (Type 2), 35% smallholder complementary gardeners (Type 3) and 32.5% by largeholder complementary gardeners (Type 4).

Table 4. Quantitative assessment of the presence of vegetable home gardening (VHG) in the pool sample and two subsectors.

	Tax plots with VHG	Houses with VHG as % of Single Houses (Estimated)	VHG Total Area	Median Area	M ² of VHG/Households	Total Area of Allotment Gardens
Total	7792	4.00% *	81.42 ha	72 m ²	1.7	98 ha
North/Roissy	3591	5.20% *	40.23 ha	79 m ²	2.7	53 ha
South/Saclay	4201	3.34% *	41.19 ha	62 m ²	1.3	55 ha

* The share of single houses with a vegetable home garden is globally low, but the indicator shows great variation between municipalities and can reach 10 to 20% in several cases.

The major contributors to local food provisioning are gardeners from Type 1, which grow more than half of the total VHG area, whereas the contribution from the three other types of gardeners is more balanced (respectively 14.2%, 16.8% and 16.75% of the VHG area). For most gardeners, the food production sector fulfils less than a third of the non-built area in the tax plot. This value even drops to 8% for the Type 4 gardeners profile. For the smallholder food providers, though, vegetable gardens take over half of the outdoor domestic space.

3.1.2. Inter-Sectors Spatial Distribution

The total number of tax plots with a vegetable garden was not equally divided between the two subsectors (Table 4). But even if they were more numerous in the South/Saclay (which subsector is larger in size and number of localities), they covered a total area that is merely equivalent to the one in the North/Roissy subsector. In this subsector, vegetable gardens were more frequent among single house households and larger, which results in doubling the amount of m² per household in this area.

While Type 1 gardens weighted equally in the total numbers of gardens in each subsector, Type 2 gardens were three times more represented among the Roissy subsector gardens, whereas Type 4 gardens were two times more represented in the Saclay subsector gardens (Table 5).

Table 5. Subsectors differentiation for each type of garden patterns (i.e., gardeners profile).

	N Tax Plots (% of Sector Total VHG)	Total Area	Median VHG Size	Ratio Food/Garden
Type 1 profile—largeholder food provider				
Total	1765 (22.5%)	42.54 ha (52.3%)	184 m ²	26%
North/Roissy	798 (22%)	19.08 ha (23.4%)	188 m ²	30%
South/Saclay	967 (22%)	23.45 ha (28.8%)	180 m ²	24.00%
Type 2 profile—smallholder food provider				
Total	765 (10%)	11.50 ha (14.1%)	139 m ²	50%
North/Roissy	554 (15.5%)	8.40 ha (10.3%)	140 m ²	51%
South/Saclay	211 (5%)	3.10 ha (3.8%)	135 m ²	51.00%
Type 3 profile—smallholder complementary gardener				
Total	2711 (35%)	13.71 ha (16.8%)	48 m ²	20%
North/Roissy	1471 (41%)	8.18 ha (10.1%)	53 m ²	20%
South/Saclay	1240 (29.5%)	5.52 ha (6.8%)	40 m ²	17.00%
Type 4 profile—largeholder complementary gardener				
Total	2551 (32.5%)	13.64 ha (16.8%)	52 m ²	8%
North/Roissy	768 (21%)	4.53 ha (5.6%)	59 m ²	10%
South/Saclay	1783 (42.5%)	9.10 ha (5.6%)	48 m ²	7%

3.1.3. Intra-Sector Spatial Distribution

In both Roissy and Saclay subsectors, the highest density values were almost ten times higher than the lowest. Vegetable gardens were not equally distributed, resulting in high contrasts between neighbourhoods (Figure 2). Moreover, the highest density values were more frequent in the northern/Roissy sector, which suggests that, in addition to the

inter-sectorial differences we pointed out, the intensity of the intra-sectorial fluctuations also differs between the two subsectors.

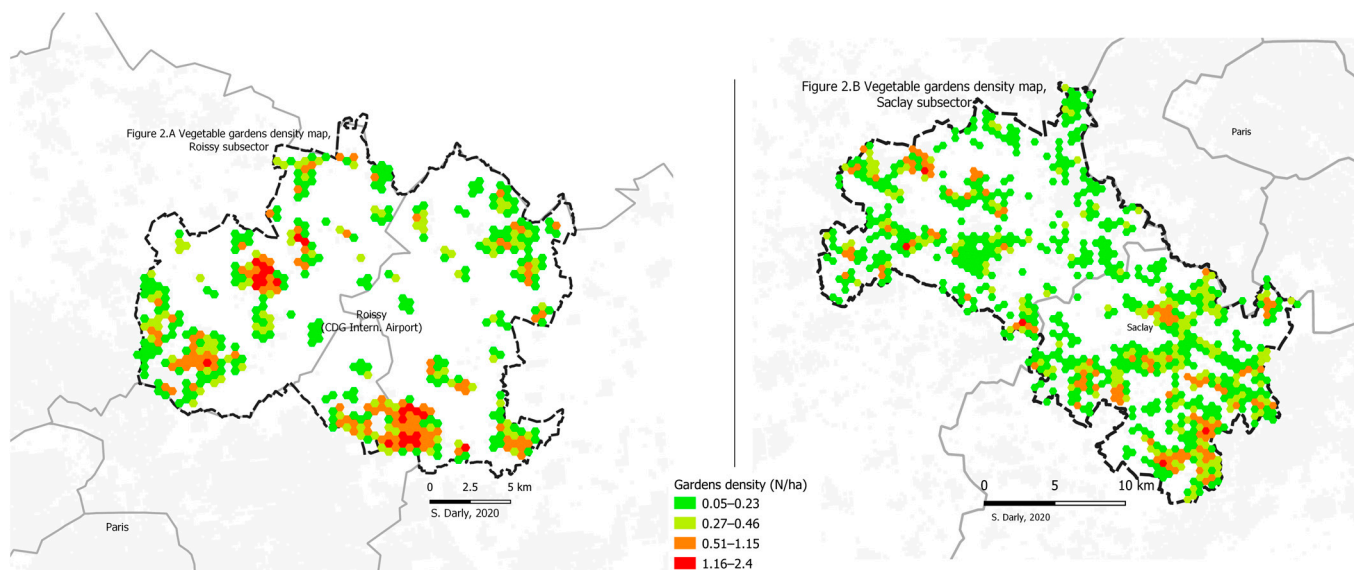


Figure 2. Vegetable gardens density maps.

3.2. Descriptive Statistics on Garden Spatial Patterning

The spatial distribution of gardens (all types and by type) was first compared to a theoretical CSR distribution using k -functions, for the whole sample and for each subsector (see Figure S1 in Supplementary Materials). In the pool sample as for each area—considering all types of gardens—we exhibited a significant trend to spatial clustering at all scales. Yet, nuances clearly appeared according to garden types. In the Roissy area, Type 1 gardens appeared to be regularly distributed (i.e., spatial repulsion) when considering a neighbouring scheme > 1000 m, while Type 4 gardens were randomly scattered at all scales. Finally, Type 2 and Type 3 gardens were strongly clustered. In the Saclay area, results were more homogeneous, with a trend to spatial clustering of all types of gardens, in particular for Type 1.

Regarding spatial relationships among types of garden, cross-type k -functions also revealed contrasted results (Figure 3). In the Roissy area, the main pattern was a significant and strong clustering trend between gardens of Types 2 and 3 (Figure 3A) and in a less measure between gardens of Types 3 and 4. We also noted a spatial repulsion between Types 1 and 4 at radii ranging from ~ 1.5 km to ~ 4 km. All the other pairs were independently distributed. In the Saclay area (Figure 3B), there was spatial aggregation between Types 1 and 2, and 1 and 4 (Figure 3B), whatever the scale, but only at the largest radii between Types 2 and 3, 2 and 4, 3 and 4 ($> \sim 2$ – 3 km). Types 1 and 3 were independently distributed, just at Roissy.

3.3. Cox process Models with Spatial Covariates

In the pool sample (both Saclay and Roissy), considering all garden types, the estimated intensities (i.e., densities) of gardens were significantly higher in middle- (high- and low-) income census tiles compared to wealthier ones (Table 6). Interestingly, there were contrasts according to garden types. The estimated intensity of Type 4 gardens was lower in median-low- and low-income areas than in high-income areas (odds ratio < 1). For instance, for a given level of urbanicity, the intensity of Type 4 gardens is 0.523 times lower in low-income areas than in high-income areas (Table 6). Regarding the urbanicity variable, there was no significant effect in the all-garden model, hiding however contrasted results by types of gardens. For instance, the intensities of Type 1 gardens were 0.56 times

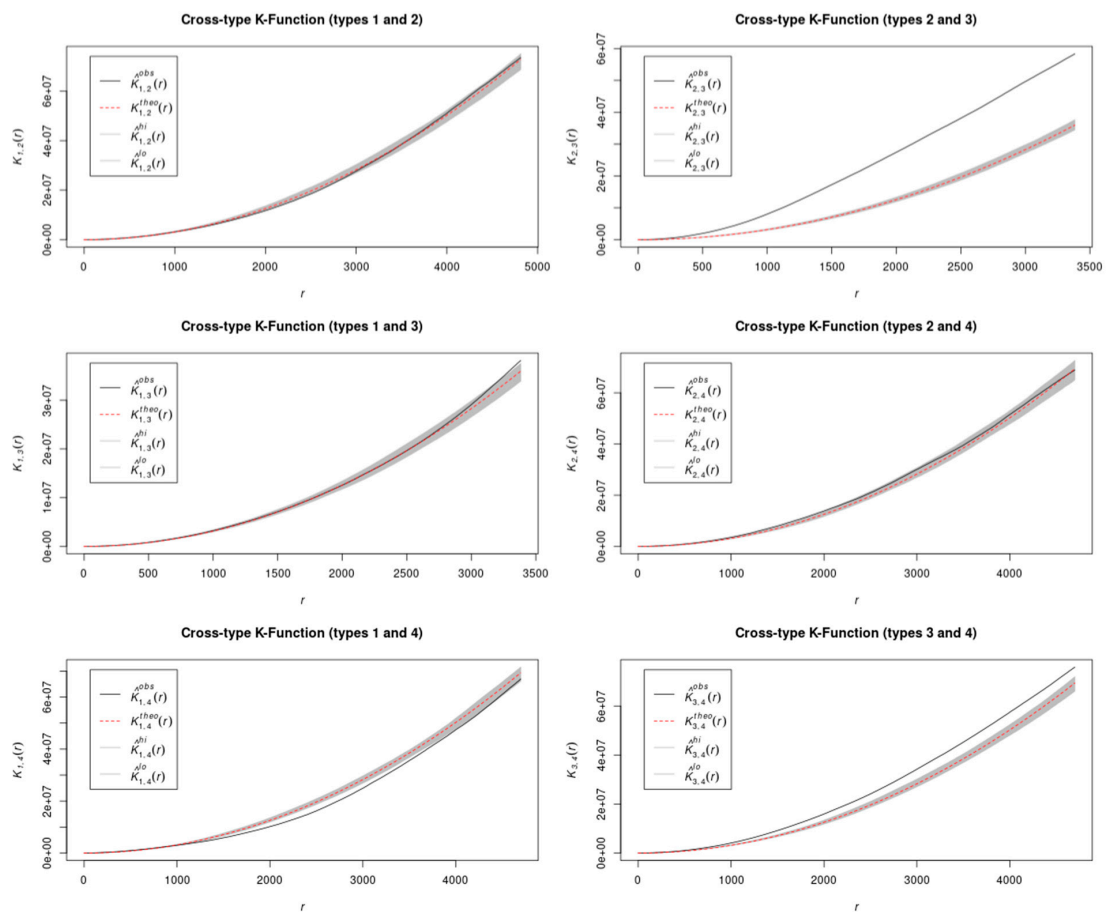
lower in rural areas than in urban areas, while Type 3 garden intensity was 2.308 times higher in intermediate urban than in urban areas (and 2.126 times higher in rural areas).

Table 6. Outputs of the Cox point process models for the pool sample (Saclay and Roissy, n = 8098), and subdivided by garden types. The response variable is the intensity of gardens.

	All Gardens		Gardens Type 1		Gardens Type 2		Gardens Type 3		Gardens Type 4	
	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest
(Intercept)	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
Standard of life										
High	ref		ref		ref		ref		ref	
MedianHigh	1.728	***	2.185	***	4.126	***	2.181	***	1.099	
MedianLow	1.827	***	1.848	**	8.572	***	3.154	***	0.667	**
Low	1.395		1.386		4.212	***	1.985	*	0.523	**
Urbanicity										
Urban	ref		ref		ref		ref		ref	
Rural	0.986		0.562	*	0.636		2.126	*	0.843	
Intermediate	1.107		0.74		0.796		2.308	*	0.933	
Goodness-of-fit (p-values) ¹	>0.05		>0.05		>0.05		>0.05		>0.05	

*** p-value < 0.001; ** p-value < 0.01; * p-value < 0.05. ¹ Diggle–Cressie–Loosmore–Ford Monte Carlo test. p-value > 0.05 indicates no evidence against the fitted model.

Cross-type K-functions - Roissy area



(A)

Figure 3. Cont.

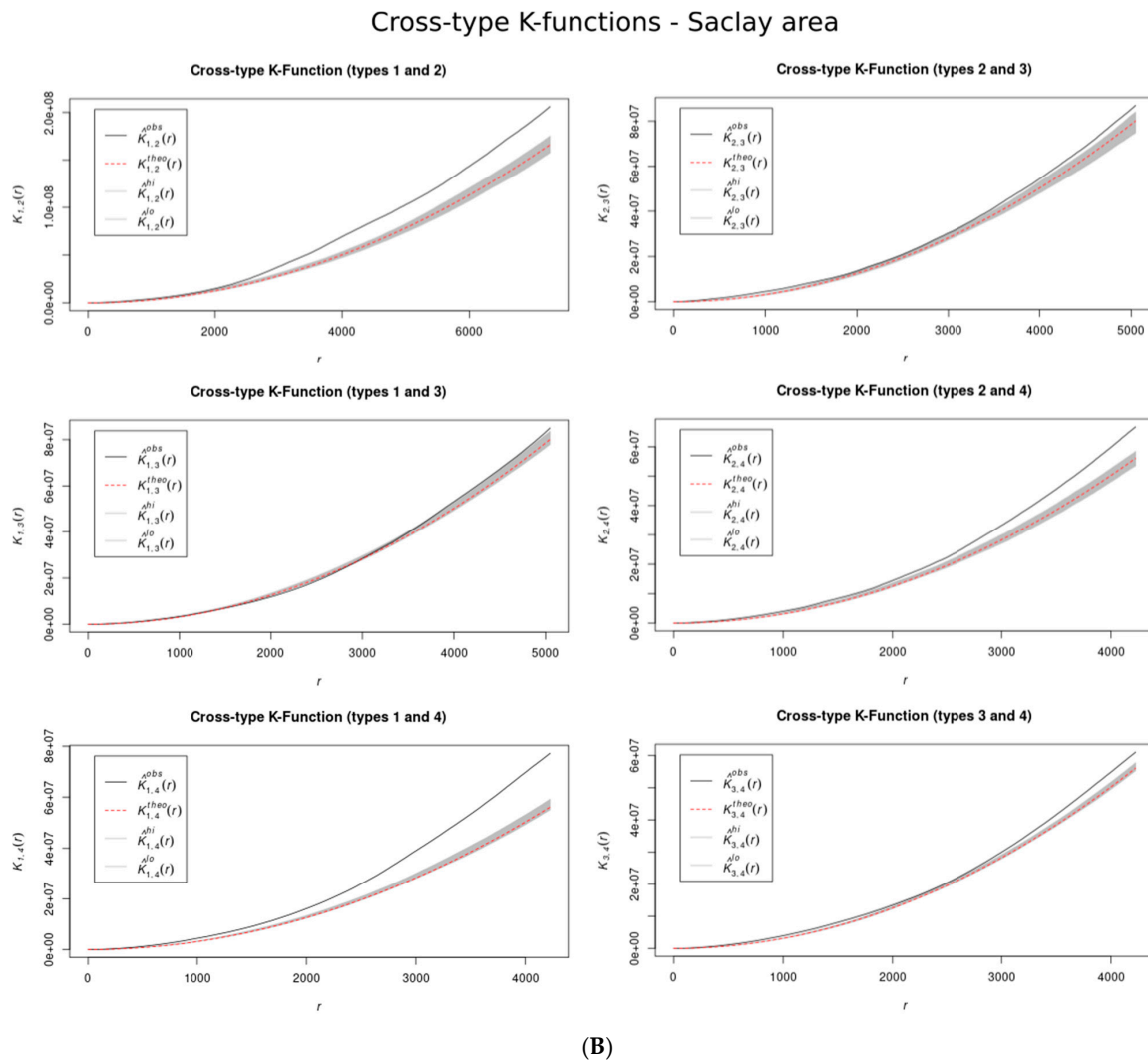


Figure 3. Illustration of the empirical cross-type k -functions for each pair of garden types ($n = 6$ pairs) in (A). The Roissy area, and (B) the Saclay area. The red dotted curve is the output of a complete spatial random process, the grey envelope is the acceptance interval with a significance level 0.05 computed from Monte Carlo simulations of CSR, and the black curve is the empirical function. The black curve above the dotted curve indicates a spatial clustering of the two types of gardens, spatial repulsion if below, random otherwise.

In the two following submodels, for Roissy and Saclay, respectively, the area-level income was considered as a continuous numeric variable (Tables 7 and 8). At Roissy, the overall effect of area income was non-significant, again hiding heterogeneous patterns according to gardens. The effect was indeed significantly negative for Type 2, but positive among Type 4. For instance, for a given level of urbanicity, the intensity of Type 2 gardens decreased by a factor of 0.93 (i.e., about -7%) for each additional k€, while that of Type 4 increased by a factor of 1.05 (i.e., around $+5\%$) for each additional k€. There was no significant effect among Type 1 and Type 3. Regarding the urbanicity level, models revealed strong differences between gardens of Types 1 and 3: Type 1 was 0.56 times lower in rural than in urban areas, but Type 3 was 3.148 times higher in rural areas and 2.68 times higher in intermediate.

Table 7. Outputs of the Cox point process models for the Roissy sample (n = 3724), and subdivided by garden types. The response variable is the intensity of gardens.

	All Gardens		Gardens Type 1		Gardens Type 2		Gardens Type 3		Gardens Type 4	
	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest
(Intercept)	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
Average annual income (k€)	0.992		0.991		0.932	*	0.966		1.053	**
Urbanicity										
Urban	ref		ref		ref		ref		ref	
Rural	1.214	**	0.56	*	1.397		3.148	**	0.808	
Intermediate	1.261	**	0.825		1.423		2.607	*	1.091	
Goodness-of-fit (<i>p</i> -values) ¹	>0.05		>0.05		>0.05		>0.05		>0.05	

*** *p*-value < 0.001; ** *p*-value < 0.01; * *p*-value < 0.05. ¹ Diggle–Cressie–Loosmore–Ford Monte Carlo test. *p*-value > 0.05 indicates no evidence against the fitted model.

Table 8. Outputs of the Cox point process models for the Saclay sample (n = 4374), and subdivided by garden types. The response variable is the intensity of gardens. In the area, there is no “rural” category in the urbanicity variable.

	All Gardens		Gardens Type 1		Gardens Type 2		Gardens Type 3		Gardens Type 4	
	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest	Odds Ratio	Ztest
(Intercept)	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
Average annual income (k€)	0.955	***	0.942	***	0.944	*	0.946	***	0.970	***
Urbanicity										
Urban	ref		ref		ref		ref		ref	
Intermediate	1.157		1.189		1.014		1.324		1.083	
Goodness-of-fit (<i>p</i> -values) ¹	>0.05		>0.05		>0.05		>0.05		>0.05	

*** *p*-value < 0.001; ** *p*-value < 0.01; * *p*-value < 0.05. ¹ Diggle–Cressie–Loosmore–Ford Monte Carlo test. *p*-value > 0.05 indicates no evidence against the fitted model.

At Saclay, the average annual income had a significant negative effect on garden intensity (i.e., the more the income increases, the more the density of gardens decreases), whatever the types of gardens. However, the level of urbanicity was non-significant.

4. Discussion

Our results led us to claim that the uneven distribution of home gardening intensity among the metropolitan outskirts should be understood as the intertwining of several place effects which unfold at three specific levels of the urban making. They shed new light on the shifting links between food providing motivations and the urban environment.

At the level of domestic-space production (the level of garden plots), the geography of micro-spaces suggests that the amount of outdoor domestic space is a factor that influences the extent of vegetable gardening. Our findings challenge the assumption that in urban contexts, only households with the lowest incomes (and therefore, can only access the smallest estates) are interested in self-provisioning practices. On the contrary, we showed that, in addition to the fact that the majority of the vegetable plots (55%) were located within large house yards (over 400 m²), 70% of the large vegetable plots (over 100 m²) are grown within large green yards, and 41% of largeholders grow large vegetable plots, which is two times higher than smallholders (22%) [43,54,55]. Moreover, the fact that the median size of house yards where vegetable plots were detected was higher than the median size of all greenyards suggests indeed that vegetable gardening is less plausible when house yard size fall under a certain threshold (yet to be measured in this case, but already shown in the literature [38,48,49]). This finding calls for more accurate field checking and unveil

one major limitation of our methodology, due to the difficulty of detecting the smallest vegetable plots (under 10 m²) by photo-interpretation.

Nevertheless, if sufficient domestic land availability seems to remain a condition for vegetable gardening to occur, it does not mean it will always result in a significant quantitative contribution to the food system. In a significant number of situations (Type 4 VG, i.e., 42.5% in Saclay and 21% in Roissy), comfortable space availability did not lead to a vegetable plot large enough to indicate strong food providing related motivations. We can assume that it relates to changing household's motivations which are less dependent on food share or exchange [48,64]. Even if they contribute to a lower share of the total food production spatial capacity (25% of the total surface), these patterns should be considered for the gardening knowledge and cultural value that are embedded and reproduced in it (even on small areas) and that are necessary for future resilience.

Moreover, this significant shift should not underscore the fact that more than 65% of the vegetable gardened area is grown by dwellers sharing a strong interest in food providing and related social practices (Type 1 and 2). For the Type 2 gardens, i.e., 15.5% of the Roissy gardens (and 5% in the Saclay sector), large VHG were even grown in much smaller estates. Even if they are less numerous, these two patterns confirmed that "relocation" of domestic food production in the metropolitan outskirts still relies on motivations related to self-sufficiency gardening, food sharing or informal exchanges. Our findings also led us to discuss the relevance of focusing on the ratio between the cultivated and non-cultivated area to assess the food consumption/sharing gardeners motivations in the case of private single house home gardens: The biggest cultivated plots (of 184 m² median value) cover, in average, less than a third of the house yard area. The maximum extent of vegetable plots is still strongly limited by domestic work resource.

A great number of studies showed that one major function of community [65] and allotments gardens are to create a local environment that supports social interactions and micro-local networks. Other studies went further and explored home gardening as a social practice, therefore, considered that micro-local gardeners networks are also essential to vernacular gardening reproduction for cultural (transmission and exchange of knowledge), economic (non-commercial exchange of goods and services), and therefore, social (maintaining a valued position in specific social networks) reasons [45,66,67].

At the house block level, the aggregation of single house plots with vegetable gardens can be seen as a micro-local environment where social interactions that unfold between dwellers enable vernacular gardening reproduction. The spatial relationships we tested in this research revealed the single house blocks profiles that are more likely to enable this kind of socio-spatial setting (higher density of individual vegetable plots planted by neighbouring gardeners). We have shown that the only type of vegetable gardeners that are denser in the "rich" house blocks is the Type 4, largeholder complementary gardeners: At the pool sample scale, Type 4 gardens are 0.667 and 0.523 times less dense in Median Low and Low average annual income areas (middle and popular social classes) and in the Roissy subsector, an increase of average income has a positive effect only on the Type 4 gardens' density. This is consistent with the fact that access to larger housing properties requires a higher level of incomes. The only exception, in this case, is in the Saclay subsector, where it appears that an increase in annual income has a negative effect on Type 4 gardens density. Given that this subsector is wealthier than Roissy, this finding suggests a certain threshold of annual income above which only households who tend to significantly less frequently practice vegetable access ownership (this individual decision can be explicitly required by the co-owners bylaws of high standing residences for example). These figures demonstrated the accuracy of extending the geographic perimeter of the study to include in the data set enough cases to cover the range of contrasted local contexts, as the same factor variation had opposite effects when looked at a different subsector.

Apart from the Type 4 gardens mentioned above, the other types of gardens were significantly denser in the median- and low-income house blocks. This finding is consistent with the assumption that lower value of incomes favours lower property prices (and loans),

fostering access to single housing, but also drives households to invest more time and energy in domestic activities.

Nevertheless, statistical models demonstrated that the level of income is not the only house block level environment factor that explains the geography of home gardening. Our results showed that, for a given level of average annual income, urbanicity (built-up density) context influences gardens frequency, specifically, Types 1 and 3: Largeholder food providing gardeners seem to be more frequent in urban house blocks, whereas smallholder complementary gardeners occur more in rural and intermediate density contexts. These features suggest that density can influence the frequency of certain types of gardening in two opposite ways: On the one hand, it can relate to more social and cultural opportunities, which could drive dwellers away from domestic activities (this could explain the significantly lower density of Type 3 gardens in urban areas); on the other hand, it implies that access to ownership is more competing from households with lower-incomes, leading them to compensate a financial effort by putting more time and energy in domestic labour for leisure, social and cultural purposes (this would explain the significantly higher density of Type 1 gardens in urban density contexts, but also the higher density of Type 3 gardens in rural and intermediate density contexts). At this point, our space-oriented approach limits our capacity to test any further these assumptions and would require additional qualitative field surveys. Moreover, we should keep in mind that other environmental variables could interfere, like the availability of allotment gardens plots, the proximity of a local food market or the density of local farms supporting direct selling.

Moreover, our spatial analysis showed variegated clustering patterns that unfold at a larger scale than the house block, from housing estate level (500 m radius sector) to small urban agglomeration (1000 m radius sector). As expected, knowing the contrasted social geography within the metropolitan, suburban and commuting belt of Paris urban area, the most significant clustering patterns that stand out were of a different kind according to the subsector (Roissy or Saclay).

In the Roissy subsector, the highest densities of vegetable gardens (see Figure 2) are explained by Type 2 and Type 3 gardens (i.e., smaller tax plots) clustering patterns, both lined up with the geography of the low-income working-class housing estates that started to flourish in this part of the region since the beginning of the 20th century (Figure 4A,B). In the Saclay subsector, if Type 2 and Type 3 gardens clusters are also present in the shape of much smaller aggregates than in the Roissy subsector, mainly within former village centres, the main garden aggregates are shaped by the clustering patterns of Type 1 and Type 4 (i.e., larger tax plots) gardens (Figure 4C,D), which follow only partly the same geography. Type 1 garden clusters are mainly located in the urban eastern part of the subsector, in houseblocks aggregates that appear as lower-average-income regarding the subsector income distribution, but which correspond more in the standard social class categories to middle-class/high-middle-class level of life. As for Type 4 gardens, several clusters were spatially independent of Type 1 clusters and located in the western urban and intermediate and richer house blocks aggregates (corresponding to “wealthy” and “rich” in the standard of living categories).

Given the high contrasts in average incomes distribution patterns between the two subsectors, these results help to refine our understanding of the relationship between the households financial resources, the differentiation of gardeners local networks and gardening reproduction conditions. It informs us how the social specialisation of the urban fabric (the aggregation of house blocks that shows similar social profiles) driven by the urban economy liberalisation [53,68] result, on the one hand, in the uneven distribution of domestic self-production [29], but also, on the other hand, in the differentiation of home gardening and gardening reproduction conditions. In the case of the Parisian suburban and commuting belt, it results in two contrasted regional dynamics: The home gardening dynamics of the most popular and middle-class contexts where vegetable plots are smaller, but overall more numerous (in a less populated context); and the home gardening dynamics of the median standard of living where cultivated plots are larger, but less numerous. In

a nutshell, our findings suggest that if higher economic capital is necessary to access spatial gardening resource throughout single house ownership (and even more access to larger estates), it does not always result in setting the conditions for vibrant local social networks that would, at the opposite, flourish in lower- or middle-class incomes single house neighbourhoods. Of course, our assumptions are challenged here by the lack of data on crop yields and intensification cultural practices and should be enhanced by additional analysis that would usefully complement the references found for the Parisian allotment gardens [56].

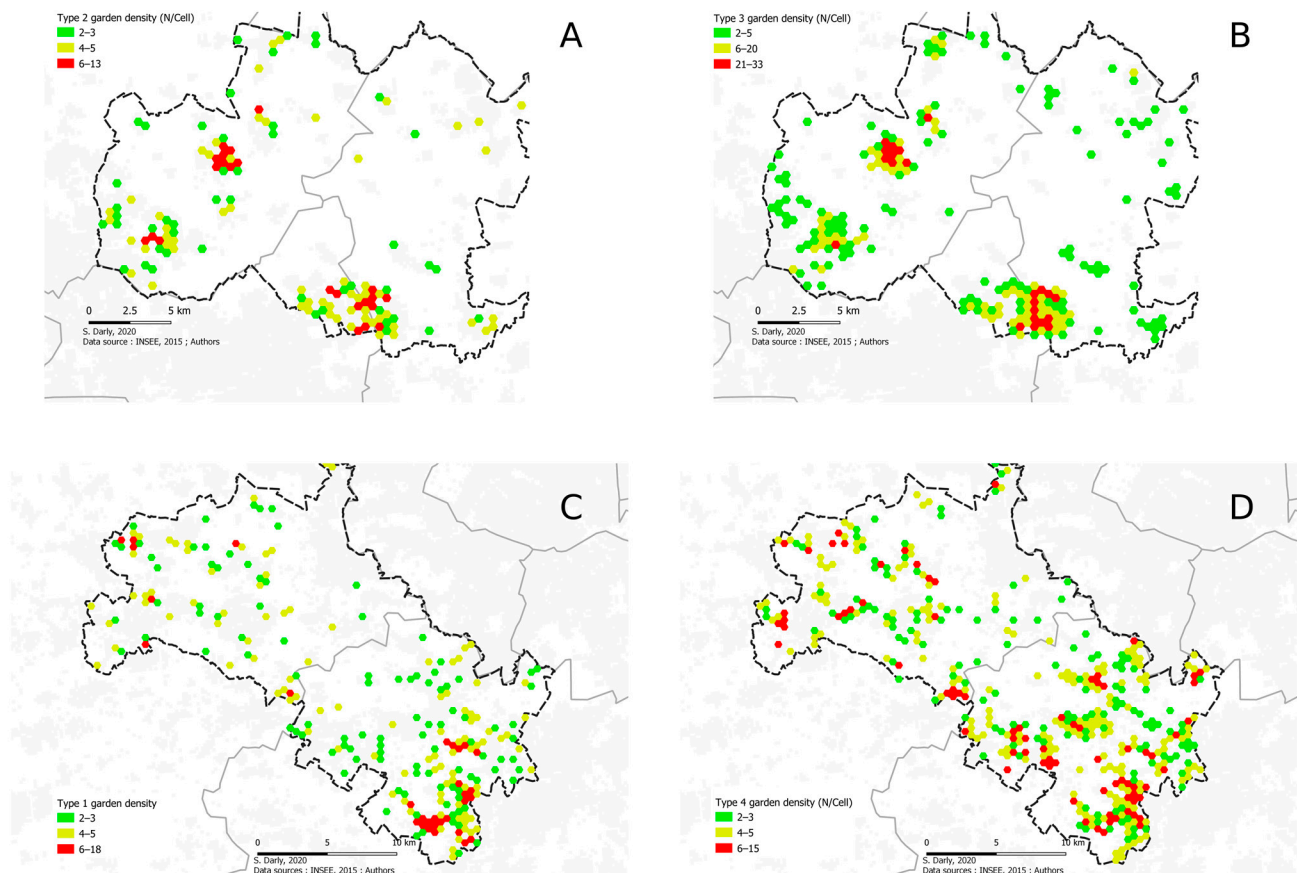


Figure 4. Density maps illustrating the most significant clustering patterns in the two subsectors. Background map represents the house block grid used as census tiles by the INSEE; it illustrates the uneven distribution of dwelling areas at a regional scale. (A). Roissy subsector, Gardens 2 densities (B). Gardens 3 densities (C). Saclay subsector, Gardens 1 densities (D). Saclay subsector, Gardens 4 densities.

5. Conclusions

This paper aimed to better understand the roots of domestic food self-production geography in metropolitan outskirts, seen as a major asset and challenge of the alternative suburban city model in Europe. We had to overcome several methodological barriers by building an original vegetable home gardens database and applying distinct qualitative and quantitative methods to assess the specific level of spatial differentiation processes involved in the complex geography of home gardening.

We demonstrated that vegetable home gardens account for almost half of the urban cultivated surfaces dedicated to domestic self-provisioning (alongside allotment gardens), and therefore, should be considered as a significant element of a sustainable suburban food system. Moreover, we showed spatial home gardening patterns at three intertwined scales. At the scale of domestic garden micro-space, we identified four classes of gardens using criteria specific to single house home gardening. The comparison of these spatial

patterns supports the idea that food growing motivations, even when they are no longer linked to financial concerns and food security, can still lead to significant cultivated area, i.e., self-provisioning activity. At the scale of the house block level, we showed that the close environment can influence the dwellers' decision of growing food. Unveiling the differential effects of average annual incomes and built-up density contexts according to gardens' type illustrates those various and sometimes conflicting environmental influences. Finally, at the scale of the housing estates or urban agglomeration, home gardens clustering patterns revealed contrasted subregional garden mix, which confirms the inclusive potential of home gardening while it unfolds in the social divide pattern of suburban space. For an equivalent quantitative contribution to the metropolitan self-provisioning system, the social network which supports the reproduction of space, knowledge and vernacular practices relies on a higher local web in low- and low-middle-class northern sectors and on bigger plots in the case of middle-class southern localities.

Finally, this study demonstrated that engaging urban agriculture studies in peripheral urban contexts (suburbs and commuting belts) bring original knowledge on its relationship with major spatial processes of the urban economy liberalisation (such as pauperisation and gentrification): As households move from the gentrified or overpopulated city centres following different residential trajectories, they relocate gardening practices and *habitus* in the outskirts following social specialising patterns which in turn alters the social profile of gardeners networks throughout which variegated gardening value and practices are reproduced.

Supplementary Materials: The following are available online at <https://www.mdpi.com/2071-1050/13/6/3243/s1>, Figure S1: Illustration of the empirical k-functions in the pool sample and the two areas, for all garden types and for each type.

Author Contributions: Conceptualization, S.D.; methodology, S.D., T.F.; software, T.F., C.L.; validation, S.D., T.F.; investigation, S.D., T.F., C.L.; writing—original draft preparation, S.D.; writing—review and editing, S.D., T.F.; supervision, S.D.; project administration, S.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research has been supported by the CAP-IDF project (financed by the PSDR Ile-de-France Research Fund), the TERRIBIO project (financed by the MSH Paris-Saclay Research Fund). They have also been supported by three research units: Ladyss (CNRS, Paris 8 University), Sad-Apt (Inrae-Agroparistech) and ESE (CNRS, Paris Saclay University).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors thank Ekaterina Konshina and Marine Levé, as well as the students from the Master ECCE (Geography Department, Paris 8 University) and Master GAED (Geography & Planning Department, Paris Ovest University) who have been involved in the early stages of the data collection. The authors would also like to thank Adrian Baddeley for his precious advice in spatial statistics.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Smit, J.; Nasr, J.; Ratta, A. *Urban Agriculture: Food, Jobs and Sustainable Cities*; United Nations Development Programme: New York, NY, USA, 1996; p. 332.
2. Zezza, A.; Tasciotti, L. Urban Agriculture, Poverty, and Food Security: Empirical Evidence from a Sample of Developing Countries. *Food Policy* **2010**, *35*, 265–273. [[CrossRef](#)]
3. Orsini, F.; Kahane, R.; Nono-Womdim, R.; Gianquinto, G. Urban Agriculture in the Developing World: A Review. *Agron. Sustain. Dev.* **2013**, *33*, 695–720. [[CrossRef](#)]

4. Viljoen, A.; Bohn, K. *Second Nature Urban Agriculture: Designing Productive Cities, Ten Years on from the Continuous Productive Urban Landscape (CPUL City) Concept*; Routledge: Abington, UK, 2014; ISBN 978-1-317-67451-1.
5. Chou, S.S. Agrarianism in the City: Urban Agriculture and the Anthropocene Futurity. *Concentric Lit. Cult. Stud.* **2017**, *43*, 51–69.
6. Lohrberg, F.; Lička, L.; Scazzosi, L.; Timpe, A. (Eds.) *Urban Agriculture Europe*; Jovis: Berlin, Germany, 2016; ISBN 978-3-86859-371-6.
7. Azunre, G.A.; Amponsah, O.; Peprah, C.; Takyi, S.A.; Braimah, I. A Review of the Role of Urban Agriculture in the Sustainable City Discourse. *Cities* **2019**, *93*, 104–119. [[CrossRef](#)]
8. Certomà, C.; Tornaghi, C. Political Gardening. Transforming Cities and Political Agency. *Local Environ.* **2015**, *20*, 1123–1131. [[CrossRef](#)]
9. Paddeu, F. From One Movement to Another? Comparing Environmental Justice Activism and Food Justice Alternative Practices; *Justice Spatiale/Spatial Justice* 2016, n°9. Available online: <https://www.jssj.org/article/dun-mouvement-a-lautre-des-luttes-contestataires-de-justice-environnementale-aux-pratiques-alternatives-de-justice-alimentaire/> (accessed on 11 March 2021).
10. Horst, M.; McClintock, N.; Hoey, L. The Intersection of Planning, Urban Agriculture, and Food Justice: A Review of the Literature. *J. Am. Plan. Assoc.* **2017**, *83*, 277–295. [[CrossRef](#)]
11. Colasanti, K. Assessing the Local Food Supply Capacity of Detroit, Michigan. *JAFSCD* **2010**, 41–58. [[CrossRef](#)]
12. Kremer, P.; DeLiberty, T.L. Local Food Practices and Growing Potential: Mapping the Case of Philadelphia. *Appl. Geogr.* **2011**, *31*, 1252–1261. [[CrossRef](#)]
13. McClintock, N.; Cooper, J.; Khandeshi, S. Assessing the Potential Contribution of Vacant Land to Urban Vegetable Production and Consumption in Oakland, California. *Landsc. Urban Plan.* **2013**, *111*, 46–58. [[CrossRef](#)]
14. Haberman, D.; Gillies, L.; Canter, A.; Rinner, V.; Pancrazi, L.; Martellozzo, F. The Potential of Urban Agriculture in Montréal: A Quantitative Assessment. *ISPRS Int. J. Geo-Inf.* **2014**, *3*, 1101–1117. [[CrossRef](#)]
15. Orsini, F.; Gasperi, D.; Marchetti, L.; Piovene, C.; Draghetti, S.; Ramazzotti, S.; Bazzocchi, G.; Gianquinto, G. Exploring the Production Capacity of Rooftop Gardens (RTGs) in Urban Agriculture: The Potential Impact on Food and Nutrition Security, Biodiversity and Other Ecosystem Services in the City of Bologna. *Food Secur.* **2014**, *6*, 781–792. [[CrossRef](#)]
16. Saha, M.; Eckelman, M.J. Growing Fresh Fruits and Vegetables in an Urban Landscape: A Geospatial Assessment of Ground Level and Rooftop Urban Agriculture Potential in Boston, USA. *Landsc. Urban Plan.* **2017**, *165*, 130–141. [[CrossRef](#)]
17. Clinton, N.; Stuhlmacher, M.; Miles, A.; Uludere Aragon, N.; Wagner, M.; Georgescu, M.; Herwig, C.; Gong, P. A Global Geospatial Ecosystem Services Estimate of Urban Agriculture. *Earth's Future* **2018**, *6*, 40–60. [[CrossRef](#)]
18. Mok, H.-F.; Williamson, V.G.; Grove, J.R.; Burry, K.; Barker, S.F.; Hamilton, A.J. Strawberry Fields Forever? Urban Agriculture in Developed Countries: A Review. *Agron. Sustain. Dev.* **2014**, *34*, 21–43. [[CrossRef](#)]
19. Certomà, C.; Martellozzo, F. Cultivating Urban Justice? A Spatial Exploration of Urban Gardening Crossing Spatial and Environmental Injustice Conditions. *Appl. Geogr.* **2019**, *106*, 60–70. [[CrossRef](#)]
20. Taylor, J.R.; Lovell, S.T. Urban Home Food Gardens in the Global North: Research Traditions and Future Directions. *Agric. Hum. Values* **2014**, *31*, 285–305. [[CrossRef](#)]
21. National Gardening Association, Special Report: Garden to Table, A 5-Year Look at Food Gardening in America. 2014. Available online: <https://garden.org/special/pdf/2014-NGA-Garden-to-Table.pdf> (accessed on 11 March 2021).
22. Comstock, N.; Miriam Dickinson, L.; Marshall, J.A.; Soobader, M.-J.; Turbin, M.S.; Buchenau, M.; Litt, J.S. Neighborhood Attachment and Its Correlates: Exploring Neighborhood Conditions, Collective Efficacy, and Gardening. *J. Environ. Psychol.* **2010**, *30*, 435–442. [[CrossRef](#)]
23. Schupp, J.L.; Sharp, J.S. Exploring the Social Bases of Home Gardening. *Agric. Hum. Values* **2012**, *29*, 93–105. [[CrossRef](#)]
24. City Farmers. 44% of Vancouver Households Grow Food Says City Farmer. 2002. Available online: <https://www.cityfarmer.org/44percent.html> (accessed on 11 March 2021).
25. Ville de Montréal. Agriculture Urbaine: Sondage Auprès de La Population de l'île de Montréal. 2013. Available online: https://ville.montreal.qc.ca/pls/portal/docs/PAGE/CHANTIER_DEMOCRATIE_FR/MEDIA/DOCUMENTS/agriculture_urbaine_sommaire_executif_05092013.pdf (accessed on 11 March 2021).
26. Vávra, J.; Megyesi, B.; Duží, B.; Craig, T.; Klufová, R.; Lapka, M.; Cudlínová, E. Food Self-Provisioning in Europe: An Exploration of Sociodemographic Factors in Five Regions: Food Self-Provisioning in Europe. *Rural Sociol.* **2018**, *83*, 431–461. [[CrossRef](#)]
27. Grange, D.; Vincelet, C. Comportements d'achats Alimentaires En Ile-de-France. In *Baromètre Santé Nutrition 2008*; Observatoire régional de santé: Paris, France, 2010; Available online: https://www.ors-idf.org/fileadmin/DataStorageKit/ORS/Etudes/2010/Etude2010_3/Comportements_achats_IdF_1_.pdf (accessed on 11 March 2021).
28. Marie, M. Estimation de La Contribution de La Production Potagère Domestique Au Système Alimentaire Local: Enseignements à Partir de l'étude Des Cas de Rennes, Caen et Alençon. *Vertigo* **2019**. [[CrossRef](#)]
29. McClintock, N.; Mahmoudi, D.; Simpson, M.; Santos, J.P. Socio-Spatial Differentiation in the Sustainable City: A Mixed-Methods Assessment of Residential Gardens in Metropolitan Portland, Oregon, USA. *Landsc. Urban Plan.* **2016**, *148*, 1–16. [[CrossRef](#)]
30. Taylor, J.R.; Lovell, S.T. Mapping Public and Private Spaces of Urban Agriculture in Chicago through the Analysis of High-Resolution Aerial Images in Google Earth. *Landsc. Urban Plan.* **2012**, *108*, 57–70. [[CrossRef](#)]
31. Pulighe, G.; Lupia, F. Mapping Spatial Patterns of Urban Agriculture in Rome (Italy) Using Google Earth and Web-Mapping Services. *Land Use Policy* **2016**, *59*, 49–58. [[CrossRef](#)]
32. Duchemin, E. L'apport Alimentaire de l'agriculture Urbaine Sociale aux Villes en Temps de Crise: Le cas de Montréal; AgriUrbain: 2020. Available online: <https://agriurbain.hypotheses.org/4739> (accessed on 11 March 2021).

33. European Commission; Statistical Office of the European Union. *Urban Europe: Statistics on Cities, Towns and Suburbs: 2016 Edition*; Publications Office of the European Union: Luxembourg, 2016; p. 282.
34. Pistre, P.; Richard, F. Seulement 5 ou 15 % de Ruraux en France Métropolitaine? Les Malentendus du Zonage en Aires Urbaines; Géoconfluences. 2018. Available online: <http://geoconfluences.ens-lyon.fr/informations-scientifiques/dossiers-regionaux/france-espaces-ruraux-periurbains/articles-scientifiques/definition-espace-rural-france> (accessed on 11 March 2021).
35. Valles, V. Entre 2011 et 2016, Les Grandes Aires Urbaines Portent La Croissance Démographique Française. 2018. Available online: <https://www.insee.fr/fr/statistiques/3682672> (accessed on 11 March 2021).
36. Mischi, J.; Renahy, N.; Diallo, A. Les classes populaires en milieu rural. In *Campagnes Contemporaines*; Editions Quæ: Versailles, France, 2016; p. 23. ISBN 978-2-7592-2515-6.
37. Tous Au Vert? Scénario Rétro-Prospectif d'un Exode Urbain. Available online: <https://theconversation.com/tous-au-vert-scenario-retro-prospectif-dun-exode-urbain-137800> (accessed on 12 March 2021).
38. Berque, A.; Bonnin, P.; Ghorra-Gobin, C. *La ville insoutenable*; Belin: Paris, France, 2006; p. 366.
39. Adelfio, M. Socially Sustainable Suburbia: Addressing a Puzzling and Multifaceted Issue. *Articulo J. Urban Res.* **2016**. [CrossRef]
40. Bourdieu, P. Habitus. In *Habitus: A Sense of Place*; Routledge: Abington, UK, 2017; pp. 59–66.
41. Dubost, F. La Scarole et Le Bégonia. Les Nouveaux Usages du Jardin. *Ethnol. Française* **1979**, *9*, 365–376.
42. Czegledy, A. Urban Peasants in a Post-Socialist World: Small-Scale Agriculturalists in Hungary. In *Post-Socialist Peasant? Leonard, P., Kaneff, D., Eds.; Palgrave Macmillan UK: London, UK, 2002; pp. 200–220. ISBN 978-1-349-41979-1.*
43. Pourias, J.; Aubry, C.; Duchemin, E. Is Food a Motivation for Urban Gardeners? Multifunctionality and the Relative Importance of the Food Function in Urban Collective Gardens of Paris and Montreal. *Agric. Hum. Values* **2016**, *33*, 257–273. [CrossRef]
44. Smith, J.; Jehlička, P. Quiet Sustainability: Fertile Lessons from Europe's Productive Gardeners. *J. Rural Stud.* **2013**, *32*, 148–157. [CrossRef]
45. Jehlička, P.; Daněk, P. Rendering the Actually Existing Sharing Economy Visible: Home-Grown Food and the Pleasure of Sharing: Home-Grown Food and the Pleasure of Sharing. *Sociol. Rural.* **2017**, *57*, 274–296. [CrossRef]
46. Kortright, R.; Wakefield, S. Edible Backyards: A Qualitative Study of Household Food Growing and Its Contributions to Food Security. *Agric. Hum. Values* **2011**, *28*, 39–53. [CrossRef]
47. Mestdagh, L. *Jardiner Entre Soi*; Éditions L'Harmattan: Paris, France, 2018; p. 306. ISBN 978-2-14-005510-2.
48. McClintock, N. Cultivating (a) Sustainability Capital: Urban Agriculture, Ecogentrification, and the Uneven Valorization of Social Reproduction. *Ann. Am. Assoc. Geogr.* **2018**, *108*, 579–590. [CrossRef]
49. Krueger, R.; Agyeman, J. Sustainability Schizophrenia or "Actually Existing Sustainabilities?" Toward a Broader Understanding of the Politics and Promise of Local Sustainability in the US. *Geoforum* **2005**, *36*, 410–417. [CrossRef]
50. Burgin, S. Sustainability as a Motive for Leisure-Time Gardening: A View from the 'Veggie Patch'. *Int. J. Environ. Stud.* **2018**, *75*, 1000–1010. [CrossRef]
51. Ančić, B.; Domazet, M.; Župarić-Iljić, D. "For My Health and for My Friends": Exploring Motivation, Sharing, Environmentalism, Resilience and Class Structure of Food Self-Provisioning. *Geoforum* **2019**, *106*, 68–77. [CrossRef]
52. Teitelbaum, S.; Beckley, T.M. Hunted, Harvested and Homegrown: The Prevalence of Self-Provisioning in Rural Canada. *J. Rural Community Dev.* **2006**, *1*, 114–130.
53. Clerval, A.; Delage, M. La métropole parisienne: Une mosaïque sociale de plus en plus différenciée. *Métropolitiques*. 2014. Available online: <https://metropolitiques.eu/La-metropole-parisienne-une.html> (accessed on 11 March 2021).
54. Ribardière, A. Les Territoires Populaires Du Grand Paris. *Métropolitiques*. 2019. Available online: <https://metropolitiques.eu/Les-territoires-populaires-du-Grand-Paris.html> (accessed on 11 March 2021).
55. Pourias, J.; Daniel, A.-C.; Aubry, C. La fonction alimentaire des jardins associatifs urbains en question. *Pour* **2012**, *215–216*, 333. [CrossRef]
56. Pourias, J.; Duchemin, E.; Aubry, C. Products from Urban Collective Gardens: Food for Thought or for Consumption? Insights from Paris and Montreal. *JAFSCD* **2015**, 1–25. [CrossRef]
57. Sovová, L. Self-Provisioning, Sustainability and Environmental Consciousness in Brno Allotment Gardens. *SS* **2015**, *12*, 11–26. [CrossRef]
58. Institut National de la Recherche Agronomique (France). *Les Fruits et Légumes dans L'alimentation: Enjeux et Déterminants de la Consommation*; Éd. Quæ: Versailles, Germany, 2008; ISBN 978-2-7592-0083-2.
59. Schwartz, C. *Jardins Potagers: Terres Inconnues?* EDP Sciences: Les Ulis, France, 2013; ISBN 978-2-7598-1037-6.
60. Brunson, C.; Comber, L. *An Introduction to R for Spatial Analysis and Mapping*; SAGE: London, UK, 2014; ISBN 978-1-4739-1120-8.
61. Ripley, B.D. The Second-Order Analysis of Stationary Point Processes. *J. Appl. Probab.* **1976**. [CrossRef]
62. Baddeley, A.; Rubak, E.; Turner, R. *Spatial Point Patterns: Methodology and Applications with R*; Chapman and Hall/CRC: Boca Raton, FL, USA; London, UK; New York, NY, USA, 2015; ISBN 978-1-4822-1020-0.
63. Lotwick, H.W.; Silverman, B.W. Methods for Analysing Spatial Processes of Several Types of Points. *J. R. Stat. Soc. Ser. B (Methodological)* **1982**, *44*, 406–413. [CrossRef]
64. Espinosa Seguí, A.; Maćkiewicz, B.; Rosol, M. From Leisure to Necessity: Urban Allotments in Alicante Province, Spain, in Times of Crisis. *Int. J. Crit. Geogr.* **2017**, *16*, 276–304.
65. Guitart, D.; Pickering, C.; Byrne, J. Past Results and Future Directions in Urban Community Gardens Research. *Urban For. Urban Green.* **2012**, *11*, 364–373. [CrossRef]

-
66. Kimber, C.T. Gardens and Dwelling: People in Vernacular Gardens. *Geogr. Rev.* **2004**, *94*, 263–283. [[CrossRef](#)]
 67. Lope-Alzina, D.G. A Conceptual Approach to Unveil Traditional Homegardens as Fields of Social Practice. *Ethnobiol. Conserv.* **2017**. [[CrossRef](#)]
 68. Moulaert, F.; Rodríguez, A.; Swyngedouw, E. *The Globalized City: Economic Restructuring and Social Polarization in European Cities*; Oxford Geographical and Environmental Studies Series; Oxford University Press: Oxford, UK; New York, NY, USA, 2003; ISBN 978-0-19-926040-9.