Age Distribution and Accessibility to Green Areas in the City of Copenhagen

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Gustavo Ribeiro and Aleksander Nowak

Abstract

This paper presents an analysis of the distribution of urban spaces, parks, and other green areas in the City of Copenhagen in relation to demographic indicators, notably concerning population density and the spatial concentration of different age groups. The broad health benefits provided by urban greenery to urban dwellers are well documented in urban studies. The aim of this paper is to further contribute to this scholarship through the analysis of accessibility to green spaces by different age groups and in this way to shed light on their opportunities for health enhancing physical activity in the urban environment. The analysis is part of an ongoing study of urban density mapping based on a collaboration with the City of Copenhagen. The analysis of distribution of green spaces is based on several datasets, including location of major green spaces and parks, location, and radius of individual trees and NDVI index. The Copenhagen Municipal Plan 2019 proposes to increase social equity through physical and mental health-promoting urban planning and through provision of good quality green public spaces. The analysis shows that vulnerable groups such as the older population ($\geq$ 65-year-olds) are not particularly challenged in terms of accessibility to green spaces. Based on this analysis, the authors formulate urban policy recommendations for meeting the targets for healthy living set by the City of Copenhagen.

Keywords

Green spaces · Age distribution · Copenhagen

5.1 Introduction

This paper presents an analysis of accessibility to green spaces in Copenhagen in view of promoting inclusivity and social equity, which are policy goals formulated by the City of Copenhagen. The analysis focuses, in particular, on conditions of accessibility to green spaces by elderly and children, as spatial proximity is particularly relevant for these age groups (Sugiyama and Ward Thompson 2007). The discussion and findings presented in this paper are based on an ongoing study involving an analysis of population density, indicators of built density (floor area ratio, building height), socio-economic indicators (such as level of education and income), detailed demographic data on age distribution, and

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distribution of specific urban facilities, such as playgrounds.

The analysis presented in this paper is based on the City of Copenhagen's political ambition "that in the existing city there is no more than 300 m in walking distance from the city's housing to a recreational area." (City of Copenhagen 2019, p. 32).

A central argument presented in this article is that by combining several levels of data—namely data on population density at different scales (including number of dwellers per household, rooms per person in one household), data on distribution of the population by age groups, and data on built density (floor area ratio)—we can provide a nuanced analysis of distribution of green spaces in view of informing a discussion on accessibility to green spaces and the potential for promoting more equitable access to parks and other green spaces, notably to more vulnerable segments of the population (such as the elderly).

An analysis of race and ethnicity in relation to accessibility to green spaces is indirectly dealt with in this study, to the extent that the spatial analysis examines the distribution of social housing areas in neighborhoods such as Nørrebro which present greatest concentrations of first and second generation migrants—where Muslims are largely represented (Møller and Larsen 2015) and the conditions for accessibility to green spaces in those areas.

The spatial analysis involved production of data maps in GIS software representing each dataset with different levels of aggregation as well as production of combined layered datasets. The initial set of maps were produced by the Catalan urban planning agency 300.000 km/s in dialog with the authors. A further set of maps, particularly on the distribution of the population by age groups, was produced by the authors.

The focus of this article on urban density and densification is related to the fact that the City of Copenhagen is faced with a projected population growth of 62,000 inhabitants by 2032 (City of Copenhagen 2022, p. 18). In view of such population growth, the development of urban policy which promotes social equity in relation to accessibility to green spaces gains further urgency.

Following this introduction, this article presents a *background* section containing a discussion of state-of-the-art scholarship in urban green spaces studies, in relation to health benefits, accessibility, and social equity and age distribution. The *methodology* section presents a description and discussion of parameters and considerations concerning data gathering, data aggregation, and analysis. This is followed by a section presenting *results* of the study and sections covering *discussion* and *conclusion*.

5.2 Background

5.2.1 Benefits of Green Spaces

A number of health related as well as other benefits associated with green spaces are documented in several studies (Pauleit 2003), (James et al. 2009). Furthermore, a number of studies have pointed to specific physical and mental health benefits of exposure to nature (Hartig et al. 2014) and to green spaces (Zhang and Tan 2019), (Triguero-Mas et al. 2015), (Gascon et al. 2015), (Tamosiunas et al. 2014), while other studies have found that green spaces were associated with social, economic, and environmental benefits (Mensah et al. 2016, p. 142). Perceived health benefits associated with proximity to green spaces also constitute an important dimension of analysis of green spaces and are documented in a number of studies (van den Berg et al. 2015; Maas 2006). Recently, under the COVID-19 pandemic, the use of parks in Copenhagen has increased significantly (Google 2021) further highlighting the importance of accessibility to green spaces in urban policy-making.[1]

[1] COVID-19 Community Mobility Report, Capital Region of Denmark May 27, 2021.https://www.gstatic.com/covid19/mobility/2021-05-27_DK_Capital_Region_of_Denmark_Mobility_Report_en.pdf.

5.2.2 Densification

The detrimental impact of compact city development and urban densification on green areas has been documented in several studies (Pauleit et al. 2005, Haaland and van den Bosch 2015). Some studies found that the fact that green spaces may come under pressure through urban densification and does not necessarily lead to a deterioration in green space accessibility or people's perception thereof (Ståhle 2010).

5.2.3 Accessibility and Proximity

Studies investigating spatial distribution of green spaces and health (Dadvand et al. 2016) show that proximity to urban green parks (as well as factors such as maintenance and cleanliness) is associated with increased frequency in physical activity (Akpinar 2016), residential proximity to greenness, and perceived (subjective) proximity to green spaces which are associated with better subjective general health (Dadvand et al. 2016). A number of studies underline the importance of assessing subjective factors (Maas 2006), when investigating accessibility to parks and other green areas.

5.2.4 The Elderly and Green Spaces

The incidence of diseases associated with lack of physical activity, such as diabetes, high blood pressure, cardiovascular diseases, as well as depression and anxiety among others, is particularly high among the elderly, and research has shown that accessibility to green spaces plays a key role in promoting active, healthier living among the elderly. (Ali et al. 2022), (Copenhagen: WHO Regional Office for Europe 2017). Accessibility to greenness and to UGS has the potential of enhancing older people's physical and mental health by promoting physical activity and social contact, and studies have shown that accessibility to green spaces contributes to reduce stress, counters adverse mental health conditions, promotes enhanced sociability (reducing loneliness), and contributes to lower the impact of cardiovascular diseases and to lower mortality (James et al. 2015), (Sugiyama and Ward Thompson 2007), (Copenhagen: WHO Regional Office for Europe 2017). Studies on accessibility to green spaces in relation to age distribution highlight the disadvantage of vulnerable segments of the population, notably the elderly, and point to challenges concerning proximity of green spaces to residences (Stathi et al. 2012), (Liu et al. 2022, p. 1), urban design features of urban spaces (such as cleanliness and barrier-free routes) (Ward Thompson et al. 2014, p. 1), design and amenities of parks such as the presence of benches and "passive use areas" (Kabisch and Haase 2014, p. 137). On the other hand, some studies also show that improvement of recreational facilities does not necessarily lead to an increase in the number of users or the levels of physical activity (Cohen et al. 2009, p. 5) and that other factors such as programming and staffing also need to be considered (Cohen et al. 2009, p. 5).

Such condition of disadvantaged access to green spaces is further accentuated by the fact that the elderly are less likely to relocate to greener neighborhoods and in social contexts where there is an aging population (Liu et al. 2022, pp. 11–13), (Kabisch and Haase 2014, p. 137). In addition, it is important to consider that different segments of an elderly population may present different park use patterns, ranging from active health oriented users, to socially oriented users to passive users (Kemperman and Timmermans 2006).

5.2.5 Children and Green Spaces

The importance of accessibility to green spaces for the physical and mental well-being of children has been documented in several studies, and access to green spaces has been shown to be associated with enhanced mental health and cognitive development of children (McCormick 2017). Furthermore, accessibility to green spaces has been associated to other mental health such as moderation of stress, attention restoration, memory improvement, and improvement of behaviors and symptoms of ADHD; as well as sociability benefits, such as competence development, social groups support, and consolidation of self-discipline, among others (McCormick 2017).

Vanaken and Danckaerts' review of the literature on the impact of green space exposure on children's and adolescents' mental health point to consistent evidence suggesting "a beneficial association between green space exposure and children's emotional and behavioral difficulties, particularly with hyperactivity and inattention problems" (Vanaken and Danckaerts 2018, p. 1).

Further studies on children's health argue for the importance of playground facilities that promote physical activity not only in view of associated health benefits but also in view of benefits for social development and basic movement skills. (Quigg et al. 2012).

The importance of pedestrian connectivity in the urban environment is also highlighted as a factor that may lead to greater levels of physical activity (Fitzhugh et al. 2010, p. 259).

5.2.6 Copenhagen Demographic Development

According to projections by the City of Copenhagen, a sharp increase of 58% in the number of citizens over 80 is expected from 2022 to 2032. Notably, according to those projections, the number of 65 to 79-year-olds will begin to rise sharply at the end of the period. The increase in 0 to 17-year-olds and 18 to 64-year-olds is expected to be stable until 2032. Since there are relatively few elderly people, the average age will only increase by 0.8 years. (City of Copenhagen 2022, p. 23).

In addition, according to projections by the City of Copenhagen, there will be an increase in the coming seven to eight years in the number of Copenhageners of child-bearing age (City of Copenhagen 2022, p. 23) (Fig. 5.1).

5.2.7 Copenhagen Green Space Policy

Social equity is a key consideration in the Copenhagen Municipal Plan 2019, which underlines that "increase social equality in physical and mental health, health-promoting urban planning should start where it is most needed [in vulnerable areas]… [through] the establishment of urban spaces whose design motivates increased physical activity or green areas that promote mental health." (City of Copenhagen 2019, p. 22).

The enhancement of accessibility to green spaces is also formulated in the Copenhagen Municipal Plan 2019 in relation to the promotion of citizens' health and in view of their socio-economic background with the aim of achieving a more equitable urban development. (City of Copenhagen 2019, p. 28).

In order to further document accessibility to green spaces in view of fulfilling the above-mentioned ambitions, the City of Copenhagen has carried out an analysis of green spatial distribution in relation to these two parameters—that is, an ambition of a maximum distance of 300 m from residential addresses to a recreational area (with a minimum of 500 m^2) in the existing city and of a maximum distance of 500 m in urban development areas to green spaces larger than 2 ha. In this analysis, the City of Copenhagen introduces specific definitions of what qualifies as a green area[2] and a blue area.[3]

[2] According to the definition used by the City of Copenhagen in its 2022 "analysis of accessibility to green and blue areas", a "green" area in the existing city needs to fulfil certain criteria, including a minimum size of 500 m2, a minimum width of 10 m, and a minimum 25% green cover (including the extent of tree canopy), and public access is secured both physically and by law (The City of Copenhagen, Financial Administration, 2022, p. 6).

[3] According to the City of Copenhagen, no minimum size or extent has been used for the definition of "blue" areas (promenades, beaches, freshwater lakes, etc.). The criterion for designation as a blue area is whether the area "is laid out in a way that enables the user to dwell there and experience the water, and where the water body makes up a significant share of the experience without being part of the dwelling area itself." (The City of Copenhagen, Financial Administration, 2022, p. 6).

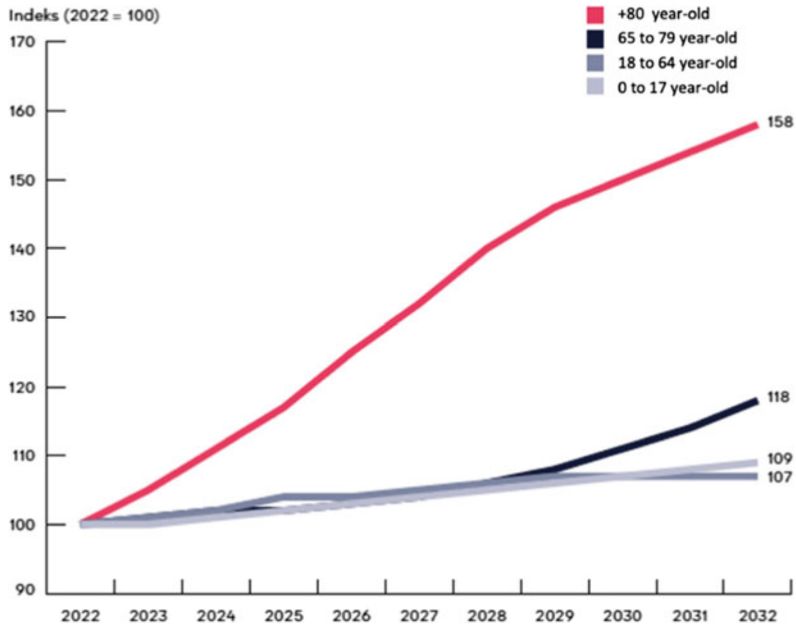

Fig. 5.1 Projection of population growth index according to age—2022–2023. *Source* City of Copenhagen

According to this analysis, 9.9% of housing (33,059 housing units) in the existing city is located at distance greater than 300 m from a green area—according to the definition by the City of Copenhagen (The City of Copenhagen, Financial Administration 2022), 34.4% of housing (114,889 housing units) in urban development areas is located at a distance greater than 500 m from a green area (incl. Amager Beach Park) larger than 2 ha. (The City of Copenhagen, Financial Administration 2022, p. 21).

5.3 Methodology

The present study is based on an analysis of spatial distribution of greenery in relation to population density and spatial distribution of different age groups (0–5, 6–17, 18–64, 65–79, and 80–99 years old). The study considers the green areas (as defined by the City of Copenhagen), trees, green courtyards/backyards, and NDVI values as well as aggregated values for amounts of people per age group in 100 × 100 m and 200 × 200 m grid cells in Copenhagen Municipality.

Publicly accessible registers consulted in this study include opendata.dk [https://www.opendata.dk/], Kortforsyningen [https://kortforsyningen.dk/], Municipal Plan 2019 map database [https://kp19.kk.dk/kortportal]. This was supplemented by more detailed and up-to-date datasets provided by the City of Copenhagen including datasets on trees, courtyard (location and presence of greenery), and location of green spaces (City of Copenhagen[4]). Data from the register listed above and from Airbnb were used to produce six types of maps:

1. Datapoint Maps—individual data points showing the location of trees
2. Heat Maps—showing intensity of concentration of data points
3. Mashup Maps—combining data from datapoint maps and heat maps
4. 200 m × 200 m Grid Maps—data aggregated on a 200 m × 200 m grid

[4] This dataset was revised by the City of Copenhagen in their 2022 “analysis of accessibility to green and blue areas” by using a new definition of publicly available green spaces (including minimum size and green cover criteria) and newly established or politically agreed green spaces.

5. 100 m × 100 m Grid Maps—data aggregated on a 100 m × 100 m grid
6. Urban Structure Maps—showing structure of road infrastructure, urban spaces, urban blocks, and courtyards.

The datasets were processed in QGIS and Python. Data from Copenhagen Municipal plan structure maps [green spaces, public spaces, streets, and blocks] [https://kp19.kk.dk/kortportal] were used not only as an underlay for the other maps in this study but were also aggregated into grid-equivalent densities and thus providing a basis for comparison between different urban areas and their public spaces. Sentinel-2 Satellite imagery was used to generate NDVI-based mappings of Copenhagen in addition to data on the spatial distribution of trees and greenery. Satellite imagery allowed for generating a consistent and uniform image of urban greenery and a detailed analysis of distribution of vegetation and its intensity. NDVI analysis further informed the level of present distribution, historical development of the green elements, or their relation to urban densification.

The household level data in the Municipality of Copenhagen were analyzed through four indicators defining housing attributes through perspectives of household size and number of rooms and cohabitation. The detailed datasets (BBR—Danish building register) were provided by the municipality. The location of publicly accessible green areas in municipalities adjacent to the City of Copenhagen as well as the location of "blue areas," though not central to this study, was both considered in the present analysis.[5]

5.4 Results

5.4.1 Distribution of Green Spaces

The analysis comprised the following datasets on green spaces and trees: (1) NDVI; (2) tree database; (3) parks and other green areas[6] (City of Copenhagen); and (4) green courtyards. Maps based on those datasets were used for analyzing the distribution of greenery in Copenhagen (both publicly and not publicly accessible, private, and semi-private). The results of this analysis were compared with those provided by the analysis carried out by the City of Copenhagen, which is limited to publicly accessible spaces (secured both physically and by law). A set comprising ten maps was analyzed through different combinations of these four levels of data and through different forms of aggregation/visualization (200 m x 200 m grid, datapoints, and urban structure maps). The maps (58, 67, 68, 69, 70, 71, 75, 76, 78, 79, 81, 90 and 91) listed on Table 5.1 show how greenery seen through the lenses of these four levels of data is very unevenly distributed throughout the city. Each dataset presents a different pattern of distribution. This uneven distribution of different types of green elements (whether they are trees, green courtyards, backyards, or green areas), as we will further elaborate upon below, is particularly relevant for an analysis of green spaces accessibility in relation to different housing typologies.

Housing areas in districts of the city, such as West Valby, Sundbyøster, Brønshøj-Husum, and Vanløse, present greater distances to green areas (map 67), but these areas consist of predominantly detached villas with green backyards. Inner Vesterbro presents housing with distances greater than 300 m to large green spaces in the city. On the other hand, Inner Vesterbro is located close to the Copenhagen Inner Harbor, one of the major blue recreational spaces in the city.

[5] This is consideration which is particularly relevant in relation to the Municipality of Frederiksberg, which is an enclave of Copenhagen, and which presents three major publicly accessible green spaces (Frederiksberg Park, Søndermark Park, and Solbjerg Cemetery Park) in close proximity to the boundaries of the City of Copenhagen.

[6] This dataset was revised by the City of Copenhagen in their 2022 "analysis of accessibility to green and blue areas" by using a new definition of publicly available green spaces (including minimum size and green cover criteria) and newly established or politically agreed green spaces.

Table 5.1 List of maps

#	Title	Data source	Description
65	Urban fabric – built density	Opendata.dk/CPH M	Representation of the built footprint and blocks hierarchy from the City of Copenhagen database
66	Public space – streets	Opendata.dk/CPH M	Street shape and public spaces as an intersection of the built footprint and blocks hierarchy
67	Major green spaces	Opendata.dk/CPH M	Major green spaces
68	Courtyards	CPH Municipality	Green courtyards
69	Vegetation NDVI	Sentinetl-2	Nature density vegetation index (Sentinel satellite network)
70	Trees	CPH Municipality	Location of trees from Copenhagen Municipality database
71	Green infrastructure	CPH Municipality	Superimposition of main public and green spaces, trees, and NDVI index
73	Built density	CPH Municipality	Built density in a 100 × 100 grid calculated from the building's footprint
74	Street density	CPH Municipality	Total surface of streets aggregated to a 100 × 100 grid
75	Density of green courtyards	CPH Municipality	Green courtyards aggregated (grid)
76	FAR vs courtyards	CPH Municipality	Superimposition of the sum of the built surface and the public spaces total surface - 100 × 100 grid
78	Trees	CPH Municipality	Total amount of trees aggregated to a 100 × 100 grid
79	Trees radius height NDVI	Sentinel-2	Average radius of trees (age indicator) & average height aggregated to a 100 × 100 grid
81	Trees + Veg. + Courtyards	CPH Municipality	Total m2 of public spaces, the total amount of trees, and the average index of vegetation - 100 × 100 grid
88	The surrounding built density	CPH Municipality	Total built surface (footprint) of the surroundings aggregated to the grid in public spaces
90	Green spaces – trees + NDVI	Multiple sources	3 levels of data combined NDVI, tree radius and tree height – 100 m x 100 m grid
91	Trees + NDVI	Multiple sources	2 levels of data – NDVI and spatial distribution of trees – 200 m × 200 m grid
92	Trees, NDVI, and yards	Multiple sources	3 levels of data combined NDVI, tree location, and green courtyards – 100 m x 100 m grid
98	Inhabited fabric	CPH Municipality	Populated areas in the city according to cadaster data
100	FAR (floor area ratio)	CPH Municipality	Plot occupation according to cadaster data
103	Pop. density / plot surface	CPH Municipality	Population per plot surface according to cadaster data
118	Demographic density/block	CPH Municipality	Demographic density aggregated at the scale of the city block

(continued)

Table 5.1 (continued)

#	Title	Data source	Description
120	Family size	CPH Municipality	Data on distribution of the population according to family size–district scale
121	Income distribution	CPH Municipality	Combined data of distribution of the population according to age and income–district scale
122	Age distribution	CPH Municipality	Age distribution aggregated on a 200 m × 200 m grid
131	Elderly population	CPH Municipality	Population density aged 65 and over ($\geq$ 65) aggregated by block
132	Young population	CPH Municipality	Population density aged 17 and under ($\leq$ 17) aggregated by block
133	Playgrounds	CPH Municipality	Distribution of playgrounds
134	Young population	CPH Municipality	Population density (0–5-year-olds and 6–17-year-olds) – 200 m × 200 m grid
135	Elderly population	CPH Municipality	Population density (65–79-year-olds and 80–89-year-olds) – 200 m × 200 m grid
136	Children	CPH Municipality	Distribution of families with 3 children or more – district scale

The distribution of green courtyards and green backyards (maps 68, 71, 75, 81) shows a pattern where the occurrence of private or semi-private green spaces is greater toward the periphery in proportion to the decrease in built density (map 73, map 100), demographic density (map 103), and density of road infrastructure and paved areas (map 66, 74). The relationship between built surface area and courtyards is shown in map 76. The analysis of NDVI maps (maps 69, 90, and 92) further illustrates the same pattern, where NDVI values (greenery) increase from the center to the periphery—where single family houses with backyard predominate. In addition, NDVI maps show the highest values where the green areas are located.

5.4.2 Green Spaces and Age Distribution

Building on the analysis presented in the article "Mapping Density and Distribution of Urban Spaces in the City of Copenhagen" (Ribeiro and Nowak 2022) and the analysis presented in the article "Green Spaces, Health, and Social Equity in the City of Copenhagen" (Ribeiro and Nowak 2022), this paper deals with the distribution of green areas in relation to indicators of population age distribution, density, socioeconomics, and individual household conditions. Based on this analysis, this study examines the distribution of the elderly population (65-year-olds or older), notably in lower-income areas, and examines conditions of accessibility to green spaces in relation to housing typology. The approach is also applied to the analysis of family with children, notably in lower-income neighborhoods. Data on children were analyzed according to two age segments, namely 0–5-year-olds and 6–17-year-olds.

The analysis of household conditions in the Copenhagen Municipality (which to some extent may be correlated with the socio-economic conditions) comprises four indicators of housing quality: (1) average household square meter size, (2) number of people per household, (3) average amount of rooms per household and, and (4) amount of people per room in one household. The GIS and statistical analyzes are performed through processing large datasets containing information on the number of inhabitants and their age (0–99) of each Copenhagen household (2020) mapped on a *school district* (skoledistrikt) level, based on the Danish Building Register (BBR) and inhabitants' age point data for all Copenhagen housing units.

The focus on lower-income groups reflects the consideration that those groups are the most reliant on public investment in green spaces. On the other hand, the medium and high-income elderly population is located in neighborhoods such as Østerbro, Christianshavn, and the Medieval City center, which do not present challenges in terms of proximity to green or blue areas (Figs. 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, and 5.9).

5.5 Discussion

The analysis shows that neighborhoods presenting the greatest concentrations of elderly people (Østerbro, the Medieval City, Christianshavn, Islands Brygge, and North Amager) are not particularly challenged in relation to accessibility to green areas, nor in socio-economic terms. Overall, residential areas with greater concentration of elderly people do not present distances greater than 300 m to green areas (as defined by the City of Copenhagen). The exception to that pattern is found in Amager South (Sundby Øster) and Amager West (Gyldenrigsvej).

Furthermore, the results of the analysis show that the areas with the greatest concentrations of children and young people ($\leq$ 17-year-olds) are not particularly challenged in relation to accessibility to green spaces—that is, areas showing higher concentrations of this age group are not located at distances greater than 300 m to green and blue spaces in the city.

An analysis of the distribution of playgrounds (map 133) shows a pattern of greater concentration of such facilities in central areas in the neighborhoods of Østerbro, Nørrebro, Vesterbro, and Amager, which are also the neighborhoods with the greater concentration of children (map 132).

The analysis of density of the elderly population ($\geq$ 65-year-olds) in relation to the overall distribution of green spaces shows that this age group is not particularly challenged in terms of accessibility (proximity to) green areas. Amager South (Sundby Øster) presents greater than average concentration of an elderly population ($\geq$ 65-year-olds) in medium to lower-income levels and is located at distances greater than 300 m to green areas. But it is important to highlight that the predominant housing typology found in this Sundby Øster is that of semi-detached houses with backyards. Thus, elderly residents living in that neighborhood have access to the green private space of their backyard. In this case urban space design, involving conditions that promote walkability for the elderly in the spaces of the neighborhood (streets, pathways, squares, among others), such as absence of barriers and maintenance of sidewalks and cleanliness (Ward Thompson et al. 2014, p. 1), come into focus and are likely to play a central role in the elderly's daily use of such spaces and the conditions for their access to green spaces. Amager West (Gyldenrigsvej) also presents greater than average concentration of an elderly population (65 + year-olds) in medium to lower-income levels. This neighborhood largely consists of social housing schemes from the late 1960s early 1970s following the principles of Le Corbusier's Athens Charter (Le Corbusier 1973, 1933). Even though it is located at a distance greater than 300 m to green areas following the classification by the City of Copenhagen, this neighborhood has generous large green spaces that have the potential of being further developed as high-quality green areas (as in the case of the urban renewal of Gellerupparken[7]) for the use of the local residents and residents from neighboring areas, notably the elderly. Investment in urban design, the provision of high-quality urban furniture, outdoors gym equipment designed for the use of the elderly and the development of nature-based solutions are of key importance in such neighborhood.

[7] https://www.landskabsarkitekter.dk/Aktuelt/gellerup-ny-naturpark-nomineret-til-green-cities-europe-award/.

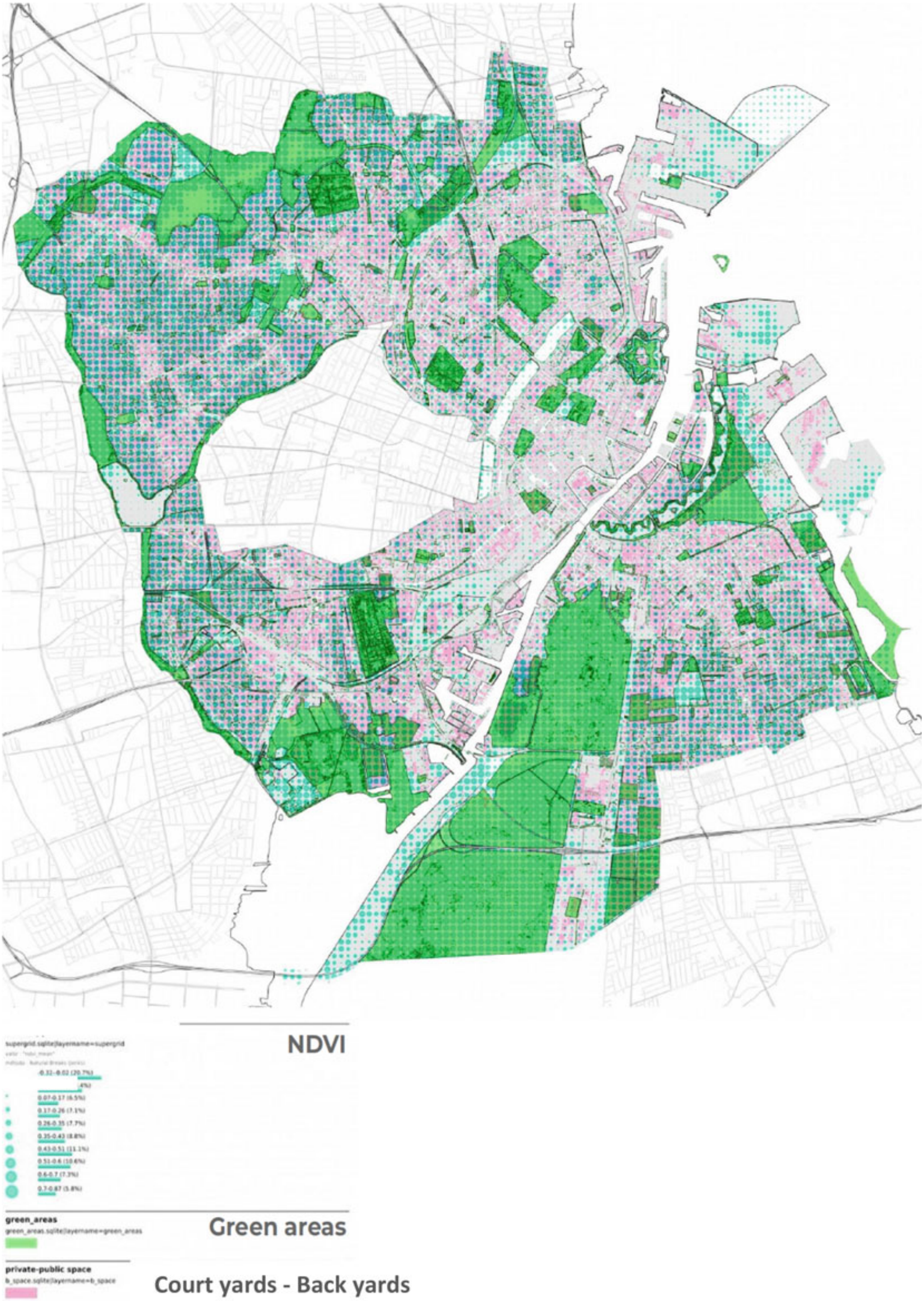

Fig. 5.2 Map 79 NDVI, green areas and green court yards/back yards. *Source* Copenhagen Municipality (300.000 km/s)

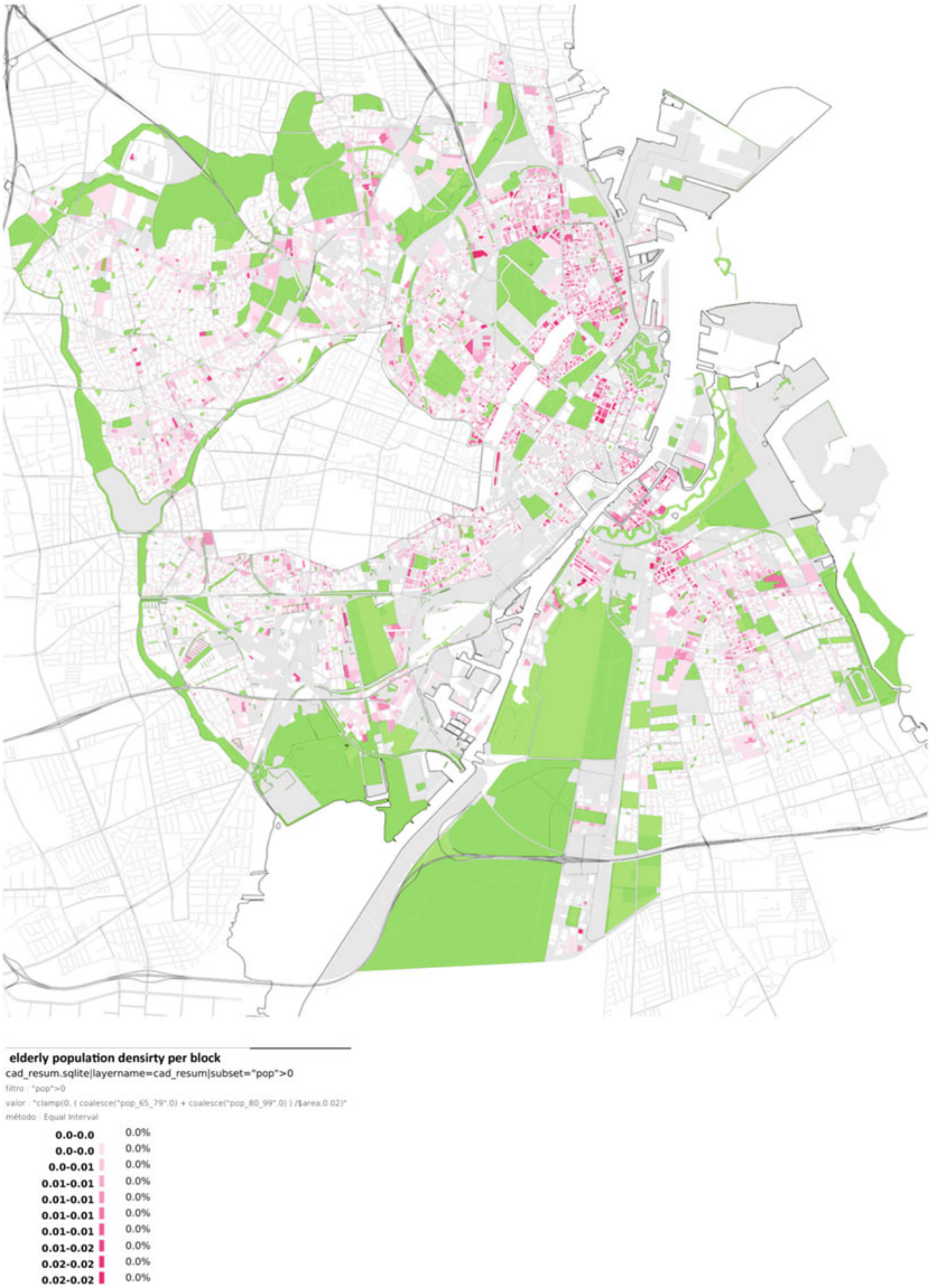

Fig. 5.3 Map 131 old population ($\geq$ 65-year-olds) density per block. *Source* Copenhagen Municipality (300.000 km/s)

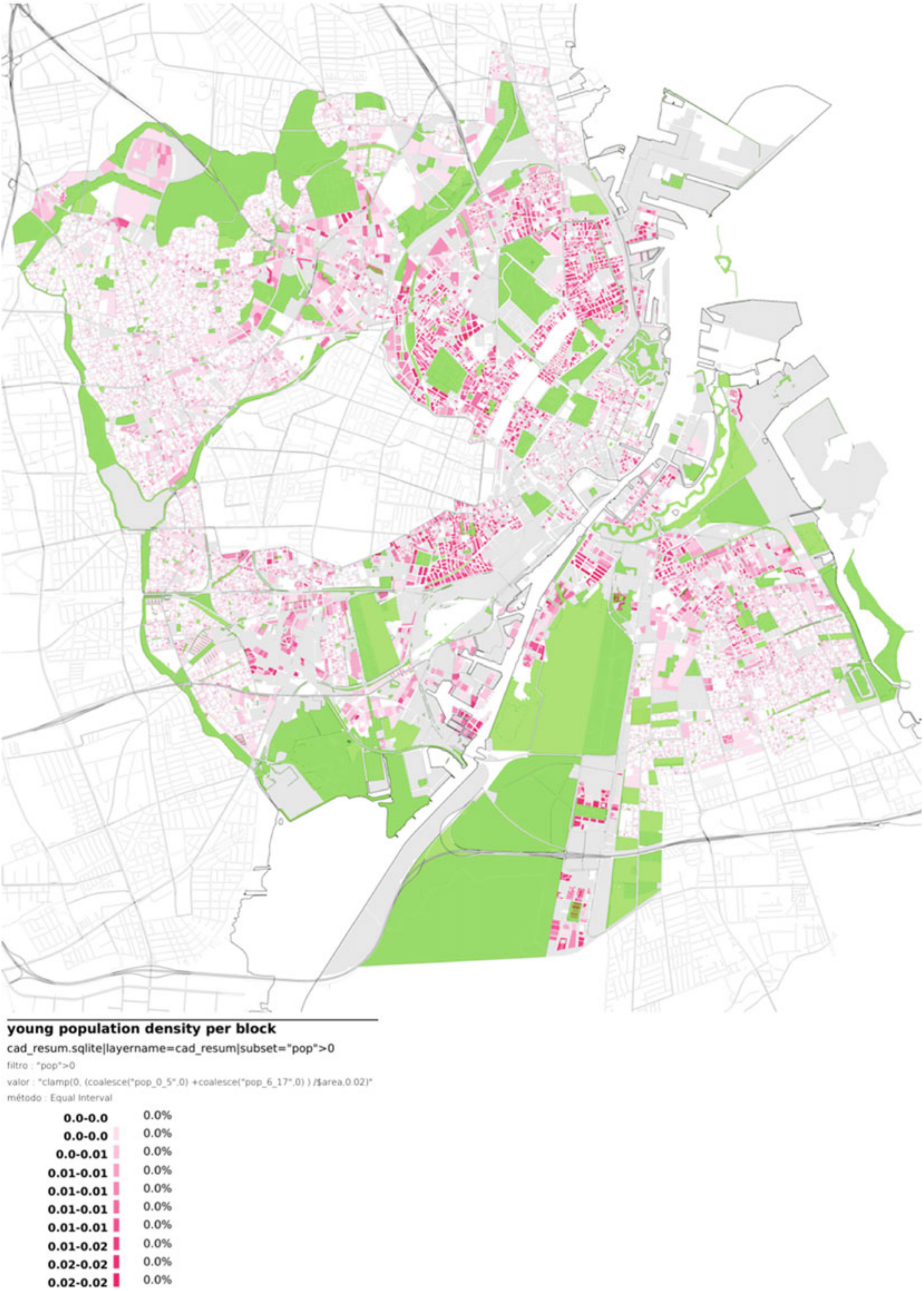

Fig. 5.4 Map 132 young population (≤ 17-year-olds) density per block. *Source* Copenhagen Municipality (300.000 km/s)

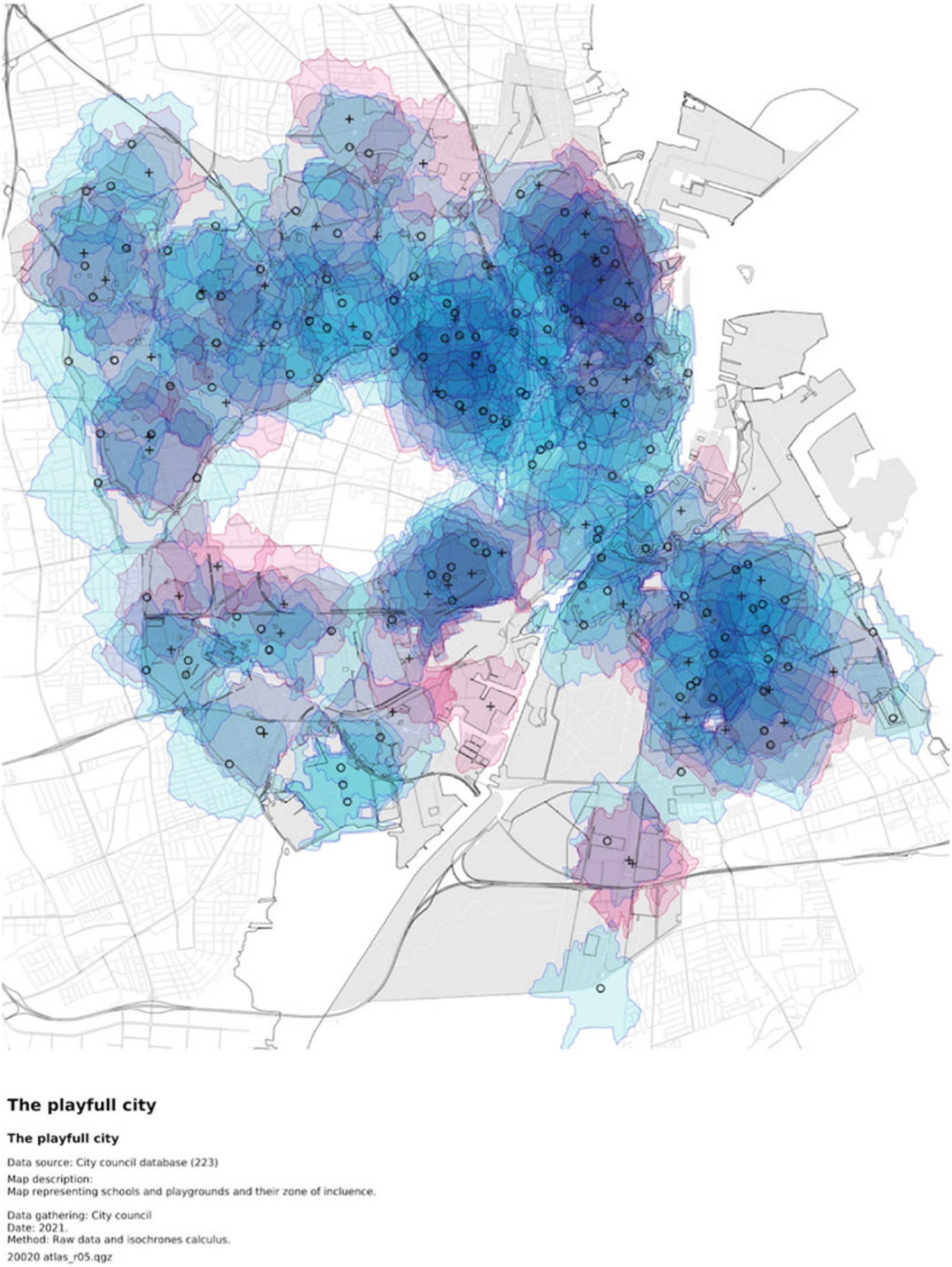

Fig. 5.5 Map 133 distribution of playgrounds—isochrone map. *Source* Copenhagen Municipality (300.000 km/s)

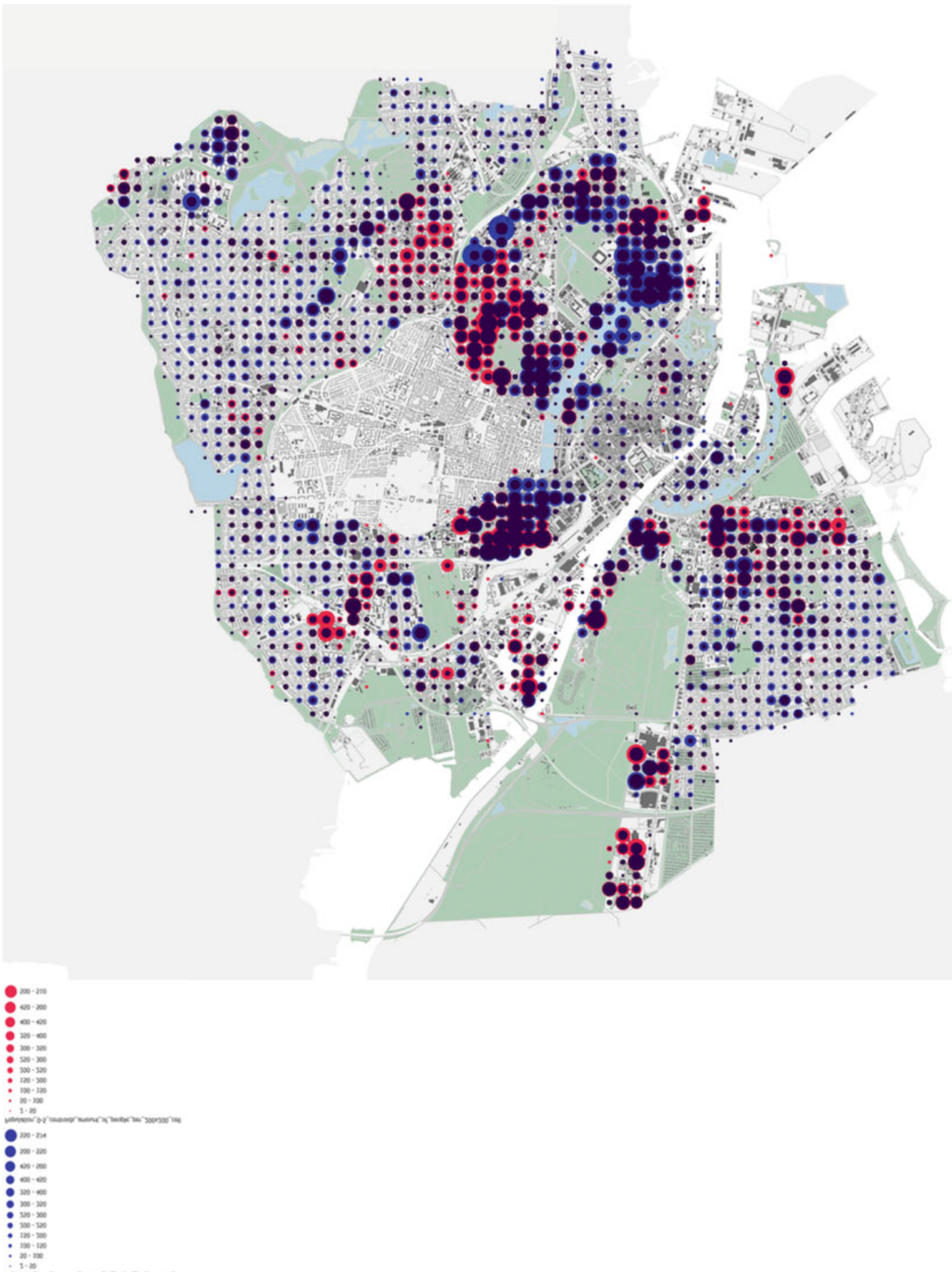

Fig. 5.6 Map 134 population density, children, and youth (age groups 0–5 and 6–17). *Source* Copenhagen Municipality

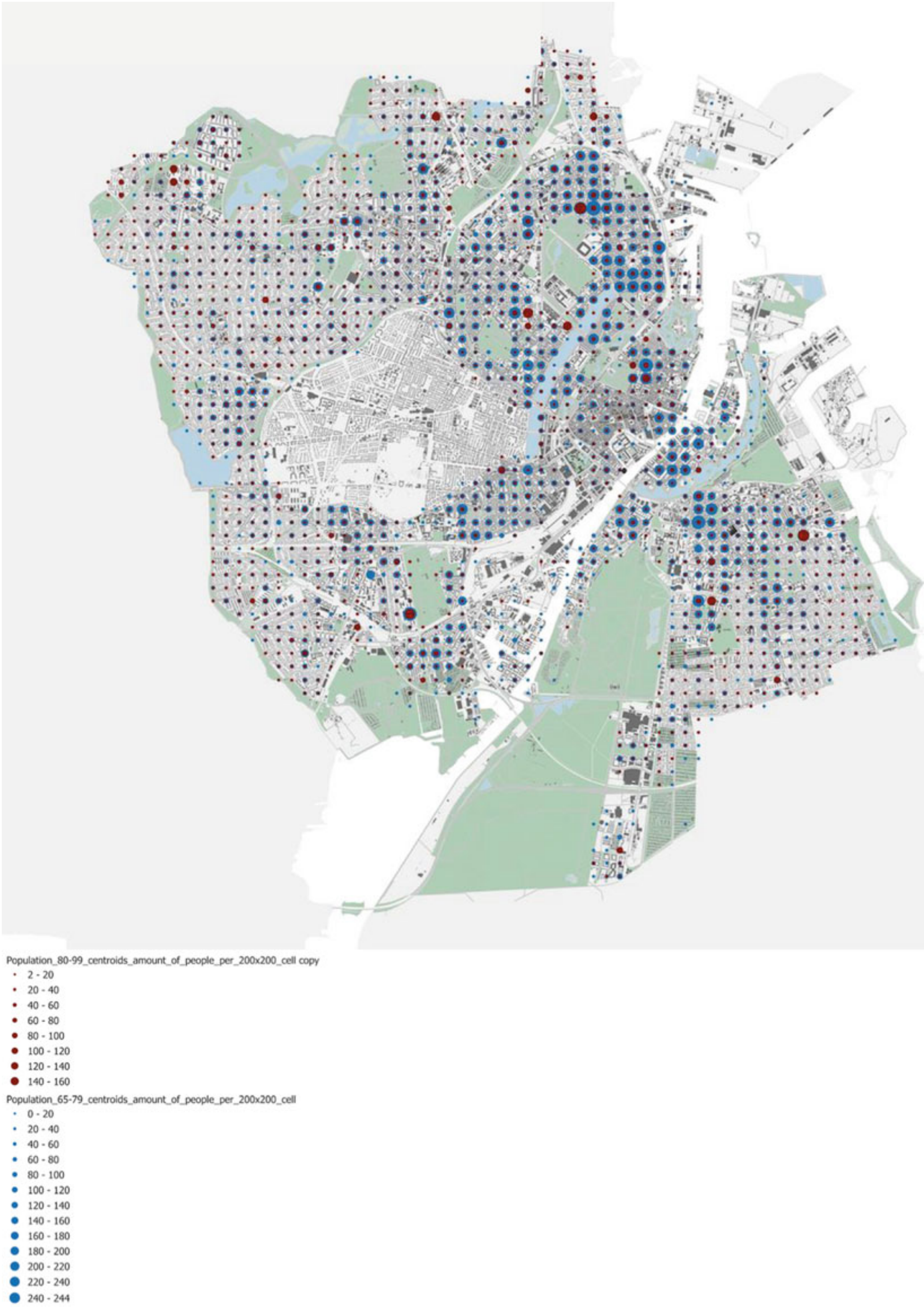

Fig. 5.7 Map 135 population density—elderly (age groups 65–79 and 80–99). *Source* Copenhagen Municipality

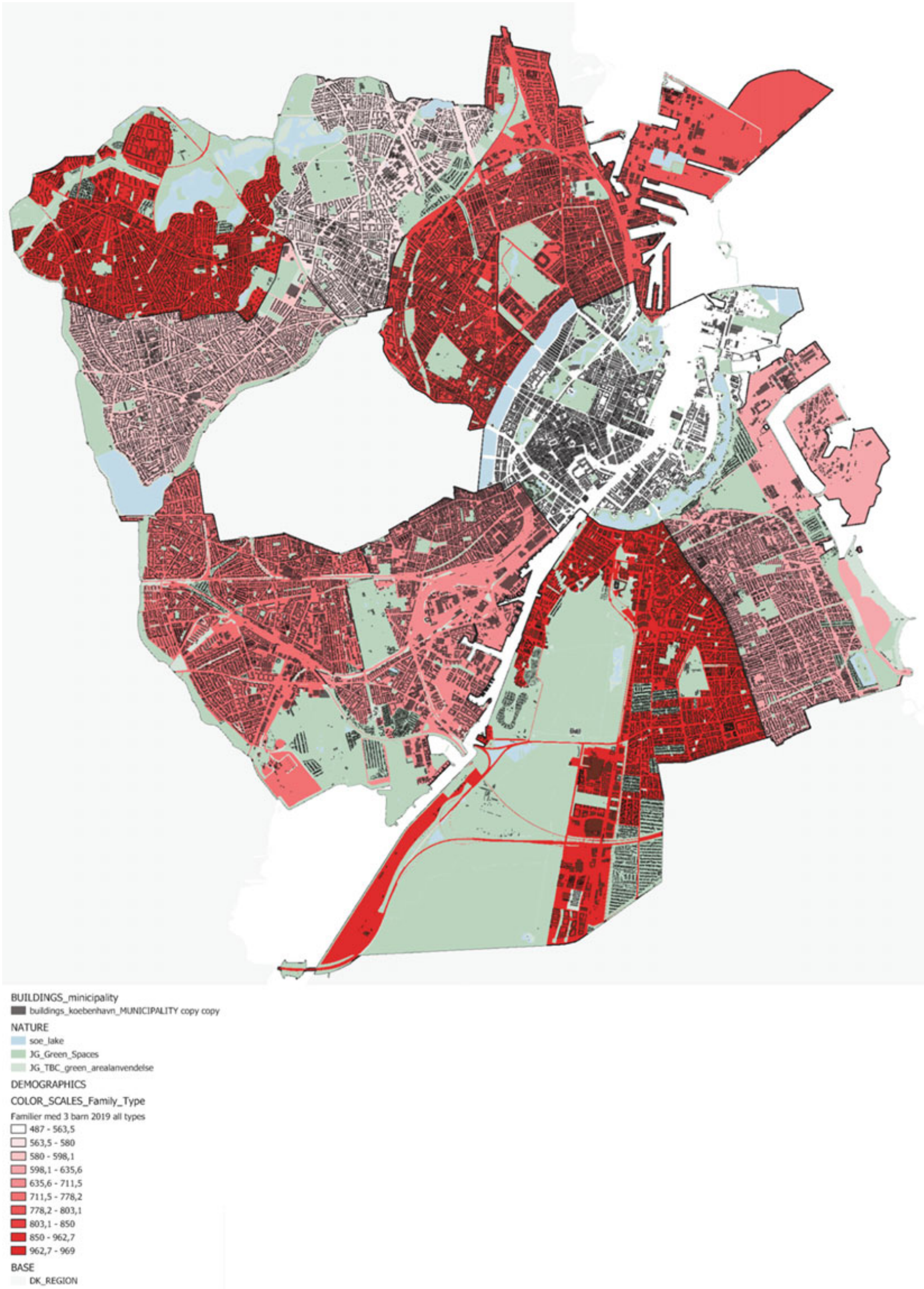

Fig. 5.8 Map 136 distribution of families with 3 children or more—district. *Source* Copenhagen Municipality

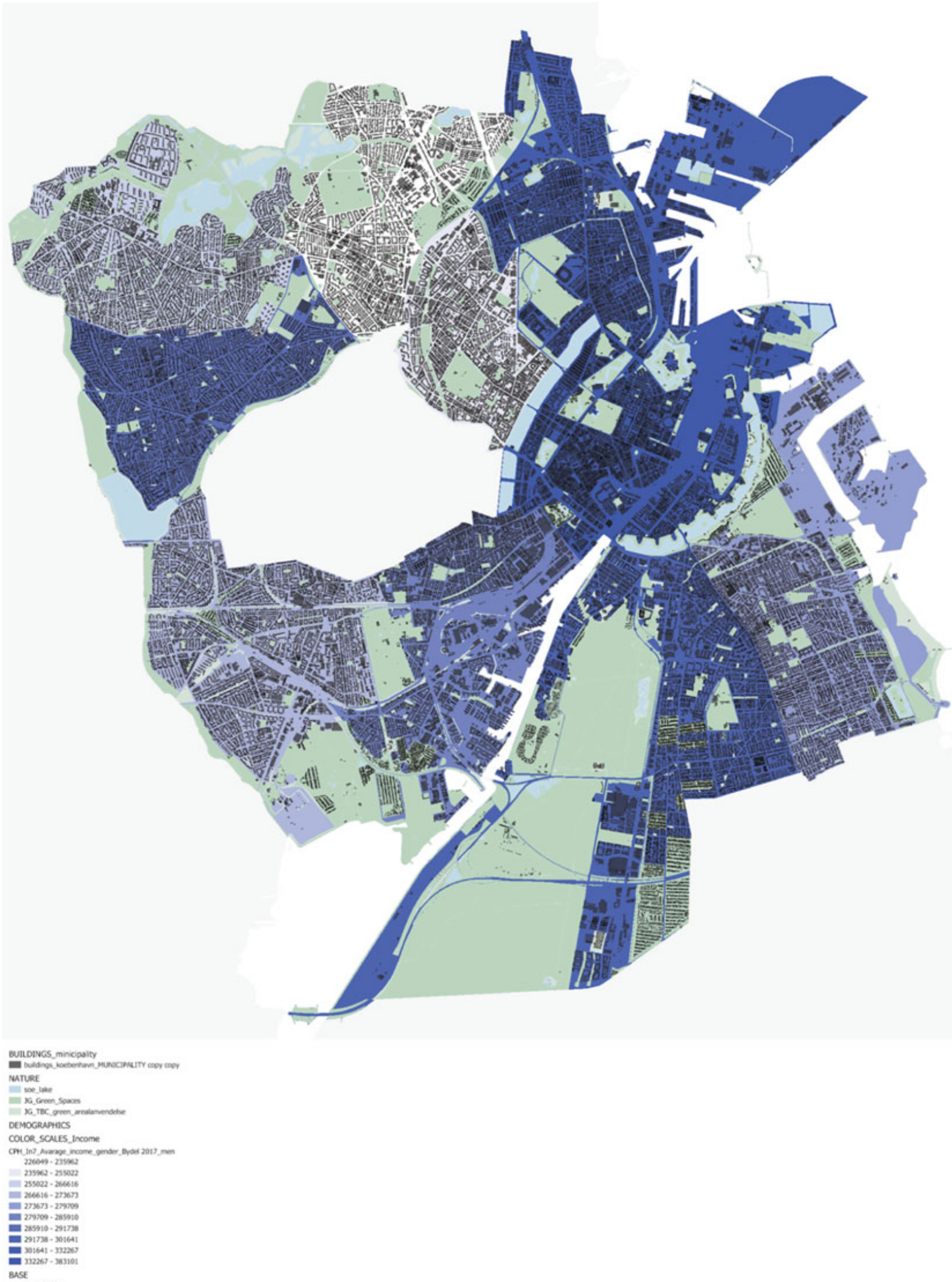

Fig. 5.9 Map 121 average income distribution—district. *Source* Copenhagen Municipality

5.6 Conclusion

The present analysis shows that the age groups primarily considered in this study, namely the elderly ($\geq$ 65-year-olds) and children ($\leq$ 5-year-olds), are not particularly challenged in relation to accessibility to green spaces, compared to other age groups. Neighborhoods with the greatest concentrations of those two age groups present green spaces and playgrounds with distances under 300 m from residential units.

This analysis also points to the importance of considering different urban typologies, whether they may be modernist housing schemes or individual houses with backyards, to investigate the potential of creating, improving, or expanding green spaces, notably in view of providing "inclusive" conditions that can accommodate the requirements of the elderly and families with children. The importance of including the elderly and children is brought further into focus given the prospect of an aging population on the one hand, and the population growth and densification which will put further pressure on use of green spaces and other public spaces on the other hand. This increased pressure on the use of public spaces is of key importance when planning for improving recreational facilities for families with children in the City of Copenhagen and accessibility to green spaces and playgrounds.

This study points to the potential of further expanding and qualifying analytical tools and methodologies used by municipalities to inform policy and decision-making on green infrastructure provision. Mappings made possible by the availability of large geolocated datasets indicating population spatial distribution according to age, and socio-economic and living conditions can enable more nuanced analysis of the actual relationships of accessibility to green and blue spaces by citizens in different neighborhoods. This may turn out to be particularly useful in face of crises such as the one experienced in connection with the recent COVID-19 pandemic and situations of lockdowns where accessibility to nearby green areas becomes even more critical in view of the promotion of mental and physical relief infrastructure.

As pointed out above, this study highlights the importance of analyzing distribution of green spaces in relation to different urban typologies (modernist housing slabs, courtyard blocks, detached houses with backyard, among others) as such typologies present different potential for green space development. Notably, large open areas laid out as car parks or grass lawns in modernist social housing complexes present a great potential for further development of city's green space infrastructure. In addition, this study underlines the need for further qualifying definitions of green spaces used in policy-making with a point of departure on specific requirements of different user groups, notably vulnerable user groups such as the elderly and children. As definitions and green spaces taxonomies based on an understanding of the needs of those groups can contribute to more impactful green space planning.

Furthermore, based on the analysis of household conditions, the study points to the importance for policy-making of taking into account overcrowding (measured in terms of square meters per inhabitant in individual households) as a an important socio-economic indicator, when analyzing accessibility to green spaces (as highlighted by the COVID-19 pandemic).

In view of the key role that green spaces play in promoting social inclusion (De Haas et al. 2021), an analysis of individual household conditions (and related socio-economic factors, such as income, ethnicity, unemployment, and education), as argued in this paper, is an important element in policy-making aimed at a more equitable provision of green areas.

One of the main limitations of the present study lies in that it does not provide a qualitative analysis of green spaces as well as playgrounds, in terms of their design, equipment, conditions (maintenance, among other factors), and additional relevant factors that are considered to play a key role in attracting users (Cohen et al. 2009, p. 5).

Further studies to qualify the use of green spaces by elderly should include an analysis of the design of equipment and amenities (Kabisch and Haase 2014, p. 137) based on different use patterns (Kemperman and Timmermans 2006). In addition, the design of urban spaces in general (streets and squares) can be analyzed in terms of conditions for elderly, focusing on urban design features such as cleanliness and barrier-free routes (Ward Thompson et al. 2014, p. 1).

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