Green Spaces, Health, and Social Equity in the City of Copenhagen

Gustavo RIBEIRO, The Royal Danish Academy, Architecture, Denmark
Aleksander NOWAK, The Royal Danish Academy, Architecture, Denmark

Abstract

This paper formulates policy recommendations for urban development in Copenhagen based on analysis of the distribution of green spaces and urban greenery in view of the official targets set by the City of Copenhagen to promote equitable access to green spaces for all citizens. Accessibility to green spaces is analyzed in relation to urban density, population density and the socio-economic profile of the population. One of the main goals of the Copenhagen Municipal Plan 2019 is that new green areas and open spaces for new construction contribute towards making the city greener for the benefit of the citizens' quality of life, towards enhancing biodiversity and towards promoting climate adaptation. In this context, a political ambition and one of the main goals in the municipal plan is the definition of a maximum walking distance threshold between residences and the nearest, publicly accessible green area. The study presented in this paper – through a comprehensive mapping of the distribution of green spaces (including location of major green spaces and parks, location, and radius of individual trees and NDVI index) and mapping of demographic and built density in relation to socio-economic status – aims to provide a more detailed documentation and discussion about accessibility to green spaces in view of environmental justice and social equity. The paper is based on an ongoing research collaboration between the Royal Danish Academy, School of Architecture and the City of Copenhagen focusing on densification, population growth, and the consequences of that development for accessibility to green spaces. One of the main conclusions from the analysis is that differences in urban typology, population density as well as household conditions and socio-economic data should be key considerations in the formulation of green space policy.

Keywords

Green Spaces, Health, Social Equity, Copenhagen

1. Introduction

This paper presents an analysis of the distribution of urban green spaces in Copenhagen in view of making policy recommendations that can inform an equitable urban development. The study is based on analysis of population density, indicators of built density (floor-area ratio, building height), data from social media platforms as well as socio-economic indicators (such as level of education and income).

Population and built density mappings were generated with data from the *Danish Building Register* (BBR - Bygnings- og Boligregistret) with resolution down to the number of inhabitants per household. Social media platform data (from Airbnb) add to the present analysis the dimension of perceived (or subjective) proximity to green spaces by residents (owner of apartments advertised on Airbnb) and are used to further qualify a discussion on accessibility to green spaces. In addition, Sentinel-2 Satellite imagery was used to generate NDVI based mappings of Copenhagen and further qualify an analysis of green spaces.

GIS maps for each dataset were produced and the analysis and data correlation involved the production of combined dataset maps. The maps were produced by the Catalan urban planning agency 300.000 km/s in

dialogue with the authors. A further set of maps was produced by the authors.

The discussion presented at the end of this paper takes into consideration the City of Copenhagen's political ambition "that in the existing city there is no more than 300 meters in walking distance from the city's housing to a recreational area." (City of Copenhagen, 2019, p. 32).

This article argues that accounting for population density at various scales (including number of dwellers per household, rooms per person in one household, amongst other parameters) can provide a basis for assessing accessibility to green spaces and the potential for promoting more equitable access to parks and other green spaces. In addition, the analysis presented in this article involves an assessment of perceived proximity to urban greenery through use of the online platform sourced datasets.

Social equity in the distribution of green spaces and the creation of urban spaces and recreational areas that contribute to enhance equity in physical and mental health are central political concerns in the Copenhagen Municipal Plan 2019. (City of Copenhagen, 2019, p. 28)

The issues of urban density and densification are key elements in the present discussion as the City of Copenhagen is faced with a projected population growth of 62,000 inhabitants by 2032. (City of Copenhagen, 2022, p. 18)

Following this introduction, this paper includes a *Background* section with a discussion of state-of-the-art scholarship in urban green spaces studies, in relation to health benefits, accessibility and social equity. 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*.

2. Background

2.1. Benefits of Green Spaces

Health related as well as other benefits associated with green spaces (and nature based solutions) are widely documented in academic studies (Pauleit, 2003), (James *et al.*, 2009). Some studies have documented specific physical and mental health benefits of exposure to nature (Hartig *et al.*, 2014) and to green spaces (Triguero-Mas *et al.*, 2015), (Zhang and Tan, 2019), (Gascon *et al.*, 2015), (Tamosiunas *et al.*, 2014), while other studies 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 constitutes an important dimension of analysis of green spaces and is documented in a number of studies (van den Berg *et al.*, 2015), (Maas, 2006).

Under the recent COVID-19 pandemic, the use of parks in the City of Copenhagen has increased significantly (Google, 2021) further bringing into focus a discussion of importance of accessibility to green spaces.[1]

2.2. Densification

The detrimental impact of urban densification and compact city development on green areas has been dealt with in several studies (Pauleit, Ennos and Golding, 2005) (Haaland and van den Bosch, 2015). Some studies found that the fact that green spaces may come under pressure through urban densification, does

[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

not necessarily lead to a deterioration in green space accessibility or people's perception thereof (Ståhle, 2010).

Whilst some research findings point to a development in residential environments across Denmark characterized by simultaneous densification and greening since the mid-1990s (Samuelsson *et al.*, 2020), the pattern of densification in the City of Copenhagen in the last two decades, which is projected to continue in the next decade (although in a less accentuated fashion), due to population growth within the boundaries of the Municipality of Copenhagen, presents challenges to planning of green spaces and call for urban analysis that can inform urban policy.

Unlike previous studies that focus on a regional scale and analyze land use changes in the green wedges that characterize the Greater Copenhagen "Finger Plan" (Caspersen, Konijnendijk and Olafsson, 2006), the present study presents an analysis of green space within the Municipality of Copenhagen. By providing a detailed spatial analysis of distribution of green spaces and population density in the City of Copenhagen this study aims to inform urban policy that can more closely address demands by residents (Tan and Samsudin, 2017) living in different neighborhoods of the city.

2.3. Accessibility and Proximity

Studies investigating the associations (Dadvand *et al.*, 2016) between spatial distribution and health show that proximity to urban green parks (as well as factors such as maintenance and cleanliness) are associated with increased frequency in physical activity (Akpinar, 2016), residential proximity to greenness and perceived (subjective) proximity to green spaces 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.

2.4. Social Inequity

Conditions and relations of social inequity have been investigated in multiple urban contexts and scales and several studies on accessibility and spatial distribution of green spaces indicate strong spatial inequity in supply and demand (Liu *et al.*, 2022), (Tan and Samsudin, 2017), (Sister, Wolch and Wilson, 2010), (Wolch, Wilson and Fehrenbach, 2005), (Schüle *et al.*, 2019). Some studies show that low-income, socially disadvantaged groups reside in urban areas where green spaces are scarce or poorly maintained (Anguelovski, 2016), (Anguelovski *et al.*, 2018), (Anguelovski, Connolly and Brand, 2018a), (Perkins, Heynen and Wilson, 2004). Other studies in an US context reveal significantly lower proportion of tree cover in neighborhoods containing higher proportion of African-Americans, low-income residents, and renters (Landry and Chakraborty, 2009), or strong positive relation between tree cover and socio-economic advantage (Shanahan *et al.*, 2014) (Zhou and Kim, 2013). Studies such as (Mitchell and Popham, 2008) have shown that income-related inequality in health is lower in populations with greater exposure to green spaces (Mitchell and Popham, 2008).

Some authors point to the paradox of a dynamic in urban development areas where the greater the amount, size and quality of green spaces, the greater their attractiveness and thus the stronger the pressure for displacement of socially vulnerable groups (Anguelovski *et al.*, 2018, p. 462) (Goodling, Green and McClintock, 2015) (Wolch, Byrne and Newell, 2014) and where urban greening generates new trends of social exclusion and segregation (Haase *et al.*, 2017), (Anguelovski, Connolly and Brand, 2018b, p. 417) – a phenomenon characterized as green gentrification (Gould and Lewis, 2017) or environmental gentrification (Curran and Hamilton, 2012), (Anguelovski *et al.*, 2018, p. 461). Building on those considerations those authors present a critique of what they call development-oriented greening (Anguelovski et al., 2018b, p. 418).

Some studies point to the importance of understanding the particularities of the contexts of creation of urban green spaces as well as of the existing built environment in order to gain proper insight into possible trends of social exclusion and green gentrification or the absence of those trends (Mears and Brindley, 2019), (Mears *et al.*, 2019), (Anguelovski et al., 2018a, p. 425-426), (Xu *et al.*, 2018).

Even though we do not directly engage in a discussion of potential green gentrification in the context of vulnerable neighborhoods in Copenhagen analyzed in this paper, we introduce it here as an important topic to be considered in relation to a discussion on green space policy.

2.5. Copenhagen Green Space Policy

The Copenhagen Municipal Plan 2019 underlines that "Copenhageners' health is generally closely linked to their background, including level of education, housing conditions and income." Furthermore, it proposes that to "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)

Furthermore, the Copenhagen Municipal Plan formulates the following goals concerning green spaces:

- "That new recreational areas and open spaces for new construction contribute to making the city more green to the benefit of the citizens' quality of life, biodiversity and to adapt the city to the climate of the future." (City of Copenhagen, 2019, p. 22)
- "That the green and blue areas and connections contribute to promoting a healthy and active everyday lifestyle and to strengthening biodiversity both locally and globally." (City of Copenhagen, 2019, p. 23)

In addition, specific goals concerning promoting healthy urban living are formulated:

- "To create safe urban areas with meeting places and outdoor areas that make up the framework for a healthy and active life." (City of Copenhagen - Financial Administration, 2019, p. 27)
- "That the city is designed so that the healthy choice becomes the easy choice in everyday living by buildings and urban spaces encouraging movement, interaction and recreational experiences to the benefit of both physical and mental health." (City of Copenhagen, 2019, p. 27)
- "The provision of new and improved recreational areas in the City of Copenhagen is also aimed at contributing to mitigation of flash floods due to cloudbursts, to the lowering of the temperature in urban spaces and to enhancing biodiversity, amongst other envisaged impacts." (City of Copenhagen, 2019, p. 23)

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)

Furthermore, the Copenhagen Municipal Plan 2019 formulates the "political ambition that in the existing city there is no more than 300 meters in walking distance from the city's housing to a recreational area." (City of Copenhagen, 2019, p. 32). And in relation to future urban development, the ambition is that there is "maximum walking distance of 500 meters from home to a larger publicly accessible recreational area (larger than 2 hectares)." (City of Copenhagen - Financial Administration, 2019, p. 17)

In order to further document accessibility to green spaces in view of fulfilling the abovementioned 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 meters from residential

addresses to a recreational area (with a minimum of 500 m2) in the existing city and of a maximum distance of 500 meters 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]. According to this analysis, 9.9 % of housing (33,059 housing units) in the existing city is located at distance greater than 300 meters from a green area – according to the definition by the City of Copenhagen (The City of Copenhagen, Financial Administration, 2022) and 34.4 % of housing (114,889 housing units) in urban development areas is located at a distance greater than 500 meters from a green area (incl. Amager Beach Park) larger than 2 ha. (The City of Copenhagen, Financial Administration, 2022, p. 21)

3. Methodology

The present study is based on an analysis of spatial distribution of greenery – consisting of green areas (as defined by the City of Copenhagen), trees, green courtyards/backyards and NDVI values – in relation to spatial distribution of population density, (based on socio-economic data on level of income and level of education) and built density (floor-area ratio). This study was further qualified by an analysis of Airbnb geolocated data concerning descriptions of accommodation in terms of proximity to green areas. The idea of including Airbnb data has been to enrich the analysis with a level of perceived (subjective) proximity to green spaces (in this case by Airbnb accommodation hosts).

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), 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. 200m x 200m Grid Maps – data aggregated on a 200m x 200m grid
5. 100m x 100m Grid Maps – data aggregated on a 100m x 100m 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 used 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

[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 meters, 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)

[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

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, 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, were both considered in the present analysis.[5]

A list of all maps used as the basis of the present analysis is shown on Table 1 below.

#	Title	Data source	Description
10	Density of sleeping tourists	Airbnb	Density of sleeping tourists - points of Airbnb apartments extracted from the platform
12	Dens. of sleeping tourists- mash-up	Airbnb	Density of sleeping tourists - heatmap of Airbnb points
43	Most visited apartments	Airbnb	Representation of the most visited apartments - number of reviews on Airbnb
44	Distribution of apartments	Airbnb	Spatial distribution of apartments – data aggregated on a 200m x 200m grid
47	Number of reviews	Airbnb	Number of reviews of Airbnb apartments – data aggregated on a 200m x 200m grid
51	Price vs. Number of reviews	Airbnb	Number of reviews and price of apartments – data aggregated on a 200m x 200m grid
58	Park – Private Garden	Airbnb	Incidence of "Park" overlayed with "private garden" in the description of apartment – 200m x 200m grid
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 x 100 grid calculated from the building's footprint
74	Street density	CPH Municipality	Total surface of streets aggregated to a 100x100 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 - 100x100 grid
78	Trees	CPH Municipality	Total amount of trees aggregated to a 100x100 grid
79	Trees Radius Height NDVI	Sentinel-2	Average radius of trees (age indicator) & average height aggregated to a 100x100 grid
81	Trees + Veg. + Courtyards	CPH Municipality	Total m2 of public spaces, the total amount of trees and the average index of vegetation - 100x100 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 – 100m x 100m grid
91	Trees + NDVI	Multiple sources	2 levels of data – NDVI and spatial distribution of trees - 200mx200m grid
92	Trees, NDVI and yards	Multiple sources	3 levels of data combined NDVI, tree location and green courtyards – 100mx100m 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
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 200m x 200m grid

[5] This is consideration 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.

Table 1: List of Maps

4. Results

4.1. Distribution of Green Spaces

Data on green spaces and trees comprises: (1) NDVI; (2) tree database (location, radius, and height of individual trees), (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 (The City of Copenhagen, Financial Administration, 2022), which only includes 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 (200m x 200m grid, datapoints, urban structure maps). The maps (58, 67, 68, 69, 70, 71, 75, 76, 78, 79, 81, 90 and 91) listed on Table 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 300m 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.

The distribution of green courtyards and green backyards (maps 68, 71, 75, 81) show a pattern where the occurrence of private or semiprivate green spaces is greater towards 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. A similar pattern of distribution, where greenery increases from center to periphery is shown in the point map (maps 70) or on the grid map (78) showing the distribution of trees. Exceptionally, the largest green space in the city, namely Amager Fælled, presents high NDVI values and abundant greenery but relatively few trees. Map 79 brings together three indicators of green infrastructure (tree height, tree radius and NDVI) and Map 80 combines data from NDVI register and tree location. These two maps further confirm the overall pattern of spatial distribution where greenery increases from center to periphery. But as indicated above, this increase in greenery in the periphery in relation to central areas is due to the greater number (and greater combined area) of green backyards in peripheral neighborhoods and is not necessarily indicative of greater proximity to parks or other large green spaces.

4.2. Distribution of Green Spaces and Social Equity

As a further development of the analysis presented in the article “Mapping Density and Distribution of

[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.

Urban Spaces in the City of Copenhagen" (Ribeiro and Nowak, 2021), this paper focusses on an analysis of greenery and in particular on the distribution of green areas in relation to indicators of population density, socioeconomics, and individual household conditions. Based on this analysis, this study examines household conditions in the Copenhagen Municipality through 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, 4) Amount of people per room in one household. The GIS and statistical analyses are performed in terms of inhabitants' age (0-99) and mapped on a *school district* (skoledistrikt) level, based on the Danish Building Register (BBR) and inhabitants' age point data for all Copenhagen housing units.

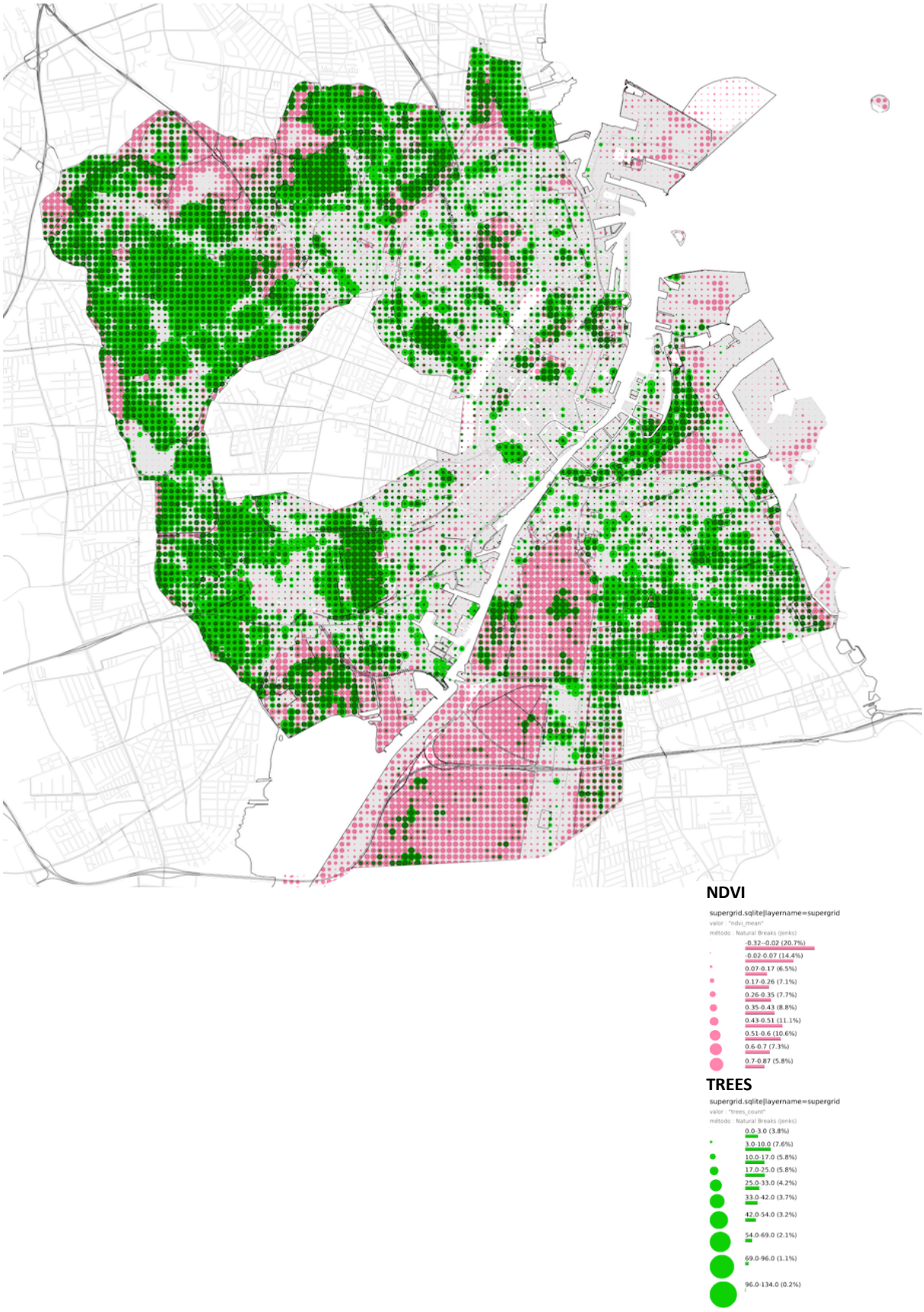

Figure 1: Map 91 – NDVI and spatial distribution of trees – aggregated on a 200-meter x 200-meter grid – source: Copenhagen Municipality

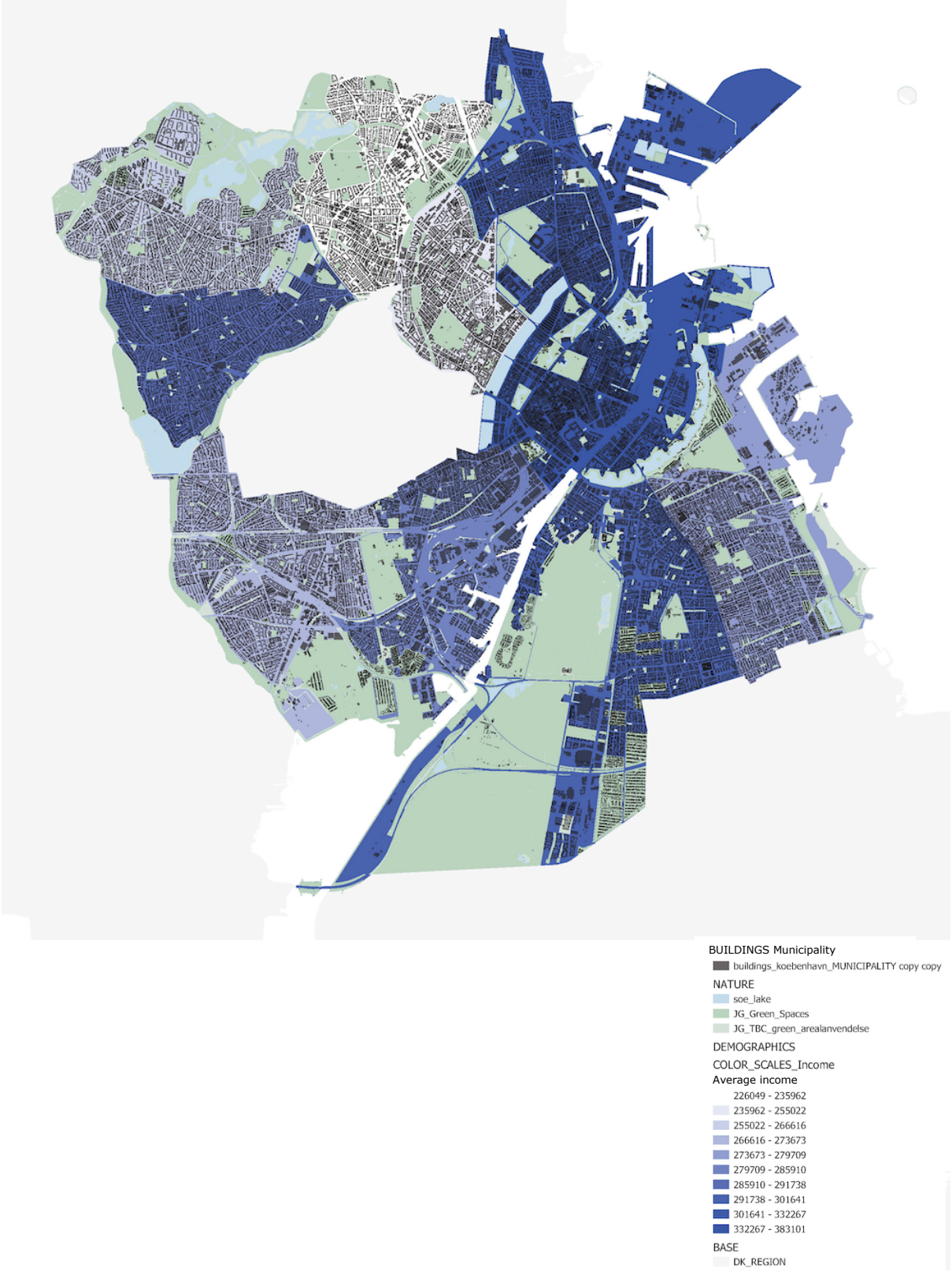

Figure 2: Map 121 – Spatial distribution of population according to income (per district) – Source: Copenhagen Municipality

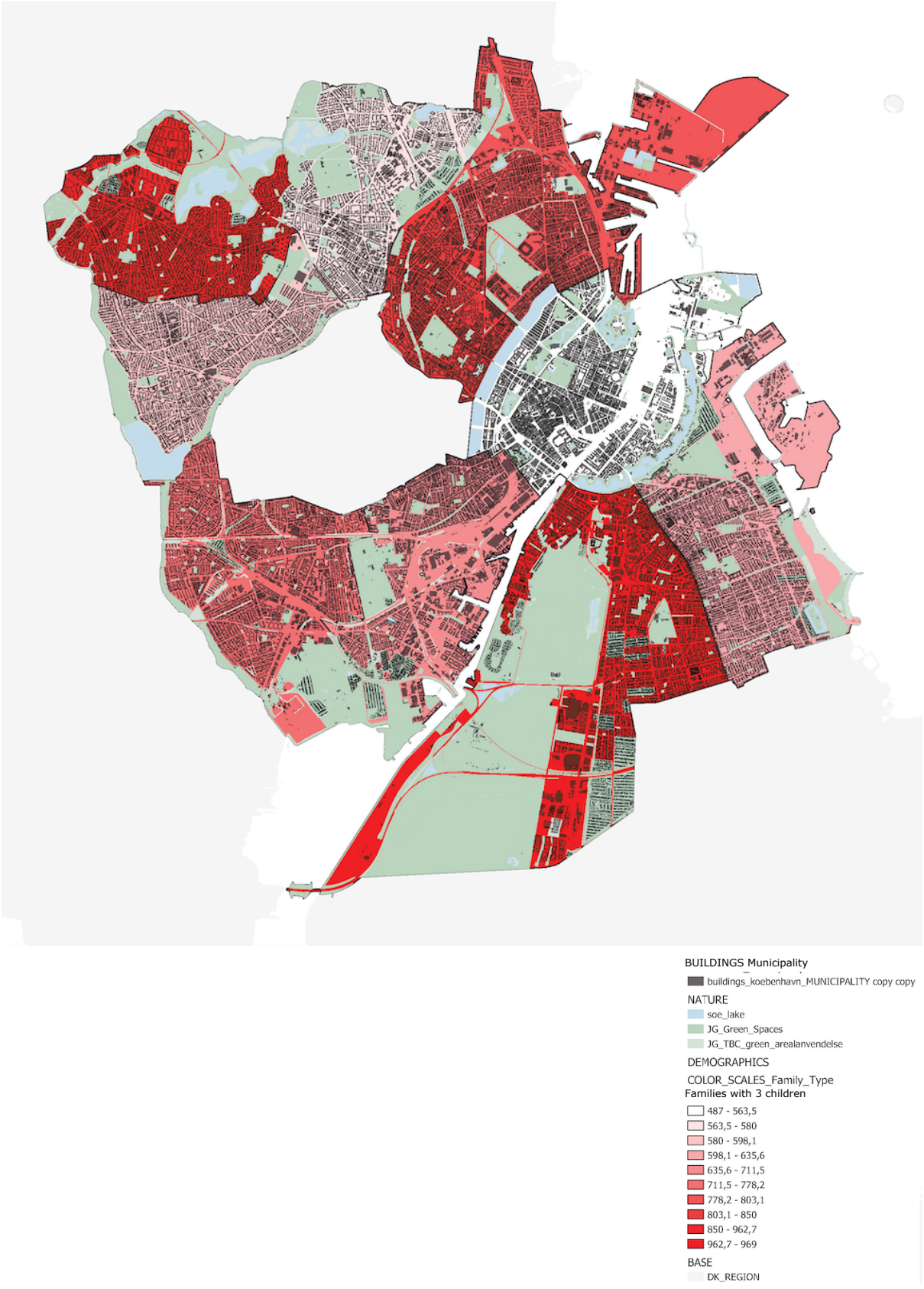

Figure 3: Map 122 – Spatial distribution of families with 3 children (per district) – Source: Copenhagen Municipality

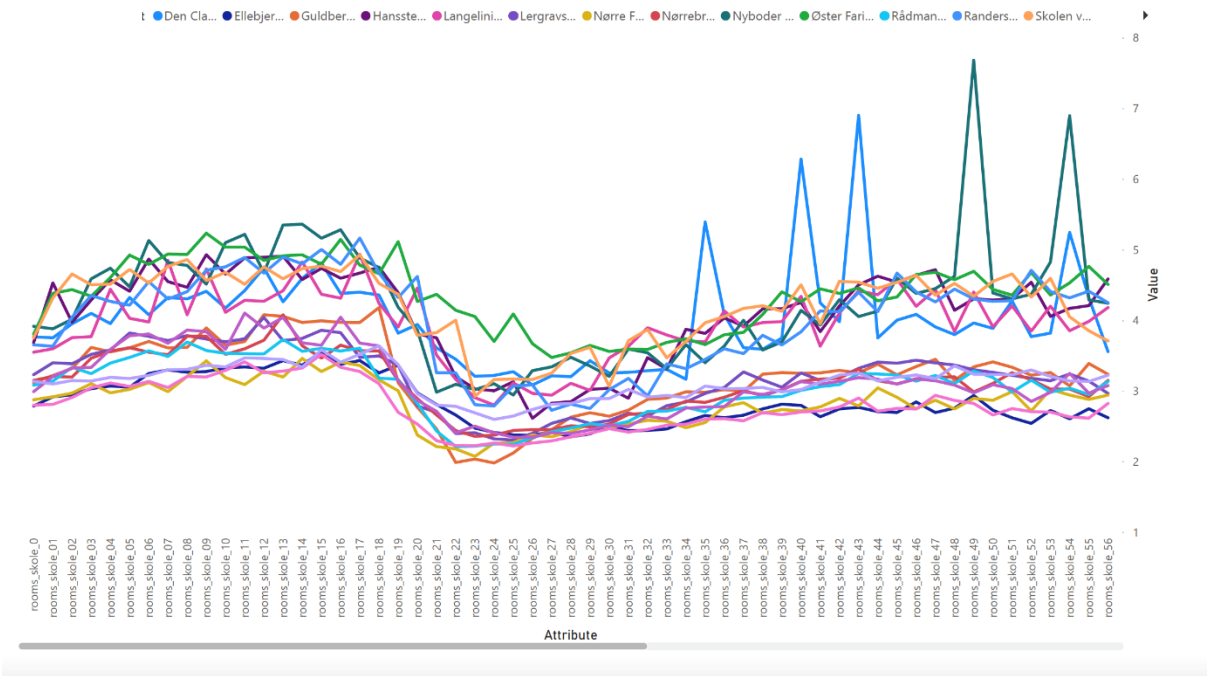

Figure 4: Average number of dwellers per room (per school district) – Source: Municipality of Copenhagen

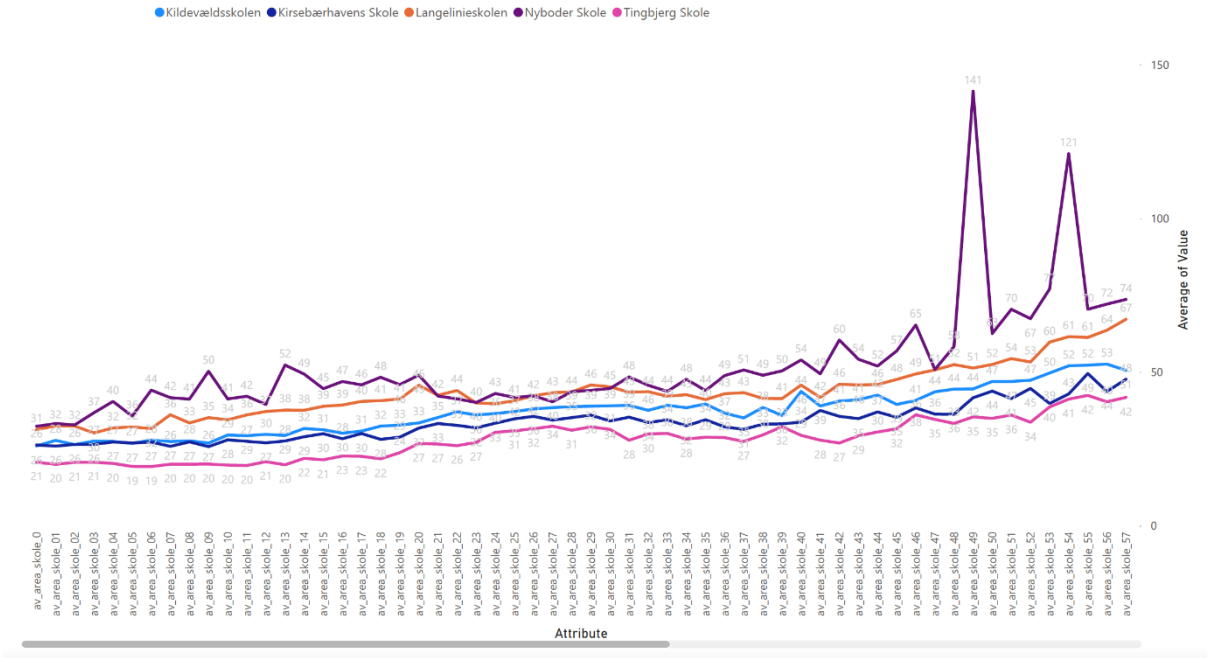

Figure 5: Average number of square meters per age (per school district) – Source: Copenhagen Municipality

5. Discussion

In this study, different types of green elements and indicators of greenery (NDVI, tree radius, green backyards/courtyards, and main green spaces) (maps 67, 68 69, 70, 71, 90, 91 and 92) are analyzed in relation to socio-economic indicators (maps 121 and 122) and indicators of built density (map 65) and demographic density (map 118). Data on green elements (green areas, trees, green courtyards/backyards), in addition to NDVI data, socio-economic data and built density data are in this analysis further qualified in reference to different urban typologies, with varying public space ratios. Urban typologies comprise single-family houses, early twentieth century low-rise residential blocks and modernist slabs (built in the 1960s and 1970s), amongst others. The present analysis as well as the analysis by the City of Copenhagen (The City of Copenhagen, Financial Administration, 2022) both show that some housing areas presenting those typologies are located at distances greater than 300 meters to green areas – such as housing areas in West Amager or South Amager which present modernist housing or areas in Bispebjerg that consist of low-rise courtyard blocks (planned in the beginning of the twentieth century), or single-family houses in Brønshøj. The analysis developed in this study shows that these different typologies present varying types of green elements (trees, pocket parks, green lawns, amongst others) in public, semipublic or private spaces and different spatial structures. Based on this analysis, we argue that these variations in urban typology, urban density, population density as well as household conditions (incl. household crowding) call for differentiated green space policy.

The analysis of data involving the use of the word *park* or *garden* to describe the urban context or neighborhood of accommodation listed on Airbnb (map 58), shows that areas (notably social housing areas in West Amager and South Amager) located at distances greater than 300 meters are not described as being in the vicinity of parks or other green spaces (by Airbnb hosts). The Airbnb map (58) that aggregate this data shows that areas lacking the description *park* or *garden* are amongst the areas that also are located at distances greater than 300 meters to major green spaces (following the classification by the City of Copenhagen). However, this result is not by any means conclusive. This result supports the thesis that perceived proximity to green spaces is lacking in areas that are located at greater distances than 300 meters. Because Airbnb hosts only represent a limited segment of the population of Copenhagen, further research is needed to further qualify the association between perceived distance to green spaces and actual walking distance.

6. Conclusion

With the aim of informing urban policy regarding planning and investment in the development of existing or new green spaces in the City of Copenhagen and in view of promoting more equitable access to green spaces, this study has used a variety of datasets concerning green spaces, greenery, population, urban density, and socio-economic data. One of this study's central contribution lies in the combination of these datasets to provide a more nuanced analysis of what is at stake in each urban area from the perspective of devising policies for better accessibility to green spaces. It is our contention that the combination of these levels of data can provide a more solid basis for the development of green space policy in Copenhagen.

We propose that further research should consist of a more detailed analysis, involving richer datasets concerning the distribution of greenery in relation to socio-economic data, population density and household conditions (such as residents per room and urban typology) to provide a set of detailed recommendations for green space policy in Copenhagen. We also acknowledge the importance of blue spaces as recreational areas and the need for further analysis on accessibility to blue spaces in relation to socio-economic data, and data on urban density.

Through the examination of these datasets, this study provides an analysis which takes into account

accessibility to green spaces in relation to urban typologies. These typologies present varied potentials for urban development and transformation in view of enhancing the green infrastructure in Copenhagen and of providing better accessibility to green spaces. In the case of (modernist) social housing areas planned in the 1960s and 1970s, there is a potential to incorporate areas originally planned as parking or lawns into the city's green infrastructure, thus improving accessibility to large recreational green spaces for the benefit of not only more vulnerable social groups, but also inhabitants of the whole city. We argue that this this level of analysis is of central importance for the future development of green areas as key public spaces and as strategic elements in an urban restructuring, which reassesses their potential not only as recreational spaces, but also in the role they can play to enhance biodiversity and make the city more resilient to the impact of climate change.

7. Acknowledgments

This study is based on dialogue and collaboration between the Royal Danish Academy and the City of Copenhagen. Our collaborators in the City of Copenhagen have provided detailed built density and geospatial socio-economic data and have engaged in a constructive dialogue about central issues connected to densification in the City of Copenhagen.

The Catalan urban planning agency 300.000 km/s (https://300000kms.net), through the work of Mar Santamaria and Pablo Martinez, has contributed with data gathering, aggregation of data and production of all maps referred to in this paper as well as map analysis.

8. References

Akpinar, A. (2016) 'How is quality of urban green spaces associated with physical activity and health?', *Urban Forestry & Urban Greening*, 16, pp. 76–83. Available at: https://doi.org/10.1016/j.ufug.2016.01.011.

Anguelovski, I. (2016) 'From Toxic Sites to Parks as (Green) LULUs? New Challenges of Inequity, Privilege, Gentrification, and Exclusion for Urban Environmental Justice', *Journal of Planning Literature*, 31(1), pp. 23–36. Available at: https://doi.org/10.1177/0885412215610491.

Anguelovski, I. *et al.* (2018) 'Assessing green gentrification in historically disenfranchised neighborhoods: a longitudinal and spatial analysis of Barcelona', *Urban Geography*, 39(3), pp. 458–491. Available at: https://doi.org/10.1080/02723638.2017.1349987.

Anguelovski, I., Connolly, J. and Brand, A.L. (2018a) 'From landscapes of utopia to the margins of the green urban life: For whom is the new green city?', *City*, 22(3), pp. 417–436. Available at: https://doi.org/10.1080/13604813.2018.1473126.

Anguelovski, I., Connolly, J. and Brand, A.L. (2018b) 'From landscapes of utopia to the margins of the green urban life: For whom is the new green city?', *City*, 22(3), pp. 417–436. Available at: https://doi.org/10.1080/13604813.2018.1473126.

van den Berg, M. *et al.* (2015) 'Health benefits of green spaces in the living environment: A systematic review of epidemiological studies', *Urban Forestry & Urban Greening*, 14(4), pp. 806–816. Available at: https://doi.org/10.1016/j.ufug.2015.07.008.

Caspersen, O.H., Konijnendijk, C.C. and Olafsson, A.S. (2006) 'Green space planning and land use: An assessment of urban regional and green structure planning in Greater Copenhagen', *Geografisk Tidsskrift-Danish Journal of Geography*, 106(2), pp. 7–20. Available at: https://doi.org/10.1080/00167223.2006.10649553.

City of Copenhagen (2019) 'Copenhagen Municipal Plan 2019 | KØBENHAVNS KOMMUNEPLAN 2019'. City of Copenhagen. Available at: https://www.kp19.kk.dk/copenhagen-municipal-plan-2019 (Accessed: 12 September 2021).

City of Copenhagen (2022) *Status på København 2022*. Copenhagen. Available at: https://www.kk.dk/sites/default/files/2022-08/Status%20på%20København%202022.pdf (Accessed: 6 September 2022).

Curran, W. and Hamilton, T. (2012) 'Just green enough: contesting environmental gentrification in Greenpoint, Brooklyn', *Local Environment*, 17(9), pp. 1027–1042. Available at: https://doi.org/10.1080/13549839.2012.729569.

Dadvand, P. *et al.* (2016) 'Green spaces and General Health: Roles of mental health status, social support, and physical activity', *Environment International*, 91, pp. 161–167. Available at: https://doi.org/10.1016/j.envint.2016.02.029.

Gascon, M. *et al.* (2015) 'Mental Health Benefits of Long-Term Exposure to Residential Green and Blue Spaces: A Systematic Review', *International Journal of Environmental Research and Public Health*, 12(4), pp. 4354–4379. Available at: https://doi.org/10.3390/ijerph120404354.

Goodling, E., Green, J. and McClintock, N. (2015) 'Uneven development of the sustainable city: shifting capital in Portland, Oregon', *Urban Geography*, 36(4), pp. 504–527. Available at: https://doi.org/10.1080/02723638.2015.1010791.

Gould, K.A. and Lewis, T.L. (2017) *Green gentrification: urban sustainability and the struggle for environmental justice*. London New York: Routledge (Routledge equity, justice and the sustainable city series).

Haaland, C. and van den Bosch, C.K. (2015) 'Challenges and strategies for urban green-space planning in cities undergoing densification: A review', *Urban Forestry & Urban Greening*, 14(4), pp. 760–771. Available at: https://doi.org/10.1016/j.ufug.2015.07.009.

Haase, D. *et al.* (2017) 'Greening cities – To be socially inclusive? About the alleged paradox of society and ecology in cities', *Habitat International*, 64, pp. 41–48. Available at: https://doi.org/10.1016/j.habitatint.2017.04.005.

Hartig, T. *et al.* (2014) 'Nature and Health', *Annual Review of Public Health*, 35(1), pp. 207–228. Available at: https://doi.org/10.1146/annurev-publhealth-032013-182443.

James, P. *et al.* (2009) 'Towards an integrated understanding of green space in the European built environment', *Urban Forestry and Urban Greening*, 8(2), pp. 65–75. Available at: https://doi.org/10.1016/j.ufug.2009.02.001.

Landry, S.M. and Chakraborty, J. (2009) 'Street Trees and Equity: Evaluating the Spatial Distribution of an Urban Amenity', *Environment and Planning A: Economy and Space*, 41(11), pp. 2651–2670. Available at: https://doi.org/10.1068/a41236.

Liu, B. *et al.* (2022) 'Evaluating the disparity between supply and demand of park green space using a multi-dimensional spatial equity evaluation framework', *Cities*, 121, p. 103484. Available at: https://doi.org/10.1016/j.cities.2021.103484.

Maas, J. (2006) 'Green space, urbanity, and health: how strong is the relation?', *Journal of Epidemiology & Community Health*, 60(7), pp. 587–592. Available at: https://doi.org/10.1136/jech.2005.043125.

Mears, M. *et al.* (2019) 'Understanding the socioeconomic equity of publicly accessible greenspace distribution: The example of Sheffield, UK', *Geoforum*, 103, pp. 126–137. Available at: https://doi.org/10.1016/j.geoforum.2019.04.016.

Mears, M. and Brindley, P. (2019) 'Measuring Urban Greenspace Distribution Equity: The Importance of Appropriate Methodological Approaches', *ISPRS International Journal of Geo-Information*, 8(6), p. 286. Available at: https://doi.org/10.3390/ijgi8060286.

Mensah, C.A. *et al.* (2016) 'Enhancing quality of life through the lens of green spaces: A systematic review approach', *International Journal of Wellbeing*, 6(1), pp. 142–163. Available at: https://doi.org/10.5502/ijw.v6i1.445.

Mitchell, R. and Popham, F. (2008) 'Effect of exposure to natural environment on health inequalities: an observational population study', *The Lancet*, 372(9650), pp. 1655–1660. Available at: https://doi.org/10.1016/S0140-6736(08)61689-X.

Pauleit, S. (2003) 'Perspectives on Urban Greenspace in Europe', *Built Environment*, 29(2), pp. 89–93. Available at: https://doi.org/10.2148/benv.29.2.89.54470.

Pauleit, S., Ennos, R. and Golding, Y. (2005) 'Modeling the environmental impacts of urban land use and land cover change—a study in Merseyside, UK', *Landscape and Urban Planning*, 71(2–4), pp. 295–310. Available at: https://doi.org/10.1016/S0169-2046(04)00083-0.

Perkins, H.A., Heynen, N. and Wilson, J. (2004) 'Inequitable access to urban reforestation: the impact of urban political economy on housing tenure and urban forests', *Cities*, 21(4), pp. 291–299. Available at: https://doi.org/10.1016/j.cities.2004.04.002.

Samuelsson, K. *et al.* (2020) 'Residential environments across Denmark have become both denser and greener over 20 years', *Environmental Research Letters*, 16(1), p. 014022. Available at: https://doi.org/10.1088/1748-9326/abcf7a.

Schüle, S.A. *et al.* (2019) 'Social Inequalities in Environmental Resources of Green and Blue Spaces: A Review of Evidence in the WHO European Region', *International Journal of Environmental Research and Public Health*, 16(7), p. 1216. Available at: https://doi.org/10.3390/ijerph16071216.

Shanahan, D.F. *et al.* (2014) 'Socio-economic inequalities in access to nature on public and private lands: A case study from Brisbane, Australia', *Landscape and Urban Planning*, 130, pp. 14–23. Available at: https://doi.org/10.1016/j.landurbplan.2014.06.005.

Sister, C., Wolch, J. and Wilson, J. (2010) 'Got green? addressing environmental justice in park provision', *GeoJournal*, 75(3), pp. 229–248. Available at: https://doi.org/10.1007/s10708-009-9303-8.

Ståhle, A. (2010) 'More green space in a denser city: Critical relations between user experience and urban form', *URBAN DESIGN International*, 15(1), pp. 47–67. Available at: https://doi.org/10.1057/udi.2009.27.

Tamosiunas, A. *et al.* (2014) 'Accessibility and use of urban green spaces, and cardiovascular health: findings from a Kaunas cohort study', *Environmental Health*, 13(1), p. 20. Available at: https://doi.org/10.1186/1476-069X-13-20.

Tan, P.Y. and Samsudin, R. (2017) 'Effects of spatial scale on assessment of spatial equity of urban park provision', *Landscape and Urban Planning*, 158, pp. 139–154. Available at: https://doi.org/10.1016/j.landurbplan.2016.11.001.

The City of Copenhagen, Financial Administration (2022) *Analyse af afstandsmål til grønne og blå områder i København Økonomiforvaltningen* •. Copenhagen. Available at: https://www.kk.dk/dagsordener-og-referater/Økonomiudvalget/møde-14062022/referat/punkt-16 (Accessed: 26 August 2022).

Triguero-Mas, M. *et al.* (2015) 'Natural outdoor environments and mental and physical health: Relationships and mechanisms', *Environment International*, 77, pp. 35–41. Available at: https://doi.org/10.1016/j.envint.2015.01.012.

Wolch, J., Wilson, J.P. and Fehrenbach, J. (2005) 'Parks and Park Funding in Los Angeles: An Equity-Mapping Analysis', *Urban Geography*, 26(1), pp. 4–35. Available at: https://doi.org/10.2747/0272-3638.26.1.4.

Wolch, J.R., Byrne, J. and Newell, J.P. (2014) 'Urban green space, public health, and environmental justice: The challenge of making cities "just green enough"', *Landscape and Urban Planning*, 125, pp. 234–244. Available at: https://doi.org/10.1016/j.landurbplan.2014.01.017.

Xu, C. *et al.* (2018) 'Spatial variation of green space equity and its relation with urban dynamics: A case study in the region of Munich', *Ecological Indicators*, 93, pp. 512–523. Available at: https://doi.org/10.1016/j.ecolind.2018.05.024.

Zhang, L. and Tan, P. (2019) 'Associations between Urban Green Spaces and Health are Dependent on the Analytical Scale and How Urban Green Spaces are Measured', *International Journal of Environmental Research and Public Health*, 16(4), p. 578. Available at: https://doi.org/10.3390/ijerph16040578.

Zhou, X. and Kim, J. (2013) 'Social disparities in tree canopy and park accessibility: A case study of six cities in Illinois using GIS and remote sensing', *Urban Forestry & Urban Greening*, 12(1), pp. 88–97. Available at: https://doi.org/10.1016/j.ufug.2012.11.004.