Graduation Plan

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Title

An interactive design tool for urban planning using the size of the living space as unit of measurement.

Research

See full proposal attached.

An interactive design tool for urban planning using the size of the living space as unit of measurement

MSc Geomatics Thesis Proposal
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1 Introduction

Geomatics and geodesign are two concepts tightly related, the first one is the discipline in charge of managing *spatial* information (*ISO/TR 19122:2004*) and the second one is the approach in which *spatial* challenges are faced by a multidisciplinary team (*Steinitz, 2012*). This research is an example of how these concepts find their connection in the living space.

In urban planning, a common unit of measurement to define the density of an area is the amount of houses per hectare. What is not clear, is the size of the houses, because this parameter is related with many cultural and, sometimes, economic variables.

One of the goals of this project is to calculate the size of the living space in Amsterdam and understand its relation with density and price of the house, among other parameters. Once the size of the interior and exterior spaces are measured, these dimensions will be used as a unit of measurement in a design tool for urban planning.

The tool will be an interactive software aimed to facilitate the decision-making in the design process in new urban developments. Sloterdijk I as a test case, one of the initial phases of the *Haven-Stad* (Port-City) project in Amsterdam, will be used as a location for testing the tool. The urban planning guidelines for Sloterdijk I, will be the minimum requirements to select the areas in which the space calculation will be carried out.

To conclude, the geodesign approach will be implemented by participating in the *Stad van de Toekomst* graduation lab (City of the Future graduation lab), a multidisciplinary group in the faculty of architecture in TU Delft. Collaborations, discussions and interaction with students from different space-related disciplines (architecture, urbanism, transportation engineering, etc.) will naturally lead to overcome the spatial challenges related with this research.

Scientific Relevance

According to an article published by the UK government (*CPRE, 2002*), when designing a new housing development with low density, the land is wasted. It is true that, every house is enjoying bigger open spaces, but it is completely unsustainable for the UK. In the Netherlands, one of the smallest and denser countries in Europe (*World Bank WV.1*), this topic has great relevance, especially in urban environments like the city of Amsterdam where the lack of housing is becoming a primal need (*Structuurvisie Amsterdam 2040*). For this reason, it is important to understand the size or our living spaces and design better urbanizations for future generations.

The quality of life, in residential areas, is another parameter recurrently studied but hardly quantifiable. For example, regarding with open spaces, if greener is the neighborhood, healthier their inhabitants (*Maas et al. 2016*) or happier (*White et al. 2012*), and regarding with the size of interior space, a bigger house can increase the levels of subjective well-being but only for a short period of time (*Foye, 2016*). To contribute to the quality of life studies in the Netherlands, this study will consider the quality of life scores from the ***Leefbaarometer*** (*livable meter – www.leefbaarometer.nl*) to analyze the space of the living space in relation with the livability for every neighborhood.

Finally, as this research will be made using exclusively open data, a secondary intension of this research is to promote the use of open data for design purposes in urban planning, in order to improve the quality of our built environment.

2 Research objectives

Research question

The main research question for this thesis is:

What is the relation between the size of the living space, housing density and the price of the house in Amsterdam and how this dimension can be used as a unit of measurement for new housing developments like Sloterdijk I?

Scope of the research

This thesis will focus on two principal objectives, the first one is the analysis of urban areas in Amsterdam to determine housing dimension standards and the second one, is to develop a parametric city-design software using these dimensions.

The main goal of this tool is to improve the quality of space in the built environment by helping urban planners in the decision-making process of city planning and promote the use of open data for design purposes.

Other expected uses of the tool related with the design-process in urban planning are:

Before: Help to set the minimum parameters for a new urban project.
During: Review the guidelines to check if the parameters are still valid.
After: To adjust parameters or add new data to the analysis over time.

3 Related work

OnTheGo – *The Why Factory 2017-2018*

Aimed to optimize interior spaces in buildings, students and researchers from TU Delft (*The Why Factory 2017-2018*) calculated the minimum needed space to realize routine activities from daily life. The volume calculation was made by placing sensors in the human body while the activities were made. The resulting information was voxelized and distributed inside of a container (the future building). Afterwards, this cluster of 3D spaces was flattened into a 2.5D representation, and interpreted as a building façade. Finally the extrusion of the façade gave the shape of the final building (fig.1).

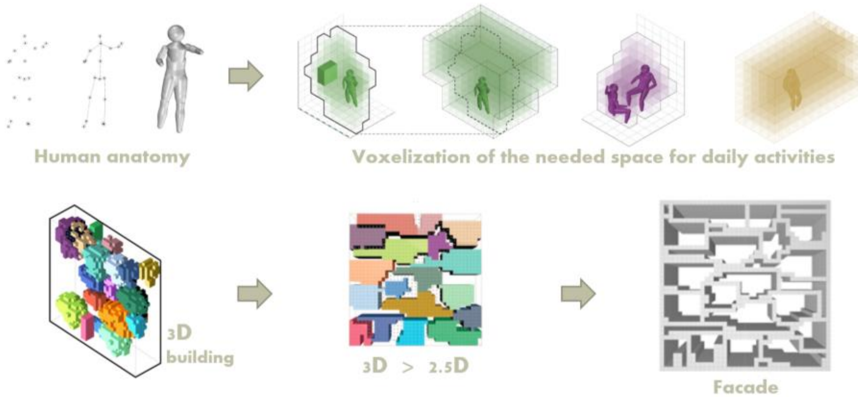

Figure 1. Extract from the procedure ONTHEGO project - The Why Factory (2017-2018).

Inspired by this project, a similar approach will be used on this research to calculate the minimum space needed by a person to live and process it to create a new part of the city.

The relation between the size of living space and subjective well-being – ***Chris Foye, 2016***

This research was focused on the effect of the living space size on people in the UK based on the British Household Panel Survey (BHPS). The concept of well-being was always considered as subjective, nevertheless, patterns of positive impact were founded mostly in male citizens than female when increasing the size of the house but only temporarily.

An interesting point of this research, is the accent on the shrinking of new homes in Great Britain, leading families to find a bigger house, definitely, a relevant topic as well for the Netherlands.

4 Methodology

The methodology of this research is divided in three main steps, the first one is the selection of candidate neighborhoods in the Municipality of Amsterdam, the second one, is the calculation of living spaces for each selected area and the last one is the creation of an interactive 3D city model (fig.2).

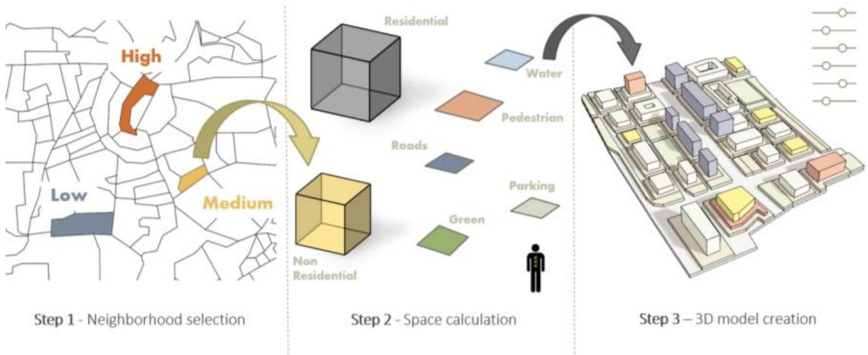

Figure 2. Overview of the methodology.

Part one: Selection of the areas

Sloterdijk I, is the second stage of the Haven-Stad project in the Municipality of Amsterdam. It is thought as a mixed-use area (80% residential and 20% business) with high housing density aimed to vent the pressure in housing needs in the city. The strategic location, one kilometer away from the Sloterdijk train station and 3.7 km away from the Amsterdam central station, make the project a desirable area to live for many residents. The guidelines of this project will be the minimum criteria for searching study areas in the city. The most relevant parameters are:

Use: 80% Residential, 20% Business.
Density: 192 Houses per hectare.
Housing typology: Social housing, medium-level and high-level housing.
Quality of life: "super high".

Source: *Sloterdijk I Strategie nota 2016*

This part of the methodology will be carried out using the neighborhood scale in the Dutch datasets (*buurt*). In order to find the mentioned characteristics within the city of Amsterdam, different open datasets were analyzed, filtered and processed with GIS tools. Following, the data analysis procedure:

Land use 2017

Grondgebruik_2017 (*Use of the land 2017*) is an open dataset created by the municipality of Amsterdam. It was overlapped to the neighborhood map of the city to find areas predominantly residential. The used attribute was Living areas (inc. facilities).

Housing density in houses per hectare

In the *CBS Wijken en Buurten 2017* (*CBS Districts and Neighborhoods 2017*), an Official Dutch dataset for the whole Netherlands, two parameters were used to calculate the density for each neighborhood: *AANTAL_HH - Aantal huishoudens* (number of households) and the *OPP_LAND - Oppervlakte land in ha* (Land surface in Ha). The new index was created using the following formula for each neighborhood:

$$\text{Neighborhood Density Index (NDI)} = \frac{H}{A}$$

H = number of houses in the neighborhood (AANTAL_HH).
A = area of the neighborhood (only land, no water areas considered) in hectares (OPP_LAND).

Finally, neighborhoods with an NDI higher than 95 houses per hectare were intersected with the Land Use map to find high density-residential neighborhoods.

Average price per square meter of houses

The price of the houses was used to have an idea about the housing typologies (social, medium or high level). The dataset *Woningwaarde_2015* (*house value 2015*) was created by the municipality of Amsterdam using contour line-shaped polygons with ranges of prices. To be able to have a price index for every selected neighborhood, the geometries were splitted by neighborhood and used the following formula:

For each neighborhood:

$$\text{Neighborhood Price Index (NPI)} = \frac{\Sigma\,(\text{Price} * \text{poly\_area})}{\Sigma\,(\text{poly\_area})}$$

Price = Price per sq. meter of a splitted polygon
poly_area = Area of the splitted polygon

Quality of life

Only as a reference (because of the subjectivity of the term quality of life), the *Leefbaarometer* (*livable meter – www.leefbaarometer.nl*), an official Dutch source of information about the quality of life in the whole Netherlands, was used as an indicator of liveness in the neighborhoods.

Buildings year of construction

Another reference to understand if the area is part of a recent expansion of the city, the average year of construction of the buildings within the neighborhoods was calculated using the *Bouwjaar* dataset (*year of construction*) from the municipality of Amsterdam. The following formula was implemented:

For each neighborhood:

$$\text{Neighborhood Year Index (NYI)} = \frac{\Sigma\,(\text{Year} * \text{buurt\_area})}{\Sigma\,(\text{buurt\_area})}$$

Year = Year of construction of a single building within the neighborhood
buurt_area = Area of a single building within the neighborhood

To conclude this part of the methodology, GIS analysis were carried out to find high density indexes, low/high prices and quality of life scores in the Amsterdam neighborhoods.

Part two: Space calculation

Once a neighborhood selection was made, the space is divided in two main categories for calculation purposes: indoor space, calculated in 2.5D and open space calculated in 2D (fig. 3).

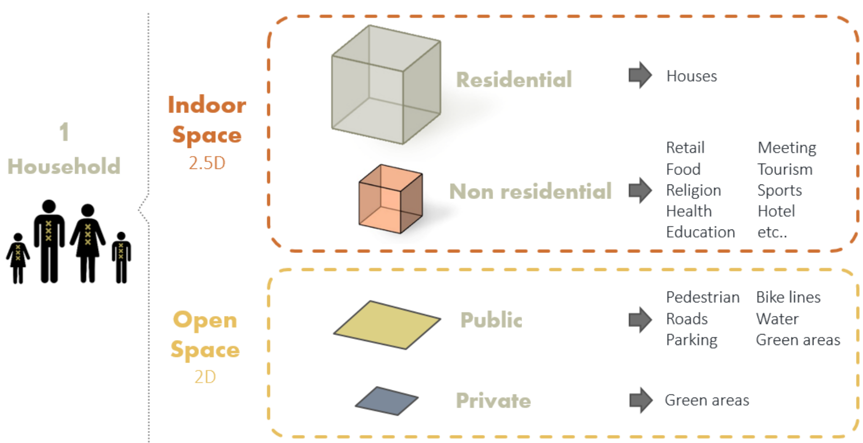

Figure 3. Overview of the second part of the methodology.

Indoor spaces are buildings or volumetric constructions comprehended in the *Bouwjaar* dataset. The volume of these buildings was computed by extruding the building polygons to the median height of the Z values for each building in the pointcloud AHN3 (*Actueel Hoogtebestand Nederland 3 – Current height file Netherlands 3*), using the building classification (fig. 4). In addition to the height of the buildings, it was considered an extra underground level of 4 meters for each building.

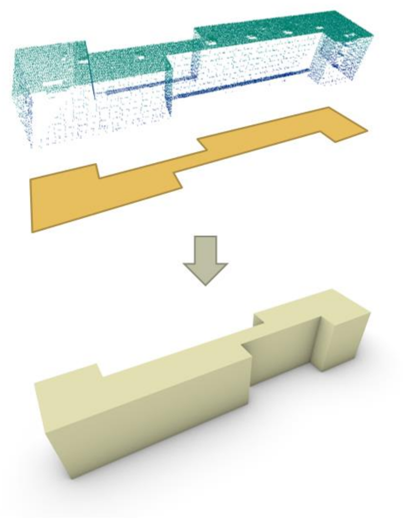

Figure 4. Extrusion of the Buildings to LOD 1.

As the AHN3 make height references to the NAP level (*Normaal Amsterdams Peil* – *Normal Amsterdam Level*), the average height of the ground level in the neighborhood was calculated with the Z values of the AHN3 in the ground classification. This aimed to set a starting height of extrusion.

The municipality has available an open dataset with all the non-residential functions in the city, the *Functiekaart* (*Function map*). This map contain 80 subcategories of uses, from which 39 were found in the selected neighborhoods of the first part of the methodology. Because of the *Functiekaart* is provided in 2D polygons and no height information is available, a number of levels were assigned to each category to calculate the volumes of the non-residential functions based on personal knowledge.

In the dataset, an attribute referred to the area of the non-residential function was available (*Oppervlakt*). A test on dividing such area by the foot print area of the building does not reflect the real number of levels, the result was only the half of the height. Because of it, a personal consideration was carried out.

The number of stories for each category was assigned using common sense, for example, a coffee shop or a phone/internet center, most of the times, are situated in the ground floor and the business area have only one level, for these reasons, the minimum story number was assigned in the list for these categories. In contrast, a large supermarket, a school or a theater have no number of levels but the whole building height is considered. These non-residential function geometries were extruded considering 4 meters height for each level.

To better understand the extrusion process, in the figure 5 is possible to see heights and considerations for volume calculations.

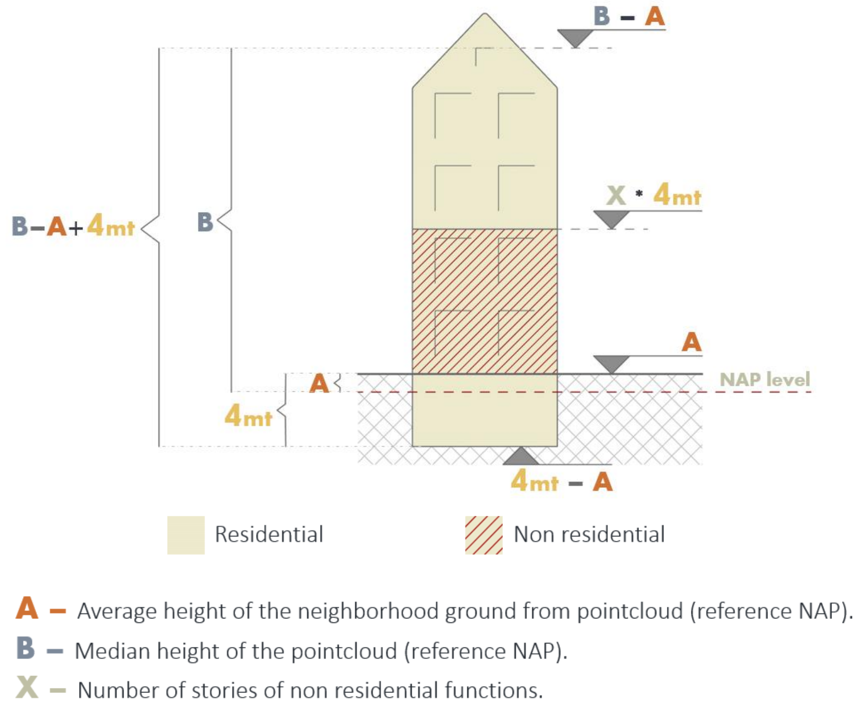

Figure 5. Extrusion criteria for indoor spaces.

Finally, to calculate the square meters of open space, the Basisregistratie Grootschalige Topografie dataset (*BGT - Basic registration Large-scale Topography*, layers: bgt_begroeidterreindeel, bgt_wegdeel, bgt_waterdeel and bgt_ondersteunendwegdeel), was used to identify the following categories of external spaces:

- Roads for vehicles
- Green areas
- Parking
- Bike lines
- Water areas
- Pedestrian areas

A final calculation was made using the Basisregistratie Kadaster (*BRK – Basic registration Cadaster*), in which the parcel division of the land is registered. This dataset was used to identify private and public soil. If a parcel contains at least one building from the Bouwjaar dataset was considered private, otherwise was designed as public.

Part three: Creation of the tool

The final part of the methodology is to create an interactive 3D city model to design Sloterdijk I. Initially a selection of parameters to include in the model should be made based on the Municipality guidelines. The following list is an example of the parameters to use:

- 80% residence
- 20% other uses
- 11,220 new homes
- 7,480 jobs
- 8 schools
- 8 health center
- 23mt. Max height commercial
- 30mt. Max height residence
- 40mt. Max height offices
- 2,2 = FSI
- 0,9 = Car index
- Retail on ground f.
- High quality of life
- Respect existing mobility infrastructure

This information should be available and modifiable in the 3D model to create the interaction and design process.
Once the parameters are defined, the sizes of the houses, size of open spaces and number of households should be added to the equation to create the 3D model (fig. 6).

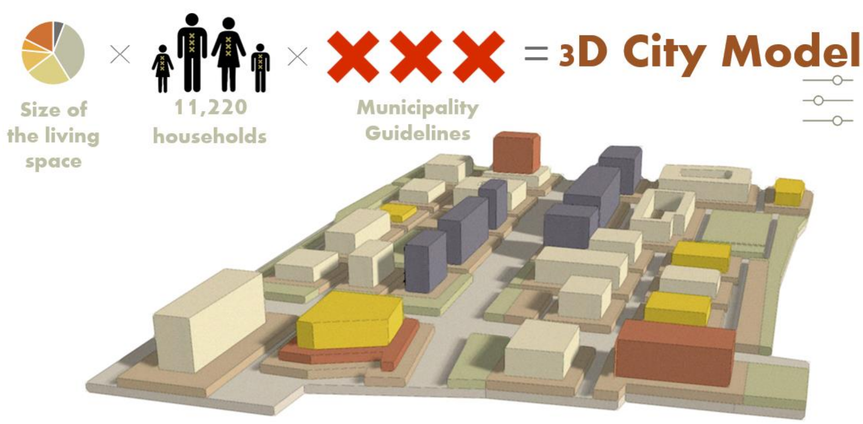

Figure 6. Creation of the 3D model.

The implementation of the software is yet to be decided if doing it with Grasshopper, Rhinoceros and Phyton or the Mobius Parametric Software (Design Automation Lab).
To conclude, an extra challenge is to implement the model online for test and get feedback from users.

5 Time planning

In the figure 7, the schedule to meet the research objectives.

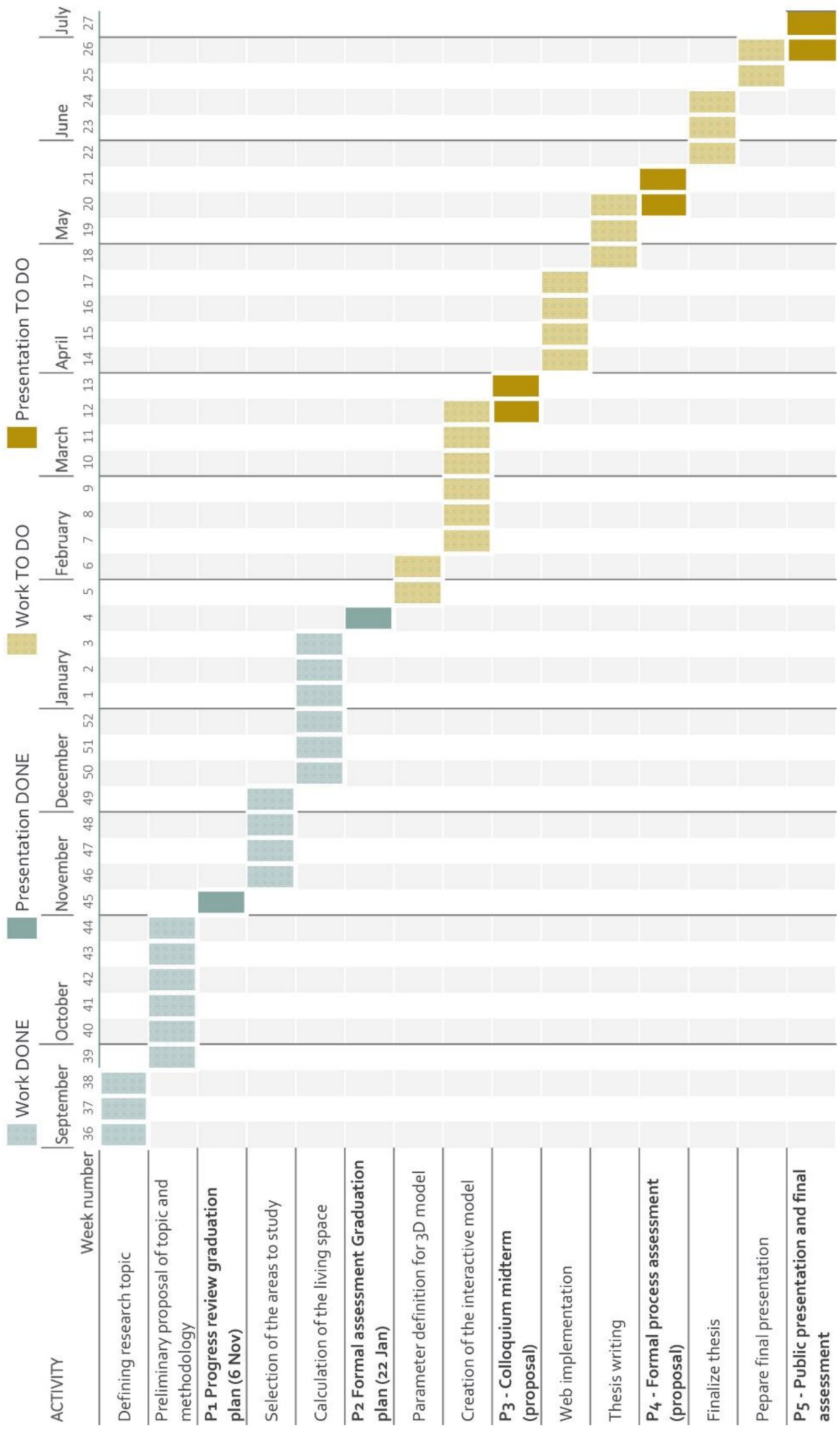

Figure 7. Graduation plan schedule.

6 Tools and data

Tools

The main tools to be used on this research are:

-Selection of the neighborhoods: Quantum GIS (QGIS Org.).

-Calculation of the living space: FME (Safe software), Quantum GIS (QGIS Org.) and Rhinoceros (Robert McNeel & Associates).

-3D model creation: Rhinoceros and Grasshopper (Robert McNeel & Associates) and Python programming or Möbius Parametric Software (*Design Automation Lab*).

Data

2017, Land use Amsterdam

Dataset	GRONDGEBRUIK_2017
Page link	*https://maps.amsterdam.nl/open_geodata/?k=152*
Number of objects	8764 (Amsterdam – CSV file with geometry)
Recency	May 2017

2017, CBS Districts and Neighborhoods Netherlands

Dataset	CBS Wijken en Buurten 2017 (ATOM)
Page link	*https://geodata.nationaalgeoregister.nl/wijkenbuurten2017/atom/wijkenbuurten2017.xml*
Number of objects	13308 (Netherlands – ESRI SHP file)
Recency	2017

2015, House value Amsterdam

Dataset	Woningwaarde_2015
Page link	*https://maps.amsterdam.nl/open_geodata/?k=52*
Number of objects	0 (Contour polygons from Amsterdam – ESRI SHP files)
Recency	2002 – 2015

2016, Livable meter Netherlands – *www.leefbaarometer.nl*

Dataset	Leefbaarometer 2.0 = meting 2016
Page link	*https://data.overheid.nl/data/dataset/leefbaarometer-2-0---meting-2016*
Number of objects	12822 (Netherlands - XLS file no geometry)
Recency	2016

2015, Year of construction Amsterdam

Dataset	Bouwjaar
Page link	*https://maps.amsterdam.nl/open_geodata/?k=110*
Number of objects	16869 (Amsterdam – ESRI SHP files)
Recency	September 2015

2018, Current height file Netherlands 3

Dataset	Actueel Hoogtebestand Nederland 3
Page link	*https://www.pdok.nl/nl/ahn3-downloads*

Number of objects	- (pointcloud LAZ)
Recency	2018

2018, Non-residential functions Amsterdam

Dataset	Functiekaart
Page link	*https://maps.amsterdam.nl/open_geodata/?k=49*
Number of objects	28189 (CSV file)
Recency	2018

2018, BGT – Basic registration Large-scale Topography Netherlands

Dataset	Basisregistratie Grootschalige Topografie (BGT)
Page link	*https://www.pdok.nl/downloads?articleid=1948972*
Number of objects	- (GML file)
Recency	2018
Layers used	*bgt_begroeidterreindeel, bgt_wegdeel, bgt_waterdeel and bgt_ondersteunendwegdeel*

2018, BRK – Basic registration Cadaster Netherlands

Dataset	Basisregistratie Kadaster (BRK)
Page link	*https://www.pdok.nl/download/embed2.html?dataset=kadastralekaartv3*
Number of objects	- (GML file)
Recency	2018

7 Preliminary results

Seven neighborhoods were selected based on their similar characteristics with Sloterdijk I, see figure 8.

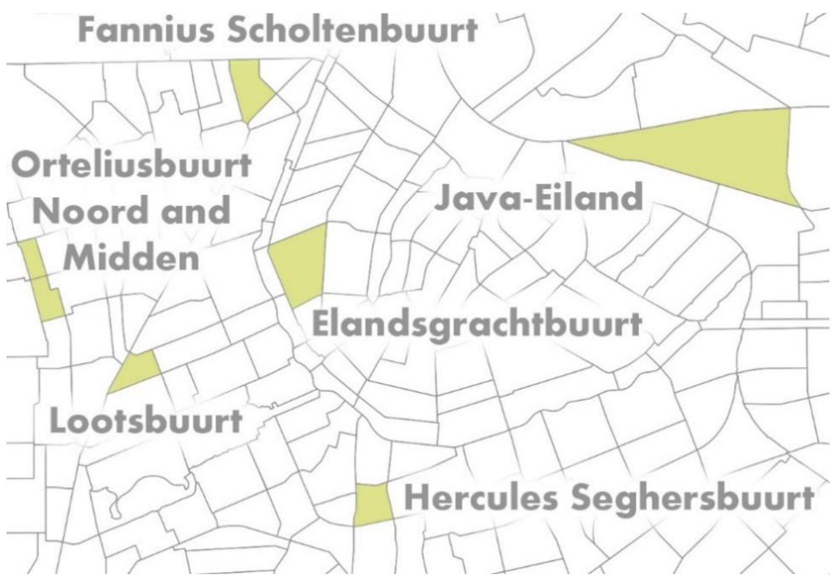

Figure 8. Seven neighborhoods selected for space analysis.

Orteliusbuurt Noord and Orteliusbuurt Midden will be considered as a single area because of their location. In the table A, the full list of attributes determining the selection criteria.

Neighborhood	Density (h/Ha)	Price Index per sq. meter	Quality of life	Year Index
Java-eiland	97	€ 4,885.00	8	1996
Elansgrachtbuurt	151	€ 6,738.00	9	1593
Orteliusbuurt	203	€ 5,442.00	4	1931
Lootsbuurt	214	€ 6,422.00	7	1918
Hercules Seghersbuurt	221	€ 6,207.00	7	1920
Fannius Scholtenbuurt	235	€ 6,151.00	4	1930

Table A. Characteristics of selected Neighborhoods.

In the neighborhood selection, four items have more than 200 houses per hectare. Based on the general densities of the city (between 15 and 235), 200 can be considered as high-density. Fannius Scholtenbuurt is the densest area in the municipality, but weak in quality of life. Three of these four areas, have a medium price per sq. meter, excluding Orteliusbuurt, with a price below the average and as well low life quality standards.
Java-Eiland, is a recent expansion of the city with less than 30 years old. Apart of being the cheapest in the list, is the one with the lower density of the list and the one containing a big project of social housing in their north facade (*http://stadseilanden.nl*).
Elandsgrachtbuurt is the only one belonging to the old part of the city, the average age of the buildings date from the XVI century. It has medium housing density, is the most expensive and also scores the highest quality of life.
To summarize this selection:
Four areas similar to Sloterdijk I project
One in the old part of the city with high quality and price standards
A recent development with low price and low density.

Regarding to the space analysis from the second part of the methodology, a data panel was made for each neighborhood containing an illustration of a building 5.4meter-wide (front facade) by 12 meter deep, containing three houses, modeled with the new calculated volumes. On this schematic building, it is possible to see the non-residential functions in the ground floor and, proportionally, the amount of square meters of open space resulting from the calculations. It is important to notice that the illustration of the building shows three houses, to create the idea of a condominium (as in the reality), but all the written data is given by a single house (fig.9).

Besides the volumetric and area calculations, three extra calculations were added to the panels:

The whole price per house: This information was computed by dividing the calculated volume of the house by 3 meters (one level height) and multiplying the result for the price index of the neighborhood.
Number of inhabitants per household: Calculated by dividing the number of inhabitants by the number of households from the *Wijken en Buurten* dataset.
Distance to the Amsterdam Central station: This distance was measured from the main entrance of the station in a straight line to the centroid of the neighborhood polygon.

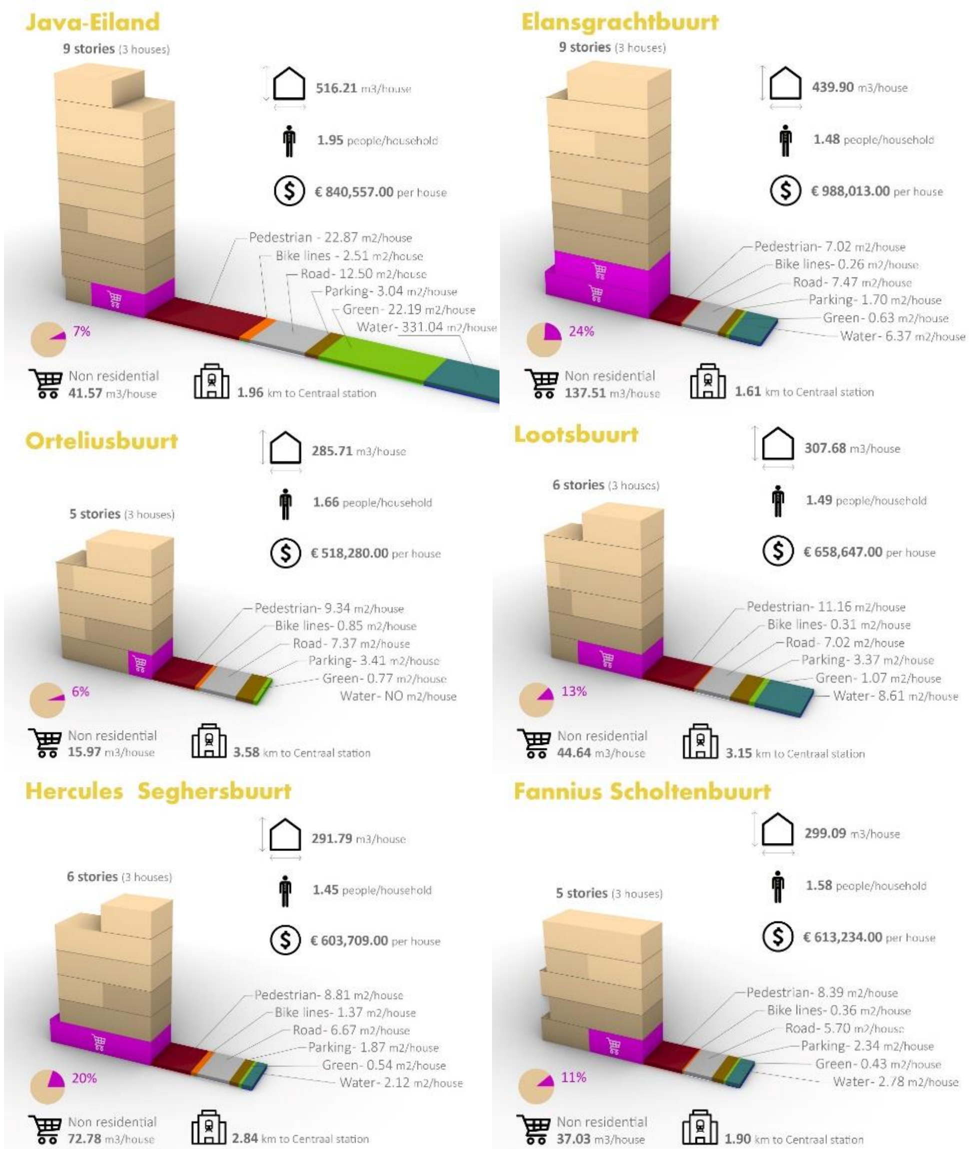

Figure 9. Calculation panels.

According with the resulting calculations, there is a strong relation between the size of the house and the density of the neighborhood, while denser is the area, the size of the living space decreases (fig.10). In contrast, the price per sq. meter seems to have relation with the percentage of private space (fig. 11).

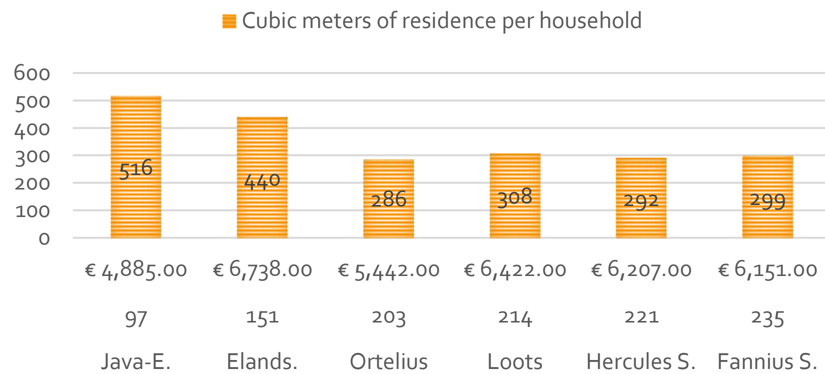

Figure 10. Cubic meter of residence per household

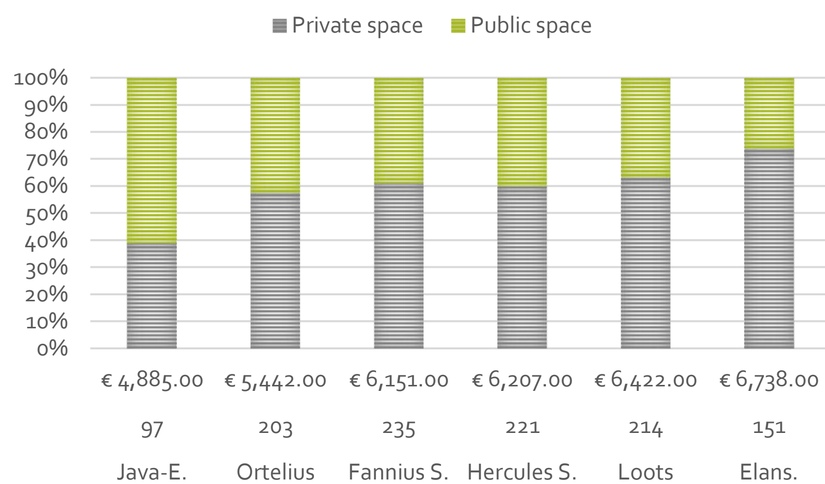

Figure 11. Public and private space.

To conclude, the four neighborhoods with higher densities have similar characteristics regarding building heights, open spaces, green areas and in some cases even the price of the whole house, excepting Orteliusbuurt, coinciding the cheapest and the furthest of the central station. Java-Eiland and Elansgrachtbuurt seem to be the odd in the list, both contrasting in size of open spaces and density but very similar in house size. It is clear that the patterns to use for Sloterdijk One are the ones found in the high density neighborhoods, but still the quality of life, a fundamental element con complement this research, should be integrated more in detail to better understand real the behavior of the city.

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