Determining and Implementing the Potential Sustainable Urban Densification:

The Case Study of Brussels-Capital Region, Belgium

Master's Thesis in Architecture for the Sustainability Design

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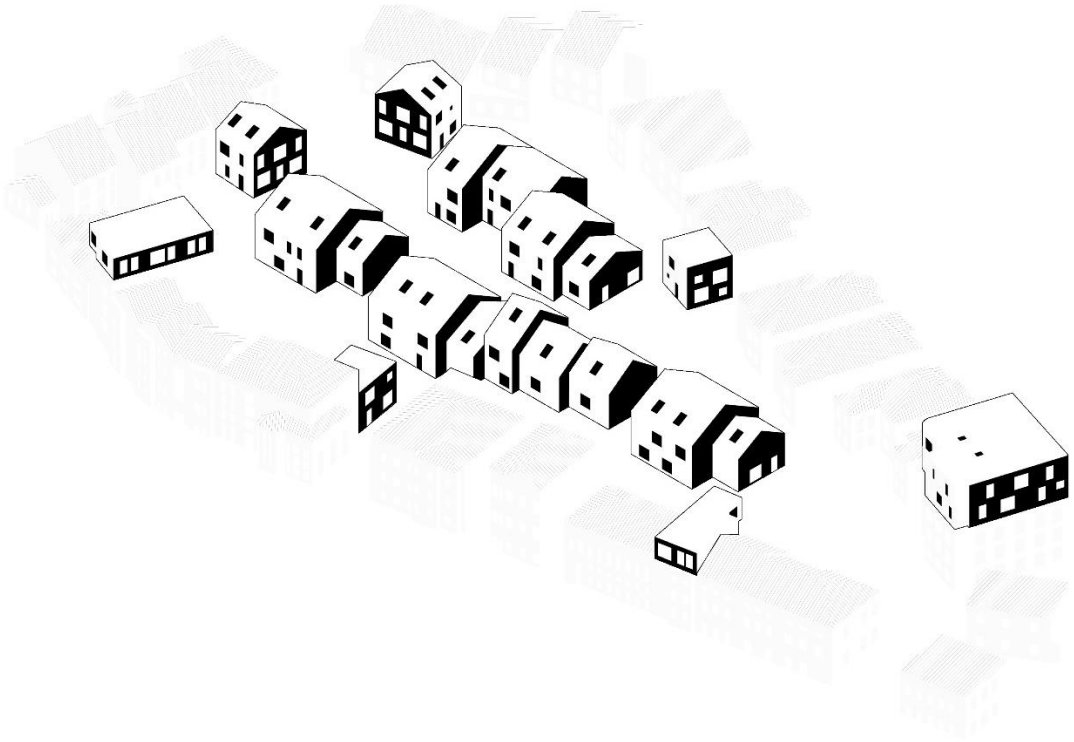

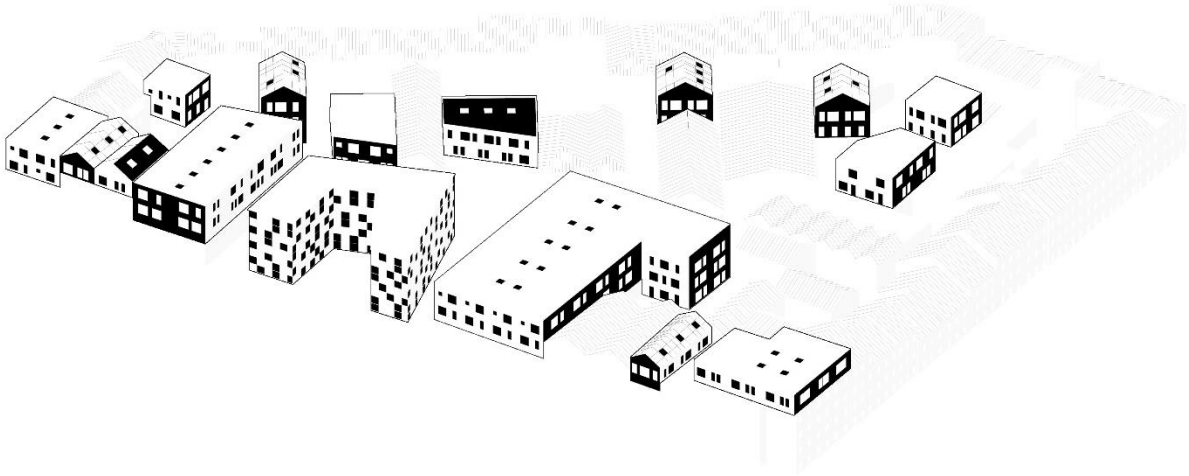

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Glossary

AH: Alliance Habitat.

BCR: Brussels-Capital Region.

BFP: Bureau Fédéral du Plan.

CdQ: Contrats de Quartiers | or Neighborhood Contracts.

COS: Coefficient d'ocupation du sol | or Land use occupation coefficient. It determines the permitted construction density: ratio expressing the number of square meters of net floor area, or the number of cubic meters likely to be built per square meter of land.

CPAS: Centre Public d'Action Sociale | or Public Welfare Center, known as well as Public Center for Social Action.

CRMS: Commission Royale des Monuments et des Sites | or Royal Commission of Monuments and Sites. It is an independent advisory body which advises the Government in matters of heritage conservation in the BCR.

DGS: Direction Générale Statistique | or General Statistic Direction.

EEA: European Environment Agency.

IBGE: Bruxelles Environnement. Governing body that conducts research and provides advices on environmental issues. It also helps the authorities and businesses in Brussels to develop environmental plans.

IBSA: Brussels Institute for Statistics and Analysis.

PDI: Plan du Développement International | or International Development Plan.

PPAS: Plan Particulier d'Affectation du Sol | or Special Land Use Plan. It has direct impact on the primary project applications for specific context cases.

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PRAS: Plan Régional d'Affectation du Sol | or Regional Land Use Plan. Different from PPAS. Governs land use and, alternatively, takes care of aesthetics. It is a zoning plan that has a binding force and regulatory value. It has direct impact on the secondary project applications.

PRDD: Plan Régional de Développement Durable | or Regional Plan for Sustainable Development.

PRL: Plan Régional du Logement | or Regional Housing plan.

P/S: Plancher/Surface | or Total Floor area/Land area. The total floor area considered in the P/S calculation excludes the floor area of spaces with less than 2.2m of clear height and basement spaces that are used for technical equipment or as storages.

a. Absolute P/S: sum of building densities per block / number of blocks – e.g. $(\frac{a}{b} + \frac{c}{d})/2$
b. Average P/S: sum of the floor areas / sum of the area of blocks – e.g. $(a + c)/(b + d)$

RCU: Réglement Communal d'Urbanisme | or Municipal Urban Planning Regulations.

RCUz : Réglements Communaux d'Urbanisme zonés | or Municipal Zoned Urban Planning Regulations.

RER: Réseau Express Régional | or Regional Express Network.

RHDA: Reinforced Housing Development Areas.

RURDA: Reinforced Urban Renovation Development Areas.

SD: Schéma Directeur | or Master Plan.

SLRB: Société du Logement de la Région Bruxelles-Capitale | or Brussels-Capital Region Housing company.

UGB: Urban Growth Boundary.

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ZEMU: Zone d'Entreprises en Milieu Urbain | or Urban Business Areas.

ZICHE: Zones d'Intérêt Culturel, Historique et Esthétique | or Areas of Cultural, Historical and Aesthetic Interest.

ZICHEE : Zone d'Intérêt Culturel, Historique, Esthétique et d'Embellissement | or Areas of Cultural, Historical, Aesthetic and Embellishment Interest.

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1- Abstract

For the past few decades, fast urbanization and big Urban Sprawl phenomena took place due to an increase in population, migration, globalization, and European integration. This caused a rise in land and property prices, together with inner-city problems, detrimental environmental issues. Faced with the need to accommodate a growing number of inhabitants in major European cities and capitals, this research aims to establish a multi-criteria methodology that identifies potential Urban Densification zones and facilitates decision-making. The Brussels-Capital Region (BCR) in Belgium which is projected to have an increase of 190,000 inhabitants by 2040 is chosen as a case study. An inventory was carried out by COOPARCH-RU team at the same time of the development of the Regional Plan for Sustainable Development (PRDD) of the BCR. This thesis highlights the mapping methodologies used by this inventory identifying potential areas for Urban Densification based on restrictive, programmatic, and localization criteria. These mapping and quantization methodologies are analyzed while highlighting intervention priorities and extracting conclusions. The urban project proposal at the end of the thesis tests the feasibility and clarifies an application of the research conclusions. Urban Densification is implemented in different scenarios on building block scale, using different methods, in the selected potential areas of the BCR. Building up on this work is a contribution for the PRDD, urban planners, and decision-makers who are responsible for setting sustainable development programs.

Keywords: Urban Densification, Sustainable Development, Urban Sprawl, Population Density, Criteria, Strategy, Mapping, Housing, PRDD, BCR.

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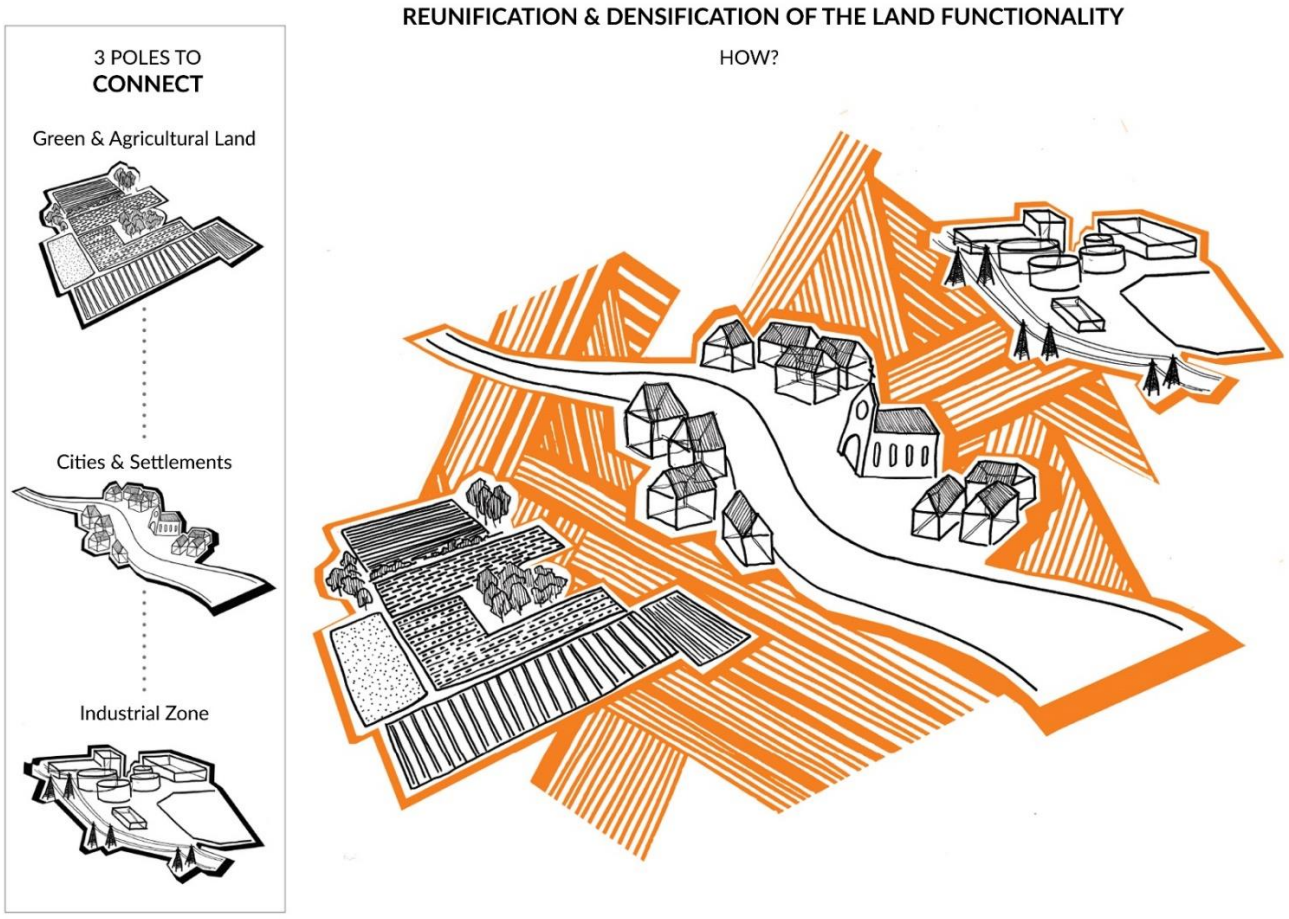

Figure 01: Introductory and generic QUESTIONS about modern urbanism and Urban Densification.

Source: Sketch produced by the thesis Author.

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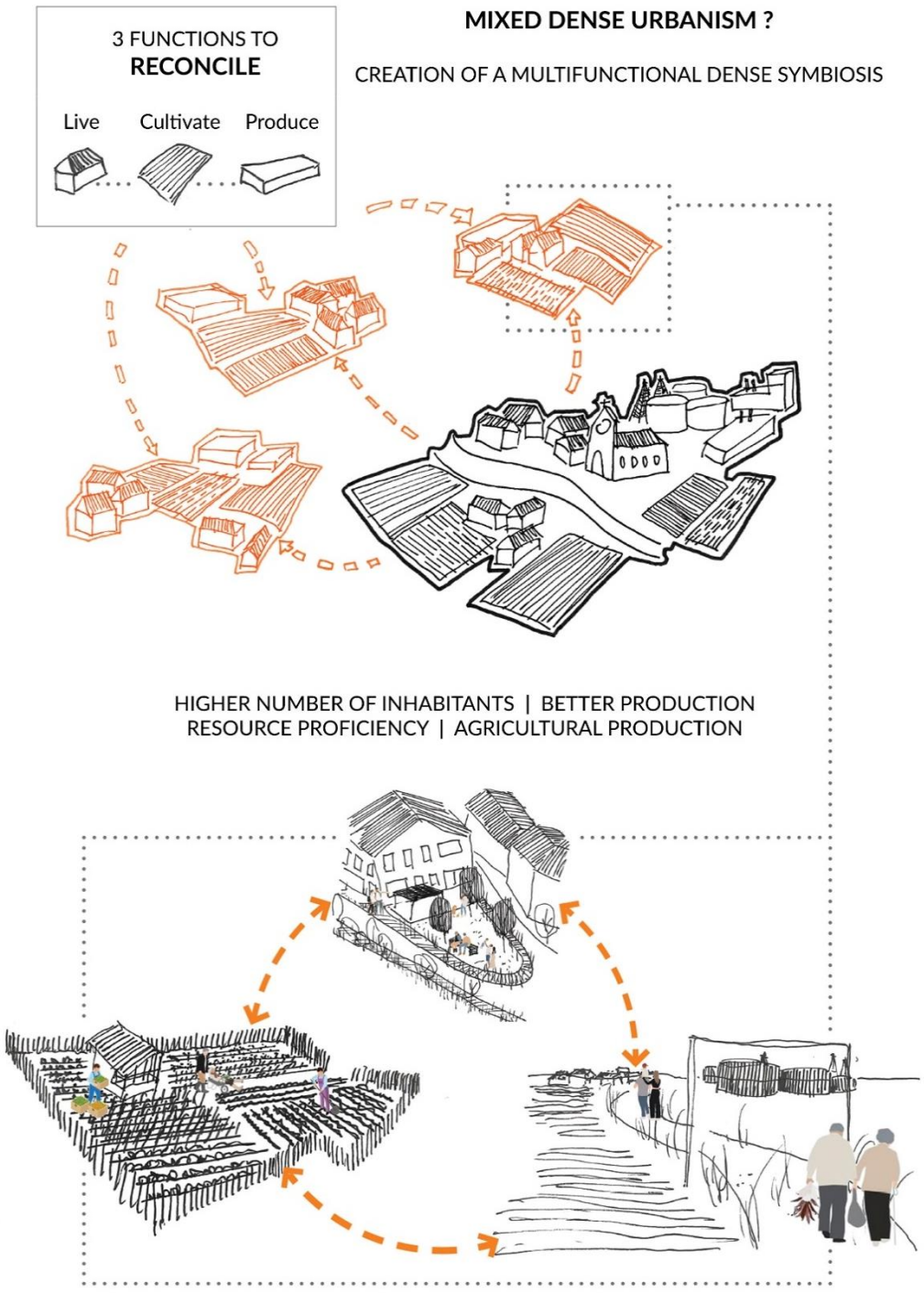

Figure 02: Introductory and generic CONCEPTS about modern urbanism and Urban Densification.

Source: Sketch produced by the thesis Author.

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Translation: The woman on the left: "where can I still put my own dream?"

The man on the right: "but where will I put my commercial center?"

Figure 03: Caricature criticizing PROBLEMATIC human's Urban Sprawl egoism and self-interest.

Source: http://urbanisation.canalblog.com/

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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2- Thesis Overview

a. Aim and Objectives

This Master's Thesis development is motivated by the goals mentioned in the Regional Plan for Sustainable Development (PRDD) of the Brussels-Capital Region and the lack of existing tools that measures a city's capacity for Urban Densification. It proposes the prominent solution that can tackle the problem of the fast increase of population in the BCR- hence, the need for new Housing projects and adequate public services. The aim is to determine a clear methodology to identify the maximum potentialities of Urban Densification and to implement it on the regional level. This is in order to sustainably contain this continuity in population growth without significantly changing the identity of the BCR and its quality of life. An urban experimental project is developed at the end of the thesis as a visualization and an application of Urban Densification scenarios on chosen parcels from different neighborhoods. The zones will be chosen based on the BCR inventory for potential Urban Densification. The inventory will help in the localization and the quantization of the total potential number of inhabitants that the BCR can contain by 2040.

b. Structure

This thesis is made by three main parts:

1. Theory: A scientific research and hypotheses concerning the main topics of Urban Sprawl and Urban Densification, and the case study choice of the Brussels-Capital Region.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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2. Methodology and Mapping: Criteria identification for a clear localization and quantization of results for the BCR potential Urban Densification.
3. Project Experiment: A visualization of the conclusions made by the proposed Mapping methodology in the case study and a test or experiment of densification proposal feasibility on the building block/parcel level.

In more details, it is structured as follows:

First, this Master's Thesis reviews existing and chosen literature from which hypothesis are established. The research methodology is outlined, research gap and limitations are underlined, and the research question is addressed. Second, it introduces a historical background about human settlement forms and current challenges of urban living, especially focusing on Urban Sprawl and its negative effects on different aspects. Then, based on different literature findings it undertakes a detailed explanatory discussion about Urban Densification, debates about the topic, indentify its drivers, effects, and its methods characteristics advantages and disadvantages. As well, it shows simple visual explanatory diagrams identifying the impacts of Urban Sprawl continuance and Urban Densification intervention. Third, it gives a timeline overview of the historical urban development of Brussels. It underlines the main issue of population growth and density in the BCR accompanied with the challenging and ongoing Housing crisis. Then, it explains the main aims of the PRDD and how it is connected with Urban Densification to find a solutions for the BCR current challenges. After, it undertakes the work done by COOPARCH-RU on an inventory report for identifying opportunities for Urban Densification in the BCR and highlighting intervention priorities based on specific detailed criteria. Then, it connects the mapping, localization, and quantization of the report to optimize the final results. Last, based on the outcome and analysis of the before-mentioned inventory and its conclusions, different building blocks are chosen for an urban experiment development as a simple visualization

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and drawn conclusion for the research. It will set the research limitations and offer suggestions for future works.

c. Hypothesis of the Study

This Master's Thesis hypothesizes that the appropriate implementation of Urban Densification will solve the challenges caused by population growth and limit Urban Sprawl problems. Thus, the study considers Urban Densification as the main sustainable strategy that increases the potentiality of a resilient city against the before-mentioned urban issues, as well as an answer to other quotidian sustainability challenges. The thesis takes the Brussels-Capital Region as a case study to try testing and validating the proposed hypothesis.

3- Research Methodology and Findings Evaluation

a. Data Collection

In order to conduct the research of this thesis an adequate number of data that correlates with the main topic of the study was collected. This data consists of:

a. Scientific articles
b. Scientific books
c. Documentary
d. Cartography

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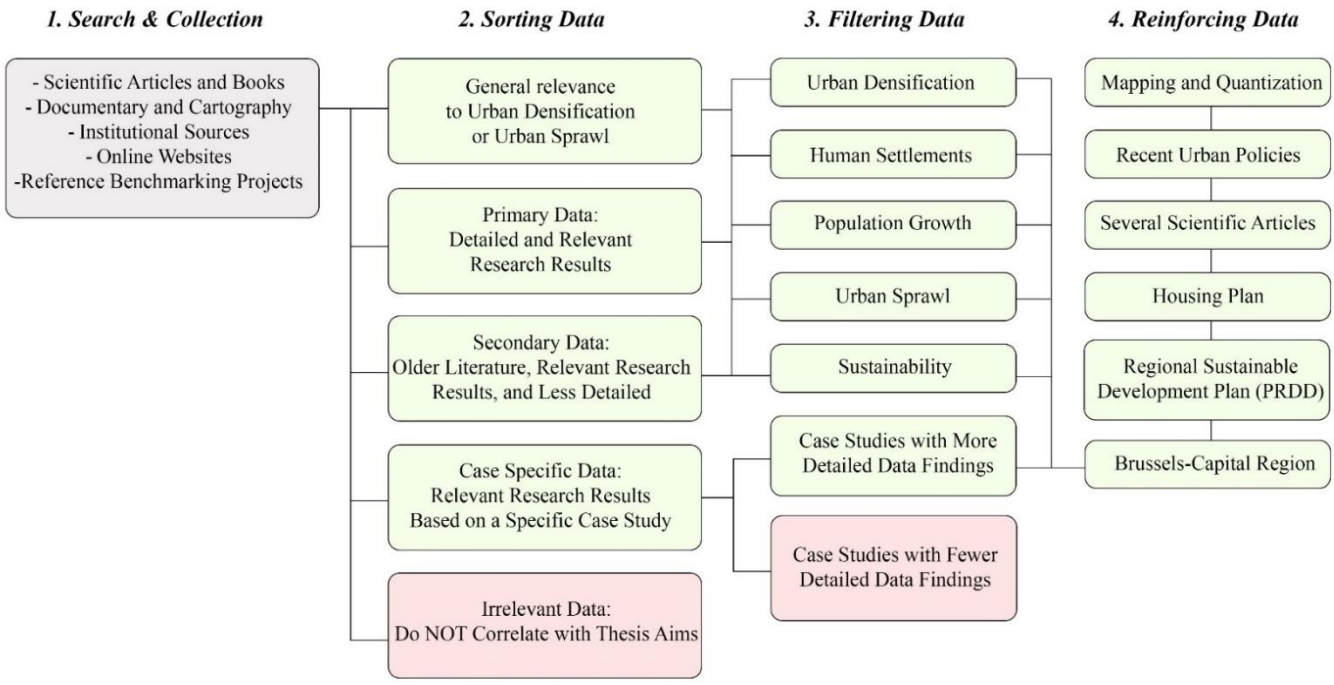
e. Institutional sources
f. Online websites
g. Benchmarking existing projects



Figures 04: Work phase diagram of Research Methodology and Data Collection for this thesis.

Source: Produced by the thesis Author.

The collection was mostly done by online search engines like *Researchgate, Microsoft Academic, Google Scholar, Google Books,* and *Emerald*. Some specific and exclusive data as the GIS data and cartography were collected by personal contact with the companies and study bureau, or by Cad Mapper, Google Earth, and the Geoportal websites specific for Brussels (Bruciel, Brugis, Urbis, etc.).

The data collected was then sorted (see figure 04) on the following basis: general relevance, primary data, secondary data, case specific data, or irrelevant data. After, the large selection

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was attentively filtered after a deep review based on the relevance of each document to the thesis determinants. Main titles and topics were chosen to be treated, and the case studies with less detailed data findings were not chosen to be elaborated on.

After extensive literature searches, results fell into the selection of the Brussels-Capital Region as a case study. That is because of the correlation between the Regional Sustainable Development Plan (PRDD) of the BCR and the topic of Urban Densification as a main phenomenon to achieve the planned objectives and face the problems treated by this Master's Thesis. As well, many institutional scholars and professional architecture and urbanism companies developed documents that can serve undergoing a deep theoretical research study leading to a project feasibility proposal. The investigation of a larger number of literature and scientific documents has led to confirm the choice of the case study and set-up a reinforced clearer path for the research methodology.

Note: Several documentations, diagrams, figures, drawings, and maps were edited and reproduced by the thesis Author to avoid any type of plagiarism. As well, other documents, maps, drawings, diagrams, and tables are totally authentic and produced exclusively by the thesis Author.

b. Literature Review

In this section, the main authors that have conduct studies with significant relevance to this thesis are identified. As well the most important findings for the thesis are divided into groups serving each a specific theme. The used literature is evaluated and the hypothesis useful for this thesis is extracted and mentioned.

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After being reviewed, the main findings can be briefly identified under specific themes as follows:

1. Human settlements and world population growth;
2. Urban Sprawl and current challenges;
3. Urban Densification, definitions, critique, effects, and methods characteristics;
4. History of Brussels city and BCR;
5. Population growth and density in the BCR;
6. Housing Crisis and Issues in the BCR;
7. Regional Plans for the BCR;
8. Mapping and quantization of a potential Urban Densification in the BCR.

In the following, each finding is linked by its hypothesis to the thesis by means of relevance.

1. Human settlements and world population growth:

Greve (2011) explains how the first agriculture-dependent human settlements started back in the Mesopotamian era, and how it changed and developed throughout the centuries passing by the Industrial era and Post-industrial knowledge age arriving to the modern human settlements of nowadays. Greve (2011) underlined the socio-economic and political complexity that accompanied the dense enlargement of human settlements.

To link a quantitative figure to the work of Greve (2011), the official website of USA census government (Historical estimates of world population, 2022) shows the fast increase of population from 14 million to nearly 1 billion inhabitants between 3000 BC and 1750 AD.

As well, to paint an image about the future projection of these numbers, the United Nations (2015; 2018; 2022) studies confirm that by 2050 the world's population is projected to increase by nearly 2 billion people and 68% of them will be living in urban areas. The UN

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2022 release for the world population prospect indicates that the world population is projected to reach just over 8 billion by the end of 2022.

Ritchie, et al. (2022) highlights the key findings from the recent UN 2022 report around how this growth will continue in the following years until 2099.

2. *Urban sprawl and current challenges:*

One of the most important Italian scholars that studied and conducted deep research about Urban Sprawl topic is Arturo Lanzani. His work is used as a significant data to build the hypothesis of this thesis. Lanzani (2012) studies and analyzes the suburbanization phenomenon leading to Urban Sprawl or Urban Expansion. He distinguishes different models of expansion throughout Italy and other European countries. As well, he identifies the problems of this diffused suburban expansion while taking into account the agricultural and environmental menaces. The paper is a study in a form of a critical perspective going conducted based on historical and contemporary analysis and researches. The study mentions how the concept of Urban Densification is a way to achieve the objective of zero consumption of new empty lands and to optimize sustainable energy usage.

Another main Author, Samuel Brody, is an American scholar from Texas University focusing a major part of his research on Urban Sprawl and expansion patterns. In his work, Brody (2013) discusses the development patterns of urbanism in the light of Urban Sprawl impacts on the ecological and environmental systems. He studies the causes and characteristics of Urban Sprawl, mainly by referring to American case studies, but also some European ones. He identifies as well the tremendous negative effects and consequences of Urban Sprawl environmentally and socially. Also, he indicates some of the most efficient ways and policies for sprawl reduction or stoppage.

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Haase & Kabisch, et al. (2013) indicate in their paper how the Urban Sprawl phenomenon is expanding all over Europe, regardless of the region's density.

To describe the nature of such phenomenon, Pelczynski & Tomkowicz (2019) imply that the urban expansion of the last decades was uncontrolled and unsustainable. They propose Urban Densification as a methodology to face such Sprawl. Their work is more focused on Urban Densification as a solution, instead of Urban Sprawl as a problem. This will be explained in details in the next theme section of Urban Densification.

In the work of Nilsson (2014), the main negative effects of this expansion are described in details in the "PLUREL" project along with the emergency call for interventions.

Rent increase notices (2019) quantifies a 3 to 5% yearly rate as a normal increase in rent prices and how uncontrolled urbanization can exceed these numbers.

Caldwell & Spiro (2019) in their article explain how smart vertical densification is a solution to attain lower Housing costs.

3. *Urban Densification, definitions, critique, effects, and methods characteristics:*

In this theme section older literature was reviewed and the hypothesis were extracted as a worthy perspective to understand the questions asked about Urban Densification. But the main focus was on the most recent literature that will be deeply identified.

Older findings tend to agree on several points as in the following:

Newman & Kenworthy (1989), and Gordon & Richardson (1997) studied dense cities in order to elaborate an ideal city model responding to mobility and energy problems.

Breheny (1992), Jenks et al. (1996), and Burton (2000) indicate that the about Urban Densification was often limited to the environmental and economic dimensions, leaving the social dimension out of the image

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Bromley et al. (2005) and Rose (2006) studies the possible problems of Urban Densification. Social issues can be generated because of the increased diversity and coexistence of different ethnic groups from several cultural backgrounds.

Da Cunha & Kaiser (2009) hypothesizes that city densification was seen as, and is a tool for sustainable urban development.

As for the more recent literature:

These specific authors in Belgium have studied and conducted deep research about the topics that are relevant to Urban Densification: Mohamed Amer, Sigrid Reiter, and Shady Attia. They are regrouped based on the fact that several of the data findings is a collaboration between two or all of them. Their scientific papers have been collected and reviewed extensively as the main literature findings for this study. They mainly studied Urban Densification potential and implementation methods in the BCR.

Attia (2015) identifies specific recommendation for an adequate implementation of Urban Densification in Brussels and Liège.

Attia (2017) identifies the positive impacts of regenerative architecture while taking Urban Densification in London, UK as a case study.

Amer & Attia (2017) conducted a research about the Zero-Energy and Light-Weight extensions as methods to increase the benefits gained from Urban Densification. Roof stacking is one of the main Urban Densification methods identified to implement such projects.

Amer, et al. (2017) proposes a methodology to determine the potential Urban Densification in the BCR, while identifying in details its five methods and characteristics. It explains the problem of fast population growth and Urban Sprawl in Brussels, which leads to conduct the work proposed in this paper.

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Amer & Reiter, et al. (2018) studied in more details the possibility of Urban Densification in the BCR through roof stacking while giving quantification results in case of the feasibility of such a project. Economic, environmental, and constructional studies were made for the study as well.

Another Belgian author whose most recent work is of crucial importance is Jacques Teller. His work is based on the management of the environmental planning and analysis. Contrarily to the afore-mentioned Belgian authors, Teller does not promote Urban Densification as a general solution. Rather, he studies and analyses the scope of Urban Densification; its purpose, nature, scale, and process. A large focus on the special issues of non-regulated Urban Densification is addressed.

Teller (2021) focuses on the methods and factors that should be considered while regulating Urban Densification. He studies as well the macro and micro-drivers of Urban Densification. He identifies the process, different scales, and purposes of soft and hard Urban Densification. This focus is motivated by the perspective of density being more and more accepted in Belgium as a necessity for no net-land take. It addresses the problems of Housing, and how policy makers should consider regulating the urban resilience. For him, the relation between Housing affordability and Urban Densification is a critical factor to research about. Also, the environmental, economic, and social effects of Urban Densification are studied among the drivers of the phenomenon.

As well, two other main Polish authors contributed in their deep research to better understand Urban Densification. They are: Janusz Pelczynski and Bartlomiej Tomkowicz; Urban Densification is analyzed based on how much it can help in sustainable development of cities.

In Pelczynski & Tomkowicz (2019) four methods of Urban Densification are precisely identified. Their characteristics are studied and hypothesis are made based on their advantages and disadvantages. The hypothesis of the study supports the concept of Urban Densification and explains its sustainable approaches, while taking into account the disadvantages that can be faced if such densification is not done in the right way. The advantages and disadvantages

take into account as well the environmental, economic, and social aspects of each type of intervention. Sustainable development can be achieved thanks to a reasonable Urban Densification.

Note: It is worthy to mention that Pelczynski & Tomkowicz (2019) and Amer, et al. (2017) identify and regroup Urban Densification methods in a different way. Amer, et al. (2017) identifies one extra method (Roof stacking) as independent while it is a part of another general method (Upward extension) in Pelczynski & Tomkowicz (2019). After the analysis of each hypothesis, the method is basically the same but perceived from a more detailed point of view by Amer et al. (2017). It is the subject of several research papers where it is chosen as a main method to implement for an Urban Densification study in the BCR. It shows more variations where it can be part of architectural and environmental retrofitting, Zero-Energy, and Light-Weight structure extensions as an intervention on existing buildings. This will be analyzed more in details in this thesis later in the section of Urban Densification. The distinction is based on the fact of addition or transformation. For Amer et al. (2017) these two interventions are distinct, but for Pelczynski & Tomkowicz (2019) they are both considered a transformation with an upper extension.

Pérez (2020) explores in his paper entitled "The Miracle of Density" the shifting deployments and political uses of urban density as a debate around Urban Densification. . It takes as reference the socio-material archives and ethnographic research on many cases studies, mainly Bogota in Colombia. In his article, Pérez (2020), refers to Urban Densification as a taken-for-granted ideology of socio-materiality. The hypothesis of his work is that densification policies shape and limit the use of urban politics. He takes a chronological path using older to most recent literature and references to ensure an adequate critic for densification policies.

Ananian (2016) studies Urban Densification and the city of proximity with Brussels as a case study. It identifies Urban Densification as a potential to resolve Housing problems and crisis. It focuses on the residential shortage in the BCR (this author will be mentioned again in the Housing issues theme section).

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Many other academic research and work by other authors is used and shown in this thesis, but is not of much relevance to be mentioned in the literature review along the other main authors. These authors are properly cited in each section to avoid discrepancies or forms of plagiarism. For instance, to identify a specific perspective or a hypothesis done by an author and take it as a reference to elaborate on, while explaining another author's research. This is largely found in the sections of Urban Densification as it is the main core of this Master's Thesis subject.

Arnberger (2012) tries to question the effects of Urban Densification projects that are implemented around green space zones on the quality of life that inhabitants get from these spaces. It is a general view for the positivity and negativity that could arise, and how could densification of inhabitant increase the density of green areas in parallel. It takes an overused green urban space "the Wienerberg" in Vienna, Austria, to test a social identification of the effects of densification on the recreational quality of public urban green areas. The study based its survey on coping behaviors in response to crowding and the new social setting conditions after densification.

Barresi (2018) investigated how Urban Densification policies could possibly shape and influence the energy demand, production, and conservation. The case study is in the southern part of Switzerland, in Lugano Paradison adopting new infill policies.

Lobaccaro & Frontini (2013) focus their work on how Urban Densification can modify the building energy demand and thermal performance, as well as the level of conservation of the existing historical buildings and urban microclimates. They claim by their conclusions that dense cities lower the report of energy usage per capita compared to more diffused suburban contexts.

4. History of Brussels city and BCR:

For this theme section, many historical and academic books findings were used.

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From 11th to 18th century of Brussels Historical Urban Development, the books Charrudas (2011) and Smolar-Meynart, et.al (1994) were the main references. Old translations from the book "Les Miracula sancti Ursmari in itinere per Flandriam" (1987) were used to identify a clearer chronological order for the Urban Development timeline diagram created by the thesis Author.

As for Brussels Urban Development after the end of the 18th century, Elliott & Cole (2010), Stubbs and Makaš, (2011) were the main findings to explain the architectural and urban concepts introduced by that period and how it affected the city character. As well some data from *Brittanica* (updated 2022) were analyzed and used a link of events.

5. *Population growth and density in the BCR*

This theme was studied by some authors already mentioned in this literature review. This is clearly according to the relevance of population growth studies to their main aim of research; as in Amer & Reiter, et al. (2018) and Ananian (2016).

Many other scholars studied the demographic increase and future projections projections, as well as some official authorities and institutions of the BCR.

The papers finding used are mainly from Brussels and Flanders scholars: Dessouroux & Romainville (2016), Van de Voorde, et al. (2015), Paryski & Pankratieva (2012), and Deboosere (2010).

The public and special institutions are: BFP (2016), DGS (2016), and IBSA (2015).

All of the data found was collected then filtered into exact and concrete numbers and percentages. This helped the author of this thesis to create a population growth diagram and give exact density numbers that summarizes maximum and minimum figures for the BCR in general and by neighborhood.

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6. *Housing Crisis and Issues in the BCR*

Official regional plans and special institutions documents and action plans data were used in this theme. Mainly: PRL (2015) Alliance Habitat (2013; 2015), SLRB, (2015), PRDD (2013). The number of residential buildings and their locations are identified as well as the status of their execution. The mapping by the SLRB (2015) clarifies the point of the research for this Housing shortage crisis.

As well, Ananian (2016) used these data to study Housing issues in the BCR in relation with the city of proximity and Urban Densification. In this paper Ananian focuses on the residential deconcentration in Brussels and how this forms a main obstacle for the PRDD to solve. It is described as a Housing crisis, based on the fact that Public and Private Housing production is not equilibrated and do not fit the needs and requirements of the population and neighborhoods. As well, it shows by numbers the gravity of Housing shortage in the BCR and how the PRDD in parallel is planning to solve that by Urban Densification mainly.

7. *Regional Plans for the BCR*

This is a theme that is mainly about the Regional Plan for Sustainable Development (PRDD) of the BCR. Another main plan is the Housing plan that takes part of the more generic and bigger one; the PRDD.

As mentioned before, Ananian (2016) identified in general some key points about the PRDD.

Official documents and institutional resources data findings are used in this theme section mainly:

a. *Bruxellesplus: Plan Régionale Du Développement Durable;*
b. *La densité à travers le plan de développement durable de la Région Bruxelloise;*
c. Brussels Housing Plan (2019);
d. PRDD (2013; 2020).

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The section mentions the aims of the PRDD for the 2020-2040 period and how Urban Densification is a master key to achieve many of these urban goals in the BCR. It shows the solution for demographic growth and concentration, and for the Housing crisis by introducing new planning policies.

8. Mapping and quantization of a potential Urban Densification in the BCR:

The inventory report of potential Urban Densification in the BCR is the main center of this theme section. This is inventory was developed in parallel with the PRDD objectives and main aims for 2040.

Several inventory documents, research, cartography, GIS data, and mapping by the Belgian-French firm *COOPARCH-RU* was used.

Some data also was extracted from *Google Earth* and *Cad Mapper.*

As well, drawings from the firm *BUUR* are used.

In this section, all the maps and drawings used from the architecture and urban planning firms are edited or reproduced by the thesis Author.

c. Existing Research Limitations

A main and common research problem concerning any Urban Phenomenon is not considering all factors that potentially affect the studied context. In the case of Urban Densification, it appears to be the lack of tools to plan such a reasonable and solid densification. Public authorities along with several study bureau and firms try to identify such tools by introducing inventories and action plans. Unfortunately, the benchmarking of these

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works shows that the factors considered in a way in some studies, are considered differently or not at all considered in some others. This leads for a risk of not achieving the desired goals of an adequate sustainable development or a better quality of urban life. Many studies can be breached to some extent. The methodologies defined provide a non-tangible to generic approach for decision making.

The team of 'COOPARCH-RU' produced an inventory in the case of Brussels that sums up the work done by several other study bureau and urban planning firms, while considering all the factors used. The criteria is detailed and made up by several layers of considerations while respecting all of the PRDD aims and urban policies. This makes the work more detailed and less generic. The mapping done, followed by a quantization relates the approach to reality which facilitates decision making.

In the inventory section of this thesis, some critical aspects in the Mapping are pointed out for each criteria. But these critics are not the exact limitation and have minor effect on the implementation of the inventory results in case of a real life scenario.

The gap or limitation that can be spotted is that the analysis stop at the parcel or building block scale. This limits the study because it does not provide a specific contextualization of each singular project according to the criteria already identified by the inventory. This does not help identifying the exact Urban Densification method for each block and the feasibility of its execution. As well, there is the problem of homogeneity and heterogeneity of proposed urban templates. By that, a method of Urban Densification on the regional level can totally work based on the mapping and quantization after passing all the considered criteria. But, the criteria itself is limited to building block scale which again does not consider the size of each parcel nor their potential in restructuring. This affects the side goals of the densification which are keeping a high standard of quality of life as the one already existing in Brussels, or changing the local character and identity of the neighborhoods.

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Hence, after concluding and identifying the potential areas for Urban Densification from the inventory, a project proposal will experiment the feasibility of such densification while using different contextualized methods on the building block scale of chosen neighborhoods.

d. Research Question

The demographic growth expected in the Brussels-Capital Region entails many social and economic challenges. This emergence underlines the need for a clear methodology to identify the potential of an implementation of Urban Densification. This Master's Thesis will aim at extracting a constructive conclusion for the development of an urban project proposal while closing a research gap.

The following research questions are addressed, where the second completes the answer of the first:

'*How useful and sustainable is Urban Densification to limit Urban Sprawl and solve increasing urban population issue?*

'How to determine the maximum potential of Urban Densification and how can it be implemented in different areas of the Brussels-Capital Region on the building block or parcel scale?

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4- Human Settlements

a. History and Forms

The notion of urban settlement comes originally from the first human encampment driven by agriculture back in the Mesopotamian era around 3500-3000 BC. This agriculture-dependent society changed and was progressively replaced throughout the years by a more merchandise-driven trade culture. Hence, human settlements grew larger and denser along with the arising socio-economic and political complexity (Greve, 2011). Since, all these factors caused a spatial regeneration and reorganization of the cities, as well as a demographic boom with the enormous increase of population from an estimated 14 million inhabitants in 3000 BC to nearly 1 billion inhabitants at the end of the 18th century (*Historical estimates of world population*, USA census.gov 2022).

The 18th century is the benchmark for the modern way of living in the cities. This is to imply that the industrial era marks the beginning of mass urbanization (Greve, 2011). Building on the research by Lousi (2020), a more philosophical approach to this argument may be represented by quoting Hannah Arendt that wrote in her book *"The Human Condition"* that the things that owe their existence to people, will continually define their creators (Arendt, 1958). The reforms created during the industrial era and its introduced tools to the society shaped permanently the behavior of cities as well as their built environment (Greve, 2011).

Even though several changes took place over time, the functioning mechanism of the urban habitat is still the same. A significant population wave moves to the city annually seeking job opportunities and higher life standards. Nonetheless, after 2007 in the post-industrial "Knowledge Age" which represents the peak development of the tertiary sectors, the world's urban population surpassed for the first time its rural one (Ritchie & Roser, et al. 2013). The

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recent United Nations studies affirm that by 2050 the world's population is expected to increase by 32% or around 2 billion people, from whom 68% will be living in urban areas (United Nations, 2018; 2022).

The concept of urbanization and its built environment transformation, or gradual development, can be summed up and illustrated in the sketched diagram (see Figure 05) by the Architect Cedric Price: "The City as an Egg". The ancient city as a boiled egg, has a fortified and dense center with clear fences. From the 17th to the 19th century, a fried egg-like shape shows the rapid urban demography and infrastructure growth outwardly driven by the industrial revolution. Last, the modern city is illustrated as a scrambled egg; flexible in the space while emphasizing the stability problem (Brandon, 2016).

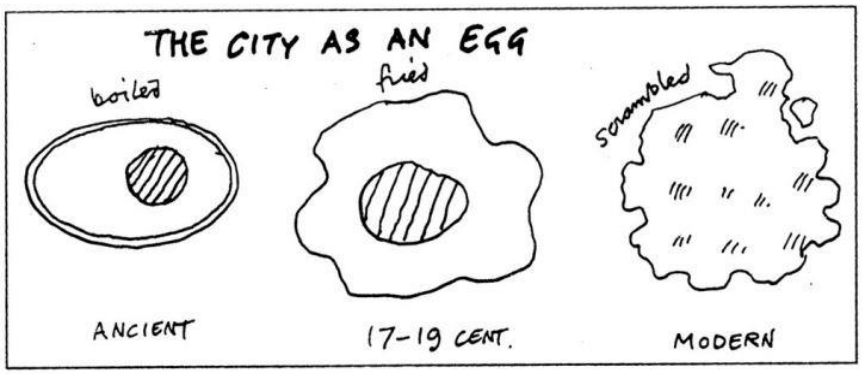

Figure 05: The City as an Egg, by Architect Cedric Price (1934-2003).

Source: The city as an egg, main page, Brandon (2016).

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b. World Population Prospects

Since 1975, every twelve years the world population has been increasing by 1 billion inhabitants (Ritchie, et al. 2022)

The recent UN release for the world population prospect 2022 highlights the following key finding: the world population was 7 billion in 2011 and this is projected to reach just over 8 billion by the end of 2022, after eleven years (United Nations, 2022).

The rate of the absolute growth in total world population is similar to previous decades, but the absolute growth rate (%) is getting lower and lower with years (see diagram 02 below).

Since 2019, this growth rate for the global population fell to 0.92% (less than 1%), compared to 1.26 % in 2009 (a decade before). That's nearly half its peak rate of growth in the 1960s equal to 2.30%. The UN studies indicate that this absolute rate will continue to fall, as long as global fertility rate is always getting lower (Ritchie, et al. 2022).

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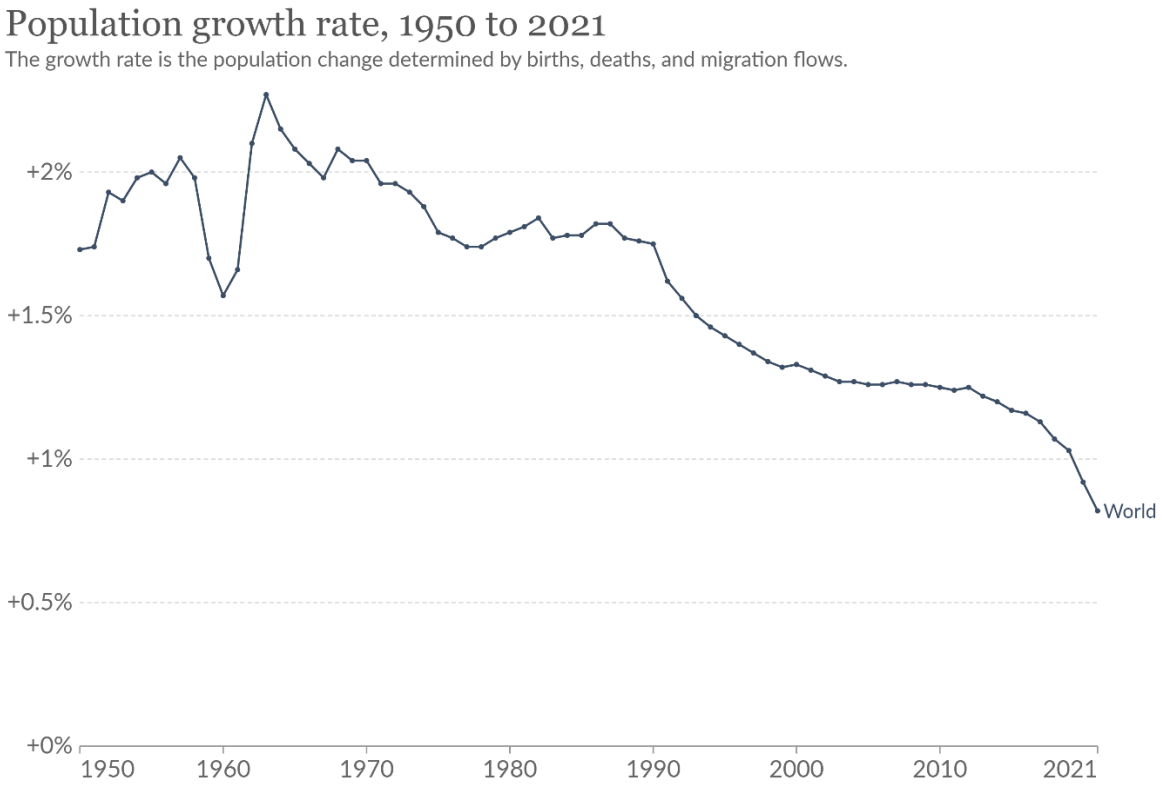

Figure 06: Diagram showing World population absolute growth rate (%) from 1950 to 2021.

Source: United Nations World Population Prospects (2022).

During the last century the global population increased so fast (by at least 4 billion people) and will continue to increase but slowly based on the recent UN projections (United Nations, 2022).

Ritchie et al. (2022) underlines the following question answered by a key finding from the 2022 UN World Population Prospects: When will the world population growth come to an end?

An answer to this question is shown in the Figure 07 below, which its data are based on the UN World Population Prospects 2022.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

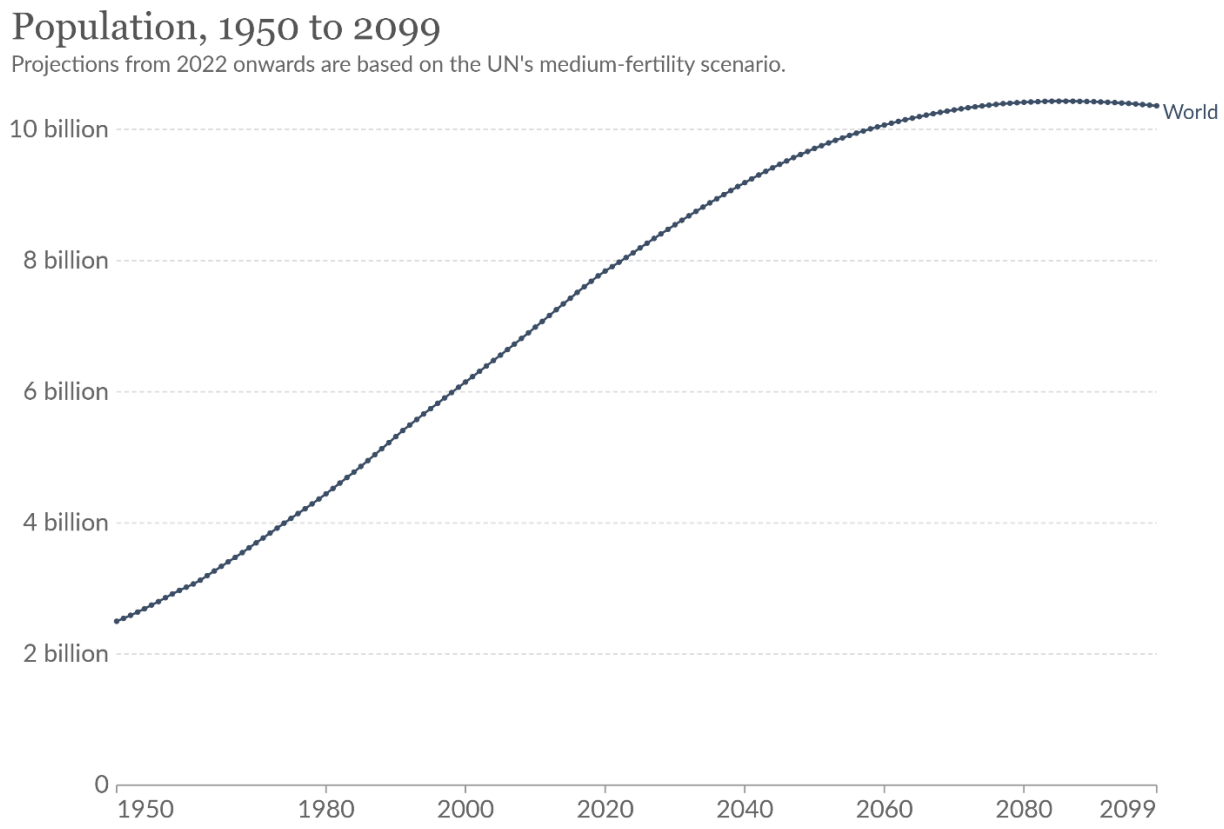

Figure 07: Diagram showing World population growth from 1950 to 2021 and projections from 2022 to 2099.

Source: United Nations World Population Prospects (2022).

The UN studies show a continuous slowdown in the growth rate as mentioned before. This growth will reach a peak and hit a plateau by the end of the 21st century. The UN projects that the global population will reach its maximum peak in 2086 at 10.4 billion people, even before the end of the century (United Nations, 2022).

This projection by UN is also based on the prediction of a significant fall in fertility rates in low-income countries and a sort of rebound in fertility rates in high-income countries after 2050 (Ritchie, et al. 2022).

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c. Conclusion

The fast world population increase will lead by its way to higher urban population: 68% of world population will be living in urban areas. This comes with several consequences. The majority of such consequences are looked at by governments as critical sustainability and urban challenges. Urban Sprawl, with all its unsustainable expansion, can be a direct cause of this tremendous population increase. This chapter underlines the conclusion of the future uncertainty in European countries about a strict policy to deal in a parallel way with demographic challenges (see Figure 08 below). Suitable urban policies should be put into place the soonest possible, and executed the right way. In the past few years, many European governments started regulating expansion, reducing sprawl, and preparing dense and smart cities to contain this projected big increase in population. Many study plans are being analyzed for a future execution (for instance Vienna, Brussels, London, Rotterdam, etc.). In the next four chapters, Urban Sprawl and Urban Densification phenomena are discussed in detail.

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5- Urban Sprawl and Current Urban Challenges

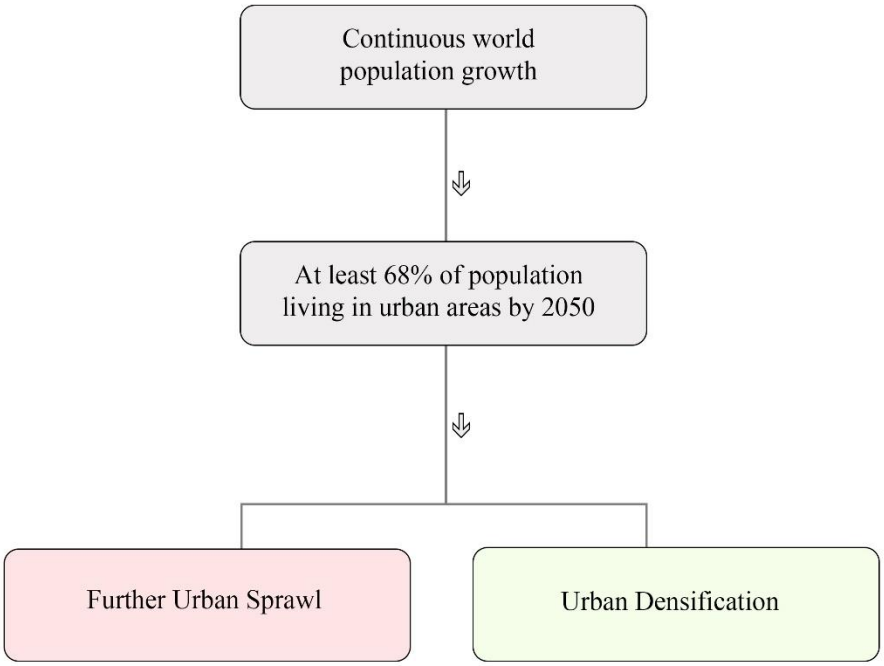

Figure 08: How to deal with population growth by urbanization?

Source: Produced by the thesis Author.

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a. Overview

Nowadays, the course in which the Earth's natural assets are being exploited determines the quality of the world's economy (Pelczynski & Tomkowicz, 2019). The significant growth of the urban human population requires relevance in the increase of the general volume of buildings and urban habitat's infrastructures. The Urban Sprawl movement is rapidly taking over all the European regions, either they have a high population density or not (Haase & Kabisch, et al. 2013). Over the past decades, the urban expansion can be labeled as "uncontrolled". This is clarified by the unsustainable and indecorous use of earth's natural resources, as well as decreasing ecosystems while enlarging the world's built environment and social problems (Pelczynski & Tomkowicz, 2019).

Since the proposal to the Oxford University Press in 1987, to quote G.H. Brundtland, for a sustainable development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (*World Commission on Environment and* Development, 1987), several regime proposals and conceptual models for a sustainable urban planning have been put forward. The main elaborating motor of these theoretical inventions is a sensible utilization of existing resources and the rational well-management of the earlier evolved urban territories (Lorens, 2017). The SDGs (see Figure 09) or Sustainable Development Goals issued in 2015 by the United Nations (UN) member states were also a base background for all the futuristic urban planning theories (*Implementing the New Urban Agenda and The Sustainable Development Goals: Comparative Urban Perspectives,* 2019).

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Figure 09: The 17 Sustainable Development Goals by UN.

Source: https://aer.eu/sustainable-development-goals-engaging-regions/ (Edited by thesis Author)

There is no way to hold back the exponential population density and flow towards cities. It would be like attempting to hold back a tsunami. Instead, policymakers must plan for an investment in formal Urban Densification of Affordable Housing (*Embracing density will help solve the global housing crisis,* 2019).

The Map 01 below shows the so-called axis of the European Megalopolis where Urban Densification is a heated and important subject. It contains the most populous and densest zones in Europe. It passes by Birmingham and London in the United Kingdom, the entirety of Belgium and the Netherlands, Lille and Paris in Northern France, then Dusseldorf, Cologne and Bonn in Germany, until reaching Milan and Turin in Northern Italy (EEA, 2011).

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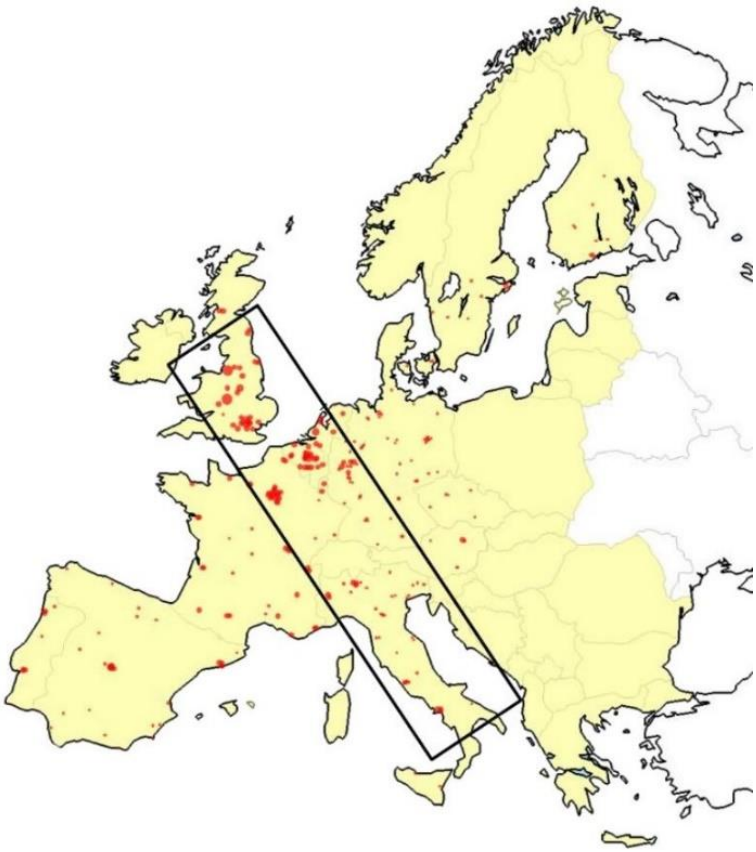

Map 01: The European Megalopolis – Urban morphological zones.

Source: Extracted from figure 1, page 2, Amer & Reiter, et.al (2018)

Urban Sprawl can be simply summarized into: "New land consumption and disposal of portions of the urbanized area." The suburbanization phenomenon leading to Urban Sprawl. He distinguishes the different models of urban expansion throughout Italy and European countries, while considering Urban Densification as a way to achieve the objective of zero consumption of new empty lands and to optimize sustainable energy usage. Recently, a coexistence of dynamics of new urbanization models has gradually begun. This growth in the urbanized space under a continuous progressive multiplication is accompanied with the phenomena of underuse, decommissioning and abandonment of more small portions of already-urbanized space (Lanzani, 2012).

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The built urban areas expansion leads directly to a major loss in agricultural land and natural green spaces beneficial for a healthy environment and ecology. Urban Sprawl increases travel distances and time by private cars or public transport, and causes landscape and habitat fragmentation (Teller, 2021).

These are increasingly frequent phenomena that started to exist since the last two centuries globally, and they accelerate Urban Sprawl negative effects:

1. New buildings are built every day;
2. Lifeless shells of old buildings and empty new buildings are existing with no use;
3. Rubble and building materials of recent and unfinished buildings are abandoned on sites;
4. Natural lands and soils are still being viciously exploited;
5. Abandoned soils coexist as a waste of natural land;
6. Continuous growing of world urban population;
7. Migration, globalization, and European (together with Canadian and Australian) immigration and integration policies.

Yesterday and Today: Land Consumption, Agriculture, and Ecology

Thirty years ago, urban planning projects of a dense and compact concentrated urban growth involved a partial abandonment and denial of the powerful dynamics as the redistribution of economic activities and population. This translated later into the change in production paradigms, and the maturation of new levels of land consumption and new Housing styles. The insistence on the issue of land consumption was at risk to divert from a necessary reflection on how to organize the new urbanized space. This is done by:

- Planning a more open and flexible territory;
- Orienting the topographical developments;
- Perfecting the performance and landscape quality of the new urban materials with which it was built;

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- Researching some possible relational rules between objects and the subjects, between the present and the past (Lanzani, 2012).

Nowadays, the hypothesis of stopping or slowing down the transformation of agricultural land seems to be a decisive move for a variety of reasons. First of all, even more than in the past, it responds to environmental and ecological needs. The slowdown of land consumption and the fragmentation of open spaces, which occurs mainly on the more fertile lowlands is now an urgent move not to further penalize the agricultural sector. This is in order not to increase the greenhouse effect (reducing the soils capable of absorbing carbon and releasing oxygen), to maintain the high level of biodiversity (as a result of the excessive fragmentation of open spaces) and to avoid that waterproofing together with a more careful management of the forest of return to marginal agricultural lands and a reorganization of existing settlements is the structural measure to reduce hydrogeological instability and avoid recurring environmental disasters. As well, it looks like a necessary move to start the process of ecological conversion of already urbanized spaces to improve the bad energy performance, through widespread renovation and building replacement activities (Lanzani, 2012).

The land, understood as an empty space, is a support for the production of buildings. The environment should not be reduced to a container of buildings and fabrics. Such actions make the environment pay the price and see the drastic reduction of soils and vegetation that can absorb carbon. Natural lands when properly vegetated can produce oxygen with the heat bubbles that feed summer energy consumption in many portions of Europe. Not only new buildings and habitable structures, but also road system developments are increasingly taking over more open spaces. Mainly in the areas where there are broken networks, new infrastructure that is not used as a highway or a pedestrian street should slow down. Certainly, the lack of attention to these spaces is more often accompanied by some great features in the infrastructure built: ring roads, motorways, expressways, high-speed rail. But, this comes with the cost of problematic connections with the dense infrastructural framework. The main fear is attaining the point of an inability "to create landscape", using the realization of these works

as an opportunity to connect and recompose the countless objects and open spaces spread over the territories (Lanzani, 2012).

Widespread urbanization is a fact, it is part of the contemporary world. It is now part of the European territory and its landscape, neither more nor less than its extraordinary historical settlement heritage. It is impossible now to cancel it and return to a world of urban centers with well-defined borders and with a countryside landscape patterns. Lanzani reinforces the importance of criticizing the ways in which that new settlements reality was created. There should be a complete review on the conditions and policies by which the whole urbanization of nowadays is being realized. There should be a main and crucial goal to reach by all means: Zero new natural land consumption (Lanzani, 2012).

b. Characteristics

The Urban Sprawl phenomenon can be explained in numerous approaches or techniques, from development aesthetics to local street patterns (Galster et al., 2001). There is not a one agreed-upon definition of sprawl. However, there are some characteristics in common which can be observed from the literature findings (Brody, 2013). These traits can be useful in comprehending and quantifying the prevalence of sprawling land development:

1- *Low-density, single family dwellings:*

   The most frequent sprawl aspect is “the abundance of large-lot (usually 0.4 to 2 hectares depending on the development context), residential Housing developments that consume large amounts of previously vacant or productive land” (Brody, 2013, p. 2). The average lot size, the number of homes in a neighborhood, or the average floor space of single-family homes can all illustrate density (Song & Knaap, 2004).

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2- *Automobile dependency even for short trip:*

Residents must rely on cars more than other any other way of transportation (more sustainable ways of mobility can be public transport busses for instance) because sprawling development patterns separate different land uses and put great distances between Housing units (Brody, 2013). Additionally, the majority of these street patterns are cul-de-sacs, which discourages walking and bicycling to neighboring places and promotes a lack of connectedness (Benfield et al., 1999). The prevalence of cars also promotes the growth of homogeneous neighborhoods devoid of a diversity of land uses (Song & Knaap, 2004).

3- *Spiraling growth outward from existing urban centers:*

Low-density development that is eroding quickly from more compact urban cores is another way to define Urban Sprawl. This means that the existing center can be dense and then when urbanism expands outwardly, it becomes predominately non-dense, vast, and spread (Brody, 2013).

4- *Leapfrogging patterns of development:*

Dispersed development, which promotes the development of parcels (building blocks) located further out in the countryside over the vacant areas next to current development, is another well-known aspect of Urban Sprawl (Torrens & Alberti, 2000). Leapfrogging results in an erratic pattern of development that uses up a lot of space (Brody, 2013).

5- *Strip Development*:

Another notable aspect of sprawl is "ribbon" development, in which homes or commercial buildings border roadways that branch out from metropolitan centers (Tsai, 2005). Dwellings located along rural highways pose risks to traffic safety;

business strips made up of fast-food restaurants and big department shops are designed for car access and frequently have extensive parking spaces in front of them (Brody, 2013).

6- *Undefined edge between urban and rural areas:*
Urban-rural boundaries are sometimes muddled by the sprawling of residential development outside of urban areas (Heimlich & Anderson, 2001). This type of growth is frequently linked to the encroachment on agricultural and open space areas (Brody, 2013).

Brody (2013) stresses that the setting of the urban-suburban environment is connected to sprawling development patterns. Moreover, Urban Sprawl is not the result of a single development project or neighborhood. It is rather the sprawling growth that needs to be examined as a whole pattern at the regional level, as a development pattern.

c. Causes

"Sprawl is the result of a complex set of interrelated socioeconomic and cultural forces" (Brody, 2013, p. 2). Nonetheless, land value is frequently regarded as the main force behind development patterns. Where there are lower property prices on the outskirts of urban centers, sprawl is more likely to occur (Pendall, 1999; Brody, 2013).

Three fundamental dynamics that interact with land values to produce spatial Urban Sprawl or development are identified by economists.

1- Continuous population growth;

2- Increase in wages and standards of living;
3- Lower investment costs in the suburbs and lower commuting costs.

First, as a result of population growth, metropolitan areas spread outward. Population decline can also sometimes indicate sprawl beforehand. Second, as wages rise, people can afford to buy bigger homes. These residents settle in exurban and suburban communities that are typically found on the outskirts of major cities, where Housing alternatives are more affordable (Carruthers & Ulfarsson 2002; Brody, 2013). Third, low threshold for new investments in the outer city projects caused lower commuting costs, brought about by earlier investments in transportation infrastructure. This encourages growth to spread outside of cities (Brueckner, 2000; Brody, 2013).

Cities expand because of their infrastructure, which provides the necessary framework for residential expansion. Residents' requests for infrastructure upgrades following new construction then spark additional growth along the urban periphery. As known, investments in the outer city and real estate or land costs are much cheaper compared to the ones near the city center. Widespread access, made possible by advancements in transportation infrastructure and reasonably low petrol prices (this does not apply in the actual global petrol cost crisis, August 2022 update), has enabled the 1990s and 2000s developers to take advantage of affordable land outside of the city core, in the suburbs (Gillham, 2002; Brody, 2013).

Another socio-economic factor of urban and suburban sprawl has been recognized as "*race or ethnicity"**.

**Note: Sociologists stress-out this point which is a hot topic in the 21st century. Brody (2013) discussed briefly this point without intervening or bending towards any political position. As well, the following statements are just a conclusion of passed data about what happened at the beginning of the 2000s. The Author do not practice ethnicity or identity politics by any means, and no groups of people are to blame based on their ethnic category identification.*

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White middle- and upper-class residents migrated to the urban periphery as a result of racial conflict in the cities' cores which are the main fusion points of diverse cultures and ethnicities (Lapping, 2000; Brody, 2013). This is a problem of a divided society seen all across the globe in first-world countries with high immigration rates (i.e. U.S.A., England, Sweden, Belgium, Netherlands, France, etc.). This "white-flight" of citizens causes cities to become more dispersed and lowers real estate values (Carruthers, 2003). The spatial pattern of development has been thought to be significantly influenced by age. Younger families in particular encourage patterns and sprawl by looking for affordable Housing alternatives on the outside of cities (Zhang, 2001; Brody, 2013). Last, many strongly desire to live on larger lots in suburban neighborhoods, despite the fact that sprawl may be an unsustainable kind of expansion (Brody, 2013).

d. Consequences

This part primarily addresses environmental issues, from both older and more recent literature findings. These detrimental effects of Urban Sprawl include disrupted or lost environmentally sensitive areas, such as vital natural habitats (e.g.: wildlife corridors and wetlands), enhanced flood risks, polluted water generated by a rise in impervious surfaces, polluted air induced from dependency on automobiles, reduced open space, and overall declines in quality of life among others (Hirschhorn, 2001; Kahn, 2000; Brody, 2013). More precisely, the prevalence of automobiles has accelerated the depletion of fossil fuels and decreased water and air quality (Nechyba & Walsh, 2004).

Nilsson (2014) pointed out the urban expansion's main negative effects synthetized in the "PLUREL" project. The most crucial impacts of Urban Sprawl included:

1. Loss of productive lands and open spaces;
2. Higher automobile dependency and longer distances to attractive sites;
3. Increasing volume of greenhouse emissions;
4. Dismantling of floristic and intertidal biotopes;
5. Lower ecosystem services;
6. Crumbling and disintegration of landscapes.

As more people move to the suburbia's periphery from urban centers, more land is being used (Dwyer and Childs, 2004; Kahn, 2000; Porter & Platt, 2000). Smaller spatial units being created by breaking up larger natural regions can limit wildlife's mobility across the landscape (Cieslewicz, 2002). Leapfrog development patterns leave open spaces interspersed with built-up areas, further fracturing natural landscapes. For a wide variety of species, roads, fences, and other abrupt, human-defined borders can operate as barriers (Brody, 2008). The commonly held belief that this type of growth pattern offers relatively affordable Housing possibilities and an apparently greater quality of life must be counterbalanced with these negative effects of sprawl (Brody, 2013).

The aforementioned impacts create a necessity for an emergent intervention. This is by implementing highly-elaborated urban policies that can fit and manage the areas that are in a fast growth phase, as well as the cities that have lived through sufficient urbanization (Haase & Lanzendorf, et al. 2009).

Otherwise, another non-environmental main challenge that arises with Urban Sprawl is the living affordability and high Housing costs. Typically, rent costs tend to rise with inflation. On average, the rent rises from 3 to 5% yearly. The gap range is surpassed due to fast to the economic boom along with uncontrolled Housing expansions. (Rent increase notices: What is a fair rent increase, 2019). Caldwell and Spiro (2019) mention in their article for “Global Views: Urban Development” magazine that “vertical living” or smart vertical densification is fundamental to attain lower Housing costs. Hence, it would lead to achieving the Sustainable

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Development (shown previously in Figure 09) Goal 11: “to make cities and human settlements inclusive, safe, resilient and sustainable.”

e. Conclusion: Sprawl Reduction Policies

Even though the causes and effects of sprawl may seem overwhelming, there are several policies, laws, and strategies that can lower the spread of unsustainable growth patterns (Knaap & Talen, 2005; Brody, 2013).

Pelczynski and Tomkowicz (2019) imply that an equitable Urban Densification of some city parts is an effective method to carrying feasible sustainability and limit Urban Sprawl. This is by allowing a preferable exploitation of the resources that are already in use while decreasing the requisite for new assets (Bolleter & Ramalho, 2014).

Local planning regulations can support local communities in achieving the intended spatial designs and land use densification and intensities. The policies can direct expansion in a more environmentally responsible manner. Particularly, planning strategies and regulations can aid in concentrating expansion within designated areas, preventing development from uncontrollably sprawling into rural areas, and assisting in the preservation or restoration of a region's natural resource base. This kind of development often called “Urban Densification” is referred to by a number of terms, such as "smart growth", "compact development", and occasionally "new urbanism" (Knaap & Talen, 2005; Brody, 2013).

Local decision-makers have a variety of sprawl control programs to choose from:

First, prescriptions on land development, such as subdivision policies, zoning arrangements, building permit restrictions, and urban growth borders, can prevent or turn around development away from undesirable areas.

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"Second, incentive-based techniques, including special taxing districts, clustering houses, development density bonuses, and transfer of development rights from rural to urban settings can encourage the containment of growth to areas within a central business district" (Brody, 2013, p. 2).

Third, infrastructure-based policies can be proactive in directing expansion away from environmentally vulnerable places. Examples include targeted public investments, capital upgrades programming, development phasing, and urban service areas.

Fourth, property acquisition strategies, which include conservation easements and fee-simple purchases of properties, allow local governments to buy and safeguard environmentally important places.

Last, outreach and education initiatives designed to help a range of audiences comprehend the negative effects of sprawl and potential solutions can be helpful. (Brody et al., 2006; Duerksen et al., 1997; Brody, 2013).

Among other policies, these can aid in reducing sprawl without sacrificing necessary development. Cleaner air and water, the preservation of natural systems, reduced infrastructure costs, and improved life quality are the end results. The majority of the time, a single growth management policy is insufficient to prevent openly growing expansion; it must be a component of a larger program (Song, 2005).

On the other hand, these methodologies can be labeled under bigger section titles, as categories. Amer et al. (2017) distinguish three different categories for urban containment in order to stop and limit Urban Sprawl.

Green belt which is the first category of urban containment strategy is a "continuous green physical space that surrounds metropolitan regions and urbanized areas" (Amer et al., 2017, p. 2). The objectives behind implementing such category include the prevention of union or merger between neighboring cities, the retention of the unique character of historic towns, the monitoring of unrestricted sprawl, the promotion of urban development, and the protection of

the countryside from intrusion (Presland, 2016). Nonetheless, negatives impacts may result from a tight green belt. Leapfrogging, which is described as the emergence of satellite neighborhoods around the green belt and has detrimental effects on the countryside, is the most frequently reported adverse effect of a tight green belt (Amer et al., 2017).

The primary goal of green belts is to preserve landscapes' biodiversity (Siedentop et al., 2016). Examining belt tightness and the quantity of land left for additional development in the expansion region between the belt and the boundary is a critical performance criterion to guarantee effective urban containment (Siedentop et al., 2016). For instance, in England green belt is allocated for about 13% of the land (Presland, 2016), while in Germany the development plants in about 60% of the planning regions have adopted green belt initiatives (Seto, Fragkias, Güneralp, & Reilly, 2016).

Urban growth boundary (UGB) is the second category of urban containment strategy and is "a regulatory line that separates and divides urban and rural areas" (Amer et al., 2017, p. 2). Urban use is meant for the area inside the boundary, whereas rural use is for the area outside the boundary. Zoning is used in order to execute and define the UGB. Moreover, the UGB can be reevaluated and enhanced depending on the current population growth needs or requirement to accommodate more people (Amer et al., 2017).

Urban service boundary (USB) is the third category of urban containment strategy. It is considered more flexible than UGB. The USB establishes the outer limit of the supply of urban infrastructure. Nevertheless, in theory, this does not prevent the development of an area outside the service boundary zone (Amer et al., 2017).

To conclude, green belt, urban growth boundary, and urban service boundary which are the three urban containment solutions presented have their shortcomings (Amer et al., 2017). A broader framework at the metropolitan and regional levels is typically required to work jointly on Urban Densification and on the three urban containment strategies. A suggested and effective framework for preventing Urban Sprawl and enabling urban containment strategies

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at the economic, spatial, and infrastructure levels is reasonable Urban Densification (Amer et al., 2017).

6- Urban Densification and Sustainability

6.1- Overview:

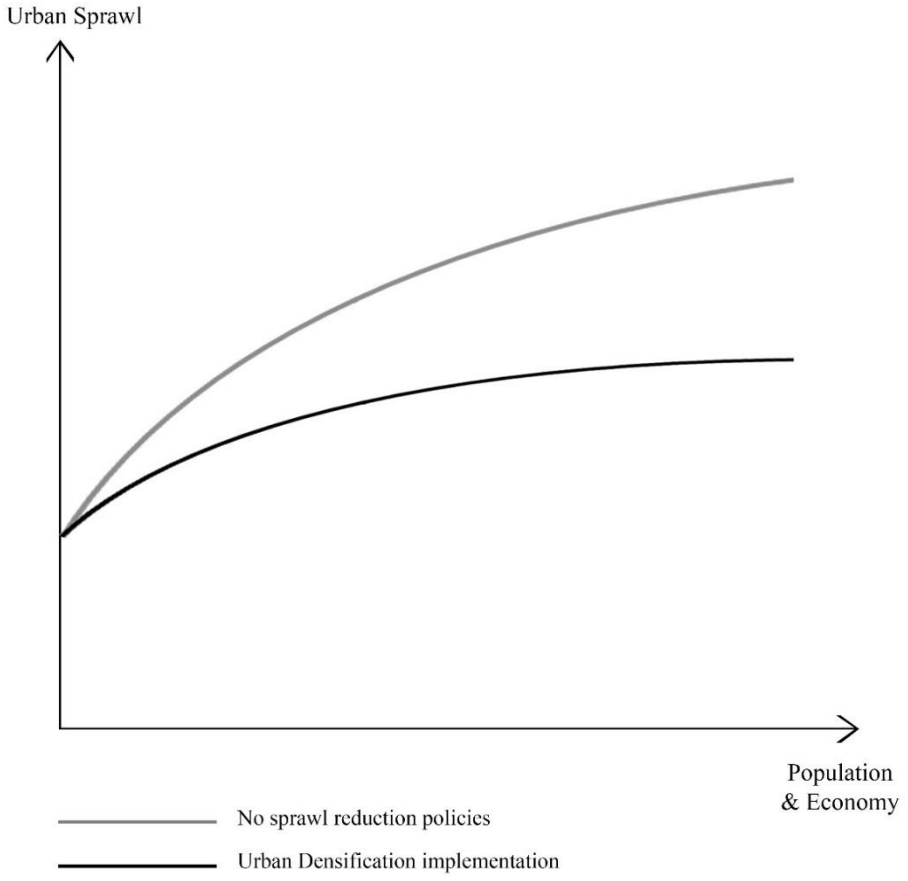

Figure 10: Hypothetical diagram concluding how Urban Densification implementation results in Urban Sprawl reduction.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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a. Definition and Importance

Urban Sprawl was confronted by several European governments that tried to limit its expansion by issuing many urban management strategies and policies (to obtain the hypothetical result shown in Figure 10, mainly about Urban Densification potentials. Those policies are not limited to the physical aspect of the cities, but to the economic, social, and political ones as well (Amer & Reiter, et al. 2018). Pendall & Martin et.al (2002) categorized three forms of urban containment strategies to confront urban expansion: Urban Growth Boundary (UGB), Urban Service Boundary, and Green belts. Hence, an approach consisting of adequate Urban Densification strategies is crucial in order to limit Urban Sprawl and to sustain containment strategies (Amer & Reiter, et al. 2018).

In order to avoid additional expansion in urban area growth and the ensuing artificialization of open and green spaces, some cities and regions have developed planning strategies that encourage Urban Densification via development and urban consolidation (Teller, 2021).

To understand all the questions that should be asked when it comes to Urban Densification, it is crucial to compare the recent literature with older ones dating back to around two to three decades ago. It was then when population size and density increased explosively in the cities which created an urge for making newer Urban Planning policies. The city densification was seen as a tool for urban development (Da Cunha & Kaiser, 2009).

The Urban Densification process is a phenomenon of the 19th century industrial city that cannot be avoided. Moreover, the process has rather negative connotations. It has now become a virtuous figure of the territorial project in the paradigm of sustainable development (Declève, Ananian et al., 2009). Nevertheless, there has been a debate on Urban Densification and the good urban form. The debate was often limited to the environmental and economic dimensions, which puts the social dimension in the background as a secondary significance (Breheny, 1992; Jenks et al., 1996; Burton, 2000).

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From an environmental point of view and since the energy crisis of the 1970s, researchers have contrasted dense cities with diffused cities, in order to elaborate an ideal city model responding to various criteria, namely: energy consumption, rationalization of transport in a managerial approach, and optimization of resources (Newman & Kenworthy, 1989; Gordon & Richardson, 1997). On the other hand, Urban Densification may have an effect on the arrangement of urban centers along with their physic-spatial forms. Densification may also potentially restructure and generate new forms of social diversity but also the coexistence of activities which poses numerous issues concerning public authorities. The diversity of ethnical groups having different linguistic backgrounds, and cultural or religious beliefs is the main factor to take into account (Bromley et al., 2005; Rose, 2006).

Questions about the opportunities offered by, and importance and risks of Urban Densification are still the same until nowadays. This is because of the complexity of the actual state in major European cities: population is continuously increasing and social diversity is getting more complex while new demands for sustainable development and environmental challenges are arising. Modern literature mainly underlines the fact that European capitals and other major cities are facing one the biggest migration challenges in history. While migration from rural areas to urban cities inside the same country is a thing itself, migration from the east and third world countries is aggravating and complicating the situation. The United Nations agenda produced a planning for solutions that can promote spatial frameworks in urban areas, and prevent marginalization along with the phenomenon of Urban Sprawl. The approach behind these frameworks is concerned by mixed-use cities, polycentrism, and compactness (Amer & Reiter, et al. 2018).

It is an unquestionable matter that the recent increase in the volume of buildings and urban areas is a logic consequence of the growth of human population. But the problem is that the menace of Urban Sprawl, being unsustainable, encompasses both natural resources of the ecosystems and population's wellbeing leading to further complications and social problems.

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Thus, spatial policy must be emphasized by strict laws to regulate newly and already urbanized area (Pelczynski & Tomkowicz, 2019).

A general definition of Urban Densification is a phenomenon of enhancing to the maximum the exploitation of the already used-up space by a city. Securing new layers within the perimeter of a city is a sustainable way of urban structure regeneration and development. As well, it is a "top up" filling strategy that can make full use of the existing infrastructures within performance limits while deriving benefits from them.

Once an urban planning for densification is in realization, a door opens for other independent activities that can insure an evolution in the urban tissue and services. A blooming can be seen by the restoration of buildings and modernization of existing technical and non-technical infrastructures. The economic benefit from this procedure is based on the economic stimulus through the activation of new capital and external funding for the evolutionary projects inside the city. Hence, an increase in the value for the property itself is highly probable (Pelczynski & Tomkowicz, 2019).

Teller (2021) claims that Urban Densification is becoming more widely recognized as essential and crucial for no-net land take. Many regions experience densification, particularly rapidly expanding cities when a combination of demographic change, significant transportation infrastructure investments, and economic pressure is at play. Comprehending the potential direct, indirect, and cumulative effects (environmental, economic, and social), both on and off-site, is crucial to understanding the costs and advantages of density (Teller, 2021).

In order to maximize densities, it is necessary to pinpoint the factors that will provide the most value to the city, identify the areas most suitable for incoming residents and their activities, and advance spatial justice. Urban Densification is shown by the studies included in this special issue as a complicated, nonlinear phenomenon that must be addressed at multiple scales. Because they provide a more comprehensive picture of the urban forms and how residents and users interact with them, multifactorial metrics of density are preferable to

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aggregated ones. In order for cities to prevent overcrowding of spaces and buildings, which can be harmful to urban resilience, both hard and soft densification must be properly monitored and regulated. Housing affordability is a crucial issue that governments must address in connection to Urban Densification (Teller, 2021).

The no-net land take target approved in 2011 by the European Commission encourages infill construction (Science for Environment Policy, 2016). In effect, this means that by 2050, brownfield sites at which developments have been made on previously undeveloped land must be restored to their original state. It recognizes the necessity to keep urban expansion to a minimum so that enough space is left for other uses such as agriculture, ecosystem services, forestry, and biodiversity among others (Teller, 2021). This represents a significant paradigm shift in the urban planning field because land is now viewed as a finite resource that must be used in a circular, closed-cycle manner as opposed to a linear, open-cycle one (Preuß & Ferber, 2008).

6.2- Political Debate and Critique

b. Scientific Approach to the Political Uses of Densification

Urban Densification has become the paradigmatic norm to follow in urbanism strategies especially after the recent global Housing crisis (Pérez, 2020).

Pérez (2020) explores in his paper entitled “The Miracle of Density” the shifting deployments and political uses of urban density as a debate around Urban Densification. A starting motive for this digging for a debate is that Urban Densification as a foundational and crucial concept in urbanism has relatively remained immune to any type of critical analysis. This study cares

mainly about the social and political aspects of Urban Densification. It takes as reference the socio-material archives and ethnographic research on many cases studies, mainly Bogota in Colombia. In his article, Pérez (2020), refers to Urban Densification as a taken-for-granted ideology of socio-materiality. The hypothesis of his work is that densification policies shape and limit the use of urban politics. Pérez (2020) takes a chronological path using older to most recent literature and references to ensure an adequate critic for densification policies.

In the U.S.A, when there was an urge to turn towards the modern urbanism of density and diversity in the 1980s, the main focus was since the mixed-use design, public space, and walkability. Now this is in no way a negative effect. But ironically, this translated into a development of idealized urban villages with high social inequalities. The inequalities were ignored and appearances were the core of diversity ideology (Fainstein, 2000).

Another example is Jane Jacob's Greenwich Village, the so-considered a model of "urban vitality". This was defended by many pro-density conferences that encourages implementing Urban Densification across the inner cities around the world. The exact words used as a promise is that density would make cities "wealthier, healthier, and more alluring than ever" (Glaeser, 2011). Another promise is that densification is the response to environmental and Housing crisis. It is in this way that Urban Densification discourses controls urban politics by selling density as the best possible practice without ensuring a description of formal urban space characteristics (Pérez, 2020).

Oppositions or reforms against Urban Densification often end up leaving the processes and practices of different methodologies unquestioned. As well, a cursory overview revealed that the conceptualization of Urban Densification has been implicitly designed by urban politicians in the global North. The concept assumes that global world countries have like Euro-American patterns of industrialization, suburbanization, and inner city gentrification. In this context, studying the multiple locations, histories and politics of density is a necessary and critical contribution to the exploration of 'new geographies of urban theory' (Roy, 2009, p. 820).

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Rao (2015) indicates that urban density is best understood as "active spatio-temporal configurations that make visible styles of structural coupling between human and non-human actors" (Rao, 2015, p. 42-44). For her, this will control how urban intervention will be executed in the future.

To build on this work, McFarlane (2016) called for a critical study about Urban Densification. He developed "topological density", a notion to counterargument the ideological and political substrates of the "shifting geographies of density". The most crucial thing is to get an answer on how differently Urban Densification could be perceived, negotiated, experienced or produced, while people move and live in cities. A reinterpretation should reveal the underlying problems and issues with density from political, economic, and socio-cultural perspectives. This will give more opportunities for new political policies and urban critiques. There should be an illumination on the plastic nature of density that is a political tool and imaginary geographic form (McFarlane, 2016).

Elden (2013) indicates that these claims by McFarlane (2016) are considering density studies as flat, as if there is only 2D rendering and mapping without taking into account the concept of the volumetric space. Density is a powerful tool that can simultaneously shape the forms of urban life. The "volumetric terrain" is a term used by Elden (2017), in which he discusses the "mechanics of calculating, measuring, surveying, managing, controlling and ordering (the metric) that constitute the political technology of territory. Urban governance thus emerges in its three-dimensional complexity as a host of techniques centrally concerned with making terrain knowable and manageable" (Elden, 2017, p. 219).

Pérez (2020) argues that density is not an objective quality of any urban space. Rather it is a way of redesigning and reshaping the terrains and isolating the socio-material properties of a context. Density has emerged more in recent years in a claim that it is a naturalized socio-material dynamic. While this may or may not be true, Urban Densification should be a subject of critique or assessment, before being widely executed. A regulatory experimentation is the right way, and can go up in size progressively. Such grammar of urban concepts should not

be only assumed, but also tested and questioned without obscuring political agendas. Eventually such speculative practices may create larger socio-spatial conflicts (Pérez, 2020).

6.3- Regulating Urban Densification:

c. Scope and Purpose: Normative vs. Descriptive

The densification principle has two main applications (Teller, 2021).

The first strategy is associated with Urban Densification as a goal and signifies a determination to gradually raise urban density through a variety of methods in order to accomplish specific objectives (Teller, 2021). This viewpoint defines densification as being specifically normative and performance-based (Teller, 2021). It evokes images of crowded cities with open spaces, a productive transportation system, a high degree of walkability, and outstanding accessibility (Neuman, 2005). It basically asserts that densification is not a virtue in and of itself and is frequently referred to as 'intensification' (Teller, 2021). In order to successfully establish a living environment, it needs to be connected to other services (Dempsey & Jenks, 2010). This teleological conceptualization is closely related to the transit-oriented development agenda (Renne & Wells, 2004, p. 12) and the 'new urbanism' movement (Duany and Plater-Zyberk, 1993).

The second strategy places more emphasis on Urban Densification as a phenomenon that can be quantified and connected to other characteristics (Teller, 2021). Here, densification is defined as the gradual rise in built-up and/or population density through time (Mustafa et al., 2018). According to this viewpoint, individual urban agents may plan for and/or promote

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densification (Teller, 2021). It may not always be goal-driven. It can emerge in a wide range of urban layouts, both central and peripheral, at varying speeds, and is tied to a wide range of results (Teller, 2021). It is always relative to a particular place or environment. In ecological and environmental sciences, this second strategy is prevalent. It does not suggest that density may necessarily be linked to advantages or disadvantages. It is portrayed in some way as a 'neutral' variable (Teller, 2021).

This is the scenario, for instance, when analyzing the impact of urban density on the spread of COVID-19 (Teller, 2021). Teller (2021) emphasizes that the subject is continually debated, in part because the term "density" is not consistently used throughout research and can refer to a variety of dimensions depending on the full range of factors taken into account. This is undoubtedly true for the contrast between density and connection, two aspects of the urban environment that are closely related but separate from one another (Teller, 2021).

Any variable's neutrality might be questioned, notably when it is used to describe human contexts like towns or metropolitan areas (Teller, 2021). According to Rinkinen et al. (2021), the distinction between normative and descriptive variables is seriously disputed, and urban metrics frequently have a performative orientation. Once a certain variable has been connected to a certain result in some way, actors and policies quickly use it to support or refute certain developments (Teller, 2021). Densification and urban density are not an exception in this aspect (Teller, 2021).

d. Scale: From Housing to Metropolitan Scale

The differences of density between scales and locations can be used to observe the problem of densification spatially. This special issue's scales range from the individual residence to the metropolitan and national levels (Teller, 2021).

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It is debatable if the analysis's scope will impact just how much density and densification are understood. Urban Densification is generally associated with overpopulation at the dwelling level, but it can also be associated with an increase in privacy and individualization of Housing. Density is tied to typologies and urban forms at the scale of the building and the block, but at the neighborhood and agglomeration scale, it is mainly connected to the settlement pattern, the availability of green space, and the relationship with transportation networks (Teller, 2021).

e. Process: Soft vs. Hard Urban Densification

When discussing Urban Densification as a process, raises the question of the appropriate time scales to study it. As a result, there are two primary types of densification: soft and hard. The distinction between strategic and tactical urban planning is reflected in this separation (Teller, 2021).

Soft Urban Densification often advances gradually through ongoing, minor changes to the urban fabric (Moudon, 1986). In essence, it is a type of urban growth that continues directly alongside already-built structures (Teller, 2021). These gradual densifications can be seen in a variety of settings. Whether they are authorized or under administrative control is up for debate. A bottom-up, people-centered method, soft densification naturally enables residents to customize homes to suit their desires and requirements (Teller, 2021). However, rules can be used to trigger it, as in the UK, where minor changes to the built environment no longer needs planning clearance (Knight & Williams, 2012).

Since soft densification may occur without affecting the building's footprint (unlike, for example, vertical densification), it is difficult to quantify using standard methods.

Densification-related administrative statistics are not always trustworthy. Additionally, there are gaps in the statistics on construction and demolition projects, a shortage of data on alterations to building usage, etc. (Teller, 2021).

On the contrary, hard Urban Densification happens as a result of extensive policy-driven projects that involve the renovation of already-existing urban buildings (Teller, 2021). These urban structures which existed before could be vacant spaces, like brownfields, or highly populated areas, such those left over after slum resettlement programs (Teller, 2021). Hard densification is typically thought of as a state-led initiative. In reality, it seems that a lot of these operations demand money from the private sector (Teller, 2021). Even in environments where central planning is practiced, the state frequently plays the role of a facilitator rather than a developer (Robinson et al., 2020). This directly affects these enterprises' value-capture mechanisms, how they affect Housing affordability, and how they ultimately shape metropolitan regions' design (privatization of public areas, provision of green spaces, etc.) (Robinson et al., 2020).

The development model that cities have implemented is intimately tied to these two tactics (Teller, 2021). Urban Densification may work using a mono- or polycentric model, according to Giddings and Rogerson (2021). The authors' intriguing argument is that hard densification schemes might not be in line with modern urban development. They are heavily reliant on the supply of retail and office space, both of which may become less important as Industry 4.0 develops and e-commerce gains in power (Giddings & Rogerson, 2021).

It should be emphasized once more that soft densification may inevitably result in houses with poor quality, in higher Housing dangers, or vertical extensions that do not meet building codes (Teller, 2021). Soft densification should be viewed as a significant but difficult urban regulation issue because it involves subtle changes that may not be covered by public surveying and whose cumulative impacts are difficult to forecast (Dunning et al., 2020). Since the emergence of short-term Housing rental platforms (like Airbnb), which may further limit Housing affordability for urban households in addition to their impacts on residential

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densification (Garcia-López et al., 2020), the problem has become much more urgent. To better govern soft densification processes at the city scale, non-traditional techniques are required to monitor them (Teller, 2021).

f. Macro- and Micro-Drivers of Urban Densification

Up until now, the majority of the literature has focused on the macro-drivers of Urban Densification. The densification of cities is primarily influenced by three macro-level factors: demography, economy, and transportation infrastructure. A transversal aspect that is impacted and influenced by these three forces is policies (Teller, 2021).

DEMOGRAPHY

The first major factor causing densification is global population expansion and urbanization (Teller, 2021). Numerous cities, particularly in the Global South, are experiencing rapid population increase and a lack of available land. As a result, existing places are being densified using either soft or hard densification procedures (Teller, 2021). Urban Densification is discussed by Rinkinen et al. (2021) and Li & Sunikka-Blank (2021), respectively, in Jinan and Hanoi (Vietnam) (China). In both instances, the dramatic rise in urban residents at the metro-scale is directly correlated with densification. Instead, one notices a structural densification of cities in the Global North, which is partially fueled by declining household sizes. The aging of the population and the evolution of lifestyles are both related to the growth of household size. Urban services are more reliant on one-person homes (Delmelle et al., 2014; Hernández-Palacio, 2017). According to Giddings & Rogerson (2021),

in order for cities to retain its population base, they must therefore build more homes, which is not always feasible given the current state of the Housing stock.

ECONOMY

The building of highly profitable locations in prominent metropolises is what the real estate market wants (Dave, 2010). The financing of the real estate industry and the commercialization of Housing are additional factors that support this mechanism by encouraging more concentrated business models and luring foreign investors (Aalbers, 2016). Densification looks to be a strategy used by investors and developers to maximize value extraction (Teller, 2021). Additionally, it is becoming more widely accepted as a way to use negotiated planning gains to pay for social and/or public services including affordable Housing, sporting facilities, and green spaces (Teller, 2021). It is therefore linked to a type of 'private Keynesianism', which does not always fulfill its promises, as argued by Livingstone et al (2021).

TRANSPORT AND MOBILITY

By making certain locations more accessible, decreasing the cost of public transportation, and raising the expense of driving your own vehicle (Amer et al., 2017; Aquino & Gainza, 2014; Hernández-Palacio 2017), transportation facilities operate as a driver for Urban Densification. High-density development is encouraged by transit-oriented development along rail lines, but it gets less dense the farther it is from the stations (Delmelle et al., 2014). Bus rapid transit (BRT) and other infrastructures promote densification as well (Rode et al., 2017). It would be naive to assume that the construction of transportation infrastructure will automatically produce structural effects like densification (Teller, 2021).

In many instances, more so than just the transportation infrastructure itself, it is the long-term mix of transportation investments, urban policies, and stakeholder agenda alignment that

support densification (Teller, 2021). Such plans for urban concentration may potentially have a substantial rebound effect (Teller, 2021). According to Giddings and Rogerson (2021), the polycentric expansion of high-density urban regions with transportation infrastructures is linked to a further deterioration of the standing of the historic center in Newcastle, Australia.

In addition to these macro-level drivers, other studies in this special issue examined potential micro-level Urban Densification drivers (Teller, 2021).

AT THE HOUSING LEVEL

Kostourou (2021) emphasizes that periodic reinvestments and home extensions are related to the size and typology of the houses, the shape of the parcel, the organization of the street layout, and the ownership cycles (number of owners through time). Kostourou (2021) asserts these small tweaks might seem laughable at first, but over time, they can significantly increase construction volumes. The author claims that during the course of 120 years in the study area, soft densification caused an 82 percent rise in ground coverage and a 62 percent increase in the built volume. This puts a substantial strain on soil sealing and the degradation of open space, in addition to the opportunities associated to Housing renovations and better use of existing infrastructures (Kostourou, 2021).

AT THE PARCEL (BILDING SITE) LEVEL

Cities and urban planners can utilize the criteria Schiller et al. (2021) suggest to find viable infill development sites. The size of properties and their proximity to existing roadways seem to be the main elements that could promote densification. Importantly, they admit that this possibility only exists in theory. The truth is that many parcels could not be suitable for development because their owners are unwilling to sell, occasionally for speculative motives (Teller, 2021). In addition, the parcel structure and its features play a key role in either accelerating or slowing urbanization (Teller, 2021). Splitting parcels is always simpler than

combining them, especially when some or all of them are already constructed (Gallagher et al., 2019).

In the densification literature, such microlevel forces are frequently disregarded. One explanation could be that data collection for macrolevel drivers and hard densification is considerably simpler than for microlevel drivers and soft densification. To properly track the actual occupation of buildings, more research is required. Activity-based use is a significant (but sometimes ignored) source of building densification in terms of user numbers, worker, or residents. It also has anything to do with a potential source for infill construction for structures with little or no occupancy (Teller, 2021).

6.4- Effects and Relation with Current Sustainability Issues:

Implementing Urban Densification projects into a city can face several complications and risks. Those obstacles or risks can be summarized into the possible occurrence of more social conflicts and increased emissions and contamination. A loss of architectural and historical heritage and local identity can be considered as a less probable risk as well. In order to ideally execute an Urban Densification project, it is fundamental to fix strict adaptation measures and formal regulations that respect architectural, social, economic, and environmental sustainability. A diagnosis of the former or current situation along with a planning prediction of the development process should be performed as well (Pelczynski & Tomkowicz, 2019).

Because of this issue, writers were urged to depart from axiomatic views of the subject and discuss both the advantages and disadvantages of Urban Densification (Teller, 2021). Densification's consequences can be generally categorized into three categories: social,

economic, and environmental (Teller, 2021). A thorough analysis of the impacts of Urban Densification is proposed by Berghauser Pont et al. (2021), taking six areas into account. They draw attention to the fact that up until now, transportation-related consequences have primarily occupied the scientific agenda. This is particularly valid for transportation's direct and indirect effects, such as air pollution and infrastructure expenses (Berghauser Pont et al., 2021). For the regulation of densification to be more effective, it is crucial to comprehend and anticipate these potential repercussions, whether they be favorable or unfavorable, promoted or endured (Berghauser Pont et al., 2021).

g. Environmental Effects:

ENERGY GENERATION AND CONSUMPTION

Something above 75% of the world's population now live and work in urban areas. It is in these cities where around 80% of available energy is consumed, and where over 50% of greenhouse gas emissions are produced (Tadi et al., 2012). Hence, it is crucial to improve the energy efficiency of inner cities in order to reduce the general consumption levels (Lobaccaro & Frontini, 2013).

Many publications identify the benefits of densification when predicting energy consumption, even though they generally recognize that these benefits are not linear and location-dependent (Conticelli et al., 2017; Asfour & Alshawaf, 2015; Lima et al., 2019). Compact building forms are primarily responsible for the reported decreases in energy use; however, this could have a negative impact on cooling loads in summer due to a lack of natural ventilation, especially in hot areas (Teller, 2021). Additionally, Urban Densification is linked to less daylight availability, which could lead to an increase in lighting-related power demand (Teller, 2021).

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The linkage between urban density and energy use is discussed by Godoy-Shimizu et al. (2021) at many scales, ranging from the building to the metropolitan level. Their research is based on data from houses about real energy use. It basically confirms that density has a beneficial impact on energy usage. Particularly in the case of gas consumption (used primarily for space heating). For electricity, far less so (Godoy-Shimizu et al., 2021). In both instances, they emphasize that the relationship between density and energy consumption is not linear and will depend on the morphology of the building. Highly dense but less compactly shaped buildings, may consume more energy than lower dense but more compact shaped buildings (Godoy-Shimizu et al., 2021).

Barresi (2018) investigated, in his paper on the VerGe project in Switzerland, how Urban Densification policies could possibly shape and influence the energy demand. This demand is also seen in light of conservation of existing heritage and how much solar energy is available to attain existing built environment pre- and post-intervention.

The VerGe project main scope is to analyze different densification scenarios in different contexts while considering the buildings as a mass. This is to consider eventually the sky-view factors and solar radiation impact analysis in order to check carefully for each scenarios if the proposed methodology of densification is adequate and proper for energy conservation behavior on the existing built context. The case study is in the southern part of Switzerland, in Lugano Paradiso. Lugano changed its Urban Sprawl policies into Urban Densification infill policies and that is why it was a suitable for Barresi's work.

Infill construction will create closed, opaque and compressed building blocks or parcels. This is clear in the Master Plan Regulation for the city of Lugano Paradiso. Many simulation and photographic diagnostic tools were used in order to examine the impacts on the energy production and conservation. This provides design guidelines for both private and public sectors investing in Urban Densification projects. The study is based on a clear awareness of the big negative effects caused by Urban Sprawl phenomenon (Barresi, 2018).

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Urban Densification can modify the building energy demand and thermal performance, as well as the level of conservation of the existing historical buildings and urban microclimates. These effects should be quantified accurately for each case scenario. Exact predictions in solar radiation energy recessions may help in understanding the real impact of such intervention and reshape the planned intervention in a "more sustainable-energy-correct-way". It is important to point out that cultural heritage should remain untouched forever, while the surrounding built context could always undergo regenerations and modifications (Barresi, 2018).

While doing these analysis on the urban level the streets and lots should be accurately oriented. At the building scale, the orientation angle, the shape, and the height of the building should be clearly considered. This is because of the shadow and light studies. These analysis done by study bureau or researchers also should understand and take into account the importance of policy makes and urban planners in shaping urban transformation projects. Urban planners can set restricting constraints, for instance in order of confirming an unobstructed flow of solar radiation and energy through adjacent parcels and building blocks in a specific zone or context. Urban planners write and administrate policies and incentives that can highly influence any future urban transformations (Barresi, 2018).

New Master Plans consider the intended use of Urban Densification to conserve energy and facilitate the use of solar energy (Barresi, 2018). "Communities can create incentives by streamlining the approval process, reducing authorization costs, and increasing flexibility for the integration of solar and local energy sources if all aspects are correctly considered since the first steps of urban codes" (Barresi, 2018, p. 29).

Dense cities lower the report of energy usage per capita compared to more diffused suburban contexts. Studies show also that density can ensure a better ecological footprint per inhabitant, by improving building efficiency and public transport. Urban Densification designs smaller spaces that use less energy for lighting, heating, and cooling, and are functionally efficient for

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the needed activity. Moreover, their construction will consume less energy and less materials (Lobaccaro & Frontini, 2013).

It is so important to underline the fact that Urban Densification does not mean exclusively tall buildings or high rise apartment blocks, but rather being an organized built intervention and an increase in public space that create a better sense of the existing context, on the building scale, as well as on the urban scale. Other than limiting Urban Sprawl and its unsustainable consumption of energy, densification provides a complex environment for a concentration of energy use without significant waste. This will lower the energy usage per inhabitant, especially in roof extensions to extend the building size (Montavon, 2010; Lobaccaro & Frontini, 2013).

AIR QUALITY AND URBAN MICROCLIMATE

In several urban areas, transportation is the biggest source of air pollution. According to Rode et al. (2017), a higher density is typically accompanied by congestion, and Urban Densification raises the number of people exposed to pollution (Yuan et al., 2017; Haaland & van den Bosch, 2015). Urban areas' air quality can be partially improved by reducing transportation and greenhouse emissions. In order to address pollution, Urban Densification should be undertaken concurrently with transportation regulations, as this can produce better results at both the local and city levels. Urban heat island (UHI) effect is generally accentuated by high urban density, which are frequently correlated with fewer green spaces and higher levels of anthropogenic waste heat (Li et al., 2020; Conticelli et al., 2017). The effects of growing Urban Sprawl must be weighed against the effect of Urban Densification on the UHI effect. Applications of Densification show a higher usage of public transport and a lower use of private cars. That is why Urban Densification should be accompanied with green densification and further regulations about transport. In that way, the air of the inner-city will not risk getting polluted or having lower quality (Teller, 2021).

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MOBILITY

Urban Densification is linked to increased usage of public transportation, shorter travel lengths, and a smaller carbon footprint (Teller, 2021). Densification brings buildings (residences, workplaces, and stores) closer to one another, which encourages people to utilize more environmentally friendly forms of transportation rather than driving their automobiles, such as walking, biking, and so on. People frequently use public transit because it is more effective in crowded areas (for example: Paris). By switching to more environmentally friendly modes of transportation (such as walking, biking, buses, and trains), one can save money and minimize energy use, and most important of all, lower greenhouse emissions. Densification has a good influence, but it also has drawbacks, such increased noise and emissions from vehicles that are used for public transport itself. The issue is especially pronounced in the Global South due to extremely high densities in many cities and a lack of adequate public transportation infrastructure. Many cities are switching to zero emission public transport busses and trains, using rechargeable electricity from renewable energy sources like in the initiatives in Barcelona and Copenhagen (Arifwidodo & Perera, 2011; van Rensburg & Campbell, 2012).

LAND USE, GREEN AREAS, AND BIODIVERSITY

Urbanization results in less land take, which benefits the amount of land that is available for agriculture, nature, recreational activities, and biodiversity. Numerous studies at the urban scale show that Urban Densification is typically linked to mixed land use, which permits the coexistence of institutional, commercial, and residential activity in a particular location. Due to small distances, mixed land use typically lowers transportation costs and promotes cycling and walking. This is a promotion of a sustainable living style (Teller, 2021).

The procedures created for no-net land take in Germany and Europe are discussed by Schiller et al. (2021). They interestingly show that densification is not limited to big cities. The

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potential for infill constructions is concentrated in small and medium-sized towns (less than 20,000 inhabitants). Municipalities with fewer than 5,000 inhabitants hold one-fourth of the potential for new densification. The human and technical resources available to different sized towns for directing and supervising infill development vary greatly (Schiller et al., 2021).

Public green areas are a crucial player when it comes to urban sustainability. These zones offer a higher recreational life quality for residents, to the point in which they are often overused spaces (Arnberger, 2012).

Urban regeneration projects tend to provide more green recreational areas. But the case for Urban Densification is not exactly the same. When densification is implemented near or around green areas, these will be overused hence their recreational quality will get lower. Monitoring recreation quality is one of the way by which sustainable green areas management can be handled properly (i.e. crowding perceptions). There will be a densification in green areas as well, not only in population density (Arnberger, 2012).

Green zones hold and promote biodiversity which provides higher quality ecosystems in the inner cities. Urban settlements are more attractive with higher ratio of recreational green areas. It is proven that such spaces offer relaxation and stress reduction. It is a way to escape from the city and practice calmer social interaction (James et al., 2009).

With Urban Densification strategies, these spaces are overused and the quality of experience can degrade gradually. That said, the demand for more green spaces is a must with the increasing urban population. The good effect of density studies is that they always take into account green space provision and access by inhabitant. They even tend to maximize that ratio of green m^2/inhabitant in their study and planning inventories. However, the measuring studies of the recreational quality of these spaces are rare. Knowledge of recreation quality study indicators definitely help in these context cases. Crowding perceptions and coping the behaviors towards the satisfaction with a specific green public space will provide information and critical constructiveness towards a more sustainable urban green management with a proper social carrying capacity (Searle et al., 2011; Arnberger, 2012).

Real estate properties located closer to public urban green zones have a higher economic value (Hui et al., 2011). This is why property developers take advantage of the situation. As for Urban Densification, it takes advantage of such contexts by building high rise buildings for example with small apartment complexes or by implementing infill constructions around green urban spaces so it increases the number of inhabitants that are getting direct access to these areas. But, as mentioned before, this could lead again to a heavy physical use of the public spaces and this could affect the social perception of such living zones. Social crowding, conflicts, and degraded environments may develop through this frequent heavy usage.This often leads for people dissatisfaction and they may tend to hang indoors or at home, or simply displace their location (Arnberger, 2012).

The question that Arnberger (2012) tends to research about is whether Urban Densification is negatively or positively affecting the life quality in terms of urban public green spaces. Also, another question arises is that if Urban Densification can satisfy this increase for the need of a higher number of, and larger green areas, while implementing density projects in a zone so the recreational quality doesn't fall down? Managing urban green spaces on sustainable basis is a necessity when Urban Densification processes take place in green space living zones (Arnberger, 2012).

In his work, Arnberger (2012) takes a heavily-used green urban space in Vienna in Austria as a case study. It is the area of "the Wienerberg". The work focused on defining the maximum number of visitors to this recreational zone before the social behaviors towards the place could get negative in an ascending manner. Urban Densification projects have been going on in this southern zone of the Viennese capital which can help identify a methodology for long-term and future densification projects. The study based its survey on coping behaviors in response to crowding and the new social setting conditions after densification (Arnberger, 2012).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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h. Economic Effects:

HOUSING AFFORDABILITY

Some studies show that the smaller size of Housing units in compact projects (fewer infrastructures and short roads) may make Housing prices more affordable when density increases. It can impact the supply chain as well (Lobaccaro & Frontini, 2014). Roof stacking, or adding structures at the roof level, is another economical efficient method for densification and to ensure affordable small and medium Housing (Amer et al., 2017). The high land cost, scarce land availability, and value capture by developers and investors can all contribute to an increase in Housing prices. Due to the lack of land compared to population in many Asian and African cities, Housing costs have risen (Boyko & Cooper, 2011; Dave 2010; Todes et al., 2018).

A recent example on the economic effects of Urban Densification on Housing are seen in Canada. Housing affordability is among the few aspects of livability that urbanization in the metro Toronto area adversely affects, according to Martino et al. (2021). The effect of London's densification initiatives on home affordability is discussed by Livingstone et al. (2021). They discover that rising property costs is not caused by increased density. Instead, it's the interplay between private and public players, with competing demands about monetary risks, potential economic advantages, and requests for the creation of affordable Housing. Rather, Urban Densification when planned for public Housing, according to the shortage and policies, gives an additional affordable layer of Housing to the city (Livingstone et al., 2021).

ECONOMIC ATTRACTIVENESS

Due to agglomeration influences in the service industry, better position in relation to existing key locations, and a higher adherence to public life in the streets of residential districts, urban density is linked to a higher appeal for businesses. (Teller, 2021)

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According to Martino et al. (2021), there is a positive correlation between the amount of jobs and the site size and centrality indices. They contend that it is optimal to measure the impacts of density and densification at intermediate urban dimensions, or at a radius of 4,800 meters (Martino et al., 2021). This has the tendency to indicate that the economic advantages of density extend far beyond the micro-scale. This is a key result of their study because too frequently, when discussing the costs and advantages of Urban Densification, local residents and activities are considered without taking into account potential spillover effects (Martino et al., 2021). Such a strategy is consistent with MacFarlane's (2016) conception of urban density as a topological artifact that links locations and people through flows described as material and immaterial. Urban regulations need to take these spillover effects into consideration (MacFarlane, 2016). Given that Urban Densification will have a lever impact on nearby spaces, it should be encouraged in certain areas. This should be driven by the results of existing experiments of densification that resulted in a clear economic growth and spread around the inner-city (MacFarlane, 2016).

INFRASTRUCTURE COSTS

Because more households can use the existent infrastructure, densification through infill development also lowers building costs (Teller, 2021). This effect is well supported by the body of literature that already exists, particularly when it comes to the financial costs of networks associated with Urban Sprawl, as well as when the portion of potential users and the costs of maintenance are taken into account (Halleux et al., 2008; Pflieger & Ecoffey, 2011).

Two studies on this topic by Martino et al. (2021) and Kostourou (2021) adopt opposing stances on causal chains, which is quite noteworthy. They discuss how a dense, well-connected road network, which is portrayed as an affordance for densification, may assist densification. According to Kostourou (2021), the amount of roads at the construction site significantly increased the cost of the project. Later, it seemed to provide more flexibility for the building's adaption over time. It is beneficial to change the subject from reasons for Urban

Densification to requisites that support it. The evaluation of these requisites during the planning process might increase urban developments' resilience (Kostourou, 2021).

i. Social Effects:

QUALITY OF LIFE

One of the most crucial conditions to think about while discussing densification is the quality of life. Nonetheless, this factor is challenging to quantify and define. Numerous studies demonstrate that high density causes smaller, occasionally overcrowded homes, which in turn causes a social stress of habitation (Boyko & Cooper, 2011; Poruschi & Ambrey, 2018; Todes et al., 2018). People in high-density areas are dissatisfied with the size of their homes (Dave, 2010). China's high-density cities are experiencing negative effects that are degrading people's perceptions of their quality of life (Wang & Shaw, 2018).

Martino et al. (2021) take into account the connection between livability and density. In contrast to quality of life which usually puts an emphasis on individuals, livability tends to focus heavily on places. Except for Housing affordability, the authors found that livability and density are positively associated. At the Housing and neighborhood levels, Rinkinen et al. (2021) discuss the relationship between density and social practices. They demonstrate how, both at the individual and household levels, densification has a significant impact on social practices. They are reminded that household structures, habits of living and working, spending patterns, transport patterns, and attitudes toward other people's closeness are all closely correlated with density and densification. This is why when density increased in the inner-cities past two decades, social conflicts increased with it. Nowadays, globalization and integration policies in several countries make Urban Densification easier to apply on the social aspect in bigger cities (Rinkinen et al., 2021).

PRIVACY

Noise and overlooking issues are brought on by the close closeness of neighboring residential buildings (Teller, 2021). Smaller homes lack internal room and separation from neighboring homes, which makes them less private. People might be willing to sacrifice their privacy in favor of other factors (Dave, 2010), but not everyone has a say in the matter. The acceptance of communal living and bonding on a social and cultural level can aid in adjusting to the lack of privacy. This element has a connection to both perceived and actual densities (Teller, 2021).

Gated communities are connected to high density in China. Li and Sunikka-Blank (2021) talk about the connection between privacy and density. In this Jinan situation, privacy and compactness increased but locals' opportunities for social interaction decreased. Previous urban typologies offered more shared areas for cooking, using the restroom, and taking a shower, giving neighbors many opportunities to socialize. This is mainly seen in countries that historically always had larger lands. Their architecture shows more personal and public space. Densification lowers that capacity (Li and Sunikka-Blank, 2021).

ACCESS TO SERVICES AND FACILITES

An essential component of the human development index (HDI) is the accessibility to all facilities and services (Teller, 2021). Urban Densification improves access to the proximity of dwellings to a variety of facilities and services, including schools, healthcare, daily-needs stores, financial services, and postal and other delivery services. According to Dave (2011), cities in emerging nations have superior service accessibility because of their mixed land-use zoning, which places essential services within easy walking distance. Due to the overpopulation of urban facilities, high floor area ratios (FAR) in compact sites may produce unfavorable outcomes (Wang & Shaw, 2018). In high-density neighborhoods, there is unequal

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access to parks and urban services. Understanding them depends heavily on both the presence of green spaces and their distribution patterns (Teller, 2021).

In order to benefit inhabitants, crowded urban areas must have green infrastructure (Teller, 2021). To sustain the ecosystem services that green spaces (such as water features, parks, and open spaces) offer, such as biodiversity, wildlife, air quality, and water management. Additionally, green infrastructures offer a setting for social contact, physical activity, and leisure pursuits, all of which are crucial if dwelling sizes are small (Teller, 2021).

According to Schiller et al. (2021), the necessity to flourish green areas possibly of a lower scale within the urban fabric should be balanced with in-fill development and no-net land take regulations. Teller (2021) emphasizes that the need for green infrastructure is particularly acute in unusual urban situations, such as those that urban residents around the world experienced during the Covid-19 pandemic. This argues that cities ought to provide more green space in order to handle such extraordinary events, particularly in areas with a high density of people (Teller, 2021).

SOCIAL DIVERSITY AND CAPITAL

Densification is anticipated to encourage interpersonal relationships and cultural variety. It also corresponds to a lesser degree of urban fragmentation (Teller, 2021). According to several studies, larger densities are associated with greater social tolerance and safety. An example of mixed variety of people in a socially and economically developed city is Copenhagen, a fast change as it was once part of the mono-ethnic state of Denmark in the 1960s. People typically share responsibilities and live in vibrant communities. According to Todes et al. (2018), South Africa's dense cities have a wider variety of people and economies. According to several studies, a dense population has a negative impact on social contact, community spirit, and social equality (Wang & Shaw, 2018; Dave 2010; Zhu 2012; Romero-

Lankao 2012). Other research focused on how densities were perceived (Dave, 2010). Some residents can have a 'fear of the unknown'.

According to Martino et al. (2021), social diversity in metro Montreal is favorably connected with urban density. Giddings and Rogerson (2021) demonstrate, however, that homogeneity is a drawback of density, as a high percentage of students may congregate in one place as a result of the lower amount of dwelling units. Although a diverse population is expected, Livingstone et al. (2021) explain that London's densification efforts are mostly aimed at more affluent groups and could further have a negative impact on Housing affordability in surrounding places. Additionally, the way locals' social behaviors have changed in response to new urban patterns might be detrimental to social capital (Teller, 2021).

7- Urban Densification Methods Characteristics: Advantages and Disadvantages

a. Methods and Characteristics

As mentioned in the previous chapters, the fast increase in world population in general, and urban population especially caused the diffusion of Urban Sprawl around many European cities. The negative effects caused by Urban Sprawl should be stopped and reduced to the minimum possible. To implement Urban Densification with its positive effects is a direct way, as one of the most efficient sprawl reduction policy to start with. Urban Densification can be executed in several ways, based on the context in which lays this densification project.

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To mitigate the effects of urban population growth and Urban Sprawl, Pelczynski & Tomkowicz (2019) identify four methods of Urban Densification:

a. Increasing the efficiency of usage of the existing buildings by transforming their functions: changing functions or adapting unused spaces.
b. Building up on free spaces in the city: constructions, side extensions, and infill.
c. Transforming (or adding) space below and over existing buildings: downward and upward extensions.
d. Replacement of existing buildings: demolition of existing structures and construction of new ones.

On the other hand, regrouped and labeled differently from the afore-mentioned identification, Amer et al. (2017) pointed out five Urban Densifications strategies:

a. Filling backyards: extending the buildings horizontally to their own backyard.
b. Infill: building in the gaps between already existing constructions.
c. Demolish and rebuild: replacing buildings in low density areas by high-rise compact frames.
d. Roof transformation: transforming a sloped or saddle roof into a flat one while enlarging floor area.
e. Roof stacking: adding one or multiple stories above a building roof.

It is worth mentioning again that Urban Densification process, along with its advantages and effectiveness, can have some multi-front risks. The presence and probability of such risks depends on the densification method adapted for a specific scenario or context.

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COMPARISON BETWEEN AUTHORS METHODS IDENTIFICATION:

As indicated in the literature review section, Amer et al. (2017) identified an extra method because of the different labeling and regrouping. For Amer et al. (2017) the methodologies of roof stacking and roof transformation fall into two different types of interventions. The first is based on adding, while the other is based on changing and replacing. This is a distinct perception from the one of Pelczynski & Tomkowicz (2019), yet shares several similarities with the way the upward extension method is labeled. For Pelczynski & Tomkowicz (2019), the space transformation as upward or downward extensions does not split the factor adding or transforming. It is more the fact that the space above the building is used differently and designed in a new innovative way. It is worth mentioning that Amer et al. (2017) do not mention any characteristics or details about the downward extensions. Hence, these scholars can share the same ideas of methodological densification concepts, even if they are categorized differently. It is clear by the advantages and disadvantages identified by each. Nonetheless, they are perceived from two different point of views when it comes to the naming and general characterization. This eventually will not change the ending result of application in an Urban Densification project.

Pelczynski & Tomkowicz (2019) identified the main characteristics of Urban Densification methods in the Tables 01.a to 01.d below:

Method	Advantages	Disadvantages
Transforming functions of existing buildings (changing functions, adapting unused space)	▪ Maintenance of public and private open spaces ▪ Low costs of densification, usually lower than the construction of new buildings	▪ Limited space for new functionalities ▪ Limited possibility for creating functional solutions

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	▪ Improved technical status of buildings; possible advancements, including greater energy efficiency and environmental effectiveness ▪ Limited interference with the existing structure of buildings – minor burden to the natural environment ▪ Improved structure of urban functionalities – replacement of unattractive, ineffective functions, the rise of diversity ▪ Preservation of spatial potential for development ▪ Possibility to preserve the historical value of buildings	▪ Inconvenience of the construction for current co-users of the buildings ▪ Technical difficulties of performing construction works in exploit buildings ▪ With a larger scale of transformations risk of gentrification ▪ Significant formal restrictions with regard to historical buildings

Table 01.a: Urban Densification: Function transformation method advantages and disadvantages.

Source: Extracted from Table 1, page 3, Pelczynski & Tomkowicz (2019). Reproduced and edited by the thesis Author.

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One of the most sustainable methods for densification is transforming the function of an existing and unused space. This can give a better utility and a total refurbishing retrofits for the considered building or space. It is possible to preserve the identity of the building and its cultural heritage, but it is a challenge based on each local building and heritage policies. Environmentally and economically this methodology is a win-win investment. This methodology can also be mixed and used with another heavier intervention as an infill construction. It will be a hybrid methodology formed by two of them. An important example that dates back to 1975 where this intervention was renowned, is "The Factory" project by Ricardo Bofill. It transformed an industrial complex with underground galleries and heavy machines into the head of Taller de Arquitectura (Kolnaar, 2020).

Figure 11: The Factory project, by Ricardo Bofill, 1975.

Source: https://archello.com/news/11-transformation-projects-that-set-the-tone-for-decades-to-come

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Method	Advantages	Disadvantages
Transforming the spaces below and over the existing buildings: ▪ Upward extension:	▪ Preservation of free terrain ▪ Preservation of existing resources of the built environment/buildings, technical infrastructure ▪ Significant formal restrictions for valuable historic buildings ▪ High densification efficiency at a relatively low cost ▪ Good access to daylight and sun ▪ High flexibility in shaping functional and formal solutions ▪ Improving the technical condition of buildings, possible upgrades including improving the energy and environmental performance of buildings	▪ Inconvenience of the construction for current co-users of the buildings ▪ Reduced sunlight, increased shading for neighbouring areas and buildings ▪ Significant formal restrictions for valuable historic buildings ▪ Risk of loss of local identity, urban heritage ▪ The potential need for urban infrastructure expansion ▪ Transformation of cityscape
▪ Downward extension:	▪ Maintenance of public and private open spaces ▪ Preservation of local identity and urban heritage ▪ Maintenance of the existing assets of built environment/buildings, technical infrastructure ▪ Maintenance access to daylight and sunlight for adjacent buildings ▪ Preservation of green surfaces	▪ High investment costs ▪ Potentially complex geo-engineering issues

Table 01.b: Urban Densification: Space transformation method advantages and disadvantages.

Source: Extracted from Table 1, page 4, Pelczynski & Tomkowicz (2019). Reproduced and edited by the thesis Author.

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This methodology is no different from the one before it, but it shows more slight complexities. Upward and downward extensions are both sustainable strategies for a densification of a specific space. Building up on the building roofs, or replacing an old roof with new stories, is nowadays one of the most common inner city interventions. A recent example of an upward vertical extension is the 2022 famous rooftop MVRDV project "Didden village" in Rotterdam, the Netherlands.

Figure 12: The Didden village project, by MVRDV, 2022.

Source: https://arquitecturaviva.com/works/atico-didden-village-1

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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While for downward extensions, complications on the structural aspect of the building may arise. While it is one of the most sustainable and useful methodologies, it is majorly a context-dependent strategy. A recent example is the transformation of the underground level for the University of Aarhus, Emdrup Campus in Copenhagen, by Alex Poulsen Arkitekter A/S. It is an extension to link two different university buildings by an underground functional and recreational area.

Figure 13: University of Aarhus - Emdrup Campus underground extension, by APA, 2022-ongoing.

Source: Photo taken by the thesis Author on working site visit with APA (10/06/2022).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Method	Advantages	Disadvantages
Building up on free spaces in the city (construction, extension, infill)	▪ Use of neglected, poorly exploited areas ▪ Increase of usable area within the same property or in its immediate proximity ▪ Good effectiveness of densification ▪ Possibility of preserve or support for the urban landscape	▪ Reduction in public and private open spaces; reduction of green areas and available recreational areas at ground level ▪ Higher costs of engineering and construction of the facilities ▪ Necessity to ensure static safety of the adjacent buildings ▪ Reduced exposure to sunlight, increased shading of the adjacent areas and buildings ▪ Necessity to preserve functionalities of the adjacent buildings ▪ Inconvenience of the construction for current co-users of the buildings ▪ Decreased liberty in designing the functionalities, compared to suburban areas ▪ Potentially greater number of collisions with existing infrastructures and greater limitations related to its reconstruction, compared to projects carried out in suburban areas ▪ Potential reduction of water absorbing surface

Table 01.c: Urban Densification: Building on free spaces method advantages and disadvantages.

Source: Extracted from Table 1, pages 3-4, Pelczynski & Tomkowicz (2019). Reproduced and edited by the thesis Author.

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Building up on free spaces around an inner city is an efficient method for sustainability when it is a high rise building, or an infill in case of clustered Housing for instance. High rise buildings or towers can ensure higher density around or near a specific green belt, commercial areas, or educational zones, etc. This density goes without occupying new land as it is based on the concept of vertical living or vertical cities. Obviously having interventions with high-rise buildings will not change the character of a city to "vertical" but overdoing it, and replacing the existing cultural and architectural character will. This is why infill are better near the central areas with dense building grid and smaller empty parcels. The most recent example of an inner city tower as a densification project, as part of "the Green line of Copenhagen" project, is "Kaktustårnene" or the ongoing Cactus Towers project by BIG at Dybbølsbro, Copenhagen, Denmark.

Figure 14: Kaktustårnene project, by BIG, 2022-ongoing.

Source: http://danishdesignreview.com/kbhnotes/2022/5/19/the-green-line-will-continue-through-kaktustrnene-cactus-towers-by-bjarke-ingels

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Method	Advantages	Disadvantages
Replacement of existing buildings (demolition of existing and construction of new buildings)	▪ High effectiveness of densification ▪ Large flexibility in designing functional and formal solutions ▪ Possibility to introduce buildings of high quality and technical effectiveness ▪ Improved structure of urban functionalities – replacement of unattractive and ineffective functions ▪ Potential of the rise the urban diversity ▪ Possibility to revitalise and support the urban landscape	▪ Reduction of the existing assets of built environment/buildings, technical infrastructure ▪ Large investment costs ▪ Increased burden for the natural environment related to effects of demolition/energy, transport, waste management ▪ Risk of overburdening of the urban tissue ▪ Risk of loss of local identity and urban heritage ▪ Risk of gentrification ▪ Risk of loss the functional diversity

Table 01.d: Urban Densification: Replacement method advantages and disadvantages.

Source: Extracted from Table 1, pages 4-5, Pelczynski & Tomkowicz (2019). Reproduced and edited by the thesis Author.

Replacement an existing building, often an older building, is a solution seen until nowadays in the architectural design fields. It is the least economically and environmentally sustainable method listed. But, after extensive and detailed analysis of the specific case of a building, replacement could be the best choice. It gives higher opportunity to solve problems and have better functionality and esthetical aspect. A recent example of a building replacement was done in 2017 in Aarau, Switzerland. A 1900s commercial and apartment corner building was replaced by a modern one having Housing function, designed by Gautschi Lenzin Schenker Architekten (see Figure 15). During an extensive analysis of said building's structure,

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planners determined that the historical structure was in a poor state. The Federal Swiss Committee for Urban Design and the committee of preservation of historical buildings in the county confirmed that a new modern building is the only appropriate solution. “The design was based on the idea that the new building should continue to be part of the existing ensemble, which was a set of three attached houses” *(Archello - New Building Replacement, 2017).*

Figure 15: New Housing building replacement project, by Gautschi Lenzin Schenker Architekten, 2017.

Source: https://archello.com/project/new-building-replacement

Note: - Refer to the Glossary section at the beginning of this Master’s Thesis for acronyms and other definitions.
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Urban Densification methods identified by Amer et al. (2017) are shown in the following Tables 02.a to 02.e:

Method	Advantages	Disadvantages
Filling Backyards	▪ Provide additional space for the same property ▪ Opportunity to improve the density while preserving the urban landscape ▪ Retains the integrity of existing dwellings	▪ Seal more surface ▪ Increasing carbon footprint ▪ Retains the integrity of existing dwellings ▪ Increase heat island effects ▪ Needs to adapt transportation infrastructure and mobility strategies ▪ Needs to increase urban services

Table 02.a: Urban Densification: Characterization of Filling Backyards method advantages and disadvantages.

Source: Extracted from Table 2, page 681, Amer, et al. (2017). Reproduced and edited by the thesis Author.

Filling construction in backyards for Amer et al. (2017) is basically creating horizontal extension, increasing the surface area of existing buildings on their backyards (Attia, 2015; Marique & Reiter, 2014a). This can be done by a side extension, mainly to the backyard, to enlarge the indoor space used for a specific needed function. One of the examples of a backyard infill extension is done by Alex Poulsen Arkitekter A/S in Amager, Copenhagen, Denmark. The intervention adds extra space to a 1930s villa (*APA - Tilbygning Kbh*).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Figure 16: Backyard extension of a 1930s Copenhagen villa, by APA, 2021.

Source: https://www.alexpoulsen.dk/projekter/tilbygning_kbh

Method	Advantages	Disadvantages
Infill	▪ Usage of abandoned areas and opportunity of revitalizing these spaces ▪ Usage of existing infrastructure	▪ Occupy spaces with a vegetation or recreational function potential ▪ Occupy spaces with parking or collective service potential ▪ Needs to adapt mobility strategies ▪ Needs to increase urban services

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	▪ Opportunity to improve the density while preserving the urban landscape and urban morphology ▪ Retains the integrity of existing dwellings	▪ Potential damage to the nearby buildings during construction process

Table 02.b: Urban Densification: Characterization of Infill method advantages and disadvantages.

Source: Extracted from Table 2, page 681, Amer, et al. (2017). Reproduced and edited by the thesis Author.

Infill constructions in this case are the act of establishing new buildings on vacant lots and gaps between buildings, or areas not built-up previously, or built-up areas with other purposes (Brunner & Cozens, 2013; Marique & Reiter, 2014). Infill is a methodology seen more inside the city, in a dense context. There is a modern architectural trend to fill in the gaps between existing buildings with new narrow ones. Normally, it takes place between an ensemble or series of buildings, and basically integrates to be part of it. In some cases an infill can be a high-rise construction, but it is less common in an already compact or dense block. An example is a narrow modern building infill in a tight gap between two residential buildings (see Figure 17). It is in the city of Nada, in Japan, designed by FujiwaraMuro Architects, the main idea of this project is to save open public spaces in the county and counteract Urban Sprawl (Cutieru, 2020).

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Figure 17: Modern house infill, by FujiwaraMuro Architects, 2020.

Source: https://www.archdaily.com/946858/fill-in-the-gaps-infill-architecture-in-urban-residual-spaces#:~:text=Infill%20architecture%20usually%20refers%20to,of%20scales%2C%20approaches%20and%20typologies.

Method	Advantages	Disadvantages
Roof transformation	▪ Does not occupy additional urban spaces and does not increase soil waterproofing ▪ Requires a minimal cost compared to other methods ▪ Easy and quick solution for already urbanized districts	▪ Limited opportunity to increase density ▪ Transformation of the city skyline ▪ Limitation for heritage buildings

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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	▪ Usage of existing infrastructure ▪ Opportunity to reduce energy consumption of existing	▪ Needs to adapt mobility strategies ▪ Needs to increase urban services

Table 02.c: Urban Densification: Characterization of Roof transformation method advantages and disadvantages.

Source: Extracted from Table 2, page 681, Amer, et al. (2017). Reproduced and edited by the thesis Author.

Roof transformation is a change of saddle roofs into a complete storey with flat roof and larger floor area. It is like an upper extension replacing an existing saddle roof with a new one for a new built storey (Tichelmann & Groß, 2016). A flamboyant and special modern application of this methodology is seen in the project by Holodeck Architects, in Vienna, Austria. The roof of a historical corner building was transformed into new modern spaces used as private apartments. The attic extension (o roof transformation) in Vienna is becoming a frequent intervention since the past decade. Having a sustainable and environmental design concept, the new roof gives better lighting, shading, and ventilation to the apartments (see Figures 18 and 19). Green terraces are added as an offset above the existing building with a panoramic view of the streets (*Archello – Roof transformations).*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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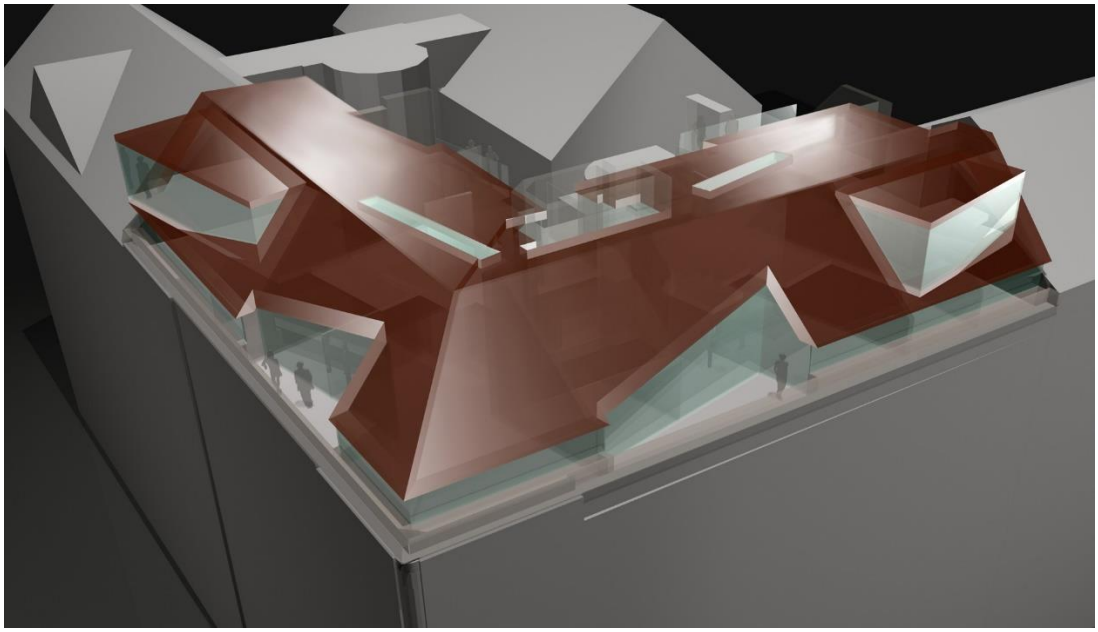

Figure 18: Render of modern roof transformation, by Holodeck Architects, 2012.

Source: https://archello.com/project/roof-transformations

Figure 19: Modern roof transformation, by Holodeck Architects, 2012.

Source: https://archello.com/project/roof-transformations

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Method	Advantages	Disadvantages
Roof stacking	▪ Does not occupy additional urban spaces and does not increase soil waterproofing ▪ Keep the actual potential for green spaces, recreational function or urban services ▪ Easily applicable in already urbanized districts ▪ Usage of existing infrastructure ▪ Opportunity to reduce costefficiently energy consumption of existing buildings (Attia, 2017; Attia, 2016) ▪ Increases the value of the existing property and creates a financial revenue (Amer & Attia 2017)	▪ Increases services loads on existing buildings and requires verification with actual strength of the building and foundation ▪ Transformation of the city skyline and urban morphology, with potential negative impact on the urban microclimate (e.g. wind tunnels & overshadowing) ▪ Risk of daylighting and solar access reductions for the neighbours ▪ Limitation for heritage buildings ▪ Needs to adapt mobility strategies ▪ Needs to increase urban services ▪ Potential of creating noise and dust during the construction process

Table 02.d: Urban Densification: Characterization of Roof stacking method advantages and disadvantages.

Source: Extracted from Table 2, page 681, Amer, et al. (2017). (Reproduced and edited by the thesis Author)

The roof stacking is basically perceived the same as an upper extension (upper space transformation) for Pelczynski & Tomkowicz (2019). On the other hand, Amer et al. (2017) separate roof stacking methodology from the roof transformation methodology, and characterize them differently. Roof stacking is an addition of a structure of one or many levels directly above the existing roof (often flat) of a building to create additional living spaces, while roof transformation is replacing a roof with a new one to create a new function. (Amer & Attia, 2017; Floerke et al., 2014; Nilsson, Blomsterberg, & Landin, 2016; Peronato, 2014).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Method	Advantages	Disadvantages
Demolish & Rebuild	▪ Higher flexibility to increasing density on any certain plot ▪ Opportunity to apply designs with higher efficiency	▪ Critical in already high dense neighbourhood ▪ Increases the use of materials and construction waste ▪ High cost is accompanied by demolition and new construction ▪ Loss of resources (existing infrastructure, etc.) ▪ Risk for the urban heritage ▪ Transformation of the city skyline and urban morphology ▪ Needs to adapt mobility strategies ▪ Needs to increase urban services

Table 02.e: Urban Densification: Characterization of Demolish and Rebuild method advantages and disadvantages.

Source: Extracted from Table 2, page 681, Amer, et al. (2017). Reproduced and edited by the thesis Author.

This is the exact same methodology mentioned before by Pelczynski & Tomkowicz (2019). It is worthy to mention that it is often applied in areas with lower density where houses are demolished and replaced with high-rise buildings or compact frame (Burton et al., 2013; Marique & Reiter, 2014a).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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b. Comments and Conclusions

To conclude an overview evaluation of the previously cited methods by means of sustainability:

The most effective and sustainable one is the transformation of function that allows taking advantage of already existing spaces in buildings underlining the principles of recycling (3R principle: reduce, reuse, and recycle). This method is the most sustainable economically and environmentally. Transformation of a place can be a light or a heavy intervention. Light interventions can be done by pure interior re-design of the space with less modification of the solids in the space. Heavy transformation of function often keeps only the interior skeleton structures of the space and re-designs the whole divisions and solids/spaces of the considered flat or building. Many fitness halls (gyms) in the historical European city centers are designed by using this densification method.

Next comes the vertical or upward extensions method creating an over layer on the existing city or area leaving the infrastructure intact. The most common form is wooden timber extensions, sustainable in material and have lighter dead load. The new upper and former lower layers will benefit simultaneously from natural light without blocking it from the near environment. Vertical extensions can also save energy waste/inhabitant, as it uses the existing infrastructure of the building (Pelczynski & Tomkowicz, 2019).

Downward extensions method offers many advantages for retrofitting, as well as opportunities for future densifications. Nevertheless, economic challenges and structural complications may arise while executing such type of extensions. In low lands like the ones in northern Belgium and the Netherlands it may be nearly impossible to perform an adequate downward extension. (Kościńska-Grabowska & Michalak 2015).

The method of building on free spaces in the city will come next. This technique exploits limited resources as unoccupied or natural land, and has a big social cost. Hence, it is not a

sustainable approach based on the necessity of human contact with green areas and nature (Mierzejewska, 2015). In addition, Gill & Handlet, et al. (2007) mentioned that this method may emphasize the effects of urban heat island. High rise buildings are often executed by this method on an empty spot in the city. In that case, several services for the new high density should be ensured in area, which can accelerate the economy around. Some overuse can be a problem, especially for the green spaces.

The in-fills addition to rows of buildings may be a less problematic way for executing this densification method. Yet, it can cause spatial insufficiency in the courtyards in some already dense scenarios, even if it is a less common effect in the suburbs. Infill policies are now considered as the norm for densification in many Western and Northern European countries.

The last method is the replacement of buildings. It is one of the least environmentally sustainable solutions, together with having the highest economic cost. However, it has the most it offers the most effective result based on the flexibility and functionality of the spaces created. Building on a spot empty parcel, a method mentioned before, can have also high flexibility depending on the building policies, which makes it a more restricted design environment (Pelczynski & Tomkowicz, 2019). Yet, it is important to mention that replacing a building is more of a governmental political position and decision (i.e. Political decision by the far right party: replacing old buildings with modern residential ones with higher costs and better developed services, in northern part of Nørrebro, Copenhagen, Denmark). It is often far above the decision of policy makers and urban planners (Pelczynski & Tomkowicz, 2019).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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8- Concluding: Simple Visualization of Urban Sprawl and Urban Densification Comparison

a. Overview

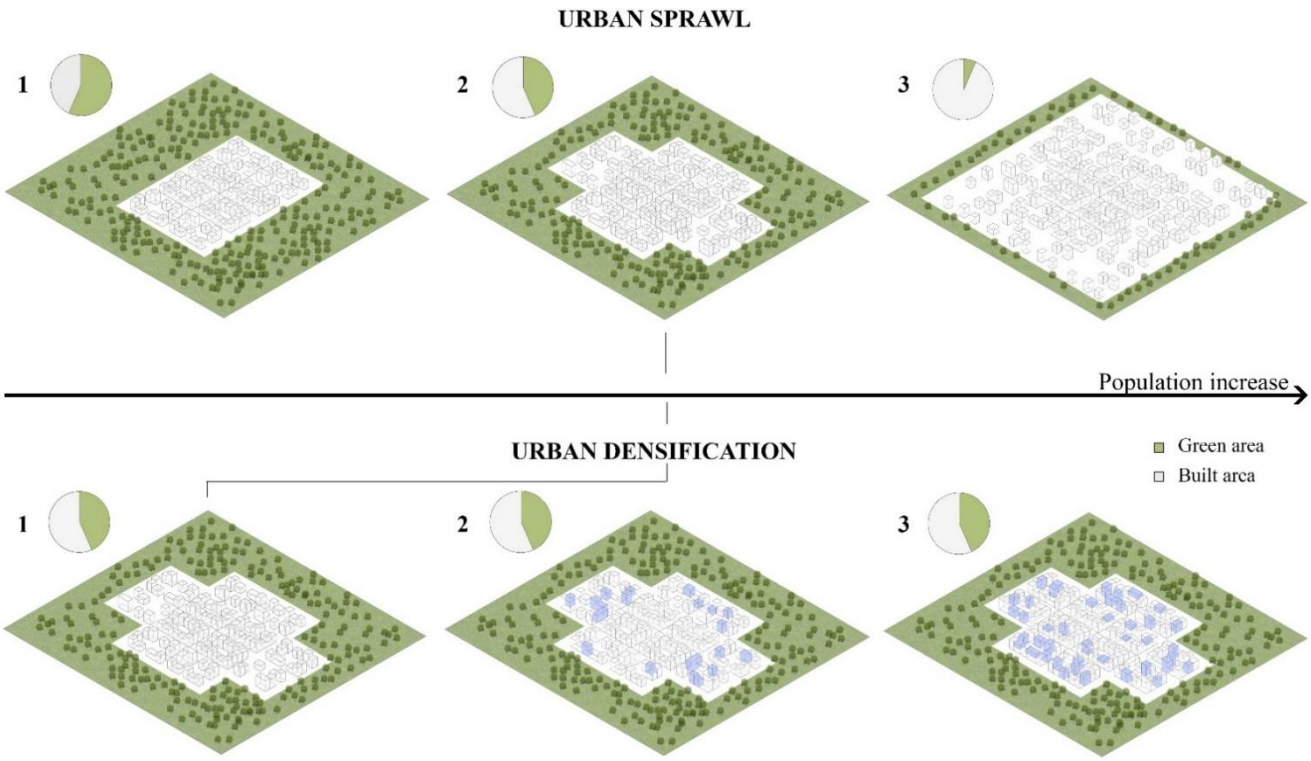

Figure 20: Simplified Diagram comparing the impact of Urban Sprawl and the effects of Urban Densification intervention.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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This section is developed fully and exclusively by the thesis Author. It develops and fortifies the theories formed about the positive effects of Urban Densification on both the green urbanism and sustainability levels (see Figure 20). As the previous sections explained the importance and positive effects of Urban Densification and highlighted the negative consequences of Urban Sprawl, this section comes as a hypothetical schematic conclusion to communicate the results visually. In addition to the data and information mentioned in the preceding sections, this part shows a part from the conclusions of the work by Arnberger (2012) on the relation between Urban Densification and public urban green spaces. Also, it is inspired by the VerGe project for a smart green city in Switzerland, and by the work of Barresi (2018) on that matter.

"The concept of Urban Densification has assumed the meaning of building volumes that are more compact and closer together, developing a sustainable urban planning model and preserving public spaces" (Barresi, 2018, p. 1)

This is to hypothetically enforce the green sustainability of Urban Densification by showing in a schematic way how densification can stop Urban Sprawl and lead to zero (net) new empty or green land consumption. As well, this part can also be relating and interpreted as a schematic form of the smart city and the city of proximity.

In this section, it is hypothetically assumed to have the shown terrain below (see Figure 21). The terrain is abstract and created to be used just for this simplified visualization and interpreting a comparison between the effects of a continuing Urban Sprawl and the impact of intervening by Urban Densification. There will be different scenarios showing what could happen in case of a continuing Urban Sprawl, and what could happen in case of an Urban Densification intervention.

This supposedly city has a starting population of two hundred inhabitants. Initially, the total covered area by buildings is somewhere around 45% while the one covered by green areas is around 55% (see Figure 21).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

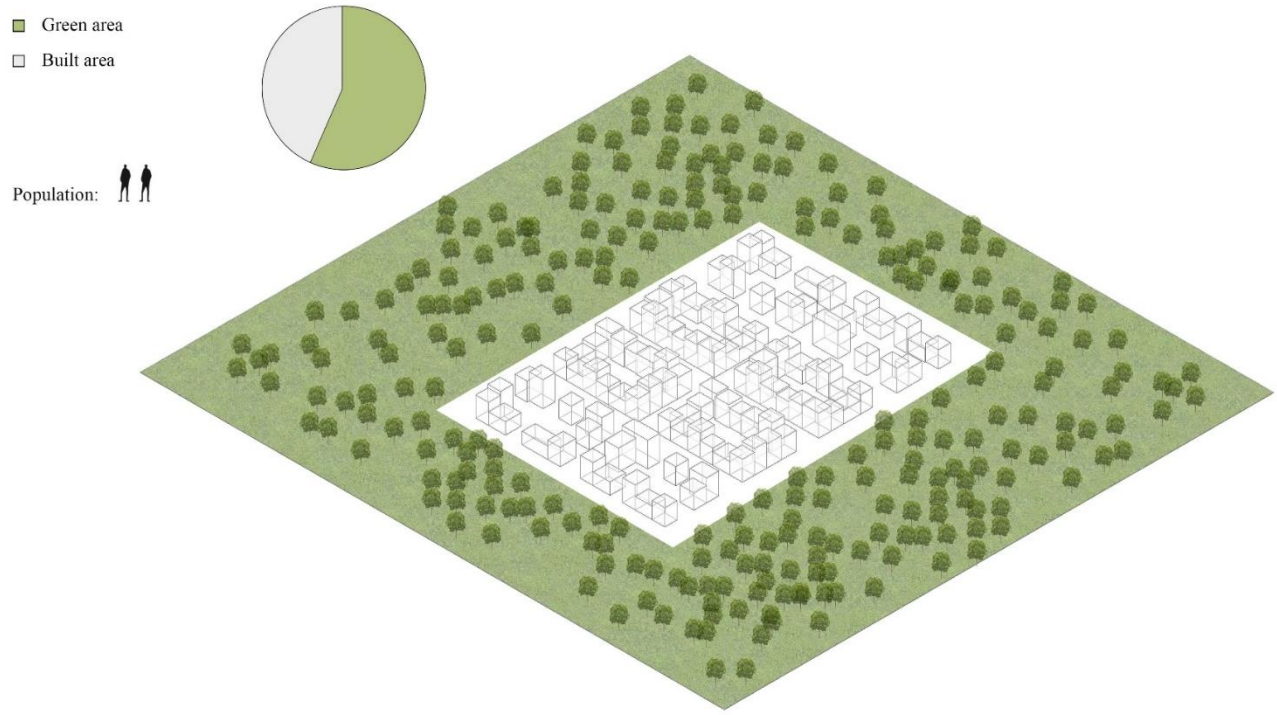

Figure 21: Simplified Diagram showing Phase 1 of population and city growth.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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In phase 2 of population growth (see Figure 22), the population is assumed to increase and double, hence reach four hundred inhabitants. New buildings are seen to accommodate the increase in population. The built area covering the terrain increases to 55%, leaving 45% for green areas. This is a normal phenomenon seen in all cities that expanded outwardly (starting point of Urban Sprawl) due to the increase of urban population and the need for new Housing, economic and service centers, etc.

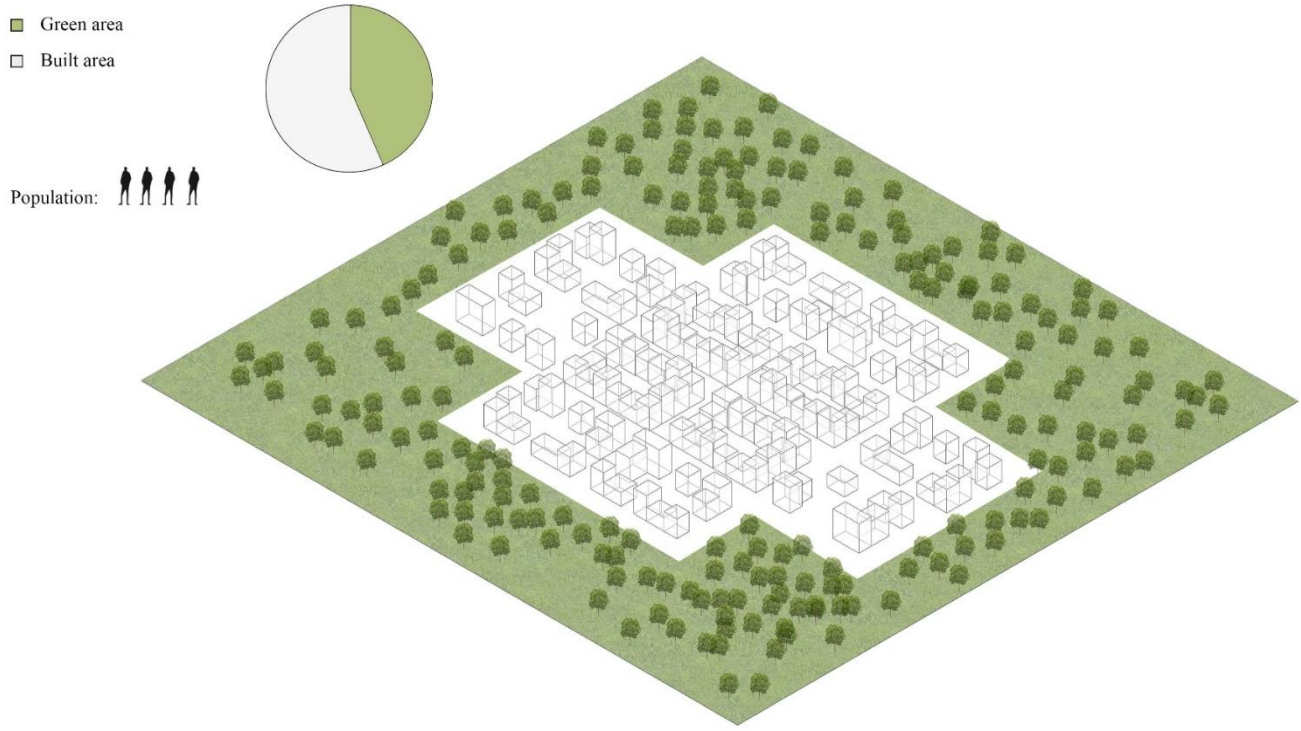

Figure 22: Simplified Diagram showing Phase 2 of population and city growth.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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b. Scenario 1: The Continuance of Urban Sprawl

In this first scenario (see Figure 23) the city outward expansion continues with the increase of population to six hundred inhabitants (Phase 3 of population increase). The total surface covered by buildings increases to 90%, leaving only 10% for green areas. This ratio is used to underline in an abstract way the non-sustainable approach of Urban Sprawl on the long term.

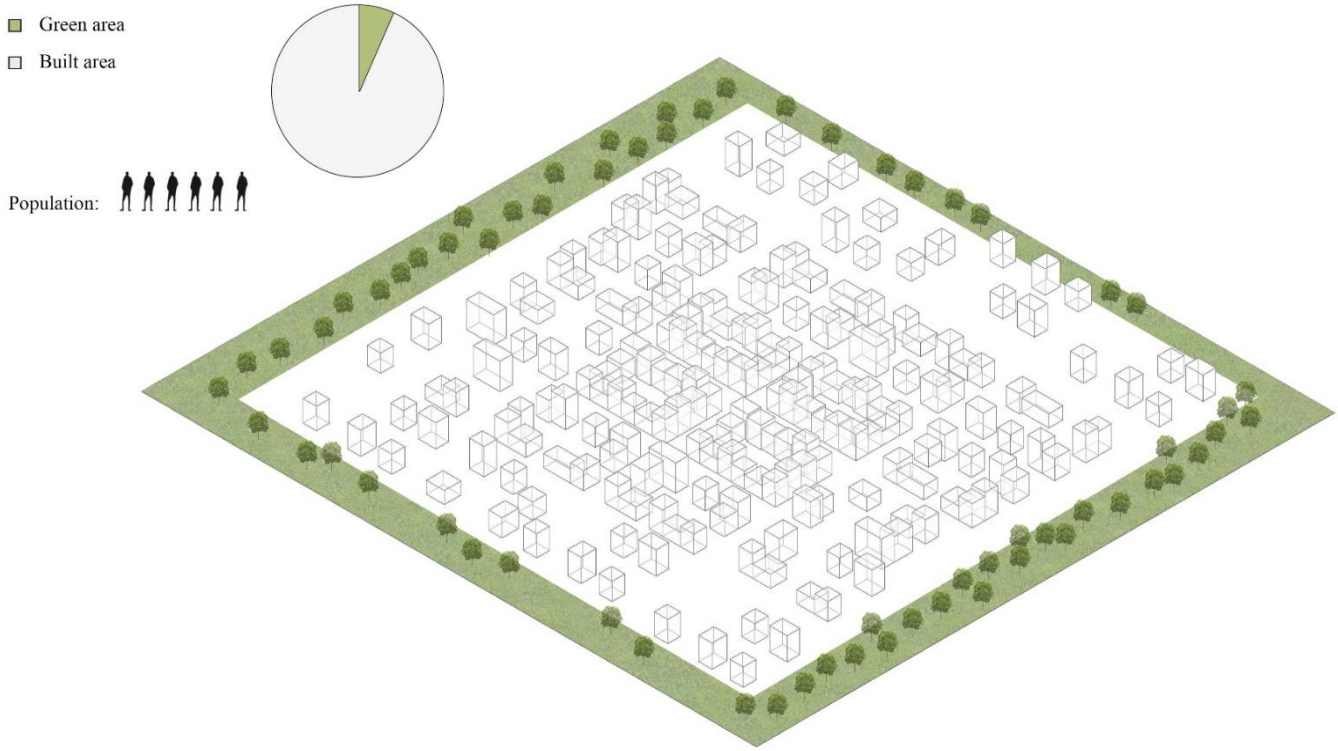

Figure 23: Simplified Diagram showing Urban Sprawl continuance in Phase 3 of population and city growth.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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c. Scenario 2: The Intervention of Urban Densification

Another scenario (Figure 24) is inner Urban Densification (in blue) using different methods instead of an outward extension. In this case, with an increase of population to five hundred inhabitants (before reaching Phase 3), the total surface covered by buildings will stay constant at around 55% and the one for green areas of 45%.

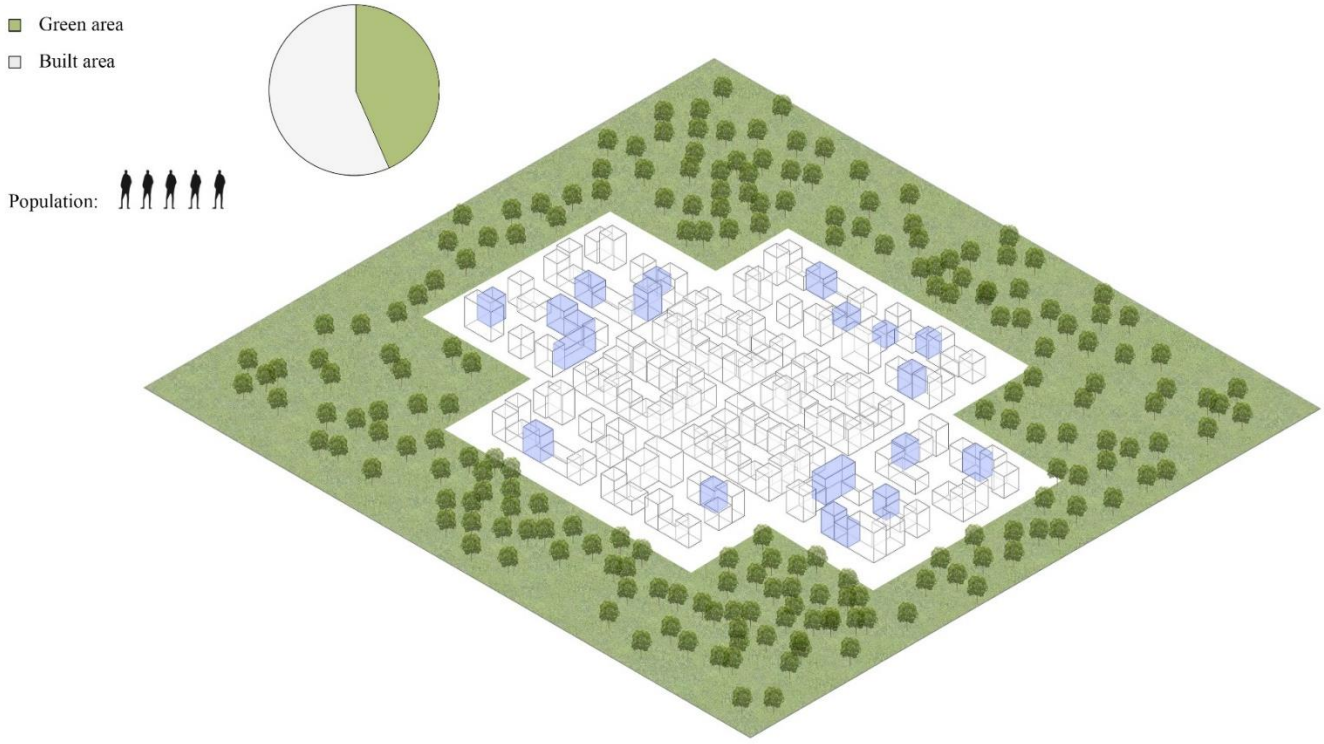

Figure 24: Simplified Diagram showing Urban Densification intervention before attaining Phase 3 of population growth.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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In Figure 25, population is reaching six hundred inhabitants (Phase 3 of population growth). Further densification (in blue) is executed in a sustainable way, proportional with the population increase. In this case as well, the surface covered by green areas stays constant at 45%. This is thanks to the Urban Densification strategy to exploit the existing built infrastructure without consuming green land and expanding (no net-land take).

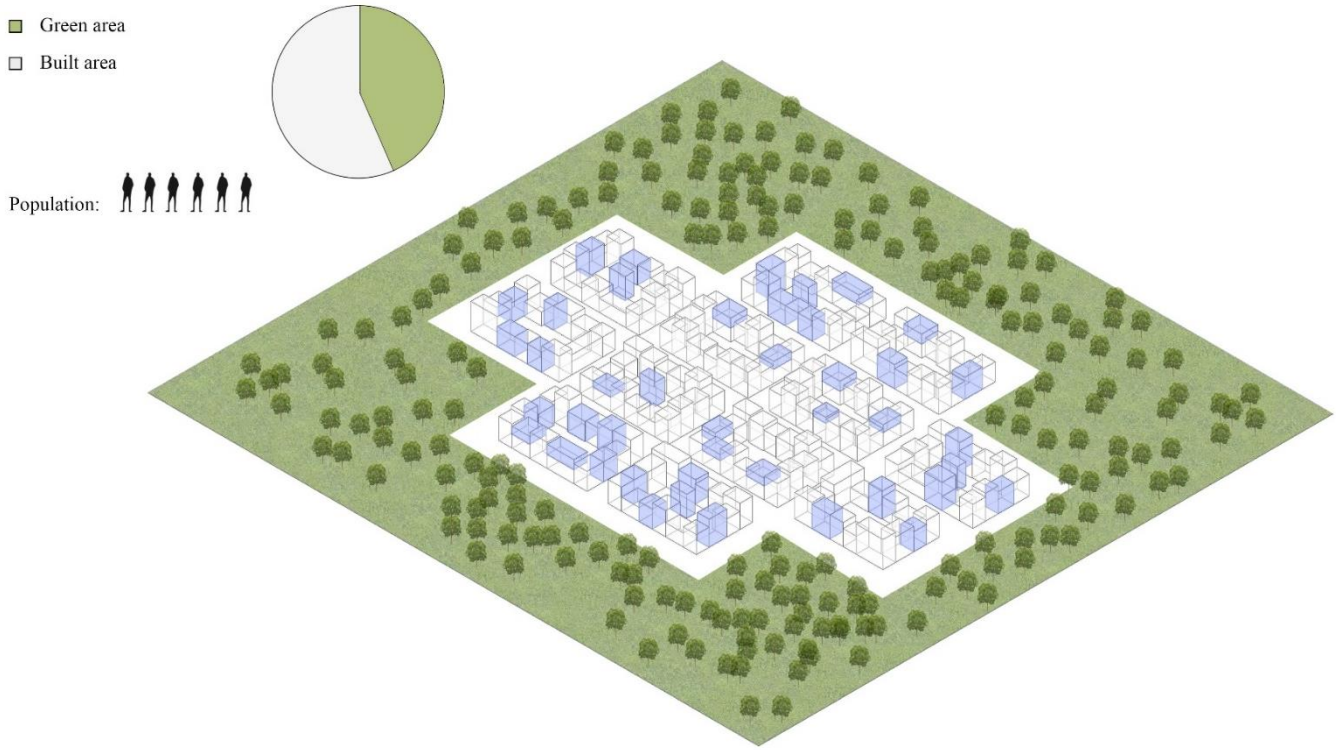

Figure 25: Simplified Diagram showing Urban Densification intervention in Phase 3 of population growth.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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d. Conclusion

Several points can be concluded from this specific section of the thesis. Mainly, it is concluded that Urban Densification is the right way to limit Urban Sprawl (Pelczynski & Tomkowicz, 2019). It is clear that Urban Densification provides environmental, economic, and social sustainability development when compared to Urban Sprawl. Further, the densification effects by Teller (2021) on the green areas, energy consumption, public spaces, and preservation of built heritage can be all confirmed.

If Urban Sprawl diffusion continues, cities will be vast, spread outwardly, and left without any green filters or large green parks. This confirms the studies and conclusions of Lanzani (2012). The air quality will get worse with time. The life quality will get lower based on the fact of lowering the green m^2/inhabitant (Brody, 2013). In this case, all the characteristics and consequences discussed by Brody (2013) can be expressed and stressed upon to make a point. Higher commuting costs will be paid and more carbon exhaust will dominate the city. Housing prices, due to the whole newly built infrastructure, can get reasonably high and unaffordable in some cases. This is already seen in real life cases for instance the rich neighborhoods of the outward city in Stockholm, the new neighborhoods and modern buildings by the former far-right Danish government in Copenhagen (especially in Nørrebro to limit the immigrants from renting cheap apartments in the area). As well, this is especially seen through the Housing crisis that Brussels lived for the past two decades (Ananian, 2016).

On the other hand, when suitable Urban Densification is executed, a higher number of inhabitants can be contained without exploiting extra green land. In this way, green areas are untouched and conserved. They are often used as to purify air, and as green filters, parks, and public spaces. The affordability factor is crucial, and Urban Densification can ensure affordable Housing, for instance the case of London city in Canada, discussed and analyzed in details in the works by Martino et al. (2021) and Livingstone et al. (2021). As well, this can

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ensure less commuting time to reach main points around the city, hence less wasted time, less traffic, and less diffused carbon from vehicles. A critical point may be that in this case scenario, a more enhanced planning for city center mobility is crucial, as it will be busier than usual. Urban Densification with its varied methods (mentioned previously in this thesis) can always sustainably contain a potentially increasing number of inhabitants (Pelczynski & Tomkowicz, 2019).

9- Brussels-Capital Region: History and Current Challenges

a. Historical Urban Development Timeline of the BCR

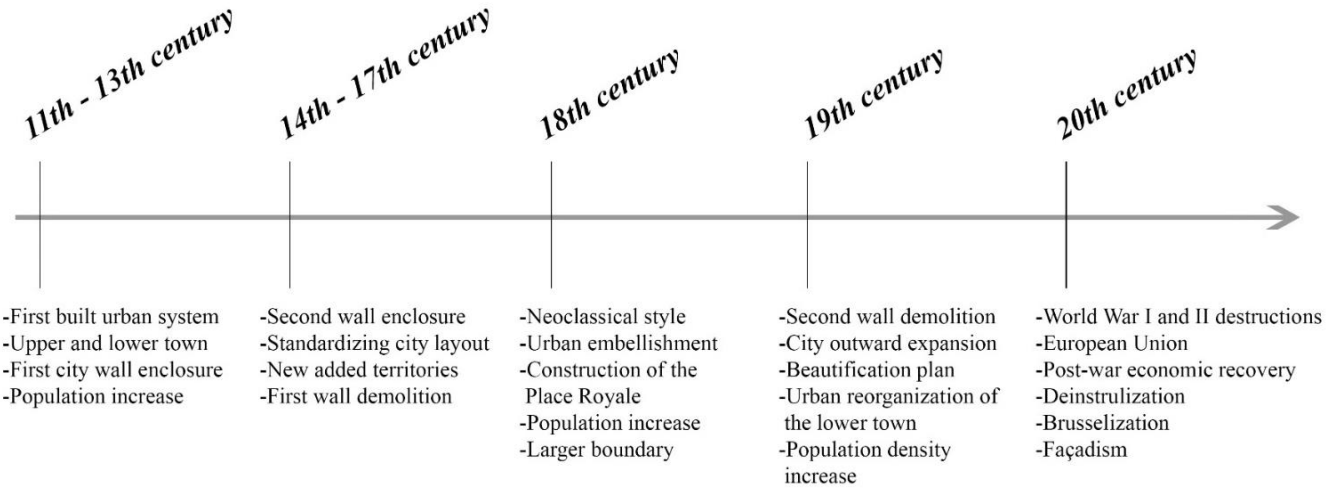

Figure 26: Scheme showing a general urban timeline of Brussels.

Source: Produced by the Thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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i. 11th – 13th century

The testimonies on the origins of Brussels indicate the first appearance of buildings at the beginning of the 11th century thanks to the economic port activities and commercial events that took place around the Senne river. This ancient zone had two main interesting centers: Saint-Géry Island and Overmolen Island, around which a primary urban system has been developed.

During this period, other important characteristics that define the city also appeared. A main one is the fast increase of the inner population and migration towards the city. The second main characteristic is the emergence of an urban development in the upper or northern part of the city, mainly occupied by the noble class and the economically dominant citizens. This is how the scheme of the lower town and higher town was presented for the first time. The lower or southern town was perceived as commercial and productive with poor and middle class citizens, and the upper town as institutional, administrative, and financial, with rich and noble citizens.

Due to the need to unite the two parts, series of roads were created. The most important was the so-called "Steenweg" in Flemish Dutch meaning Main Street, the only paved one at the time. Its importance lays not only in the unification of the upper and lower city, but it was also a part of a larger system of outward main roads towards Bruges and Cologne.

In the 13th century, Brussels area was again far more populated and constituted city, growing in its urban composition with sinuous lines on the medieval way. During this century the construction of, what was, the first enclosure wall surrounding the city was completed. It had a length of four kilometers, with a total of more than fifty towers of vigilance. This first enclosure had seven access gates that were connected to the external road network. This led to the creation of new and various surrounding population centers which are neighborhoods that make part of the Brussels-Capital Region nowadays (Charrudas, 2011).

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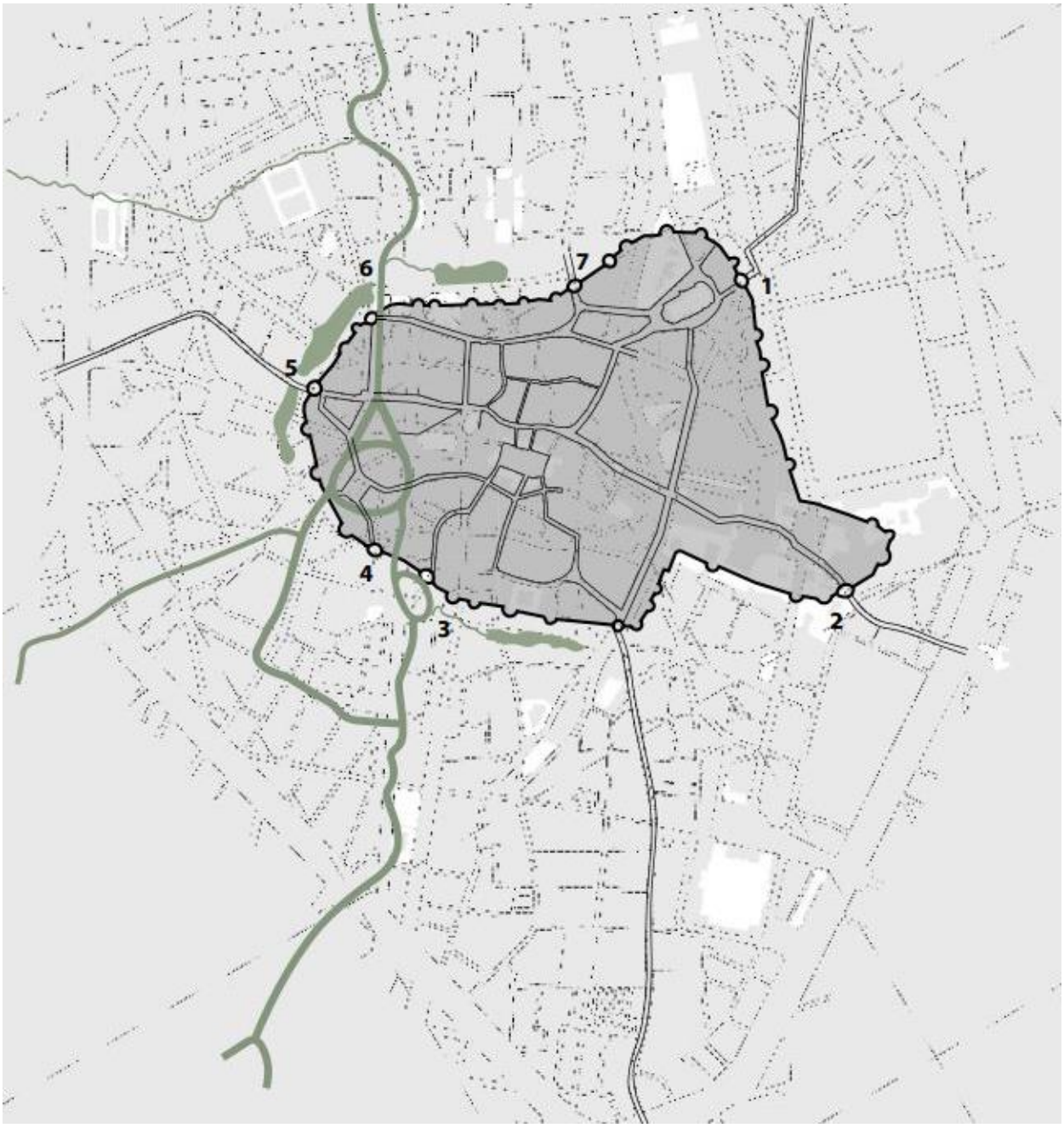

Legend: 1. Treurenberg Gate 2. Coudenberg 3. Gate Overmolen Gate.

4. The Lion Gate 5. Sainte-Catherine Gate 6. The Laeken Gate 7. The Warmoesbroeck Gate.

Map 02: Gates positioning of the first wall during the 13th century in Brussels.

Source: Extracted from page 20, Campos Laredo (2020). Edited by the Thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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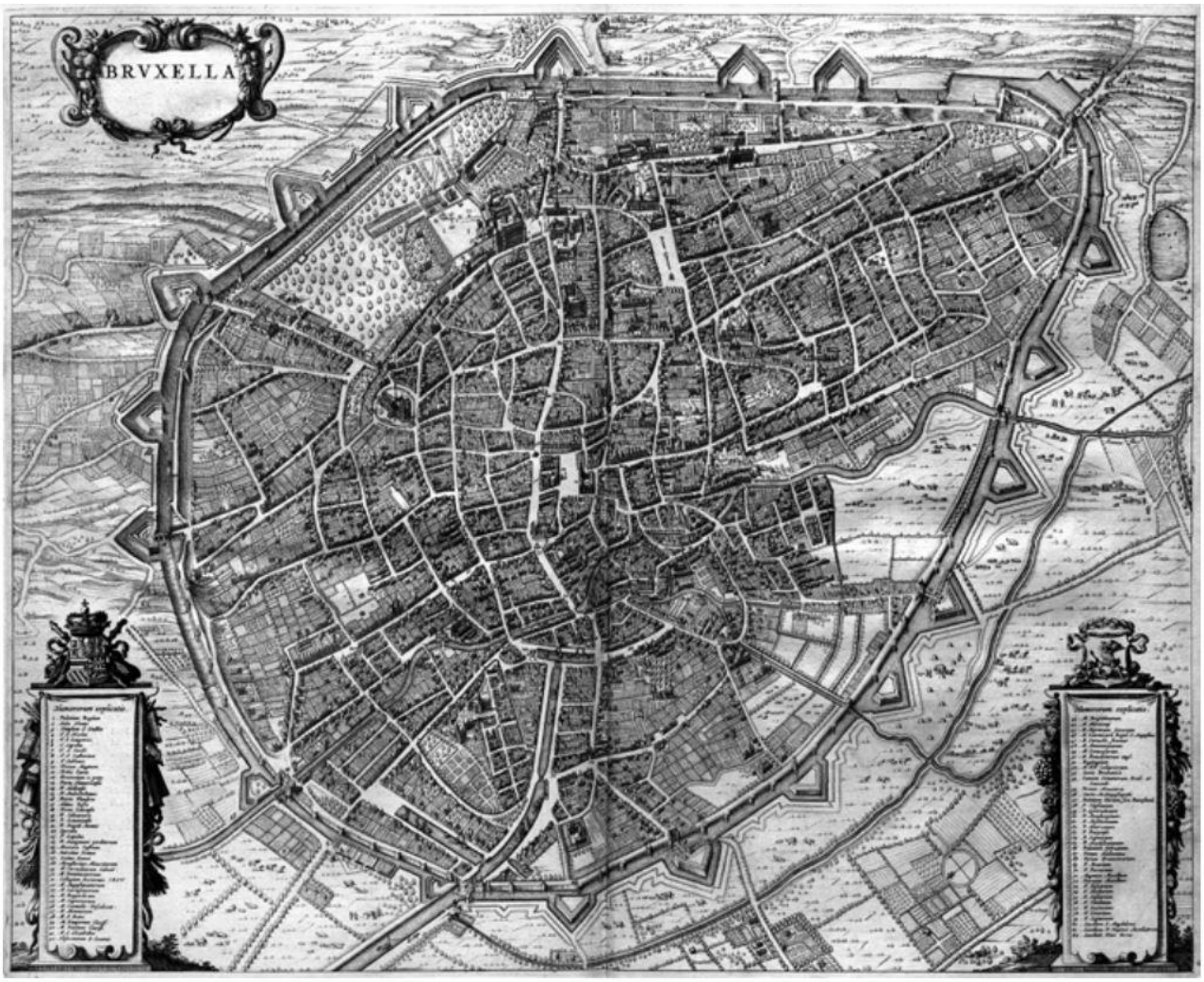
ii. 14th – 17th century

During the fourteenth century, that the second city wall was built. It was much larger and stronger (eight kilometers long) and with the characteristic to have the shape of a pentagon. This second enclosure would contain a territory three times larger than the former one and would be equipped with seventy-four towers of vigilance. The new wall would also have 7 gates:

1. Laeken Gate.
2. Flanders Gate.
3. Anderlecht Gate.
4. Halle Gate.
5. Namur Gate.
6. Leuven and Schaerbeek Gate.
7. Shore Gate.

Following its construction, new territories and neighborhoods have been integrated within the city, such as the district of the Chapelle churchnand and the Béguinage district. The first and oldest wall will not be demolished until the 16th century, which means that the city has long lived with the two enclosures.

Other transformations took place in the city during this period, mainly the reconstruction works after the devastating bombardment by the troops of King Louis XIV in 1695. This was taken as an opportunity to renew the city and standardize its irregular layout inherited from the Middle Ages (see Map 03). It should also be noted that significant works has been done in the palace on the Coudenberg hill and in the public spaces surrounding it like the park that would later become the Royal Park (Charrudas, 2011).



Map 03: Brussels Map 1649 by Joan Blaeu.

Source: Extracted from page 24, Campos Laredo (2020).

iii. 18th century

At the beginning of the 18th century, major paving works were carried out on the roads that linked Brussels to the most important towns in the surrounding area, such as Ghent, Mons, Leuven and Luxembourg. This work improved the land transport conditions and optimize the

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travel time. Inside the Pentagon, the construction of the Royal Quarter has begun, as well as the construction of the Place Saint Michel (currently Place des Martyrs).

These major urban planning and embellishment works mark the beginning of the neoclassical style presence in the city. It is within the framework of this management that the design and construction of the Place Royale took place with a marked influence of the French royal squares. This is how the Coudenberg, located in the upper part of the city, acquires a new neoclassical identity largely preserved to this day (Smolar-Meynart, et.al 1994).

Before the existence of the Place Saint-Michel, the area had a certain commercial importance in the past. It is in this context that the city decided to build the neoclassical square and the surrounding buildings entrusting the project to the architect-engineer Claude Fisco (Charrudas, 2011).

iv. 19th century

In the first half of the 19th century the demolition of the second pentagon wall was started as it was no longer necessary for the defense. As well, it limited the city growth, expansion and integration in a broader and more contemporary vision influenced by the industrial revolution.

The progressive demolition of the wall was carried out with a beautification plan of the city created by the architect-engineer Jean-Baptiste Vifquain. Thanks to his project, the old wall became a boulevard surrounding the city endowed with public spaces, rest areas, and small squares which would receive the main avenues converging on the Pentagon. This would generate differentiated perspectives characterizing each place (see Figure 27). The removal of the wall made it possible to organize an urban planning linking the urban fabric of the inside with the outside. It also allowed the creation of new related neighborhoods, one of the first and most important being the Leopold district. New population arrived to the city and neighborly districts which increased the overall population density at the time (Charrudas, 2011).

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The vaulting works of the Senne were done during this century. The river was no more used for transportation and presented serious sanitation and contamination problems with increased flooding (see Figure 28). For this reason it was covered with vaults in order to generate new embellishment activities and urban reorganization of the lower town. These activities consisted mainly of demolishing the old buildings that lined the streets and building the glamorous Boulevard Anspach, along with residential and commercial new buildings (*Regards sur le Développement Urbain de Bruxelles*, 2009).

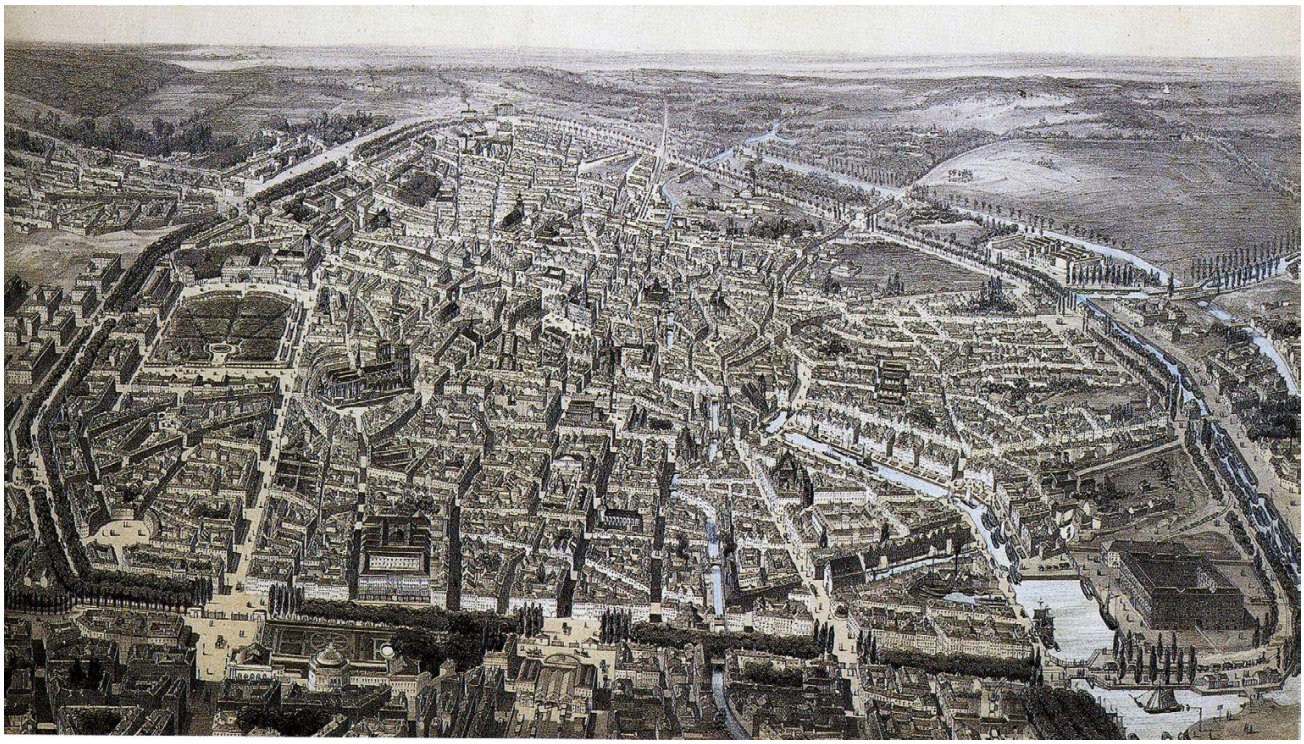

Figure 27: Panorama view of the "Boulevard pentagonal", Brussels 1850.

Source: Urba (2022).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Figure 28: The Senne River vault covering works.

Source: Histoire de l'urbanisme à Bruxelles: comprendre son urbanisation. From: https://jeretiens.net/histoire-urbanisme-bruxelles-evolution-ville/

v. 20th century

In the 20th century, the magnificent tree-lined pentagonal boulevard became a high-traffic highway called "the Little Belt" with a contemporary view of the surrounding context (Charrudas, 2011).

During World War I and II, several residential and public buildings were destroyed all around the city. After World War II, Brussels became more international with the establishment of the headquarters of the European Communities which helped to rejuvenate the weakened postwar economy.

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- Zoom in while using the thesis digital version to see more details in the drawings.

After the constitutional and administrative reforms done, Belgium became a federal state. The Brussels-Capital Region (BCR) was established in 1989 (*Brittanica*, updated 2022).

As the second half of the 20th century progressed, the Brussels region experienced a "Modernization" by suburbanization and deindustrialization, accompanied by the physical decline of the historic city center. The notion of "Brusselization" indicates the uncontrolled and non-standardized urban development of the city during the 1960s and 1970s. "Buildings were torn down without regard either to their architectural or historical importance" (page 64, Elliott & Cole, 2010). During this period there was a lack of zoning regulations and several historical buildings and monuments were demolished which caused architects, preservationists, and environmentalists to protest. Reforms in policies took place in the 1990s and the notion of "Façadism" was presented for the first time. Since 1991, all facades with historical, aesthetic, or cultural significance should be preserved and any change in function or demolition would take place exclusively in the interiors (Stubbs and Makaš, 2011).

b. Demographic Growth and Density in Brussels-Capital Region (BCR)

Year	BCR population (inhabitants)	Increase rate from 2015 (%)
2015	1,175,000	–
2022	1,218,000 *(current)*	+ 3.65%
2040	1,365,000	+ 16.17%
2060	1,551,000	+ 32.00%

Table 03: Population increase in the Brussels-Capital Region since 2015.

Source: Produced by the Thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

The Brussels-Capital Region finds itself at a turning point in its development. It faces various challenges established in particular in the Regional Plan for Sustainable Development project (PRDD, 2015) where population growth and the fight against poverty are included. There are already more than 1,175,000 inhabitants in the Brussels-Capital Region (IBSA; Direction Générale Statistique, January 1st 2015). Furthermore, according to the projections done by the Brussels Institute for Statistics and Analysis (IBSA), since 1996 the demographic growth is continuing to expand. This growth in BCR population by the year 2040 is anticipated to attain at least 190,000 inhabitants (Deboosere, 2010; Paryski & Pankratieva, 2012). The Bureau fédéral du Plan (BFP, 2016) and the General Statistic Direction (DGS, 2016) announced a population growth of about 32% equal to 376,000 inhabitants in 2060 compared to 2015 for the Brussels-Capital Region. This is a problematic growth rate compared with respectively 14% and 16% in the two other regions of Flanders and Wallonia (DGS, 2016).

To elaborate on this population increase, Brussels has been the quickest developing metropolis by means of demographic growth compared to other cities. There are some predominant facts causing this phenomenon that dates back to the beginning of the 1990s. One of the main reasons is because of the primary wave of worldwide migration mostly represented by work and economic migrants. Despite the importance of migrations, the demographic growth of Brussels is largely domestic. This is due to a high birth rate and mostly concerns populations weakened by their socio-economic conditions and their difficulties in accessing Housing (ADT États des lieux de la Région de Bruxelles-Capitale, 2011). Hence, the population of the Brussels-Capital Region has grown over 220,000 inhabitants in less than 20 years with a significant increase in families that reached 75,000 units (Van de Voorde, et al. 2015). More recently, following the new influx of asylum seekers, there has been an upwards revision of short-term annual population growth (BFP, 2016).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Population growth leads to an escalation in the number of inhabitants per ha or km^2 and the number of residences in the Brussels-Capital Region. This high densification strongly influences the types of Housing units constructed as well as their locations (Dessouroux & Romainville, 2016).

This results in a higher population density within the inner city and even in non-constructible areas. A recent quantization of this density shows that it reached more than 66 inhabitants/ha. Whereas the net population density in Brussels varies from a specific borough to another. The maximum density reached as much as 362.43 inhabitants/ha dominated by the middle and lower income earning socioeconomic groups. On the other hand, the lowest density reached 2.64 inhabitants/ha predominantly ruled by the higher and better earning socioeconomic groups (Amer & Reiter, et al. 2018).

Public authorities oversee Urban Densification in means of urban planning as an opportunity and solution. The densification of Housing and public services in the Brussels-Capital Region has for a few years become an investment and a tool for urban development. The objective was to cope with population growth and the growing gap between supply and demand for social and medium Housing. The location choice and the diversity or “mixité” of function during Urban Densification is essential to overcome these challenges which are labelled particularly in the Regional Plan for Sustainable Development (PRDD) project (Ananian, 2016).

Note: - Refer to the Glossary section at the beginning of this Master’s Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

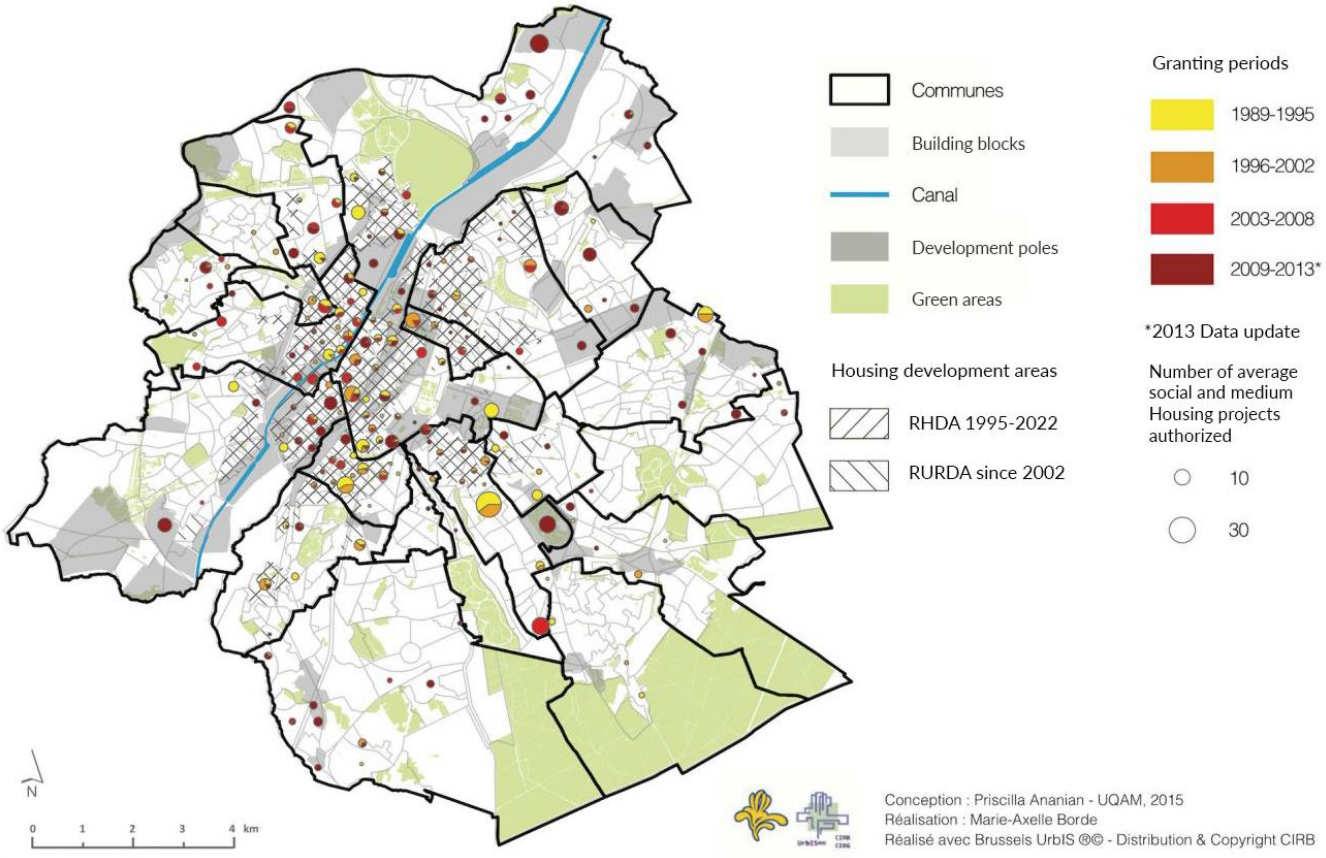
10- Housing Crisis in Brussels-Capital Region and Background Issues

a. Evolution of the Geography of Public Residential Production

The legal production of Housing is examined to the extent that the unit of analysis is the authorized dwelling and not the dwelling built. The gap is around 6% between the number of dwellings authorized and built (Ananian, 2016).

Maps 04 and 05 below show the geography of public residential production of more than ten dwellings along with all operations of the same size in Brussels (Ananian, 2016). The Reinforced Housing Development Areas (RHDA) and the Reinforced Urban Renovation Development Areas (RURDA) are two Housing reinforcement perimeters. RHDA have contributed to concentrate public production in the central districts and peri-central located west of the canal. In the first and second Regional Development Plans, the perimeters RHDA and RURDA aimed to concentrate the government investments in sectors where the built environment was degraded and where the poorest populations were gathered. In these regions, a number of policies supporting Housing and urban renovation have been created, including grants for house rehabilitation, neighborhood contracts, public space redevelopment initiatives, and the development of local facilities (Ananian, 2016).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 04: Public Residential Production 1989-2013 (Operations of More than Ten Dwellings).

Source: SLRB, 2015 (Edited by the thesis Author).

During the first two periods, i.e. from 1989 to 1995 and from 1996 to 2002, the public residential production embarked in operations that represent respectively 24% and 23% of all production of more than ten Housing units (see Map 04) (Ananian, 2016).

Across production, the number of authorized slots is particularly large in the Pentagon and the inner ring (see Map 05). This is partially linked to a proactive policy of reinvestment in central districts (Van Criekingen, 2013).

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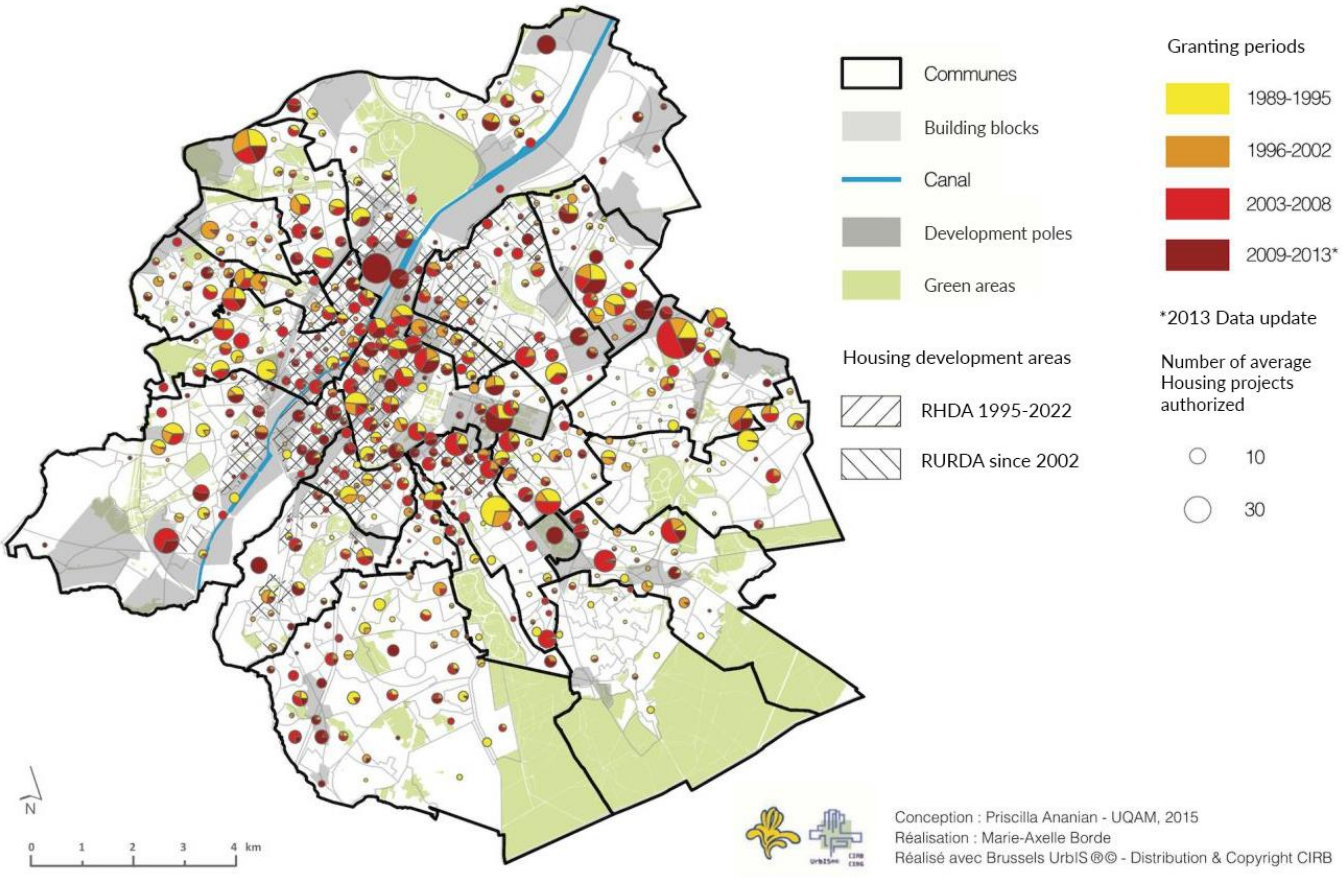

Map 05: Overall of the Residential Production 1989-2013 (Operations of More than Ten Dwellings).

Source: SLRB, 2015 (Edited by the thesis Author).

The number of dwellings authorized for the residential production in both public and private areas is much lower at the scale of the Brussels Region for the period 1996-2002 corresponding to the first Regional Development Plan. Between 1989 and 2013, Ananian (2016) observes the lowest average annual number of authorized dwellings which is 1,583 (see Table 04). This is partly due to economic factors linked to interest rates and an orientation of real estate development in Brussels towards the production of offices (Ananian, 2010).

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Period	Private production Number of authorized dwellings (annual average)	Public production Number of authorized dwellings (annual average)	Total production Number of authorized dwellings (annual average)	Share of public production (%)
1989-1995	1659	512	2171	24
1996-2002	1215	368	1583	23
2003-2008	2931	470	3401	14
2009-2013	2474	517	2992	17

Table 04: Number of dwellings authorized per production sector (annual average)

Source: SLRB, June 2015 (Edited by the thesis Author).

The situation significantly changed from 2003 to 2008, with massive housing production throughout the region of Brussels (see Map 05 above). Moreover, in the second western ring, Ananian (2016) observes the start of a process of deconcentration of public residential production. The share of public production in all residential production of more than ten dwellings amounts to only 14%, which corresponds to a decrease of about 10% compared to the two previous periods 1989-1995 and 1996-2002 (see Map 04 above).

This period also corresponds to the implementation of the Regional Housing Plan in 2005 and the 1,000 Housing Plan of the City and the CPAS (Public Center for Social Action) of Brussels in 2006 (Ananian, 2016). The share of public residential production is declining despite attempts by public authorities to build more Housing units as a result of a sharp rise in Housing production by private entities. Finally, since 2009, the practice of deconcentrating public production toward the second eastern ring with larger operations has persisted. Regarding the overall residential production of more than ten dwellings, it is concentrated in the Canal Zone and the inner western ring. The production is less sustained than during the previous period. For the years 2003–2008 and 2009–2013, the average number of homes approved decreased from 3,401 to 2,992 units (Ananian, 2016).

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b. The Contribution of Residential Production to the Brussels Regional Urban Project

In the Brussels Region, several locations can be observed in the successive development projects. In the first Regional Development Plan, there are the urban rings (which encompass the Pentagon, first ring born from the urbanization of the 19th century, and second ring born from the urbanization of the 20th century), and the municipalities. In the second Regional Development Plan and the proposed Regional Sustainable Development Plan, the regional development poles and the Canal Zone can be found (Ananian, 2016).

Concerning the urban rings, the share of public residential production of more than ten dwellings in the Pentagon and the first ring has decreased considerably since 2003 in favor of private residential production. Between 2009 and 2013, more than 70% of public residential production was concentrated in the second ring, while private residential production continued to grow in the first ring, even if this production located in the peri-central neighborhoods only represents a third of the total private residential production of more than ten dwellings (Ananian, 2016).

A comparison of the evolution of public residential production shows that the disparities between first and second ring municipalities decrease over time (Ananian, 2016). This decrease is related to a change in the direction of public policies. During the first and second Regional Development Plans, the territorial public policies of positive discrimination of the districts in difficulty to renovate delimited perimeters of reinforcement of the Housing. Moreover, the policies consolidated a territory organized in rings around the center (Ananian, 2016).

RHDA and RURDA have resulted in a concentration of public investments in the central and peri-central districts (Ananian, 2016). Even if public residential production mainly invested in these neighborhoods during 1989-1995 and 1996-2002, the share of public residential

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production in RURDA has decreased considerably since 2003, compared to all public residential production. A reinvestment by the private sector in the first ring is noticeable, despite the fact that on average the share of private residential production in the territory of RURDA is around 20% compared to 48% for public residential production (see Figure 29) (Ananian, 2016).

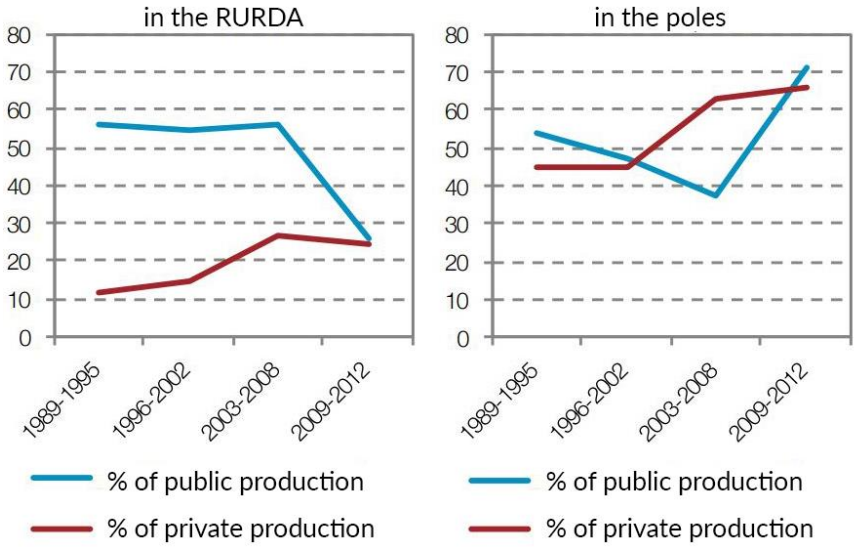

Figure 29: Left: Share of the average annual number of authorized Dwellings of Public and Private Residential Production in RURDA || Right: Share of the average annual number of authorized Dwellings of Production Public Residential and Private in Development Centers and their surroundings (PRDD).

Source: Extracted from p. 8, Ananian, 2019 (Edited by the thesis Author).

Since the elaboration of the Brussels International Development Plan in 2007 and the Declaration of the Brussels Government in 2009 concerning the elaboration of a new city project, a project emerges (Ananian, 2014b). This project is based on the concept of development poles, going beyond the logic of municipalities or urban crowns (Ananian, 2016). Development poles aim at consolidating regional ambitions and integrating sectoral

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strategies relating to the various areas of public action such as Housing, employment, and transport among others. Development poles are identified sectors in the city presenting strategic development opportunities where it is necessary to coordinate land use planning, Housing production and transport. Investment in the poles and their surroundings by the private sector is slightly more intense than that of the public sector (see Figure 29) (Ananian, 2016).

Residential production has evolved in the Canal Zone. This zone is a strategic territory for regional development identified both in the second Regional Development Plan and in the Regional Sustainable Development Plan project (Ananian, 2016). For 2009-2012, almost a third of the Housing authorized for the private sector is concentrated on the territory of the canal, while public Housing production favors the second western ring. This outcome needs to be qualified because a significant portion of these units are a component of two important construction projects: the Up Site tower, and Tour & Taxis. Although the first has been completed since 2013, the construction of the second has not yet begun (Ananian, 2016).

It can be concluded that the private residential production has only lately benefited from proactive policies of reinvestment in central areas that have led to strengthened Housing perimeters. The surroundings of the areas of regional interest designated as development poles in the Regional Sustainable Development Plan project benefit from an investment of private residential production that is older and stable over time (Ananian, 2016).

c. Public and Private Housing Production: Issues of Location: 1989-2013

Demographic growth and the gap extension between demand and supply, for social and medium Housing demand, increased for the recent public residential production in the Brussels-Capital Region. Nevertheless, it is crucial to put the production of novel and flamboyant Housing units into perspective by public authorities with the residential

production dynamics of the private sector. This is not to forget the administrative limits of the whole BCR which act as a constraint to the regional development because of land cost among other factors (Vandermotten, 2014). Accordingly, it is important to understand the extent to which public residential construction is affected by private residential construction that is often not a necessity. From which comes the issue of location: the almost impossibility to suitably locate new social or public residences inside the Brussels-Capital Region. The increasing low and mid-income households with the need to live in medium public or affordable residences will be in risk of ending up having a lower life quality. That is based on the Housing location and neighborhood condition and federal tax service status, or not finding a suitable Housing hence residing outside the BCR and having to commute on everyday basis (Ananian, 2016).

d. Regional Housing Plan and Alliance Habitat: Issues of Residential Deconcentration

Since 2005, the Brussels-Capital Region is facing a Housing crisis. With the aim of addressing the challenge of demographic growth and in turn of Urban Densification, the BCR has boosted its extension strategies regarding the stock of social and medium-sized Housing. This was achieved by implementing the Regional Housing Plan, which foresaw 5,000 new units from which 3,500 are social Housing units and 1,500 are medium sized dwellings. The financial framework of Alliance Habitat was added at the beginning of 2015 to the Regional Housing Plan. The goal is to create new operations starting from 2020 as a response to the significantly increasing Housing crisis (Ananian, 2016).

To quantify and sort the production: in June 2015, the Regional Housing Plan accounted for fifty-six projects for a total production of 4,070 Housing units, while the number of projects from the financial framework of the Alliance Habitat amounted to thirty-four projects for

1,117 dwellings. From these thirty-four, only eight were notified by the government of the Brussels-Capital Region which represent 253 dwellings (see Table 05). Ten projects were added to this total and are from the SFAR (filiale de la Société Régionale d'Investissement de Bruxelles – SRIB) for a total of 848 Housing units and sixteen projects were added from the governmental "Fonds du logement" or Housing Fund corresponding to 399 residences.

Number of Housing units	Plan Régional du Logement (PRL)	%	Alliance Habitat (AH)	%	Total (PRL+AH)
Social Housing	3039	75	566	51	3605
Medium Housing	901	22	257	23	1158
Other: yet to be defined	130	3	294	26	424
Total	4070	100	1117	100	5187

Table 05: Number of Housing units planned under the Regional Housing Plan and the Alliance Habitat financial framework.

Source: SLRB, June 2015 (Edited by the thesis Author).

The seen "lower and lower" concentrated public Housing production is not strategically contributing to the BCR Urban Project. The Map 06 depicts the distribution of the two programs (the Regional Housing Plan, and the financial framework of the Alliance Habitat) operations in regard to the share allocated to social and medium Housing.

There is definitely a deconcentration of regional public residential production which appears not to devote to the emergence/manifestation of new polarities. Actually, most operations do not include a mix of functions beyond a few equipment items of collective interest. For instance: communal halls, restaurant social, local associations, nurseries.

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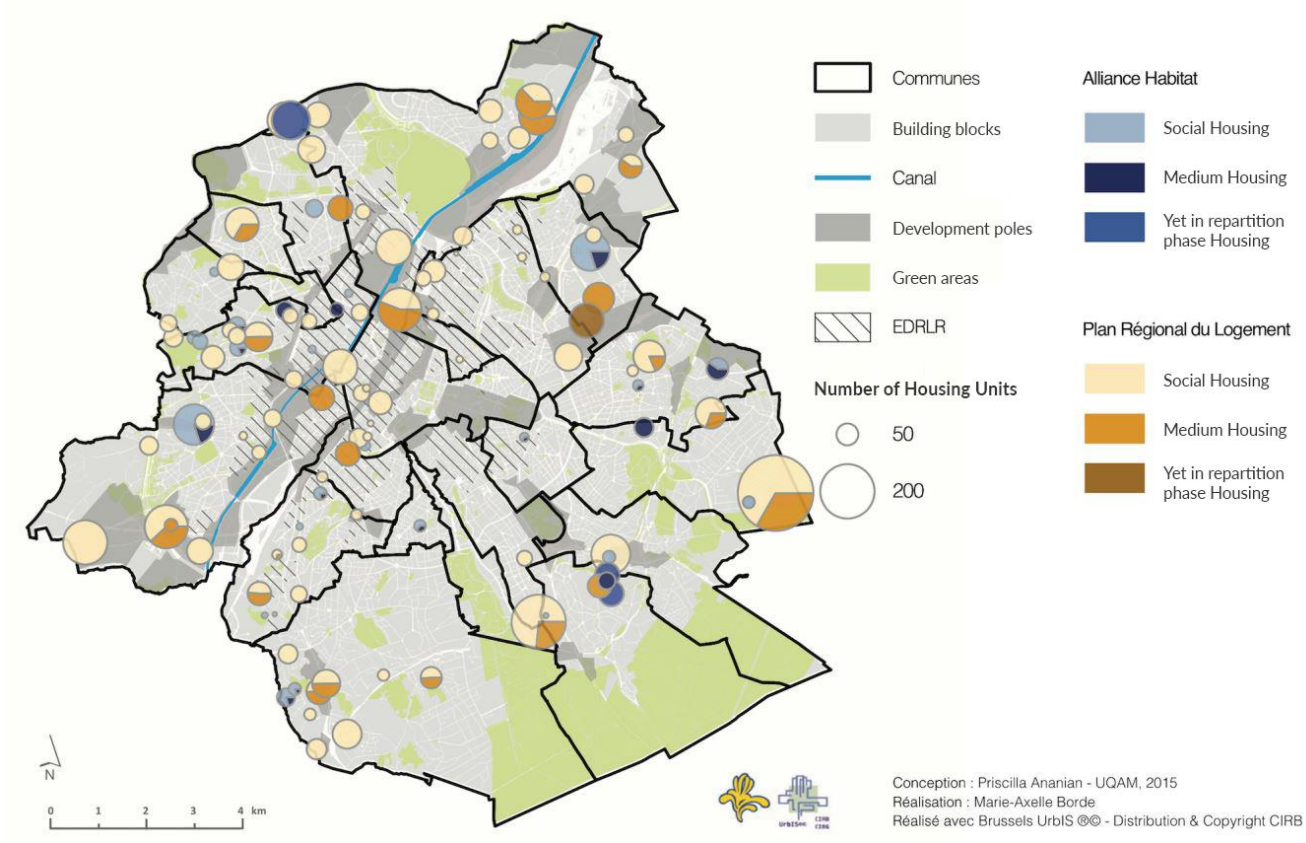
Social Housing encompasses more than two-thirds of public production, in particular in the second crown to the west of the canal, besides the average Housing being mainly located in the first ring, with a view to diversity crossing. Medium Housing is situated in the peri-central neighborhoods and social Housing in the second ring. This is underlined in the programming of the Regional Plan for Housing and is shown as well on the map.



Map 06: Operation types of Regional Housing Plan and Alliance Habitat financial framework.

Source: SLRB, 2015 (Edited by the thesis Author).

Ten years after the reveal and announcement of the Regional Housing Plan, the balance sheet/outcome is mixed. Only a quarter of the initially planned Housing units has been delivered. It principally comprises operations located in the second ring. The quarter of the

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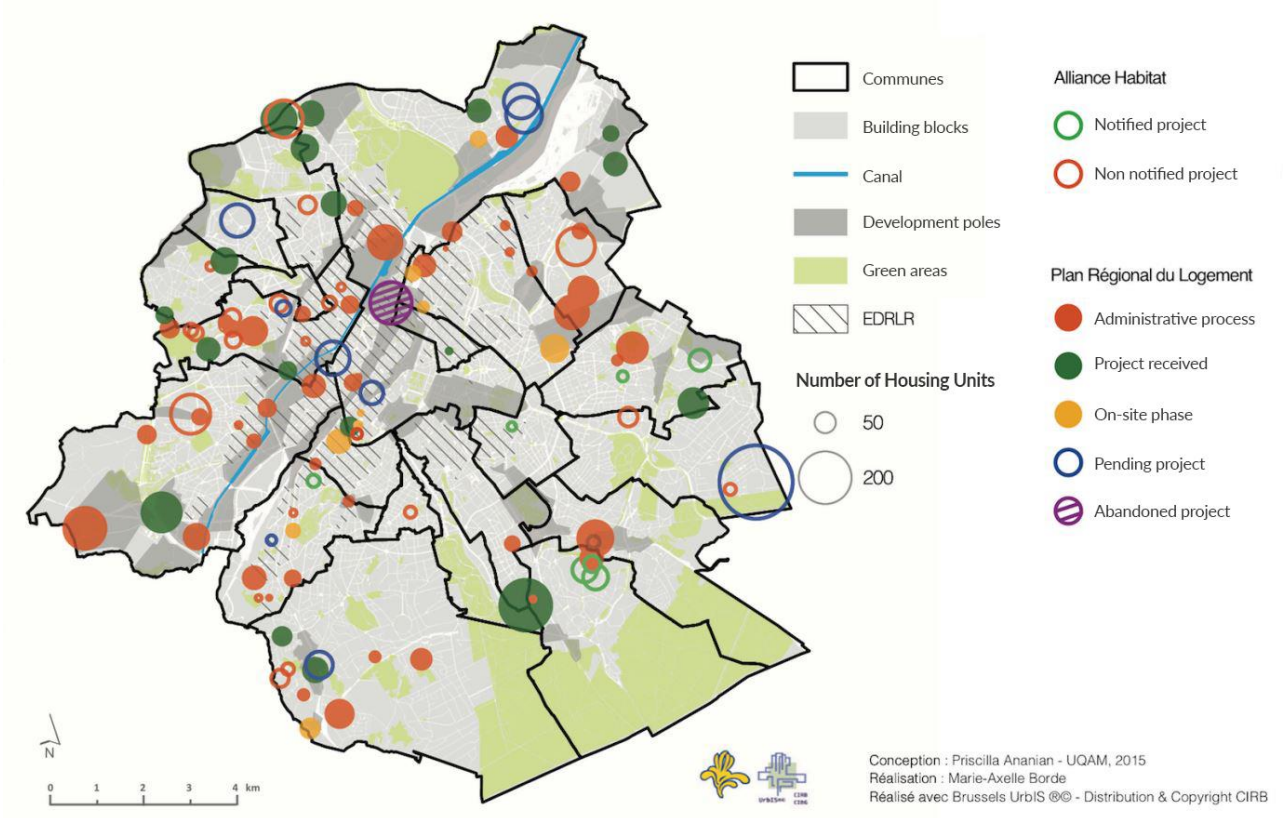
initially planned units embodies fourteen projects and 1,290 dwelling units (Data transmitted by the SLRB, 2015).

The map illustrates how the majority of operations always proceed in one or other of the administrative stages (see Map 07). These stages include obtaining planning permits, acknowledgement of service contracts, and acknowledgement of work contracts among others. This finding emphasizes the urgent need to justify and speed up processes of executing Housing projects for an adequate Urban Densification. Several pending and abandoned projects in the Brussels-Capital Region are highlighted.



Map 07: State of progress of the operations by the Regional Housing Plan and the Alliance Habitat.

Source: SLRB, 2015 (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Ananian (2016) identifies a long list of obstacles affecting these projects, mainly the following:

i. The accomplishment of major real estate projects relating to the project assembly.
ii. The development of planning instruments.
iii. The acquisition of urban permits.
iv. The citizen opposition movements concerning the programming of social diversity in the wealthy neighborhoods of the BCR.

e. Conclusion: Prospects for an Integrated Urban Planning Strategy

Ananian (2016) shows that the recent production of public Housing does not necessarily consolidate the Regional Plan for Sustainable Development project, whereas it could be a powerful lever in favor of the city project developed by the Brussels Region. This observation highlights in public action the need for integration of the development of regional Housing policy and urban planning. Producing enough Housing units to address the supply-demand gap in a region's integrated Housing policy is insufficient in the face of urgency (Ananian, 2016).

To succeed in such integration, it would be necessary to develop a strategy for the location of social and medium-sized Housing in the regional territory, and no longer operate piecemeal according to opportunities (Ananian, 2016). Such a localization strategy must encompass principles that contribute to consolidating both the regional urban project based on development poles and their surroundings, and the local city at the neighborhood level. According to Ananian (2016), this cannot be done without supporting the dynamics generated by private residential production, which seems to consolidate the model of the local city for the more affluent classes.

Three major principles of this strategy can be listed. The first principle concerns the coordination between the production of public Housing, urban planning, and transport. The restructuring of transport networks should be done upstream to regulate Urban Densification. Additionally, the location of new units should promote connectivity with transport networks because social Housing residents depend more on public transportation; ideally, these locations should be close to metro, pre-metro, tram, and train stations, especially the urban stations inaugurated as part of a project like Germoir in Ixelles (Ananian, 2016).

The second principle consists in aligning the programming of the residential operation with the urban programming in terms of equipment and amenities. Only 50% of the average annual number of Housing units authorized for public real estate operators are served by nurseries, schools and public playgrounds. Accordingly, setting up the project is challenging since different actors and funding programs are in charge of building houses and developing facilities or public services (Ananian, 2016).

The third principle comprises consolidating the place of social and medium-sized Housing in the development poles and their surroundings. In particular through master plans, major urban projects under development in strategic areas include social and medium-sized Housing in their programming. However, these are only incentive mechanisms (Ananian, 2016). In addition to the urban planning fees imposed when issuing urban planning permits authorizing Housing operations of 1,000 m^2 or more, it is critical to strengthen the normative mechanisms intended to promote the creation of social and medium-sized Housing in the centers suggested by the Regional Plan for Sustainable Development project (Ananian, 2016):

Furthermore, since 2003, the surroundings of planned development centers are increasingly taken over by private residential production (Ananian, 2016). Since this private production has more control over land and can set up large-scale enterprises more swiftly than its public counterpart, private production is more stable over time. The usefulness of measures following RURDA, i.e. stimulating small renovations, upgrading of Housing above shops or management by public authorities of Housing private, through Social Real Estate Agencies,

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is questioned. With the creation of new Housing operations, these devices can contribute to strengthening the place of social and medium-sized Housing in the surroundings of the poles (Ananian, 2016).

Development poles in the Regional Sustainable Development Plan project reinforce the will of the Brussels Region to ensure the consistency of a series of projects at different stages of progress (Ananian 2014a; Ananian 2014b). Accordingly, the multipolar city is a reflection of a strategy that originated with the regionalization in 1989, developed through the first two Regional Development Plans, and was finally integrated into the Regional Sustainable Development Plan project. This image of the city project shifts away from a municipal logic and in crowns toward a regional logic based on regions that are nowadays devoid of centrality, with the majority of the project's development poles being port wastelands, railroad, or industrial (Ananian, 2016).

A limited number of levers exist in the Brussels Region to support the creation of projects of this nature and to secure the position of social and medium-sized Housing among real estate developers. However, the municipalities can count on historical structures to build Housing and facilities such as the Public Service Real Estate Companies. Furthermore, the ring-by-ring approach has benefited over the past twenty-five years from territorial policies with positive discrimination of neighborhoods such as RHDA and RURDA among others (Ananian, 2016).

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11- Brussels Regional Plan for Sustainable Development (PRDD) 2020-2040

a. PRDD: Definition and Aims

The Regional Plan for Sustainable Development (PRDD)[1] is a strategic plan (2020-2040) focused on the guidelines and decision-making for public authorities and private sectors concerning the Brussels-Capital Region. This framework functions as a tool for leading all regional public action through 3 main stages:

1. Planning a preliminary vision of the desirable future for the Region starting from the current situation;
2. Defining the strategic goals and objectives to achieve the established vision;
3. Defining the operational procedures to achieve these goals.

The PRDD presents a transversal and common vision for all city stakeholders which covers numerous aspects:

1. Socio-economic (economy, employment, training, social, etc.);
2. Territorial planning (zoning, urban projects, mobility, etc.);
3. Living environment (environment, green spaces, urban renewal, public spaces, etc.);
4. International (tourism, events, transport, economic expansion, etc.);
5. Institutional (skills, finances, budget, governance, etc.).

[1] *For more info visit: https://perspective.brussels/en/node/1323*
& https://www.ieb.be/Le-Plan-Regional-de-Developpement-Durable-un-projet-creux-depasse-et
& check: Hamon, F. & Troper, M. (2018). Droit constitutionnel (39é). LGDJ

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The plan also takes into account the metropolitan scale problems in the context of globalization. It is important to consider the resourceful socio-economic basin and future RER (Regional Express Network) zone represented by areas beyond the institutional borders of the BCR. In this framework, several development projects have been taking place and it is essential to explore cooperation initiatives. This will diversify in a complementary way the fields of socio-economic strategies, regional planning, Housing, and mobility.

The PRDD's priority is to respond to the city's new challenges such as:

1. Demographic growth
2. Housing
3. Unemployment
4. Training, and education
5. Environmental and sustainability matters
6. Dualization and internationalisation of the city.

Furthermore, the PRDD looks at the future of Brussels. With a highly operational vision, it provides quick and effective responses to the citizens' problems (medium-term objectives), as well as more forward-looking solutions for different potential evolution scenarios of the Region (long-term objectives, by 2040). This dual goal has the purpose to take into consideration trends and issues and determining concrete, appropriate actions.

The PRDD allows coherence between the different areas of governmental action. It integrates the new plans (PDI[2], Housing Plan[3], Climate Plan[4], etc.) and the existing tools (Master Plans,

[2] *For more info visit: https://www.marketing-territorial.org/article-le-plan-de-developpement-international-pdi-de-bruxelles-52262156.html*

[3] *For more info visit: https://www.brussels.be/housing-plan-2019-2024*

[4] *For more info visit: https://www.brussels.be/climate-plan*

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District Contracts[5], etc.). Hence, it improves the government's performance and organizes political decision-making.

Finally, it aims to improve the BCR influence on both national and international levels. The PRDD function as a promotion plan for Brussels, advertising a dynamic and future-oriented image of a city that meets the needs of its inhabitants in the best way possible (*Bruxellesplus: Plan Régionale Du Développement Durable*).

FINANCE-BUDGET

Annex Translated from « Plan Régional de Développement Durable, Phase Préparatoire, État des Lieux de la Région de Bruxelles-Capitale » in the section « FINANCES-BUDGET », p. 199-201.

In terms of revenue

> Between 2004 and 2008, the increase in revenue for the Brussels-Capital Region was 18%, which is precisely the same as in the Walloon Region and less than in the Flemish Region where the increase in revenue is 20% over this same period.

> The main source of funding for the Brussels-Capital Region is its regional taxes. In 2010, the taxes alone represented more than 40% of the total revenue of the Brussels Region. The development of these recipes in the Brussels Region has been experiencing a marked slowdown for several years, mainly linked to the country's economic situation (real estate, etc.). It is also advisable to remain attentive with regard to the phenomena of tax eviction. Over the years, the Brussels Region has made significant changes in terms of rates and exemptions for its regional taxes. The tax reforms have had a real impact on the development of regional tax revenues, but the Region has not been able to curb unwanted effects, such as

[5] *For more info visit: https://www.brussels.be/district-contracts*

the increase in real estate prices in the Brussels Region. The Regions do not control certain basic data on this subject, given that it is the federal power which manages the heritage documentation for the three regions (land register, registration, estates and mortgages), collects the revenue, and manages litigation. The effects of tax reforms on regional taxes are therefore difficult to measure. In this context, should not the Brussels Region equip itself with more effective and binding regulatory and collection instruments? The establishment of a regional tax administration becomes an absolute imperative. Indeed, Brussels needs an effective tax tool that alone can guarantee sustainable revenue.

> The second source of revenue for the Brussels-Capital Region is its share allocated to personal income tax. In 2010, this revenue represented more than 37% of the total revenue of the Brussels Region in the 2010 budget. Between 2007 and 2008, the average income in Brussels (based on 2007 IPP declarations) increased by 2.35% against a growth rate of 3.27% for the country and the Flemish Region, and 3.55% for the Walloon Region.

These numbers demonstrate a loss of fiscal capacity of the Brussels-Capital Region compared to the rest of the country. The maintenance of the IPP recipe is done by the mechanism of the national solidarity intervention which has not stopped since 2002 to increase for the Brussels Region. This increase reflects the growing impoverishment of the population of Brussels compared to the rest of the country. On the other hand, municipalities are directly affected by a weak growth in their PIT receipts. Currently, a large part of the middle-income population of Brussels is composed of international civil servants who are exempt from paying taxes in Belgium.

How to increase the fiscal capacity of the inhabitants of the Region? What public policies (taxation, housing, etc.) should the Region put in place to attract and maintain a middle-income population on its territory?

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In terms of expenses

> Between 2004 and 2008, the general expenditure budget grew by 38%. The main expenditure items of the Brussels Region are "equipment and travel" (25% of total expenditure), "local authorities" (15.7% of total expenditure) and "employment" (7.9% of total expenses).

> In 2009, if expenditure on transport and equipment are neutralized, expenditure per inhabitant in the Brussels Region is equivalent to that of the two other regions. These expenses for transport and equipment represent 729 euros per inhabitant in Brussels compared with only 268 euros in the Walloon Region and 403 euros in the Flemish Region.

What avenues can be considered to "share" the additional cost of transport expenses in the Brussels Region, which is, at present, entirely borne by the people of Brussels?

> In a context of greater accountability of the federated entities, it is important to remember that many important decisions taken by the Federal government have a direct influence on municipal revenues which generate a transfer of the financing burden to the Brussels Region (delays in payment surcharges to the communes, reform of personal income tax in 2001, expenses linked to the missions of the CPAS).

What avenues should be put in place to ensure adequate funding of Federal decisions and relieve the Brussels Region which compensates for the lack of means of the municipalities?

> Expenses specific to the Brussels Region (bilingualism, police, etc.) weigh heavily on the Region's expenses. What mechanisms should be provided to compensate for the specific charges of the Brussels-Capital Region? Should not the finance law be revised?

> Like the other entities, the Brussels-Capital Region has always respected the objectives assigned to it via the cooperation agreement between the federated entities, which has also enabled it to reduce its debt.

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> The role of the Brussels Region as an economic engine for our country is not sufficiently taken into account in the financing of the Brussels Region. The economic wealth produced in Brussels nevertheless benefits the two other Regions, even though it is often dependent on regional levers in Brussels (such as, for example, economic expansion policies).

The Brussels Region uses all the means at its disposal to continue to carry out its public policies, but the margins available are increasingly thin. Public spending, necessary for the continuity of the public service, is increasingly jeopardized. The Brussels Region must therefore benefit from structural refinancing (minimum 720 million euros) which no longer needs to be demonstrated and which future institutional agreements at federal level will have to confirm.

ECONOMY-EMPLOYMENT

Annex Translated from « Plan Régional de Développement Durable, Phase Préparatoire, État des Lieux de la Région de Bruxelles-Capitale » in the section « ÉCONOMIE-EMPLOI », p. 127, 128, 132, 133.

- ***The economic situation of Brussels makes it possible to affirm that the Capital of Europe is a rich City Region.***

The Brussels-Capital Region produces 18.9% of the country's wealth and comprises only 10% of the Belgian population. Brussels is the Region which costs the country the least and brings in the most. Nonetheless, this wealth only benefits the inhabitants of Brussels too little. In this context, the actions of public economic players (ABE, Atrium, the Port, SDRB, SRIB, etc.) support economic activity in Brussels, particularly in the neighborhoods of the Priority Intervention Zone (ZIP). A reflection on the rationalization of the various missions carried out by these actors is in progress in order to make aid for investments in the regional territory more effective.

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- ***The urban industry is changing and must be supported in all its dimensions, including at the planning level.***

Due in particular to the strong real estate pressure on "urban industrial areas" and on "mixed and highly mixed areas", it is becoming essential to adapt them to new urban conditions. This reflection should in particular be carried out within the framework of the PRDD with a view to adapting the prescriptions and the glossary of the PRAS.

The Economic Coordination Council has also sounded the alarm, considering that productive activities must today be considered as weak functions to be protected, and that their development requires more land.

Nevertheless, questions must be asked about the usefulness of maintaining a certain number of functions that consume space but do not generate added value on a narrow regional territory. Similarly, the question of urban diversity should be examined.

Therefore, it seems essential to ask what economic activities are compatible with housing, and to facilitate their integration into the urban fabric, in order to reserve the most isolated areas for activities that cannot be integrated into the existing buildings.

It is crucial to question what activities are useful or even necessary for the functioning of the city and support their installation: services to businesses and residents, supply, upkeep and maintenance of buildings, equipment, the environment …

Should not support be given to productive businesses (particularly medium-sized ones) through "urban business zones"? This type of assignment would make it possible to establish them near residential areas, in order to better coordinate the reception of productive activities compatible with the habitat. The reception of productive activities less compatible with the latter would be found in "industrial zones".

Furthermore, should not certain existing industrial zones be densified, which would make it possible to respond at least partially to the demand for an increase in the surface area reserved for urban industrial zones?

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

The Economic Coordination Council also suggests providing for compulsory quotas of economic activities in the mixed and highly mixed areas of the PRAS, which currently can be occupied entirely by housing.

For activities generating environmental nuisances, the land provided for in the urban industry zone must be reserved. On the other hand, should not projects that allow economic activities and housing to coexist be encouraged?

- ***The Sustainable Urban Growth Pact constitutes the framework for concerted action between the Government and the social partners.***

The Pact aims to create sustainable, quality jobs, for the benefit of the people of Brussels, with a view to sustainable urban growth.

The priority sectors are:

- the field of the Environment (via the Employment-Environment Alliance and its various axes) but designed from a broader perspective than that centered on specific sectors, and more specifically, on construction-renovation;

- the field of international development, including tourism, culture, the events sector, the recreational sectors;

- the "trade & horeca" sector, including quality craftsmanship;

- the field of non-market and public service and local services; - the field of innovative and creative sectors.

The principles of action are:

- the development of the training offer;

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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- the fight against school dualisation and the increase in the level of schooling in general, among other things through a better knowledge of languages;

- support, accompaniment and adjustment of job-creating economic sectors;

- the transition of the economy and the transformation of modes of production of services or goods designed around the balanced articulation of economic, social and environmental issues;

- the establishment of a real synergy between the social partners and the political institutions of Brussels (Region and community organisations) on the basis of a clear and transparent form of collaboration.

The partners have also made a triple commitment as a condition for success:

- promote dialogue between the social partners and cooperation between them and the public players;

- promote, at the operational level, collaboration between economic, employment and training operators (public and subsidized);

- mobilize all public and private stakeholders and resources via a form of cooperation with a view to promoting employment for the people of Brussels and sustainable urban growth.

The Pact also proposes to put in place monitoring instruments, in particular concerning changes in the economy and corporate restructuring, and to entrust this mission to the Economic and Social Council in the Brussels-Capital Region (CESRBC). As part of the governance of the PRDD, would it not be useful to provide for a specific dashboard?

In the same way, the Pact proposes to promote synergies and complementarities between all the local and regional employment and training systems, by promoting the creation of

structured partnerships, combining reciprocal actions, with a view to avoiding redundant offer of services and to facilitate procedures for job seekers and employers. It also proposes to guarantee the consistency of the employment policy throughout the entire territory of the Region through:

- actiris, at the regional level, through its Management Contract;

- the participation of the social partners at the zonal level: the management bodies of the Local Missions and the "Lokale Werkwinkels", of the Zonal Commission (the modalities are still to be determined);

- actiris branches, at the local level.

b. Urban Densification Notion underlined in the PRDD

As mentioned in the previous section, the PRDD aims to respond the BCR uprising challenges. The main priorities are demographic growth and Housing. On that end, the PRDD integrates the Regional Housing Plan (PRL)[6] and Alliance Habitat[7]'s projects as a tool to resolve these problems along with strategic and systematic facilitation in the new urban policies that were a main obstacle for new Housing infrastructure to serve more inhabitants (*Bruxellesplus: Plan Régionale Du Développement Durable ;* Ananian, 2016).

Responding to population growth involves several responses:

1. Urban Densification of the existing mixed and residential urban fabric.

[6] *For more info visit: https://www.brussels.be/housing-plan-2019-2024*

[7] *For more info visit: http://www.doulkeridis.be/blog/wp-content/uploads/2013/09/Alliance-Habitat-dossier-Presse-2.pdf*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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2. Transformation of urban industry zones or port and transport activity zones into mixed spaces (urban business areas or ZEMU[8] introduced by the PRDD 2013 and 2018 as well)
3. Functional transformation of buildings for economic use.

The diversity of existing urban fabrics and spaces means that the city cannot undergo densification the same way everywhere.

An operational procedure is defined by the PRDD for a suitable Urban Densification to face demographic growth and Housing crisis. It plans to mainly mobilize the Region's urban planning tools in order to welcome in the better conditions possible this increase in population while promoting the local character of Brussels. The strategic objective is to transform this constraint into an opportunity (*La densité à travers le plan de développement durable de la Région Bruxelloise*).

The PRDD and PRL (Housing plan) confirm that 469 new dwellings and units will be spread throughout the Region in the first 4 years (2020-2024). As well, the coordination with the CPAS[9] (public welfare center) of the BCR indicates a possibility of adding 750 future Housing units. Once such project is confirmed, the Property Management Agency in Brussels will ensure to implement the functional mix of the targeted neighborhoods (*Brussels Housing Plan, 2019*).

In order to confirm such an agreement, the strategy is simplified to obtain an intensified urbanity due to the lack of empty sites and to avoid further Urban Sprawl and city outward expansion. This is by implementing an adequate Urban Densification of the potential zones. Adding infill buildings and new extensions of different types with mixed-use functions (mainly Housing). A positive index in this plan is that other big cities such as Paris, Milan,

[8] *For more info visit: https://urbanisme.irisnet.be/pdf/pras/brochure*

[9] *For more info visit: https://cpasbxl.brussels/*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Zurich, and Vienna, started dealing some years ago with fairly similar challenges and are succeeding.

The plan execution is totally possible once the BCR capacity to accommodate higher densities is identified. This identification should as well spot the potential sites and zones for such densification while indicating its maximum potential. In this case, a clear mapping should be put in place. As well, giving a quantization for the maximum potential for Urban Densification would allow to compare the numbers obtained with the projected population increase. From a methodological point of view, in parallel with the new put in order policies in Brussels, such a study should take into account the gross built area instead of the number of Housing units as a starting base point. It is therefore a question of being able to work on urban density within the framework of the elaborations and policies of Neighborhood Contracts (CdQ)[10], Special Land Use Plans (PPAS)[11], Master Plan (SD), Municipal Planning Regulations (RCU)[12], etc. (*La densité à travers le plan de développement durable de la Région Bruxelloise*).

HOUSING

Annex Translated from « Plan Régional de Développement Durable, Phase Préparatoire, État des Lieux de la Région de Bruxelles-Capitale » in the section « LOGEMENT », p. 267, 273, 275, 276.

- ***There is a mismatch between housing production and estimated population growth. This testifies to a tense situation whose negative effects will be measured more in the medium term if all things remain equal.***

[10] *For more info visit: https://www.bruxelles.be/contrats-de-quartier*

[11] *For more info visit: https://perspective.brussels/en/node/709*

[12] *For more info visit: https://urba.irisnet.be/fr/lesreglesdujeu/les-reglements-durbanisme/les-reglements-communaux-durbanisme*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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The effects will indeed depend on the level of future production and the importance of population growth. Although housing production has increased over the past decade, this has not provided room to ease market stress. Accordingly, what impact will demographic pressure have on the already tight housing market? How will behaviors and ways of living evolve in this context?

The periurbanisation of some households is a valve to this situation, but its continuation is neither fiscally nor budgetary desirable for the Region, knowing that it concerns a large proportion of working households with children. As a result, social dualisation increases: young families leave the city and people in precarious situations seek a solution in the city. Suburbanization is also undesirable from an environmental point of view. In this respect, it is necessary to take into account the situation on a metropolitan scale and to take into account, in the strategies of housing development, the question of urban sprawl and the implications in terms of mobility.

It is therefore necessary to find public responses to this mismatch: produce more public housing, identify public alternatives to influence the housing market and encourage new housing behavior, without housing conditions being undermined.

As current housing policies have been unable to anticipate or respond to the magnitude of the demographic challenge, should not the City's "production" strategy not be thoroughly reviewed in the context of housing production, either by mobilizing in a coordinated manner between the various existing operators or by creating a new operator, with the aim of servicing new sites and putting an end to the land freeze? This new strategy could respond effectively to the needs for new housing generated by demographic change and answer fundamental questions about the housing to be produced: where to produce housing?, what types of housing?, how to improve the implementation?, for which target audience?,…

With this in mind, would it not be interesting to consider studying the potential for densification of the Region (particularly in terms of housing), which would make it possible to define strategies adapted to the specificities of certain parts of the Region (first ring, second

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crown, administrative areas, high-rise constructions, issues of mixed functions in the city, etc.)?

Belgian Regions, municipalities and cities must also take their share of social demands: the city creates a suction effect on people in difficulty.

- ***The response to the demographic challenge does not only target the production of housing, but also involves enhancing the existing stock. This could involve realistic measures to discourage under-occupation and the conversion of obsolete office buildings into housing.***

  The main question is how to further optimize the occupancy of the current housing stock. Should not the current obstacles to the possibilities of dividing existing buildings (RRU, municipal policies, parking, etc.) be considered to be removed, while remaining attentive to the quality of living in these dwellings? Similarly, should not land set-aside be discouraged and the densification of certain areas be encouraged, in particular near intermodal public transport hubs?

  In addition, a clear delay must be comprised in the fight against vacant housing. Should not more incentives (technical assistance, investment aid, etc.) and regulatory measures (urban planning regulations, taxes) be combined?

- ***"Urban revitalization" has marked the urban landscape.***

The so-called "urban revitalization" policy has marked the Brussels urban landscape in recent years. Since the creation of the Region, it has been concentrated in the central areas in difficulty in order to respond to a significant deficit of private and public investment in these districts. This has contributed to restoring a certain quality to the physical appearance of degraded neighborhoods and to reintroducing services to the population there, through an integrated approach. It therefore does not focus solely on the question of housing, but provides a cross-cutting response (housing, equipment, public spaces, socio-economic

projects, environmental approach, social cohesion, etc.) to local problems, which makes it rich. This policy is materialized by various tools: neighborhood contracts, SDRB, FEDER program. They greatly contribute to the responses to be provided to demographic, socio-economic and environmental issues.

Despite this important policy for housing, the challenges of the central areas of the city remain very numerous. While there has been a physical improvement in the appearance of neighborhoods and a relative revival of private investment in housing, the social, economic, urban planning and environmental challenges remain enormous. Moreover, it is these central districts that bear the brunt of the effects of certain "pressures" inherent in the evolution of the urban context.

In view of these findings, an evolution of urban revitalization policies should be considered. It is no longer so much a question of "revitalising", of giving life back to "backward" neighborhoods, but of improving the ability of central neighborhoods to cope with the pressures identified.

The lines of thought are numerous and vary according to the tools.

The Sustainable Neighborhood Contracts will have to respond to this evolution of central neighborhoods, by finding a response to the various "urban shocks" (changes in land, demographic growth, climate change, economic crisis, etc.), and by giving priority to local facilities (in particular those devoted to children and young people), actions of a social and economic nature, and operations of an environmental nature, on projects aimed solely at the beautification of public spaces. The objectives in terms of creating housing accessible to low-income households must be maintained.

Concerning the SDRB, the populations with the most modest incomes could claim to acquire housing, while maintaining the current ceilings, in order to continue to reach more affluent incomes. The re-establishment of the partnership with the Housing Fund is part of this same idea. It can also consider changing the mechanisms for allocating its accommodation to

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people on its waiting list, by integrating other criteria than just the "chronological order of registration". Following studies on the implementation of systems such as "Community Land Trusts" and considering, where appropriate, partnerships with such a structure constitutes a prospective response which seems interesting both in terms of economic accessibility and the plan for integrating interventions into the social fabric of the neighborhoods.

In summary, the major findings of population growth, the scarcity of land, the sustainable approach, "urban revitalization" to which it is likely that it will be necessary to add new regional skills in terms of housing, oblige the Brussels-Capital Region to structurally reformulate the historical axes of its housing policy and to open up to new alternative and innovative fields. This need must be accompanied by taking into account the probable evolution of Belgian federalism towards greater financial accountability of the federated entities.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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12- Inventory of Potential Urban Densification Areas in the Brussels-Capital Region in Parallel with the PRDD

a. Objectives and Operational Guide

An inventory report of places of potential Urban Densification in the Brussels-Capital Region was launched by the Belgian-French firm COOPARCH-RU[13] in the context where the territory must deal with the continuous growing population. It was developed at the same time as the new Regional Plan for Sustainable Development of the Brussels-Capital Region.

The report has a general objective of identifying opportunities and potential for Urban Densification on the regional territory of Brussels and highlighting intervention priorities. Densification of buildings by extensions or other methods must be understood in the sense of a mixed-use functional building that will be divided into Housing mainly, along with schools, shops, facilities, and economic activities. This urban strategy should highlight the spirit of a sustainable neighborhood.

To better achieve this objective several steps have been taken by developing the strategic reflections on urban scale density at Brussels regional level. This serves as a tool for administrations and for project management at all scales. The reflections carried out within the framework of the PRDD[14] contributes to different degrees for the construction of this strategic document for the BCR.

[13] *For more info visit: https://wbarchitectures.be/en/architects/COOPARCH-RU//115/*

[14] *For more info visit: https://perspective.brussels/en/node/1323*
& https://www.ieb.be/Le-Plan-Regional-de-Developpement-Durable-un-projet-creux-depasse-et
& check: Hamon, F. & Troper, M. (2018). Droit constitutionnel (39é). LGDJ

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Several parameters were analyzed such as: the continuity of buildings, openings, and building extensions. Thus, the study had proposed to work carefully in accordance with this physical base. It involves minimum P/S[15] coefficients *(check glossary)* that are defined according to the capacities of existing urban fabrics.

In this inventory report, the different operational modes of densification of Brussels urban fabric have been distinguished. In other words, the different Urban Densification methods cited in this Master's Thesis are identified and taken into consideration in the mapping and quantization.

At the scale of neighborhoods and blocks, the report allows a better understanding of the urban fabric by analyzing then establishing the neighborhood diagnoses. It is also a question of giving tools to identify the potential of the site and a first vision of the feasibility of the project (*Inventaire des lieux de densification potentielle de la RBC*).

Later in this Thesis, the feasibility of such projects is experimented and visualized in several potential Urban Densification blocks and spots.

[15] *P/S: Plancher/Surface | or Total Floor area/Land area. The total floor area considered in the P/S calculation excludes the floor area of spaces with less than 2.2m of clear height and basement spaces that are used for technical equipment or as storages.*

Absolute P/S: sum of building densities per block / number of blocks – e.g. $\left(\frac{a}{b} + \frac{c}{d}\right) \Big/ 2$

Average P/S: sum of the floor areas / sum of the area of blocks – e.g. $(a + c) \Big/ (b + d)$

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b. Mapping: Territorial Prioritization Criteria for Urban Densification

In this section, three types of criteria are identified to be involved in territorial prioritization:

• Restrictive criteria;

• Programmatic criteria;

• Location criteria.

For each type, it is necessary to operate a selection of criteria that correspond to the vision that the authorities planned for the BCR. The study by COOPARCH-RU does not claim these choices by the PRDD. Rather, it limits the study to analyze and explain them, while giving a clear vision of their impacts on the identification of the maximum potential for a regional Urban Densification. The authorities' vision in the PRDD is based on strict policies that are integrated in all the phases and layers of the inventory Mapping and Quantization (*Inventaire des lieux de densification potentielle de la RBC*).

i. Restrictive Criteria:

The restrictive criteria are directly linked to:

1. The symbolic and historical values of the territory, such as heritage;
2. The physical constraints of the territory, such as the landscape and the special view cones.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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To assess these criteria, it is important to include in the study the 5 sites under the protection of UNESCO, where urban planning intervention in terms of building densification is highly limited.

On the other hand, there are sites subject to light protection such as those of ZICHE[16], where an urban or architectural project requires the consultation of the CRMS[17]. In terms of landscape, it is necessary to respect the city view cones and natural views and perspectives.

Heritage:

The Brussels-Capital Region has a rich historical architectural heritage. There is an inventory of the architectural heritage of the BCR. This tool identifies and documents the built heritage, in order to promote it. It is aimed at researchers, heritage stakeholders as well as anyone interested in architecture and urban planning in Brussels.

COOPARCH-RU's cartography mapped different layers (Figure 30) that overlap to form the BCR Remarkable Heritage Map (Map 08): UNESCO perimeters, protection perimeters, monuments, exceptional group of architectural and other elements, Municipal Zoned Urban Planning Regulations (RCUz[18]), Zones of Cultural and Historical Interest and Aesthetics (ZICHE), and the Areas of Cultural, Historical, Aesthetic and Embellishment (ZICHEE[19]).

[16] *For more info visit: https://perspective.brussels/fr/plans-reglements/plans-reglementaires/plan-regional-daffectation-du-sol-pras/la-carte-des-affectations*

[17] *For more info visit: https://crms.brussels/*

[18] *For more info visit: https://www.bruxelles.be/sites/default/files/bxl/Travaux%20et%20Mobilit%C3%A9/Mobilit%C3%A9/RCUzon%C3%A9-siteVille_Unesco.pdf*

[19] *For more info visit: https://perspective.brussels/fr/plans-reglements/plans-reglementaires/plan-regional-daffectation-du-sol-pras/la-carte-des-affectations*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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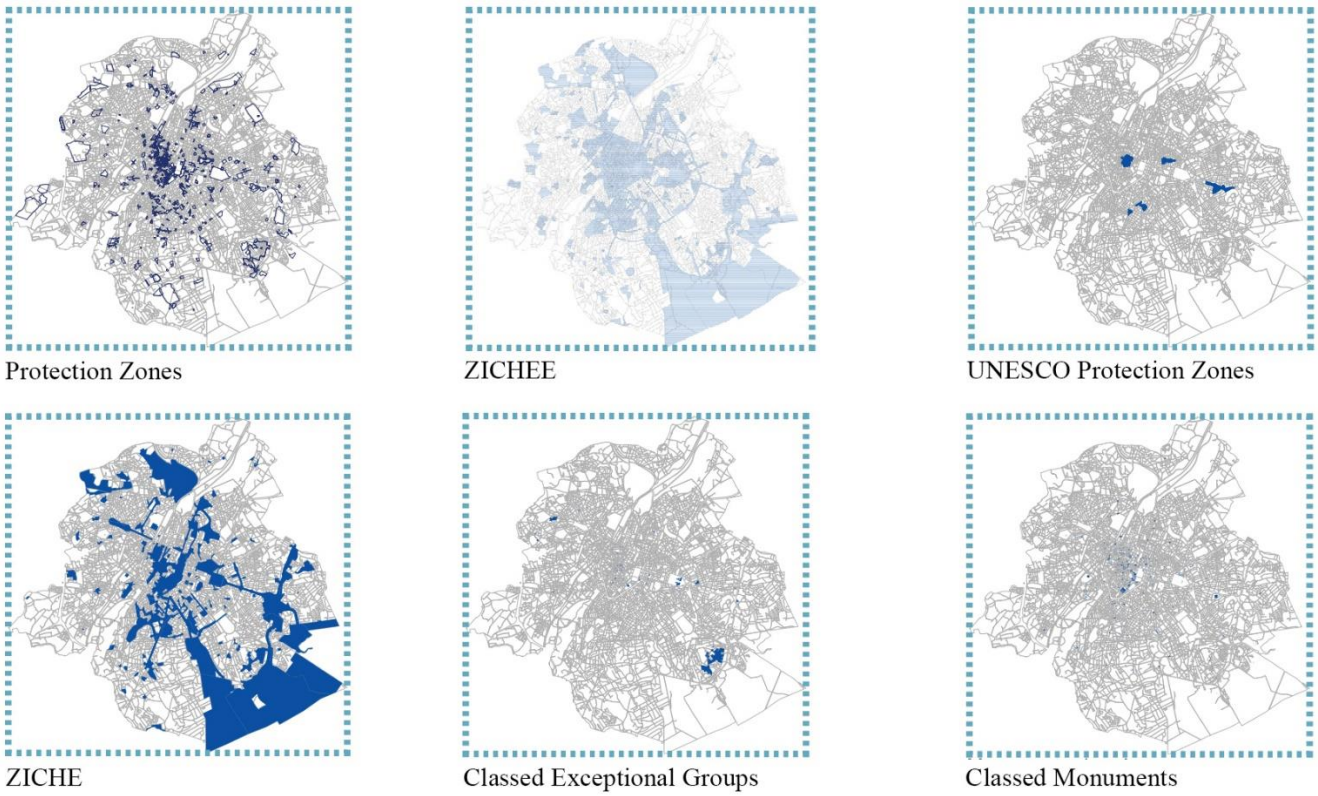

Figure 30: Layers and Elements composing the Remarkable Heritage Map of the BCR.

Source: Extracted from page 75, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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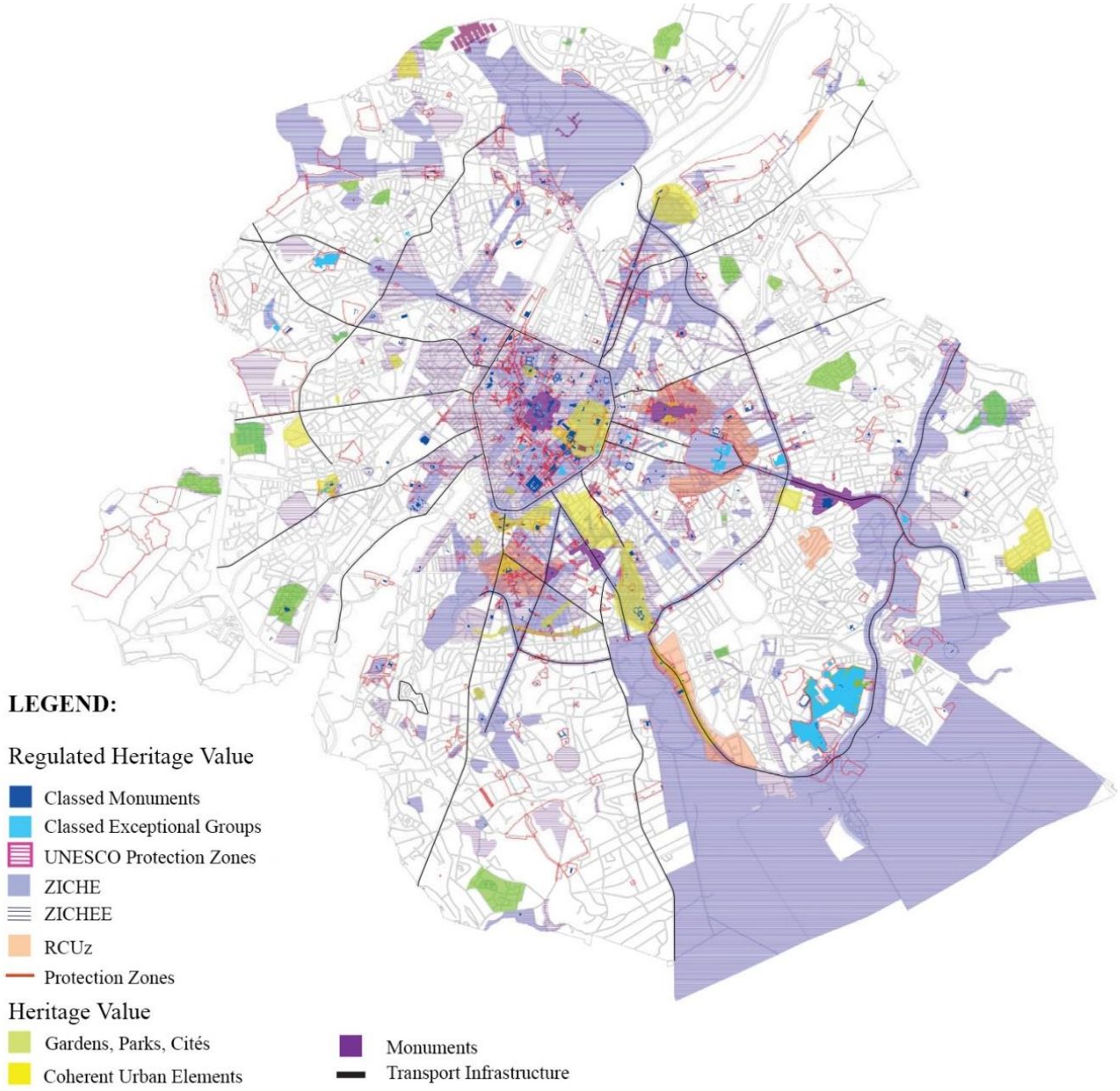
All these factors (Figure 30; Map 08) form a base of restrictive criteria for interventions on the urban fabric that covers part of the territory mainly inside of the Pentagon. Outside the historical city center, a real wealth of heritage is located mainly in the eastern part of the first crown: monuments, coherent groups of elements, RCUz[20], etc. The western part is slightly poorer of monuments but rich in industrial tradition and buildings. The second crown is characterized by several zones of protection. The large parks and gardens of Brussels are located in the peripheral areas of the region.

These are restrictive criteria for Urban Densification of the frame, but they do not prohibit a complete densification. However, special requirements must be adopted in order to intervene while respecting the regulations and without distorting the assets.

[20] *For more info visit:* *https://www.bruxelles.be/sites/default/files/bxl/Travaux%20et%20Mobilit%C3%A9/Mobilit%C3%A9/RCUzon%C3%A9-siteVille_Unesco.pdf*

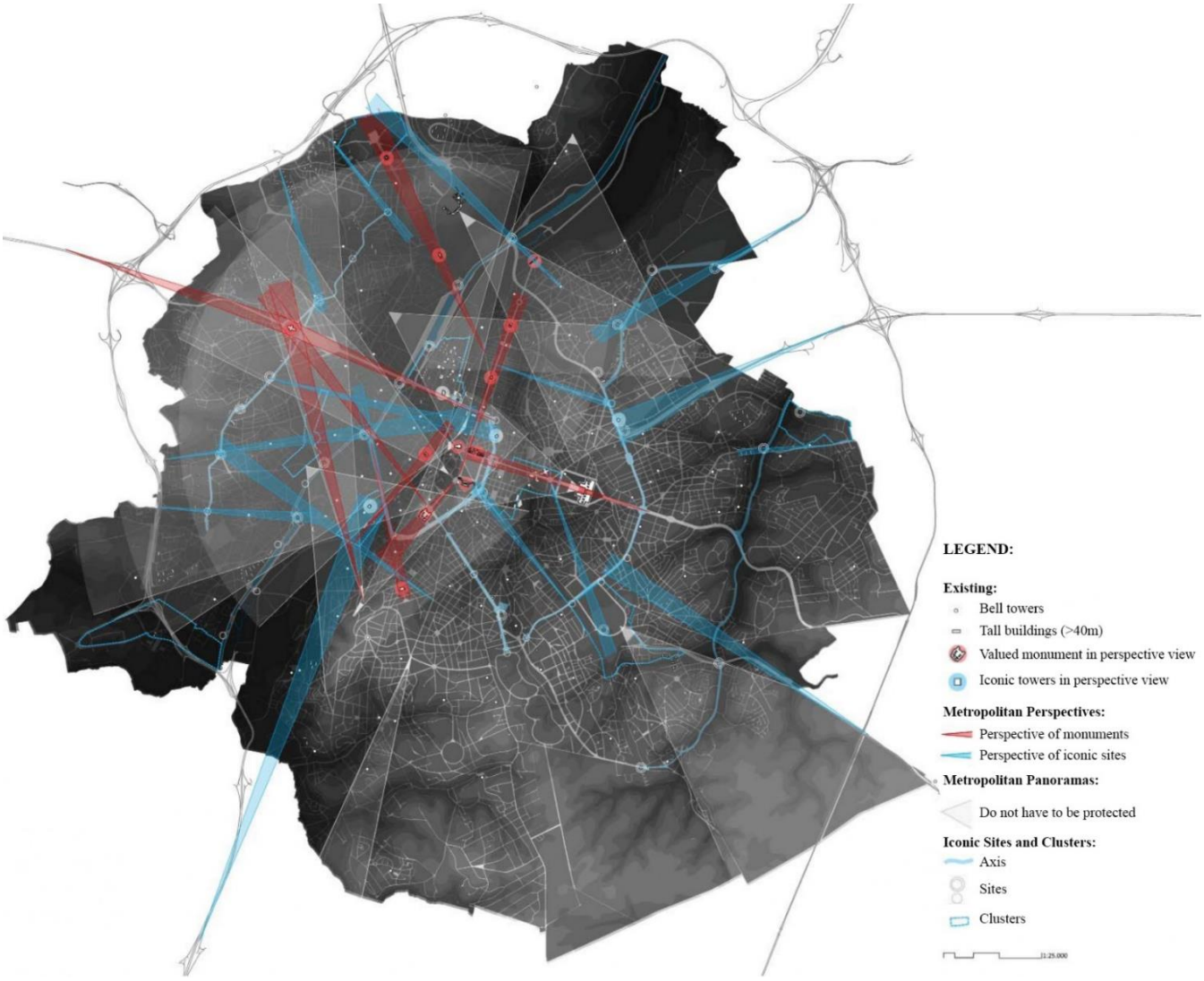
Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 08: Remarkable Heritage in the BCR.

Source: Extracted from page 74, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 09: View cones and landscape in the BCR.

Source: Study office of BUUR, 2012 (Edited by the thesis Author).

View cones are important to conserve for a historical city like Brussels. The skyline of historical center and sites around the neighborhoods give the identity of the city. It should not be modified under any circumstances.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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ii. Programmatic Criteria:

The criteria considered in this section focuses on 4 types of zoning:

1. Green areas accessibility;
2. Areas with flooding risk;
3. Areas with acoustic annoyance;
4. Areas with technological risks.

1. Green areas accessibility:

The figures rank Brussels among the greenest capitals in Europe. The question therefore relates more to the distribution of these green spaces and their accessibility to the public.

In the context in which there is a challenge in the accessibility of green areas, it is desirable that the densification of buildings is accompanied by the development of green spaces. This should ensure a green openness to the public and consider improving the accessibility to existing green areas (*Inventaire des lieux de densification potentielle de la RBC*).

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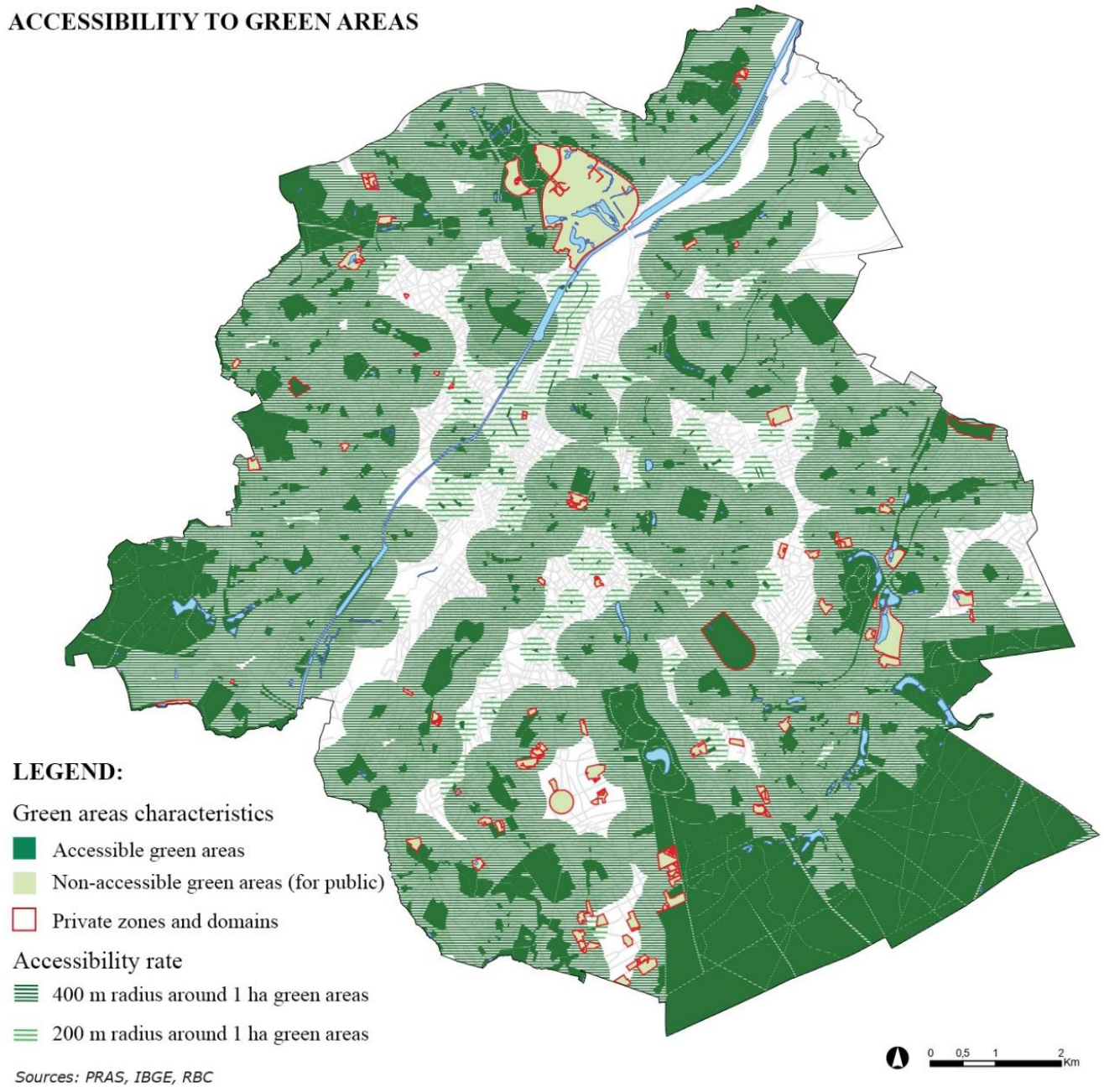

Map 10: Green areas accessibility in the BCR.

Source: Extracted from page 74, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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Aim:

- The Map 10 makes it possible to locate the green spaces accessible to the public in the BCR, and to make a distinction according to their size. It locates the areas of plant reinforcement, where there is a need to create green spaces, or even improve public accessibility to these spaces.

Methodology:

- Green areas shown in Map 10 are those assigned to green zones in the PRAS and by the BCR consultancy (e.g. the campus of La Plaine).

- Private spaces are considered according to two sources: the PRAS[21] and the IBGE[22] study entitled "the components of the green network".

- Non-accessible green spaces are defined on the basis of private domains as defined by the PRAS and by the BCR consultancy.

- Radius of 400 m is taken into account around the accessible green areas of more than one hectare, corresponding to a journey five minutes on foot. COOPARCH-RU assumed in this study that the radiation of the green spaces of less than one hectare is less important, hence the application an accessibility radius reduced by half.

Critic:

- The Map 10 does not take into account the cut in accessibility constituted by the canal (water) that crosses green areas.

[21] *For more info visit: https://urbanisme.irisnet.be/lesreglesdujeu/les-plans-daffectation-du-sol/le-plan-regional-daffectation-du-sol-pras*

[22] *For more info visit: https://be.brussels/about-the-region/regional-bodies/bruxelles-environnement-ibge*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Result Overview Analysis:

- There are nearly 4,000 ha of green spaces in the BCR (representing nearly 25% of the territory). The green density per inhabitant is about 36 m² / inhabitants. These figures rank the Brussels Region among the greenest capitals in Europe (*Inventaire des lieux de densification potentielle de la RBC*).

- Forest and agricultural areas represent half of the green spaces in the region.

- The sectors of plant/green reinforcement are located:

> Along the canal;

> In a space going from the canal to the level of Tour et Taxis to Jette/Ganshoren;

> Along a series of roads: Charleroi – Brugman - Alsemberg south;

> Along boulevard Saint-Michel;

> Along NATO;

> Along other sites of smaller surface.

2. *Areas with flooding risk*

In these flood-prone areas, building densification must be accompanied by the necessary measures to protect buildings against flooding. Particular attention must be paid to limit the impermeability of the ground.

3. *Areas with acoustic annoyance risk*

In these areas, the densification of buildings must be accompanied by the necessary measures to promote protection against acoustic disturbances. These areas are defined in the "Transport noise" study (IBGE).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

4. *Areas with technological risk*

Near industrial zone it is crucial to strengthen analysis of the possible environmental risks.

iii. Localization Criteria:

Localization criteria is related to mobility and accessibility. It takes into account as well the criteria linked to metropolitan polarities.

The mobility study was based on the Flemish study bureau TRITEL project with a perspective for the 2020 development of the BCR public transport.

Concerning the metropolitan polarities, the sites of the major urban projects were taken into account. These major projects carry the development dynamics. They involve in their dynamics the surrounding districts and their influence go beyond the limits of the scope of a considered project. Taking this phenomenon into account leads to a very careful analysis of the capacity to fill or restructure these surrounding districts.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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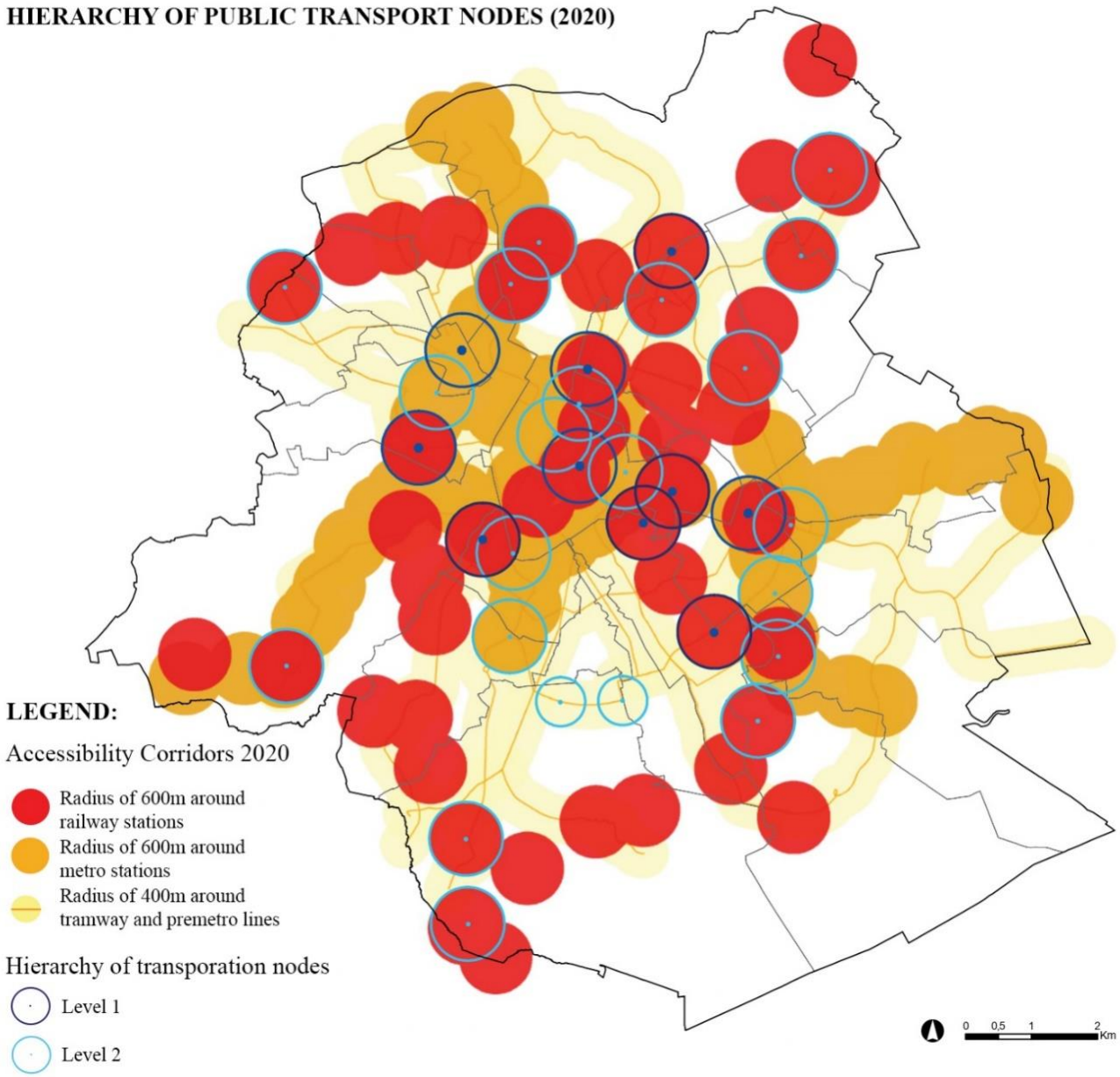


Map 11: Hierarchy of public transport for 2020 in the BCR.

Source: Extracted from page 80, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Methodology:

- The Map 11 is based on the TRITEL study for the hierarchy of transport nodes. The nodes taken into account here are the nodes level 1 and 2 of the projected situation.

- A radius of 600 m around "heavy and busy" stations (train stations and metro) is chosen. It represents the pedestrian accessibility of these knots. A radius of 400 m is taken into account for trams and the premetros (less heavy).

Result Overview Analysis:

- The public transport network is structured by the main stations serving the Pentagon and its surroundings: central station, northern station, southern station, western station, etc.

- The Pentagon, then the western, eastern and southern fringes seem be the best served areas.

- On the external part of the Pentagon, the railway and metro network ensures good accessibility along their routes.

- The least served sectors are the large forest and agricultural areas, as well as the following zones:

> The south of Uccle;

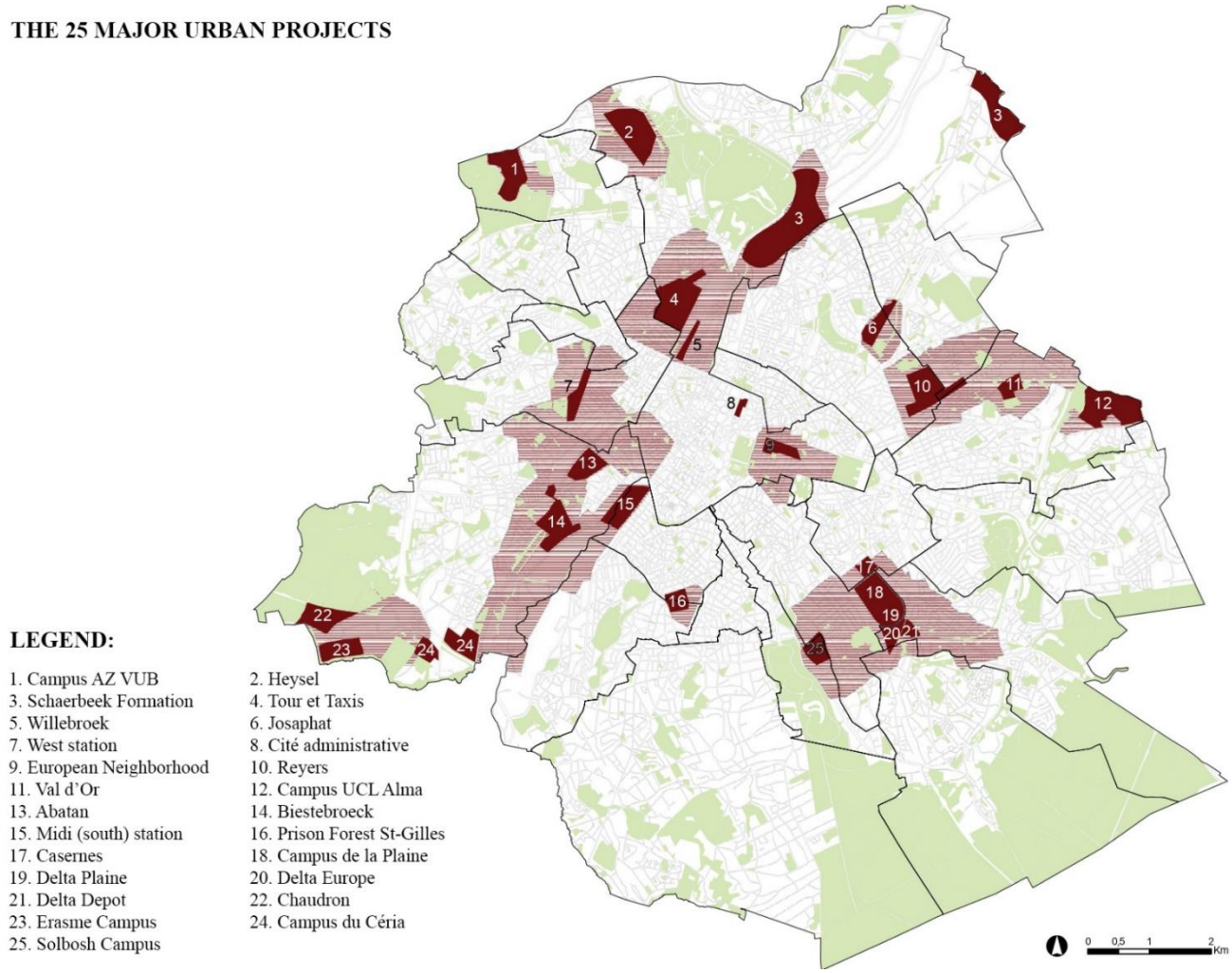
> The west of Molenbeek-saint-Jean;

> Berchem-sainte-Agathe;

> Hembeek and Industrie Nord districts;

> Paduwa and Brussels Cemetery districts.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 12: The 25 major urban projects in the BCR.

Source: Extracted from page 81, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Methodology:

- The map 12 is based on the PRDD study.

- Based on the BCR consultancy the list of projects has been extended beyond the PRDD: e.g. the Barracks site or the former Maneuver Plain has been added (*Inventaire des lieux de densification potentielle de la RBC*).

Critic:

- It is impossible to strictly delimit the areas influenced by major urban projects, nor the surrounding context fabrics of influence. This implies that the areas indicated on the map are only hypothetically indicative and do not have strict limits.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

c. Mapping and Programming: Building and Population Density

This section will discuss the following:

1- General principles of building densification in urban zones based on the existing typo-morphology;
2- Urban Densification by criteria (programming and adding detailed criteria layers for the general Map).

Methodology:

- COOPARCH-RU proposes according to the different components of the territory, a "minimum construction density" (minimum P/S)[23] for new projects (the new constructions or major renovations).

- The minimum construction density (minimum P/S) would be applied to all built or buildable areas, taking into account the zoning and their land use.

- The main programming methodology in this section starts with map titled "General Principles of Density." It will form a basic plan to subsequently carry out densification procedures according to different priority criteria.

---

[23] *Plancher/Surface | or Total Floor area/Land area. The total floor area considered in the P/S calculation excludes the floor area of spaces with less than 2.2m of clear height and basement spaces that are used for technical equipment or as storages.*

Absolute P/S: sum of building densities per block / number of blocks – e.g. $\left(\frac{a}{b} + \frac{c}{d}\right)\Big/_2$

Average P/S: sum of the floor areas / sum of the area of blocks – e.g. $(a + c)\Big/_{(b + d)}$

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

- Further maps will work with multiple layers corresponding to the different densification prioritization criteria.

- Green areas (PRAS) are excluded from this part of the study, even if some may contain built elements.

- Water lines and elements are excluded by their "non ædificandi" character (non-buildable areas).

i. General Principles: Existing P/S

- According to each typo-morphology, a minimum P/S is applied based on the calculation of a reference P/S for each urban area of the territory.

- In case of a building restoration or its identical reconstruction, the existing P/S will be maintained.

- Three major typo-morphological zones are identified. The definition of these zones is directly related to their urban physical forms.

Three P/S typo-morphological orders are identified for existing building density:

1. Closed order: minimum P/S = 1.

This is the threshold value for the transition towards closed order. This allows managing densification within the framework of an already relatively dense urban fabric with existing P/S greater than or equal to 1 ($P/S \geq 1$).

In this typo-morphological order some of the blocks are distinguished by their location in highly dense built environment. They can be identified under "Closed order with high density". They correspond to parcels located in statistical sectors whose existing P/S exceeds

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- Zoom in while using the thesis digital version to see more details in the drawings.

2.1. Generally these blocks are found in the central part of the City. This area has a minimum P/S = 1.85.

2. Semi-open order: minimum P/S = 0.7.

This ratio makes it possible to manage densification within the framework of urban fabric that presents an existing P/S of approximately 0.5 (managing blocks with existing P/S ≥ 0.5).

3. Open order: minimum P/S varies.

In this large zone order, three sub-order sections can be identified by their location and function characteristics:

> Open order – industrial fabric: no P/S (correspond to ZEMU).
> Open order – high-rise and relatively high buildings: no P/S.
> Open order – relatively low buildings: minimum P/S = 0.5.

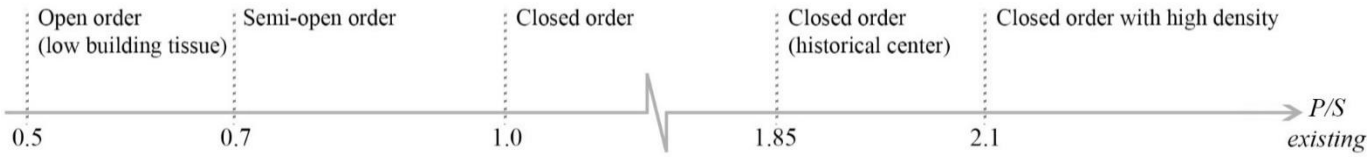
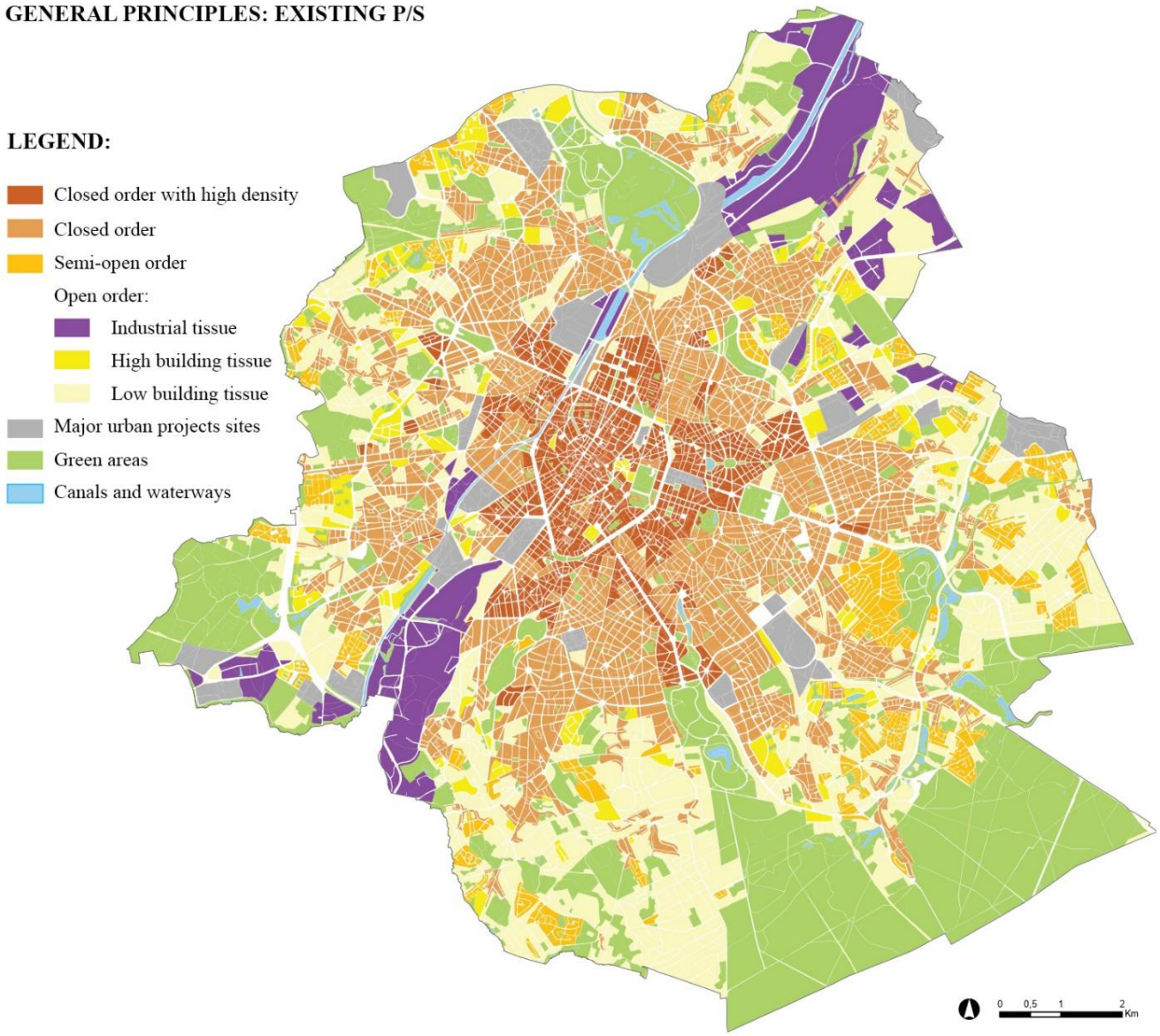


Figure 31: Scheme showing the existing building density orders (P/S) in the BCR based on general principles.

Source: Produced by the Thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 13: General Urban Densification principles: P/S typo-morphological orders in the BCR.

Source: Extracted from page 86, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

There are several methods for calculating population density. This study adopted the method of number of inhabitants per hectare (inhabitants/ha).

However, the size of buildings and Housing units varies vastly depending on the location around the BCR. The distribution of the population in a specific context is directly linked to the territorial capacities. These capacities are linked to the physical characteristics of the territory.

As part of the recent Housing operations in the BCR, COOPARCH-RU proposed to define the minimum thresholds of population density assigned to "urban areas", according to the typo-morphology of buildings:

- Closed order: density of 150 inhabitants/ha (corresponding to the average population density for these zones typology).

-Open and Semi-open orders: density of 60 inhabitants/ha (corresponding to the average population density for these zones typology).

ii. Densification by Criteria: Proposed P/S

All the criteria mentioned in the Territorial Prioritization section are either favorable or restrictive for Urban Densification. The criteria in this section will be added as additional Mapping layers above the main general principles shown in Map 10. This will result in new recommended P/S values for each zone, and eventually lead to the creation of a Delta Map showing the differential between the values of recommended P/S and existing P/S values. Hence, the inventory will precisely identify the potential Urban Densification in specific zones accompanied by a quantization study.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

One of the favorable criterion for densification is the proximity of public transport. The poles of mobility therefore appear as conducive spaces to strengthen the density. The areas selected according to the criteria of accessibility were established in correspondence with the project for the development of public transport (TRITEL[24], 2020). Accessibility corridors have been developed along the Metro and RER[25], which correspond to a radius of 600 m around these metro stations and railway stations.

In these accessibility corridors, COOPARCH-RU proposed different P/S values according to the different morphology orders:

- Closed order with high density: Minimum P/S = 2

- Closed order: Minimum P/S = 1.85

- Semi-open order: Minimum P/S = 1.3

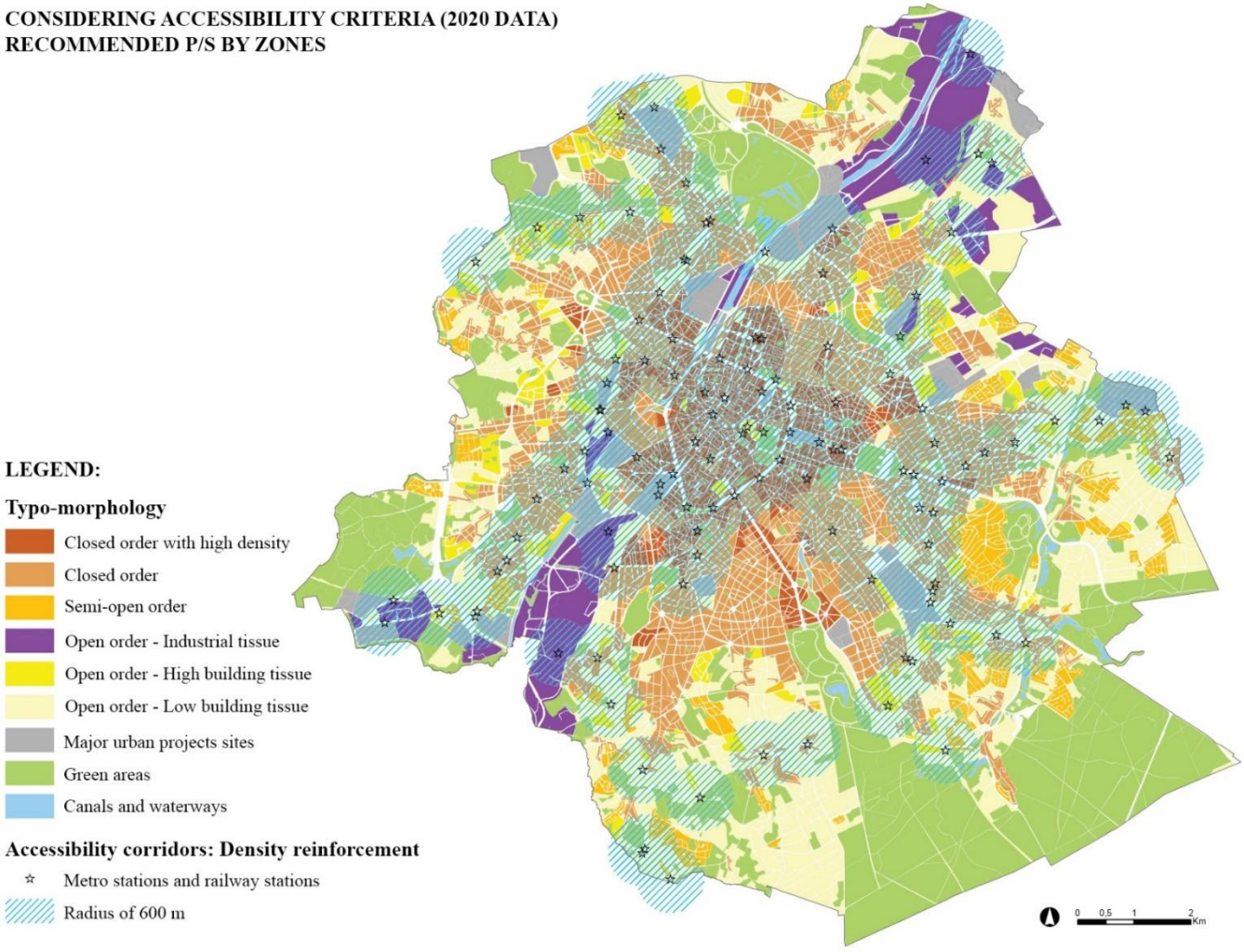
- Open order:

> Open order – industrial fabric: no P/S recommended.
> Open order – high-rise and relatively high buildings: no P/S recommended.
> Open order – relatively low buildings: minimum P/S = 0.8 (below the transition threshold to closed order ≤ 1).

[24] *For more info visit:* *https://opentender.eu/be/company/EU_body_ec74cf27d0142157e030094b0563032948bca5a95f46725753785d4a1c590650*

[25] *For more info visit:* *https://www.moustique.be/actu/belgique/2022/04/27/ou-en-est-le-rer-voici-ce-qui-coince-236014*

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 14: Accessibility criteria consideration: Recommended P/S typo-morphological orders in the BCR.

Source: Extracted from page 89, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

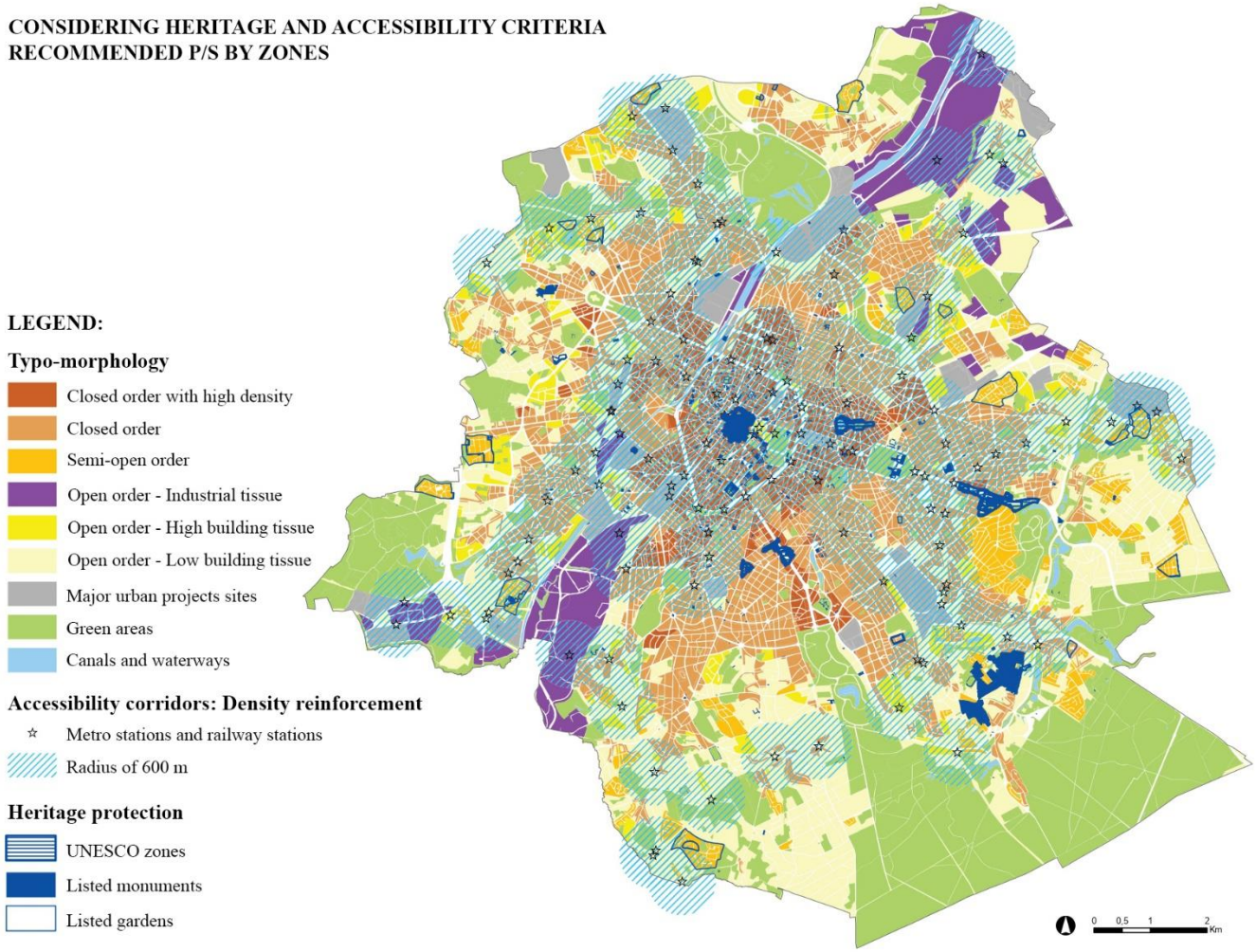
Another criterion but a restrictive one, is the heritage protection perimeters. In the UNESCO perimeters and listed monuments and gardens, it is highly suggested to respect the existing P/S.

Generally while respecting the "general" P/S of the zone, an upward review or recommendation of the P/S can be done but subject to a prior opinion from the DMS and CRMS consultancies:

4. In the legal protection zones around listed monuments;
5. In view cones (shown in BUUR study, see Map 06);
6. In the ZICHE and ZICHEE.

In the following Map 15, another layer represented by the “heritage” restrictive criterion is added to the results of the previously shown Map 14 that represented the favorable criterion of “accessibility and proximity of public transport”.

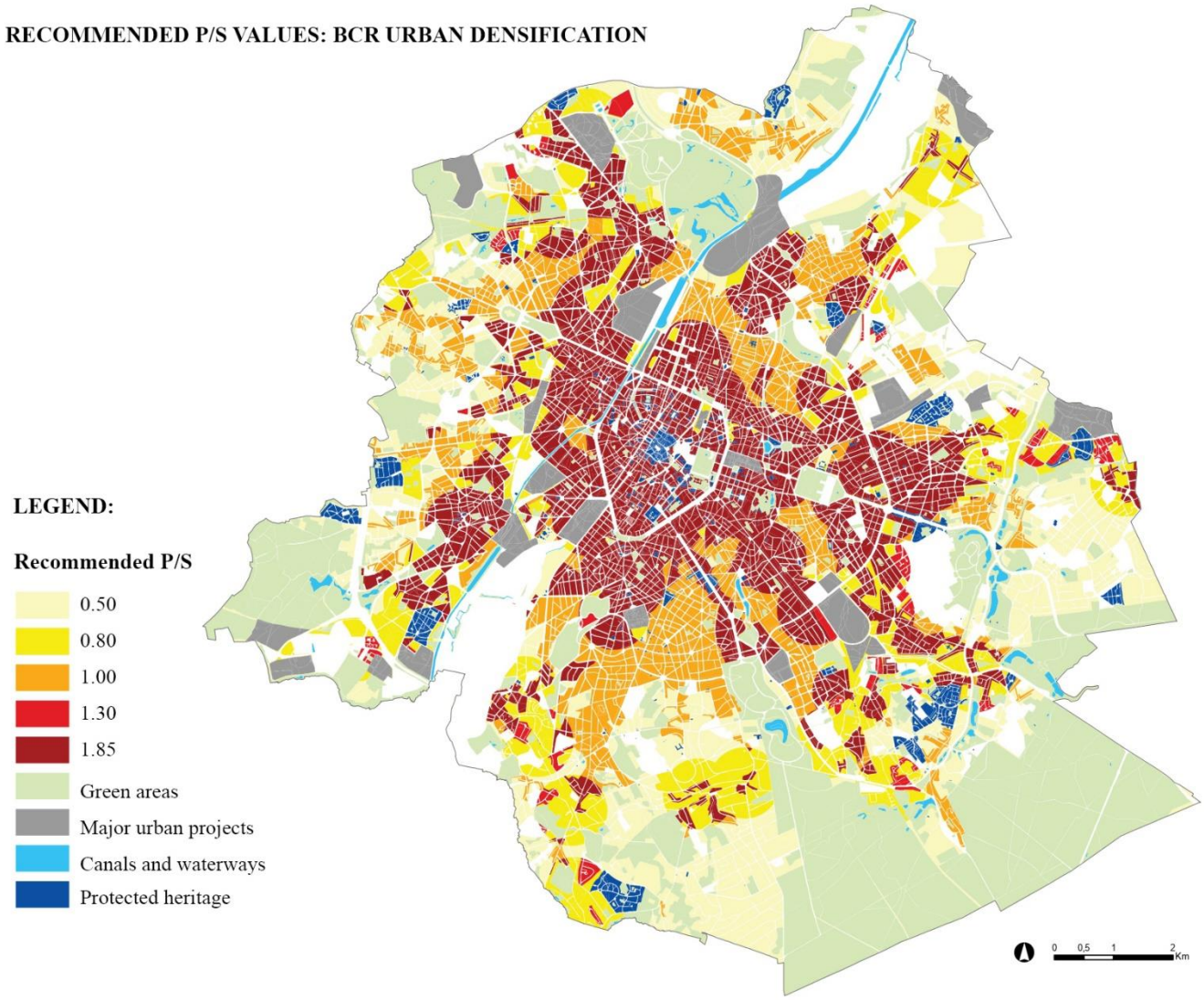
Note: - Refer to the Glossary section at the beginning of this Master’s Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 15: Heritage and Accessibility criteria consideration: Recommended P/S typo-morphological orders in the BCR.

Source: Extracted from page 91, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

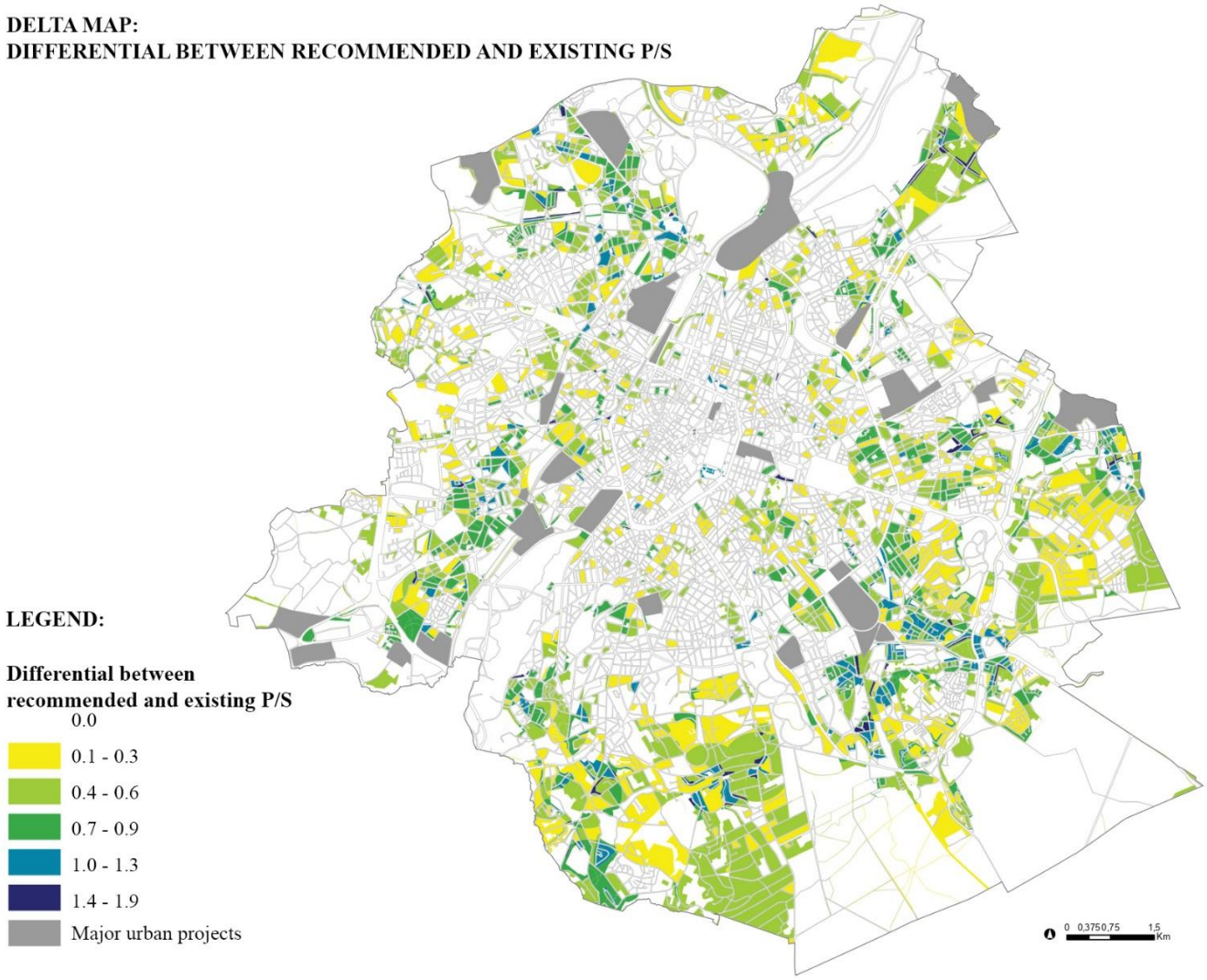
Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 16: Recommended P/S values in the BCR.

Source: Extracted from page 92, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.



Map 17: Differential value between the recommended and existing P/S in the BCR.

Source: Extracted from page 93, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Both the Maps 16 and 17 represent an overview to conclude the building density section.

Map 16 shows the recommended P/S values which can be translated in a way into the maximum potential of densification that is recommended in the study based on all of the previous Mapping.

Map 14 shows the differential values between the recommended P/S values (Map 16) and the existing P/S values (Map 13). In another way: Map 17 Δ = Map 16 – Map 13. These values shown in Map 17 are of crucial importance. They represent the exact value of additional densification that each zone of the city can still bear. Map 17 translates and clarifies the maximum potential of Urban Densification in terms of P/S. It shows which building blocks can have a bigger intervention with higher density intake, and which ones can have more lightweight interventions in order to reach the desired densification goals. This is a step further to knowing which type of projects can be done in each of the highlighted potential zones.

d. Quantization of Urban Densification Potential

In this last part of the inventory, COOPARCH-RU conclude an estimate of the additional number of inhabitants that the BCR can take based on the potential Urban Densification study. These estimates are based on the study Mapping and its criteria. The other general guidelines taken into account in this estimation are:

- Neighborhoods that lost population between 1981 and 2008, because these neighborhoods have the capacity to accommodate the lost population.

- The potential increase in size of buildings by vertical upper extensions and other methods (shown in Urban Densification methods section).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

- Car parking of more than 1,000 m², which present a great territorial opportunity easy to use.

- Buildings with one floor area of more than 800m² that occupy large terrains. Demolition-reconstruction operations can make it possible to achieve higher densities although it is not the most sustainable solution.

- Buildings facing the street present particularly significant opportunities.

- Voids between built blocks which offer empty lands.

- Large and sparsely populated blocks that correspond to green and semi-open buildings on which the interventions can be mainly done by restructuring the urban fabric.

General Quantization Methodology:

- This part of the study is a calculation in form of an estimation and may not refer to 100% accurate results.

- The proposed method is based on a double approach. These two approaches are depending on whether one is ***inside*** or ***outside*** the accessibility corridors.

- Heritage protection zones (UNESCO Zones, Monuments, or Classified Groups and Gardens) are not considered in the calculation.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

i. Outside the accessibility corridors

Methodology:

- The approach is based on the recommended P/S[26] (building density section), according to the typo-morphology of the fabric:

> Closed order with high density: P/S = 1.85

> Closed order: P/S = 1.00

> Semi-open order: P/S = 0.70

> Open order (low urban fabric): P/S = 0.50

> No recommendation in open order for industrial fabric and tall buildings.

- In each parcel the floor area differential is calculated between the existing and the recommended P/S.

If the existing P/S is greater than or equal to the recommended P/S, the floor area differential is equal to 0 m². If the existing P/S is less than the recommended P/S, the floor area differential is calculated in |x| m².

[26] *Plancher/Surface | or Total Floor area/Land area. The total floor area considered in the P/S calculation excludes the floor area of spaces with less than 2.2m of clear height and basement spaces that are used for technical equipment or as storages.*

Absolute P/S: sum of building densities per block / number of blocks – e.g. $\left(\frac{a}{b} + \frac{c}{d}\right) \Big/ 2$

Average P/S: sum of the floor areas / sum of the area of blocks – e.g. $(a + c) \Big/ (b + d)$

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Example:

> Building block A (area = 100 m²) is in a closed order with high density. It has a P/S = 1.55.

The floor area differential is 100 x (1.85 - 1.55) = 30 m².

> Building block B (area = 200 m²) is in a closed order with high density. It has a P/S = 2.00.

The floor area differential is zero.

> From the area obtained, a coefficient of 30% is deducted. It is estimated that out of 100 m² of surface area, 30 m² will be intended for the green spaces or other equipment).

> Based on the obtained differential area an estimate of additional inhabitants is concluded.

- The population estimate is based on two assumptions:

> The high estimate is based on an average of 35 m² / inhabitant (average area observed in 2001 in the BCR by the Monitoring of neighborhoods).

> The low estimate is based on an average of 42 m² / inhabitant (reference area from the PRDD, which is based on an average of 90 m² / house and 2.1 inhabitants / household).

Results:

	Area (ha)	Absolute average P/S	Median P/S	Recommended P/S	Floor area differential (m^2)	High inhabitants estimation taking 35 m^2/inhabitant	Low inhabitants estimation taking 42 m^2/inhabitant
Closed order with high density	180	2.33	2.23	1.85	190,230	3,805	3,171
Closed order	1,254	1.38	1.54	1.00	905,128	18,103	15,085
Semi-open order	346	0.52	0.50	0.70	759,879	15,198	12,665
Open order	1,964	0.43	0.46	0.50	3,219,310	64,386	53,655
Subtotal	3,744	-	-	-	5,074,547	101,491	84,576

Table 06: Estimations of the additional number of inhabitants that the BCR can take outside the accessibility corridors.

Source: Produced by the thesis Author (based on the numbers of COOPARCH-RU inventory).

The high inhabitants estimate (35 m^2 / inhabitant) shows that the BCR can contain 101,491 inhabitants outside the accessibility corridors. On the other hand, the low inhabitants estimate shows that this number stands at 84,576 inhabitants. It is important to underline again that this estimation is based on the study outside the accessibility corridors and without taking into account the territorial opportunities offered by the typo-morphology in some parts of the BCR context (Map 18).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

ii. Inside the accessibility corridors

Methodology: (taking into account the territorial opportunities)

The territorial opportunities considered in this part are shown in Map 18.

- Main territorial opportunities:

> Voids between built blocks which offer empty lands;

> One floor buildings with an area over 800 m² and facing the street;

> Parking lots of more than 1000 m².

To this sum in m² of floor area is applied the P/S recommended for each typo-morphology.

- Formula: Floor area differential = sum in m² of opportunities x recommended P/S.

- The estimate per inhabitant takes into account a coefficient of 30% (same applied for the afore-mentioned methodology outside the accessibility corridors) and is based on an average area of 35 m² / inhabitants.

- For the potential increase in size (i.e. vertical extensions), the estimated surface in m² corresponds to an additional level. Therefore, the P/S does not apply: the additional area corresponds to the floor area.

- The high and low estimations of inhabitants that the BCR can contain inside the accessibility corridors use as well the same criteria used previously.

Results:

	Voids between built blocks (surface area in m^2)	One floor buildings with an area over 800 m^2 (surface area in m^2)	Parking lots of more than 1000 m^2 (surface area in m^2)	Subtotal (m^2)	Recommended P/S	Floor area differential (m^2)	Increase in size by building extensions (surface area in m^2)	High inhabitants estimation taking 35 m^2/inhabitant	Low inhabitants estimation taking 42 m^2/inhabitant
Closed order with high density	24,832	65,376	6,179	96,387	2.00	192,774	699,245	2,834	19,862
Closed order	76,703	195,868	13,666	286,237	1.85	529,538	1,804,028	62,134	51,779
Semi-open order	3,868	4,142	0	8,010	1.30	10,413	13,293	588	490
Open order	80,268	206,963	48,836	336,067	0.80	268,854	499,539	19,650	16,375
Subtotal	185,671	472,349	68,681	726,701	-	1,001,579	3,016,105	106,206	88,505

Table 07: Estimations of the additional number of inhabitants that the BCR can take inside the accessibility corridors (while considering the territorial opportunities).

Source: Produced by the thesis Author (based on the numbers of COOPARCH-RU inventory).

Overview of the results shown in the tables 06 and 07:

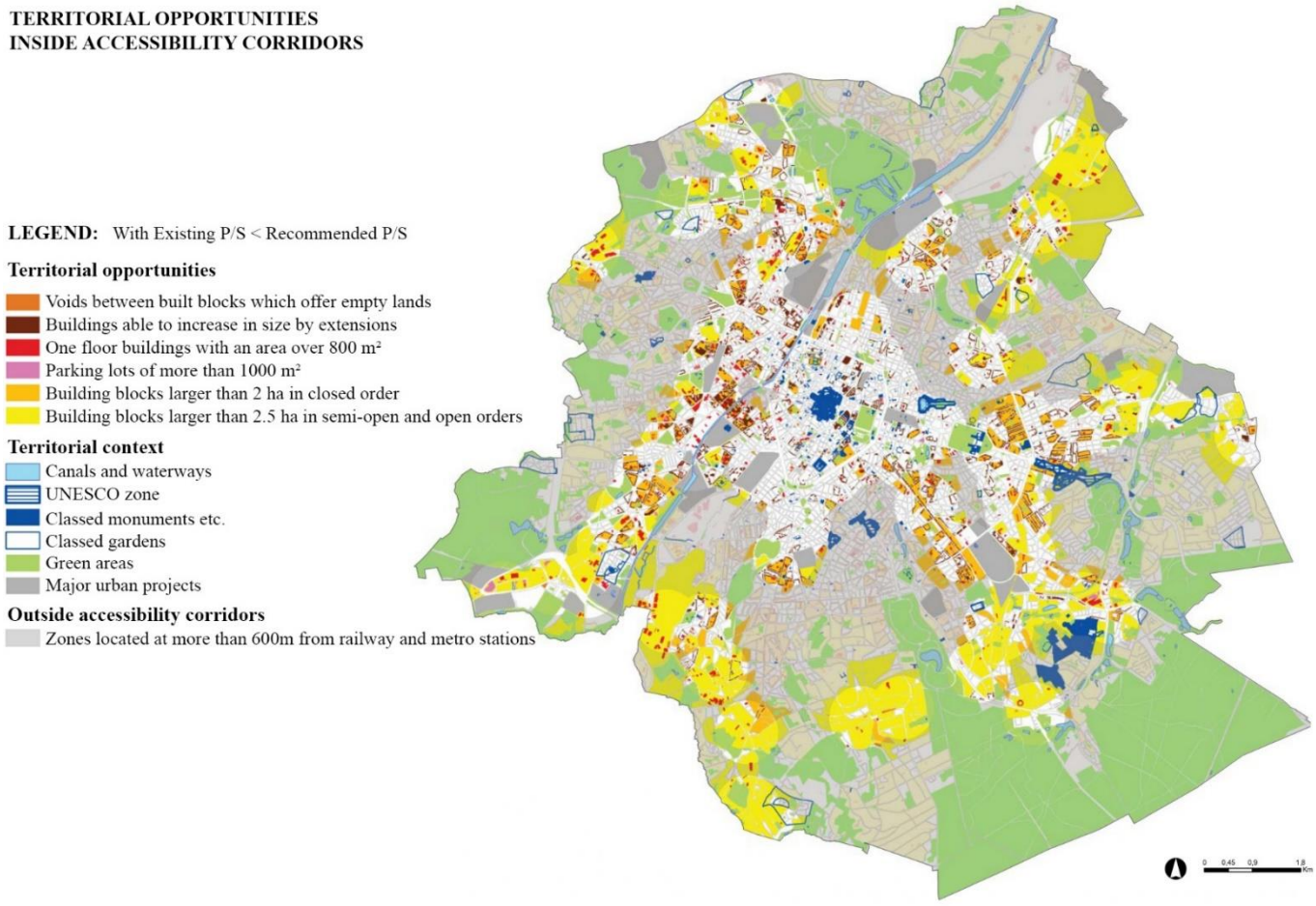
- The estimated inhabitants number that the BCR can potentially contain inside the accessibility corridors while taking into account the territorial opportunities is higher than the one for the study outside the accessibility corridors.

- High estimate: 101,491 inhabitants (outside accessibility corridors) < 106,206 (inside accessibility corridors with territorial opportunities).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

- Low estimate: 84,576 inhabitants (outside accessibility corridors) < 88,505 (inside accessibility corridors with territorial opportunities).

- The estimations inside and outside the accessibility corridors added together represent the overall total potential number of inhabitants that the BCR can contain.



Map 18: Territorial opportunities in the BCR inside the accessibility corridors.

Source: Extracted from page 99, Inventaire des lieux de densification potentielle de la RBC (Edited by the thesis Author).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

iii. Overall Quantization Results and Conclusions

Overall Results

	Area (ha)	Absolute average P/S	Median P/S	Recommended P/S	Floor area differential (m^2)	High inhabitants estimation taking 35 m^2/inhabitant	Low inhabitants estimation taking 42 m^2/inhabitant
Infrastructure	2,625	-	-	-	0	0	0
Major urban projects	702	-	-	-	0	0	0
Canals and waterways	170	-	-	-	0	0	0
Green areas	3,944	-	-	-	0	0	0
Closed order with high density	861	2.83	2.90	-	190,230	27,639	23,033
Heritage zone	51	3.20	3.28	Existing P/S	0	0	0
Outside heritage zone	810	2.80	2.71	-	190,230	27,639	23,033
- Inside accessibility corridors	629	2.94	2.81	2.00	0	23,834	19,862
- Outside accessibility corridors	180	2.33	2.23	1.85	190,230	3,805	3,171
Closed order	2,789	1.45	1.62	-	905,128	80,237	66,864
Heritage zone	27	1.33	1.57	Existing P/S	0	0	0
Outside heritage zone	2,762	1.45	1.62	-	905,128	80,237	66,864
- Inside accessibility corridors	1,508	1.51	1.66	1.85	0	62,134	51,779
- Outside accessibility corridors	1,254	1.38	1.54	1.00	905,128	18,103	15,085
Semi-open order	659	0.51	0.49	-	759,879	15,786	13,155
Heritage zone	187	0.47	0.48	Existing P/S	0	0	0
Outside heritage zone	472	0.53	0.50	-	759,879	15,786	13,155
- Inside accessibility corridors	126	0.56	0.50	1.30	0	588	490
- Outside accessibility corridors	346	0.52	0.50	0.70	759,879	15,198	12,665
Open order – Industrial tissue	941	0.49	0.50	-	0	0	0

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

Heritage zone	0	-	-	Existant P/S	0	0	0
Outside heritage zone	941	0.49	0.50	-	0	0	0
- Inside accessibility corridors	226	0.58	0.62	Existant P/S	0	0	0
- Outside accessibility corridors	715	0.46	0.43	Existant P/S	0	0	0
Open order – High buildings	461	1.17	1.28	-	0	0	0
Heritage zone	4	2.50	2.64	Existant P/S	0	0	0
Outside heritage zone	457	1.16	1.28	-	0	0	0
- Inside accessibility corridors	222	1.23	1.28	Existant P/S	0	0	0
- Outside accessibility corridors	235	1.09	1.24	Existant P/S	0	0	0
Open order – Low tissue	3,106	0.52	0.55	-	3,219,310	84,036	70,030
Heritage zone	27	0.69	0.58	Existant P/S	0	0	0
Outside heritage zone	3,079	0.52	0.58	-	0	84,036	70,030
- Inside accessibility corridors	1,115	0.66	0.67	0.80	0	19,650	16,375
- Outside accessibility corridors	1,964	0.43	0.46	0.50	3,219,310	64,386	53,655
Subtotal	16,258	-	-	-	-	207,697	173,082

Table 08: Estimations of the additional number of inhabitants that the BCR can contain in total and by order zones.

Source: Produced by the thesis Author (based on the numbers of COOPARCH-RU inventory).

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

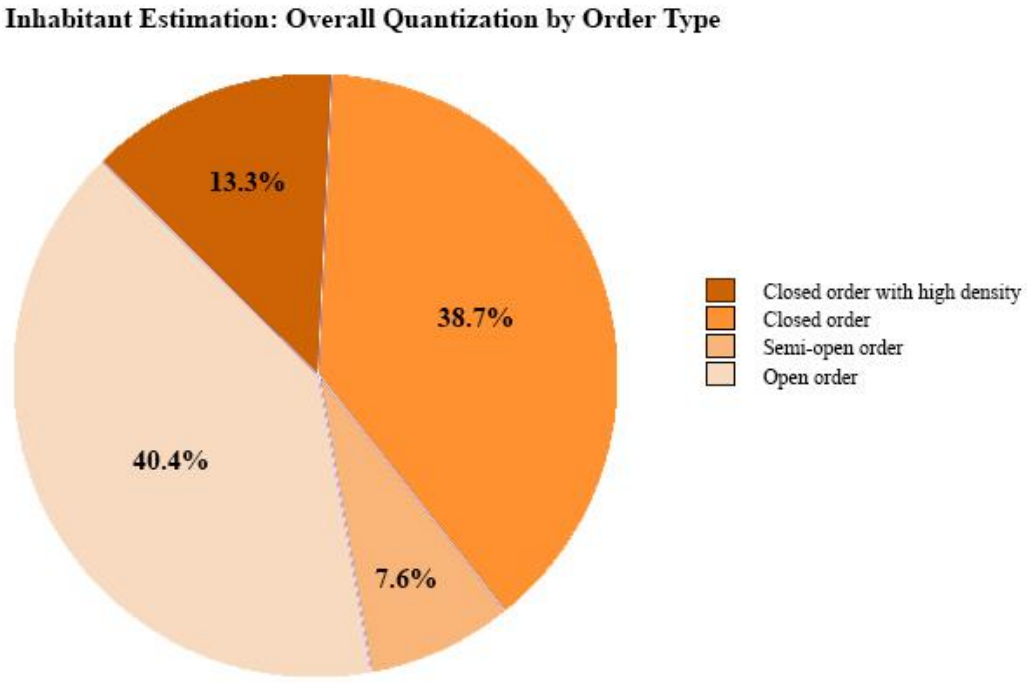


Figure 32: Circular diagram showing the percentage repartition of inhabitant estimation by typo-morphological orders.

Source: Produced by the thesis Author.

Conclusions and Comments:

- Table 08 shows a quantization of the number of inhabitants that the BCR can contain in each zone order. As well, it shows how many square meters of additional surface can be added to these zones while taking into account restrictive and favorable criteria.

- Figure 32 shows the percentage of the repartition of the estimated number that each typo-morphological order zone can contain in case of Urban Densification application. The diagram is for overall and total estimations. The repartitions (%) for both high and low

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estimation of inhabitants have the same percentages shown in the circular diagram in Figure 32. The diagram represents any of both scenarios.

- The total number that the BCR can potentially contain in case of such an adequate Urban Densification is 207,697 inhabitants for the high estimation and 173,082 inhabitants for the low estimation.

- The PRDD project for 2040 can be achieved based on the results obtained by this inventory. By 2040, the BCR population is projected to increase around 190,000. The high estimation results of the inventory quantization exceeds by far this number (207,697 > 190,000). While in case of a total Urban Densification based on a low estimation factor by giving more area / m^2 to each inhabitant, the result of the inventory may not be totally satisfactory to the 2040 population increase projection (173,082 < 190,000).

- It is worth mentioning that the inventory shoed the high and low value estimates exactly for the purpose of flexibility. While it is the duty of each individual architectural and smaller scale urban projects to contain the highest density while conserving the high quality of life. In some cases $35m^2$ / inhabitant will be considered while other contexts may consider $42m^2$ / inhabitant.

- COOPARCH-RU mention in the conclusion section of the inventory their subjective confidence that reasonably, the physical territory has the capacity to accommodate the projected population without significantly changing the identity and quality of life of the BCR.

- “After around a thousand years of existence, Brussels can demonstrate its ability as a city-region, to adapt, evolve and be resilient” (p. 105, *Inventaire des lieux de densification potentielle de la RBC*).

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13- Experimental Project Application: Implementing Urban Densification on Building Block Scale

a. Potential areas: Selected Zones and Parcels Characteristics (Based on the COOPARCH-RU Inventory)

This section is developed fully and exclusively by the thesis Author. It is an extension and an application of the conducted analysis and results by the COOPARCH-RU inventory on the parcel (building block) scale. As mentioned in the limitation section at the beginning of this thesis, the inventory's deep and detailed analysis and mapping stop at the building block level. There is no follow-up on that part. Hence, this section was developed by the thesis Author to propose an application of the feasibility of such Urban Densification Projects. It should ***not*** be confused with a project proposal, rather it is an experiment with different scenarios.

Two different building blocks are chosen from two different neighbors of the Brussels-Capital Region. Each block chosen has different urban morphology and type of building density, existing P/S, recommended P/S, functions, forms, heights, and characteristics. This choice is a conclusion from the layering of different mapping and analysis done in the inventory for the potential BCR densification.

Different methods of Urban Densification are applied in these different chosen context, as an experiment of these methods in a tangible and feasible way on a chosen parcel. These methods are a conclusion of the potentialities of the territory from the analysis done by COOPARCH-RU. These potentials are linked directly to the differential value of P/S. For example, one of the specific selected blocks can take much higher additional density than another, while having one of different potentials as a built-on empty spot, infill, backyard extension, upward or downward extension, roof transformation, etc. These potentials are of course based on the

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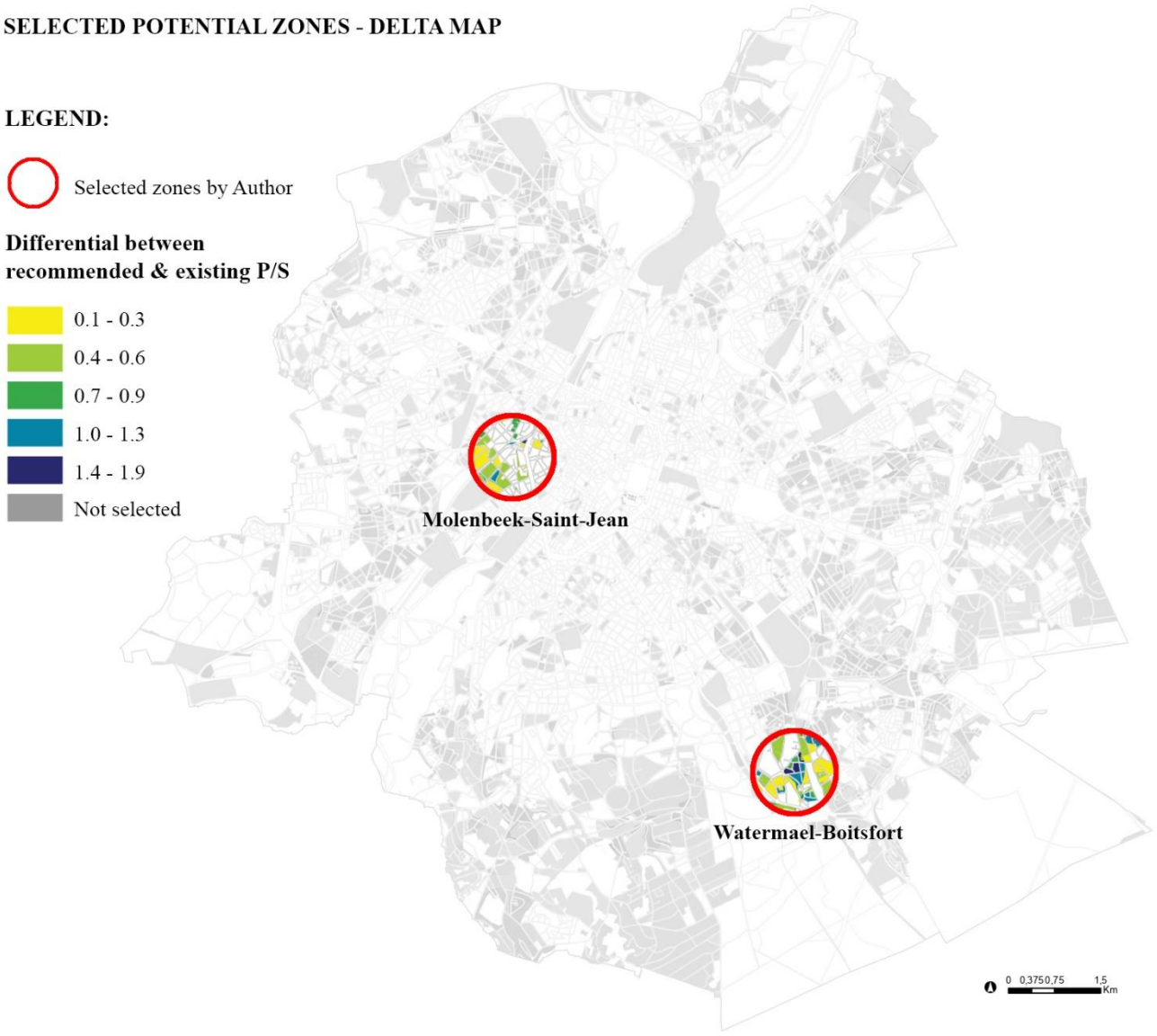
layering of maps (from the inventory), while complying with the different restrictions and regulations and taking into account the territorial opportunities.



Map 19: Selected zones for project application: differential value between the recommended and existing P/S.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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The two selected blocks (Map 19) are from the following zones:

- Molenbeek-Saint-Jean
- Watermael-Boitsfort

The first block selected is in Molenbeek-Saint-Jean: located to the West of the inner ring of Brussels (1km^2 of the zone shown in Map 20). This zone is very close to the historical center (directly on the inner ring border). It is characterized by a very high density of population and buildings. Molenbeek is one of the poorest and the densest neighborhoods in the region. The majority of its population are from foreign background, mainly Moroccans. It makes part of the low-income population concentration. The urban grid is clear, straight, strongly shown in angles on street intersections. Otherwise, the chosen block represents several territorial opportunities, which can offer high living standards and higher population containment potentialities (based on COOPARCH-RU inventory mapping and quantization).

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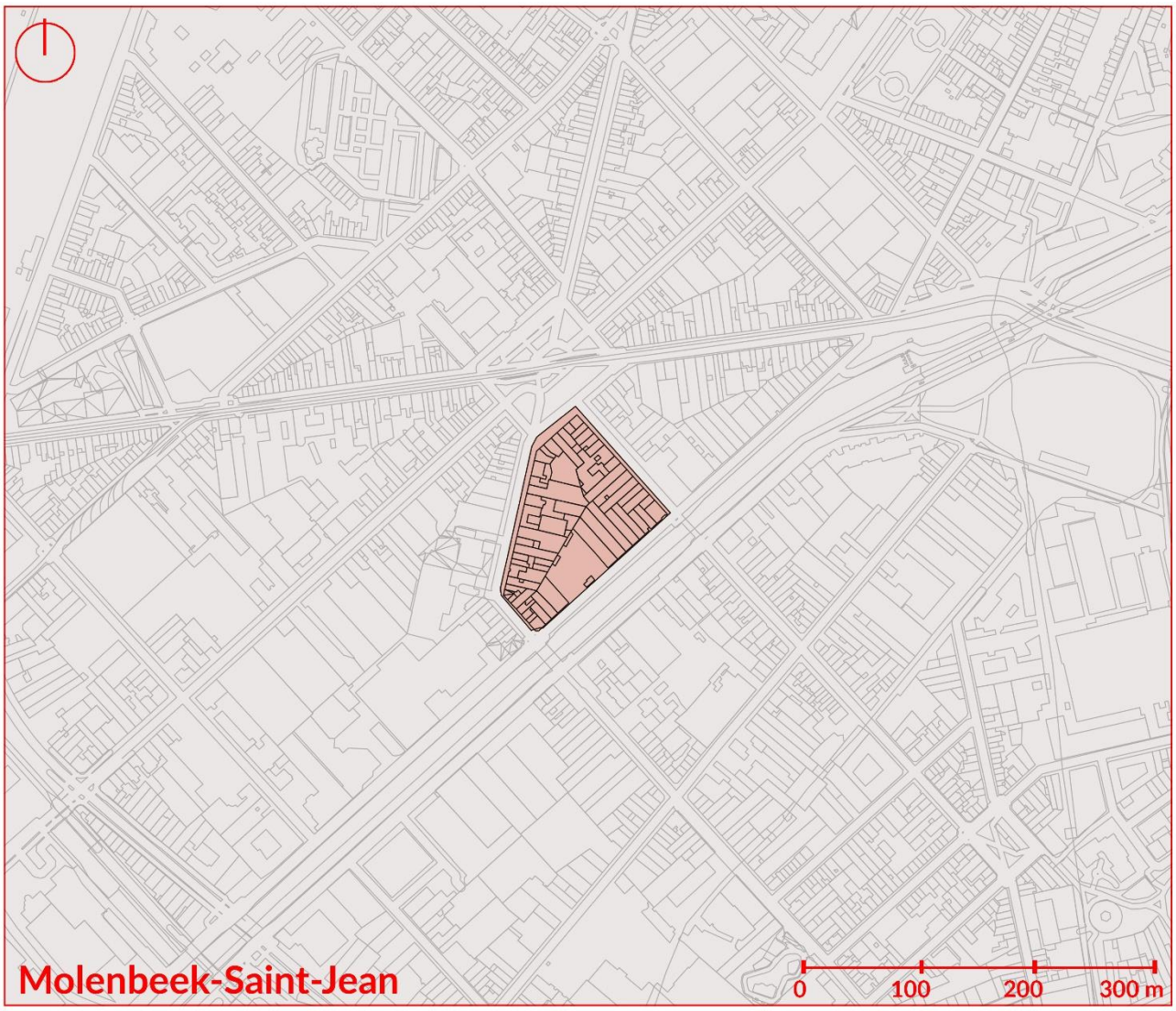

Map 20: Selected block in Molenbeek-Saint-Jean, Brussels - for Urban Densification application.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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The other block selected is in Watermael-Boitsfort (1km^2 of the zone shown in Map 21). It is located far from the central area of Brussels, to the South-East. It makes part of a green context with a significantly low density compared to the other two selected blocks. The zone is characterized by having a low density with single Housing and other private properties. The urban grid is more curvy and going with the green topography of the zone. Significant distances and empty parcels can be clearly spotted in this zone. That is why the Delta (differential) P/S is shown to be extremely high compared to the city center. The selected site can undergo several interventions, as it offers many territorial opportunities. Empty and flat land, single housing with enough separation and distancing between buildings. The intervention mainly should preserve this opportunity of having 3 to 4 facades for these buildings. If a densification of the block is complete to reach the maximum recommended density, it is a privilege and total success to have 3 to 4 facades for each building.

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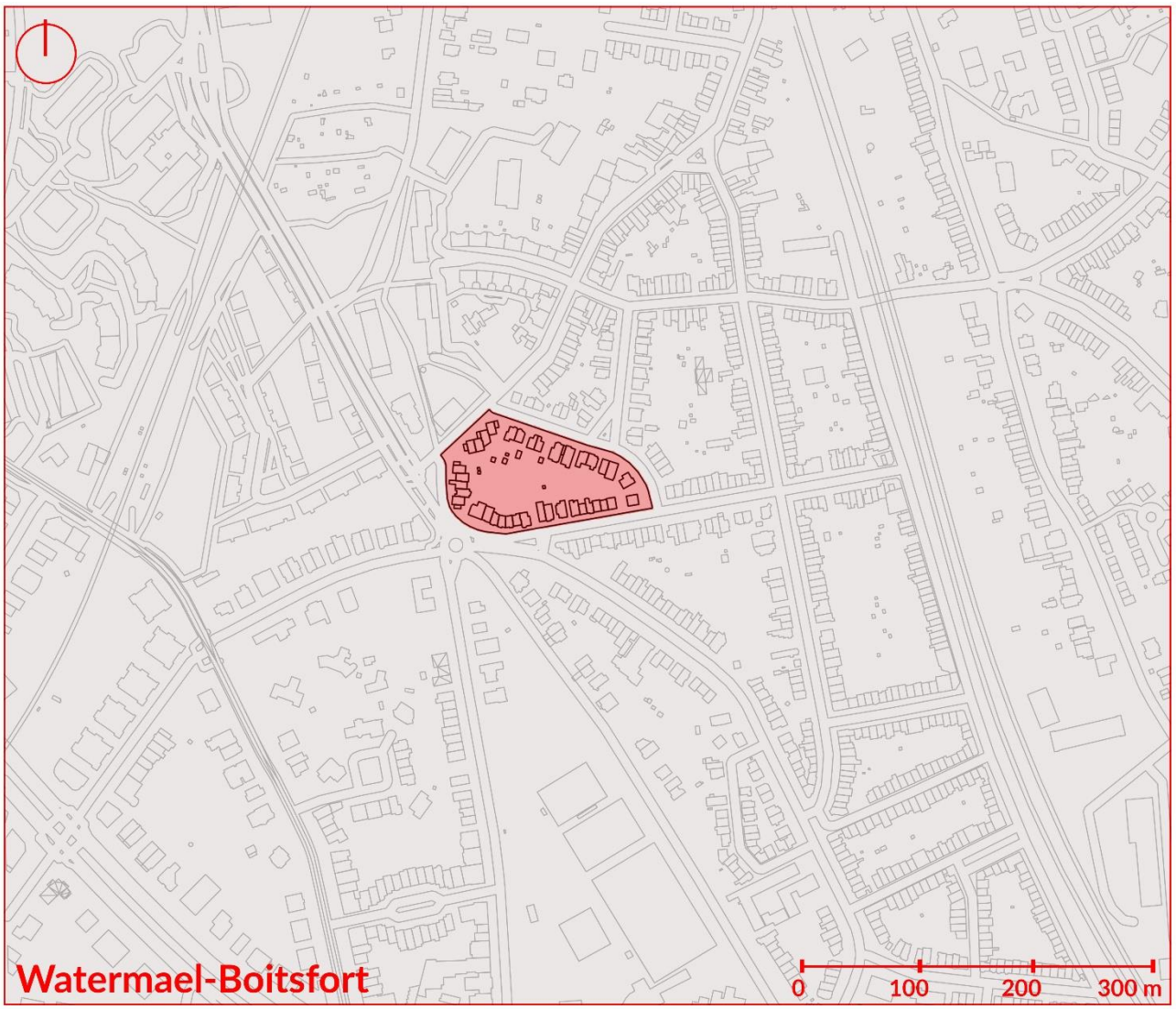

Map 21: Selected block in Watermael-Boitsfort, Brussels - for Urban Densification application.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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b. Experimental Scenarios and Results

In this section, of the selected blocks will undergo a series of three scenarios. Each scenario represents a level of density, from lowest (scenario 1) to highest (scenario 3). This experiment is by starting with a low recommended P/S, to reach the maximum recommended P/S by the inventory of COOPARCH-RU. Experimenting and answering the doubts and limitations around the following question: *'how feasible and doable is this maximum potential of Urban Densification on the parcel scale?'*

To start, the block selected in Molenbeek-Saint-Jean (Figure 33) will undergo a mixed function densification (ville de *mixité* in French). It is, as recommended by Ananian (2016), the better way of applying density in Brussels. In tis intervention, the minimum spacing between buildings and maximum heights should be respected.

Figure 33: Axonometric view showing the existing state of the block in Molenbeek-Saint-Jean.

Source: Produced by the thesis Author.

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The scenario 1 (Figure 34) shows a light Urban Densification intervention, mainly with upper extensions (roof stacking and roof transformation) with the following functions: Housing, public services, post office (recommended by the inventory). The wasted empty part in this zone used to be filled with old cars and material waste. To take advantage of the river side in front of this potentially open space, the considered part is transformed into a public square with several functions as: Green areas, recreational and gathering areas, children playgrounds, and outdoor fitness and sports. This square will potentially serve the block inhabitants with the new population added, as well as the neighborhood population on the lower scale.

Figure 34: Scenario 1 of Urban Densification Experiment on the block in Molenbeek-Saint-Jean.

Source: Produced by the thesis Author.

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In the scenario 2 (Figure 35), the densification is getting higher while adding more elements and new extensions. More upper extensions and courtyard infill constructions are shown. More affordable housing is available to contain higher population. The green public square is again preserved as an important spot in parallel with the added density. More density means more inhabitants are in need for recreational areas and green spaces. This was discussed in the thesis pointing out Teller (2021) points about Urban Densification effects on Urban microclimate and the overuse/overcrowding in green and public spaces.

Figure 35: Scenario 2 of Urban Densification Experiment on the block in Molenbeek-Saint-Jean.

Source: Produced by the thesis Author.

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In the third and last scenario for this block (Figure 36), further courtyard infill and upward extensions densification is done. As well, the biggest added structure is the main addition, a built-on the empty spot. It is a modern building with commercial and marketing functions, having private offices, stock market, grocery and other main brand stores. It is an economic incubator for the area. This last scenario shows the highest potential for the block to undergo densification. This is the highest Delta P/S (approximately) shown in the inventory for this selected block. The social and green square is no longer existing, the functions that were added once in the square, can be found on smaller spots around the new big building.

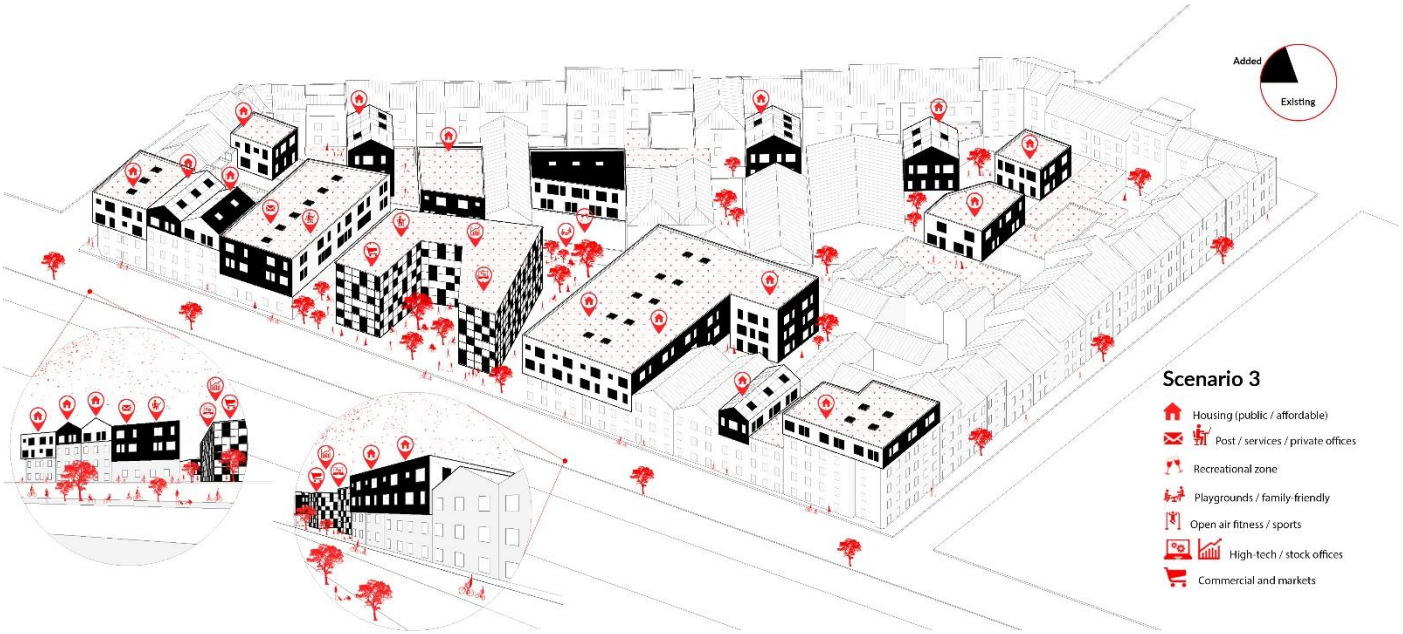

Figure 36: Scenario 3 of Urban Densification Experiment on the block in Molenbeek-Saint-Jean.

Source: Produced by the thesis Author.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
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As for the second block selected in Watermael-Boitsfort (Figure 37), the intervention is a less mixed-function one. It has mainly three functions of Housing, offices, and children and family outdoor spaces. The inventory by COOPARCH-RU shows one of the highest Delta P/S (differential value between existing and recommended for this block). It has many territorial opportunities for Urban Densification. This mainly because of the large courtyard. The intervention should preserve at least 3 facades from mixed use buildings, and all the 4 facades from the private buildings. The minimum spacing between buildings and maximum heights should be respected.

Figure 37: Axonometric view showing the existing state of the block in Watermael-Boitsfort.

Source: Produced by the thesis Author.

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In the scenario 1 for this block (Figure 38), upper extensions (roof stacking) are added. As well, backyard extensions are added with mainly affordable Housing function. Additional spaces to existing building may serve other extra functions as well. Inside the courtyard, the space is organized in a way to have more inclusive family-friendly areas, with children playgrounds, private or common, with green areas to be used by the block inhabitants.

Figure 38: Scenario 1 of Urban Densification Experiment on the block in Watermael-Boitsfort.

Source: Produced by the thesis Author.

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In the scenario 2 in this context (Figure 39), a higher density in the courtyard is already seen. Many new buildings are added. The design is perceived in a way to be in relation with the context and respecting the existing architectural character in the neighborhood (pitched roofs with average heights and proportions). These new buildings have mainly Housing function and private offices with small services. The family and children areas around are preserved but with a lower inclusivity as the space is divided by the added buildings and their pathes.

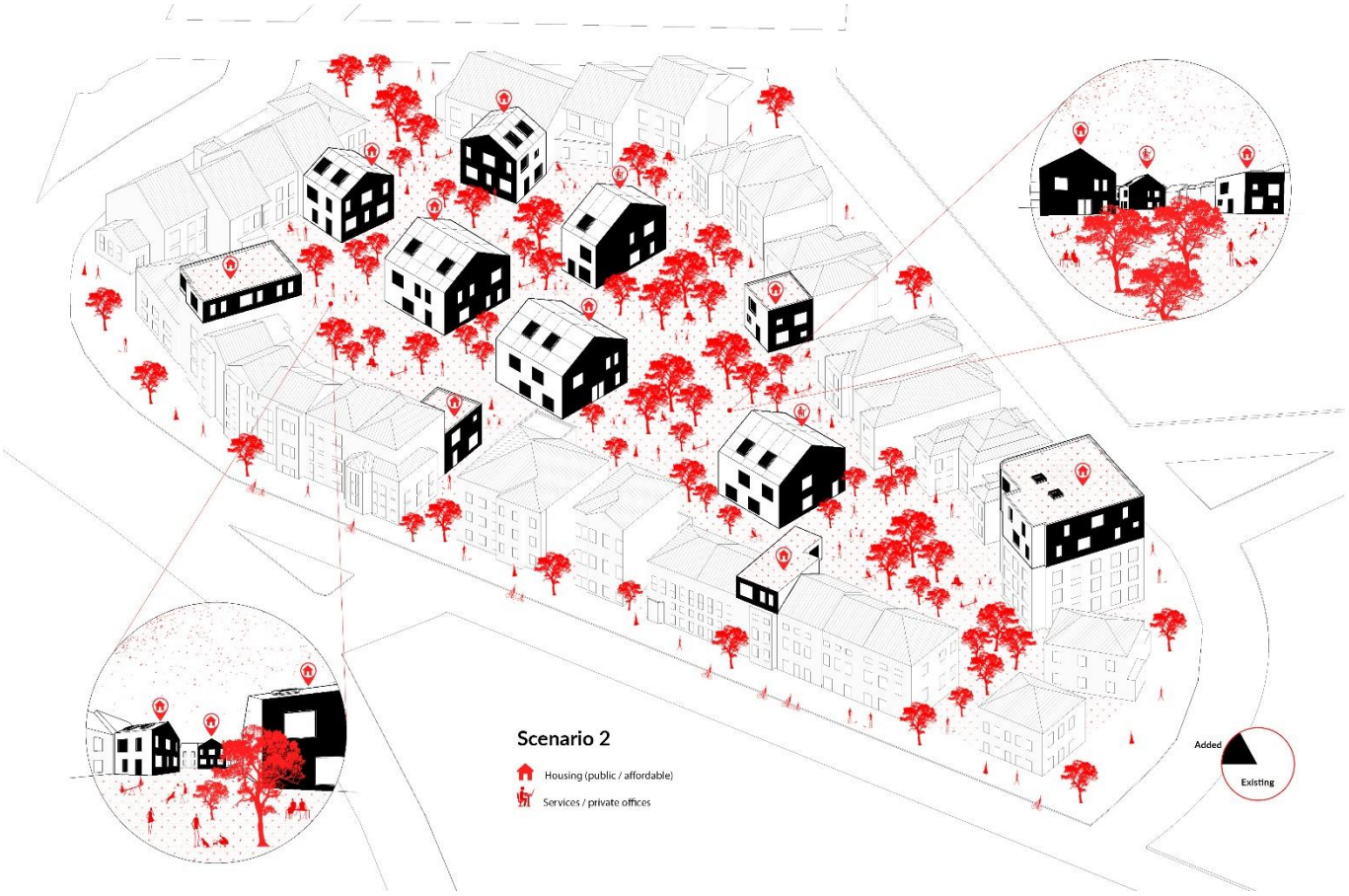

Figure 39: Scenario 2 of Urban Densification Experiment on the block in Watermael-Boitsfort.

Source: Produced by the thesis Author.

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Finally, in the scenario 3 (Figure 40), a complete sequence of new buildings is added in the courtyard. Again, the design is perceived in a way to be in relation with the context and respecting the existing architectural character in the neighborhood (pitched roofs with average heights and proportions). This time, the series of attached housings give exactly the image of the local identity of a neighborhood in Brussels. These additions are as well affordable Housing units and extra offices (mainly private and for small public services). The green areas around for the families, children, and new inhabitants in general are still existing and designed as clusters of smaller activities around each ensemble of buildings.

Figure 40: Scenario 3 of Urban Densification Experiment on the block in Watermael-Boitsfort.

Source: Produced by the thesis Author.

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c. Conclusions

In conclusion to this section, it is crucial to point what is the level of feasibility based on the Author's point of view, and compared with the Urban Densification goals mentioned in this thesis scientific research.

First, it is clearly that each block has its own identity and territorial potentialities. Hence, the conclusions are made separately for each of the two specific block cases.

For the block in Molenbeek-Saint-Jean, it is clear that the scenario 2 is the one that suits more the sustainability goals. It offers higher population density, and still offers large green areas and public recreational activities in open spaces. It plays the role of a green filter in this highly dense urban grid. On the contrary in the scenario 3 for this same block, it is clear and important to state that the new large building addition is important for the economy of the area on the small scale, but it may not be worth losing such an opportunity for public spaces that offer a higher living quality for the inhabitants. Rather, the ideal situation would taking all the added additions in scenario 3 (roof extensions and backyard infill constructions) but without the big urban project with commercial function.

As for the block in Watermael-Boitsfort, it is important to mention that the Urban Densification could be done successfully without changing the identity of the neighborhood nor lowering the number of open facades in the existing buildings. It is clear that it is possible to reach the high recommended P/S by COOPARCH-RU inventory in this case. The scenario 3 shows a totally acceptable view of a feasible densification with high potentialities.

To conclude a general view on Urban Densification application on the building block scale, clearly it is a feasible method in the case of Brussels-Capital Region. It is crucial to experiment such feasibility on each case for each potential parcel or building block. This is clearly a shortage in architectural experiments on the regional level after following such urban

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inventories. Based on these two experiments, it is safe enough to state that the quantization estimations by the inventory are most probably reachable with adequate densification.

14- Conclusion and Suggestions for Future Work

Human settlement are continuing to change progressively with the changing political and socio-economic aspects, as well as the continuing increase in global population (Greve, 2011). Urbanization and built environment development is directly influenced by human's reaction to these aforementioned unstable factors. The Earth's natural resources are being exploited shows a lack of sustainable strategies while planning, by looking at the quality of the world's economy (Pelczynski & Tomkowicz, 2019). The significant growth of the urban human population requires relevance in the increase of the general volume of buildings and urban habitat's infrastructures. The Urban Sprawl movement is rapidly taking over all the European regions, either they have a high population density or not (Haase & Kabisch, et al. 2013).The UN projects that the global population will reach its maximum peak in 2086 at 10.4 billion people (United Nations, 2022). At least 68% of world population will be living in urban areas by 2050. This comes with several consequences. Through the last century this growth in population cause a vastly built urban expansion over large territories, known as Urban Sprawl (Teller, 2021). New green, natural, and agricultural lands are still being consumed and exploited around the world (Lanzani, 2012). This demographic growth along with migration and globalization, put higher pressure on cities. This is causing a rise in prices known as hard inflation, together with social problems, and serious detrimental environmental issues, etc. (Amer et al., 2017).

Urban Sprawl, has shown an unsustainable continuant existence. It is causing a massive loss of productive agricultural lands and open spaces that are indispensable for cities and countries. Also, a high number of commuting automobiles for longer times with their fossils burnt and

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exhaust in the air, causes all the negative environmental effects of an increasing volume in greenhouse emissions as drastic climate change. As well, Urban Sprawl causes a loss in biodiversity equilibrium, disintegrates landscapes, and lowers the global ecosystem performances (Nilsson, 2014).

Although the drastic effects of sprawl may seem overwhelmingly negative, there are several policies, laws, and strategies that potentially may slow, or put an end to, the unsustainable urban expansion (Knaap & Talen, 2005; Brody, 2013). The green belt, urban growth boundary, and urban service boundary are three of the most important urban containment solutions presented (Amer et al., 2017). A suggested and effective framework for preventing Urban Sprawl and enabling the effectiveness of urban containment strategies at the economic, spatial, and infrastructure levels is reasonable Urban Densification (Amer et al., 2017).

Urban Densification has several positive effects to limit Urban Sprawl and provide a more sustainable living. But, it was debated since it has become the paradigmatic strategy for urbanization especially after the recent global Housing crisis. These oppositions against Urban Densification often leave different methodologies unquestioned (Pérez, 2020).

Urban Densification is a phenomenon of maximizing the usage of the already man-built space in a city. Securing new layers within the perimeter of a city is a sustainable way of urban structure regeneration (Pelczynski & Tomkowicz, 2019). It is a type of urban growth that continues directly alongside already-built structures. As well, Urban Densification is becoming more and more widely recognized as an essential strategy for no-net land take (Teller, 2021).

Hence, density has several positive effects on the environmental, social, and economic levels. There are benefits of densification when predicting energy consumption, although these figures are not linear and location-dependent (Lima et al., 2019). High dense and compact urban grid may help reduce the energy consumption on the long term compared to a non-dense and vast urban tissue (Godoy-Shimizu et al., 2021). Also, Urban Densification ensures a better and cleaner air quality and promotes the urban microclimate. Lesser commuting and

lesser use of automobiles, as well as less consumption of green areas are direct factors for this positive effect. Urban Densification is linked to an increased in the usage of public transportation and a smaller carbon footprint (Teller, 2021). As well, dense urbanization results in less net-land take, which benefits the amount of land that is available for agriculture, nature, recreational activities, and biodiversity. Housing in the city center or in the areas around inner-cities may probably become more affordable because of the lower maintenance and construction costs, and the usage of existing resources. In addition, Urban Densification applications until now show a result of having a higher economic attractiveness. That is due to agglomeration influences in the service industry and better position in relation to existing key locations. Lower infrastructure costs mentioned before are also a reason for better economic attractiveness for investors and start-ups. Because more households can use the existent infrastructure, densification through infill development lowers building costs. Accessibility to main services and facilities around the city will get easier and faster. Living in the inner-city will facilitate that, which will result in higher human development index (Teller, 2021).

Urban Densification with all its positive effects, has some complications in its execution, and sometimes in specific context its effects may be questionable and problematic as any other modern urban strategy. There are several methods for the application of this densification. The application should arrive to the block level as a conclusion of extensive and deep analysis, on the regional and urban scales, of the micro- and micro-drivers of this need of higher density in a specific city. Different authors identify the methods in different ways but result in the same way of application. The most common and important methods are: roof stacking or upper extensions, roof transformation, demolishment and rebuilding, infill or empty spot constructions, filling backyards or side extensions, and lower space function transformation or lower extension (Amer et al., 2017; Pelczynski & Tomkowicz, 2019). Each of these methods has its own characteristics and way of application, accompanied with advantages and disadvantages. Reasonably, some Urban Densification methods are more environmentally and economically sustainable than the others. Mainly, function transformation and roof

extensions are highly more sustainable than demolishing and rebuilding. Each context has a potential for specific method application (Pelczynski & Tomkowicz, 2019).

Nowadays, the Brussels-Capital Region (BCR) is living a turning point in its urban and demographical development. It faces various challenges established in particular in the Regional Plan for Sustainable Development project (PRDD, 2015) where population growth and the fight against poverty are included. The region will have a projected population growth of about 32% equal to 376,000 inhabitants in 2060 compared to 2015. This is a problematic growth rate. Brussels has been the quickest demographic developing metropolis in the past two decades (DGS, 2016; BFP, 2016).

Since 2005, the Brussels-Capital Region is facing a Housing crisis. Public authorities oversee Urban Densification in means of urban planning as an opportunity and solution. The densification of affordable Housing and public services in the Brussels-Capital Region has recently become a tool for urban and economic development. Mainly densification is to cope with population growth, As well, it is meant to solve the ongoing Housing crisis with the growing gap between supply and demand for social and medium Housing. Mainly it is a gap problem between authorized and built dwellings (Ananian, 2016).

The share of public production from the whole residential production in the BCR amounts to only to 14%. The larger part of residents, low and mid-income households that only afford living in medium public residences will risk of ending up with a lower life quality. Several limitations exists in securing the position of social and medium-sized Housing among real estate developers. However, the municipalities can benefit from the Regional Plan for Sustainable Development (PRDD), and territorial policies with positive discrimination of neighborhoods such as RHDA and RURDA in some parts of the region between the inner and outer rings (Ananian, 2016).

The PRDD takes in action a plan of suitable Urban Densification to face demographic growth and Housing crisis. The strategic objective is to transform this constraint into an opportunity (*La densité à travers le plan de développement durable de la Région Bruxelloise*). The plan

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execution is totally possible once the BCR capacity to accommodate higher densities is identified. This identification should spot the potential sites, parcels, and buildings for such densification while indicating its maximum inhabitant containment potential (PRDD, 2013; 2020).

An inventory was carried out by COOPARCH-RU in parallel with the development of the Regional Plan for Sustainable Development (PRDD) of the BCR. The main aim is identifying the potential areas for Urban Densification based on restrictive, programmatic, and localization criteria. These mapping and quantization methodologies are analyzed while highlighting intervention priorities and extracting conclusions. Deep and detailed layering of each map is filtered and added to attend the needed conclusion from each map. Then, it connects the mapping, localization, and quantization to optimize the final results. The final results are directly giving a clear picture about the expected potential number of inhabitants that the city can take in case of both soft and hard Urban Densification until 2040. It highlights as well the potential of each building block that would offer territorial opportunities for an adequate densification. The resulting conclusion of the inventory shows that the physical territory of the Brussels-Capital Region has the capacity to accommodate the projected population without significantly changing its quality of life. The PRDD project for 2040 can be achieved based on the results obtained. The high estimation results of the inventory quantization exceeds the projected population growth (207,697 > 190,000). While in case of Urban Densification based on a low estimation factor by giving more area / m^2 to each inhabitant, the results of the inventory may not be totally satisfactory to the 2040 population increase projection (173,082 < 190,000). But this number in the global overall result is still satisfactory to the projected increase. The inventory shows that the majority of the densification can be potentially executed by high estimation for Urban Densification interventions (BCR Monitoring of neighborhoods). Hence, the PRDD 2040 population containment can be reasonably achieved based on the overall conclusion obtained.

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The limitation that can be spotted is that the analysis stop at the parcel scale. This limits the study because it does not provide a specific contextualization to the criteria identified. This does not help identifying the exact Urban Densification method for each block and the feasibility of its execution. As well, there is the problem of homogeneity and heterogeneity of proposed urban templates. By that, a method of Urban Densification on the regional level can totally work based on the mapping and quantization after passing all the considered criteria. But, the criteria itself is limited to building block scale.

This is the motive for the thesis Author to carry on the work and develop the final experiment to test the feasibility on the parcel scale as a follow-up conclusion for the work done in the inventory.

For the block in Molenbeek-Saint-Jean, the ideal situation would taking all the added additions in scenario 3 (roof extensions and backyard infill constructions) but without the big urban project with commercial function.

As for the block in Watermael-Boitsfort, it is clear that it is possible to reach the high recommended P/S by COOPARCH-RU inventory in this case. The scenario 3 shows a totally acceptable view of a feasible densification with high potentialities.

To conclude a general view on Urban Densification application on the building block scale, clearly it is a feasible method in the case of Brussels-Capital Region.

For future work, it is crucial to experiment such feasibility on each case for each potential parcel or building block. This is clearly a shortage in architectural experiments on the regional level after following such urban inventories. Based on the two experiments done in this thesis, it is safe enough to state that the quantization estimations by the inventory of COOPARCH-RU are most probably reachable and realistic with adequate densification taking advantage of all the territorial opportunities and potentialities.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

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- *https://arquitecturaviva.com/works/atico-didden-village-1*
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- *https://www.archdaily.com/946858/fill-in-the-gaps-infill-architecture-in-urban-residual-spaces#:~:text=Infill%20architecture%20usually%20refers%20to,of%20scales%2C%20approaches%20and%20typologies.*

Benchmarking adopted by the thesis Author, scholars, and COOPARCH-RU:

- APUR (Atelier Parisien d'Urbanisme), Comment produire du logement accessible au centre de l'agglomération métropolitaine.
- APUR (Atelier Parisien d'Urbanisme), Etudes et réfl exions sur le devenir des grandes voies radiales.

Note: - Refer to the Glossary section at the beginning of this Master's Thesis for acronyms and other definitions.
- Zoom in while using the thesis digital version to see more details in the drawings.

- APUR (Atelier Parisien d'Urbanisme), Le logement, une ambition pour la conférence métropolitaine.
- Bau und Zonenordhung, Zurich.
- Le logement à Paris - Un état des lieux pour préparer le Programme local de l'Habitat.
- PDU (Plan de Deplacement Urbain), Lille Metropole, 2011.
- PGT (Piano di Governo del Territorio), Comune di Milano, 2012.
- PLU (Plan Local d'Urbanisme), Lille Metropole.
- PLU (Plan Local d'Urbanisme), Paris.
- Planungs und Baugesetz, Zurich.
- Regards croisés. Métropoles européennes, Berlin, Londres, Madrid, Milan, Paris, la Randstad.
- Situation et perspectives de la place de la nature à Paris - synthèse de 9 ateliers thématiques.
- VerGe Project, Switzerland.

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- Zoom in while using the thesis digital version to see more details in the drawings.