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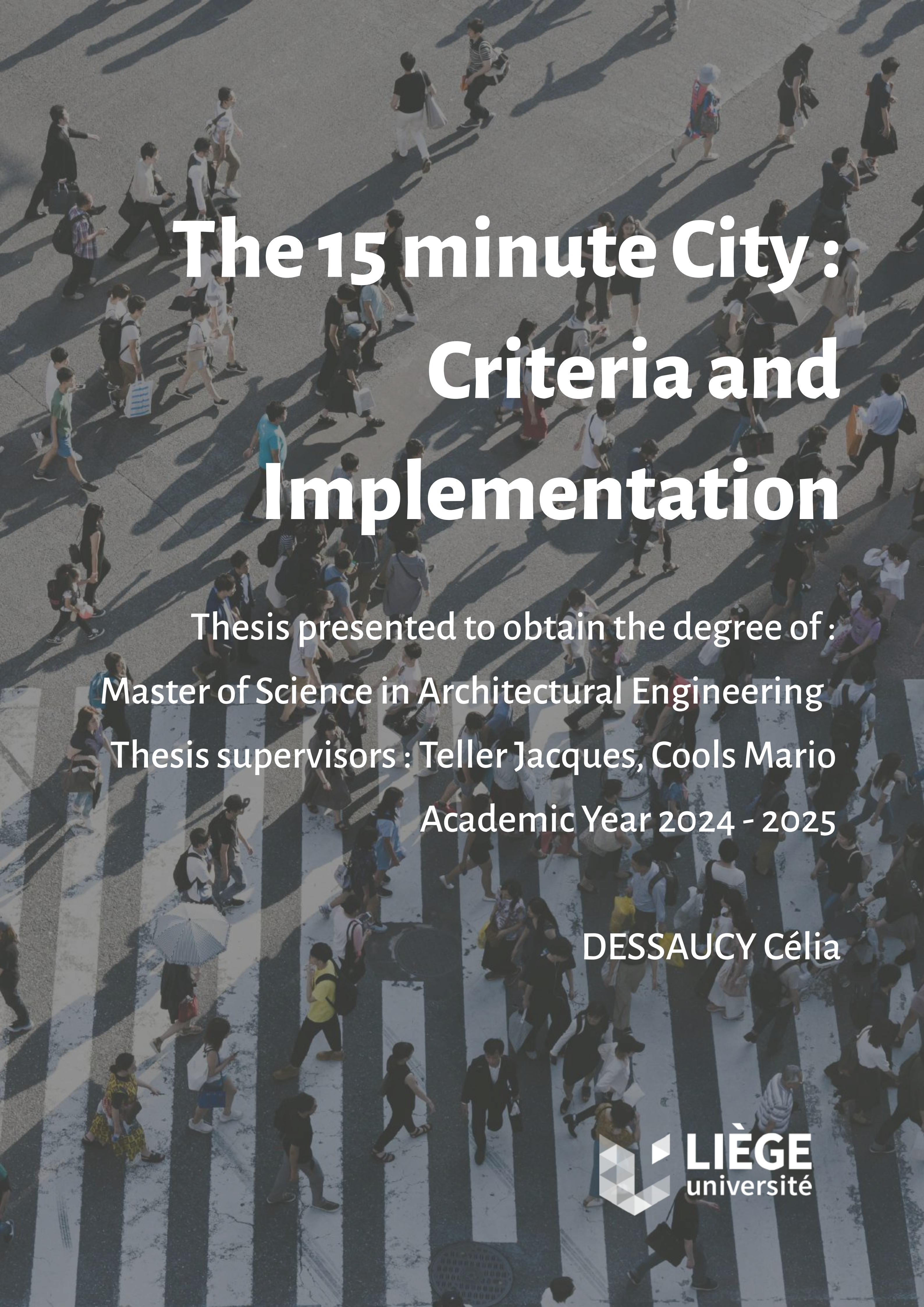

The 15 minute City : Criteria and Implementation

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Summary

In the context of this thesis work, the main subject of the research focuses on the concept of the 15-minute city. The 15-minute city is a concept introduced by Carlos Moreno after the 2015 Paris Climate Conference as a framework to combat greenhouse gas emissions. Since then, this concept has been gaining popularity and is of increasing interest to researchers and urban planners due to its human-centric approach, in contrast to smart cities, which are more technology-focused.

This urban planning concept emphasizes the accessibility and sustainability of the urban environment by advocating for access to essential life services within 15 minutes by foot or bicycle. This reduces dependence on motor vehicles, enhances the sense of community in cities, improves mental and physical health of residents, and decreases urban pollution. However, how can this be effectively implemented in existing cities ? This concept, studied in depth by many researchers and already applied in several cities, lacks a formalized methodology. The criteria vary from one study to another, which naturally influences the results and, consequently, the implemented urban policies.

This paper focuses on the creation of a methodology for efficiently calculating a city's accessibility and walkability. This methodology is based on a GIS analysis of accessibility, and the use of NetAScore software to calculate walkability. These results will be cross-referenced with socio-economic indicators and verified by a series of surveys of the population and field surveys in a selected area, in order to obtain a methodology that is as close to reality as possible. To conclude the work, a series of medium- and short-term solutions are developed for the whole of the area studied, in order to improve the comfort and quality of life of residents with regard to soft mobility.

Contents

List of Figures

List of Tables

Introduction

At a time when the car has taken control of cities in terms of transport, but also at a time when the future of the planet is more than uncertain due to our inaction in the face of climate change and our previous actions, it is time to change. It is time to transform this city. This city that we do not talk about enough, the way it was built, which nevertheless determines the way we live, the way we inhabit it. We absolutely have to change now, because we have reached an impasse, where the city is at the heart of the main crises: resources, biodiversity, and climate.

Our cities today face many challenges. The number of cars is increasing as the population of cities grows, taking up space on infrastructures that are becoming more than saturated. We're thinking bigger and bigger, and the city is taking up more and more land, urbanizing and sealing off huge tracts of natural land that are becoming concrete. This way of building cities, sprawling along road networks, is destroying our landscapes, threatening natural ecosystems and creating problems we are unprepared for, such as floods, heat waves, droughts and hurricanes. This model of the city needs to be rethought and adapted to the problems of today and tomorrow. The linear urbanism that has guided us for so many years is now vulnerable and consumes so much energy in a reality where energy is the new gold. We must advance towards circular urbanism, curtail urban sprawl, and optimize the resources we already possess. Many derelict buildings in towns and cities are wisely waiting for a second life. This approach also allows us to move away from car-centric cities towards soft-mobility cities.

It is up to us to adapt our cities to be more economical in terms of space, resources and mobility. A city that drastically reduces resources, waste and pollution. The solution may be in the fifteen minutes city.

The 15 minutes city is a concept in urban planning that promotes the access of services and amenities in a 15-minute walk or cycle ride to everyone from their home. This idea means that the inhabitants of a city can meet most of their daily needs without the need of a motorized mean of transport. This concept promotes the reduction of greenhouse gas emissions linked to cars, the improvement of people's health, the reduction of air pollution and noise, etc. It has numerous advantages, including economic, social, environmental, health benefits [Moreno et al., 2021].

This concept of a 15-minute city could help our cities deal with the many challenges they face on a daily basis. It is a concept that goes hand in hand with circular urbanism. By making 15-minute cities a reality, we are moving in the right direction to improve our quality of life and the quality of life of our planet. Now the question: How can we effectively achieve that in existing cities ?

Objectives

The aim of this final thesis is to contribute to the implementation of the 15-minute city concept in an existing urban context by developing a rigorous methodology for evaluating accessibility, walkability, and socio-territorial disparities simultaneously. The case study focuses on the Sainte-Walburge neighborhood in Liège, and the objective is to propose an integrated approach combining digital tools, open data, and user feedback to highlight issues of functional proximity and spatial justice.

More specifically, the research has the following objectives:

1. To measure accessibility to essential services (e.g. shops, healthcare, education and transport) from the built environment within a 15-minute walking radius, using spatial analysis methods based on isochrones and OpenStreetMap data.

2. To assess the walkability of the urban environment using the NetAScore index, which allows for a detailed analysis of the pedestrian network at the street segment level, taking into account multiple criteria such as slope, noise, the presence of pavements and building density.

3. Cross-reference these two indicators with local socio-economic data, in particular the synthetic difficulty index (SDI), in order to highlight areas with low accessibility, poor quality pedestrian routes and social vulnerability.

4. Supplement and compare the quantitative analysis with a qualitative field survey, including on-site observations and semi-structured interviews with local residents, in order to better understand the local perception of proximity, the obstacles encountered, and the needs expressed.

5. Formulate a set of operational, graduated recommendations ranging from one-off adjustments to structural redevelopment. These recommendations should aim to improve quality of life, pedestrian continuity, and equitable access to services in the neighborhood under study.

The ultimate goal of this paper is to examine the methodological choices made throughout the analysis, such as data selection, criteria weighting, distance thresholds and spatial units, to reveal their impact on the results and the potential for local public policy in terms of development.

Chapter 1

State of the art

1.1 Consolidation of the literature review

This section sets the context for the 15 minute city concept. It begins with an explanation of the origin and definition of the concept and its defining principles. It then discusses examples of studies and concrete applications of the concept, as well as its challenges and limitations and its applications. Accessibility and walkability indicators will then be explained, along with their central role in the 15 minute city concept. Their calculation methods, tools and criteria are discussed in detail in order to analyze the best methods to use. Finally, the political and social stakes of the city and the concept will also be explained, with a reflection on its possibilities and real limits, followed by a conclusion on this current state of the literature.

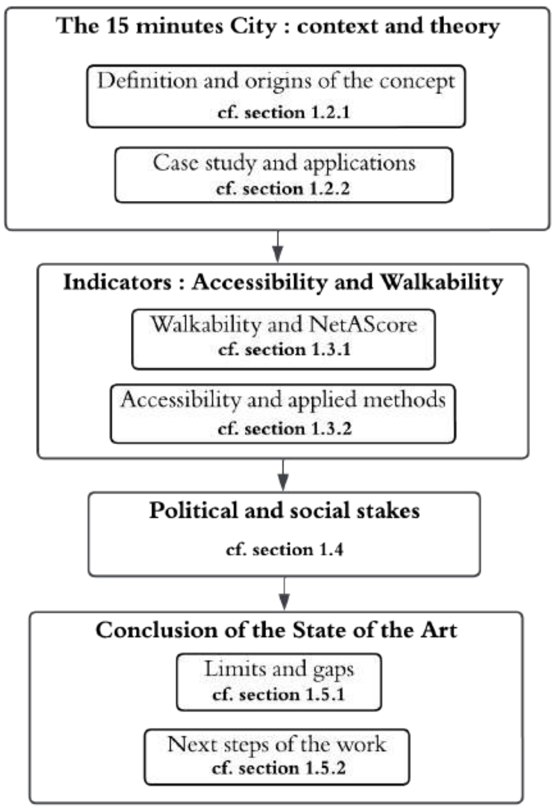

Figure 1.1: State of the art - structure. Source : Author

1.2 The 15 minute City : context and theory

1.2.1 Definition and origins of the concept

The concept of the 15 minute city has emerged to respond to the climate change crisis the world is facing. With the rising of socio-spatial inequalities and the car dependency, the concept gained popularity after being introduced by Carlos Moreno in 2016 after the 2015 Paris Climate Change Conference, as a framework to combat greenhouse gas emissions. In recent years, the concept has established itself as a new urban utopia. It is based on a simple yet ambitious idea : to allow all residents of a city to access all the essential amenities for living in less than 15 minutes by foot or by bicycle from their homes [Moreno et al., as cited in A. R. Khavarian-Garmsir et al., 2023].

Carlos Moreno is a Franco-Colombian academic and expert in smart cities, urban innovation and sustainability. He is an associate professor at the IAE (Institut d'Administration des Entreprises) at the Université Paris 1 Panthéon-Sorbonne. His work focuses on transforming urban models and adapt them to contemporary challenges, in particular climate change, social segregation and health crises. He is recognized for having introduced in 2016 the concept of the 15 minute city, which has gained international prominence, particularly through its adoption by the Mayor of Paris, Anne Hidalgo, as part of her post-COVID urban transformation strategy [Moreno et al., 2021].

This approach advocates to rethink the city with a logic of proximity, breaking with the urban sprawl tendency. It is about recenter urbanism around people, by reducing distances, encouraging soft mobility and functional mixing. The objective of this concept is not only environmental but also social (strengthening social cohesion), economical (supporting proximity shops), democratic (citizen-participation in decision-making) and health-related (promoting physical activity). This logic has been described by several authors [Capasso Da Silva et al., Moreno et al., and Weng et al., as cited in Vich et al., 2023].

Carlos Moreno defines the 15 minute city as a urban poly-centric system in which each neighborhood acts as a system in itself, allowing the access to essential amenities, without the need for long journeys. The 15 minute city concept is directly inspired by the concept of chrono-urbanism, which tells us that the quality of life is inversely proportional to the transportation time. The residents of cities should benefit from a better quality of life i.e. less time spent in transports, and have access to six essential urban social functions including living, working, commerce, education, healthcare and entertainment. The 15 minute city concept is based on 4 principal components of the urban built landscape to ensure its success : proximity, diversity, density and ubiquity. Complementary components are sometimes added, such as connectivity, flexibility of use, human scale urbanism, adaptability and/or modularity [A. R. Khavarian-Garmsir et al., 2023; Moreno et al., 2021].

The concept of the 15 minute city is built upon more than a century of urban planning concepts focused on proximity and human-scale design. It is a synthesis of the foundational principles of multiple neighborhood planning movements.

The first roots of the concept go back to Ebenezer Howard's Garden City, envisioned in 1898. This utopian concept aimed to create self-sufficient cities, circled by green areas, integrating housing, work and amenities in response to the effects of the urban industrialization. However, this approach was difficult to apply at a larger scale and favored scattered, low density, single-family housing, encouraging urban sprawl [A. Khavarian-Garmsir et al., 2023].

In the early 20th century, Clarence Perry envisioned the concept of the neighborhood unit, an urban unit designed with basic services (schools, parks, shops), accessible by foot. This concept aimed to create social, self-sufficient and lively neighborhoods. Nevertheless, it was based on a rigid grid with exclusive zoning separating residential, commercial and educational functions. This approach led to a lack of mixed-use and did not match with the social dynamics of cities [A. Khavarian-Garmsir et al., 2023].

During the first half of the 20th century, modernist urbanism appeared with Le Corbusier and other figures. It aimed the rationalization of spaces, with a strict separation of functions and the dominance of the car on other means of transport. This concept widely implemented in cities after the second world war contributed intensively to urban fragmentation, socio-spatial segregation as well as increasing our dependence on the car [Gottdiener, M., Basiago, A. and Watson, V., as cited in A. Khavarian-Garmsir et al., 2023].

During the second half of the 20th century, and in reaction to the modernist movement, the postmodern urbanism appeared, reintroducing proximity, mixed use and soft mobility. Inspired from the Garden City and the neighborhood unit, this approach aimed to create an environment that promotes walking and cycling and combines work and leisure. Post-modern urbanism was implemented in various neighborhoods in the late twentieth and early twenty-first centuries. However the application was often limited with an excess of physical determinism, thinking that optimal urban design would be enough to improve cities, without taking into account social and cultural dimensions [Sharifi, A., as cited in A. Khavarian-Garmsir et al., 2023].

Since the 2000s, the concept of eco-urbanism aimed to reconcile urban development with environmental sustainability. It was implemented through the use of numerical technologies, alternative mobilities as well as renewable energies. Nevertheless, the projects were often criticized for their lack of social inclusiveness, high costs and techno-centered solutions. The concept was often reserved for the middle or upper class and did not really transform the overall urban fabric [Low, M., Caprotti, F., as cited in A. R. Khavarian-Garmsir et al., 2023].

The analysis of all these currents, shows us that all of them tried to respond to specific problems without taking into account the multi faced issues that cities face. None of these concepts has been able to consider all the dimensions required for a sustainable, resilient and equitable city. Their failure is due to excessive segregation, poor adaptability to local contexts, A utopian vision that remains detached from practical realities, poor consideration of social-inequalities as well as excessive reliance on urban form or technology to solve systemic problems [A. Khavarian-Garmsir et al., 2023].

In the late 2010s, the outbreak of COVID-19 has caused an unprecedented global crisis, forcing governments to impose strict confinements and mobility restrictions. Public-transport was a high risk area for the transmission of the virus leading to a significant drop of transports. Moreover, walking and cycling were largely used as they were able to meet everyday needs as well as promoting physical distance. As a result of the pandemic, many municipalities redesigned their public spaces to encourage active mobility. Health, long considered in second place, in planning policies has become a priority and the proximity of essential amenities has established itself as a central issue in planning policies. The pandemic showed us the vulnerability of car-dependent cities born of modernist urban planning. This experience reinforced the need to rethink our cities around more sustainable and resilient models. It is in this context that the concept of the 15 minute city, initially proposed by Carlos Moreno in 2016 was revived as a solution to the challenges of the climate change and as a strategy for post-pandemic reconstruction [Barbarossa, L., Sharifi, A., Teixeira, J.F., as cited in A. Khavarian-Garmsir et al., 2023].

The 15 minute city concept is an evolving synthesis of all the previous models integrating their contributions (proximity, compactness, mixed-use, resilience) while correcting excesses. Unlike previous models, it aims not only to change the urban form but also to transform uses, lifestyles and governance priorities, to build the post-COVID urban transformation [Pozoukidou, G., as cited in A. Khavarian-Garmsir et al., 2023].

Neighborhood Planning Movements	Proximity	Density	Diversity	Mixed-Use	Modularity	Adaptability	Flexibility	Human-Scale Design	Connectivity	Digitalization
Garden city	×	×	✓	×	×	×	×	×	✓	×
Neighborhood unit	✓	×	×	×	×	×	×	✓	×	×
Modernism	×	×	×	×	×	×	×	×	×	×
Post-modernism	✓	✓	✓	✓	×	×	×	✓	✓	×
Eco-urbanism	✓	✓	✓	✓	×	✓	×	✓	✓	✓
15-minute city	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure 1.2: Comparing neighborhood planning movements. Source : [A. Khavarian-Garmsir et al., 2023]

This approach of the 15 minute city is not rigid. The duration of 15 minutes constitutes an indicative norm. Some researchers stress the need to adapt this duration to local practices, topography, means of transport and social context [Guzman et al., 2024; Weng et al., 2019]. Others stress that the evaluation of proximity cannot be limited to a duration but must also include the perception of distances, different uses of urban spaces and inequalities in access [Guzman et al., 2024; Pezzica et al., 2024].

The concept embodies an urban paradigm shift, the aim is no longer to maximize the speed of journeys, but to reduce the need to travel by bringing living, working, service and leisure locations altogether. This model does, however, raise a number of questions, about its practical implementation, the risks of gentrification, its feasibility in dispersed urban areas as well as the measurement tools to be used. These issues are explored in the following sections.

1.2.2 Case study and applications

In this section, different case studies of the 15 minute city concept are discussed as well as practical application of the concept in existing cities.

Although the 15 minute city concept is based on universal principles such as proximity and accessibility, its practical implementation remains a challenge, depending on the cultural, geographical and political context. A various number of cities have interpreted the concept following their own priorities, infrastructures, and urban forms, generating various forms of implementation or adaptation [A. R. Khavarian-Garmsir et al., 2023].

Paris is the emblematic city where the concept "ville du quart d'heure" has been officially institutionalized, thanks to the collaboration between Carlos Moreno and Anne Hidalgo, the Mayor of Paris. The concept translated into various actions: streets were transformed in shared spaces, increase of proximity amenities (nurseries, schools, shops), pedestrianization, greening public spaces and supporting the local economy. This model also received political support as part of the C40 Cities Climate Leadership Group, which promoted it as a recovery strategy for the post pandemic [A. R. Khavarian-Garmsir et al., 2023]. It relies also on the development of schools open to the neighborhood, the implementation of "streets of schools" and the reorganization of the territory around local centralities [Guzman et al., 2024].

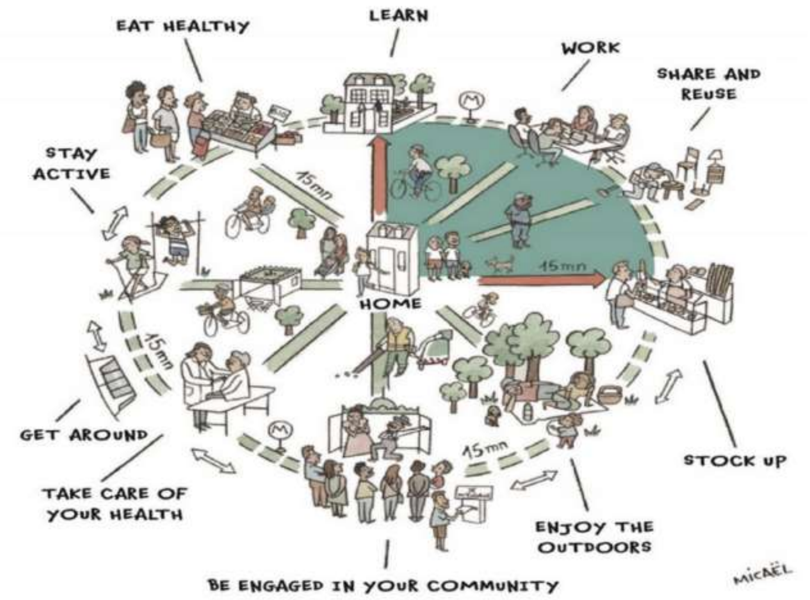

Figure 1.3: Illustration of the 15-minute Paris. Source : [Moreno et al., 2021 as cited in A. R. Khavarian-Garmsir et al., 2023]

In Barcelona, the approach was implemented through the "Superilles" (superblocks). These structures aim to reduce motorized trafic in some blocks by closing internal streets to trafic while increasing the pedestrianization, greening and social uses. This transformation has enabled a significant recovery of public space [Vich et al., 2023]. In the case study of Vich et al., 2023, they propose three different methods to measure the accessibility of Barcelona : a grid-method (100x100m), a method based on building parcels and a method based on mobility behaviour. The study shows that these tools allow to identify the inequalities between neighborhood despite the apparent uniformity of the urban layout [Vich et al., 2023].

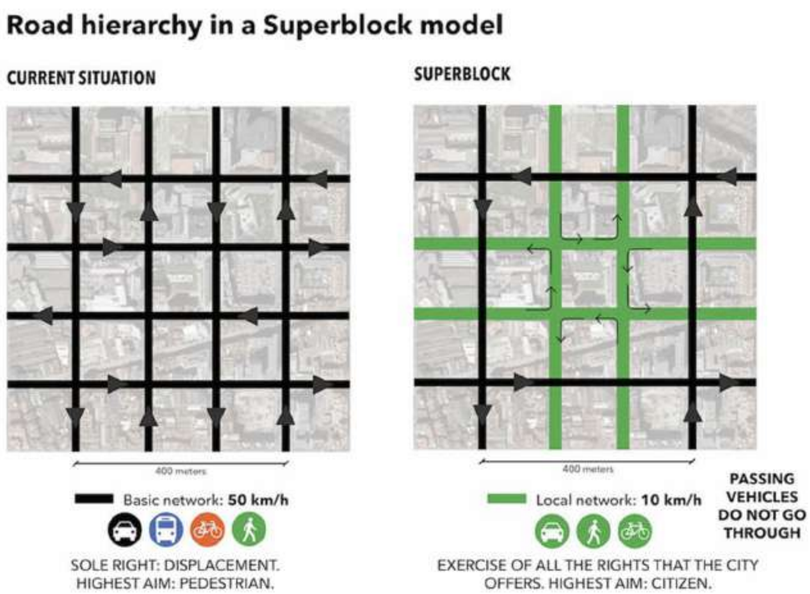

Figure 1.4: Illustration of the "Superilles" in Barcelona. Source : [Behling, 2017].

In Italy, the approach of the 15 minute city concept was explored in several cities with different profiles. The comparative study conducted by Murgante et al. (2024) was led in Cagliari, Pisa, Perugia and Trieste. The study suggests spatial indicators as space syntax to evaluate the density, proximity and diversity of urban services. It investigates two questions regarding the spatial variation of conditions of access to services and the influence of urban form factors, including compactness, permeability and centrality, on the levels of service access [Murgante et al., 2024]. This approach uncovers the strong disparities between historical centers, dense and mixed, and modern suburbs, often mono-functional. It also highlights the importance of the urban configuration to implement the model [Murgante et al., 2024].

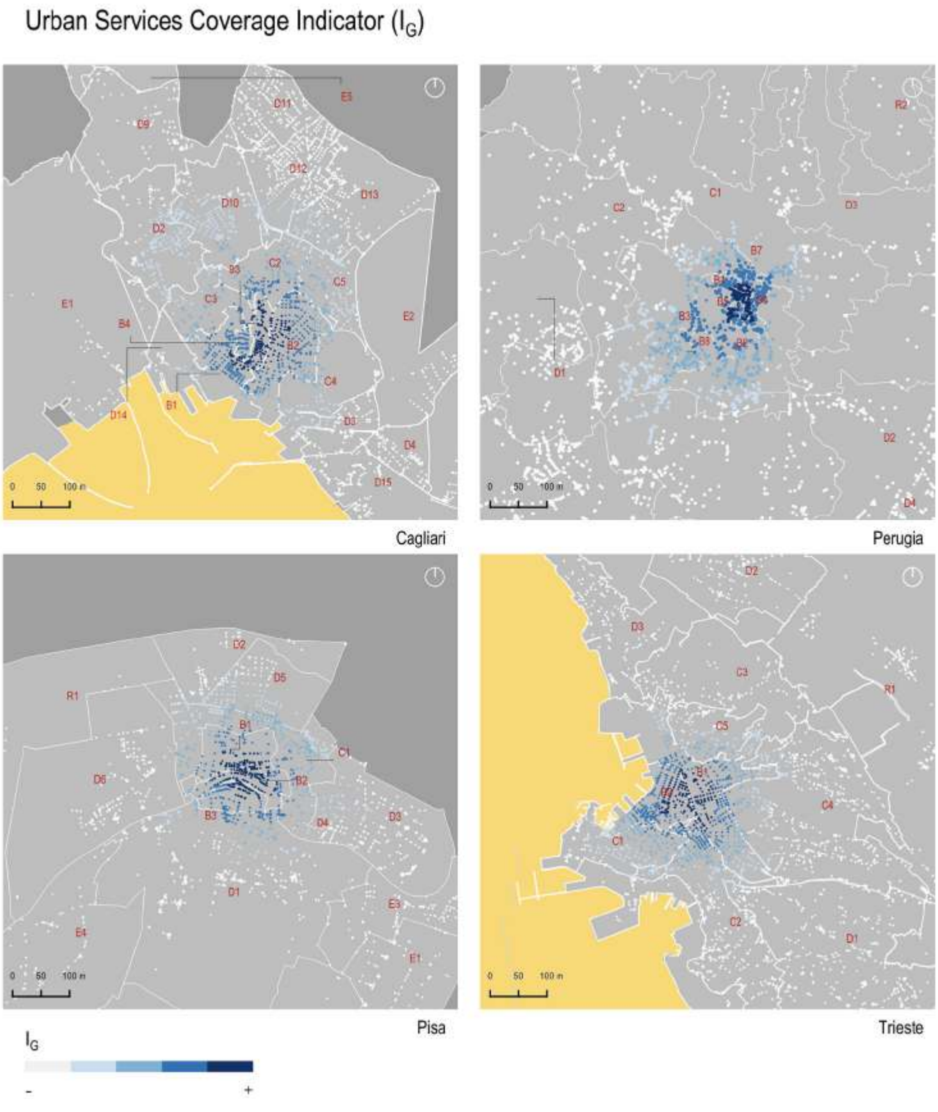

Figure 1.5: Values of the Urban Services Coverage Indicator in the four areas of study. Source : [Murgante et al., 2024]

In Australia, the city of Melbourne developed an adjusted version of the concept with the 20 minute neighborhood, better suited to low-density areas. This adaptation shows the flexibility of the concept and that it can be adapted to the local morphology and the socio-economic context [Chau, et al., as cited in Teixeira et al., 2024]. Other cities have also experimented interesting adaptation of the concept. This is the case of Oslo, in Norway, which explored the role of remote work and new workplaces as catalysts of proximity to reduce commuting distances [Di Marino et al., 2023]. Shanghai and other Chinese cities have implemented "Community Life Circle", well established for years. With the same approach of the 15 minute city concept, the Community Life Circles are planned urban areas that offer essential services in a 15-minute walk buffer [Zhou, D., as cited in Teixeira et al., 2024].

In their researches, Teixeira et al. (2024), propose a comparative international analysis of the implementation of the 15mC[1] concept. Based on an exhaustive review of the literature, a survey of 230 experts and an analysis of 98 case studies, the authors identify 414 urban practices linked to the 15mC concept and classify cities according to five profiles inspired by the theory of diffusion of innovations [Rogers, E.M., as cited in Teixeira et al., 2024].

1. Innovators (pioneers of the concept with systemic and radical strategies) : Barcelona, Melbourne, Paris.
2. Early adopters (structured and advanced strategies) : Milan, Valencia, Edinburgh, Portland, Sydney, Tucson, Zagreb, Shanghai. These cities generally have quantitative targets (90 percent of neighborhoods becoming 20-minute neighborhoods by 2032).
3. Early majority (which are adopting certain 15mC practices without an overall strategy that has yet been fully developed) : Oslo, Neumünster, Ottawa.
4. Late majority (have started very limited projects, often in the exploratory phase) : 39 cities e.g. Sheffield, Launceston, Charlotte.
5. Latecomers or laggards (have expressed an interest but no concrete actions to date) : 12 cities e.g. Krakow, Seoul, Hamilton.

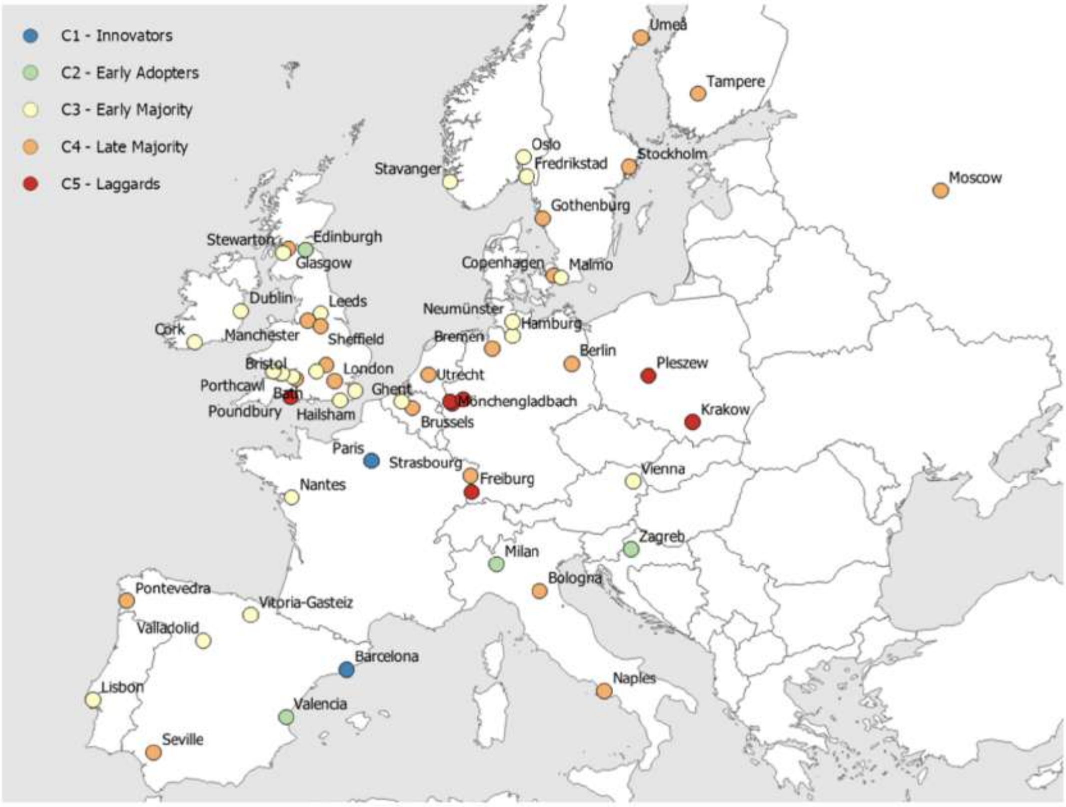

Figure 1.6: Classification of the cities according to the five 15mC categories (Europe). Source : [Teixeira et al., 2024]

[1]15mC : 15 minute City

The study shows that, although the concept of the 15mC is now widely recognized, the majority of cities are still at the planning phase and truly radical strategies are still in the minority [Teixeira et al., 2024].

The case studies presented show that the 15mC model is not a fixed model, but a framework for action that can be modulated according to the local context and realities. The fundamental objectives - to improve quality of life, reduce car dependency and strengthen urban resilience - remain constant. However the way in which they are applied depends on the political context, the urban form, the technical tools available as well as the capacity of local authorities to take actions. Despite the diversity of contexts and the used tools, a number of learning emerge from all these case studies :

- The central role of political and institutional leadership in the implementation (Paris, Barcelona, Melbourne);
- The importance of service density and integrated planning;
- The difficulty of adapting the model in low-density contexts, where the supply of services is usually fragmented;
- The use of technical tools which make it possible to simulate or assess real accessibility;

Another finding identified by Elldér (2024), shows the issues of equity in access to urban functions, with the risk of gentrification or spatial segregation amplified due to the implementation of the 15mC model [c.f. Section 1.4].

1.3 Indicators : Accessibility and Walkability

1.3.1 Walkability and NetAScore

In the context of the 15mC concept, **walkability** constitutes a central factor. It refers to the ability of an urban space to enable and encourage safe walking as a daily mode of travel. Closely linked to the accessibility, walkability goes beyond the mere presence of sidewalks to encompass the built environment, the attractiveness of places, the safety and quality of the pedestrian travel [Weng et al., 2019]. A walkable city promotes an active mobility, reduces the car dependency, improves public health and supports local economy. It is thus an essential component to implement the 15mC concept, where accessibility and proximity is not enough if it is not walkable.

The walkability is often evaluated with several indicators regrouped as **6D**. 6D consists of Density, Diversity, Design, Destination accessibility, Distance to transit and Demand management. These indicators are used in global models such as **Walk Score**, a destination based metric which has been validated and highly recommended for its effectiveness in measuring neighborhood walkability in different regions [Carr, et al., Duncan, D.T., as cited in Weng et al., 2019; Jeong et al., 2023].

Other approaches are based on user perceptions, measured via qualitative surveys or participatory systems. But these methods, while important, are often limited by their subjectivity or lack of territory coverage [Weng et al., 2019].

In this context of urban planning and promotion of active mobility, Werner et al., 2024 present **NetAScore**, an open and extendible software designed to assess walkability and bikeability in a systematic way and on a fine scale : that of road segments (edges) [Werner et al., 2024]. NetAScore bridges a gap in current assessment tools, which often suffer from limitations by their focus on zonal approaches (by neighborhood), dependent on private data, not adaptable and not transparent or reproducibility. The aim of NetAScore is thus to provide an open, extensible, adaptable platform based on open source data (mainly OpenStreetMap) and able to analyze the pedestrian and cycling environment at a road segment level [Werner et al., 2024].

The evaluation model is based on an approach using indicators derived from geographical data. Each segment is analyzed according to specific criteria, then a bikeability and walkability index is calculated using a configurable weighting. The data used is issued from OpenStreetMap directly, using the road network structured as a graph (nodes and edges). Additional data can also be added such as digital elevation models, noise, green spaces, etc [Werner et al., 2024].

The NetAScore model has been tested in several studies, for modeling soft mobility. Concrete examples are available for several cities including Salzburg, in Austria. NetAScore is also used as an impedance coefficient in pedestrian and cycle routing models [Kaziyeva, et al., as cited in Werner et al., 2024].

NetAScore constitutes a major step forward in assessing the quality of present infrastructure for active mobility. By combining openness of code and data, adaptability to local contexts, scientific reproductibility and extensibility to add new indicators, NetAScore has positioned itself as a robust and modular tool for researchers, urban planners and local authorities.

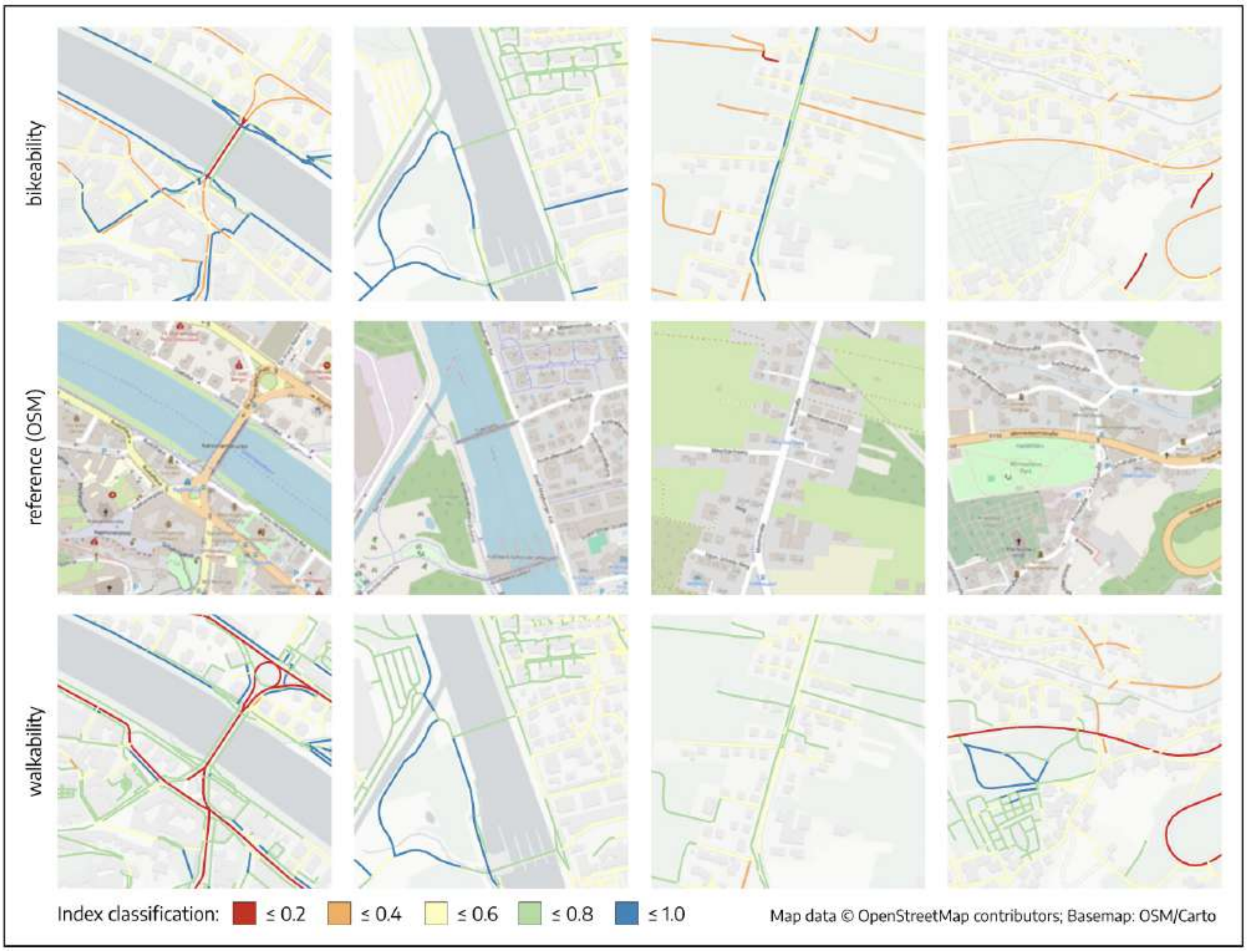

Figure 1.7: Examplary results of NetAScore for bikeability and walkability (Salzburg, Austria). Sources : [Werner et al., 2024]

Despite its many strengths, NetAScore does have certain limitations. It requires a detailed urban database, which can be a constraint in cities where data is lacking or obsolete. It does not take into account the user's perception (fear, comfort, liveliness, etc) as well as the quality of sidewalks (width, type of pavement), which plays a crucial role in the way people walk. The complexity of its use can slow down its adoption in local authorities. It is therefore recommended to use NetAScore in conjunction with other tools (observations, surveys, isochrones, network analysis), and to adapt it to the local scale and context [Werner et al., 2024].

1.3.2 Accessibility and applied method

In this section, different methods of calculation of accessibility are discussed, to understand their assets and limits. The aim of this analysis is to be able to use one of this method for the purpose of this paper.

Accessibility is a central concept in urban planning, particularly in the context of the 15mC concept. It refers to the ease with which people can reach a set of resources or destinations, from a given location, taking into account not only distance but also travel time, the mean of transport as well as the quality of travel. In the context of the 15mC, accessibility refers more specifically to the ability of residents to meet their daily needs within a 15-minute walk or cycle ride from their home. It is not limited to the service location. Accessibility also takes into account the analysis of the urban structure, the road network and the spatial distribution of functions. To translate this concept into operational indicators, with the aim of improving the concept of accessibility, the scientific literature uses a multitude of calculation methods producing accessibility scores or other variables [Farber and Fu, 2017].

The **grid-based approach** proposes to divide the study area into a grid of regular cells (often 100x100 meters). Each cell is then evaluated according to the accessibility of urban services from its centroid, using distances calculated with the road network. This makes it possible to create a continuous accessibility map for the whole city, providing a uniform diagnosis of the distribution of services [Vich et al., 2023]. In their article, Pezzica et al. (2024) tell us about the methodological challenges associated with the spatial modeling of 15mC, and highlight the importance of technical choices in the final results. The main objective of their study was to examine how seemingly secondary technical decisions, such as the choice of spatial grid, the method of generating isochrones, or the classification of urban functions, strongly influence the results of accessibility evaluation in the context of the 15mC concept. Their analysis is based on a grid-based approach and pedestrians isochrones. The authors use data from OpenStreetMap and GIS tools, combined with statistical databases [Pezzica et al., 2024]. The model is based on four major and variable technical components :

- Spatial tessellation (grid) : comparison between square, hexagonal and Voronoi-type grids with variable sizes ($500m^2$, $1km^2$). The form and the size of the grid influence the position of barycentres and therefore the areas covered by the isochrones. A finer grid increases the accuracy but makes more calculations. Different grids produce different maps for the same area.
- The method of generating isochrones, comparison between different tools. Significative differences appear regarding the tool used, with constant parameters, revealing a lack of transparency about the internal algorithms.
- The travel speed that vary with age (from <30 to >85). Walking speed is often assumed constant but varies greatly between age groups, a 15mC for a young adult is not the same for an elderly person.
- The classification of urban functions. Two classifications are tested, a strict one (only categories defined by Carlos Moreno) as well as a wider one (also public services, waste management and

transportation). The choice of classification influences greatly the results.

The article shows that the results depend as much on the data as on the methodological choices made. It stresses the importance of explaining all the methodological choices in detail to avoid the generation of misleading maps or indicators. The article calls for a standardization of procedures, a greater transparency in software tools as well as a modeling that is more citizen-centered (real speed, accessibility as experienced). It also opens up the perspective towards a more dynamic modeling (real time, behavior), going beyond the current static approach [Pezzica et al., 2024, Megahed et al., 2024].

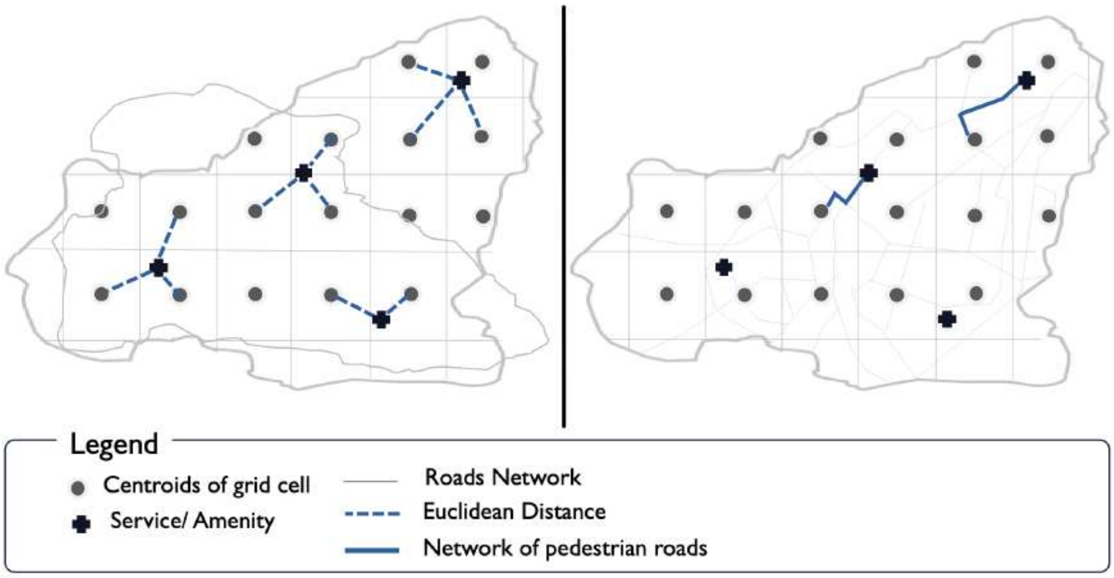

Figure 1.8: Concept behind the grid-based approach. Source : [Megahed et al., 2024]

The **Point of interest (POI) catchment area approach** is a commonly used approach in the context of the 15mC concept. It is based on a simple principle, from each POI (i.e. an urban service such as a school, a nursery, a shop), a catchment area is defined based on a distance or travel time threshold, generally, 15 minutes by foot. This zone is constructed using circular buffer or more realistically, isochrones[2] calculated with the road network. This allows to take into account actual walking distances. Once the zone is defined, the analysis consists of counting the number of residential buildings, parcels or individuals located within this area and considering them to be served by the service concerned [Vich et al., 2023, Megahed et al., 2024].

In their article, Vich et al., 2023, describe this method as one of the three main approaches to assess accessibility. It is a method widely recognized in the literature. In their article, Megahed et al., 2024, identify this method as the most frequently used method, present in 34 percent of the studies analyzed. This method allows to create concrete spatial indicators, such as the population coverage rate, or the number of accessible services for a given area. It is particularly useful for assessing equity of access to urban functions regarding the spatial justice.

However, this method has certain limitations. The temporal threshold used (often 15 minutes) can be arbitrary and may not reflect the actual practices of residents. This method also does not take

[2]isochrones : An isochrone map, represents the area that can be reached from a given location within a specified time threshold. An isochrone is defined as "a line drawn on a map connecting points at which something occurs or is reached at the same time." In practice, isochrone maps are commonly used to illustrate accessibility, for example, identifying areas that can be reached within 15 minutes by walking.

into account the quality of the pedestrian path (presence of pavements, safety, obstacles). Despite these limitations, the POI catchment area approach remains a robust, reproducible and widely proven method [Vich et al., 2023, Megahed et al., 2024].

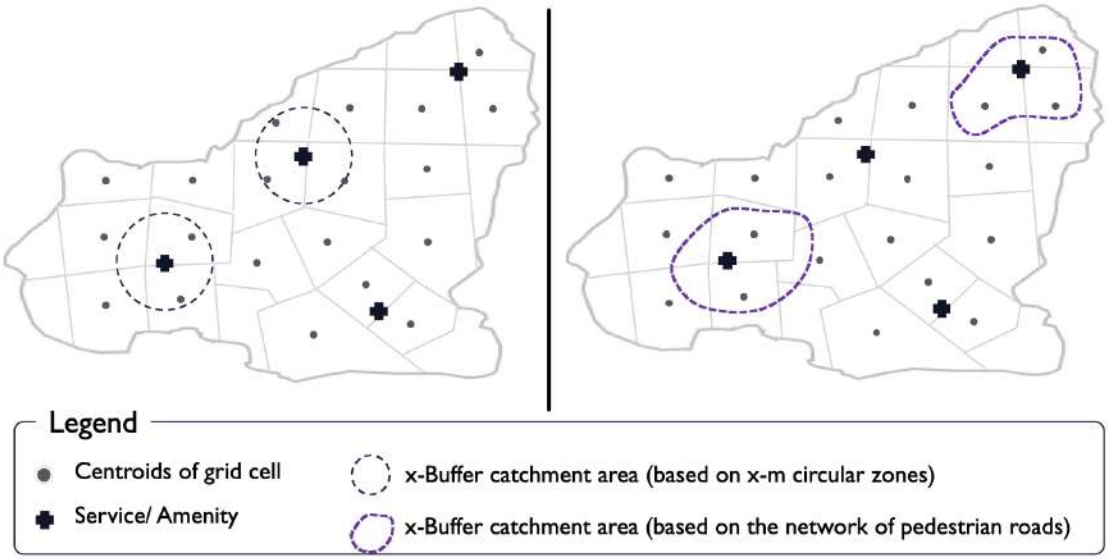

Figure 1.9: Concept behind the POI catchment area approach. Source : [Megahed et al., 2024]

The **Building catchment area approach** is an approach measuring the accessibility. It takes residential buildings as the points of origin for the analysis. Unlike the POI catchment area approach, this method aims to assess, for each residence, the number or diversity of services accessible within a 15 minute walk buffer. In practice, this method calculates for each residential building, the number of services that can be reached through the actual road network. These can include schools, health centers, shops, cultural facilities, etc depending on the chosen classification of functions. The result is an accessibility score assigned to each building, representing the level of accessibility for each residence. It enables a detailed assessment of inequalities in terms of accessibility. It allows to identify, on a micro-local scale, the dwellings that are best or worst connected to essential services. This method, is also among the dominant approach recognized by Megahed et al., 2024 in their article.

In a study applied in Sweden, Akrami et al., 2024 use this approach to quantify disparities in access between various urban areas. Their methodology is based on the calculation, for each building, of an accessibility score for eight essential urban functions. The score is then aggregated to highlight spatial as well as socio-economic disparities. This approach has numerous advantages. it produces an interpretable numerical indicator for each building, enables a high-resolution analysis of inequalities at a neighborhood or street level and is particularly useful for targeting development actions and redistribution of facilities. In terms of limitations, the approach does not take into account the quality of pedestrian route, unless combined with walkability scores. In many studies, the approach assumes equivalence between services, but weightings can be applied correctly to their importance or attractiveness [Megahed et al., 2024, Vich et al., 2023].

In addition to these methods, focusing on distances and travel times, other more structural approaches have been used in recent studies, in particular methods based on **space syntax**. This approach makes it possible to analyse the configuration of the road network based on the notion of angular integration : an indicator that measures the extent to which a street is fluidly connected to the rest of the network. Space syntax can be used to identify the routes most likely to attract pedestrian traffic and optimize the network [Murgante et al., 2024]. The **place syntax** extends this logic by integrating urban functions (POI) into the calculation. It produces indicators such as attraction reach, which combines network structure and density of accessible services. These methods are less widespread than approaches based on buffers or grids, but offer a complementary reading, focusing on the logic of spatial organization, rather than on metric movement [Murgante et al., 2024].

In addition, some studies adopted a **mixed methodological approach**, combining several approaches in a single study. This may involve combining network-calculated isochrones with buffers, or cross-referencing accessibility scores with walkability or socio-economical values. These hybrid models aim to compensate the limitations of each method by integrating functional, morphological and social dimensions. According to Megahed et al., 2024, these methods represent a total of 13 percent of scientific publications on the 15mC subject, and reflect a move towards a more integrated and contextual measurement of accessibility.

The relevance of the methods explained is confirmed by the study of Megahed et al., 2024, which propose a systematic review of the approaches measuring proximity used in the scientific literature on X-minute cities. This review is based on 38 articles published between 2020 and 2023. Three methods stand out to be the most frequently used : the POI catchment area approach : 34 percent of studies, the Grid-based approach : 18 percent of studies, the Building catchment area approach : 16 percent of studies. These methods are considered the most appropriate for generating high resolution indicators, enabling a detailed analysis of the accessibility. Two other families completed the analysis, the mixed-approaches as well as the graph-based approaches. Megahed et al., 2024 draw attention to some limitations of the current methods. Many of them still neglect the quality of pedestrian routes, differentiated social factors as well as perceived proximity or actual use of urban space. These limitations call for the use of a hybrid methodology, combining quantitative approaches and qualitative or participatory approaches.

Method name	Scale of analysis	Calculation principle	Output / Variable type	Strengths / Limitations	Main sources
Grid-based accessibility	Regular grid (e.g. 100x100m	Division of territory into uniform cells; accessibility calculated from each centroid to surrounding services.	percentage of accessible services per grid cell; spatial accessibility surface.	Easy to compare spatial units; sensitive to grid size and shape.	Vich et al., 2023
POI catchment area	Service points (POI)	Buffers or isochrones generated around services; counts population/buildings within the coverage zone.	percentage of people/buildings covered by services within a defined radius.	Simple to implement; overestimates access without network modelling.	Vich et al., 2023
Building catchment area	Housing unit	Travel time or network distance measured from each building to surrounding POIs.	percentage of services reachable per building via walking network.	Fine-scale accuracy; data-intensive, requires complete road network.	Vich et al., 2023

Table 1.1: Validated accessibility measurement methods used in 15-minute city research. Source : Author

1.4 Political and social stakes

1.4.1 Spatial justice and urban inequalities

The concept of the 15mC has rapidly established itself as a response to the contemporary climatic, health and urban challenges of our cities. But it also raised a series of complex political and social issues. Behind its utopian vision of universal accessibility, it raises questions about the distribution of urban resources, spatial justice as well as governance arrangements and public acceptance. Several studies show that the implementation of the 15mC can produce paradoxical effects, by reinforcing certain inequalities while claiming to reduce them.

A major issue associated with the 15mC concept is spatial justice i.e. the equity in access to urban essential services. Various studies have shown that richer neighborhoods are structurally better endowed with local amenities, which give them an advantage to implement the model in their area. On the contrary, peripheral or working-class areas often suffer from a lack of services, low density and car dependency [Akrami et al., 2024]. For example, the study of Weng et al., 2019 shows that low-income neighborhoods have a significantly reduced accessibility to health, education and transport services, despite sometimes a high density. Similarly, Akrami et al., 2024, in their study point out that spatial inequalities are reinforced by differences in income, migratory status or family structure.

These studies confirm that the objective of a city accessible to all cannot be achieved without an active policy of rebalancing, with targeted investments in under-served neighborhoods and vigilance regarding the reproduction of inequalities in the distribution of services. The socio-economical component of the various neighborhoods of a city must be taken into account when analysing the accessibility of a city.

1.4.2 Gentrification and paradoxical effects

Another crucial issue concerns the unintended side-effects that the 15mC concept can generate, particularly in terms of gentrification. By making well-served neighborhoods more attractive, the improved local accessibility can lead to higher property prices, displacement of vulnerable populations and social homogeneisation, creating gentrification. A study carried out by Elldér, 2024 perfectly illustrates this paradox. The central districts with the highest 15-minute accessibility scores are also those with the highest gentrification indicators. These results reflect the fear expressed by many researchers about the risk of a "15mC for the rich", where the lower classes would be displaced to less accessible areas. Megahed et al., 2024, in their article, stress the importance to couple the implementation of the 15mC concept with affordable housing policies and social mixing strategies. Otherwise the model could accentuate the dynamics of exclusion that it seeks to correct [Megahed et al., 2024].

1.4.3 Political tensions and controversies

On the political plan, the model has raised contrasting ideological interpretations. It is promoted by international networks such as C40 and UN-Habitat as an ecological and inclusive solution, but also has been used in public debate, sometimes in polemic ways. In France, in the UK and in Canada, the model has been the subject of conspiracy accusations associating the 15mC with authoritarian control of travel or restrictions of freedom [A. R. Khavarian-Garmsir et al., 2023]. These conspiracies relayed on social networks, reflect a mistrust of top-down urban policies, but also a misunderstanding of the model. Researchers are calling for the democratic dimension of the concept to be clarified, to show that the aim is above all to give residents back their autonomy, not to restrict their freedom. This stresses the importance of transparent governance in implementing such transformations.

1.4.4 Local governance, acceptability and participation

The implementation's success of the concept depends largely on its local governance. A number of studies highlight the central role of local authorities, local players and residents themselves in the co-construction of projects.Teixeira et al., 2024 in their article show us that cities that incorporate participatory mechanisms from the design phase (neighborhoods workshops, walking diagnoses, participatory mapping) obtain better results in terms of accessibility and appropriation of the model. Conversely, a purely technical approach tends to produce rejection and even conflicts of use. Megahed et al., 2024 also stress the importance of contextual and adaptive planning, which takes into account the specific local characteristics and the needs expressed by inhabitants. The 15mC concept cannot be a strict concept, but a flexible framework to be adapted locally.

1.4.5 Between shared utopia and political tensions

The 15mC concept appears to be an appealing response to a series of contemporary crises : environment, health, social and democratic. It is driven by a vision of proximity, slowness and territorial rebalancing. The concept proposes a reconfiguration of the city based on the scale of everyday life. However, as explained, its implementation raises a number of political, social and ideological tensions that cannot be ignored.

On the one hand, the model is admired for its ability to make cities more inclusive, accessible and resilient. Various studies show that it helps to reduce certain inequalities, as long as it is integrated into an overall strategy, with housing, mobility and participation policies [Elldér, 2025b].

On the other hand, more critical researches warn of the paradoxical effects the model can have, gentrification of active-neighborhoods, reinforcement of inequalities of access, exclusion of peripheral areas, tensions around governance. Cremaschi, 2022 even goes further in its article "Ville du quart d'heure, ville des GAFA". He questions the apparent neutrality of the discourse surrounding the model. He highlights the risk of a depoliticized urbanism, driven by platform, surveillance or flow management logics, where proximity becomes a simple variable to be optimized in algorithm urban management systems.

This critique encourages us to place the model within a broader perspective. It raises questions not only about what the model does to the city, but also who implements it, how it is told and its consequences for local residents.

In the end, the 15mC is neither a miracle solution nor a consensual utopia. It is a powerful framework, but its scope is highly dependent on social contexts, political choices and implementation methods. To make it a sustainable and fair tool, we need to recognize its political dimension, debate it collectively and ensure that it remains at the service of the city dwellers rather than technocratic optimization logics.

1.5 Conclusion of the state of the art

1.5.1 Limitations and gaps

This section concludes our review of the current literature on the subject of the 15mC. The analysis of the literature highlights the potential of the model, but also its limitations in terms of methodology and implementation. This requires a critical and contextualized reading.

Firstly, the concept suffers from a lack of framing. The notion of "15 minute" varies from author to author. Is it about only cycling or walking, or both ? Is it 10, 15 or 20 minute walk ? For which services ? For whom ? This flexibility is beneficial for adapting the model to local contexts, but it complicates standardization. [Megahed et al., 2024, A. R. Khavarian-Garmsir et al., 2023]. Some articles show that, depending on the type of functions or urban morphology, a threshold of 10, 20 or 30 minute may be more relevant [Teixeira et al., 2024].

Regarding the methodology, a significant progress has been made, notably through network analyses, accessibility scores and indicators such as the NetAScore, but various shortcomings remain. On the one hand, methods are mostly quantitative ones, ignoring perceptions, actual practices and the quality of paths. Only a few studies incorporate the subjective dimension of proximity and accessibility, even though they play a crucial role in the urban experience [Akrami et al., 2024, Weng et al., 2019]. On the other hand, accessibility models are still not sensitive enough regarding the social profiles of users. Travel times and conditions are not the same for an elderly person, a child or a 35 year old. Some methods are also based on assumptions about the homogeneity of services, without weighting them according to size, capacity or attractiveness [Pezzica et al., 2024].

Over and above the technical aspects, recent studies stress the potentially ambiguous social and political effects of the 15mC. The model aims for inclusion, but it can also generates gentrification by promoting well-served neighborhoods [Elldér, 2025a]. In reality it is often the already favoured areas that meet the accessibility criteria, accentuating spatial inequalities. At the same time, ideological or conspiracy-based tensions has emerged in certain contexts, revealing a lack of public ownership and transparency in the governance of the model [A. R. Khavarian-Garmsir et al., 2023].

Finally, authors like Cremaschi, 2022, warn about the risks of technocratisation of the concept, when accessibility is reduced to an optimizable metric in algorithm city management models. From this perspective, the concept of the 15mC, if not anchored in democratic practices, could become a neoliberal management tool rather than a lever for emancipation [Cremaschi, 2022].

1.5.2 Next steps of the work

Based on the findings of the literature review, the next phase of this research aims to transpose these theoretical and methodological insights into a practical application, anchored in the specific urban context of the Sainte-Walburge district in Liège.

The main objective is to produce a spatial diagnosis of local accessibility and walkability, in line with the principles of the 15-minute city (15mC) model. This is achieved through a combination of two complementary approaches.

First, the analysis will rely on the building-based catchment area method, which calculates, for each residential building, the number of essential services reachable within a fixed walking time. This method was chosen because it suits the micro-scale of the analysis and corresponds to the type of spatial and functional data available in Liège.

Second, to evaluate walkability, the work will use the NetAScore index, a detailed metric that incorporates several attributes of the pedestrian network (such as slope, surface quality, safety, and urban form) at a fine spatial resolution. This allows for an assessment not only of proximity to services, but also of the quality and comfort of pedestrian routes.

While spatial configuration methods such as space syntax and place syntax offer valuable insights into network morphology, they are not applied here, as they remain largely disconnected from actual conditions of use and the spatial distribution of services. Moreover, these methods require specific technical tools and standardized data structures that exceed the scope and available resources of this project.

The results of the accessibility and walkability analyses are cross-referenced with socio-economic indicators, particularly the synthetic difficulty index (ISD), to identify areas where limited access or poor walkability overlaps with higher social vulnerability. This spatial cross-analysis aims to reveal local inequalities in access to the 15mC, both in terms of service proximity and pedestrian experience.

Finally, the spatial diagnosis is enriched through fieldwork and resident interviews, providing qualitative insights into the daily practices, perceived obstacles, and real-life constraints experienced by the inhabitants. This will allow the comparison between objective spatial data and the subjective experience of urban mobility.

This integrated approach aims to support the operationalisation of the 15-minute city model at the neighborhood scale by combining spatial analysis, social equity considerations, and user perception. The ambition is to propose a reproducible, mixed-method framework that is both sensitive to local context and adaptable to other Belgian urban realities.

Chapter 2

Methodology

2.1 Research questions, evaluation criteria and study area

The objective of this paper, as explained in the state of the art, is to test the operationalisation of the 15mC concept in a Belgian context. The use of spatial quantitative analysis tools, socio-economic data and qualitative approach based on residents, is used to produce a methodology that best respects the local context of the city of Liège. The study aims to answer two research questions,

1. **How can the walkability and urban accessibility of a neighborhood be reliably assessed, and what solutions can be put in place to improve them?**

2. **How do socio-economic characteristics influence a neighborhood's walkability and accessibility?**

The first question is based on the methodological limitations found in the analysis of the scientific literature, which highlight the lack of standardized tools adapted to local contexts for measuring accessibility and walkability [Vich et al., 2023, Megahed et al., 2024]. In response, this paper seeks to test and validate a reproducible spatial diagnostic method, combining digital tools (NetAScore, GIS software) and field observation, with the ultimate goal of finding the concrete planning levers. The second question refers more to the critical contributions of the literature, which remind us that accessibility indicators are not rigid and neutral. The conditions of access vary according to social characteristics and individual abilities [Elldér, 2025a, Pezzica et al., 2024, Akrami et al., 2024]. Linking the results with socio-economic data aims to highlight territorial inequalities, to achieve spatial justice. To answer these questions, two main evaluation criteria have been defined, based on the analysis of the scientific literature.

1. **Accessibility** - to assess the number and diversity of services accessible within a 15-minute walk from each residential building. This accessibility is measured using the building catchment area approach widely used in 15mC studies [Vich et al., 2023, Megahed et al., 2024].

2. **Walkability** - refers to the ease with which a person can move around on foot, taking into account the quality of pedestrian routes, comfort and clarity of the space. It is measured using NetAScore software, which produces an index of pedestrian quality at road segment level [Werner et al., 2024].

These two indicators will then be cross-referenced with socio-economic data to produce a spatial diagnosis incorporating both objective accessibility, walkability and vulnerability of populations. The study area is the **municipality of Liège**, which is of methodological, operational and contextual interests for several reasons. Liège has incorporated the 15mC concept in its regional planning, notably through the European DUT 15-minute city program [Driving Urban Transitions Partnership, 2025]. This makes it relevant for assessing how the model is applied at a local level. The city has also a particular topographical situation, with steep slopes that makes it another difficulty to integrate the 15mC model in the city. This physical constraint allows to test the limits of the model in a real context. Liège has significant socio-economic differences between its neighborhoods, in terms of income, distribution of services, household composition, etc. These disparities reinforce the relevance of a cross-referenced analysis between accessibility, walkability and socio-economic data. Finally, Liège was also chosen for practical reasons, the availability of detailed data and the proximity of the site makes it easier to carry out qualitative surveys and interviews.

Among the neighborhoods that constitutes the municipality of Liège, **Sainte-Walburge** was chosen as test area for the qualitative extension of the study. This choice was also based on several converging criteria. Firstly, Sainte-Walburge has an urban layout typical of the outlying districts of Liège, characterized by a hilly topography, with steep slopes that complicates the pedestrian mobility. Unlike the heart of Liège, which is flatter and largely pedestrianized, Sainte-Walburge is more representative of the physical and structural constraints found in many suburban neighborhoods. The neighborhood is also characterized by great socio-economic diversity. Some areas have a relatively privileged population, while others have a combination of precariousness and working-class population. This diversity allows to carry out a detailed analysis of inequalities within the neighborhood. Finally, Sainte-Walburge was chosen also for logistical and practical reasons. Local-contacts and pre-existing data were already available, facilitating the fieldwork phase. The proximity of the site was also essential for interviews with local residents and field survey.

2.2 Data collection

The study is based on the cross-reference of spatial, socio-economical and qualitative data. The data was selected on the basis of three main criteria : its availability at the local level, its relevance for the two dimensions studied (accessibility, walkability), and its compatibility with the methodological tools used (NetAScore, QGIS). The data used is as follows;

2.2.1 Spatial data

- The **road and pedestrian network** was extracted from OpenStreetMap (OSM). This allows the reproducibility of the work with the use of open data. This network forms the basis for calculating both the accessibility isochrones and the walkability scores ["OpenStreetMap", n.d.].
- A **Digital Terrain Model** (DTM) was used to calculate local gradients. This factor is crucial for estimating the physical difficulty of walking, particularly in Liège, where the topography is marked. This data was collected from WalOnMap ["WalOnMap | Géoportail de la Wallonie", n.d.].
- The **noise levels** were incorporated to enhance the assessment of pedestrian comfort, as a NetAScore criterion. This data was also collected from WalOnMap ["WalOnMap | Géoportail de la Wallonie", n.d.].
- The **urban services, POI** (shops, sustenance, financial, healthcare, education, entertainment, transportation) were extracted from OpenStreetMap data. These essential functions were retained, in line with recommendations from the literature on the 15mC [Moreno et al., 2021, Vich et al., 2023].
- The **cadastral data** was used to recover the footprints of residential buildings, which were used as point of origin in the accessibility calculation (building catchment area). Each building is treated as an individual spatial unit. This data was also extracted from WalOnMap, then cleaned to only keep residential buildings ["WalOnMap | Géoportail de la Wallonie", n.d.].

2.2.2 Socio-economic data

- The **Socio-economic indicator** used is a synthetic difficulty index (SDI) which was calculated by the Lepur laboratory at the University of Liège. It is then aggregated at the level of statistical sectors, the reference unit in Belgium (c.f. section 2.4.1). People's vulnerability does not solely depend on their income, but also on the social support structures they benefit. it is therefore important to take into account all parameters of precariousness in the socio-economic data used, hence the choice of the synthetic difficulty index. ["Open Data | Statbel", n.d.; Poussard, 2019].

2.2.3 Qualitative data

- A **field survey** was carried out at 60 randomly chosen segments in the Sainte-Walburge district. This survey allows to refine the NetAScore model locally with the addition of obstacles and to verify its validity in a topographic complex context.
- **Qualitative interviews with residents** were conducted in order to gain a better understanding of their perceptions of accessibility and walkability, the obstacles to active mobility in the neighborhood and their daily travel patterns.

Taken together, these data make it possible to adopt a mixed methodological approach, combining objective spatial analysis and lived experience of the area.

2.3 Applying the different methods

2.3.1 Accessibility

As explained, the accessibility method is based on the building catchment area approach, which involves calculating, for each residential building selected, the number of services that can be reached in a 15-minute walk via the pedestrian road network. The calculations are done with a GIS software, in this case, QGIS.

Implementation steps in QGIS :

1. **Preparation of the cadastral data** : selection and cleaning of residential buildings from the cadastral layer, and exclusion of buildings smaller than $30m^2$ (garden sheds, garages, etc).
2. **Spatial join** : association of residential buildings with their statistical sector
3. **Sampling** : stratified random selection of 5 percent of buildings per statistical sector, with a ceiling of 10 buildings per sector to limit the weight of the calculations.
4. **Conversion to points** : transformation of the selected buildings into starting points for the isochrones.
5. **Generation of isochrones** : use of the QGIS plug-in, ORS tool, to produce distance pedestrian isochrones. The distance used were, 1134m and 855m corresponding to the distance traveled on foot in 15min by a person aged 30 to 60 and then by a person aged 65 to 85 years.
6. **Processing urban services (POIs)** : importing and reclassifying services into 7 essential categories : shop, sustenance, financial, healthcare, education, entertainment and transportation.
7. **Spatial cross-referencing** : identification of POIs achieved within each isochrone.
8. **Assigning a score** : calculating an accessibility score for each building (number of functions met),

with weighting by type of service (25% for healthcare, 20% for education, 15% for entertainment, 15% for shops (containing shops, finance and sustenance) and 25% for transportation). The score was normalized to obtain a score going from 0 (least accessible) to 1 (most accessible). This allows a good comparison between walkability and accessibility as they are in the same range of values.

9. **Aggregation** : at the level of statistical sector, enabling cross-referencing with socio-economic variables.

This way we can assess for each statistical sector and also for each point analyzed in the statistical sectors, a value for accessibility and also a socio-economical value. This allows to analyze the correlation between the two indicators. The same process is done with the walkability indicator allowing to compare accessibility, walkability and socio-economic values at the same time.

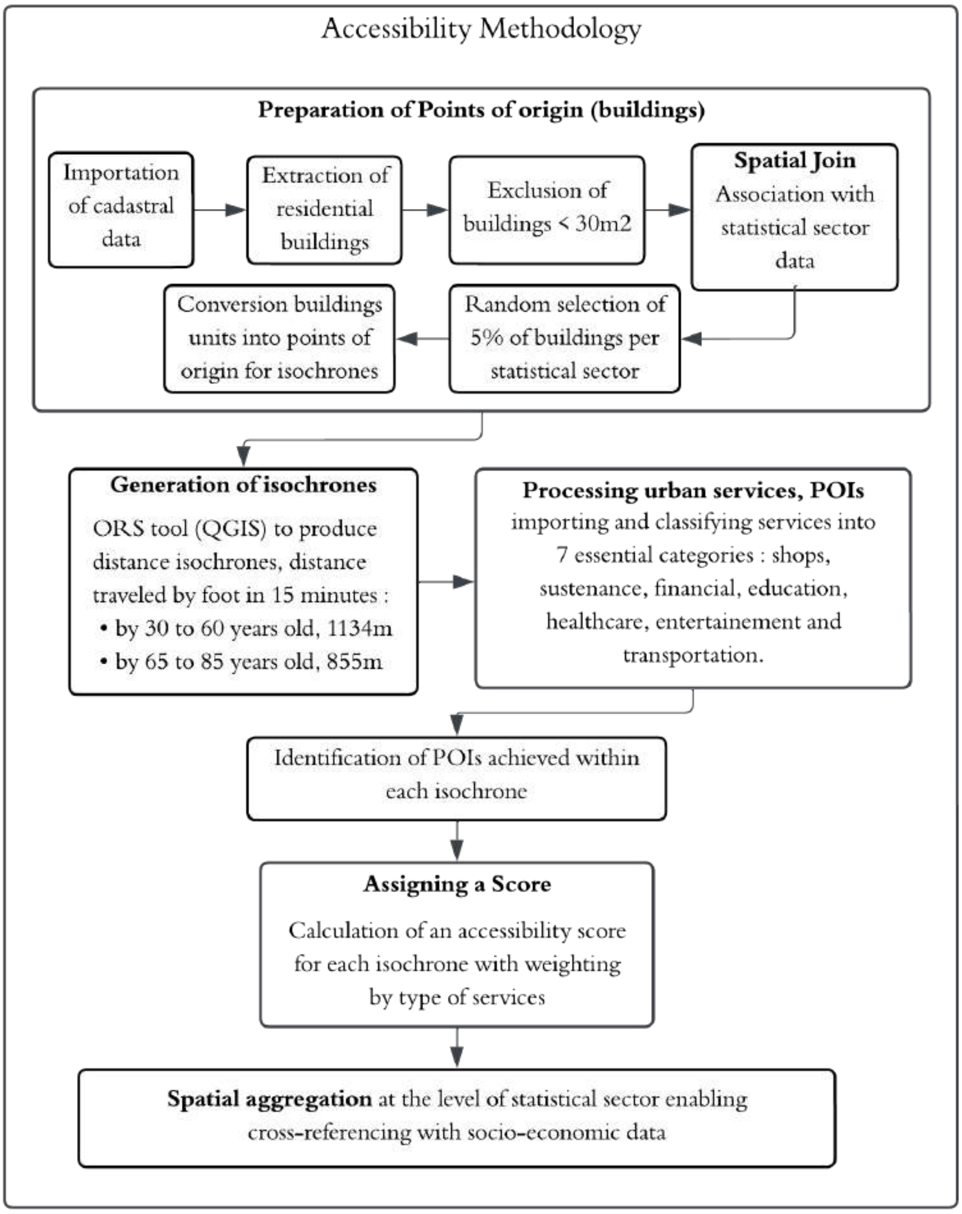

Figure 2.1: Methodological framework for the Accessibility. Source : Author

2.3.2 Walkability

NetAScore is an open source software tool that allows to assess the quality of the pedestrian routes at the level of road segments. It provides default profiles for cycling and walking and can be used as a foundation for network analyses to support urban planning. It is also easily customizable by simply adapting or creating new mode profiles for adressing a specific purpose, specific target group, etc. In this section, the procedure of the calculations done with NetAScore is explained as well as the processing of the results in QGIS. The structure of the NetAScore software will firstly be explained to understand clearly how the calculations are done ["Github", n.d.].

The NetAScore software produces a walkability and bikeability index for each road segment, on a scale from 0 (very pood conditions) to 1 (optimal conditions). In this paper the walkability index is the main focus, the bikability will not be analyzed. It works by integrating OpenStreetMap data and also additional data such as noise or topography. The process of the software is composed of different stages, as follows :

1. **Import step** : the road network is extracted from OSM. Additional data can be added such as topography or noise data. In the case of this study we added the Digital Terrain Model of Liège (.tiff) as well as the noise data (.gpkg).
2. **Network step** : The final network dataset is created. The dataset is cleaned and simplified and a unique edge ID is created for each network edge to serve as a reference for calculations and mapping.
3. **Attribute step** : each road segment is enriched with multiple attributes based on the OSM tags. These attributes are translated into normalized values based on predefined value domains to ensure that all attributes are comparable, regardless of their original scale or type.
4. **Index step** : Index are calculated based on the mode profile defined in the settings file. The index is calculated as a weighted average over all available indicators for every edge. According to the weights defined in the mode profiles, the indicators are combined into a single index value per edge. The default weights for the indicators are as follows in the table.

Indicator	**Assigned Weight**
Pedestrian infrastructure (sidewalks, crossings)	0.4
Road category (residential, primary, etc.)	0.3
Max speed greatest	0.3
Gradient (slope)	0.3
Number lanes	0.1
Facilities	0.3
Crossings	0.2
Buildings (built-up density)	0.1
Noise	0.3
Greenness	0.3
Water (rivers, ponds, etc)	0.4

Table 2.1: Weighting of indicators in the walk profile of NetAScore. Source : Author

Note : The weights are relative importance scores used internally in NetAScore and do not need to be normalized to 1, they are directly used in the weighted average formula to compute the walk *index.*

In the weighting of indicators, some indicators are defined but not included in the final calculation of the walkability index. This is particularly the case for, *pavement, width and parking.* This choice is linked to significant limitations in the availability and quality of OSM data.

- *Width* is rarely provided is OSM. When it is present, it may correspond to the total width of the road (cars + sidewalk) and not specifically to the pedestrian space.
- *Pavement* is often missing from OSM data.
- *Parking*, although important for legibility and pedestrian safety, is poorly marked in OSM.

The inclusion of these indicators in the final weighting could introduce methodological biases that would distort the overall index. Their presence in the profile makes it possible to prepare for their future inclusion, should the quality of the data improve. This case highlights a structural limitation of approaches based on open data, the quality of the results in highly dependent on the quality and accuracy of the data used.

5. **Export step** : in this step, the resulting index value for each edge is exported, as defined in the settings file. In this paper, the results are exported as a geopackage file. This file serves as the main dataset for the spatial analysis in QGIS. The results file can then be opened in QGIS software to visualize the results as maps and also as tables. In the table below you will find an example of the result table for one road segment. In this exemple, bikeability results are not showed as it is not the focus of the work.

Variable	Value
edge id	106
osm id	4783123
from node	71436
to node	71520
length	150.92
net type	road
access car ft	1
access car tf	1
access pedestrian ft	1
access pedestrian tf	1
bridge	0
tunnel	0
stairs	0
pedestrian infrastructure ft	sidewalk
pedestrian infrastructure tf	sidewalk
designated route ft	no
designated route tf	no
road category	residential
max speed ft	50
max speed tf	50
max speed greatest	50
pavement	asphalt
width	/
gradient ft	-1
gradient tf	1
number lanes ft	/
number lanes tf	/
facilities	0
crossings	0.66
buildings	0.5
greenness	49.49
water	0
noise	74
parking ft	/
parking tf	/
index walk ft	0.4966
index walk tf	0.4966
index walk ft robustness	0.9667
index walk tf robustness	0.9667

Table 2.2: Example of NetAScore output per road segment. Source : Author.

Calculation of the walkability index :

For each segment of the road network,

1. Each indicator is evaluated on the basis of OSM attributes or imported data (noise, DTM).
2. Standard values are assigned to each class of the attribute (i.e. slope > 8 percent = 0.25 ; pavement = asphalt = 1 ; residential road = 0.8 ; noise > 70 dB = 0 ; etc).
3. The final value is obtained by weighted sum of the indicators, according to the following calculation,

$$\text{Walkability}_{\text{score}} = \sum_{i=1}^{n} (w_i \times I_i)$$

where w_i is the weight of the indicator and I_i its normalized value.

An essential feature of this index is that it takes into account the bi-directionality of streets, each segment is analyzed in both directions, i.e. from node A to node B (from-to) and from node B to node A (to-from). This distinction is made because walkability conditions can vary depending on the direction of travel. NetAScore takes this orientation into account by calculating separate score values for each oriented segment, each taking into account the attributes in the direction concerned (ft or tf). This allows a finer-grained analysis that reflects the conditions of the pedestrian environment. The final score can then be used as it stands for each direction, or aggregated (as an average) when the aim is to represent general walkability independent of direction.

In this paper, the choice to use an aggregated value of the walkability was made, because the aim is not to evaluate precisely differences in travel conditions according to direction, but rather to obtain an overall measure of the pedestrian quality of a segment as a whole. This choice is consistent with the scale of analysis in the work, which aims for an overall assessment of walkability at neighborhood level, rather than detailed modeling of streets in one direction or another.

Each indicator corresponds to an attribute (from OSM data or imported data). For every attribute, a conversion rule is specified :

– by mapping : if the values are textual or discrete.

– by classes : if the values are numerical, such as a speed or a percentage.

1. Pedestrian infrastructure

YAML structure of pedestrian infrastructure

```
mapping:
  "pedestrian_area": 1
  "pedestrian_way": 1
  "mixed_way": 0.85
  "stairs": 0.7
  "sidewalk": 0.5
  "no": 0
```

This indicator evaluates the type of infrastructure available for pedestrians.

– Full pedestrian areas (pedestrian area, pedestrian way) get a score of 1.

– Sidewalks and shared spaces receive lower scores (e.g., 0.5 or 0.85).

– No infrastructure leads to a score of 0.

2.Gradient

YAML structure of gradient

```
mapping:
  4: 0.25
  3: 0.5
  2: 0.7
  1: 1
  0: 1
  -1: 1
  -2: 0.7
  -3: 0.5
  -4: 0.25
```

This indicator describes the gradient class of a road segment for downhill and uphill (±). Here is the class representation of slope,

– Flat segments (-1 to +1) are rated 1 (easy to walk).

– Moderate slopes (±2 or ±3) get medium scores.

– Steep slopes (±4) are heavily penalized (score = 0.25).

Class	Definition
0	0 - 1,5 %
1	> 1,5 - 3 %
2	> 3 - 6 %
3	> 6 - 12 %
4	> 12 %

Figure 2.2: Gradient class of a road segment. Source : NetAScore.

3.Road category

YAML structure of road category

```
mapping:
  "primary": 0
  "secondary": 0.2
  "residential": 0.8
  "service": 0.85
  "calmed": 0.9
  "no_mit": 1
  "path": 1
```

This indicator classifies road types based on their compatibility with walking.

- Main roads (primary, secondary) are unfavorable (score 0 to 0.2).
- Residential and service roads are more walkable (score 0.8 to 0.9).
- Traffic-calmed roads and paths are considered optimal (score = 1).

4. Noise

YAML structure of noise

```
classes:
  g70: 0
  g55: 0.6
  g10: 0.8
  ge0: 1
```

This indicator describes the noise level of a road segment in decibel..

- Segments exposed to noise levels over 70 dB get a score of 0.
- Between 55 and 70 dB, the score is moderate (around 0.6).
- Very low noise (< 55 dB) receives a high score, up to 1.

5. Crossings

YAML structure of crossings

```
classes:
  e0:
    indicator: road_category
    mapping:
      "primary": 0
      "secondary": 0
      NULL: 0
      "residential": 0.5
      _default_: 1
  g0: 1
```

This indicator is conditional and evaluates the presence of pedestrian crossings.

- If there is no crossing (e0), the score depends on the road category:
  - primary, secondary, NULL, score = 0
  - residential, score = 0.5
  - all others, score = 1
- If a crossing is present (g0), the score is automatically 1.

6. Number of lanes

YAML structure of number lanes


```
classes:
  g4: 0
  g3: 0.1
  g2: 0.2
  g1: 0.5
  ge0: 1
```


This indicator estimates how lane count affects pedestrian friendliness.

- Fewer lanes = better score.
- Four or more lanes are considered very unfriendly to pedestrians (score = 0).
- One-lane roads score up to 0.5.

7. Facilities

YAML structure of facilities


```
classes:
  g0: 1
  e0: 0
```


This indicator describes the number of facilities (POIs) per 100m segment length within a 30 meters buffer along the road segment.

- Segments with facilities score 1.
- Absence of facilities results in a score of 0.

8. Buildings

YAML structure of buildings


```
classes:
  ge80: 0
  g60: 0.2
  g40: 0.4
  g20: 0.6
  g0: 0.8
  e0: 1
```


This indicator represents the proportion of the area covered by buildings within a 30 meters buffer along the road segment: 0 to 100. The higher the built density, the lower the score (perceived lack of openness).

- Very dense areas (over 80 percent) are penalized (score = 0).
- Lower or balanced densities receive higher scores.
- Completely open surroundings (e0) are ideal (score = 1).

9. Greenness

YAML structure of greenness

```
classes:
  g75: 1
  g50: 0.9
  g25: 0.8
  g0: 0.7
  e0: 0
```

This indicator describes the proportion of the green area within a 30 meters buffer: 0 to 100.

- Dense greenery (>75 percent) provides the best pedestrian comfort (score = 1).
- Moderate greenery is still positive (score = 0.7 to 0.9).
- Absence of green features results in a score of 0.

10. Water

YAML structure of water

```
mapping:
  True: 1
  False: 0
```

This indicator describes the presence of water bodies within a 30 meters buffer.

- If there is a presence of water within the buffer, it receives the maximum score (1).
- If no water is nearby, the score is 0.

11. Max speed greatest

YAML structure of max speed greatest

```
classes:
  ge100: 0
  ge80: 0.2
  ge70: 0.3
  ge60: 0.4
  ge50: 0.6
  ge30: 0.85
  g0: 0.9
  e0: 1
```

This indicator uses the maximum value of speed limits for both directions along the segment.

- High speeds reduce walkability: values >100 km/h score 0.
- Low-speed areas (<30 km/h) are favorable, scored up to 1.

These indicators are then aggregated using a weighted average formula to produce the final walkability index. This approach enables a robust multi-criteria assessment that can be adapted to different urban contexts and is sensitive to actual walking conditions.

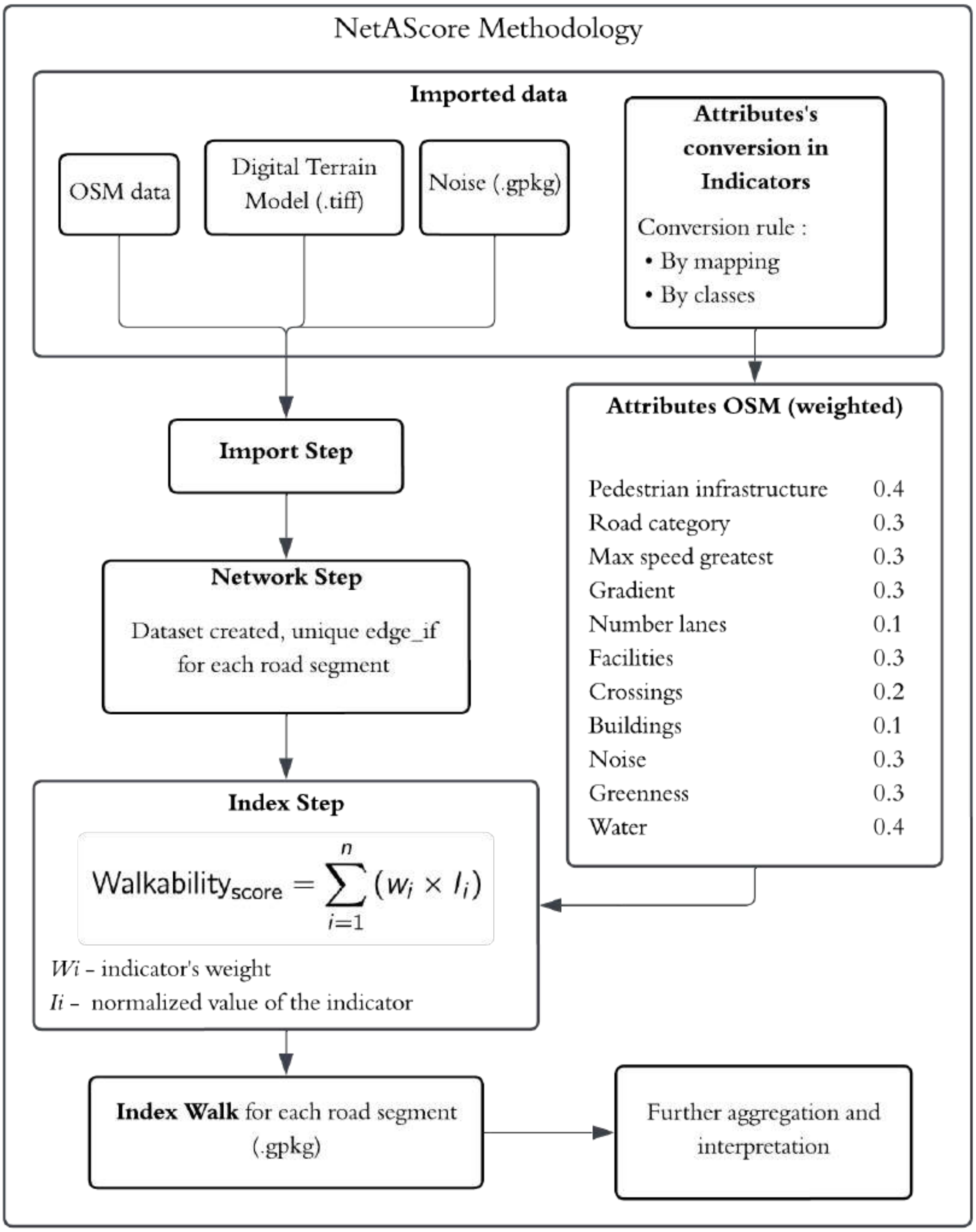

Figure 2.3: Methodological framework for the walkability. Source : Author

This diagram summarizes the methodology of the calculation of the walkability index for each road segment. It illustrates the imported data, the calculation steps and logical structure of the methodology. From the import of spatial data to the conversion of attributes into normalized indicators and the final weighted aggregation, each step is essential to the methodology and contributes to the production of a walkability index tailored to the context of Liège. This diagram aims to better understand the calculations behind this indicator and enable a robuts, transparent and reproducible analysis of the pedestrian infrastructure quality. The final index serves as the basis for further spatial aggregation and interpretation in the next stages of the work.

2.4 Aggregation and cross-referencing of socio-economic data

2.4.1 Statistical sector aggregation

To enable comparison between accessibility and walkability, and to cross-reference them with socio-economic indicators, it was necessary to perform a spatial aggregation of the data. The chosen aggregation unit is the statistical sector, which is the smallest administrative division used by Statbel in Belgium for publishing population and socio-economic data. This level of granularity is particularly relevant for this study, regarding the local context. It allows a fine analysis of spatial inequalities, and a homogeneous spatial grid for comparison across the study area ["Open Data | Statbel", n.d.; Poussard, 2019; Vandermotten et al., 2006].

The socio-economic indicator used in this paper is the Synthetic Difficulty Index (SDI), which is an indicator developed to measure socio-economic precariousness on a fine geographic scale, the statistical sector in Belgium. It was created by the LEPUR laboratory (Centre de recherche sur la Ville, le Territoire et le Milieu rural de l'Université de Liège), in 2013, as part of the project, "Dynamiques des quartiers en difficulté dans les régions urbaines belges". Unlike the traditional approaches, often limited to census data alone, the SDI adopts an innovative method by incorporating a wide range of indicators from various administrative sources. Its construction is based on Principal Component Analysis (PCA), a multivariate statistical method that allows a large number of correlated variables to be synthesized into main axes that explain the variance in the data. 23 socio-economic indicators were analyzed and grouped into four main dimensions : origin (e.g. proportion of foreign population), income, job insecurity (e.g. unemployment rate, low qualifications) and dependence on transfer incomes (e.g. proportion of households receiving social assistance) [Poussard, 2019; Vandermotten et al., 2006].

These data are calculated for statistical sectors with more than 50 inhabitants, which avoids the statistical bias related to small numbers effect. The sectors are classified into five SDI categories, ranging from level 1 (the 20 percent of population with the most precarious living conditions) to level 5 (the least precarious) [Poussard, 2019; Vandermotten et al., 2006].

However, despite its methodological robustness, the indicator has certain limitations. It does not take into account the quality or status of housing, or variables such as real purchasing power or informal transfers between households. These omissions can lead to distortions into the results, such as the erroneous classification of student neighborhoods among the most precarious because of their low declared incomes, despite often substantial family support [Poussard, 2019; Vandermotten et al., 2006].

Despite these limitations, the SDI has become a central tool for territorial analysis and the definition of public policies, by allowing to identify neighborhoods with the greatest difficulties and requiring targeted intervention.

The aggregation is applied to both indicators :

1. Walkability results

After calculation, the resulting .gpkg file is imported to QGIS for analysis and visualization. The main steps to perform a spatial aggregation of the results are :

1. Re-projection into the Belgian coordinate system (Lambert 72)
2. Spatial join to attach each segment to the corresponding statistical sector
3. Creation of a weighted score field : for each segment, a field "long-pond" = score x length is created.

4. Aggregation by sector, the final walkability score for each statistical sector is calculated as :

$$\text{Average walkability score} = \frac{\sum(score \times length)}{\sum(length)}$$

This ensures that the segment contributes proportionally to its length to the sector's average score.

2. Accessibility results

After calculation made in Excel, the results are imported to QGIS for visualization and aggregation. the main steps to visualize the results and perform the aggregation are :

1. Importation of the results in QGIS as points (not as isochrones) for a better visualization. The points of origins are used to create maps of the accessibility.
2. The socio-economic data was spatially joined to the points of origin data before the calculation of isochrones to have the data in the results.
3. Re-projection into the Belgian coordinate system (Lambert 72)
4. Aggregation by sector, the mean value of the accessibility is calculated for each statistical sector.

This aggregation allows us to analyses both accessibility and socio-economic data in the same time and at the same scale level.

2.4.2 Analysis and correlation

After aggregating the accessibility and walkability results at the statistical sector level, an analysis is carried out to highlight spatial disparities and links between the accessibility and walkability indicators and the socio-economic characteristics of the area.

Firstly, a **descriptive cartographic analysis** is used to visualise the distribution of scores throughout the area. Maps were produced for each of the two indicators and for each of the two scales (Liège municipality and Sainte-Walburge neighborhood), as well as for their combination. These maps allow to identify areas with low scores (general lack of proximity), but also contrasting situations where accessibility is good but walkability conditions are unfavorable, or vice versa.

Secondly, a **statistical analysis** is carried out to quantitatively assess the correlations between the indicators and the socio-economic characteristics. More specifically, correlations were calculated between,

– The walkability score for each statistical sector and the synthetic difficulty index also for each statistical sector.

– The accessibility score for each statistical sector and the synthetic difficulty index also for each statistical sector.

– The walkability score and the accessibility score for each statistical sector.

These two approaches facilitate the examination of how areas with limited urban proximity overlap with vulnerable socio-economic profiles, thus paving the way for a more equitable territorial assessment.

2.5 Verification of results with a field survey

In order to verify the reliability of the two indicators produced, a field survey is carried out in the Sainte-Walburge neighborhood. The aim is to compare theoretical results with the reality observed in the field. A total of 60 segments were visited on the basis of the stratified random selection of isochrone's points of origin assessed in the accessibility approach. At each point, a field survey is carried out, to collect the real attributes, and compare them to the ones used in NetAScore. The observations gathered were used to adjust certain model parameters and validate the general relevance of the walkability indicator.

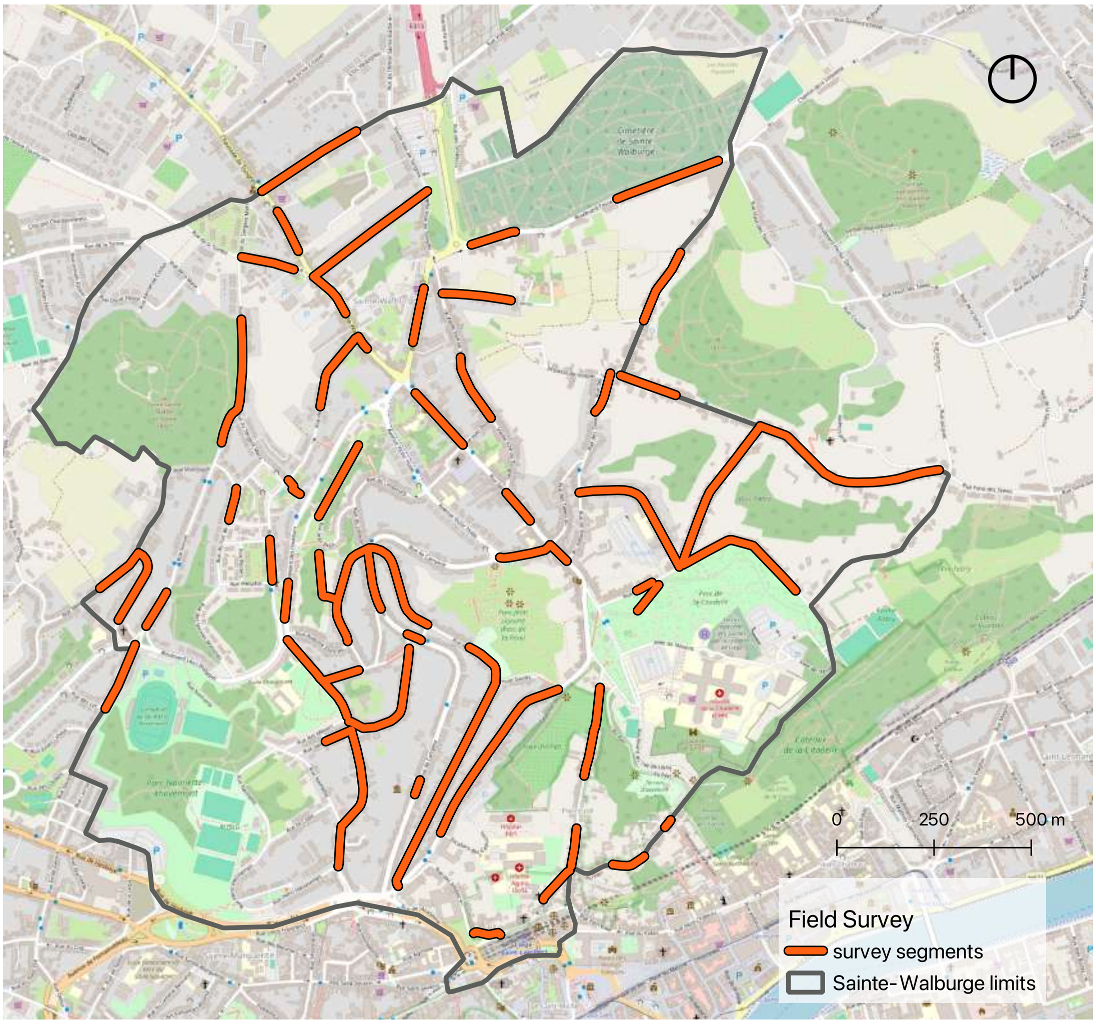

Figure 2.4: Field survey segments map. Source : Author

2.6 Interviews with local residents

2.6.1 Choice of profiles and type of interviews

As part of the study of the Sainte-Walburge neighborhood, a qualitative survey is conducted in the form of interviews with residents. The aim of this qualitative approach is to enrich the spatial analysis with user's perceptions and their daily life experiences of walkability and accessibility in their neighborhood. The aim is also to compare objective indicators, with subjective feelings.

To conduct these interviews, I had the opportunity to meet the delegate from the neighborhood committee, who greatly assisted me in reaching out to individuals for conducting the interviews. A flyer was distributed in several places in the neighborhood, and an announcement was posted on social media through the page of the neighborhood committee. The communication campaign was a success, a total of twenty people contacted me to participate to the project. Unfortunately, I did not have the time to meet with twenty people so I interviewed ten people in the neighborhood. The interviews were carried out in French as it is the language spoken in Wallonia.

The announcement set out the objectives of the project, the themes addressed (pedestrian mobility, access to services, the quarter-hour city), and the practical arrangements: an exchange lasting around an hour, at home or at an agreed meeting point, based on a discussion accompanied by a map of the neighborhood. A variety of profiles were sought: men and women, young and old, motorised and non-motorised users, people with or without reduced mobility. The aim of this diversity was to gather a wide range of viewpoints and gain a better understanding of the obstacles and levers to pedestrian mobility.

2.6.2 Interview structure

The interview guide used is based on a structured questionnaire, divided into several themes:

- Daily mobility and usual journeys on foot;
- Modes of transport used and obstacles encountered in the neighborhood;
- The quality of pedestrian infrastructure (condition of pavements, safety, obstacles);
- Perception of the 15-minute city and accessibility to essential services;
- A subjective rating of the walkability of the street and neighborhood.

The interview is based on a map of the neighborhood, on which people were asked to locate their home and frequent journeys. With the consent of the participants, the interviews were voice-recorded and transcribed in compliance with the GPDR rules and with respect for anonymity ["Règlement général sur la protection des données (RGPD) | EUR-Lex", n.d.]. All the interviews and the questionnaire, can be found in the appendices (cf. Section **??**). All the feedback gathered is then analyzed by theme, in order to identify recurring elements and enrich the diagnosis of the neighborhood with a sensitive dimension, which is essential in an urban project based on proximity.

2.7 Implementing solutions for the intervention zone

The last stage of the methodology is to draw up proposals for action. The aim is not to mechanically apply the results of the diagnosis, but to construct reasoned and justified responses, based on a cross-reading of quantitative, qualitative and contextual data.

The process is based on the identification of problem areas, defined by cross-referencing score maps (accessibility, walkability) and sectorial socio-economic indicators. These overlay maps make it possible to identify cumulative sectors of vulnerability, combining a lack of accessibility, walkability and vulnerable social-profiles. This identification is carried out using GIS, at a statistical sector level and at a micro-scale level.

This spatial data is then enriched by the results of the field survey and interviews in Sainte-Walburge. The qualitative analysis enables the identification of specific obstacles, gathers perceptions of discomfort or spatial injustice, and provides a clearer understanding of the concrete expectations of resident [Yin, 2017 ; Batty, 2013].

On this basis, an interpretation process is carried out to move from diagnosis to actions. The levers for action are classified according to three levels of intensity, depending on their scale, feasibility and scope.

1. Level 1 - Enforce the existing legal framework;
2. Level 2 - Intelligent redesign without major changer;
3. Level 3 - Urban structure and flow logic complete redesign.

In addition to that, students projects carried out previously on the same area are used as a material for solutions and inspirations. They are critically and comparatively read, identifying constants and divergences in solutions. The aim is not to replicate these solutions but to draw inspiration from them and develop a synthetic and contextualized vision. This approach corresponds to a tool-box approach, integrating previous experiment into new thinking.

Beyond rigid planning, the proposals for action aim to be part of tactical urban planning, which favors, punctual, reversible actions that are rooted to the daily life of residents, and also part of proactive urban planning, which assumes more ambitious development choices in favor of active mode and quality of public spaces. This approach aims to overcome the limitations of purely prescriptive planning or planning that is overly dependent on regulation, by incorporating more flexible, experimental or participatory levers [Teller, n.d.].

This stage is part of a process of progressive, iterative and situated construction of solutions, consistent with an approach to operational urban planning based on observation, contextual adjustment and the mobilization of previous experience.

2.8 Methodological framework

The methodology developed in this paper aim to develop a spatial diagnosis and planning approach that is both rigorous and context-sensitive. The framework is based on a mixed-methods strategy that combines quantitative spatial modeling, socio-economic cross-analysis, and qualitative feedback from residents, rather than relying on a single technique. It begins with the calculation of the accessibility and walkability indicators at the scale of the city, both implemented within GIS environments. These two indicators are then aggregated at the statistical sector level, enabling comparison with socio-economic indicator such as the synthetic difficulty indicator. At each stages, methodological choices are carefully documented and justified based on the current literature and the specific context of Liège.

Beyond the production of indicators, the framework also integrates a validation phase through field survey and qualitative interviews with the population. This qualitative dimension is essential to ensure that the quantitative analysis does not overlook lived realities and everyday practices. The interviews serve as a complement to the spatial data and enrich the diagnosis with a human perspective.

The elaboration of proposals for the intervention zone (Sainte-Walburge), is guided by the same logic. It is not merely a response to data, but the outcome of a triangulation process involving maps, statistical indicators, and user experience. Proposals are structured in increasing levels of intervention, from simple regulatory enforcement to structural re-qualification.

This methodological framework is therefore designed to be reproducible in other contexts, while remaining adaptable to the specificities of each urban situation. It is a step towards operationalizing the 15-minute city in a realistic, socially aware and locally rooted way.

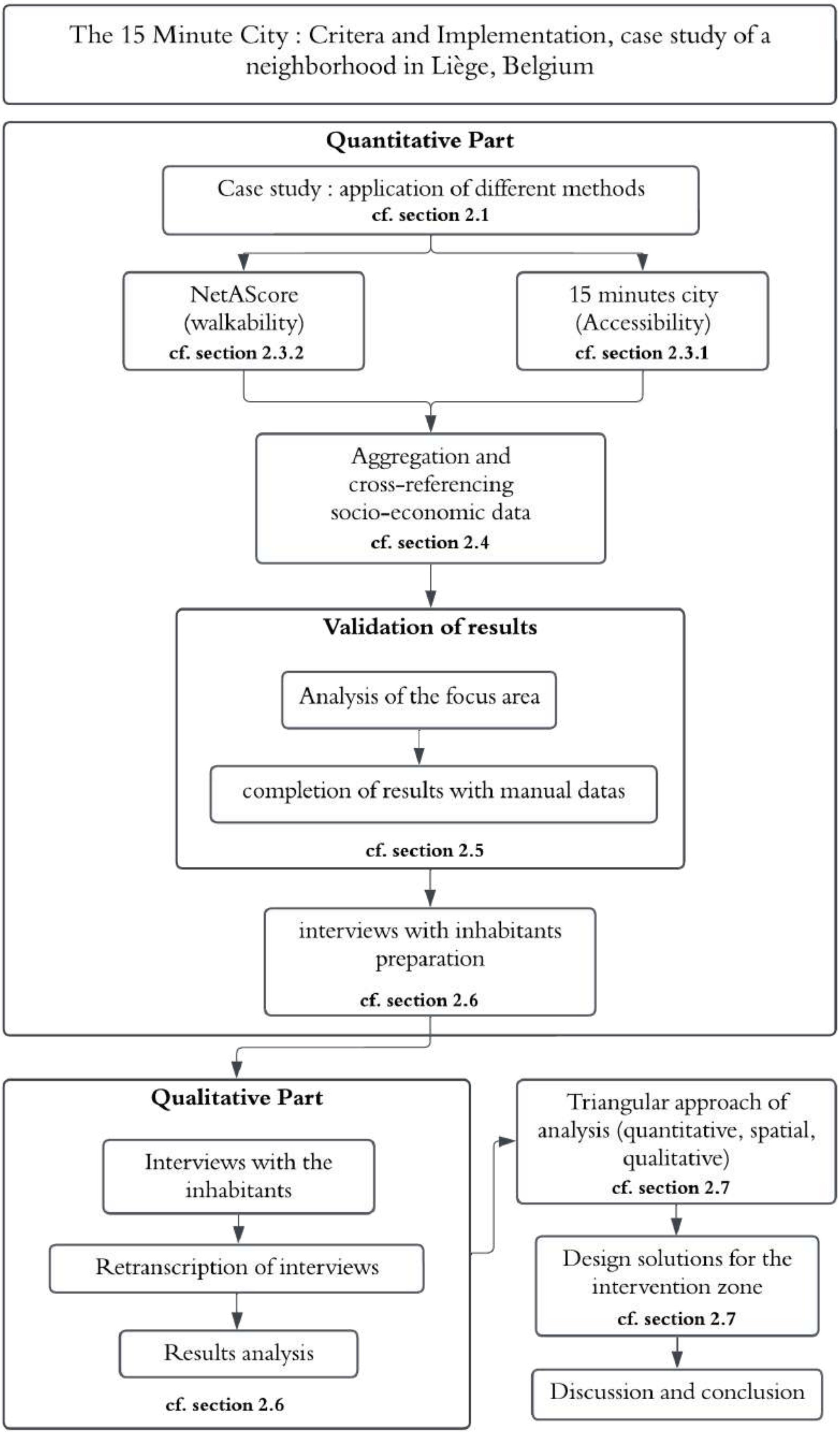

Figure 2.5: Methodological framework. Source : Author

Chapter 3

Results and Discussion

This chapter presents the results obtained from accessibility and walkability analyses and socio-economic data, as well as a discussion of these results. Through cross-referencing indicators, thematic maps, descriptive statistics and interviews with residents, this chapter includes a critical analysis aimed at identifying the challenges, limitations and areas for improvement for the effective implementation of the 15-minute city in Liège.

3.1 Contextualization

3.1.1 Liège

The city of Liège is a major regional city in Wallonia. It has a population of around 197,000 inhabitants and is part of an extended agglomeration that includes Seraing, Saint-Nicolas and Herstal with a population of around 628,000 people. This agglomeration is the largest in Wallonia in terms of population. Liège's urban structure is greatly influenced by its topography. The relatively flat city center is set in a valley through which the Meuse flows, while the outlying districts, including Sainte-Walburge, are built on slopes of varying steepness. This particular geography creates contrast in terms of accessibility and mobility.

The urban fabric is dense in the center, mixed and well-served, while the urban peripheries are often more spread out, with a lower density of services and a preponderance of individual housing. The city of Liège has incorporated the concept of the 15 minute city into its planning documents, such as the City's Territorial Project and the Walloon Region's Territorial Development Plan. These documents aim to build a more accessible, resilient and sustainable city by reducing dependence on the private car [Ville de Liège, 2024b; Région wallonne, 2023].

The figure below shows the perimeter of the municipality of Liège and of the Sainte-Walburge district. It clearly shows the district's elevated position in relation to the city center, as well as its steep slopes. The contour lines every 5 meters highlight the marked differences in level, which are an important factor to consider when analyzing walkability and pedestrian accessibility.

Figure 3.1: The city of Liège and the Sainte-Walburge neighborhood. Source : Author

3.1.2 Sainte-Walburge

Sainte-Walburge is a residential district located to the north of Liège city center, on the heights of the left bank of the Meuse. It covers an area of around $3km^2$ and has an estimated population of 8400 inhabitants. The neighborhood has a composite urban fabric, with a mix of single-family homes, blocks of flats, social housing, public facilities, schools, local shops and green spaces. The morphology of the district is marked by a low density of internal urban centers, numerous breaks in the road network and a steep gradient. The topology is a key feature in Sainte-Walburge. The district lies on a sloping plateau with large differences in altitude compared with the center of the city. This topography has a significant impact on walking and cycling, particularly for the elderly and people with reduced mobility.

In socio-economic terms, Sainte-Walburge is quite diverse. Some areas contain household on modest, sometimes precarious incomes, while others are occupied by a more stable or wealthier population. The neighborhood has a number of essential services (identified by red dots on the map below), including local shops, schools, bus stops, pharmacy, bakeries, parks, as well as a major hospital, "la Citadelle", which generates a fairly high flow of traffic through the district.

Despite the presence of essential services, they are unevenly distributed, increasing the distances for some residents. The neighborhood also remains highly dependent on the car, particularly due to the absence of safe cycle paths and the lack of facilities for active mobility. The neighbourhood is also an important route for cars leaving the city, as it provides direct access to the highway (in the North of the district). This is a key factor in the neighbourhood's mobility.

The figure below shows the perimeter of the Sainte-Walburge district. We can see the highway's entry in the North, the Citadelle hospital on the east side of the district. The city center of Liège is situated in the south, and we can also see the large presence of green areas in the neighborhood.

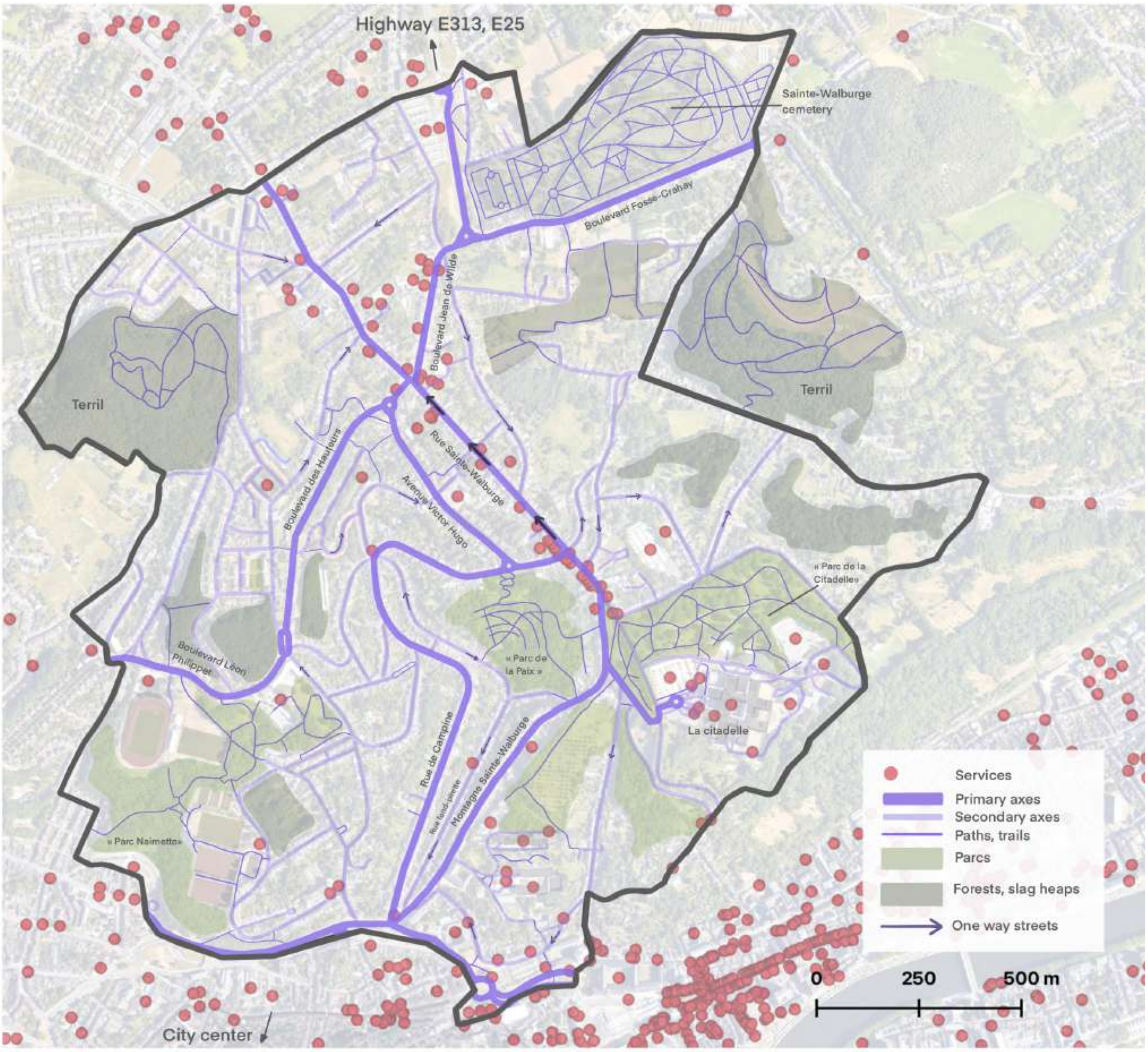

Figure 3.2: The Sainte-Walburge neighborhood - actual state. Source : Author

Figure 3.3: The Sainte-Walburge neighborhood. Source : Author

3.2 Results for Liège - Accessibility

3.2.1 Accessibility - histogram

The accessibility assessment is carried out across the whole territory of the Liège municipality, using 1,426 spatial sampling points distributed evenly. The aim is to measure the spatial proximity between residents and essential services in the context of a quarter-hour city, i.e. a 15-minute walk.

Two distances were selected based on different speed profiles:

1. **Adult profile :** 1134 meters for an adult aged between 30 and 60.

2. **Senior profile :** 855 meters for a person aged 65 to 85.

These thresholds were used to generate pedestrian isochrones via the actual road network (not as the crow flies), enabling an accessibility score to be calculated for each point, normalized between 0 and 1. Accessibility scores have been aggregated by statistical sector to develop a better comparison between the indicators (walkability, accessibility, socio-economic data).

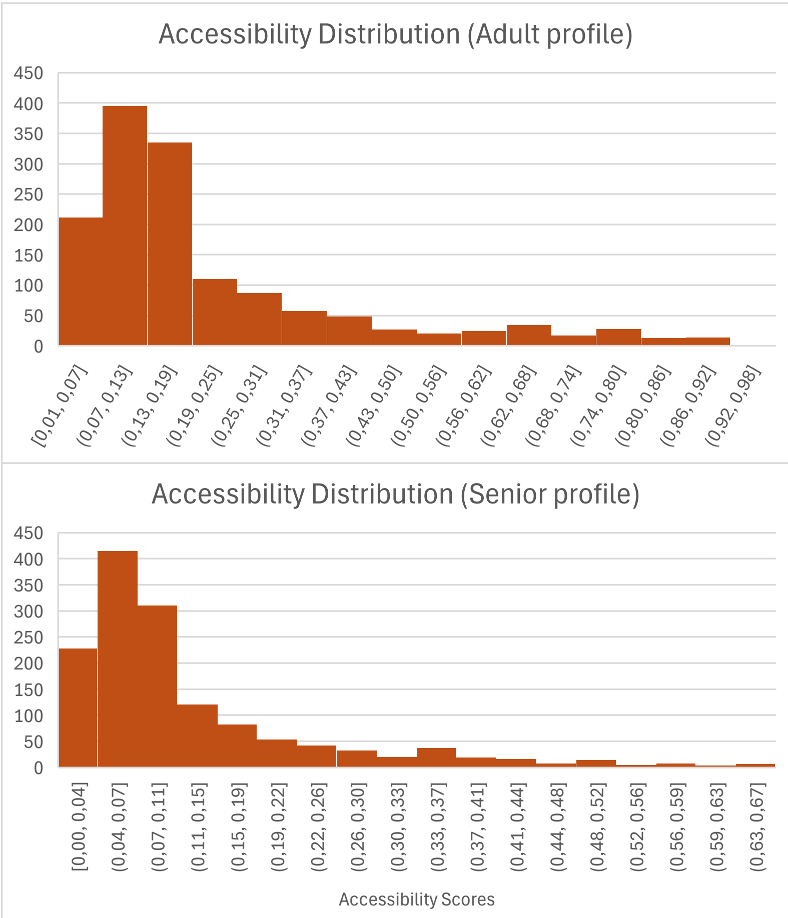

Figure 3.4: Histogram of accessibility results. Source : Author

The histograms reveal asymmetrical distributions highly concentrated in the lower classes for the two profiles studied. For the **adult profile** (1134 m), the majority of sectors show scores below 0.25, with a clear concentration in classes between 0.1 and 0.2. The mean is 0.204, and the standard deviation of 0.190 indicates a wide spread of values. The median score of 0.138 shows that more than half the sectors in Liège have very limited access to services, even for adults able to walk at a normal pace.

For the **senior profile** (855 m), the situation is more critical. The scores are massively clustered below the 0.2 mark, with a dominant concentration between 0.05 and 0.15. The mean falls to 0.116, and the median to 0.078, confirming that pedestrian accessibility for the elderly is very poor in most sectors. No sector exceeds a score of 0.6, reflecting a general lack of local access for this more vulnerable group.

These results highlight the importance of taking mobility profiles into account in urban planning, particularly in towns with marked topographical constraints such as Liège.

3.2.2 Accessibility - maps

The maps below show the spatial distribution of the 15-minute pedestrian accessibility scores for the two profiles studied: adult (1134 m) on the left, and senior (855 m) on the right. The contour lines (5 meters) were added to show the influence of relief on actual accessibility.

For the **adult profile**, the central areas of the city, in particular the historic center and the immediate banks of the Meuse, benefit from high accessibility (scores > 0.6), shown here in blue and green. These areas have a high density of services, a fine road network and a relatively flat topography. On the other hand, the outlying areas, particularly those located at higher altitudes or on slopes, appear to be very disadvantaged. Most outlying areas have scores of less than 0.25, and sometimes even less than 0.1 (in dark red), reflecting very poor pedestrian accessibility.

The situation deteriorates sharply for the **senior profile**, as shown on the second map. The accessibility area is visibly shrinking, and many areas that were previously moderately accessible (0.25-0.4) are falling into lower categories. Blue areas are becoming rare, concentrated only around a few central centers. In contrast, red now dominates the urban periphery, underlining the increased spatial vulnerability of the elderly.

The difference observed between the two user profiles is logical and expected. In fact, the distance covered on foot in 15 minutes by an elderly person (855 m) is significantly shorter than the one of an active adult (1134 m). In this context, it is nearly impossible for an area to achieve an accessibility score for seniors that is equal to or higher than that for adults unless it is situated in the core of a region with exceptionally high functional density. This finding does not therefore point to any specific deficiencies in the area, but serves as a reminder of the need to adapt accessibility policies to the actual travel capacities of the various population groups, particularly the most vulnerable.

A cross-analysis of the two maps confirms that the city of Liège, has unequal pedestrian accessibility depending on the user profile. It also reveals the importance of the terrain as a factor exacerbating inequalities in access, particularly in sloping or sparsely populated areas.

The accessibility maps visually confirm the trends observed in the previous histograms. In both cases, the data reveals a high concentration of scores in the lower classes, reflecting generally limited accessibility, particularly for the elderly.

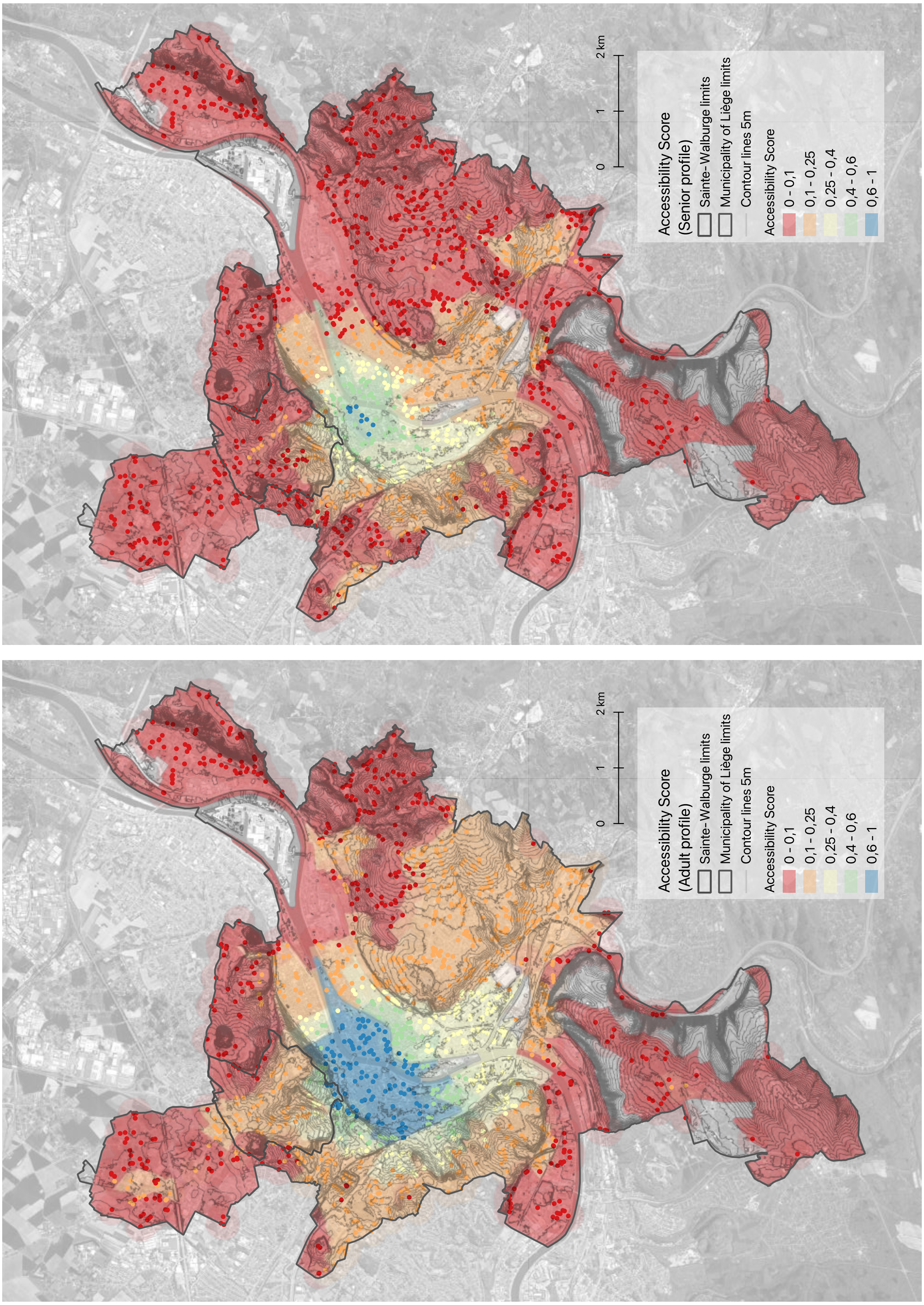

Figure 3.5: Map of Accessibility results. Source : Author

3.2.3 Accessibility VS SDI index

To assess whether inequalities in pedestrian accessibility overlap with social fragility, the accessibility scores calculated for the adult and senior profiles were cross-referenced with the Synthetic Difficulty Indicator (SDI). This indicator explained in section 2.4.1, reflects the level of precariousness of households at statistical sector level (income, unemployment, level of education, etc.).

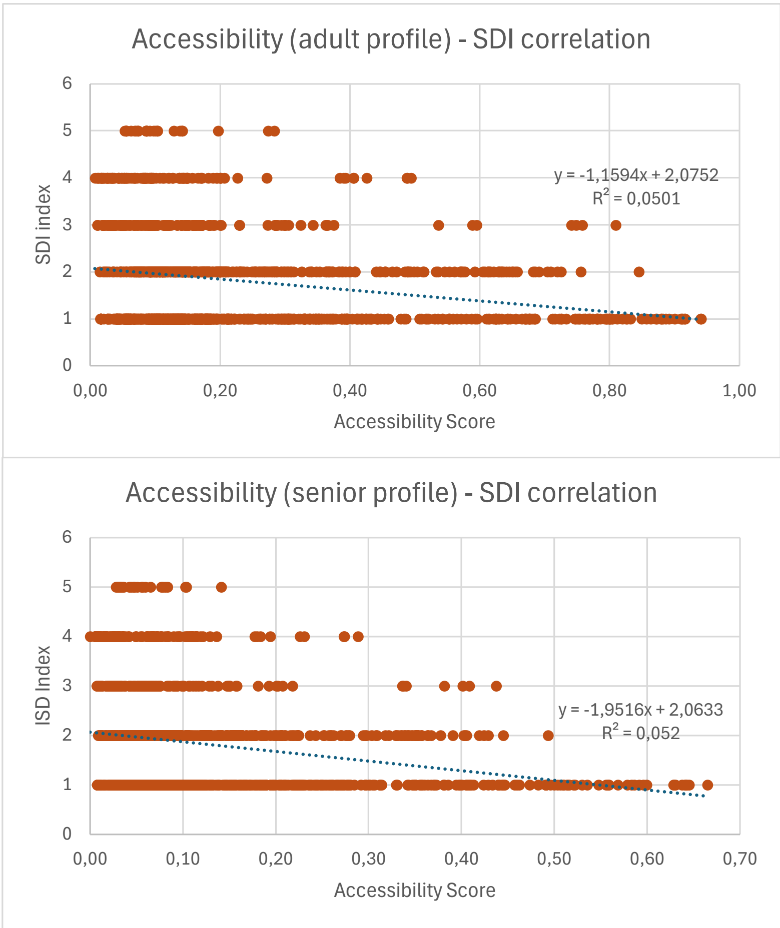

Figure 3.6: Accessibility - SDI correlation. Source : Author

The graphs above show the correlation between the synthetic difficulty index (SDI) and the 15-minute pedestrian accessibility scores for the two profiles studied: adult and senior. It is essential to bear in mind that in this classification, an SDI of 5 corresponds to the most advantaged neighborhoods, and an SDI of 1 to the most precarious neighborhoods.

For the **adult profile**, the trend line shows a slight negative slope (-1.16) with an R^2 of 0.0501, indicating a weak correlation between wealth and accessibility. It is observable that the most affluent neighborhoods (SDI = 5) often have lower accessibility scores, while working-class neighborhoods (SDI = 1-2) have more scattered scores, sometimes very good, sometimes very bad.

This trend is even more marked in the case of the **senior profile**, with a steeper slope (-1.95) and a similar R^2 (0.052). This shows that older people living in more affluent neighborhoods are on average less well served on foot, while some socially more fragile areas benefit from better accessibility.

These results show that accessibility does not follow the expected socio-economic hierarchy. The more affluent neighborhoods, often located on the outskirts, at higher altitudes or in sparsely populated areas, combine spatial conditions that are unfavorable to pedestrian accessibility, despite their high standard of living. Conversely, some working-class neighborhoods that are denser, central or close to services score better.

This finding underscores the complexity of spatial inequalities, revealing that the most vulnerable segments of the population are not always the least well-served. The combined effects of relief, urban density and the structure of services can reverse social patterns. In a quarter-hour city approach, it is essential to cross-reference mobility profiles with local conditions to avoid generalizing inequality models that do not apply uniformly to all urban contexts.

Accessibility - SDI maps

The two maps below provide a visual cross-reference between pedestrian accessibility within 15 minutes and the level of socio-economic vulnerability of the statistical sectors of the city of Liège. On the first map, the accessibility scores relate to the adult profile (1134 m), and on the second map to the senior profile (855m). In both cases, the colored dots represent the value of the accessibility score, while the solid colors in the background indicate the level of SDI (1 = most precarious neighborhoods, 5 = most advantaged).

It is apparent that the most precarious sectors (SDI 1 to 2), located mainly in the center, on the left bank and in certain dense inner suburbs, do not systematically have low accessibility scores. On the contrary, several of them have average to high scores, which may be explained by their proximity to urban centers and services within walking distance.

On the other hand, the most advantaged sectors (SDI 5), often located on the southern, eastern or northern outskirts, frequently have low accessibility scores (particularly in red). This is particularly visible on the map of senior citizens, where the shrinking accessibility radius accentuates spatial disparities. These affluent residential neighborhoods, often on slopes and sparsely populated, suffer from functional remoteness, despite their high standard of living.

This cross-referencing reveals an inversion of traditional social logic, wealthy neighborhoods are not always the best served on foot. At the same time, certain working-class areas paradoxically benefit from more favorable accessibility. It also confirms that accessibility does not linearly follow social hierarchies, but is highly dependent on location, urban fabric, density of services, and topography.

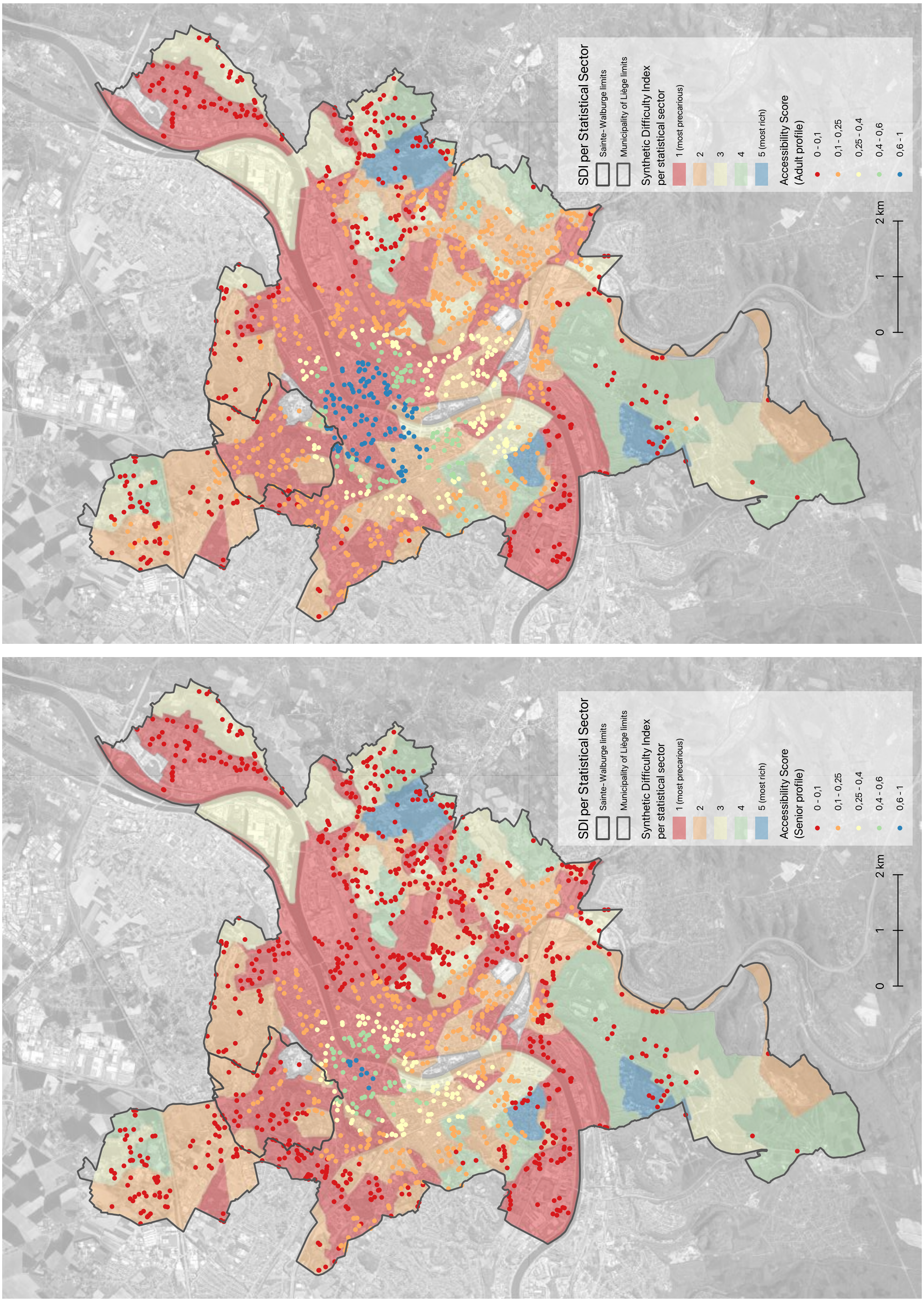

Figure 3.7: Accessibility - maps. Source : Author

3.3 Results for Liège - Walkability

3.3.1 Walkability - histogram

In addition to spatial accessibility, the quality of the pedestrian environment is assessed using the NetAScore applied to the entire Liège road network. This composite indicator is based on the evaluation of several criteria, such as the presence and continuity of sidewalks, slope, type of roadway, noise environment, etc. Scores were calculated for each road section, then normalized between 0 and 1, where 1 represents an optimal walking environment.

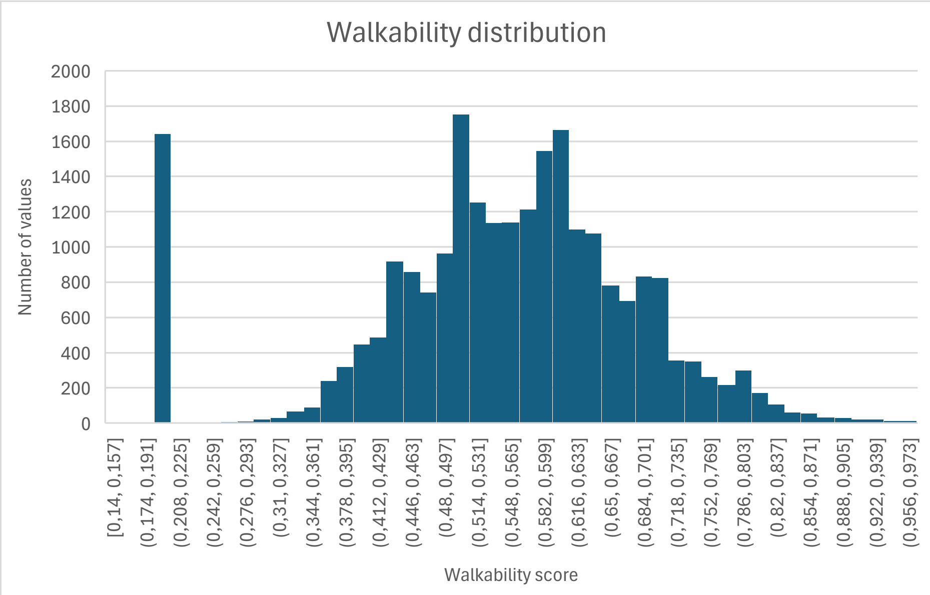

Figure 3.8: Histogram of walkability results. Source : Author

The NetAScore is assigned to 23 907 segments, corresponding to the pedestrian segments that could actually be evaluated. A further 1869 segments (7.25%) were not assigned a score, as they corresponded to infrastructures not accessible to pedestrians (mainly highways or primary roads), and were therefore excluded from the analysis.

The histogram of the score distribution shows an asymmetrical shape, with the majority of sections concentrated between 0.4 and 0.6, indicating average pedestrian quality. The mean score is 0.581, with a standard deviation of 0.121, indicating moderate dispersion around this mean.

However, there is a clear peak at the exact value of 0.2, corresponding to 1641 sections. This phenomenon is directly linked to a methodological choice in the NetAScore configuration. Some "primary" or "secondary" sections (roads with heavy traffic) with sidewalks automatically receive this low score of 0.2, to reflect technical accessibility but poor pedestrian quality (noisy, unpleasant or unsafe environment despite the presence of a sidewalk). This is neither an error nor a lack of data, but a clear signal: walking is possible, but in conditions deemed unfavorable.

The results suggest that Liège offers moderate walkability on its territory, without great excellence but without extreme generalized degradation either. The fact that the majority of scores are around the median indicates a certain homogeneity in pedestrian quality, but with strong reservations concerning certain types of axis. In particular, the peak at 0.2 shows that a significant proportion of the network is unfavorable to walking, often due to a lack of comfort or safety, even when the technical infrastructure is present. These sections represent priority areas for any policy aimed at improving walking conditions.

3.3.2 Walkability - maps

The NetAScore score is calculated on the scale of the Liège road network to assess walking conditions. Scores were normalized between 0 and 1 and aggregated on two scales: by statistical sector (second map) and by road section (first map), for a finer reading.

Statistical sector level

At statistical sector level, the results reveal considerable spatial heterogeneity. The highest scores (> 0.545) are concentrated in certain Meuse Valley neighborhoods, notably in the outskirts of the historic center, in quiet, well-developed residential areas or in green and natural areas. In contrast, the lowest-rated sectors (< 0.42) are mainly located in sloping neighborhoods, poorly connected urban bangs or areas of discontinuous, low-density housing. The effect of relief is noticeable, areas with narrow contours, particularly in the city's higher elevations, present lower scores. This reflects the direct impact of topography, which is a constraint on walking, both in terms of network continuity and comfort of use.

Road segment level

The map by street segment reveals significant intra-sector heterogeneity. Even in average or well-scored areas, there are sections that are very walkable (dark blue, > 0.65), often located near amenities, schools, shops or pedestrian zones, and others that are very poor (red), often in secondary streets, on slopes, or near road infrastructures.

This level of detail highlights the contrasts within a given neighborhood, and underlines the importance of a multi-scale reading to assess walkability. It also enables us to better target priority areas for pedestrian development.

There is a noticeable bias in the highest scores. In fact, a number of highly rated sectors actually correspond to areas with little or no construction (urban parks, nature areas, urban forests, sparsely urbanized areas along the Meuse). This result can be explained by the NetAScore methodology: the absence of buildings, combined with the presence of practical paths, a gentle slope and a calm, green environment, mechanically produces a good score. However, these areas don't necessarily meet the needs of everyday walking (the quarter-hour city), since they don't provide access to any services or functional centrality.

This bias underlines the need for a contextual interpretation of the results: a good walkability score does not mean that the area is well integrated into urban life, but rather that the physical conditions for moving around on foot are pleasant.

These maps reveal a city of Liège whose overall walkability is average, with strong disparities linked to relief, building structure, service density and roadway quality. This confirms the need to combine a multi-scale analysis (score by sector and detailed analysis by section and terrain), in order to target sectors to be reinforced and streets to be strengthened.

It also appears essential to cross-reference walkability data with accessibility data, in order to gain a better understanding of walking conditions. An area may be very well designed for walking, but poorly located in relation to basic services, or vice versa. It is therefore by combining these two dimensions that we can accurately assess the reality of the quarter-hour city, and identify the most vulnerable or priority areas in terms of development.

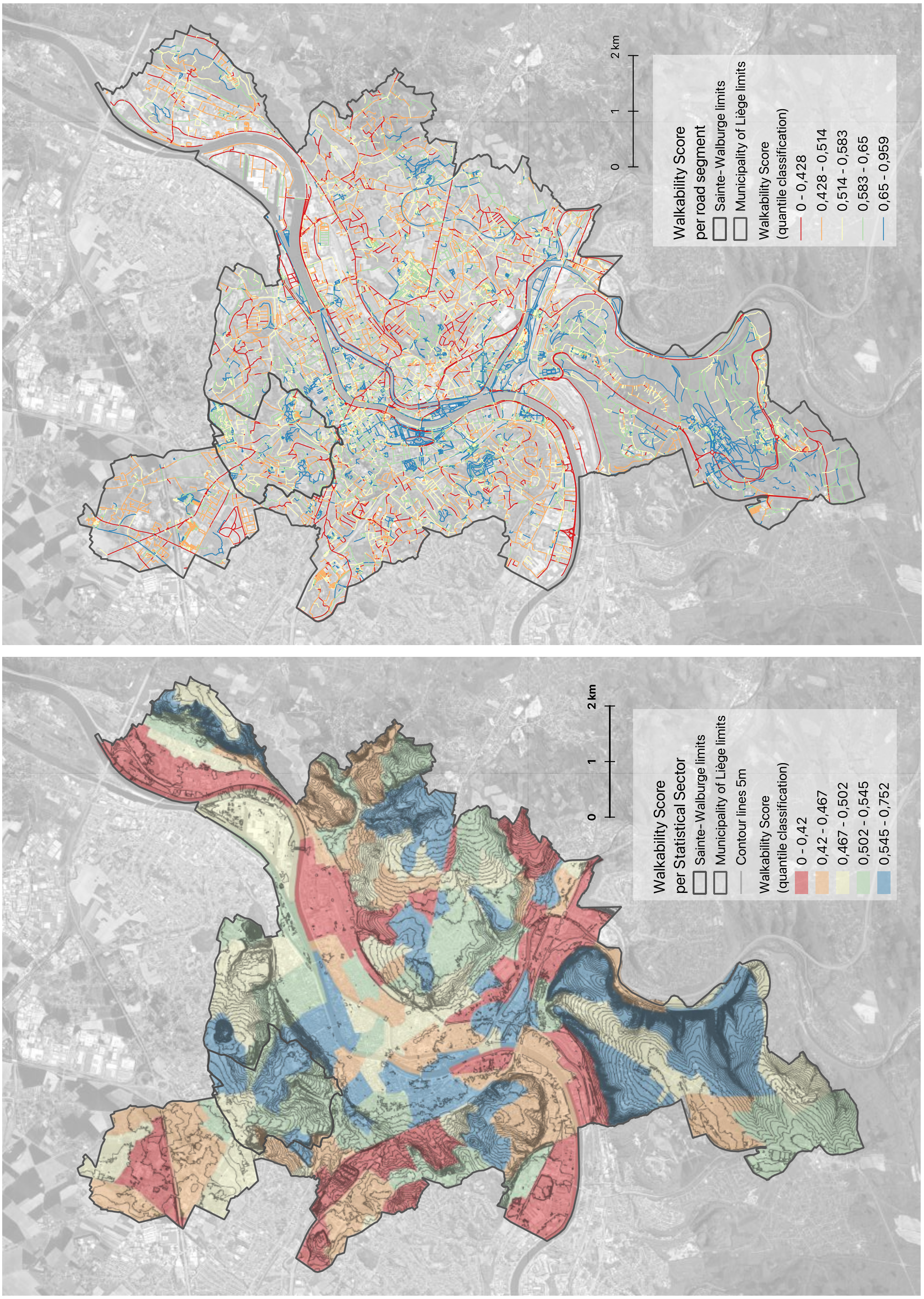

Figure 3.9: maps of walkability. Source : Author

3.3.3 Walkability vs SDI index

The aim of this section is to assess the relationship between the walkability of the Liège road network (measured by the NetAScore) and the level of social vulnerability represented by the Synthetic Difficulty Index (SDI).

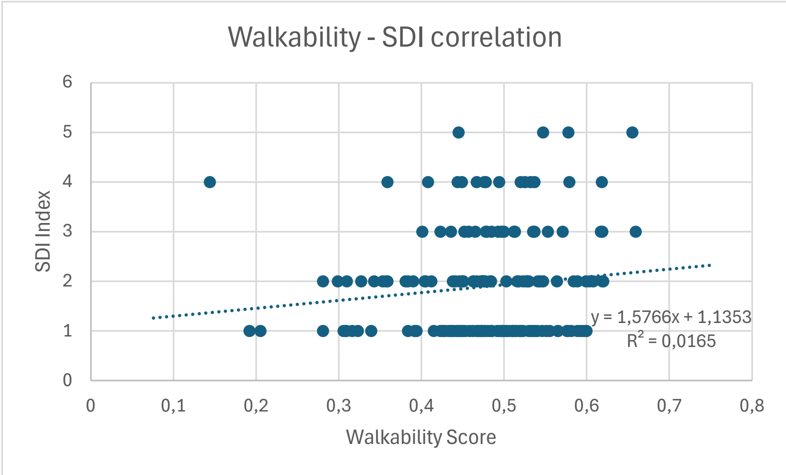

Figure 3.10: Histogram of accessibility results. Source : Author

The graph above illustrates the correlation between the walkability score (NetAScore) and the synthetic difficulty index (SDI) for the statistical sectors of the city of Liège.

The regression line shows a slight positive slope (1.58) and a coefficient of determination R^2 = 0.0165, indicating a virtually non-existent correlation between the two variables. In other words, the level of wealth or precariousness of a neighborhood is not a predictor of the pedestrian quality of its environment, as assessed by NetAScore.

There is a wide dispersion of scores for each level of SDI: very poor areas may enjoy good walking conditions, while other very well-off areas may have low scores. This lack of structural link can be explained by the fact that walkability is above all conditioned by physical factors : road structure, gradient, continuity of sidewalks, discontinuities, etc., independently of the socio-economic profiles of residents.

Unlike accessibility, which shows a slight inverse trend between wealth and functional proximity, walkability appears to be socially neutral. This can be explained by the technical logic of the NetAScore calculation, which is based on an analysis of the road network rather than on the range of services or location.

This result highlights the fact that the pedestrian environment is not systematically degraded in disadvantaged neighborhoods, and that, in contrast, affluent neighborhoods do not necessarily guarantee good walking quality. This suggests that we need to cross-reference the analysis with the field, in order to understand how these conditions are reflected in the experience of residents.

Walkability - SDI maps

The maps below show the spatial distribution of walkability (NetAScore) and the Synthetic Difficulty Index (SDI) by statistical sector.

The walkability map reveals significant spatial heterogeneity, with no clear radial or peripheral organization. Well-rated sectors (in dark blue) can be found in a variety of contexts, in some dense, well-developed central districts, but also in sparsely built-up areas where walking conditions are favorable (e.g. parks, flat, quiet areas). In contrast, poorly rated areas (in red/orange) can be found in outlying residential areas as well as in certain central discontinuous or sloping areas.

A comparison with the SDI map shows that there is no clear overlap. Some precarious neighborhoods (SDI 1-2) benefit from good walkability, in particular because of their old, continuous and pedestrian-friendly road network. Conversely, a number of advantaged neighborhoods (SDI 4-5), which are often residential, spread out or on slopes, have low walkability scores, due to poorly adapted, discontinuous or unsafe roads.

This spatial comparison confirms what is shown in the correlation graph, the pedestrian quality of urban space is not directly linked to the socio-economic level of residents.It seems to be determined more by physical and morphological factors (relief, road structure, built density) than by the logic of precariousness or wealth.

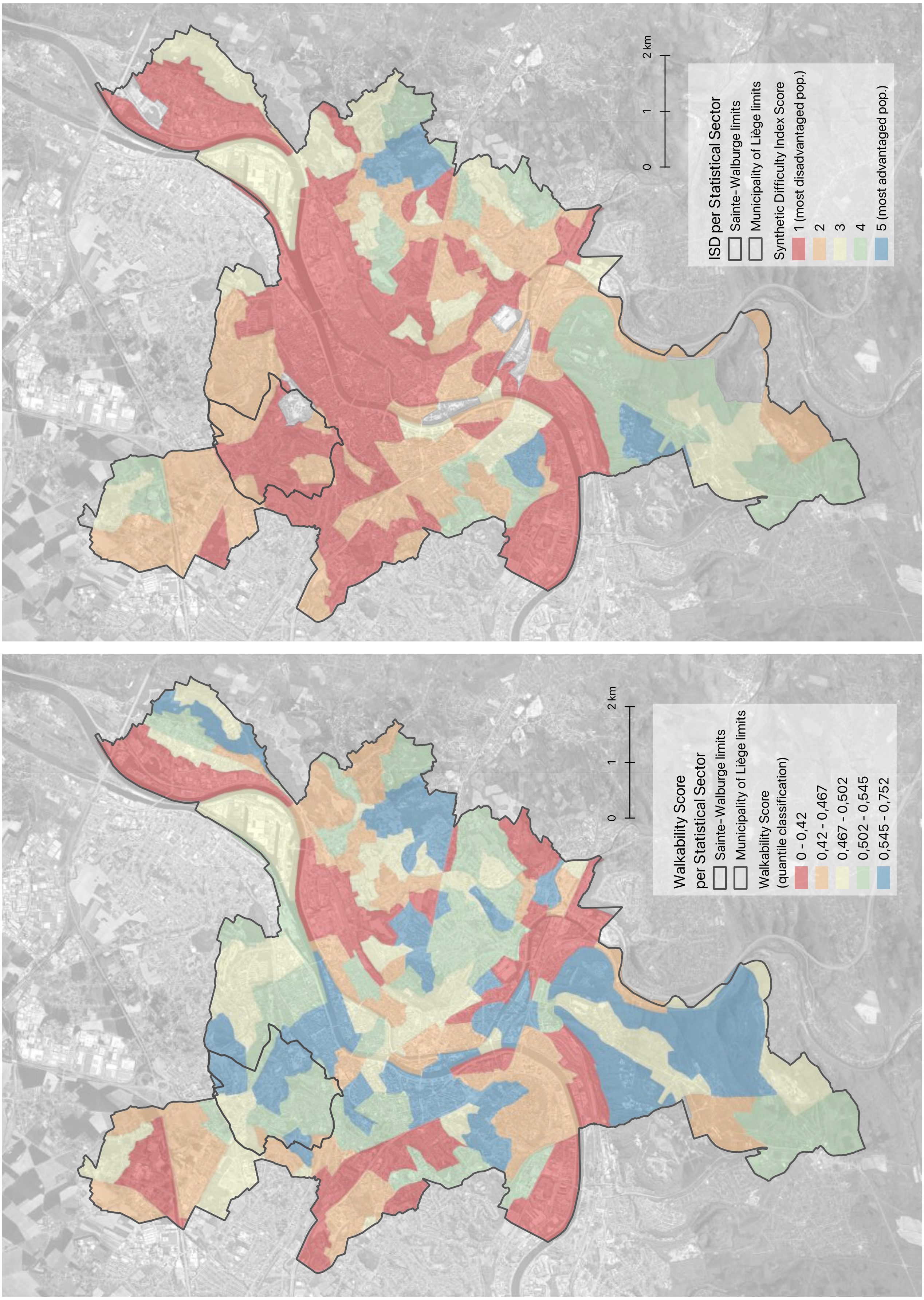

Figure 3.11: Maps of walkability and SDI results. Source : Author

3.4 Results for Liège - Accessibility vs walkability

In this section, we will discuss the comparison and correlation between the two indicators : accessibility and walkability.

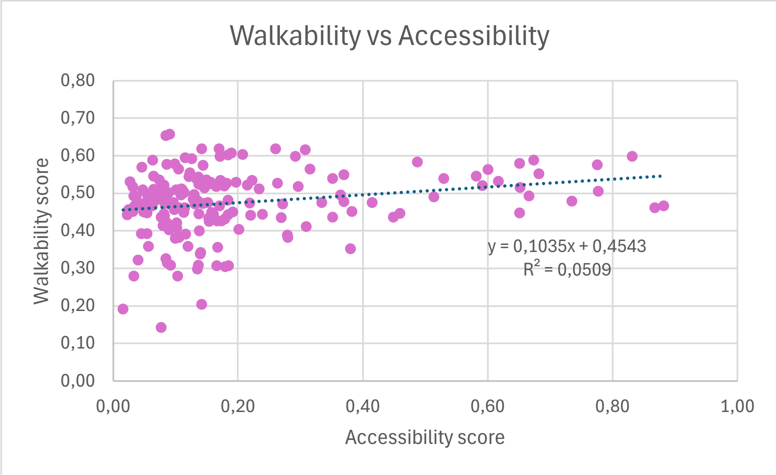

Figure 3.12: Accessibility - walkability correlation. Source : Author

The graph above illustrates the relationship between accessibility scores (adult profile) and walkability scores (NetAScore) for all statistical sectors in the city of Liège. The regression line shows a slight positive trend, with a slope of 0.1035 and a coefficient of determination $R^2 = 0.0509$, indicating a low correlation between the two indicators.

In other words, areas with good pedestrian accessibility are not necessarily those with the best walking conditions, and vice versa. This weak correlation confirms that the two indicators measure distinct dimensions:

- Accessibility depends mainly on the location and density of nearby services,
- Walkability is more closely linked to the physical quality of the pedestrian environment, independently of the presence of services.

There is a wide dispersion of points, particularly in the low accessibility scores (between 0 and 0.2), where walkability varies greatly. This shows that some neighborhoods that are a long way from services can still offer pleasant conditions for walking, while others that are well located suffer from roads that are not favorable to walking (slopes, discontinuities, discomfort, danger, etc.).

These results reveal contrasting situations:

- Neighborhoods that are accessible but not very walkable (e.g. close to services but crossed by main roads),
- Neighborhoods that are not very accessible but very walkable (e.g. quiet residential areas on the outskirts),
- and neighborhoods that combine good accessibility with good walkability, often in central areas.

This distinction shows that spatial proximity and ease of travel do not always go hand in hand, and that it is essential to cross-reference them in order to identify areas that are genuinely favorable to daily walking.

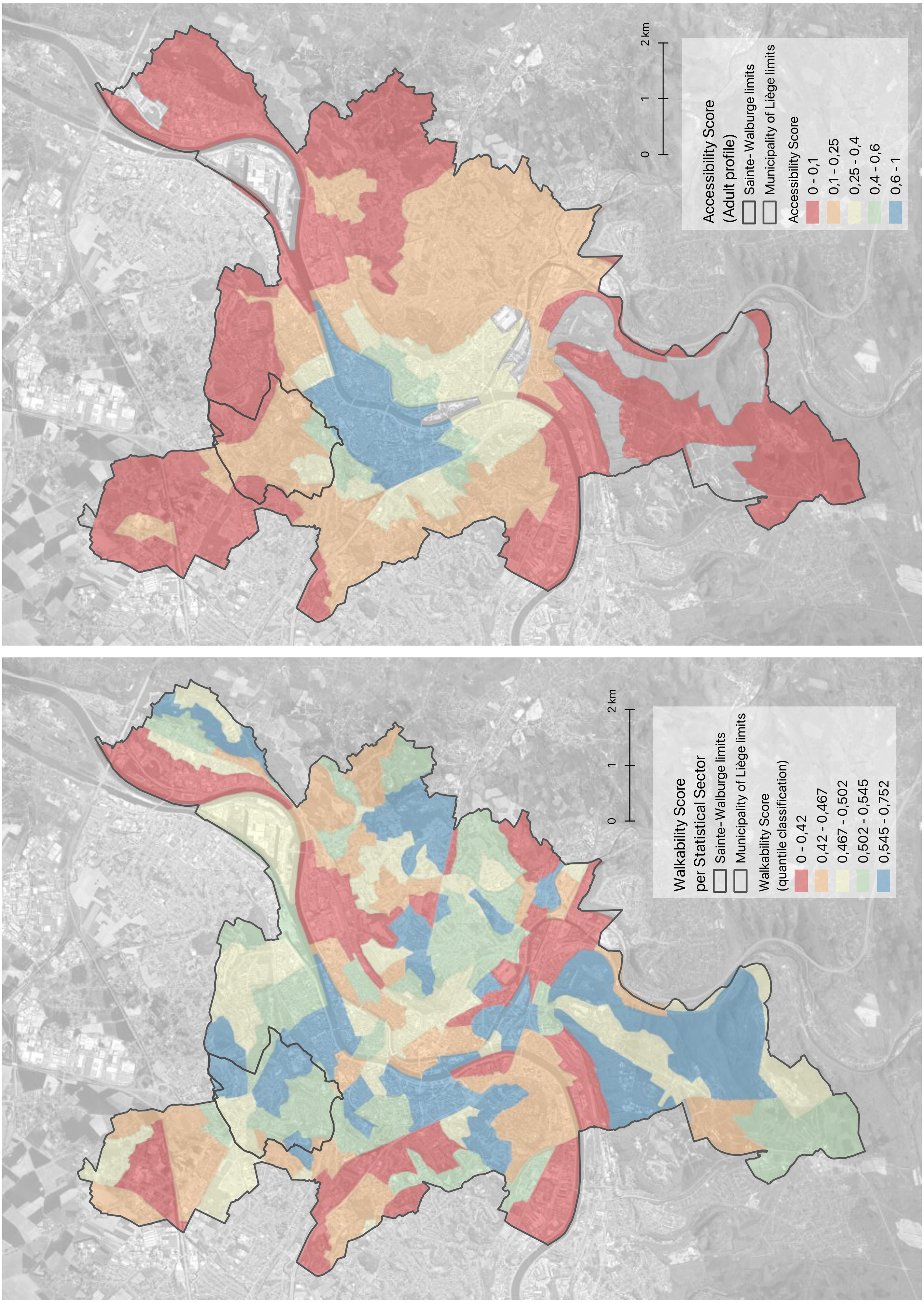

Figure 3.13: Accessibility - walkability maps. Source : Author

The two maps above show the distribution of pedestrian accessibility scores for adults, and walkability (NetAScore), for the statistical sectors of Liège.

The accessibility map shows that the central sectors, particularly around the historic center and the major urban centers, are the best served on foot (in blue and green), while the outlying areas, which are sparsely populated or on slopes, obtain the lowest scores (in red).

Conversely, the walkability map reveals a more fragmented logic. Some central neighborhoods with good access have average or low walkability scores, particularly where pedestrian infrastructure is discontinuous or poorly adapted. Other areas further away from the central areas show good walkability despite poor functional accessibility. This comparison reveals that the two indicators only partially overlap.

These maps confirm that pedestrian accessibility does not guarantee a good walking experience, and that the quality of the pedestrian environment is not sufficient to ensure access to services. To achieve the objectives of the quarter-hour city, it is essential to combine functional proximity and travel comfort, by targeting as a priority :

- Sectors with a combination of poor accessibility and poor walkability,
- And those where one of the two scores is very low, in order to restore the balance.

3.5 Results for Liège - Final diagnosis

Final diagnostic maps were produced to determine the statistical areas requiring priority action in terms of walkability and accessibility. These maps combine three key urban diagnostic indicators:

- walkability (most unfavorable segments according to NetAScore),
- 15-minute pedestrian accessibility (adults and senior map),
- socio-economic vulnerability (ISD = 1, most vulnerable areas),

while incorporating topographical constraints via 5 meters contour lines. The cartographic analysis reveals a clear spatialisation of cumulative vulnerabilities at the city level. The most affected areas are concentrated on the outskirts of the city, particularly:

- Wandre, Droixhe, in the north-east,
- Sclessin, Kinkempois, in the south-west,
- and also a part of Sainte-Marguerite (west) and Chênée (east) districts identified on the senior map (most critical accessibility).

These areas share three characteristics : low accessibility (< 0.1), very few services accessible within a 15-minute walk, poor walkability (< 0.42), missing, discontinuous, or uncomfortable pavements and high social vulnerability (ISD = 1), precariousness, modal dependency, isolation. These areas face structural challenges that can be explained as much by their current urban form as by their development history.

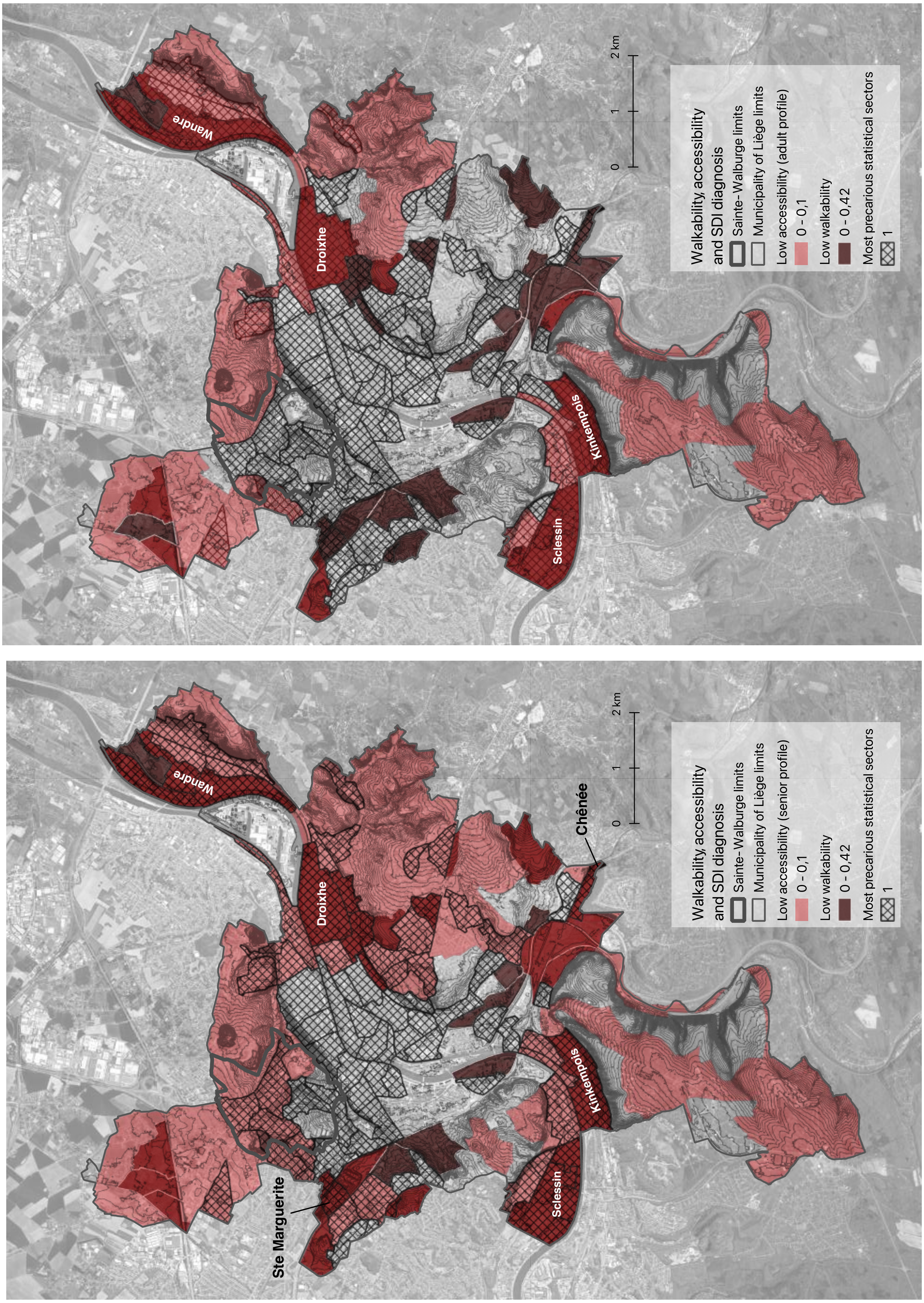

Figure 3.14: Diagnosis maps. Source : Author

3.5.1 Sclessin

Historically shaped by the steel industry, Sclessin is a working-class neighborhood structured around production and traffic flows rather than residential life. Its public space remains strongly marked by wide, busy roads (Quai de Wallonie, Rue Ernest Solvay), industrial istelands and vast car parks and a road network that is not very pedestrian-friendly.

Local shops are rare, and walking is often discouraged by the lack of continuity, noise, and a feeling of insecurity. Although close to the city center in terms of distance, Sclessin remains functionally isolated.

3.5.2 Kinkempois

This neighborhood, nestled in the Ourthe Valley, faces two major obstacles: a very steep topography, which makes walking difficult for vulnerable groups, and a massive railway footprint (marshaling yard, high-speed lines, freight tracks), which divides the area.

Pedestrian links to close neighborhoods are few and far between. Car dependency is high, reinforced by a loose built environment with no commercial center. Kinkempois appears to be an under equipped poorly connected intermediate space that is not very inclusive for an active journey.

3.5.3 Wandre

Late annexed to the city of Liège, Wandre retains the morphology of a peri-urban village, spread out and sparsely populated. The neighborhood is structurally cut off from the rest of the city by the E25 motorway, the port and industrial areas, and natural barriers (the Meuse and Ourthe rivers).

Active travel is not very comfortable there: lack of continuous pavements, dangerous crossings, inhospitable roads. Basic services are far away and not very accessible without a motor vehicle. This combination of spatial isolation and social precariousness makes Wandre particularly vulnerable.

3.5.4 Droixhe

Built in the 1960s as part of a modernist urban renewal plan, Droixhe embodies a style of urban planning characterized by slabs and towers, designed according to a strict separation of functions. Today, the neighborhood faces the following challenges, a strong disconnection from the close neighborhoods, a pedestrian network that is difficult to navigate and sometimes unsafe and underused or poorly maintained public spaces. Despite high residential density, local services are not very diverse. The neighborhood also suffers from social stigmatization, which reinforces the isolation of its residents.

3.5.5 Sainte-Marguerite and Chênée

Sainte-Marguerite is an old neighborhood located in close proximity to the city center that is marked by high social deprivation. Although it is in a central location, it suffers from reduced accessibility due to significant urban divides, particularly those linked to the construction of expressways in the 1970s, which fragmented the urban fabric. In terms of walkability, the neighborhood is not conducive to soft mobility, pavements are often narrow and discontinuous, and the terrain poses an additional challenge for pedestrians, especially vulnerable groups.

Chênée, which is more remote, also has a mixed social structure, with a significant proportion of social housing. While the neighborhood has certain transport advantages, such as a railway station and several bus routes, these facilities are poorly connected to the rest of the neighborhood by suitable pedestrian routes. Walkability is generally poor due to car-centric development, poor-quality pavements, and a lack of user-friendly spaces that facilitate walking. These two neighbourhoods therefore face major challenges that justify their designation as priority intervention areas.

3.5.6 Final diagnosis

These six neighborhoods appear to be the areas with the greatest urban vulnerabilities in Liège, with disadvantageous physical infrastructure (brownfield sites, expressways), historical planning that is not conducive to soft mobility, a lack of local services, and a more socially vulnerable population. These neighborhoods do not only suffer from a lack of pavements or services accessible on foot. They highlight the structural limitations of decades of sectoral urban planning, often geared towards cars, industry or functionalist zoning logic.

They should be priority areas for any policy aimed at transitioning to a more equitable and accessible city. In light of these findings, the response cannot be solely technical or localized. These areas must be subject to comprehensive development projects, tailored to their morphology and uses, which combine pedestrian redevelopment, improved services and the redevelopment of public spaces is essential to make local life practical and desirable.

Although the final diagnostic maps highlight priority neighborhoods such as Droixhe, Sclessin, Wandre, Kinkempois, and parts of Sainte-Marguerite and Chênée, which combine poor accessibility, poor walkability and high social vulnerability. It is also relevant to pay particular attention to the **Sainte-Walburge** neighborhood.

Sainte-Walburge is not among the most critical areas in the city, but it nevertheless has several localised weaknesses: a challenging topography, significant pedestrian discontinuities, and marked heterogeneity between different street segments. In addition, certain areas of the neighborhood are characterized by significant socio-economic vulnerability and very limited accessibility for the most vulnerable groups, particularly the elderly.

This neighborhood is therefore a relevant case study for proposing targeted solutions. It allows for experimentation with local development options, with a view to spatial re-balancing, without accumulating all urban vulnerabilities. Working on Sainte-Walburge means anticipating and correcting imbalances before they worsen, while being part of a more comprehensive approach to improving living conditions and mobility across the city.

3.6 Focus on Sainte-Walburge - Accessibility

3.6.1 Accessibility - maps

The maps below show the 15-minute pedestrian accessibility scores for the Sainte-Walburge district, calculated for the adult and senior profiles. Each point corresponds to a sampling housing unit location evenly distributed throughout the neighborhood, while the contour lines (5 m) show the effects of relief on accessibility conditions.

For the **adult profile**, the results show strong spatial variability in accessibility. A concentration of low to very low scores (< 0.25, in red and orange) covers the majority of the neighborhood, particularly in its central and northeastern part, where the terrain is more constraining. The highest scores (> 0.6, in blue), which are rare, are located in the southern part of the district, in the immediate surroundings of the valley, the main roads and near the city center. This reflects the very limited pedestrian accessibility in the higher elevations, due to steep slopes, breaks in the road network and distance to amenities.

The results are even more marked for the **senior profile**, whose walking radius is reduced to 855 m. Scores fall considerably, with a massive concentration of points in the minimum class (< 0.1) across the whole district. This reveals widespread inaccessibility for the elderly, except in the lower part of Sainte-Walburge, where a few points barely reach the intermediate classes (0.25-0.4). The terrain accentuates these inequalities, sharply reducing the area that can be reached in a given time.

These results show that topography is a determining factor in accessibility in this neighborhood. Even at equivalent theoretical distances, effective walking is limited by gradients, discontinuities and distance from services. The contrast between the two profiles highlights an even greater inequality of access for the elderly, whose ability to get around is limited by the gradient and the duration of effort.

According to the Synthetic Difficulty Index (SDI), a large part of the district is in classes 1 and 2, among the most precarious sectors of the Liège commune. These social dimensions are particularly important to cross-reference with the analysis of accessibility: they reveal that the populations most dependent on walking are also those who live in the areas least accessible on foot, notably due to the terrain, the distance from central areas, and the fragmented urban form.

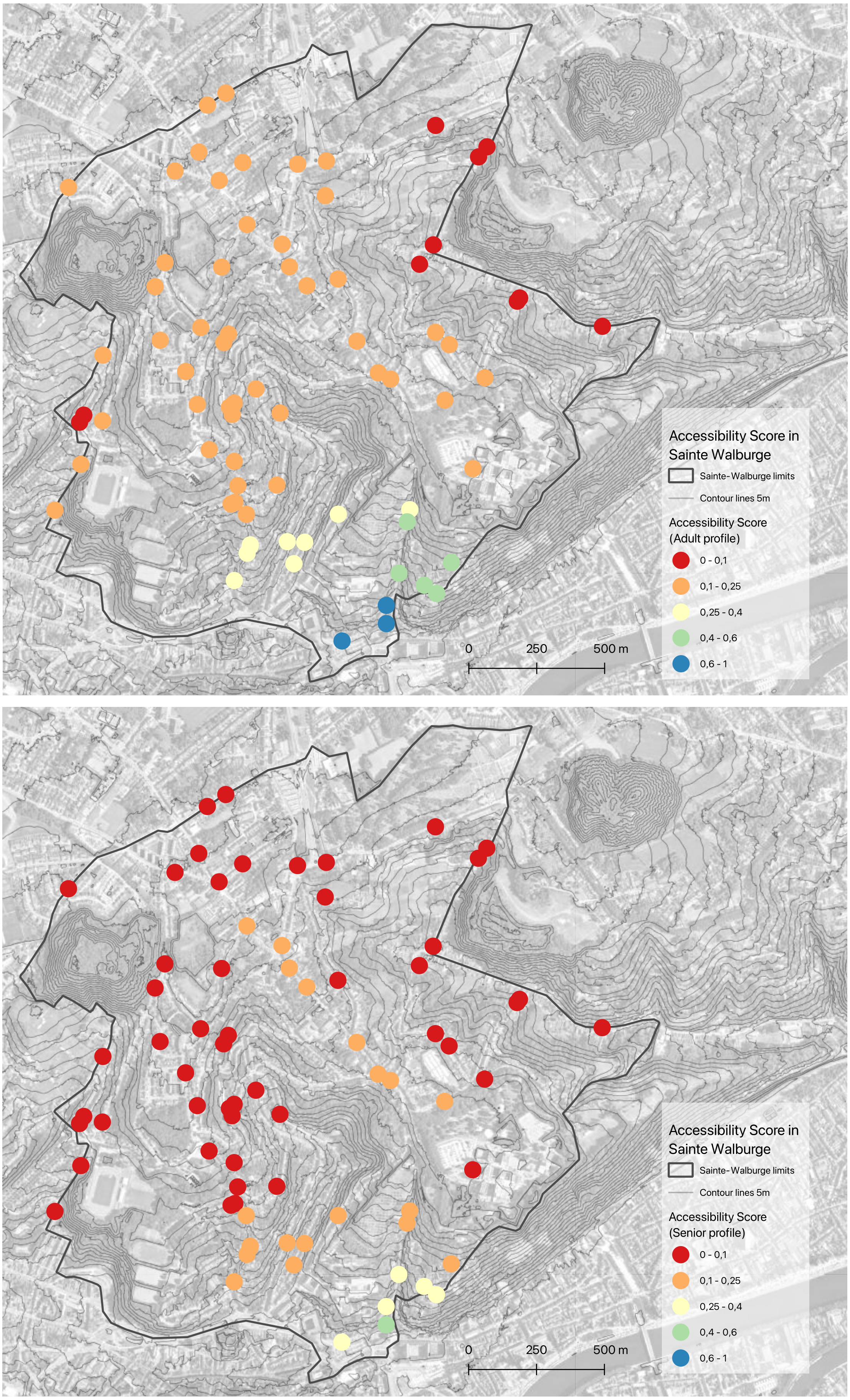

Figure 3.15: Accessibility maps for Sainte-Walburge. Source : Author

3.7 Focus on Sainte-Walburge - Walkability

3.7.1 Walkability - map

The map below shows the walkability scores calculated for each road segment in the Sainte-Walburge district. The scores are classified into five quantile classes, ranging from red (poorest walkability) to blue-green (best quality). The contour lines (5 meters) show the direct influence of relief on walking conditions.

The map shows a high degree of intra-neighborhood heterogeneity. Some areas, notably in the lower center of Sainte-Walburge, show well-marked stretches (in blue and green), with continuous, gently sloping roads, well-equipped with sidewalks and relatively safe. These areas are located around a few public facilities, schools and commercial centers, and often coincide with flat or accessible parts of the neighborhood. The three large blue areas in the neighborhood correspond to parks with lots of green and safe paths for pedestrians.

In contrast, a large part of the neighborhood, in particular outlying areas, slopes and steeply inclined streets, scores low to very low in walkability (in red and orange). These areas suffer from strong pedestrian discontinuities, narrow sidewalks, steep roads, or limited safety conditions for pedestrians.

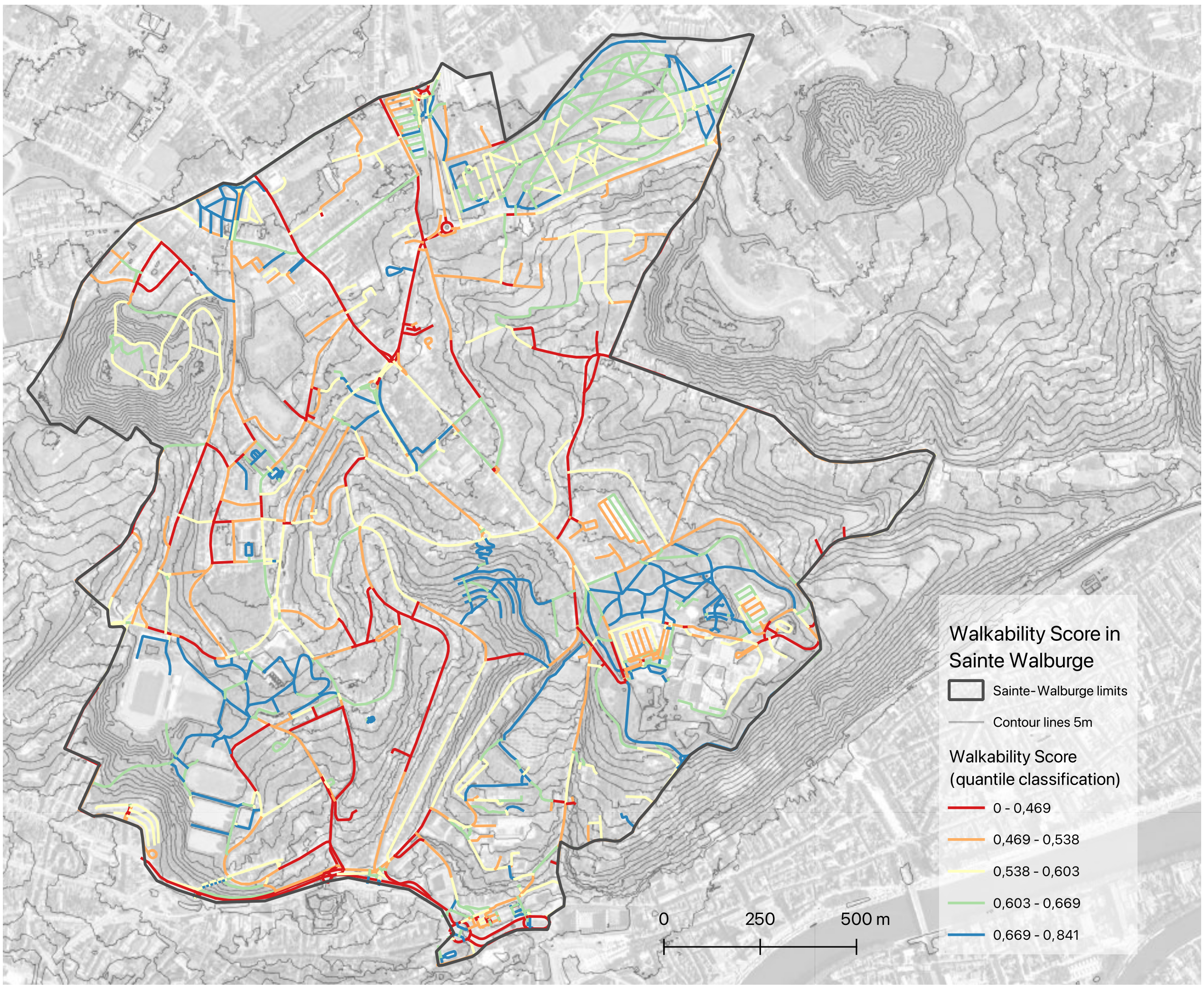

Figure 3.16: Walkability map for Sainte-Walburge. Source : Author

These results confirm the penalizing effect of uneven topography on pedestrian quality in the district. However, they also reveal that certain sections located in less steeply sloping areas are poorly rated, pointing to development problems that are independent of topography: degraded roadways, lack of maintenance, insufficient width, or an unfriendly environment for walking.

A detailed reading of the sections allows us to locate precisely the priority areas for intervention, and underlines the fact that the neighborhood is not homogeneously walkable, walking conditions vary considerably from one street to another.

3.8 Focus on Sainte-Walburge - Field survey

To assess the validity of the walkability score (NetAScore) at the scale of the Sainte-Walburge district, a sample of 60 sections is selected for direct comparison between OSM data and field surveys. Several versions of the index were compared:

- the score calculated on the basis of OpenStreetMap data (NetAScore),
- the score corrected by field data ("field survey"),
- and variants enriched by the addition of specific attributes missing : obstacles, pavements and width.

The field survey is realized on site. Each OSM attribute is verified and corrected if necessary to calculate the new improved index walk. Obstacles, pavements type and the width of the sidewalks were also identified to enrich the new index walk score, as these attributes were not taken into account in the NetAScore index walk.

For each section, the following attributes were observed in the field :

- Effective sidewalk width,
- Presence/absence and type of pavement,
- Occasional obstacles (parked cars, etc.),
- Speed limits
- Presence of greenery, water
- Number of traffic lanes
- Type of street (main, secondary, residential, services, etc.)
- Presence of crosswalks,
- Presence of services.

The map below illustrates the segments that were analyzed in the Sainte-Walburge neighborhood during the field survey.

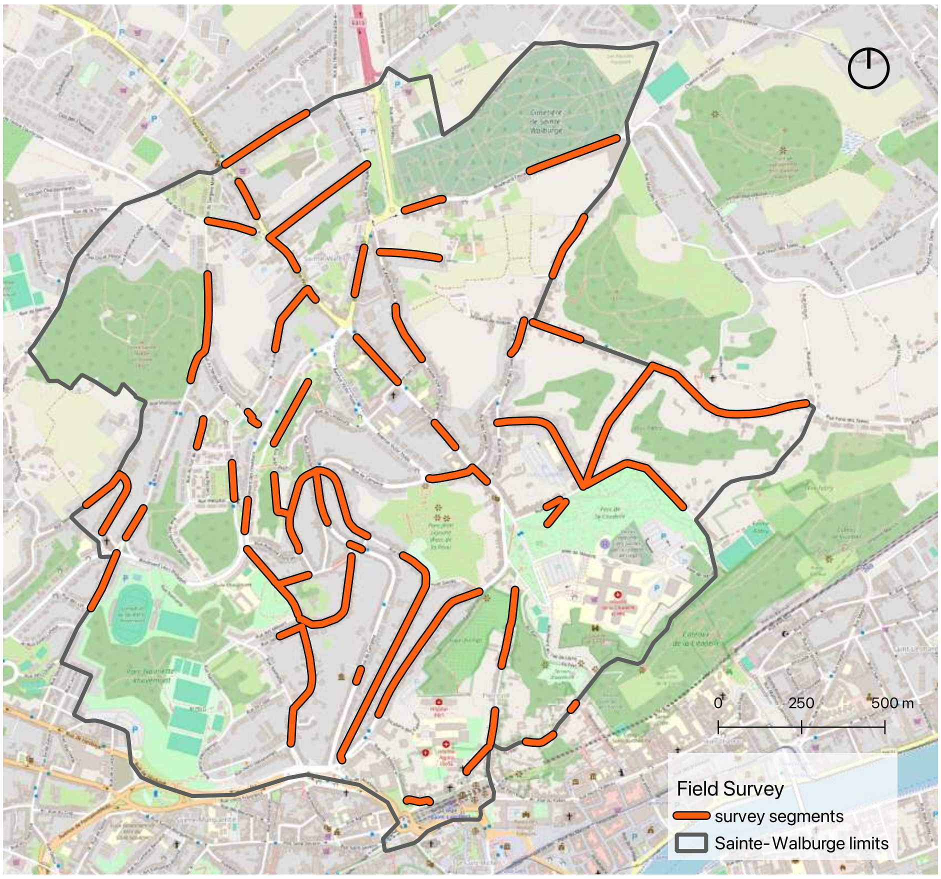

Figure 3.17: field survey segments map. Source : Author

The graphical results below show good overall agreement between NetAScore scores and field survey scores, with deviations often limited to $0.05 - 0.10$. However, there are some differences, mainly due to, obstacles not indicated in OSM (illegal parking), sidewalks that exist but are degraded, or that are narrow. Versions enhanced with width, obstacles and pavement criteria better capture these nuances. This confirms that certain qualitative aspects are difficult to model without field verification.

This comparison shows that the NetAScore model, while effective on a large scale, can produce inaccurate results locally when OSM data is incomplete or obsolete. In Sainte-Walburge, where the morphology of the neighborhood (slope, narrow roadway, mixed use) complicates the pedestrian experience, these adjustments are essential to translate the lived reality.

This paper demonstrates the importance of combining automated indicators and qualitative validation, particularly in urban contexts where walking comfort is affected as much by geometry as by daily use.

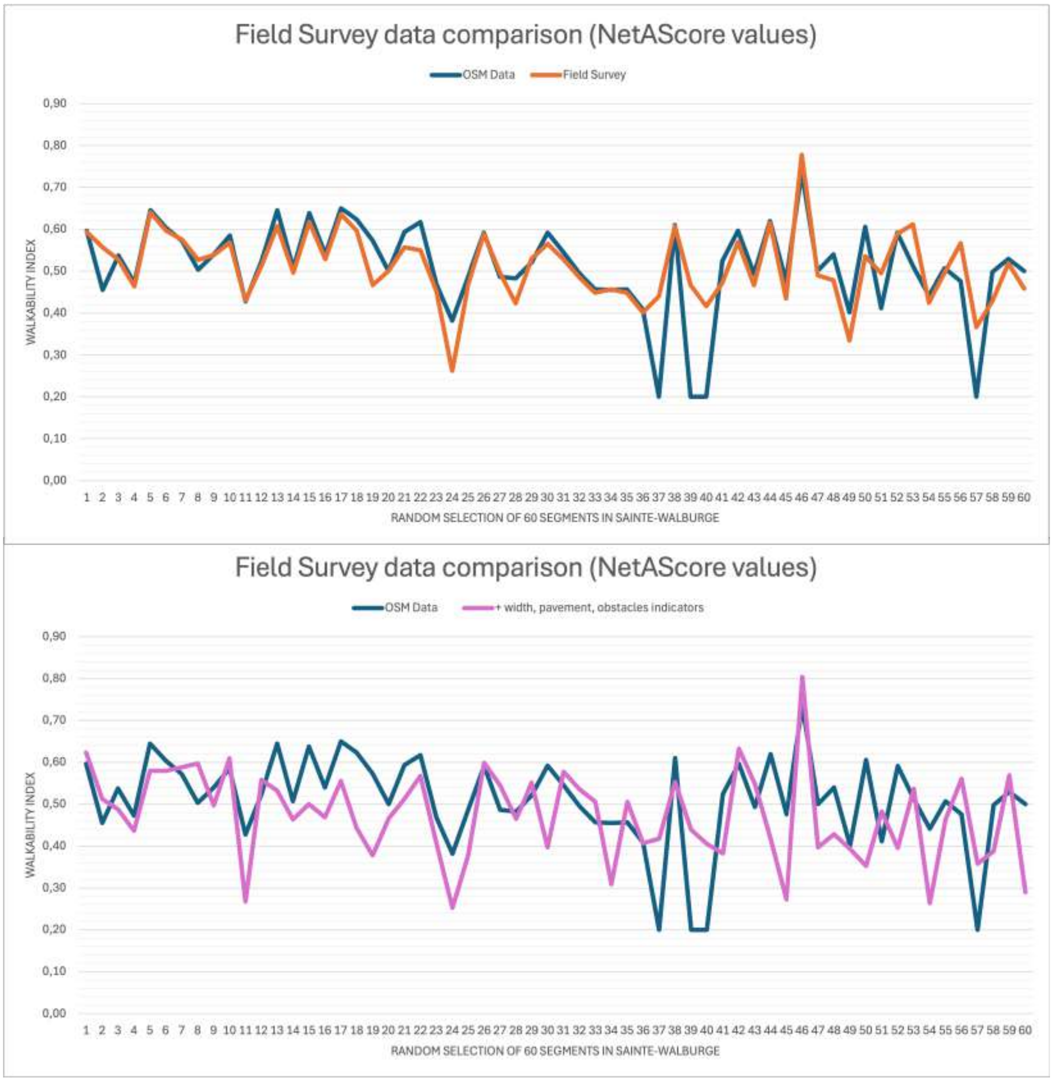

Figure 3.18: field survey and OSM data comparison. Source : Author

3.9 Focus on Sainte-Walburge - Accessibility vs walkability

Having analyzed pedestrian accessibility and the quality of the walking environment separately, this section proposes a cross-reading of the two indicators for the Sainte-Walburge district. The aim is to identify areas where there is an accumulation of weaknesses, where there is an imbalance, or where there is a good complementarity between accessibility and walkability.

Previous results have shown that 15-minute pedestrian accessibility (especially for senior citizens) is very low in a large part of the district, due to topography, urban form and distance from services. Conversely, walkability shows a finer variability, with sections rated highly in flat or well-developed areas, even in sectors with poor overall accessibility.

This dissociation produces highly contrasting situations:

- doubly disadvantaged areas, with difficult access to services and poor walking conditions (often on the slopes and edges of the neighborhood),
- areas that are well walkable but poorly connected, particularly around residential cores,

– and a few centered, flat, well-connected areas that score well on both dimensions.

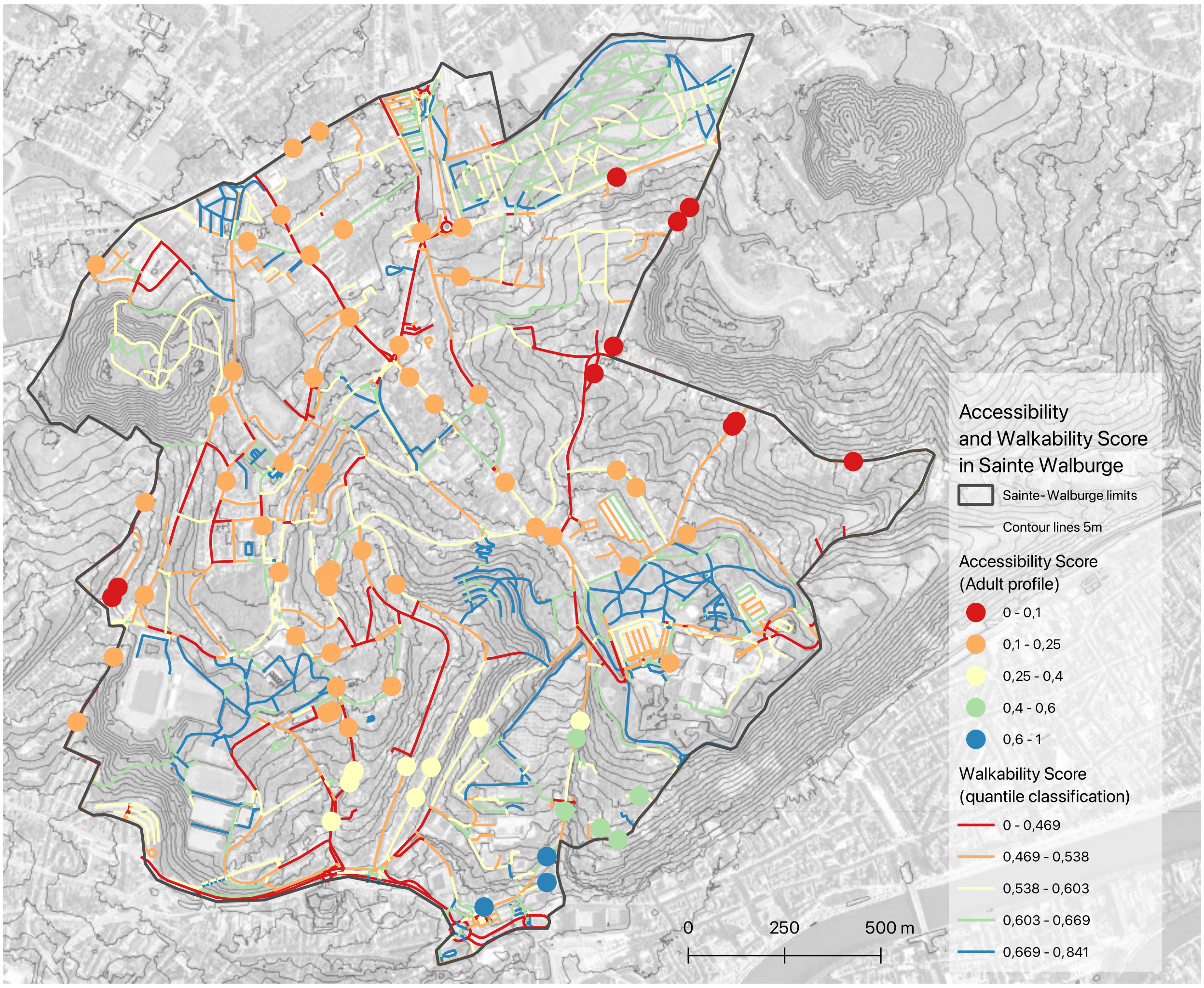

Figure 3.19: Accessibility - walkability map. Source : Author

The map shows a high degree of internal heterogeneity, and above all a frequent dissociation between accessibility and walkability:

Many areas with low scores on both dimensions appear in red and orange, particularly on the northern and western slopes of the district, where relief, low density and pedestrian discontinuities combine.

Some well-walkable sections (in blue or green) are located in areas with limited access to services (orange or red dots), as in outlying residential neighborhoods. In contrast, points of moderate accessibility are located in areas with degraded roadways or unfavorable to walking, revealing unbalanced sectors. A few central areas, notably in the southeast of the district, combine good performance on both dimensions, but these cases remain spatially limited.

In Sainte-Walburge, the effect of the terrain accentuates spatial inequalities, reducing both walking range and comfort. This justifies targeted action in areas where there is a combination of inaccessibility and poor walkability, with priority given to the most vulnerable users.

3.10 Focus on Sainte-Walburge - Interviews

As part of this study, ten semi-structured interviews were conducted between February and April 2025 with residents of the Sainte-Walburge district of Liège. The aim of these interviews is to gain a better understanding of how residents perceive and use their urban environment in relation to soft mobility, walkability and accessibility of services. The participants have a wide range of profiles: different ages, different family structures, different socio-economic statuses. Some have lived in the neighborhood all their lives, while others have moved in more recently. This heterogeneity makes it possible to cross points of view and paint a nuanced picture of local reality.

The data collected is analyzed using an inductive thematic approach. After full transcription, the discourse is manually coded according to categories derived both from the interview grid and from emerging recurrences. This analysis identified six major themes, presented below. The interview questionnaire and all interviews transcriptions can be found in the **??** appendices section.

3.10.1 Perception of mobility

The vast majority of respondents identified car traffic as an obstacle to soft mobility. This is particularly true of the neighborhood's main thoroughfares, such as rue de Campine and Boulevard Jean de Wilde, which are perceived as urban "mini-motorways". Car use is omnipresent, often to the detriment of other road users. Excessive speeds, noise and the aggressiveness of some drivers are regularly mentioned.

Public space is perceived as unfairly shared, to the advantage of motorized vehicles. Several residents deplore a road design that does not take into account the needs of pedestrians, cyclists, children or people with reduced mobility. This inequality of use is seen as a form of spatial injustice.

- Resident 2 explains (talking about the "boulevard Jean De Wilde") : *There are four lanes, but they're all used by cars. And sometimes at really excessive speeds. We've already had accidents, mirrors ripped off of parked cars, it's very dangerous for pedestrians.*

3.10.2 Daily and weekly mobility

However, walking is the preferred mode of transport for everyday journeys: to school, to the shops, to visit a relative, to access a local service. All respondents say they make several walking trips a week, or even daily. This mode of transport is perceived as simple, quick and economical. It also helps to maintain a healthy level of physical activity.

- Resident 6, who no longer owns a car, explains: *I do everything on foot, except for the big shopping trips with my daughter. I go to the cheese-maker's, the baker's, my daughter's, I walk every day. I walk around 3000 km a year!*

Cycling, although less frequent than walking, is increasingly used, particularly in electric form. It is seen as an efficient way of getting around topographical obstacles (steep gradients) and avoiding traffic jams. 8 out of 10 participants use their bikes on a daily basis and some participants have cargo bikes for transporting children or shopping.

- Resident 7, who uses a cargo bike, explains: *We do all our shopping by bike or on foot. Bread, vegetables, etc, except for the big ones at Delhaize in Rocourt.*

- Resident 5 adds: *At rush hour, rue de Campine is unbearable. That's why we walk as much as we can.*

The car is still used for long journeys, major shopping trips and transporting several people. 6

out of 10 participants have a car. However, several respondents expressed their desire to reduce their dependence on this mode.

3.10.3 Resident's maps of frequent journeys

The mind maps produced during the interviews illustrate the daily and weekly journeys undertaken by residents of Sainte-Walburge. These visualizations reveal routines that are centered around certain attractions and confirm several key points of the spatial diagnosis.

Recurring central destinations include the city center of Liège, local shops (notably Delhaize and Aldi), small producers on rue Sainte-Walburge, the Citadelle (hospital) and schools emerge as the most frequent destinations, as do workplaces. Several participants also mention traveling to Rocourt, "Baladins" or leisure facilities such as the swimming pool.

Short journeys are predominantly made on foot or by bus. The vast majority of local journeys are made on foot, especially for shopping, school and visiting relatives. The bus is used to access the city center or more distant destinations, often in combination with walking.

Pedestrian routes are fragmented. Despite the geographical proximity of certain services, the maps reveal gaps in accessibility and detours due to a lack of continuous pedestrian links, topography, and the dangerous nature of certain routes (e.g. Montagne Sainte-Walburge and Rue de Campine).

(All the maps made by residents can be found in the section **??**).

3.10.4 Obstacles to walking

Unauthorized parking is cited by almost all participants as a major nuisance. Cars parked on sidewalks force pedestrians onto the road, creating a hazard. This situation is considered particularly critical for vulnerable people: children, the elderly and wheelchair users.

- Resident 9 says: *What annoys me most are the cars on the sidewalks. We don't know how to pass, especially with bags or strollers.*

The quality of pavements is another cause for concern. Deformed sidewalks, holes, slippery or poorly-maintained cobblestones make travel uncomfortable or even dangerous. Some residents report having fallen, or avoiding certain routes for this reason. Access to the neighborhood is also unevenly distributed between main streets and back alleys.

- Resident 8 confides: *On Rue Font-Pirette, there are holes in the road, and it's dangerous by bike. You have to get out of the way, and it can be risky if there's an oncoming car.*

3.10.5 Perceived security

While the general feeling of safety is good during the day, the situation worsens after dark particularly in poorly lit areas. Several of the interviewed women said they avoid certain routes alone in the evening. Some green spaces, such as "Parc de la Citadelle" or the area around "Tier Savary", were cited. Others mentioned the presence of drug addicts or the homeless, which can be a source of unease.

It should be noted, however, that these perceptions vary according to respondents' gender, age and familiarity with the neighborhood. Men generally feel less concerned by these issues.

- Resident 5 qualifies: "I feel safe, but I understand that my wife doesn't like to go down certain paths alone, especially in poor lighting.

3.10.6 Accessibility to services

Overall, residents feel that essential services are accessible on foot or by bike in less than 15 minutes: grocery stores, bakeries, schools, nurseries, doctors, pharmacies, bus stops, parks. This reinforces support for the quarter-hour city model.

- Resident 1 notes: *For me, everything is within easy reach. We do everything on foot, we're rarely impacted even by bus strikes.*

However, a number of shortcomings were identified: lack of cash dispensers, lack of specialized food shops, few cultural or meeting places. Some explain that major facilities (cinema) are located outside the neighborhood, requiring motorized travel.

- Resident 10 points out: *There's no vending machine in the neighborhood. For me, it's one of the few things missing.*

It is important to highlight an interesting contrast between the qualitative and quantitative results concerning accessibility. While objective indicators calculated using the accessibility method showed that the neighborhood performed poorly overall in terms of accessibility to services, the majority of residents expressed daily satisfaction. This is probably due to a strong sense of ownership of the neighborhood and very local travel habits, centered on walking within an individually defined comfort zone. This gap highlights the need to combine approaches in order to fully assess the reality of everyday life.

3.10.7 The 15 minute concept

The majority of those interviewed had not heard of the concept prior to the interview. Once it had been explained, 8 out of 10 residents found it to be in line with their experience of the neighborhood, while pointing out its limitations.

- Resident 4 explains: *It's a nice idea on paper, but it needs to be put into practice. There are services, but not for everyone. And it all depends on whether you can walk easily or not.*

3.10.8 Subjective assessment of walkability

In addition to the qualitative interviews, each participant is asked to give a walkability score (out of 10) to his or her direct street, as well as to the Sainte-Walburge district as a whole. The results are summarized in the table below:

Resident (anonym)	**their street (/10)**	**district (/10)**
Resident 1	9	8
Resident 2	4	7
Resident 3	5	8.5
Resident 4	5	7
Resident 5	8	7
Resident 6	7	8
Resident 7	9	7
Resident 8	5	7
Resident 9	7	8
Resident 10	4	8

Table 3.1: Residents' perceived walkability scores. Source : Author

These ratings show an overall positive perception of walkability, with a majority of evaluations between 7 and 9, particularly for the neighborhood in general. Many people rate their street as particularly pleasant or well laid out, while others report very localized problems (parking, sidewalks, gradients) that strongly influence their rating.

It should be noted that the differences between the rating for the street and that for the neighborhood are sometimes significant (up to +1.5), suggesting that some residents differentiate between their immediate local feelings and a more general assessment of the pedestrian environment. A number of people pointed out that the quality of walking depends to a large extent on the street used, and not on the neighborhood as a whole

- Resident 3 says, *it's quiet in the neighborhood, but there are places where walking is stressful.*

This subjective assessment reinforces the cartographic and field observations, it confirms that residents have a nuanced but demanding perception of walkability, and that certain weak points can severely degrade feelings, even in a neighborhood that is generally considered pleasant.

3.10.9 Improvement suggestions

The suggestions put forward by respondents show a clear desire to improve public space. Several requests converge:

- Creation of safe, continuous cycling infrastructure, separate from the roadway;
- Effective regulation of parking, with increased enforcement;
- Regular maintenance and repair of sidewalks;
- Increased planting and shading, particularly in response to heat waves and air pollution;
- Improved street lighting in sensitive areas;
- Improvement of local shuttles linking outlying areas to the city center.

Some more innovative ideas are also mentioned, such as the creation of car-free "school streets" at school entry and exit times, or the installation of public benches to encourage breaks and encounters.

The interviews with residents revealed the streets on which priority action should be taken. The priority streets are :

- **Montagne Sainte-Walburge** : very steep street that is difficult to walk on. The steep slope, combined with narrow pavements, makes walking difficult, especially for elderly people.
- **Rue Fond-Pirette** : Poor overall condition, damaged road surface, deteriorated pavements, few pedestrian facilities, illegal parking on both sidewalks.
- **Rue de Campine** : perceived as dangerous. Traffic is heavy and too fast, sidewalks are often obstructed, and coexistence between users is difficult.
- **Boulevard Jean de Wilde** : very wide and structured around cars, leaving little room for pedestrians. High speeds and a lack of pedestrian infrastructure reinforce the feeling of insecurity.

3.10.10 Interviews conclusion and summary

The interviews conducted in Sainte-Walburge revealed a rich, nuanced and everyday perspective on mobility, accessibility and walkability in their neighborhood. These testimonies reveal a strong attachment to a local lifestyle, mainly structured around walking and, to a lesser extent, cycling. Despite sometimes poor infrastructure conditions, residents adopt adaptive strategies (choosing alternative routes, staggered schedules, using electric bikes) to preserve their independence of movement.

This subjective reality contrasts with the quantitative results obtained through geographical analyses, which points out the accessibility deficits and sometimes limited service coverage. This paradox highlights the importance of territorial appropriation and lived experiences in the assessment of urban quality. It calls for going beyond normative diagnoses by cross-referencing data and residents' accounts.

In addition, the proposals put forward by respondents converge towards concrete and shared demands: traffic calming, improvement of the condition of pavements, development of cycling infrastructure, greening of public spaces and improved access to certain local services. These courses of action, formulated from direct experience in the field, are powerful levers for designing truly inclusive urban developments that are adapted to local needs.

In short, this qualitative analysis confirms that Sainte-Walburge has many assets that could help it move towards a 15-minute city model. However, its concrete implementation necessarily requires a detailed understanding of structural constraints (traffic, development inequalities) and social resources (habits, attachment to the neighborhood), which alone make it possible to design urban planning that is functional, equitable and humane.

3.11 Focus on Sainte-Walburge - Previous work of students

As part of the "Urban Planning and Transportation" course at the University of Liège, several groups of students have conducted in-depth analyses of the Sainte-Walburge neighbourhood in 2024. This paper, has identified the main mobility issues and formulated concrete proposals to improve walkability, accessibility and quality of life. This section presents a critical summary of the most recurrent and relevant recommendations, directly linked to the specific challenges facing the neighborhood [Student, 2024].

3.11.1 Improving walkability and pedestrian continuity

Several groups highlighted the poor condition of pedestrian infrastructure and its discontinuity along the neighborhood's main arteries. The diagnosis is based on both field observations and data from

Telraam, which highlight a low modal share of walking in certain areas due to narrow pavements, a lack of signage and a feeling of pedestrian insecurity (Groups 1, 3, 6).

The recommendations converge on:

– Widening pavements, maintaining them regularly and adding safe pedestrian crossings;

– The creation of green corridors crossing the neighborhood to safely connect the north-south hubs and promote soft mobility.

3.11.2 Development of cycling infrastructure

All groups agree that the infrastructure dedicated to cycling is inadequate and fragmented. Several proposals are based on the guidelines of the Municipal Mobility Plan, which provide for "cycle corridors" on main roads [Ville de Liège, 2024a].

Among the proposed courses of action:

– The development of separate one-way cycle paths, particularly along Rue Sainte-Walburge and Boulevard Jean de Wilde;

– Improving safety at intersections, with priority given to cyclists and better visibility of facilities;

– Integrating cycling into an inter-modal approach, in conjunction with bus stops and future multi-modal transport hubs.

3.11.3 Reduction of transit traffic and reorganisation of traffic flows

The neighborhood suffers from heavy use as a transit route between the north of the conurbation, where the motorway is located, and the city center of Liège. This situation causes significant congestion and conflict between different modes of transport. Several groups propose reorganizing the traffic plan in order to limit through traffic (Groups 4, 11, 2):

– The introduction of local traffic loops to discourage non-residential transit;

– Making certain secondary streets one-way to calm traffic and facilitate parking;

– The introduction of a network of traffic-calmed zones (20 and 30 km/h zones) favorable to pedestrians and cyclists

Here is a example of a mobility plan designed by the students in the course "Urban Planning and Transportation". This mobility plan is proposed by the group 5 (Baptiste Stangherlin, Ema Vlasic, Rupin Bwami). In their proposition, the students proposed a new mobility plan for cars, bicycles, buses as well as pedestrians, to promote more equitable and sustainable mobility for all.

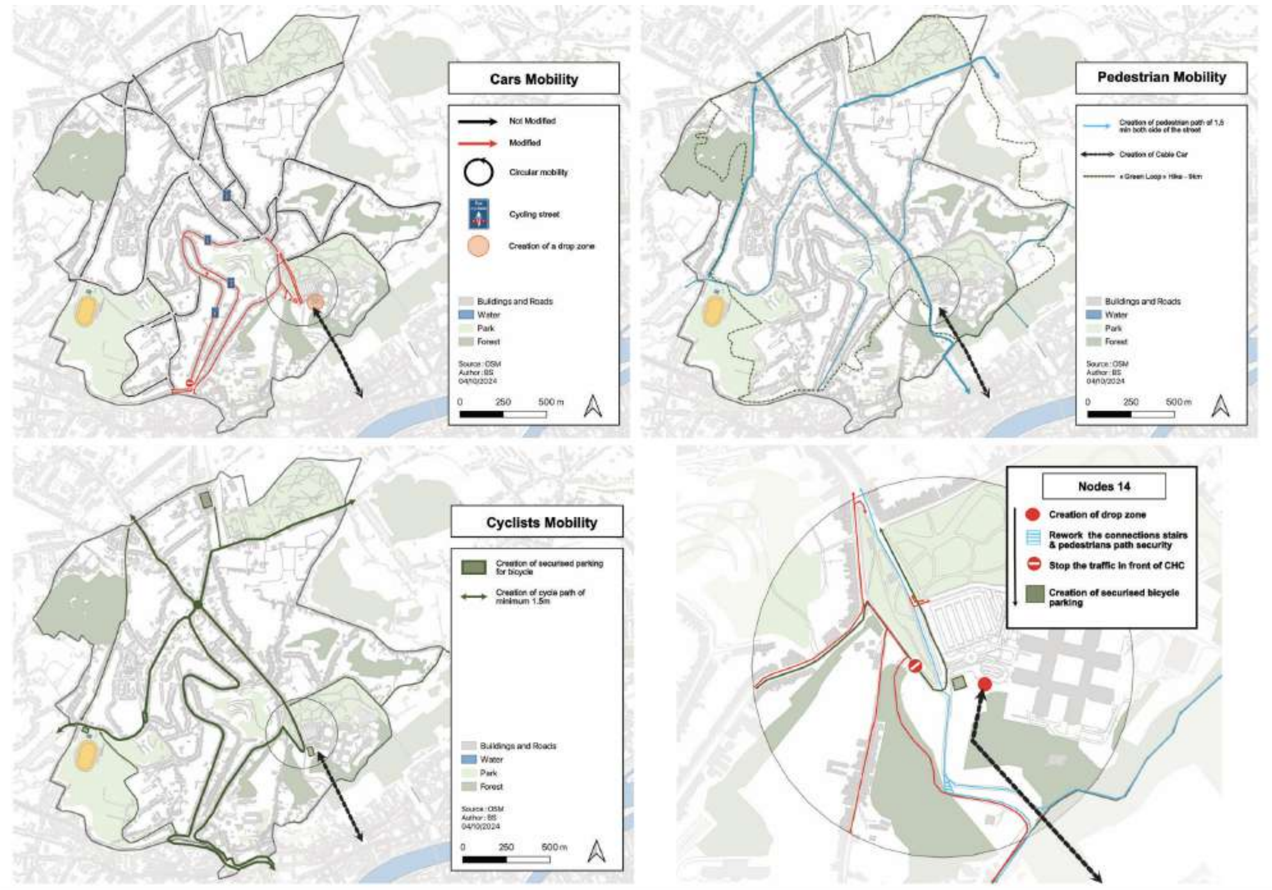

Figure 3.20: Mobility Plan Proposition by group 5. Source : Baptiste Stangherlin, Ema Vlasic, Rupin Bwami

3.11.4 Improvements to public transport services

Although the neighborhood is generally served by several bus routes, many groups have highlighted a lack of frequency, slow speeds and punctuality issues during rush hour. To remedy this, the following proposals have been put forward:

- Creation of dedicated bus lanes on strategic routes (Groups 5, 7, 9);
- Improvement of connections between Sainte-Walburge and peripheral employment centers (Hauts-Sarts, Rocourt);
- Development of inter-modal infrastructure (PEM, P+R) in the north of the neighborhood to encourage modal shift and relieve congestion on local roads.

3.11.5 Valorization of public space

Finally, many proposals include improving the quality of public spaces, which are often constrained by on-street parking. Several groups suggest rethinking the space allocated to cars in order to free up space for pedestrian and green areas:

- Reducing on-street parking on main roads, with shared car parks for shops and public facilities;
- Transforming certain parking pockets into green spaces or meeting areas (Groups 1, 4);

– Including the neighborhood in a generalized 30 km/h zone, with street furniture that encourages walking and socializing.

3.11.6 Accessibility analysis

An analysis of accessibility reveals a contrast between the results of quantitative approaches and qualitative ones. From a quantitative perspective, indicators highlight relatively low accessibility. However, qualitative interviews tell a very different story. Many feel that they live in a neighborhood where everything they need is accessible on foot or by bus. The map of attractors produced by the students highlights this relative density of services, particularly around shopping areas, parks and schools. This tends to show that, despite objectively average accessibility according to standard tools, the neighborhood is perceived as functional and relatively well served by its users.

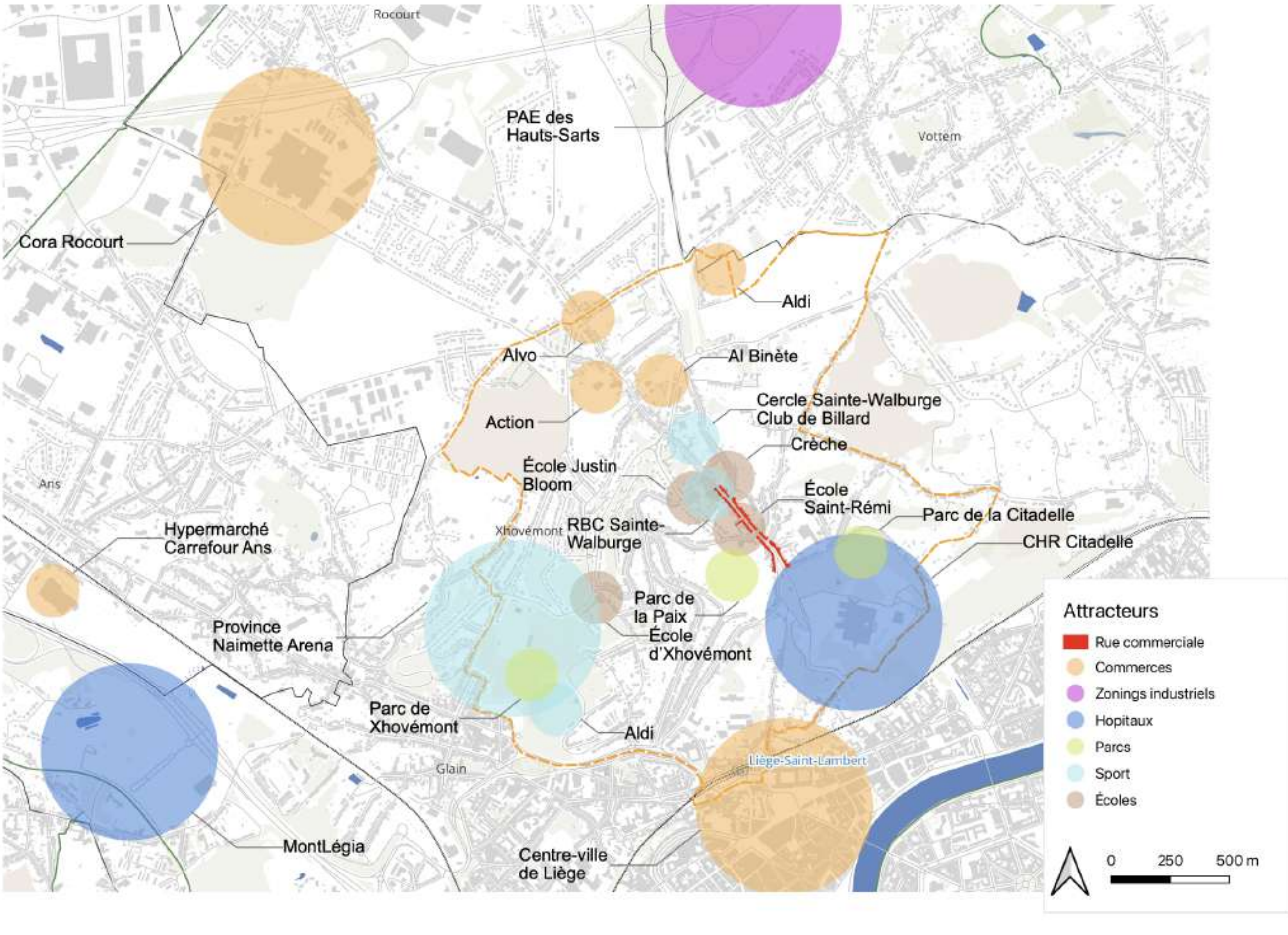

Figure 3.21: Accessibility hubs in Sainte-Walburge. Source : Students of the course "Urban Planning and Transportation", Clotilde Bourdoux, Matteo Dequecker, Nicolas Pluymers

3.11.7 Student work conclusion

The collective work of the students has produced a diverse yet coherent set of proposals for addressing the mobility challenges in Sainte-Walburge. Despite methodological differences, several cross-cutting themes have emerged, including the need for safer and more continuous pedestrian and cycling infrastructure, reducing transit traffic through localized circulation schemes, enhancing public transport efficiency and reallocating public space in favor of active travel and social activities. Notably, the question of accessibility, initially perceived as limited through quantitative analysis—proved to be more nuanced when confronted with the lived experiences of residents and the work of students.

These recommendations, which are based on spatial analysis and field observation, demonstrate a strong alignment with contemporary planning goals, such as modal shift, spatial justice and urban resilience. Integrating these insights into municipal strategies could meaningfully contribute to Sainte-Walburge's transition towards becoming a more accessible, walkable and livable urban environment.

3.12 Summary of results

3.12.1 Liège

The analysis conducted in this study reveals contrasting situations in terms of accessibility, walkability and user perception in Liège, particularly in the Sainte-Walburge neighborhood. Across the city, pedestrian **accessibility** scores within a 15-minute radius are generally low to moderate. This observation is even more pronounced for senior citizens, whose reduced walking range accentuates territorial inequalities. Central areas, which are flat and densely populated, offer good accessibility, while peripheral neighborhoods, which are often hilly and poorly served by services, appear to be disadvantaged. Topography plays a key role here, limiting the ability to travel on foot, particularly for vulnerable populations.

Walkability, measured using NetAScore, shows a more balanced distribution but is also marked by significant disparities. While many street segments have average scores, a significant proportion receive very low scores, often due to uncomfortable conditions (heavy traffic, narrow or discontinuous pavements). Conversely, some parks or sparsely built-up areas obtain artificially high scores due to favorable criteria such as the presence of vegetation, tranquility or low building density. This observation highlights the importance of a contextualized reading of the indicators.

A comparison between **accessibility and walkability** reveals a weak correlation between the two dimensions. Many areas are well located but not very pleasant to walk through, while others offer a comfortable walking environment but remain far from essential urban functions. This dissociation shows that the 15-minute city cannot be reduced to a logic of geographical proximity: it must also integrate the quality of the pedestrian journey.

The intersection with the **Synthetic Difficulty Index** (SDI) produces unexpected results. Contrary to expectations, the most disadvantaged neighborhoods are not systematically the least well served. Some of them, located close to the center, even enjoy good accessibility. Conversely, several more affluent neighborhoods, located on higher ground or on the outskirts, combine functional remoteness with poor pedestrian accessibility. This demonstrates the complexity of spatial inequalities, which do not always follow the traditional lines of social deprivation.

3.12.2 Sainte-Walburge

A detailed analysis of the Sainte-Walburge neighborhood confirms these trends while revealing local specificities. **Accessibility** is very uneven, heavily constrained by the terrain, discontinuities in the road network and distance from central areas. Older people are particularly disadvantaged.

Walkability, meanwhile, varies greatly from one street to another. Some flat, well-equipped and safe areas offer good conditions for getting around, while others, which are sloped or poorly maintained, make walking difficult or even dangerous.

A **field survey**, conducted on 60 street segments, made it possible to compare the scores from NetAScore with actual observations. While the differences are generally small, several cases revealed inconsistencies due to the lack of data on obstacles, narrow pavements or their deterioration. These results highlight the value of combining automatic indicators with qualitative validations.

Interviews with Sainte-Walburge residents provide an essential additional dimension. They reveal a high level of daily walking, an attachment to the neighborhood, but also a series of clearly identified obstacles: illegal parking, poor pavement conditions and night-time insecurity. Notably, the majority of residents perceive accessibility as satisfactory, despite the low scores calculated. This disparity can be explained by local travel habits, appropriation of the territory and different expectations depending on profiles.

The residents' suggestions converge around a set of pragmatic measures: improvement of pedestrian and cycling infrastructure, traffic calming, greening, improvement of public lighting and better accessibility to local services. These proposals largely overlap with the **work carried out by students** at the University of Liège, who have developed several development scenarios for Sainte-Walburge. These proposals are part of a transition towards a more equitable, accessible and resilient city.

In short, the results of this study show that the practical implementation of the 15-minute city model must take into account local specificities, both topographical and social. They also highlight the importance of combining quantitative analysis and qualitative research to reflect the complexity of the situation.

Chapter 4

Solutions and recommandations

In light of the results analysed in the previous chapter, this chapter proposes a series of concrete levers for action to improve the walkability and accessibility of the most vulnerable neighborhoods, particularly in Sainte-Walburge. These recommendations are classified according to their level of intervention, ranging from simple improvements to existing infrastructure to more structural transformations of public space. They aim to address the challenges identified while taking into account the technical, social and political constraints specific to the city of Liège.

4.1 Priority areas for actions

Cross-analysis of data on accessibility, walkability (NetAScore) and socio-economic vulnerability (SDI) has identified several neighborhoods with significant weaknesses:

- **Sclessin**
- **Wandre**
- **Droixhe**
- **Kinkempois**
- a part of **Sainte-Marguerite**
- and a part of **Chênée**

These areas are characterised by poor accessibility to essential services, poor quality pedestrian infrastructure, and a population that is more exposed to social precariousness.

The **Sainte-Walburge** neighborhood is a relevant intermediate case. Although it is not among the most problematic, it presents specific challenges in terms of pedestrian connectivity, discontinuities in road surfaces and topography. It is also selected because it has already been the subject of previous student research as part of the master's program, thus providing a complementary basis for observation and a solid academic foundation for the present study. This is why it is selected as a testing ground for the proposed solutions.

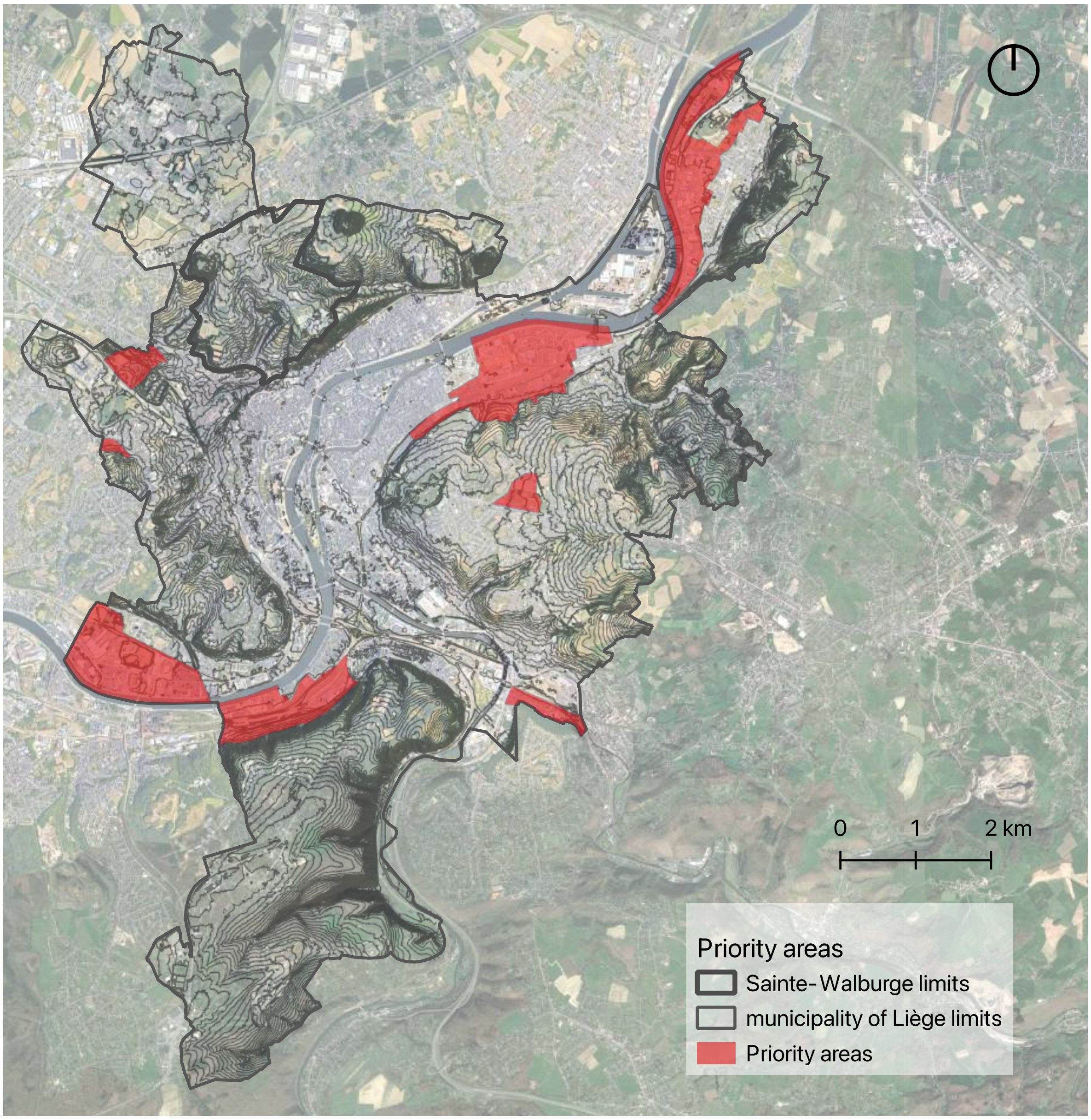

Figure 4.1: Priority areas for actions. Source : Author

4.2 Catalog of solutions for Sainte-Walburge

This catalogue presents a range of concrete proposals aimed at improving walkability, accessibility and quality of life in the Sainte-Walburge neighborhood, in accordance with the principles of the 15-minute city. It is based on the results of a cross-analysis of quantitative data and qualitative feedback from residents. Three levels of intervention are proposed, classified according to the intensity and impact of the necessary transformations.

4.2.1 Level 1 - Enforce the existing legal framework

This first level of intervention includes the most basic measures: they do not require a major reorganization of public spaces, but consist of the strict application of existing legislation, in particular the Highway Code, PRM (Persons with Reduced Mobility) requirements, and minimum maintenance standards for public spaces.

This initial intervention does not require a change in urban planning strategy; rather, it involves bringing the neighborhood into compliance with existing national standards. It is a prerequisite for ensuring basic safety, even before detailed discussions about accessibility or the 15-minute city are held. Due to its immediate effectiveness, inclusive scope and limited cost, it is an essential first phase in any action program.

Enforcement of speed limits

In several areas of the Sainte-Walburge neighborhood, particularly in residential streets and around schools, speed limits (30 km/h zones or 20 km/h shared zones) are poorly enforced or poorly marked. This compromises pedestrian safety and discourages active travel, particularly among vulnerable groups.

Proposed actions:

- Improve vertical and horizontal signage (road markings, visible signs).
- Add passive speed control devices (speed bumps, raised platforms, chicanes, optical markings).
- Prioritize pedestrian crossings: systematic marking with white stripes, lighting and continuous pavements (pedestrian crossings must be lowered and have contrasting surfaces for visually impaired people).
- More expensive but works, active speed control : install a fixed speed camera at issue locations.

Speed limits must be enforced on the most problematic streets, such as Rue de Campine, Montagne Sainte-Walburge and Boulevard Jean de Wilde.

Maintenance

Several sections of streets, particularly in the lower part of the neighborhood (Fond Pirette, Rue des Glacis, Rue Volière), have cracked, disjointed or deformed surfaces, which pose a danger to users, especially in rainy weather or for people with reduced mobility. The recommended actions are : spot repairs of potholes, repair of slab joints, stabilization of uneven paving and implementation of a maintenance plan.

4.2.2 Level 2 - Intelligent redesign without major changes

This second level of intervention aims to re-balance public space in favor of active mobility, without radically transforming the structure of the road network. These are medium-term operational actions, feasible at the scale of a street or a sector, which aim to improve the clarity, comfort and safety of walking and cycling.

This type of intervention generally requires coordination between technical services and a certain degree of urban design, and can have a significant impact on the quality of daily life.

Widening and improving sidewalk

In many streets in Sainte-Walburge, pavements are less than 1,5 meters wide, discontinuous, or obstructed by illegal parked vehicles. This situation seriously impairs walkability, particularly for people with reduced mobility, parents with pushchairs, and elderly people.

Recommendations:

- Increase the width of pavements to a minimum of 2,4 meters (recommended by "Global Street Design Guide", n.d.) on main roads (Montagne Sainte-Walburge, Rue de Campine, Boulevard Jean de Wilde).
- Unify the paving materials to ensure continuity for pedestrians.
- Adding new pedestrian crossings to ensure pedestrian continuity. Particularly in Boulevard Jean de Wilde, adding a crossing in the middle of the segment (asked by a resident for pedestrian comfort).
- Move or remove unnecessary obstacles (posts, cabinets, poorly placed signs).

In the historic streets near the city center in Sainte-Walburge, such as rue Volière, the route surface is traditional paving stones. It makes walking and cycling difficult and dangerous, for the elderly and cyclists. It would also be advisable to create a dedicated cycling area with a flatter, safer surface. This would also highlight the diversity of uses on the streets. The traditional pavings are maintained in this way, and the road is made safer for active mobility.

Creating spaces for rest and socializing

Feedback from residents indicates a lack of public benches, rest areas and green in certain streets, particularly on steep or busy streets. This lack limits mobility, for the elderly and people with reduced mobility, and increase heat island effects and air pollution.

Recommendations:

- Install public benches every 150-200 meters along the busiest pedestrian routes.
- Create small widened areas or squares with vegetation, rows of trees or fountains.
- Encourage the creation of informal spaces for interaction, for example in front of schools, shops or bus stops.

Reorganization of parking

Unregulated parking or parking on pavements significantly reduces the space available for pedestrians. This affects accessibility and walkability and often makes it difficult to understand the hierarchy of uses.

Recommendations:

- Eliminate parking that encroaches on pavements in streets less than 10 meters wide.
- Create alternating parking zones, marked out and integrated into the street profile.
- Prioritize residential parking and delivery needs over long-term parking.

Interventions at this level bring about visible and measurable improvements in the quality of public spaces without requiring major structural changes. They make walking more comfortable, safer and more attractive, while encouraging collective ownership of the street. These actions can serve as levers for rapid transition to more sustainable and inclusive urban forms.

4.2.3 Level 3 - Urban structure and flow logic complete redesign

The third level of intervention concerns strategic actions aimed at rethinking the logic of urban functioning at the neighborhood level, or even at the level of the road network. These structural transformations address the root causes of accessibility inequalities, motorized transit flows, and spatial imbalances that hinder the emergence of a true 15-minute city.

These interventions are the most complex to implement: they require a long-term vision, strong political will, and often the coordination of several levels of actors (city, region, transport operators, private actors). In return, they offer a profound and lasting impact on quality of life and territorial equity.

Establishment of a structuring traffic loop

One key measure proposed is the establishment of a neighborhood-wide traffic loop, inspired by previous student work. This loop would be based on a differentiated one-way system for the neighborhood's two main roads:

1. The Montagne Sainte-Walburge would be dedicated to uphill traffic (towards the top of the neighborhood) and reserved for motor vehicles.
2. Rue de Campine would become a one-way downhill road, easing outgoing traffic.

This system has several objectives:

- To reduce through traffic by closing certain secondary crossings;
- To clarify the direction of travel and improve the readability of the neighborhood;
- To free up space on the two roads for the development of wider, accessible pavements, safe one-way cycle lanes and plantings or rest areas.

This loop could be complemented by modal filtering at certain key intersections (Rue Curie, Rue des Glacis) to preserve residential tranquility and encourage active mobility in the heart of the neighborhood.

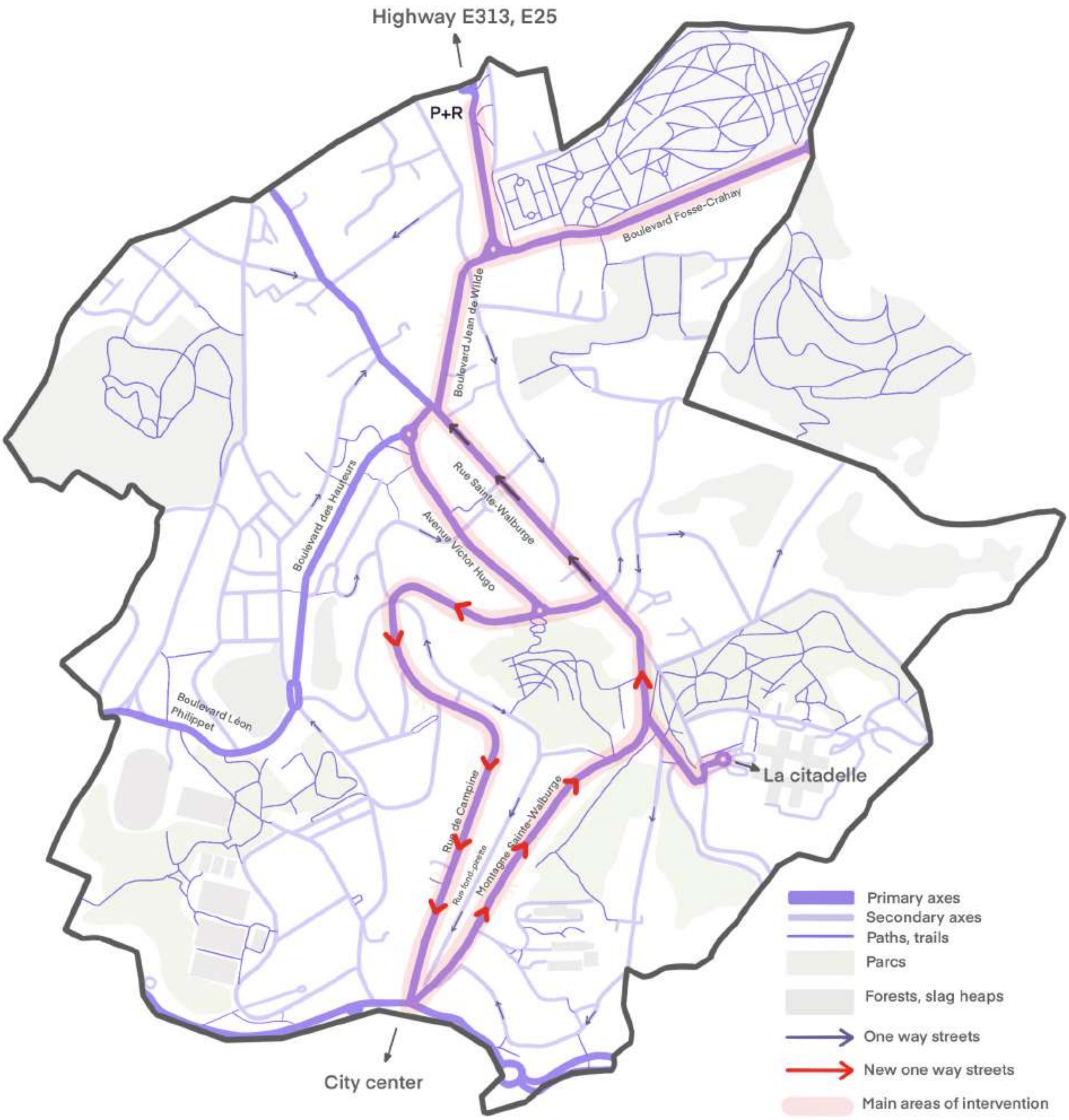

Figure 4.2: Car mobility. Source : Author

Improving pedestrian and cycle connections to the city center

One of the main challenges identified is the lack of connection between the neighborhood and the lower part of the town, due to the slope, the discontinuity of the infrastructure and the lack of safety on the routes.

Creation of a continuous and safe pedestrian/cycle route connecting the upper part of Sainte-Walburge to the city center via:

- a protected downhill cycle lane on Rue de Campine,
- public stairs or ramps in the steepest areas,

- clear and attractive signage for active journeys.
- Connection with existing major cycle routes.
- Integrated signage (walking time, direction, slope level) to make the route visible and usable on a daily basis.

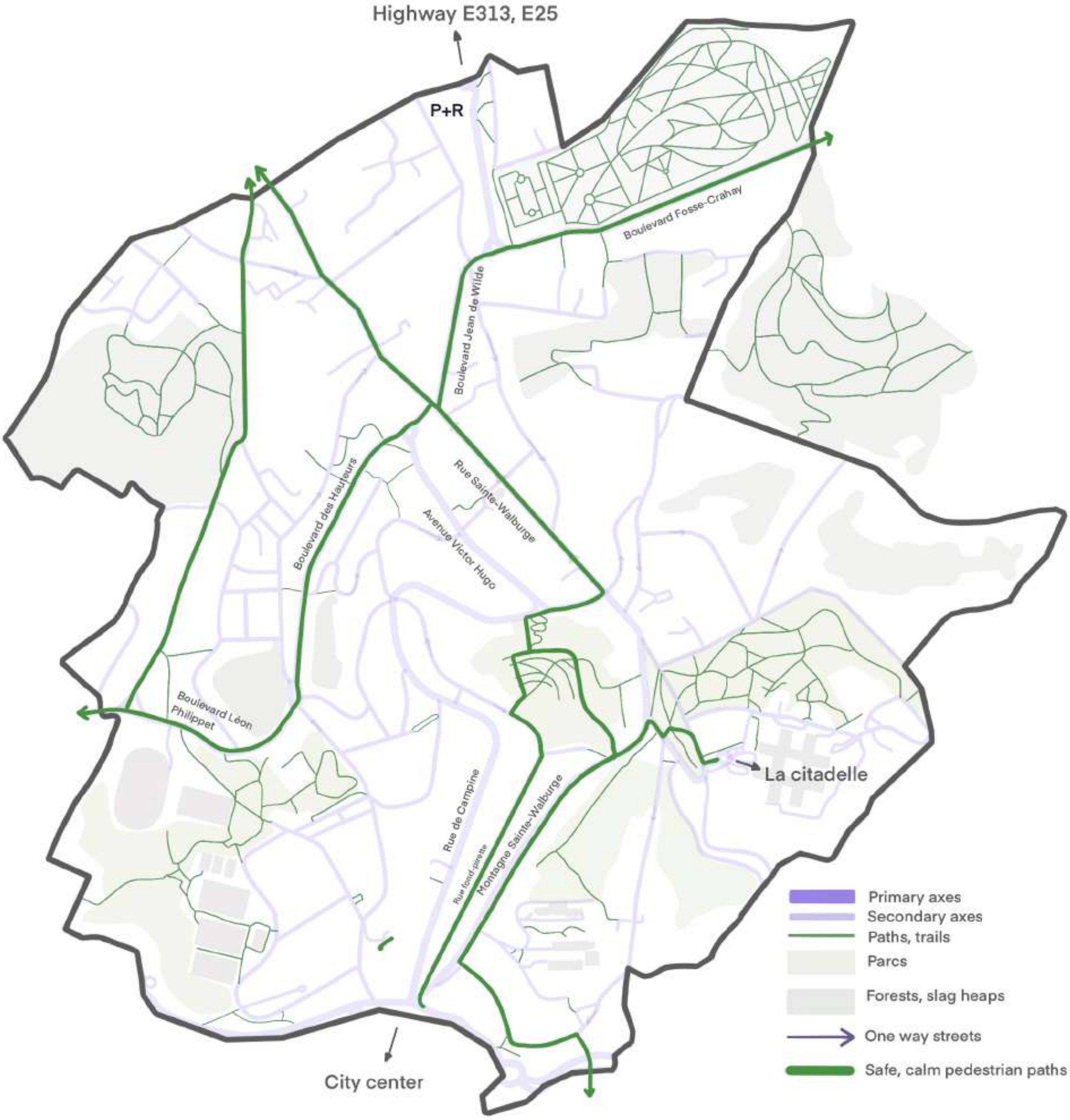

Figure 4.3: Pedestrian mobility. Source : Author

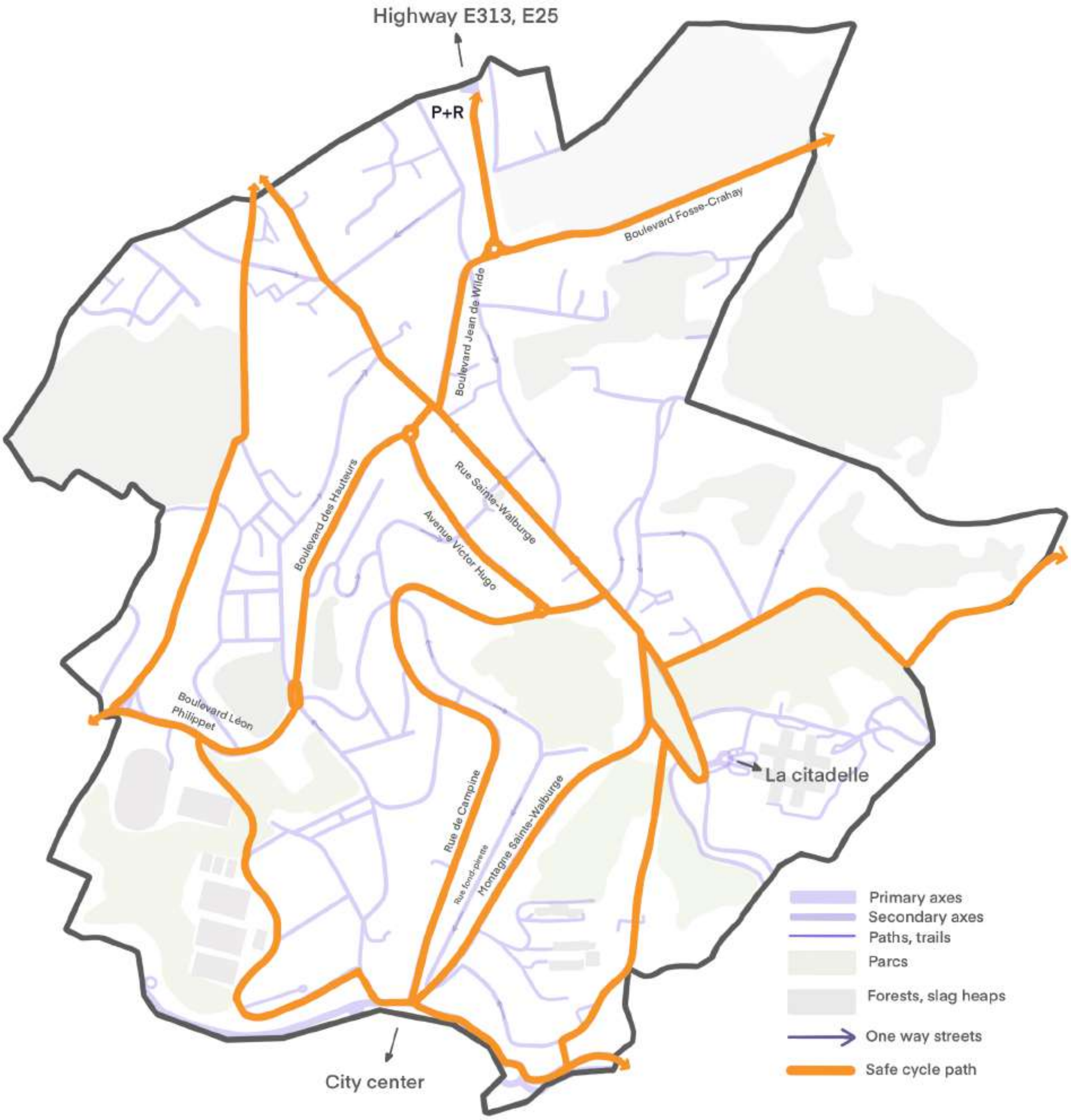

Figure 4.4: Bicycle mobility. Source : Author

Strengthening pedestrian and green networks

Finally, the aim is to reconnect neighborhood facilities (schools, shops, parks, bus stops) by creating soft connections, addressing transitions (slopes, uneven terrain) and integrating nature into daily routes. In the main roads of the neighborhood, the implementation of trees and vegetation is primordial to help reducing heat island effects and improve the quality of pedestrian and cycle paths.

Scenario propositions

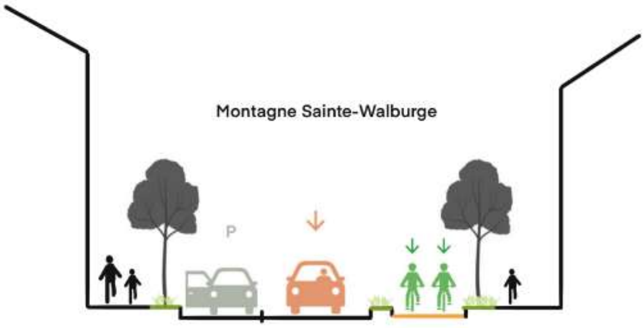

Figure 4.5: intervention proposition. Source : Author

Figure 4.6: Montagne Sainte-Walburge

Figure 4.7: intervention proposition. Source : Author

Figure 4.8: Rue de Campine

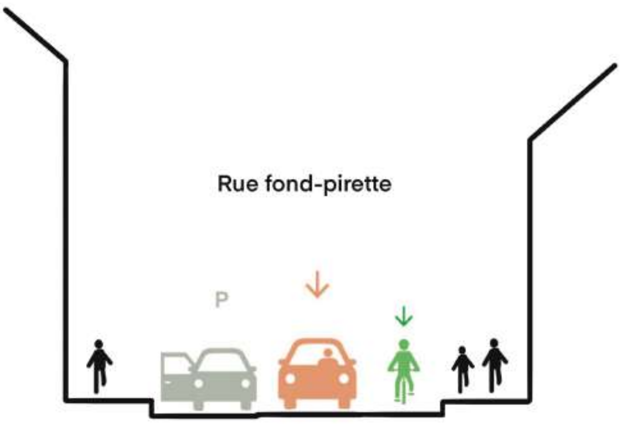

Figure 4.9: intervention proposition. Source : Author

Figure 4.10: Rue Fond-pirette

The development scenarios presented above propose a targeted transformation of three key areas in the Sainte-Walburge neighborhood: Montagne Sainte-Walburge, Rue de Campine and Rue Fond-Pirette. Each intervention is based on a dual approach: on the one hand, a critical analysis of the existing situation through photographs of the site, and on the other hand, a prospective projection through cross-sections illustrating the planned redevelopment.

Montagne Sainte-Walburge
The redevelopment proposal provides for a single lane of traffic in the uphill direction, freeing up space for wider sidewalks, a secure cycle lane in both direction and the addition of planting and rest areas. This reorganization aims to improve safety, traffic flow and comfort for pedestrians on this key street in the neighborhood.

Rue de Campine
The proposed scenario would transform the street into a one-way downhill route for leaving the neighborhood. This enables the space to be reorganized to include a wide, continuous sidewalk on both sides, a protected cycle lane in both directions, and planting between the different lanes of mobility. The parking layout is redesigned to minimize the impact of vehicles on the pedestrian space, thereby improving safety and enhancing the route's appeal. To prevent illegal parking, a high edge can be created, and barriers can be added at critical locations. Street furniture such as benches, litter bins, etc. can be added to the sidewalk at pedestrian crossings to also prevent the risk of illegal parking.

Rue Fond-pirette
The proposed intervention is based on widening pavements and better defining parking spaces. The integration of street furniture, planting and occasional landscaping enhances the street's conviviality and comfort, transforming it into a peaceful space, suited to a neighborhood-oriented approach. A creation of a dedicated cycle lane is also a good way to improve active, safe mobility.

These intervention scenarios illustrate a gradual, concrete and realistic redevelopment strategy that is compatible with the principles of the 15-minute city. They aim to restore pedestrians to their rightful place, encourage active mobility and significantly improve the quality of life for the residents of Sainte-Walburge, while taking into account the specific topographical constraints of the site. By combining the reorganization of traffic flows, the creation of central hubs and the strengthening of active continuity, it constitutes an operational model for implementing the 15-minute city in a peripheral urban context with topographical constraints.

All of the proposals set out in this chapter are based, among other things, on the principles and recommendations of the "Global Street Design Guide", n.d., published by NACTO (National Association of City Transportation Officials). This guide is a major international reference for the design of urban public spaces that are conducive to walking, cycling, public transport and social interaction. It offers a detailed classification of streets according to their functions, clear design standards, and a series of developments adapted to different urban contexts.

With its precise illustrations and analysis grids adapted to all types of environments, this guide is particularly useful in the context of the gradual redevelopment of public spaces. It enables the design of streets that meet the challenges of safety, comfort, sustainability and social inclusion. This paper draws on these standards to propose realistic solutions that can be applied on the scale of Sainte-Walburge.

This typological framework constituted of three levels of intervention is summarized in the table below and provides a basis for organizing spatial recommendations according to their intensity, scale and complexity of implementation.

Level	Main Objective	Scale of Intervention	Examples of Actions	Complexity / Cost
Level 1	Enforce existing legal frameworks (traffic rules, accessibility norms)	Street detail (crosswalks, curbs, signage)	Curb lowering, repainting faded markings, obstacle removal, basic speed enforcement	Low (quick, inexpensive, mandatory)
Level 2	Functionally reorganize street space to support walking and cycling	Entire street or small sector	Sidewalk widening, shared zones, street furniture, parking adjustments	Moderate (requires design and coordination)
Level 3	Redesign urban mobility flows and neighborhood logic	District or street network level	Redesign boulevards, centrality creation, new circulation plans, green corridors	High (strategic, long-term investment)

Table 4.1: Typology of intervention levels in Sainte-Walburge. Source : Author

4.3 Integration into local policies

The proposed solutions are not intended to function as isolated or utopian interventions, but rather as a practical addition to the urban policy tools already in place at a local level. At city level, these objectives are directly aligned with the Liège Territorial Development Plan (Projet de territoire de la Ville de Liège), which promotes the development of compact, walkable neighborhoods and strengthens secondary urban centers such as Sainte-Walburge.

At the regional level, the Walloon Spatial Development Plan (Schéma de Développement Territorial – SDT) explicitly promotes short-distance urban living, mixed-use street design and active mobility as drivers of territorial cohesion. The typology and spatial strategies proposed in this paper, particularly the prioritization of vulnerable areas and the reconfiguration of mobility loops, respond to these objectives by operationalising the '15-minute city' model within a Walloon planning framework.

These proposals could also be integrated into future neighborhood mobility contracts, urban renovation programs or pilot projects funded by the Walloon Region. The use of open data and replicable indicators such as NetAScore further reinforces the potential for scaling up or transferring this methodology to other districts of Liège, or even to other intermediate cities in Belgium.

Chapter 5

Conclusion

5.1 Answers to research questions

This paper set out to answer two complementary research questions.

1. **How can the walkability and urban accessibility of a neighborhood be reliably assessed, and what solutions can be put in place to improve them?**

2. **How do socio-economic characteristics influence a neighborhood's walkability and accessibility?**

To address the **first question**, a mixed-methods approach is adopted, incorporating geospatial analysis, NetAScore software, a catchment area method for accessibility and qualitative techniques such as field surveys and semi-structured interviews. This triangulation ensured a more realistic and grounded diagnosis of urban space. The study showed that, although accessibility and walkability are commonly treated separately, they must be analyzed together to accurately assess proximity in urban settings. The developed methodology also succeeded in identifying different typologies of street segments and public spaces that could benefit from targeted improvements.

The **second question** is addressed by correlating walkability and accessibility indicators with socio-economic vulnerability using the Synthetic Difficulty Index (SDI). This revealed some unexpected patterns: some of the most socio-economically vulnerable neighborhoods (Droixhe, Sclessin and Wandre) also suffer from a lack of access to essential services and poor pedestrian infrastructure, which reinforces spatial inequalities. Conversely, other disadvantaged areas demonstrated relatively good accessibility, indicating that socio-economic conditions and spatial indicators are not always aligned, a crucial consideration for the fair and efficient design of policies.

5.2 Contributions of the work

5.2.1 Methodological

This thesis presents a robust and replicable methodology for evaluating urban accessibility and walkability within the framework of the 15-minute city. It shows how these concepts can be operationalised using open data (OSM), NetAScore and GIS tools, while also incorporating subjective and qualitative dimensions. This mixed-methods approach helps to bridge the gap between theoretical models and real-life mobility experiences. Notably, it emphasizes the added value of field validation, particularly in contexts where topographical and infrastructural nuances cannot be fully captured by digital tools alone.

The developed accessibility indicator is refined through personalized weighting of services, and walkability is measured at street-segment level, taking into account slope, noise, vegetation, infrastructure and crossings. This methodological design is context-sensitive and adaptable to other urban environments.

5.2.2 Practical

From a practical standpoint, this research offers a thorough and spatially explicit analysis of Liège city and the Sainte-Walburge neighborhood. It proposes a structured, multi-level catalog of planning interventions, ranging from the enforcement of existing legal standards (level 1) to intelligent micro-interventions (level 2) and the full reconfiguration of mobility patterns and spatial flows (level 3).

Specific solutions include widening pavements, creating continuous cycle infrastructure, reducing motorized traffic and strengthening pedestrian connections between different parts of the neighborhood. These interventions are detailed and supported by visual aids such as street sections, plans and scenarios, enabling planners, municipalities and local stakeholders to understand them more easily.

The research also identifies other priority neighborhoods in Liège where these interventions could be translated within local context, including Sclessin, Wandre, Droixhe, Kinkempois, Chênée, and Sainte-Marguerite.

5.2.3 Scientific

From a scientific perspective, this thesis makes a valuable contribution to the ongoing academic debate surrounding the operationalisation of the 15-minute city concept. It confirms that accessibility is a multi-dimensional issue involving not only distance, but also infrastructure quality, urban form, topography and social context. It also draws attention to the potential disparity between quantitative indicators and residents' lived experience, a theme that is often overlooked in literature on the 15-minute city.

Furthermore, the study clarifies the limitations of existing methods (such as isochrone buffers) by demonstrating the dramatic effect that data choices, indicator weighting and user profiles can have on outcomes. The study also supports the call for more context-aware, socially inclusive, and empirically validated planning tools in urban research.

5.3 Limitations of the study and methodological biases

Despite its contributions, this paper also has limitations that must be acknowledged.

– Data completeness and reliability: NetAScore relies heavily on OpenStreetMap data. Some key attributes, such as pavement type, sidewalk width and parking areas, were missing or inaccurate, resulting in an incomplete representation of walkability.

– Static and generalized modeling: The accessibility indicator is based on standardized walking speeds and fixed thresholds (15 minutes), which may not accurately reflect the diversity of abilities across age groups, disabilities or daily life constraints. Although a senior profile is included, the analysis could be further enriched by including other categories (e.g. children and people with reduced mobility).

– Subjectivity and representativity: Although qualitative interviews added great value, the sample size is limited to ten participants. A broader, more demographically diverse sample could provide deeper insights.

– Temporal dynamics: The study provides a static snapshot of mobility and accessibility. It does not account for variations related to weather, time of day, seasonality or temporary disruptions (e.g. roadworks or traffic congestion).

While these limitations do not compromise the validity of the findings, they do highlight important areas for refinement and future investigation.

5.4 Research prospects

The research opens up several promising leads :

– Refining dynamic modeling. Future studies could incorporate time-based variations, such as peak/off-peak hours, night accessibility and seasonal changes, or simulate the impact of interventions on accessibility in real time.

– Wider application and comparison: The methodology could be applied to other Belgian cities (e.g. Charleroi, Namur and Mons) or neighborhoods within Liège, enabling comparisons to be made and a typology of 15-minute city profiles to be developed across different urban morphologies.

– Integration of user-centered technologies: Participatory mapping, sensor-based street evaluations or mobile app-based walkability feedback could enrich the assessment process and encourage greater community involvement.

– Policy integration: Working directly with municipalities to co-construct policy scenarios and pilot interventions based on these findings would provide real-world feedback loops and political grounding for the model.

5.5 Conclusion and learnings

This thesis explored the relevance and feasibility of implementing the 15-minute city model in Liège, focusing specifically on the Sainte-Walburge neighborhood. Essentially, the study aimed to evaluate how urban proximity, not just in terms of distance, but also in terms of quality, accessibility and equity, could be realized through spatial analysis, informed planning and a better understanding of lived experiences.

The research began by questioning how urban accessibility and walkability are usually measured. This study addressed this issue by developing a multi-criteria framework based on three pillars: (1) objective indicators of accessibility and walkability (using GIS and NetAScore to calculate building catchment areas), (2) socio-economic vulnerability (using SDI), and (3) qualitative fieldwork and interviews. This integrated approach enabled a nuanced diagnosis of Liège's territory to be made, revealing spatial inequalities, functional disconnects and potential reconfiguration.

The case study of Sainte-Walburge illustrated the challenges and opportunities involved in transforming a peripheral, topographically complex neighborhood into a livable, connected and inclusive place. Despite the presence of key urban amenities and a relatively compact structure, the area suffers from fragmented pedestrian networks, unsafe crossings, a lack of greenery on certain streets and poor overall walkability. The proposed solutions, developed in a three-tier structure comprising legal enforcement, tactical interventions and structural redesign, offer actionable pathways to reshape public spaces, re-balance modes of transport and reinforce centrality.

Beyond this specific case, the research identified several priority zones in Liège where similar issues persist: Sclessin, Wandre, Kinkempois, Droixhe, Chênée and Sainte-Marguerite. These neighborhoods have accessibility and walkability issues as well as socio-economic vulnerabilities, highlighting the urgent need for equity-based planning strategies.

From a methodological perspective, the thesis shows that combining spatial data with field-based validation is crucial in overcoming the biases and blind spots of purely quantitative models. It also emphasizes the importance of considering not only the presence of services, but also how people access them and their experiences of these journeys. The 15-minute city is not just a question of geometry, but also of perception.

From a scientific perspective, this paper makes a valuable contribution to the growing body of research that advocates a more grounded, participatory and context-aware interpretation of the 15-minute city concept. By suggesting that flexible and adaptable methods are needed to reflect the diversity of urban realities, it adds nuance to the discourse surrounding this concept, which is often overly prescriptive or utopian.

In practical terms, the proposals and visualizations developed in this thesis can inform urban interventions, pilot projects and participatory planning processes. The multi-scalar approach, which combines city-wide diagnosis with neighborhood-scale solutions, provides a framework that can be applied beyond Liège by researchers, planners and local authorities.

Ultimately, this thesis demonstrates that a more livable, inclusive and accessible city is possible, but achieving this requires us to look beyond abstract goals and focus on the everyday, concrete barriers that shape urban life. Proximity is not just about how far things are, but also how easily, safely, and pleasantly we can reach them. Designing a fair and sustainable city means designing for all people and putting their daily experiences at the heart of urban planning.

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