Master of Science program in

Urban & Regional Planning

Master's Degree Thesis:

Evaluating the Impact of Street Network Reconfiguration on Children's Accessibility to Public Spaces

A comparative analysis of Turin and Braga

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Abstract

Accessibility of children to public spaces is one of the important indicators of urban equity, safety, and daily quality of life. However, it is often limited by street networks primarily designed to prioritise the movement of motor users. This thesis explores how street network configuration influences children's accessibility to public spaces and examines whether superblock street reconfiguration can improve access. The study focuses on destinations for children, including parks, playgrounds, schools, and kindergartens. It employs a comparative method across two European cities with contrasting urban layouts: Turin, Italy, and Braga, Portugal.

This research integrates Space Syntax analysis and scenario modelling using the Superblockify tool within a GIS-based workflow. Angular Integration and Choice metrics are applied at two spatial scales (R = 400 m and R = 800 m) to capture local-scale and neighbourhood-scale accessibility patterns that apply to various age groups and mobility ranges. An aggregate measure of accessibility is created to jointly assess spatial accessibility and exposure to through-movement around child-related public spaces. Existing conditions are compared with the post-intervention scenario generated through superblockification to evaluate spatial change.

The findings show that the effects of superblockification are based on context, increasing children's accessibility in dense, Street networks that are highly connected, while producing limited or uneven benefits in fragmented, peripheral urban structures. street network configuration is a key determinant of child-oriented accessibility and spatial equity, underscoring the need for context-sensitive superblock implementation.

Keywords: Accessibility, Superblockification, Space syntax, Public space

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Chapter 1: Introduction

1.1 Background and problem statement

Cities are increasingly expected to support sustainable, inclusive, and healthy forms of everyday mobility. Over recent decades, urban planning discussion has changed away from vehicle-oriented efficiency toward concepts such as walkability, accessibility, and the overall quality of public space. But, in many cities, street networks still pay attention first to motorised movement, often at the expense of local accessibility and pedestrian safety (Ewing & Cervero, 2010; Litman, 2021). This imbalance has made neighbourhoods more fragmented and has reduced safe and independent movement for non-motorised users.

These conditions are likely to affect vulnerable population groups more, particularly children. Children's everyday mobility depends mainly on their immediate environment, such as street connectivity, traffic intensity, and clear routes to nearby destinations(Hillman, Adams, & Whitelegg, 1990; Shaw et al., 2018). Even when public spaces such as parks, playgrounds, and schools are located within short distances, factors such as unsafe crossings, high-speed roads, and discontinuous pedestrian networks can significantly limit children's ability to access them independently. As a result, children's mobility increasingly depends on adults and private cars, reinforcing spatial inequality and reducing their connection to their neighbourhood.

Research on Children's Independent Mobility (CIM) has highlighted a long-term decrease in children's freedom to move by themselves within urban areas, particularly in cities characterised by high traffic volumes and car-oriented street design especially in cities with heavy traffic and car-focused street layouts (Hillman et al., 1990; Tranter & Whitelegg, 1994; Schoeppe et al., 2014). This decline has implications not only for children's physical activity and health, but also for their cognitive development, social interaction, and sense of belonging within the city (Kytta, 2004; Ferreira et al., 2023).

From an equity perspective, reduced independent mobility reflects inequalities in urban form that favour some users over others.

The configuration of the street network emerges as a critical factor shaping accessibility outcomes. Beyond simple measures of distance, the spatial arrangement and connectivity of streets influence how safe, direct, and understandable everyday routes are for children navigating the city (Hillier & Hanson, 1984). To improve children's accessibility, it is not enough to consider land use alone; the structure of the street network also shapes everyday movement and traffic exposure.

1.2 Research objectives and questions

The main objective of this thesis is to investigate how street network configuration influences children's accessibility to public spaces. Clearly, the study focuses on child-related destinations, including parks and green areas, playgrounds, schools, and kindergartens, and evaluates how the neighboring street network shapes their accessibility.

The research aims to evaluate whether changes in street network structure especially, those introduced through superblock-based interventions, can improve children's access to public spaces while reducing exposure to through-movement and traffic-related risks. The study addresses the following research questions:

- How does the existing street network configuration affect children's accessibility to public spaces?
- To what extent does street network reconfiguration alter accessibility and exposure conditions for children?
- How do these effects differ across cities with contrasting urban morphologies?

As the research is based on an iterative spatial analysis process, the research questions are refined alongside the analytical results, allowing findings to inform and sharpen the investigation.

1.3 Case study areas

The thesis takes a comparative approach and focuses on two European cities: Turin (Italy) and Braga (Portugal). These cities were selected because they show clear differences in street network structure and their urban form.

Turin is characterised by a dense, almost regular, and highly connected street network shaped by multiple historical phases of urban development. Braga, by contrast, combines a compact historic centre with more dispersed and fragmented peripheral areas, resulting in a less uniform street network. This difference offers a useful basis for exploring how similar spatial interventions can lead to different accessibility outcomes depending on existing urban conditions.

By analysing both cities within the same analytical framework, the study aims to identify context-specific effects of street network reconfiguration on children's accessibility.

1.4 Methodological overview (Superblockify + Space Syntax)

The methodology mixes spatial network analysis with scenario modelling to examine children's accessibility before and after changes to the street network. Space Syntax is used to study the configurational properties of street networks, with a focus on angular Integration and Choice metrics to understand patterns of accessibility and potential exposure to through-movement at different spatial scales.

At the same time, the Superblockify tool is used to simulate a superblock-based street network reconfiguration. This approach reorganises streets into low-traffic neighbourhood units while keeping a limited network for through-movement. Space Syntax analysis is then applied to both the existing network and the reconfigured scenario, allowing a clear comparison of accessibility conditions.

This approach helps move beyond description to see how spatial interventions affect street networks and children's access to public spaces.

Chapter 2: Theoretical Framework

2.1 Accessibility in urban planning: definitions and dimensions (physical, social, perceptual)

2.1.1 Accessibility: Definition and Conceptual Background

Accessibility is a foundational concept in urban studies, referring to the ability of individuals to reach opportunities for movement and interaction between origins and destinations within a network. Rather than focusing solely on the ease of travel, Handy and Niemeier (1997) emphasized accessibility as the extent to which people can reach locations that are meaningful or desirable to them. This interpretation was further developed by Geurs and Ritsema van Eck (2001), who framed accessibility as an outcome shaped by both spatial structure and individual opportunity.

Understanding accessibility is essential when examining the relationship between urban design, social equity, and inclusion. At its core, accessibility reflects the spatial and social connections that structure everyday urban life. It plays a central role in urban and transport planning by indicating how effectively individuals can reach services, resources, and social activities. For this reason, accessibility is often used as an indicator of urban quality and fairness, as it links land-use patterns, transport systems, and social participation.

Over time, the concept of accessibility has expanded beyond a narrow infrastructure-based perspective. Early approaches focused primarily on physical networks, whereas later frameworks increasingly acknowledged individual characteristics and contextual constraints. In this tradition, accessibility has commonly been described through four interrelated components:

- **Individual component**, referring to personal attributes such as income, physical ability, age, and car ownership
- **Activity component**, which considers the number, diversity, and attractiveness of reachable destinations
- **Spatial component**, associated with network characteristics such as distance, travel time, and cost
- **Transport component**, reflecting the performance and availability of transport systems

These dimensions were articulated by Vickerman (1974) and later formalized by Ben-Akiva and Lerman (1979). Subsequent scholarship also introduced an important distinction between potential accessibility and realized accessibility. Potential accessibility describes the opportunities theoretically available within a given area and is widely applied in spatial and transport analysis. Realized accessibility, by contrast, refers to the opportunities that individuals actually use, taking into account personal constraints, preferences, and perceptions. While this thesis primarily relies on spatial methods to measure potential accessibility, it recognizes that the translation of potential into actual use is strongly shaped by subjective experience.

Accessibility is frequently contrasted with mobility, a concept that focuses mainly on the performance of transport systems. As noted by Ewing (1995) and Ikhrata and Michell (1997), mobility evaluates how efficiently people move, whereas accessibility considers how land-use patterns and network structures shape relationships between people and places. Pirie (1979) argued that accessibility therefore provides a more socially meaningful lens for understanding urban environments.

Breheny further contributed to this debate by identifying three core elements of accessibility: the benefits achieved, the costs incurred, and the individuals who ultimately gain from access. This perspective highlights that accessibility should be understood in relation to needs and social outcomes, rather than as a simple reflection of travel demand.

Taken together, these interpretations suggest that accessibility extends beyond the ease of movement. It emerges from the interaction between urban form, transport systems, and individual circumstances. From an equity perspective, accessibility is therefore central to evaluating whether cities enable fair participation in urban life. Improving accessibility requires attention not only to physical connectivity, but also to the social and perceptual factors that enable or constrain access.

2.1.2 Analytical Dimensions of Accessibility in Street Networks

In its conventional interpretation, accessibility has often been framed in physical or spatial terms, focusing on the ease of reaching destinations through pedestrian or transport networks. Measures based on time, distance, or cost remain common and are widely used to link land use and mobility (Duranton & Guerra, 2016). While this approach captures efficiency of movement between home, work, education, and leisure, it represents only one dimension of the urban experience.

Within street network analysis, accessibility is typically distinguished into several analytical categories:

- **Physical or metric accessibility**, based on measurable distances, travel time, or effort along the network, often calculated using shortest-path algorithms (Levine & Waddell, 2009).
- **Topological or configurational accessibility**, which focuses on the number of directional changes required to reach destinations and is commonly assessed using integration measures derived from Space Syntax theory (Hillier, 1996).
- **Visual accessibility or permeability**, referring to visibility and lines of sight within the urban environment, which influence orientation, perceived safety, and pedestrian behavior (Turner et al., 2001).

These dimensions can be operationalized using network-based indicators, including metric shortest paths and configurational measures derived from Space Syntax methods (Kwan, 1998). Although analytically distinct, they often interact in practice, shaping how individuals experience and navigate urban space.

2.1.3 The Multidimensionality of Accessibility and the Human Experience

Recent research emphasizes that proximity alone does not guarantee meaningful or inclusive access. Accessibility is increasingly understood as a multidimensional concept that extends beyond physical space to include temporal constraints, social and cultural conditions, information availability, and psychological factors (Virmasalo & Hasanen, 2022). From this perspective, accessibility emerges through the interaction between tangible infrastructures—such as street layouts, service locations, and transport systems—and individual experiences, including perceptions of safety, comfort, and belonging.

The social dimension of accessibility examines how characteristics such as age, gender, economic status, and physical ability influence an individual's real capacity to participate in urban life. Even when public spaces are geographically close, social barriers such as limited resources, exclusionary design, or stigma may restrict their use. The perceptual dimension, meanwhile, relates to how people experience and interpret their surroundings. For example, a child may live near a park, yet face limited accessibility if reaching it requires crossing wide, high-speed roads or navigating spaces perceived as unsafe.

These non-physical factors are particularly significant for vulnerable groups, whose mobility is often shaped by fear, dependence, or social norms. Shaw et al. (2018) describe such constraints as "soft barriers," which limit movement not through physical obstruction but through perceived risk and reduced confidence. Measures such as traffic calming and street redesign can therefore play a crucial role in reducing perceptual barriers and enhancing overall accessibility.

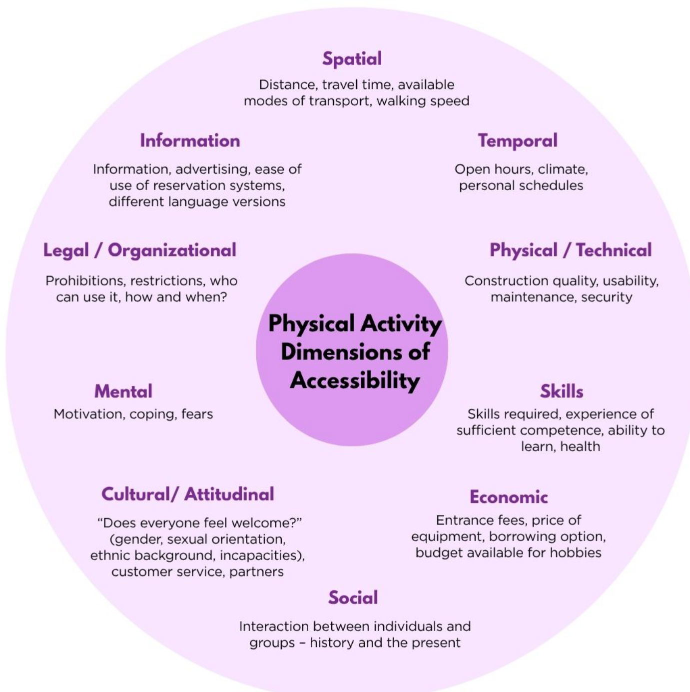


Figure 2-1: Dimensions of accessibility (Virmasalo & Hasanen 2022)

2.1.4 Accessibility thresholds and the debate on the 15-minute city

In recent years, the 15-minute city concept has drawn increasing attention in urban planning as an approach aiming to improve everyday accessibility.The framework brings essential services closer to where people live, making them reachable. While the concept got particular visibility during the Covid-19 pandemic, it is based on earlier discussions on walkability, closeness, and local access as important contributors to urban quality of life (Moreno et al., 2021). The pandemic showed how vulnerable urban systems can be when they rely mostly on private cars or public transport, especially under conditions of blocked mobility and limited access to spaces that are indoors. In this context, neighbourhood level access to public spaces and essential services became very important, augmenting the 15-minute city as a model that supports local needs and reduces dependence on motorised transport (Staricco, 2022).

Although it has become more widely discussed in planning, the *15-minute city* has been criticised for being applied as a fixed standard across different contexts. Drawing on an empirical analysis of access to services in Turin, Staricco demonstrates that the use of a single time threshold can obscure important spatial variations within the urban fabric (Staricco, 2022). In connected areas, many places are already accessible with a short walking times, it means that extending the threshold to 15 minutes often produces limited additional benefits. The study further points out that accessibility is influenced not only by pedestrian conditions or street network structure, but also by how services are distributed across the city and by their specific functions. Viewed in this way, the 15-minute city is more effectively interpreted as a flexible analytical framework rather than a rigid planning standard, one that requires context-sensitive thresholds to accurately reflect local accessibility conditions (Staricco, 2022).

2.1.5 The Principle of Equitable Accessibility and Operationalization

Equitable accessibility shifts attention away from average levels of access toward the distribution of accessibility across different population groups. Rather than asking how accessible destinations are in general, it examines who is able to benefit from them and under what conditions. This perspective is especially relevant for groups facing structural disadvantages, including children, older adults, and residents of low-income neighborhoods (Litman, 2021). For these populations, physical proximity alone rarely ensures genuine access; unsafe routes, inadequate infrastructure, or psychological barriers can significantly limit independent use of public spaces.

Viewing accessibility as an experiential and socially differentiated condition reframes it as a core principle of spatial justice. A fair city is one in which all individuals, regardless of age, mobility, or socio-economic status, can safely and independently access resources that support well-being. This requires planners to integrate physical, social, and perceptual dimensions of accessibility, ensuring that spatial interventions do not unintentionally reinforce existing inequalities.

In this thesis, equitable accessibility is operationalized through an analysis of the spatial distribution of access to child-oriented destinations across different urban contexts. Equity is assessed using quantitative indicators based on distance and street network properties, including integration, choice, and permeability. By examining whether network reconfiguration benefits all areas equally or disproportionately advantages already well-served neighborhoods, the study connects theoretical discussions of equity with concrete spatial outcomes.

2.2 Children's mobility and independent access to public spaces

2.2.1 Children's Independent Mobility (CIM)

The focus on vulnerable populations within accessibility theory calls for a specific examination of children's mobility patterns. One of the most influential concepts in this field is Children's Independent Mobility (CIM)**,** introduced by Hillman, Adams, and Whitelegg in *One False Move*. They defined CIM as "the ability of children to navigate their neighborhood or city without being accompanied by adults" (Hillman, Adams, & Whitelegg, 1990). Since its introduction, CIM has become a widely used indicator for evaluating the child-friendliness of urban environments and the accessibility of public spaces for younger users (Prezza et al., 2001; Schoeppe et al., 2014).In this thesis, CIM is treated not only as a behavioral outcome, but also as a spatial indicator reflecting how urban form, street networks, and perceived safety interact to shape children's everyday access to the city.

2.2.1.1 Multidimensional Interpretations of CIM

Research on accessibility increasingly emphasizes that children's mobility cannot be understood through distance or infrastructure alone. CIM is inherently multidimensional, shaped by a combination of spatial, social, and perceptual factors. Although Hillman et al. (1990) initially framed CIM in terms of adult supervision, subsequent studies have expanded the concept to include broader questions of autonomy, confidence, and environmental support.As a result, CIM is now widely recognized as a key indicator of how welcoming, legible, and navigable urban environments are for children (Prezza et al., 2001; Schoeppe et al., 2014). This broader interpretation aligns with contemporary accessibility theory, which acknowledges that mobility outcomes emerge from the interaction between urban structure and individual experience.

2.2.1.2 CIM as a Developmental Necessity

Independent mobility is widely acknowledged as a fundamental component of children's development and is closely related to the concept of realized accessibility. Having the ability to reach public spaces independently supports children's physical, cognitive, and social growth (Ferreira et al., 2023).

From a physical perspective, CIM provides daily opportunities for active movement and outdoor play, helping to counter sedentary lifestyles that are increasingly common in contemporary childhood (Ferreira et al., 2023). Beyond physical activity, independent exploration contributes significantly to cognitive development. As Kytta (2004) notes, navigating familiar environments without adult supervision enhances spatial awareness, decision-making, and risk assessment skills.CIM also plays an important social role. Independent movement enables children to engage in spontaneous social encounters, form peer relationships, and gradually build a sense of competence and belonging within their neighborhoods (Prezza et al., 2001). These experiences are difficult to replicate in supervised or car-dependent travel patterns.

Understanding CIM therefore requires attention to both physical conditions—such as traffic exposure, street connectivity, and safety—as well as psychosocial factors, including parental attitudes, neighborhood trust, and perceived danger. When independent mobility is restricted, the street network may shift from being a space of social learning to one perceived primarily as a source of risk, significantly limiting children's access to urban opportunities.

Empirical research commonly operationalizes CIM through four main indicators, each capturing a different dimension of children's freedom of movement (Marzi & Reimers, 2018).

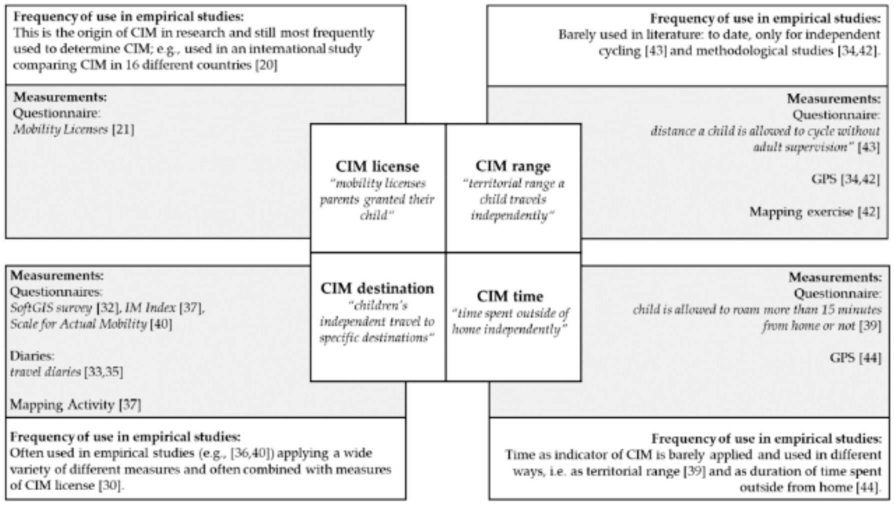


Figure 2-2 Definitions, Measures, and Frequency of Application in Empirical Projects of Four Children's Independent Mobility Indicators (Marzi & Reimers, 2018).

2.2.2 The Decline of CIM: The Traffic Danger Hypothesis and Perceived Risk

The decline of Children's Independent Mobility is one of the most consistently documented trends in contemporary cities. Across many urban contexts, children today travel independently far less than previous generations (Hillman et al., 1990; Gleave, 2021), altering their relationship with streets and public spaces.

A central explanation for this trend is the Traffic Danger Hypothesis, which attributes declining CIM to both real and perceived risks associated with motorized traffic, particularly its speed, volume, and complexity (Gaster, 1913). While the danger of road accidents is well documented, this hypothesis also highlights a broader cultural shift toward heightened parental risk aversion (Hillman et al., 1990). Notably, studies show that parents often express greater concern about "stranger danger" than traffic, despite traffic posing a statistically higher risk to children (Pugh, 2000).

These perceptions establish a direct connection between CIM and the perceptual dimension of accessibility. Parents' subjective assessments of their environment—such as fear of wide roads or fast-moving vehicles—often outweigh objective measures of distance or route quality when determining whether children are allowed to travel independently (Ferreira et al., 2023). Shaw et al. (2018) describe these constraints as soft barriers, where mobility is restricted not by physical obstacles, but by social norms and supervision requirements.

The consequences of reduced CIM are twofold. First, children lose opportunities to develop autonomy, confidence, and spatial competence, increasing long-term dependence on adults (Kytta, 2004). Second, access to essential public spaces such as parks and schools becomes uneven, shaped by parents' time availability, resources, and willingness to accompany their children.

Ultimately, the traffic danger hypothesis exposes a fundamental tension in urban design: prioritizing high-speed vehicle movement often conflicts with the creation of safe, socially supportive environments for children and other vulnerable groups.

2.2.3 Public Spaces and the Urban Network as a Mediator of Equity

2.2.3.1 Definition of Public Spaces

Public spaces are generally defined as areas that are open and accessible to all, regardless of ownership or formal classification. This includes streets, squares, and parks that form the everyday setting of urban life (UN-Habitat; INU). However, legal openness alone does not fully capture what makes a space genuinely public.

Scholars emphasize that accessibility, inclusivity, and lived experience are essential to publicness (Marcuse, 2005). Contemporary examples such as privately owned public spaces (POPOS) illustrate this tension: although they may appear open, access is often regulated, subtly shaping who feels welcome and who does not.

Public spaces function as key arenas for social interaction, movement, and informal encounters. Their quality and inclusiveness strongly influence how individuals—particularly vulnerable groups such as children—experience and engage with the city.

<u>The Role of Urban Networks in Children's Access</u>

For children, public spaces are closely tied to developmental needs. Playgrounds, parks, and schools represent critical destinations that support physical, cognitive, and social growth (Ferreira et al., 2023). Children’s ability to reach these spaces safely and independently reflects their level of realized accessibility and aligns with the Right to Play recognized by the United Nations Convention on the Rights of the Child (UNCRC).

The street network acts as the primary connector between children and these destinations, and is often the most frequently used public space itself. When streets are designed primarily for vehicle throughput, their social and developmental functions are diminished. From a child’s perspective, navigating the street network depends on three interrelated factors: physical distance, network connectivity, and perceived risk arising from traffic and social conditions.

2.2.3.2 The Justification for Spatial Intervention

Street network configuration plays a decisive role in shaping spatial equity (Litman, 2021). Networks that prioritize vehicular movement while limiting pedestrian permeability create systemic barriers, disproportionately affecting vulnerable populations—especially children (Shaw et al., 2018). In such contexts, children’s access to public spaces becomes increasingly dependent on parental car availability rather than on inclusive urban design.

Spatial interventions that reconfigure street networks, such as the Superblock model examined in this thesis, directly challenge this imbalance. By reducing through-traffic, improving safety, and enhancing local connectivity, these approaches support independent movement and promote more equitable access. In doing so, they reposition the street as a shared public space, capable of supporting social life and everyday mobility for all users, including children.

2.3 Vulnerability and equity in public space design

Urban public spaces play a central role in promoting social inclusion and equality among different groups within society. However, access to and use of these spaces is rarely distributed evenly. Marginalized populations—including children, older adults, women, low-income residents, and people with disabilities—often face a combination of structural and perceptual barriers that limit their ability to benefit fully from public environments. Despite improvements in the overall quantity and design quality of public space infrastructure, inequalities persist in how these spaces are distributed, maintained, and experienced, particularly in older or disadvantaged urban areas. While affluent or newly developed neighborhoods tend to receive higher levels of investment and better maintenance, under-resourced areas frequently contend with poor pedestrian infrastructure, limited accessibility, and facilities that fail to accommodate diverse users (Lee, 2015).

2.3.1 Defining Vulnerability in the Urban Context

Vulnerability refers to an increased likelihood of experiencing harm, arising from the interaction between available resources and the challenges faced by individuals or communities. Rather than being a fixed condition, vulnerability emerges through a combination of personal characteristics, social circumstances, and environmental conditions. These include developmental constraints, physical or cognitive limitations, social disadvantage, weak support networks, neighborhood decline, and long-term exposure to unfavorable environments. As Mechanic and Tanner (2007) argue, the way societies recognize—or overlook—different forms of vulnerability reflects broader social values and priorities.

Several interrelated factors contribute to vulnerability in urban contexts. Economic disadvantage limits access to essential services and opportunities, particularly for individuals and families with unstable employment or insufficient income (Gruber, 2000; Nyman, 2002). Discrimination based on race, ethnicity, language, or citizenship status further constrains access to healthcare, insurance, and public resources, independently of economic status (Weinick, Zuvekas, & Cohen, 2000). In addition, impaired decision-making capacity—often associated with cognitive or mental health challenges—can reduce individuals' ability to advocate for themselves within complex institutional systems (Hall, 2004).

These factors tend to concentrate within specific population groups, including people living in poverty, children, racial and ethnic minorities, individuals with chronic illnesses, older adults, and those experiencing mental health or substance-related challenges. Children are particularly vulnerable because they depend on adults for access to resources, mobility, and decision-making related to health, education, and public space use. When multiple disadvantages overlap across different aspects of life, individuals may experience what Hall (2004) describes as "double jeopardy," a condition that significantly intensifies vulnerability.

2.3.2 From Equality to Spatial Equity (The Guiding Principle)

2.3.2.1 Equality vs Equity

In urban planning, equality typically refers to providing the same resources or conditions to all individuals, regardless of their specific needs or circumstances. While this approach may appear fair, it often fails to account for structural inequalities that shape people's real opportunities. Children, older adults, people with disabilities, and low-income households do not experience the city in the same way as able-bodied adults with access to private vehicles. As a result, equal provision can unintentionally reinforce existing disadvantages.

Equity, by contrast, emphasizes fairness rather than uniformity. It recognizes that different groups require different levels or types of support to achieve comparable outcomes (Fainstein, 2010). In planning practice, an equity-oriented approach prioritizes context-sensitive interventions that respond to varying levels of need, ensuring that those starting from disadvantaged positions are not further excluded from urban life (Litman, 2024).

2.3.2.2 Spatial Equity as an Urban Principle

Spatial equity extends this concept by asserting that justice must be embedded in the physical organization of cities. Urban environments are not neutral; street layouts, traffic systems, land-use patterns, and public space distribution all influence who can access opportunities and who is marginalized. This perspective aligns with Soja's assertion that "justice has a geography," highlighting the spatial dimension of inequality in everyday life.

From a spatial equity perspective, the key question is whether all groups—including non-drivers and economically disadvantaged residents—can safely, comfortably, and independently access essential destinations such as schools, parks, and public spaces. For children, spatial inequity often manifests through high-speed roads, disconnected pedestrian routes, and environments designed primarily for vehicle movement. Even when public spaces are evenly distributed across districts, unsafe or fragmented connections can result in deeply unequal access in practice (Soja, 2010; Litman, 2024).

2.3.3 Implementing Equity: Design as an Act of Social Justice

The principle of spatial equity implies that justice must be actively produced through urban design and planning decisions. Acknowledging this responsibility requires confronting the legacy of past interventions—such as highway expansion or traffic-oriented planning—that have systematically disadvantaged vulnerable populations (Sturzaker & Nurse, 2020). As Harvey (2008) argues, the "right to the city" involves expanding access and opportunity for groups that have historically been excluded from urban benefits.

From this perspective, urban design becomes an instrument of social justice. Planning must move beyond the goal of equal provision and instead redistribute safety, accessibility, and environmental quality in relation to differing needs. This approach requires deliberate intervention to counteract inequalities generated by market forces and inherited infrastructure patterns (Sturzaker & Nurse, 2020).

When spatial inequalities stem from street network configuration, they must be addressed through spatially informed interventions. Analytical tools such as Space Syntax allow planners to identify areas with low connectivity, high movement risk, or poor pedestrian accessibility. Building on this analysis, reconfiguration strategies—such as the Superblock model examined in this thesis—offer concrete design alternatives that reduce through-traffic and strengthen safe, local networks. In this way, spatial equity is translated from an abstract principle into an operational design strategy, enabling children and other vulnerable groups to navigate the city more independently and safely (Fainstein, 2010; Litman, 2024).

2.4 Street network configuration and its effects on accessibility

2.4.1 Street Network Configuration: Definition & Components

Street network configuration refers to the spatial arrangement, connectivity, and geometric structure of streets within an urban area. It describes how street segments, intersections, and blocks combine to form a navigable system that shapes movement flows and conditions accessibility across the city. Rather than functioning as a neutral background, network configuration actively influences how direct, legible, and safe routes are for users—particularly pedestrians and other non-motorized groups (Boeing, 2019).

From an accessibility perspective, configuration determines not only where movement is possible, but also how intuitively and comfortably people can navigate urban space. Small differences in layout can therefore produce substantial variations in mobility outcomes.

Arrangement and Patterns

Urban street layouts are commonly categorized into several recurring patterns:

- **Grid systems**, characterized by regular blocks and frequent intersections, found in both historic and modern cities.
- **Radial patterns**, organized around a central core from which major routes extend outward.
- **Organic patterns**, which evolve incrementally over time, resulting in irregular and winding street forms shaped by historical growth rather than formal planning.
- **Mixed configurations**, typical of contemporary cities, where multiple patterns coexist and overlap.

These patterns influence route choice, connectivity, and movement predictability, shaping how different users experience accessibility at both local and citywide scales.

Orientation (Street Directionality)

Beyond connectivity alone, the angular orientation of street segments plays a significant role in network efficiency and spatial intelligibility. Directional bias—such as dominant north–south or east–west alignments—is often associated with gridded layouts, whereas organically developed networks tend to exhibit a more balanced distribution of street angles. This variation affects navigational clarity and the cognitive effort required to move through the city (Boeing, 2019). As illustrated by polar histograms of street orientation, cities with strong directional regularity display pronounced angular peaks, while organically grown networks show a more even distribution. These differences have direct implications for wayfinding, perceived complexity, and pedestrian comfort.

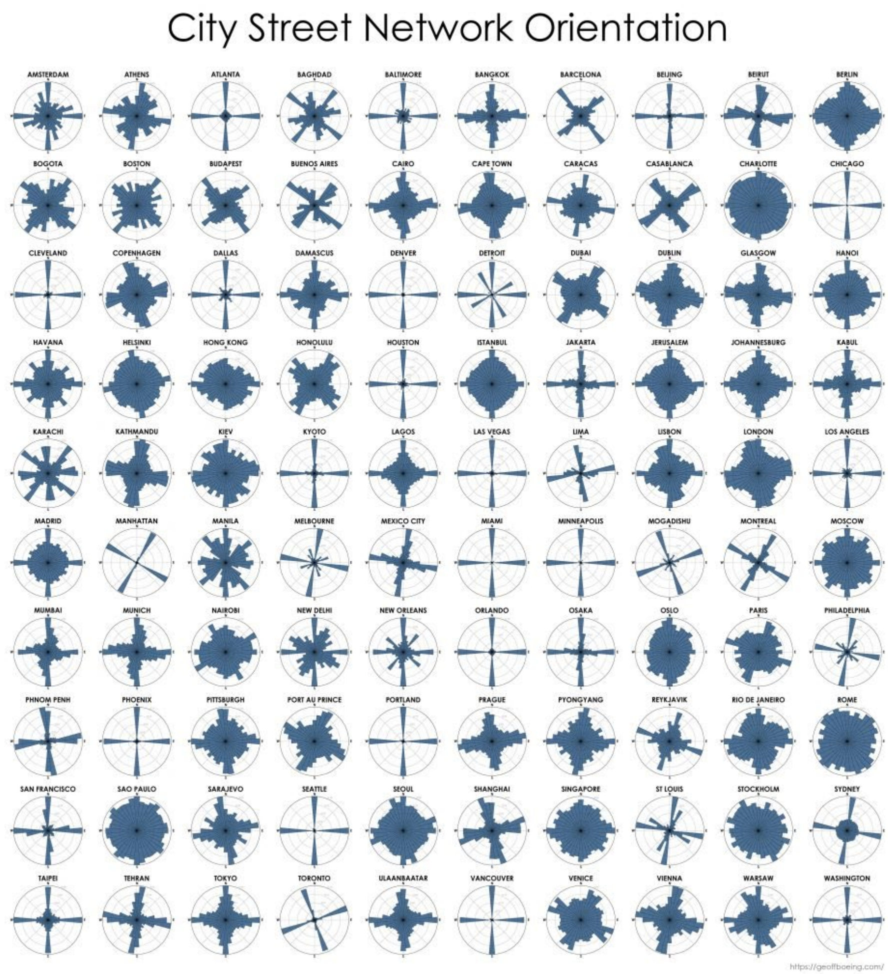


Figure 2-3 City Street Network Orientation (Boeing, G. 2019).

2.4.1.1 Connectivity and Its Impact

Connectivity describes the degree to which streets are linked within a network and is a fundamental determinant of urban accessibility. Highly connected networks provide multiple route options, allowing users to choose shorter, quieter, and safer paths. In contrast, poorly connected systems—often dominated by cul-de-sacs-restrict route choice and concentrate movement onto a limited number of streets.

Connectivity influences several key dimensions of urban life:

1. **Safety**
   Hierarchical networks that channel traffic onto high-capacity roads often increase crash severity and exposure for pedestrians and cyclists. Conversely, fine-grained, interconnected networks distribute movement more evenly and are associated with lower accident rates.

2. **Transportation Choice**
   Higher connectivity supports walking, cycling, and public transport use by reducing travel distances and avoiding dependence on arterial roads.
3. **Emergency Accessibility**
   Interconnected networks offer redundancy, enabling emergency services to reach destinations more efficiently without being constrained by dead ends.

To assess connectivity, planners commonly rely on metrics such as link–node ratio, intersection density, and the proportion of intersections relative to dead ends. Together, these indicators provide insight into the permeability and navigability of street systems.

2.4.2 Configurational Analysis: Topological, Metric, and Visual

Configurational analysis examines how the structure of a street network shapes movement potential and spatial behavior. Rather than focusing solely on distance, this approach investigates how connections are organized and perceived. Three interrelated dimensions are central: **topological**, **metric**, and **visual** configuration.

Topological Properties (Connectivity & Relational Structure)

Topological analysis represents the street network as a graph of nodes and edges, emphasizing the number of steps or turns required to move between locations. Measures such as connectivity, degree centrality, integration, and choice capture the relative importance of streets within the network.

Highly connected streets tend to attract greater pedestrian and vehicle flows, support mixed land uses, and contribute to urban resilience (Hillier, 1996; Porta et al., 2006). Large-scale analyses demonstrate that topological measures effectively distinguish between gridded, organic, and suburban layouts (Boeing, 2018). Batty et al. (2014) further show that greater topological diversity increases configurational complexity, influencing how movement disperses across the network.

Metric Properties (Distance, Depth, and Effort of Movement)

Metric analysis focuses on physical distance and travel effort. Attributes such as street length, block size, circuity, and metric reachability shape how far people must travel to access destinations.

Shorter blocks and more direct routes are strongly associated with walkability and lower travel costs, particularly at the neighborhood scale (Boeing, 2021). Importantly, metric depth interacts with street hierarchy: tree-like networks with many cul-de-sacs can generate long, indirect routes even when destinations are geographically close, reducing practical accessibility.

Visual Properties (Visibility, Field of View, and Spatial Perception)

Visual configuration addresses how users perceive and understand the street network while moving through it. Unlike metric or topological measures, this dimension captures the cognitive experience of navigation.

Angular analysis is particularly relevant, as people tend to prefer routes with fewer directional changes, even if they are not the shortest in distance. This “least-angle” principle explains why visual continuity is a strong predictor of pedestrian movement.

Key visual attributes include angular deviation, continuity of sightlines, street orientation patterns, and overall intelligibility. Cities with consistent directional structures tend to be easier to navigate, while visually fragmented networks impose higher cognitive demands (Serok & Bar, 2018).

Space Syntax operationalizes these ideas through measures such as angular integration, angular choice, and visibility-based accessibility (VGA), which together link visual structure to observed movement patterns.

2.4.3 How Configuration Shapes Accessibility and Movement Potential

Street configuration establishes the underlying conditions for accessibility. Well-connected, visually legible networks support walking, social interaction, and everyday mobility, while fragmented or visually confusing layouts constrain movement and discourage use.

2.4.3.1 Configuration as the Foundation of Accessibility Patterns

Urban morphology research consistently shows that accessibility outcomes vary according to intersection density, block size, and street orientation. As Boeing (2021) demonstrates, these structural differences translate into measurable variations in walkability and travel behavior across cities. Simply put, how streets are arranged influences how people move.

2.4.3.2 Connectivity, Integration, and Intelligibility as Accessibility Drivers

Connectivity, integration, and intelligibility jointly shape accessibility. Highly connected streets offer multiple route options, while integrated streets provide efficient access across the network (Dalton, 2001). Intelligible networks—where local cues help users understand the broader structure—are especially important for children and other vulnerable groups who rely more heavily on visual information than on abstract distance optimization (Omer & Kaplan, 2017).

2.4.3.3 Natural Movement and the Emergence of Movement Hierarchies

Movement potential, often referred to as "natural movement" in the context of urban studies, pertains to the instinctive flow of people or objects that arises solely from the layout of a space, without yet factoring in specific attractions like shops or significant landmarks.

Focusing on Movement Corridors: The arrangement of the street network itself plays a crucial role in generating movement patterns. Broad, uninterrupted, and well-integrated main routes typically become key movement corridors, drawing larger volumes of pedestrian and/or vehicle traffic, while outlying areas might experience minimal movement potential.

Movement Hierarchy: The design of a city's network establishes a hierarchy. Streets that are globally integrated attract more "through-movement" (individuals passing through to reach other locations), whereas locally integrated streets encourage "to-movement" (people heading towards specific local attractions).

Physical Attributes: The physical characteristics of an area, such as the width of sidewalks, impact pedestrian capacity. Additionally, elements like land incline and urban geography contribute to the determination of walkable paths.

Social Dynamics: The layout of a space influences human behavior and social interactions. Well-designed public areas can boost social engagement and enhance vibrancy, while poorly designed spaces may lead to isolation and decreased activity (Hiller, 1993).

Hillier (1996) illustrates that the geometry of street layouts inherently shapes foundational movement patterns, even before specific attractions like shops or schools are considered. Continuous, globally integrated streets encourage higher levels of through-movement, while intricately connected local streets facilitate neighborhood-scale interactions. Recent research highlights that the alignment and coherence of angles significantly impact route selection: people tend to prefer paths with the least angles over those that are the shortest in distance, as visual continuity reduces cognitive effort (Omer, 2021). This indicates that minor geometric variations,such as curves, offsets, or misalignments,can profoundly alter the distribution of pedestrian traffic.

2.4.3.4 Configurational Constraints and Their Social Implications

The layout of a city influences not only how much movement occurs but also its quality. Street networks that feature closely situated intersections, shorter blocks, and various alternative routes improve walkability by reducing effort required to travel and increasing safety. According to findings from the Sustainability study on reconfiguring pedestrian networks, disconnected or low-permeability street layouts create “soft barriers” that particularly impact vulnerable populations, including children, the elderly, and low-income individuals.

2.4.4 Implications for Vulnerable Groups and Design Interventions

2.4.4.1 vulnerable groups accessibility urban form

Spatial vulnerability arises when the physical design of urban environments limits mobility for groups who already face difficulties in moving. The arrangement of streets significantly influences how various social groups experience accessibility. Studies consistently indicate that vulnerable populations are more reliant on the immediate physical layout, meaning any structural shortcomings in the street network have a greater impact on them (Bishop, 2024). For residents without personal vehicles—such as children, low-income families, women, older adults, and individuals with mobility challenges—inaccessible urban designs lead to diminished access to public services, job opportunities, education, and social activities.

2.4.4.2 street network vulnerability children

Children are especially affected by vulnerabilities in the street network because their ability to move independently depends on finding short, direct routes that are safe and easy to navigate. When street networks are disjointed, featuring long blocks, cul-de-sacs, high-speed roads, or poor facilities for pedestrians, children encounter a lack of safe pathways to schools or parks. This situation curtails their autonomy and increases the need for parental supervision, thereby exacerbating social and mobility disparities (Sustainability, 2019). Bishop’s research (2024) further highlights that the lack of permeable and well-connected routes inhibits children from creating stable “mental maps,” which increases their reliance on adults for essential mobility. These infrastructural weaknesses also amplify perceived dangers: issues like traffic noise, reduced visibility, and inadequate crossing areas serve as cognitive and emotional hurdles, further eroding children's confidence to explore their neighborhoods alone.

2.4.4.3 disadvantaged populations urban connectivity

For marginalized or disadvantaged groups, urban connectivity represents a form of systemic privilege. Research by Nicoletti et al. (2022) illustrates that low-income and minority communities tend to reside in areas with lower street densities, reduced intersection connectivity, and fewer safe, multimodal pathways—conditions that systematically limit access to healthcare facilities, transit options, green spaces, and public amenities. These spatial disparities are not coincidental; they stem from entrenched patterns of neglect in infrastructure, significant road separation, and segregation in land use. According to Ali (2011), vulnerability is worsened when social disadvantages coincide with environmental factors, resulting in compounded mobility restrictions. In such settings, the street network itself becomes a tool through which exclusion is solidified.

2.4.4.4 barriers to mobility, vulnerable users

In addition to physical and structural challenges, vulnerable groups encounter mobility obstacles related to perceptions, mental well-being, and emotional safety. Poor visibility, unclear sightlines, isolated areas, and environments that lack “eyes on the street” can trigger strong avoidance reactions from women, elderly individuals, and those with anxiety or trauma-related issues (Mental Health Mobility Study, 2020). For these groups, accessibility is not only about distance but also about a sense of safety. When fear, stress, or uncertainty influence route selection, significant sections of the network become effectively unreachable, creating a divide between "theoretical access" and "actual access." Thus, spatial barriers function on both physical and psychological levels, restricting not only where vulnerable individuals can travel but also how confidently and independently they can navigate.

2.5 Concepts of walkability, permeability, and safety

2.5.1 Walkability: Urban Form and Movement Support

2.5.1.1 Urban Form & Its Role in Walkability

Research on walkability has consistently emphasized the importance of urban form. Cervero and Kockelman (1997) famously identified the “three Ds”—design, density, and diversity—as the primary factors shaping walking behavior, with design often regarded as the most influential. The physical layout of streets, blocks, and buildings directly affects how people move through urban space and how intuitive walking feels.

Early empirical work by Handy (1996) examined the relationship between urban form and walking behavior, largely through comparisons of grid-based neighborhood typologies. While influential, this approach treated urban form as a set of discrete layouts rather than as an integrated spatial system. Subsequent research addressed this limitation by adopting Space Syntax theory, which conceptualizes urban form as a continuous network of spatial relationships. This shift enabled a more nuanced understanding of how configuration, connectivity, and visibility shape pedestrian movement. From this perspective, walking is not only influenced by distance or land-use mix, but also by how urban space is structured and perceived.

2.5.1.2 Walkability as a Multidimensional Capacity

Walkability has evolved into a central concept linking urban design with public health, climate resilience, economic vitality, and social equity. Despite its frequent use, the term resists simple definition, as it emerges from the interaction of multiple spatial and social factors. Three core components are commonly identified.

Density concentrates people and destinations within walkable distances, creating the basic conditions for everyday walking. However, density alone is an ambiguous indicator, as similar numerical densities can produce very different spatial and experiential outcomes (Dovey & Pafka, 2014).

Functional mix refers to the co-location of residential, commercial, educational, and recreational activities. This concept builds on Jacobs' (1961) critique of single-use zoning, which separated daily functions and increased travel distances. A diverse land-use mix shortens trips and increases opportunities for walking, a relationship widely supported in planning and transport research (Cervero, 1989; Frank et al., 2006; Grant, 2005).

Access networks describe how street layouts enable or constrain movement. Small blocks, frequent intersections, and continuous pedestrian routes reduce travel distances and support smoother walking experiences. Jacobs' emphasis on permeability and fine-grained urban fabric has since been incorporated into walkability metrics used in public health (Moudon et al., 2006), transport planning (Krizek, 2003), and urban design (Lee & Talen, 2014). Together, this literature demonstrates that network structure is as critical as density or land-use mix in shaping walkable environments.

This combination of density, diversity, and access reflects the structural foundations of walkability. At the same time, evidence shows that walkable cities support broader societal goals, including improved public health (Stevenson et al., 2016), sustainable mobility systems (Ewing & Cervero, 2010; Newman et al., 2009), and social interaction and knowledge exchange (Storper & Venables, 2004). Walkability also plays an important role in promoting equity across differences of age, gender, ability, and socio-economic status (Massey, 2005; Sennett, 2018). As such, walkability should be understood not merely as walking frequency, but as a spatial capacity that enables safe, comfortable, and socially meaningful pedestrian movement.

The relational nature of walkability is illustrated by the Urban DMA model (Dovey & Pafka, 2020), which frames density, mix, and access as interdependent conditions rather than isolated variables. In this framework, walkability is distinct from actual walking behavior. It represents a morphological potential embedded in urban form—one that facilitates, but does not guarantee, pedestrian activity.

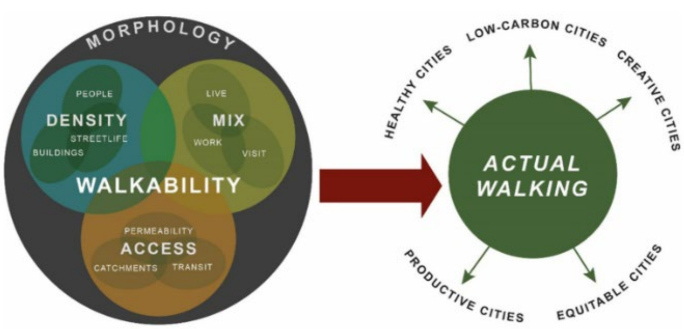


Figure 2-4 The Urban DMA – Walkability and actual walking (Dovey and Pafka, 2020).

2.5.1.3 Defining Urban Form & Its Spatial Logic

Urban form encompasses the arrangement of streets, buildings, blocks, open spaces, greenery, and street furniture, as well as the spatial relationships between these elements. Walking allows individuals to experience this structure directly, revealing how routes connect origins and destinations through spatial logic (Hillier, 2008). Consequently, urban form must be understood not only in physical terms, but also through its geometric and topological properties.

Traditional distinctions between organic and orthogonal layouts highlight the diversity of urban fabrics (Kostof, 1992; 2001). However, Medeiros (2013) argues that walkability depends less on fabric type than on how different urban patterns connect and interact. Seam conditions, route continuity, and transitions between fabrics often matter more than formal typology. From a mobility perspective, analyzing urban form therefore requires attention to street organization, density patterns, population distribution, and everyday travel distances. Solnit (2001) further contrasts cohesive traditional forms with fragmented contemporary environments, showing how structural discontinuities affect pedestrian experience.

2.5.2 Permeability and Street Network Accessibility

2.5.2.1 Definition of Permeability in Urban Design

Permeability refers to the ease with which people and vehicles can move through an urban area (Urrohmah, Ellisa, & Fuad, 2023). It reflects how effectively street networks connect different parts of the city, enabling direct and efficient routes between destinations. Lynch (1961; 1984) emphasized that well-connected networks enhance urban legibility and accessibility, strengthening relationships between neighborhoods and supporting everyday activities.

Permeability is also a perceptual quality. Residents often judge how navigable their environment feels based on block structure, pathway continuity, and street hierarchy, which together shape how open or restrictive an area appears (Silavi et al., 2017).

2.5.2.2 Physical and Visual Dimensions of Permeability

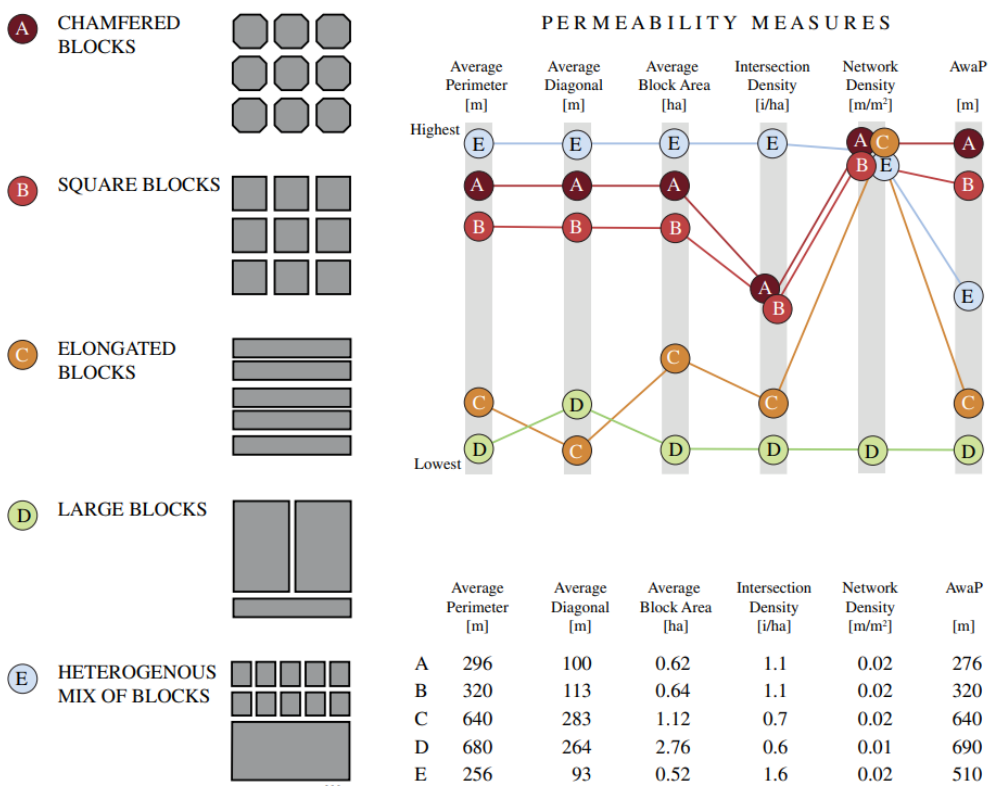
Permeability operates through two closely related dimensions. Physical permeability concerns the actual availability of routes connecting places, while visual permeability refers to whether those routes are visible and legible to users (Puwantiasning et al., 2022). Both depend on block size, street alignment, and hierarchical organization.

Urban theorists have long associated permeability with vibrant and walkable environments. Jacobs (1961) linked small blocks and frequent intersections to lively street life, while Sitte (1980) warned that excessive uniformity could reduce spatial richness. Later work demonstrated how permeability supports social interaction, sustainable transport, and everyday movement (Alexander et al., 1977; Gehl, 1987).

Traffic conditions also mediate permeability. High traffic volumes disrupt pedestrian activity and social interaction, whereas calmer streets promote human-scale movement and neighborhood cohesion (Appleyard, 1981). From a configurational standpoint, metrics such as integration and choice reveal how permeability shapes both actual and potential movement (Hillier & Hanson, 1984). Concepts such as filtered permeability further illustrate how limiting car access while preserving pedestrian continuity can enhance safety and reclaim street space for social use (Marshall, 2004).

2.5.2.3 Block Structure, Connectivity, and Functional Permeability

Block dimensions play a critical role in shaping permeability. Classic urban design research suggests that block lengths between 60 and 90 meters are optimal for walkability, with 120 meters often considered a functional upper limit (Jacobs, 1961; Whyte, 1980). Morphological studies show that larger blocks tend to subdivide over time, improving access and connectivity (Siksna, 1997). More recent research demonstrates that heterogeneous block structures—combining varied sizes and shapes—achieve higher permeability than uniform configurations (Pafka & Dovey, 2017). Functionally, permeability supports both to-movement, enabling access to local amenities, and through-movement, facilitating longer journeys across neighborhoods. Networks that balance these functions provide short, safe routes while minimizing exposure to high-speed traffic. Fragmented layouts, by contrast, hinder both forms of movement and disproportionately affect children, older adults, and residents without cars (Newman, 2010).



	Average Perimeter [m]	Average Diagonal [m]	Average Block Area [ha]	Intersection Density [i/ha]	Network Density [m/m²]	AwaP [m]
A	296	100	0.62	1.1	0.02	276
B	320	113	0.64	1.1	0.02	320
C	640	283	1.12	0.7	0.02	640
D	680	264	2.76	0.6	0.01	690
E	256	93	0.52	1.6	0.02	510

Figure 2-5 Permeability Measures for Different Block Typologies (Pafka & Dovey, 2017)

chamfered, square, elongated, large, and heterogeneous—based on average perimeter, diagonal length, block area, intersection density, network density, and average walking perimeter (AwaP). The heterogeneous block mix demonstrates the highest permeability, while large blocks consistently perform the lowest.

Further explanation

Permeability refers to how effectively a street network allows pedestrians and cyclists to navigate easily within and across an area. It consists of two main functional aspects.

1. The first aspect is to-movement, which relates to how well individuals from surrounding areas can reach local amenities, public spaces, and services within a neighborhood. A highly permeable network offers numerous short, direct, and safe routes to important destinations, which is particularly vital for children, whose travel ranges are naturally limited.
2. The second aspect is through-movement, which pertains to the capacity to move across a neighborhood efficiently as part of longer journeys in the urban environment. Networks that provide uninterrupted, clear routes without detours promote smoother travel and decrease reliance on major roads. This continuity is especially important for vulnerable populations, as it reduces their exposure to fast-moving traffic and offers safer alternatives.

Neighborhoods that foster both to-movement and through-movement typically demonstrate high permeability, marked by well-connected blocks, a dense network of intersections, and various route choices. In contrast, fragmented networks with long blocks, dead-end streets, or obstacles hinder both local access and movement between neighborhoods, creating structural challenges that disproportionately affect children, older individuals, and residents without cars (Newman, 2010).

2.5.3 Understanding Safety in Urban Environments

In the context of urban design, safety refers to a situation where individuals can navigate a city without facing unnecessary physical risks or accidents. This concept revolves around managing hazards that typically arise from everyday interactions between people, materials, and the urban environment, including incidents like traffic accidents, falls, fires, and various environmental threats (DCAF, 2019). Therefore, creating a secure urban area necessitates designing streets, buildings, and public spaces in a way that minimizes these risks and ensures that the urban environment is predictable, clear, and easy to navigate. While safety addresses unintentional injuries, security is concerned with intentional threats such as crime and aggression. Together, these factors influence how comfortable, confident, and free individuals feel while using urban spaces (DCAF, 2019). A safe urban environment is built upon thoughtful design elements like clear sightlines, well-lit pathways, effective traffic regulations, resilient infrastructure, and responsive emergency systems. These features enable all users, especially vulnerable groups, to move about independently and without fear, enhancing the overall quality of urban life (DCAF, 2019).

Figure 2-6 Urban safety and security (DCAF, 2019).

2.5.3.1 Neighbourhood Safety and Everyday Mobility

Safety within neighborhoods is crucial in influencing how individuals navigate urban spaces. When people feel secure in their surroundings, they are more likely to move freely,whether that means walking, biking, or reaching local destinations. Conversely, urban areas that lack safe crosswalks, proper lighting, or predictable behavior from drivers can hinder mobility, especially for vulnerable populations like children, older adults, and individuals with mobility challenges (DCAF, 2019). Numerous studies have shown that worries about safety,ranging from traffic hazards to social instability,create obstacles that discourage outdoor activities, hinder active transportation, and limit public space usage (Zougheibe et al., 2021). Thus, neighborhood safety is not just a matter of environmental conditions; it is also a key factor in determining everyday mobility options, affecting whether individuals can fully take advantage of walkable and accessible urban designs.

2.5.3.2 Parental Perceptions and Children's Mobility

For children, the concept of neighborhood safety is largely shaped by how their parents perceive it. Research indicates that parents' opinions on factors like sidewalk conditions, traffic speed, stranger danger, and overall trust in the neighborhood significantly affect how far and independently their children are permitted to travel (Santos et al., 2013). Even if the infrastructure is conducive to walking or destinations are nearby, children's freedom of movement can be restricted if parents feel the area is unsafe. Parental worries have been identified as one of the main factors influencing children's independent mobility and active travel, often having a greater impact than objective measures of safety (Zougheibe et al., 2021). These perceptions create what can be described as "mobility boundaries," determining where children are allowed to play, whether they can walk to school, and how confidently they can explore their surroundings. Consequently, perceptions of safety, along with the actual physical conditions, are crucial in shaping children's genuine access to public spaces.

2.5.3.3 Traffic and Social Safety in Child-Friendly Urban Design

In designing urban spaces that are friendly to children, both traffic safety and social safety are critical for promoting independent mobility. Hazards such as fast-moving vehicles, wide roads, and insufficient facilities for pedestrians are commonly identified obstacles for children and their caregivers, which greatly limits opportunities for active travel and outdoor play (Marzi et al., 2018). Research on urban mobility further suggests that neighborhoods with high traffic levels tend to have lower rates of walking and cycling among children, leading families to rely on cars even for short trips (Janssen, Ferrao, & King, 2016). Additionally, social safety concerns,related to fears of strangers, crime, or a lack of natural oversight,create mental hurdles that restrict children's freedom, regardless of the physical setting. These combined challenges highlight the necessity for a comprehensive approach to child-friendly mobility: creating streets that minimize vehicle dominance, improving visibility and lighting, and fostering social trust within communities. Ultimately, enhancing both traffic and social safety is vital for increasing children's ability to navigate independently and engage confidently with their city.

Chapter 3: Methodology

3.1 Research Approach

In this thesis I used a comparative approach, looking at two cities, Turin and Braga, to understand how their street networks shape everyday mobility for vulnerable groups, especially children. The main idea is to see how the structure and logic of the street network can either support or limit children's ability to move safely and independently in their neighbourhoods.

To explore this, the study relies on two key methods. The first is Space Syntax, which helps reveal how accessible and connected different streets are by analysing the network's spatial configuration. The second is Superblockify, a Python-based tool that creates alternative street layouts designed to reduce through-traffic and make local areas calmer and safer. I combined these methods with other GIS-based techniques to build a clear picture of both current conditions and potential improvements.

Then I compared the findings from these analyses in a before-and-after framework, allowing the research to show how the existing network performs today and how accessibility could change under improved, child-friendly scenarios. This approach enables understanding not only what the problems are, but also how targeted spatial interventions could meaningfully enhance mobility for children across different urban contexts.

3.2 Overview of Analytical Tools

3.2.1 Space Syntax (QGIS Environment)

Space Syntax is a approach based on science that spatial configurations. Unlike traditional transport planning (which focuses on origin-destination traffic), Space Syntax analyzes the geometry and topology of the street network itself to predict human movement. The rationale behind it is

, People intuitively navigate cities by minimizing angular deviation (straightest lines) rather than just minimizing metric distance; and the goal is to identify which streets are "naturally" more accessible (integrated) or more likely to be used as through-routes (choice).

The Space Syntax component of this studyis realized in a QGIS-based workflow, using the Space Syntax Toolkit (SST) as an interface to run axial and segment analyses via the depthmapXnet engine. This integration enables a seamless process in which data preparation, model verification, analysis, and visualization occur inside a single GIS environment. The approach reduces the need for multiple external formats. It minimizes modelling errors an improvement emphasized by Gil et al. (2014), who describe QGIS as an increasingly accessible platform for configurational analysis.

The integration offered by the SST significantly improves the traditional Space Syntax workflow, which typically involves several software platforms and repeated export import procedures. These disconnected actions not only increase the chance of modelling errors but also slow down the analytical process. By combining network preparation, model verification, computational analysis through depthmapXnet, and visualisation within a single QGIS environment, the SST provides a streamlined and more reliable workflow for both beginners and experienced researchers.

Table 3-1- Key metrics of Space syntax (Elaborated by Author)

Metric	Picture	What it Measures	Interpretation
Integration **(**Closeness Centrality)		"To-Movement" How easy it is to reach this segment from all other segments.	High values indicate Destinations. These are typically commercial cores, public squares, or lively hubs where people gather.
Choice **(**Betweenness Centrality)		"Through-Movement" How often this segment lies on the shortest path between any two other points.	High values indicate Routes. These are the main arteries or "high streets" that handle flow. Good for retail that relies on passing trade.

3.2.2 Superblockify (Python Environment)

Superblockify (https://superblockify.city/) works with the concept of superblocks: a superblock is a neighbourhood transformation strategy combining multiple urban blocks, forbidding, or severely limiting drive-through traffic through built means, thereby pacifying its streets and giving priority to active modes of transport (walking, cycling) and multiple uses (Nieuwenhuijsen et al., 2024).

Superblockify is a Python package created to help with upcoming arrangements. superblock implementations by partitioning an urban street network into superblock-like neighbourhoods and providing tools for visualizing and analysing these partition results (Büth et al., 2024). As such, It primarily serves to support local specialists and stakeholders in providing a vision and quantified metrics to help designing future urban plans.

It is designed to be both vertical and modular. Without any programming knowledge, one can apply Superblockify to any city simply by naming it. However, with better knowledge of the tool, it is possible to create alternative rules to partition the city and observe or study the results from the given partitioning rules.

Superblockify defines streets as a mathematical network. A network is composed of edges (or links) connected by nodes (or vertices). For the street network, each edge is a road between intersections, and each node is an intersection. To design superblocks, each edge is designated as

part of one of the superblocks, also called components in a more general sense, or part of the so-called sparse network in between the superblocks that connects them, see Figure 3.1 Components are defined as being a connected component (in the network sense of a set of nodes connected by edges) in which drive-through traffic is forbidden, meaning that the roads of a component are only allowed to be accessed if starting or ending a trip within the same component.

Althought, Superblockify is capable of facilitating large-scale urban redevelopments, it is equally suitable for smaller-scale interventions. By defining coherent areas across the network, the tool can be used to explore targeted measures such as 30 km/h zones, filtered permeability, or local calming schemes within a single neighbourhood.

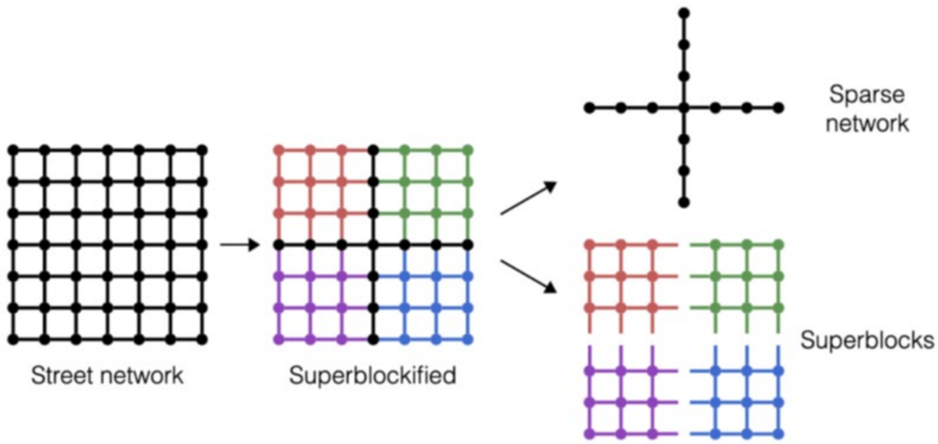


Figure 3-1- Visual explanation of how Superblockify partitions a city's street network into superblocks (coloured) that are connected by a sparse network (black).

3.3 Workflow

3.3.1 Data Collection

The analysis is based on the integration of open spatial datasets describing the street network, child-related public spaces (Parks & Green areas, Playgrounds, Schools & Kindergartens), and neighbourhood boundaries for the two case-study cities, Turin and Braga. Data were mainly obtained from official municipal open-data portals, namely the Geoportale della Città di Torino and the Municipality of Braga, in order to ensure data reliability and local relevance. Where information on public and recreational spaces was incomplete or missing, additional data were collected from OpenStreetMap (OSM).
The study focuses on children between approximately 3 and 14 years of age, covering kindergarten, primary school, and lower secondary school stages. This age range reflects different levels of everyday mobility, from trips that are usually accompanied by adults to short neighbourhood movements that may be partially independent.

3.3.2 Data Preparation

Street network data for both case-study cities prepared by using QGIS. First the datasets were cleaned to be sure about topological correctness, including the removal of duplicate geometries, correction of disconnected intersections, and verification of network continuity. These operations were important to ensure that the street networks could be translated into valid graphs for configurational analysis.

All spatial layers were projected into a consistent UTM coordinate reference system to enable metric-based analysis and ensure cross-city comparability. Child-related public spaces, originally represented as polygon features, were converted into point geometries and merged into a single dataset to allow spatial association with the street network in later analytical stages.

The street networks were converted into segment representations suitable for angular analysis. Segment maps were generated from road centreline data for supporting Space Syntax calculations, as angular segment analysis is recognised as an effective method for modelling pedestrian movement and route choice.

Topological validation was conducted before analysis, including the removal of overshoots and dangling segments, enforcement of node-to-node connectivity at intersections, verification of projection consistency, and inspection of network continuity. These steps are essential, as Space Syntax metrics depend on a fully connected and topologically valid graph structure (Beyhan, 2011).

Space Syntax analyses were required using the depthmapX software as a standalone environment. Street network data were first prepared in QGIS and after imported into depthmapX, where axial and segment representations were generated directly within the software. Angular segment analysis was subsequently performed on these segment maps.

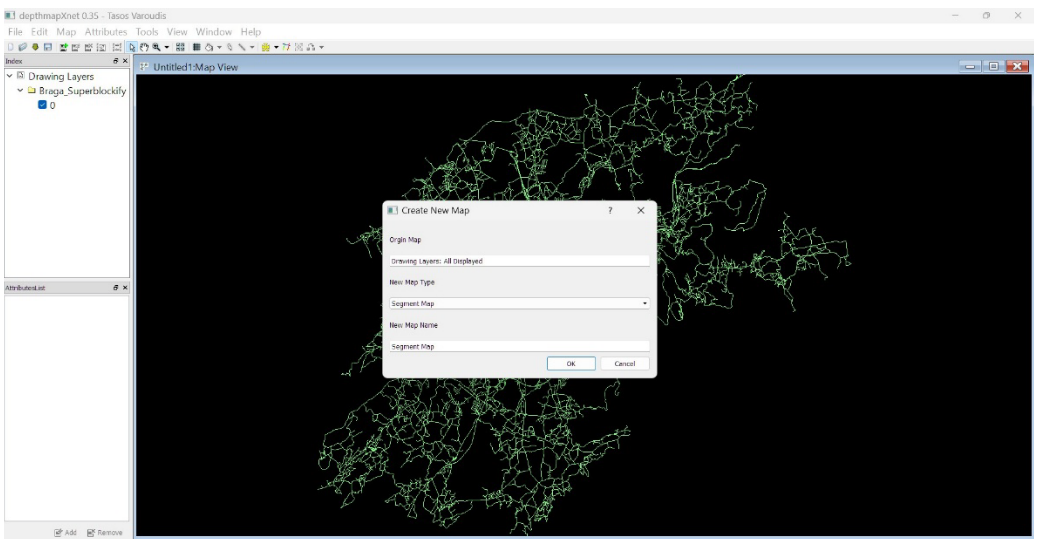


Figure 3-2- Converted the street network to segment through Deptmax software

3.3.3 Baseline Spatial Configuration Analysis

3.3.3.1 Angular Segment Analysis (R400 and R800) – Space Syntax

Baseline spatial configuration analysis was conducted using Angular Segment Analysis to evaluate the structural properties of the street networks under current conditions. The analysis was performed using two metric radius in each case-study city:

- R = 400 m, representing neighbourhood-scale walkability and short daily trips;
- R = 800 m, representing a broader local catchment area.

For each radius, standard Space Syntax indicators were calculated. Integration was used to describe the potential for to-movement and overall spatial accessibility, while Choice was employed to capture the potential for through-movement and route selection within the network. These metrics provide complementary insights into destination-oriented accessibility and movement flows.

All analyses were applied consistently to both Turin and Braga to ensure methodological symmetry and allow direct comparison between the two urban contexts.

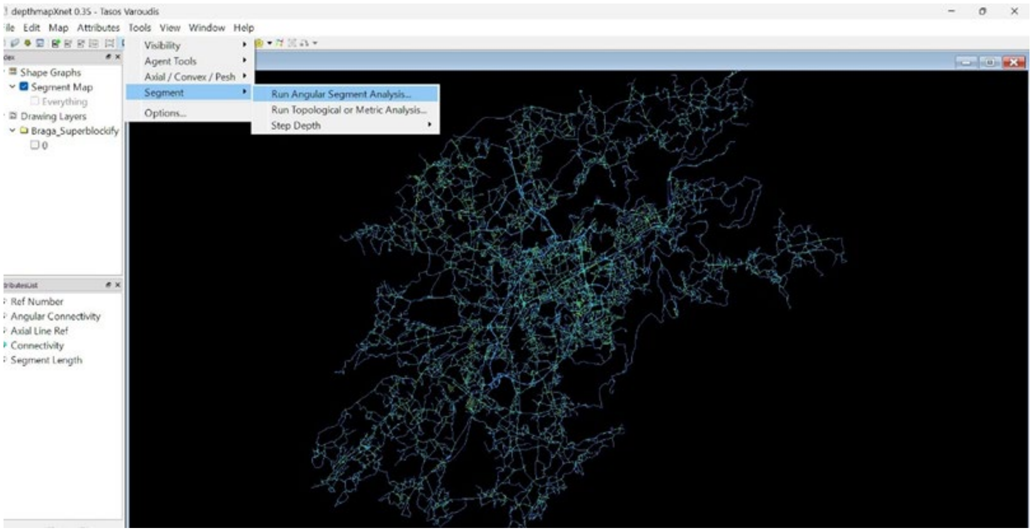


Figure 3-3-Angular Segment Analysis setup in depthmapX

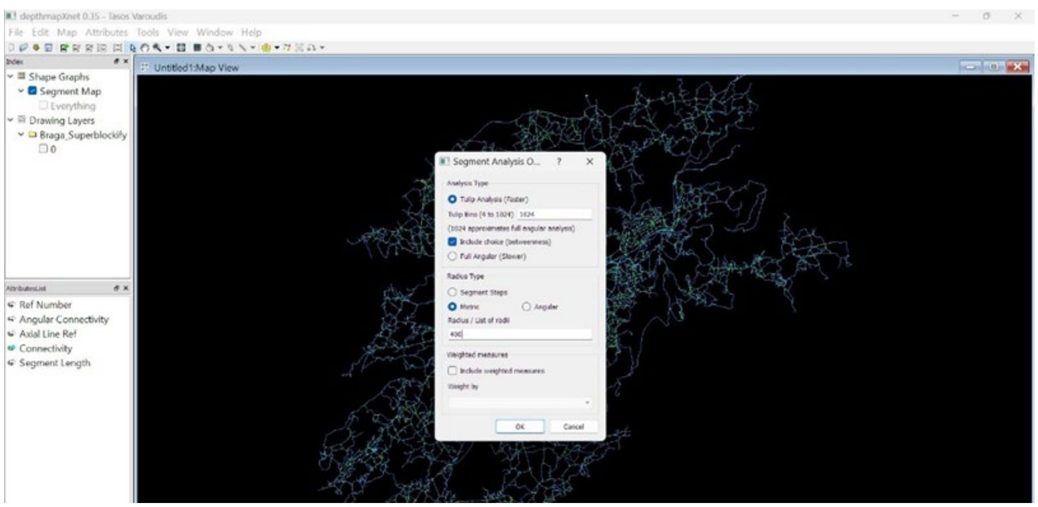
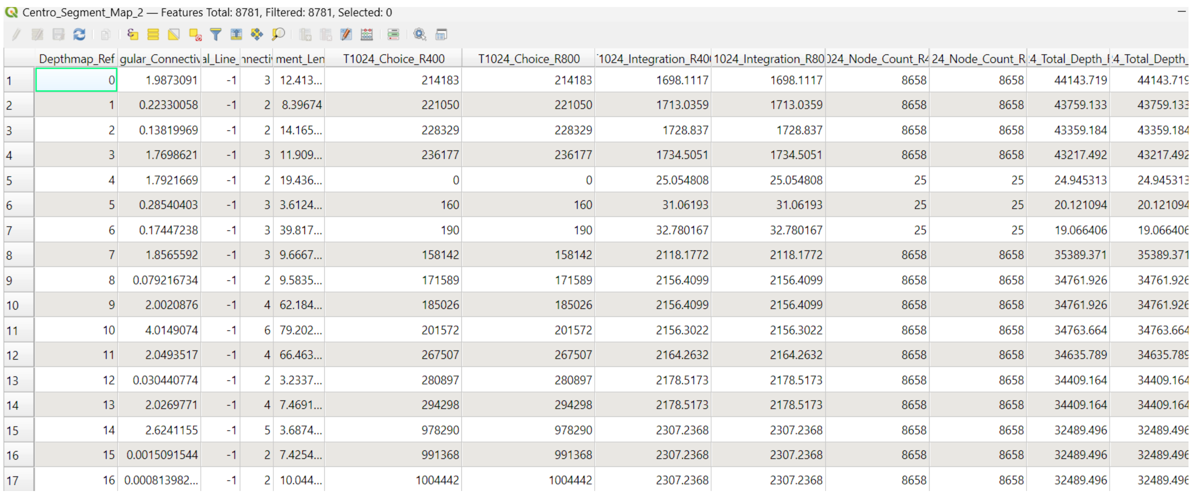


Figure 3-4- Execution of Angular Segment Analysis in depthmapX under baseline conditions

3.3.3.2 Export and GIS integration

Following analysis, the resulting attribute tables, including Integration and Choice values at R400 and R800, were exported from depthmapX and then imported into QGIS.
The syntactic values were joined to the corresponding street segments and prepared for further spatial processing and cartographic visualisation. This step produced baseline maps of street-network accessibility and movement potential for both cities.



Centro_Segment_Map_2 — Features Total: 8781, Filtered: 8781, Selected: 0

	Depthmap_Ref	gular_Connectiv	al_Line_	nnecti	ment_Len	T1024_Choice_R400	T1024_Choice_R800	1024_Integration_R40	1024_Integration_R80	24_Node_Count_R4	24_Node_Count_R	4_Total_Depth_I	4_Total_Depth_
1	0	1.9873091	-1	3	12.413...	214183	214183	1698.1117	1698.1117	8658	8658	44143.719	44143.719
2	1	0.22330058	-1	2	8.39674	221050	221050	1713.0359	1713.0359	8658	8658	43759.133	43759.133
3	2	0.13819969	-1	2	14.165...	228329	228329	1728.837	1728.837	8658	8658	43359.184	43359.184
4	3	1.7698621	-1	3	11.909...	236177	236177	1734.5051	1734.5051	8658	8658	43217.492	43217.492
5	4	1.7921669	-1	2	19.436...	0	0	25.054808	25.054808	25	25	24.945313	24.945313
6	5	0.28540403	-1	3	3.6124...	160	160	31.06193	31.06193	25	25	20.121094	20.121094
7	6	0.17447238	-1	3	39.817...	190	190	32.780167	32.780167	25	25	19.066406	19.066406
8	7	1.8565592	-1	3	9.6667...	158142	158142	2118.1772	2118.1772	8658	8658	35389.371	35389.371
9	8	0.079216734	-1	2	9.5835...	171589	171589	2156.4099	2156.4099	8658	8658	34761.926	34761.926
10	9	2.0020876	-1	4	62.184...	185026	185026	2156.4099	2156.4099	8658	8658	34761.926	34761.926
11	10	4.0149074	-1	6	79.202...	201572	201572	2156.3022	2156.3022	8658	8658	34763.664	34763.664
12	11	2.0493517	-1	4	66.463...	267507	267507	2164.2632	2164.2632	8658	8658	34635.789	34635.789
13	12	0.030440774	-1	2	3.2337...	280897	280897	2178.5173	2178.5173	8658	8658	34409.164	34409.164
14	13	2.0269771	-1	4	7.4691...	294298	294298	2178.5173	2178.5173	8658	8658	34409.164	34409.164
15	14	2.6241155	-1	5	3.6874...	978290	978290	2307.2368	2307.2368	8658	8658	32489.496	32489.496
16	15	0.0015091544	-1	2	7.4254...	991368	991368	2307.2368	2307.2368	8658	8658	32489.496	32489.496
17	16	0.000813982...	-1	2	10.044...	1004442	1004442	2307.2368	2307.2368	8658	8658	32489.496	32489.496

Figure 3-5- Attribute table of exported street network within deptmax

3.3.3.3 Normalisation of syntactic values

To enable direct comparison between Turin and Braga, syntactic indicators were standardised using z-score normalisation:

$$z = (x - \mu) / \sigma$$

where x is the original syntactic value, μ is the mean, and σ is the standard deviation calculated separately for each city and indicator.
This procedure reduces scale bias and allows comparative interpretation across different urban contexts.

3.3.3.4 Baseline spatial mapping

Using the normalised values, thematic maps of Integration and Choice were produced for both radii. These maps represent the baseline spatial performance of the street networks, highlighting areas of higher and lower accessibility before any intervention.
Once the analysis layer is created, QGIS's visualization tools are used to style results following Space Syntax conventions:
1. Style by Gradient: Use "Graduated" symbology in QGIS.
2. Spectral Ramp: Standard Space Syntax convention uses a "spectral" color ramp:
3. Attribute Explorer: The SST plugin has an "Attribute Explorer" tab that creates scatter plots (e.g., comparing Integration vs. Choice) directly within QGIS to identify different urban typologies (Gil et al., 2014).

3.3.3.5 Linking street configuration to child-related public spaces

To assess accessibility to child-related public spaces, the point-based dataset of public spaces was spatially linked to the street network. A **Join by Nearest** operation was performed in QGIS, assigning each public space the Integration and Choice values of its nearest street segment. This approach enables the interpretation of accessibility to public spaces through the configurational performance of the surrounding street network.

3.3.3.6 scoring and classification

To translate the normalised Space Syntax indicators into interpretable measures of accessibility for child-related public spaces, a multi-step scoring procedure was applied.

1. Choice-based exposure scoring

Choice represents the potential for through-movement within the street network. Higher Choice values indicate greater exposure to passing trough network, which is generally less desirable for children's environments. For this reason, Choice values were inversely scored: street segments with higher Choice values received lower scores, while segments with lower Choice values received higher scores.
Based on the normalised Choice values (Z_Ch_400), an exposure score ranging from 0 to 4 was assigned, where higher scores indicate lower exposure to through-movement and therefore more child-friendly conditions.

Table 3-2- Choice Score

Normalised Choice value (Z_Ch)	Exposure score
Z_Ch < 0	4
0 ≤ Z_Ch < 0.5	3
0.5 ≤ Z_Ch < 1.0	2
1.0 ≤ Z_Ch < 1.5	1
Z_Ch ≥ 1.5	0

The resulting scores were then grouped into three qualitative exposure classes:

Table 3-3- Exposure level

Choice score (ChScore400)	**Exposure level**
ChScore400 ≤ 1	High exposure
ChScore400 = 2 or 3	Medium exposure
ChScore400 ≥ 4	Low exposure

2. Integration-based accessibility scoring

Integration reflects the potential for movement and overall spatial accessibility. In this case, higher Integration values indicate better accessibility and are therefore considered more favourable for children's access to public spaces.

Accordingly, Integration values were scored directly: higher normalised Integration values received higher scores, while lower values received lower scores. Based on Z_In_400, an accessibility score ranging from 1 to 5 was assigned.

Table 3-4- Integration Score

Normalised Integration value	Integration score
Z_In < −1.0	1
−1.0 ≤ Z_In < −0.5	2
−0.5 ≤ Z_In < 0.5	3
0.5 ≤ Z_In < 1.0	4
Z_In_400 ≥ 1.0	5

These scores were subsequently classified into three accessibility categories:

Table 3-5- Accessibility level

Integration Score	Accessibility level
InScore400 ≤ 2	Low accessibility
InScore400 = 3	Medium accessibility
InScore400 ≥ 4	High accessibility

3. Composite accessibility quality of public spaces

Finally, the Choice-based exposure score and the Integration-based accessibility score were summed to obtain a **composite accessibility quality score** for each public space. This combined indicator captures both the degree of exposure to through-movement and the level of spatial accessibility. Based on the total score, public spaces were classified into five composite accessibility quality classes:

Total score (Integration + Choice)	Composite accessibility quality class
≥ 8	A — Very high composite accessibility quality
7	B — High composite accessibility quality
6	C — Medium composite accessibility quality
4–5	D — Low composite accessibility quality
≤ 3	E — Very low composite accessibility quality

Finally, thematic maps were produced based on these classification schemes, visualising each child-related public space according to its assigned composite accessibility quality class.

3.3.4 Superblock Scenario Modelling

The Superblockify workflow consists of:

- selecting a partitioning strategy
- extracting and preparing the street network
- computing network metrics
- partitioning the network into superblocks
- sparse network, and exporting the results for further analysis.

In this study, the baseline street network served as the input for scenario modelling.
Street network extraction for the superblock scenario was based on the baseline street network datasets prepared for both case-study cities. These datasets, originally compiled as GIS shapefiles, were imported into the Python environment and converted into network representations for use in Superblockify. As superblocks primarily aim to reduce motorised through-traffic, the analysis was conducted on the drivable street network. The extraction was constrained to the defined study-area boundaries, with a buffer applied to ensure network continuity at the edges. Following conversion, the network was cleaned and simplified to remove peripheral artefacts and interstitial nodes, resulting in a computationally efficient and topologically consistent graph suitable for scenario modelling.
Superblockify then partitioned the street network into two main components:

- a sparse network, which retains streets intended for through-traffic, and
- a set of superblocks, representing low-traffic neighbourhood areas.

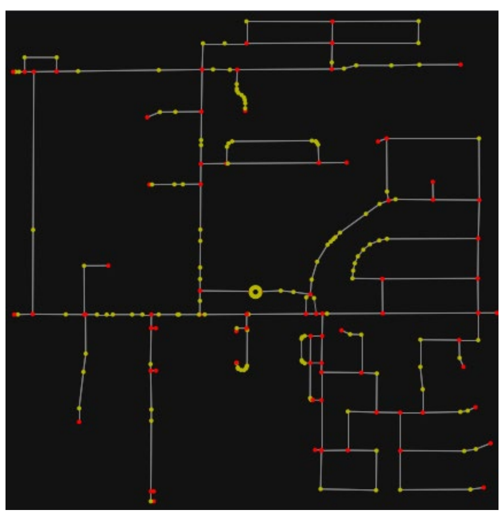


Figure 3-6- Simplification of a street network. In yellow are the interstitial nodes, here to create curved geometries. They are removed in the simplification step

Partitioning is based on a Boolean edge attribute, whereby each street segment is classified as either part of the sparse network (value = 1) or not (value = 0). The largest connected component of edges marked as 1 defines the sparse network, while all remaining connected components are identified as superblocks. This graph-based approach ensures that the resulting partitions reflect the structural properties of the street network rather than simple attribute filtering.

Two partitioning strategies available in Superblockify were considered:

- a residential partitioner, which assigns non-residential streets to the sparse network, and
- a betweenness-based partitioner, which assigns streets with the highest betweenness centrality (typically the top 15 %) to the sparse network, representing the main through-movement corridors.

The resulting superblockified network represents a hypothetical intervention scenario characterised by reduced traffic permeability within neighbourhoods.

Export and preparation of scenario outputs

The superblockified street network was exported from the Python environment and converted into GIS-compatible formats with geopackage, including separate layers for edges, nodes, and the transformed street network. Special care was taken to maintain consistency with the baseline datasets in terms of spatial extent, topology, and coordinate reference system. This ensured that the scenario outputs could be directly compared with the baseline network in subsequent analyses.

3.3.5 Post-Intervention Spatial Configuration Analysis (Space Syntax)

3.3.5.1 Re-running Space Syntax analysis

To evaluate the effects of the superblock scenario, the same Space Syntax workflow applied to the baseline condition was repeated on the transformed network. Segment modelling was carried out, followed by Angular Segment Analysis at R = 400 m and R = 800 m, and the calculation of standard syntactic indicators, including Integration and Choice. Applying identical analytical parameters ensured full comparability between baseline and post-intervention conditions.

3.3.5.2 Change detection and interpretation

Baseline and post-intervention results were compared through difference mapping and statistical inspection of changes in syntactic values. Particular attention was given to variations in Integration and Choice around child-related public spaces, to assess whether the superblock scenario altered local accessibility patterns and exposure to through-movement.

This comparative analysis supports the identification of spatial locations where the intervention produces improvements, as well as areas where limitations persist. Overall, the post-intervention analysis enables an evaluation of whether the proposed superblock configuration enhances neighbourhood-scale accessibility and creates street environments more supportive of vulnerable users, especially children.

Chapter 4: Case Study Analysis

This chapter puts together the theoretical framework and methodological approach developed in the previous chapters and applies them to the selected case studies of Turin and Braga. The goal is to examine how the existing street network configuration in each city shapes children's access to everyday public spaces and to assess whether network reconfiguration through the Superblockify approach can improve the safety and accessibility of these environments or not.

The analysis follows a comparable workflow for both case studies. First, each city is examined under current conditions, using Space Syntax methods to analyse the street network configuration. In this stage, angular Integration and Choice metrics are used to evaluate the network's structural accessibility and its effects for children's access to key public spaces, including playgrounds, parks, schools, and kindergartens. Child-related public spaces are represented as point-based destinations and assessed in relation to their surrounding street network properties, allowing differences in accessibility and exposure to through movement to be identified. Based on the baseline results, the analysis highlights spatial barriers related to street network configuration, including potential exposure to through-movement, weak local integration, and peripheral locations. These aspects guide the reconfiguration scenario.

In the next step, the Superblockify tool is used in each city to create an alternative street network that limits through-movement within neighbourhoods and improves local accessibility. The reconfigured network is then analysed using the same Space Syntax metrics and parameters as in the baseline condition, allowing a direct and consistent comparison between the two situations.

4.1 Turin

4.1.1 City Overview, Street Network Configuration, and Distribution of Child-Related Facilities

4.1.1.1 City overview

Turin is a city and an important business and cultural center in northern Italy. It is the capital city of the Piedmont region and of the Metropolitan City of Turin. From 1861 to 1865, it served as the capital of the Kingdom of Italy. The city is mainly on the western bank of the River Po, below its Susa Valley, and is surrounded by the western Alpine arch and Superga hill. The municipality covers roughly 130 km², and the population of the city proper is 856,745 as of 2025 (ISTAT, 2025), while Eurostat estimates the urban area's population at 1.7 million. The OECD estimates the Turin metropolitan area's population at 2.2 million (OECD, 2009).

Figure 4-1- Picture of Turin Municipality

Map 1 provides an overview of Turin’s geographical context at different spatial scales. At the national level, the first map highlights the Piedmont region within Italy, situating the study area in the north-western part of the country. The second map zooms in to the regional scale, showing Turin’s position within Piedmont and its role as the region's main urban center. The third map further narrows the focus to the Metropolitan City of Turin, illustrating the administrative municipalities that form the wider urban area and indicating Turin as its core municipality. Finally, the last map presents the official boundary of the Municipality of Turin, which serves as the primary study area for the analyses in this chapter.

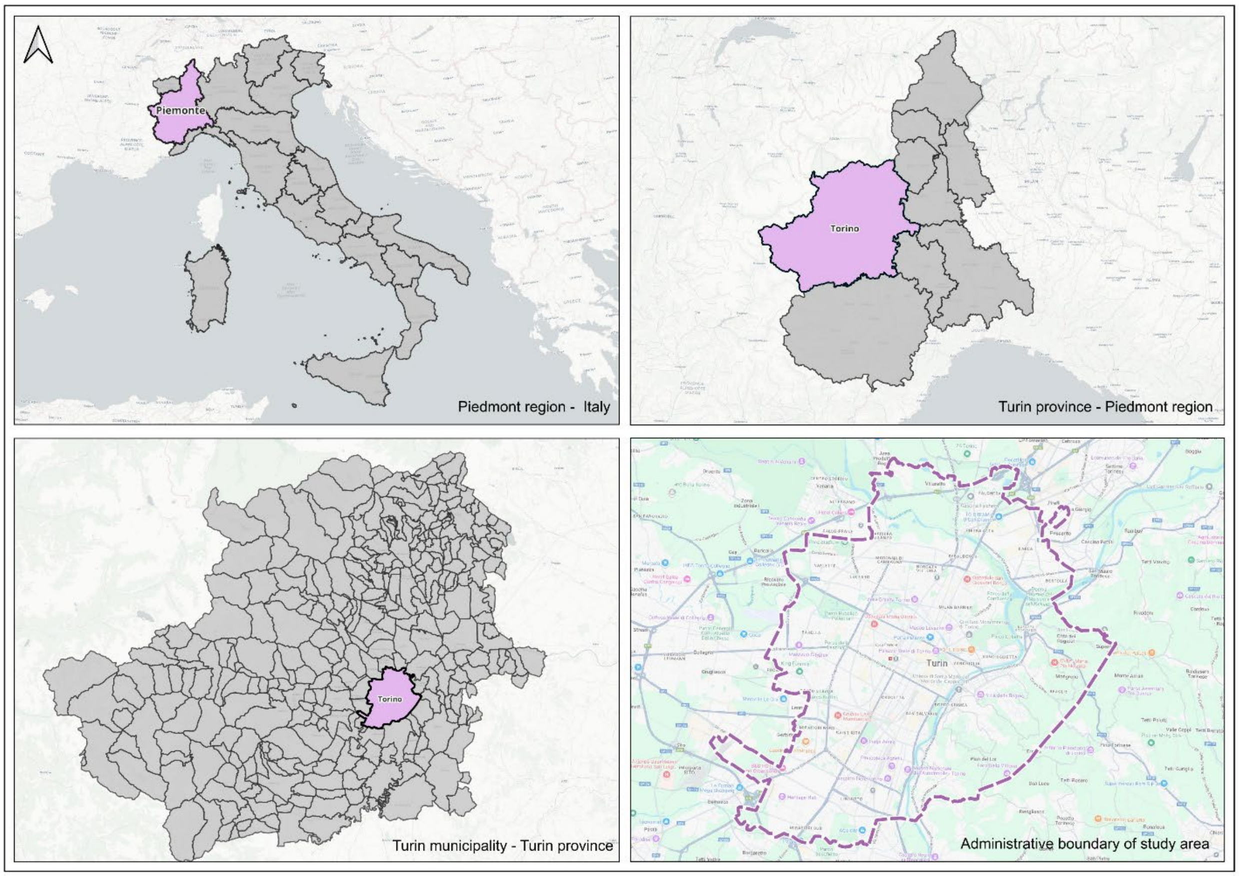


Figure 4-2 situation of the Municipality of Turin

4.1.1.2 Current Street Configuration in Turin

The map below illustrates the current street network configuration of the Municipality of Turin, classified into three main categories: primary, secondary, and local streets.

The primary network comprises major arterial roads that structure movement at the metropolitan scale and ensure connectivity between different parts of the city. These streets form a recognisable backbone that concentrates through-movement and supports longer-distance travel. The secondary network provides an intermediate level of connectivity, linking neighbourhoods to the main arterial system and distributing traffic across the urban fabric. Finally, the local street network consists primarily of residential streets that serve local access and everyday activities, shaping the fine-grained structure of neighbourhoods. This structural framework provides the baseline for the accessibility analyses developed in the following sections.

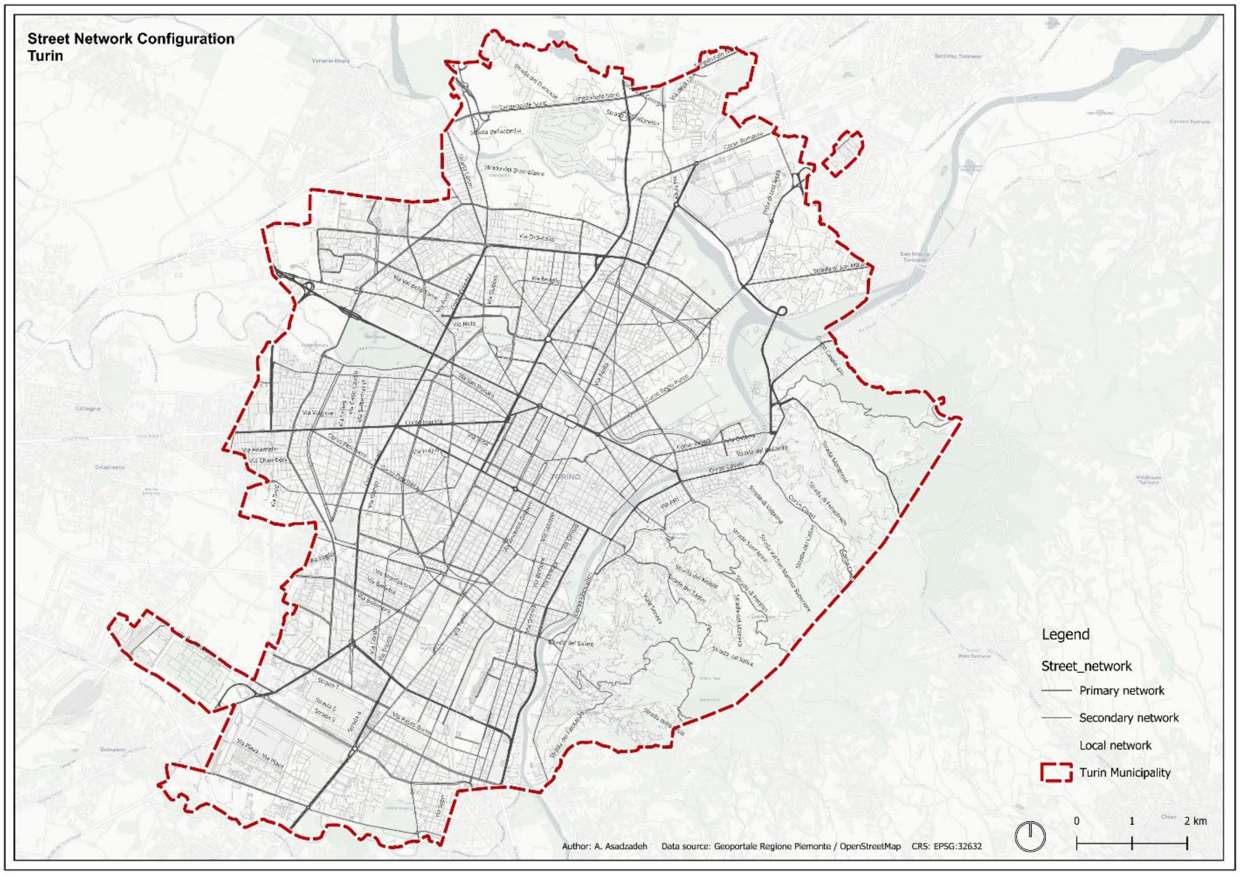


Figure 4-3 Street Network Configuration – Turin Municipality

4.1.1.3 Public Spaces (Parks, Playgrounds, and Schools)

The spatial distribution of child-related public spaces across Turin provides an initial overview of their availability at the neighbourhood scale. In total, 1,129 places are identified within the municipal boundary, including **432 parks and green areas, 194 playgrounds, and 503 Schools & Kindergartens**.

Overall, these destinations are widely distributed across the urban fabric, with a higher concentration in central, consolidated neighbourhoods and a more dispersed pattern in peripheral areas. This distribution establishes the spatial baseline for the subsequent accessibility analysis based on street network configuration.

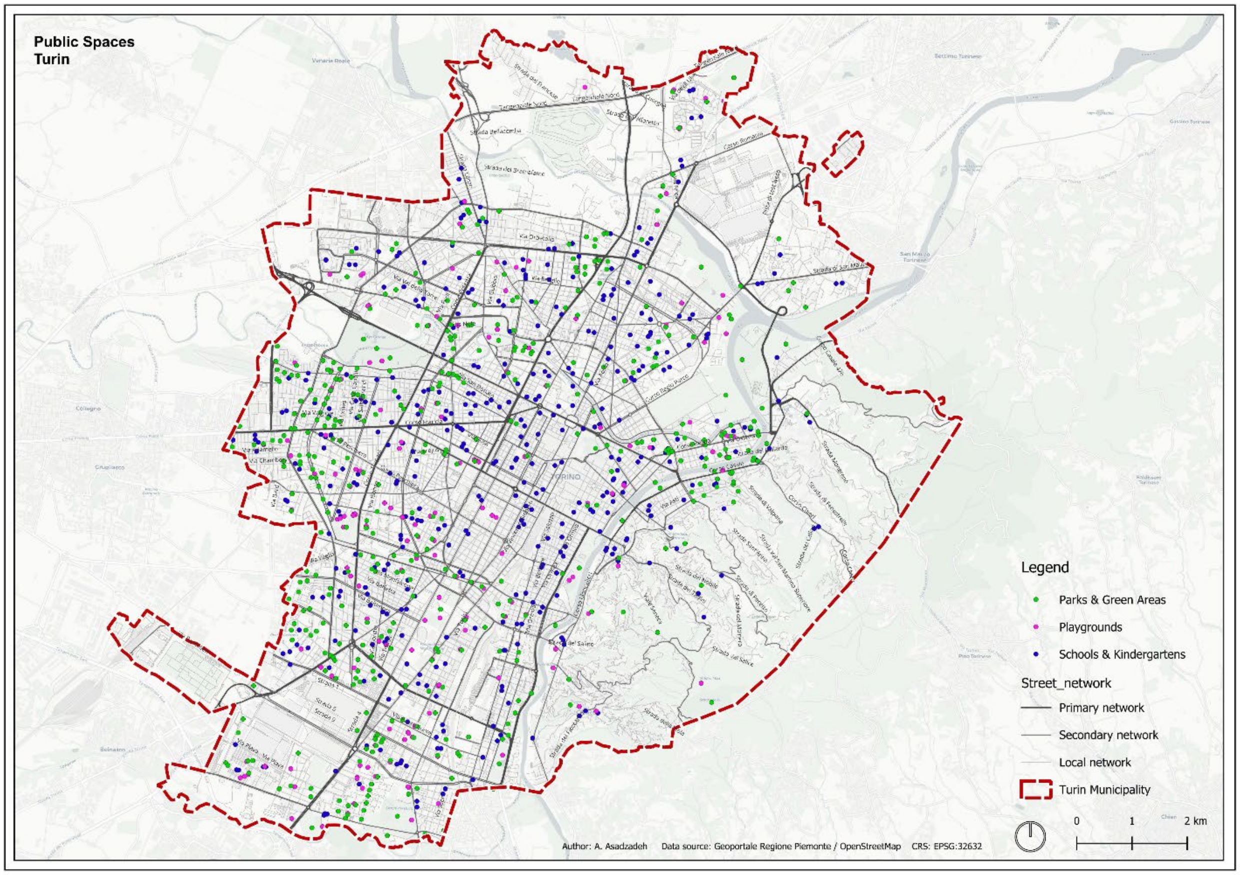


Figure 4-4 Public Spaces of Turin related to children

4.1.2 Baseline Spatial Analysis – Current Condition

This section presents the baseline analysis of Turin's street network under existing conditions. The purpose is to describe the network's current spatial structure before any reconfiguration is applied.

The analysis is carried out on a segmented representation of the street network, which allows the spatial structure of movement to be examined at a detailed level. The resulting configurational values are later linked to child-related public spaces in order to assess their level of integration within the network and their potential exposure to through-movement. This approach enables evaluation of how accessible these public spaces are under current conditions and how their locations relate to the surrounding street network. The analysis is organized using two metric radii, 400 m and 800 m, to capture accessibility patterns at different spatial scales. The 400 m radius represents local, walkable conditions most relevant to everyday child-oriented trips, while the 800 m radius reflects a broader neighbourhood context. Using both radii allows differences between local and extended accessibility patterns to be identified and provides a Powerful baseline for comparison with the post-intervention scenario.

4.1.2.1 Choice

Choice is a configurational measure that explains the potential role of street segments in through-movement within the street network. Streets with higher Choice values are more likely to function as routes connecting different parts of the city, while streets with lower values tend to support local movement. This measure is important for understanding children's environments because higher through-movement potential is often associated with greater exposure to movement intensity and reduced suitability for independent child mobility.

In this section, Z-score normalised Choice maps are used to identify streets with different levels of through-movement potential under existing conditions. These values are then linked to child-related public spaces to assess potential exposure and understand how their location relates to the surrounding street network. In this section, Z-score normalised angular Choice values are classified into five categories, ranging from values **below 0 to values above 1.5**. Based on these Choice scores, child-related public spaces are grouped into three exposure levels**: low, medium, and high**. This classification allows the assessment of how the spatial location of public spaces relates to different degrees of potential exposure to through-movement within the street network under existing conditions.

Map 4-4, with a radius of 400 m, shows that Choice values between 0.5 and 1.5 are mainly concentrated in the central part of Turin, indicating higher levels of through-movement within the inner urban fabric. This pattern suggests that public spaces in these central areas may be more exposed to through-movement than other parts of the city. In contrast, several peripheral and linear corridors display lower Choice values, reflecting a more limited role in neighbourhood-scale through-movement and lower exposure levels.

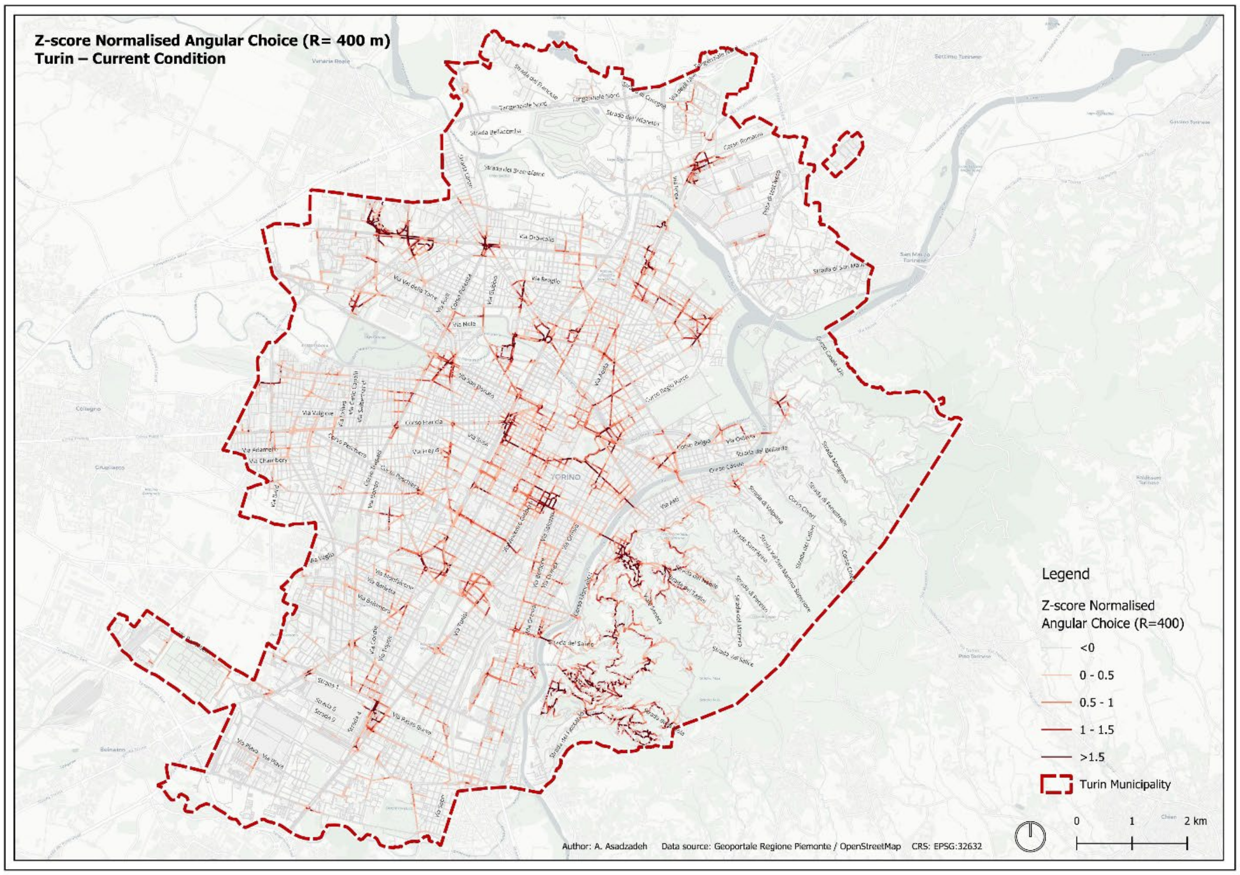


Figure 4-5 Z-Scorenormalized angular choice (R= 400m) – Turin Current condition

At a radius of 800 m, the distribution of Choice values shows a more continuous and structured pattern compared to the cal-scale analysis. Streets with high Choice values (Z > 1 and especially > 1.5) form extended and connected corridors, mainly across the central area of Turin and along major transversal and radial axes. These corridors clearly structure neighbourhood-scale movement across the city.

Streets with medium Choice values (0.5–1) are more widely distributed and act as secondary connectors linking central corridors to surrounding neighbourhoods. In contrast, low Choice values (< 0.5) dominate most inner residential streets and peripheral areas, indicating limited involvement in neighbourhood-scale through-movement.

Overall, the 800 m analysis highlights a shift from fragmented local patterns to broader movement corridors, suggesting that potential exposure to through-movement becomes more spatially extensive at the neighbourhood scale. This distribution provides the basis for assessing how the exposure of child-related public spaces changes when accessibility is considered beyond the immediate local context.

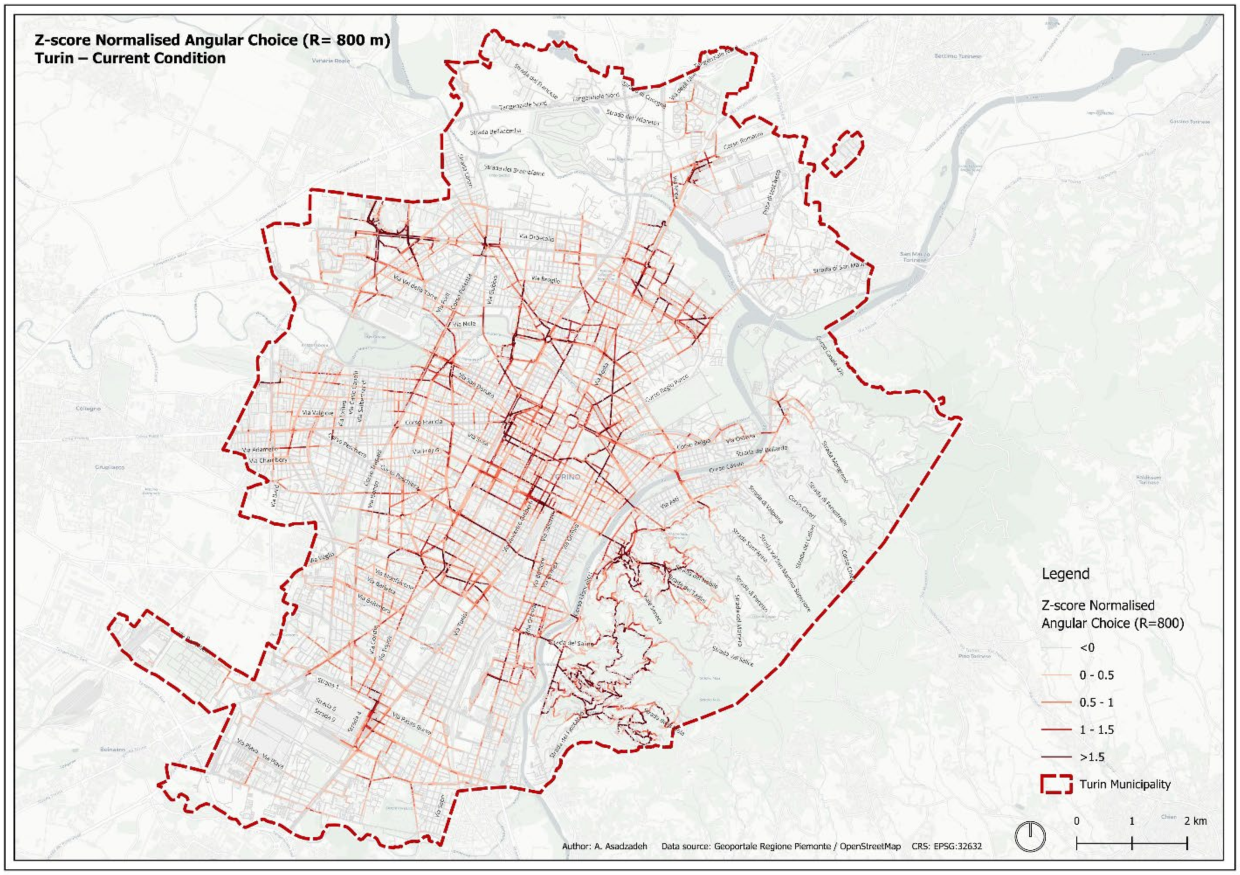


Figure 4-6- Z-Score normalized angular choice (R= 800m) – Turin Current condition

Comparing the two radii shows a clear shift from locally fragmented and discontinuous patterns at 400 m to more continuous and connected movement corridors at 800 m. While higher Choice values at 400 m remain limited to short segments within neighbourhoods, at 800 m they extend across larger parts of the network, particularly in central areas. This difference indicates that potential exposure to through-movement increases and becomes more spatially widespread when accessibility is considered at the neighbourhood scale.

Exposure of Public Spaces based on Choice

At the local scale, the majority of child-related public spaces in Turin fall within the low exposure category, accounting for 84.8% of all destinations. This indicates that most public spaces are located along streets with limited local through-movement. Medium exposure represents 13.7% of cases and is mainly associated with spaces located near local connectors within the central urban fabric. Only a very small share of public spaces (1.5%) experience high exposure, typically concentrated along specific locally important streets. Overall, the pattern suggests that under current conditions, children’s public spaces are largely embedded within relatively protected local street environments at the walkable scale.

Table 4-1- Exposure of Public Spaces based on Choice (R=400 m)

Exposure – 400 m	Percentage
Low exposure	84.8
Medium exposure	13.7
High exposure	1.5

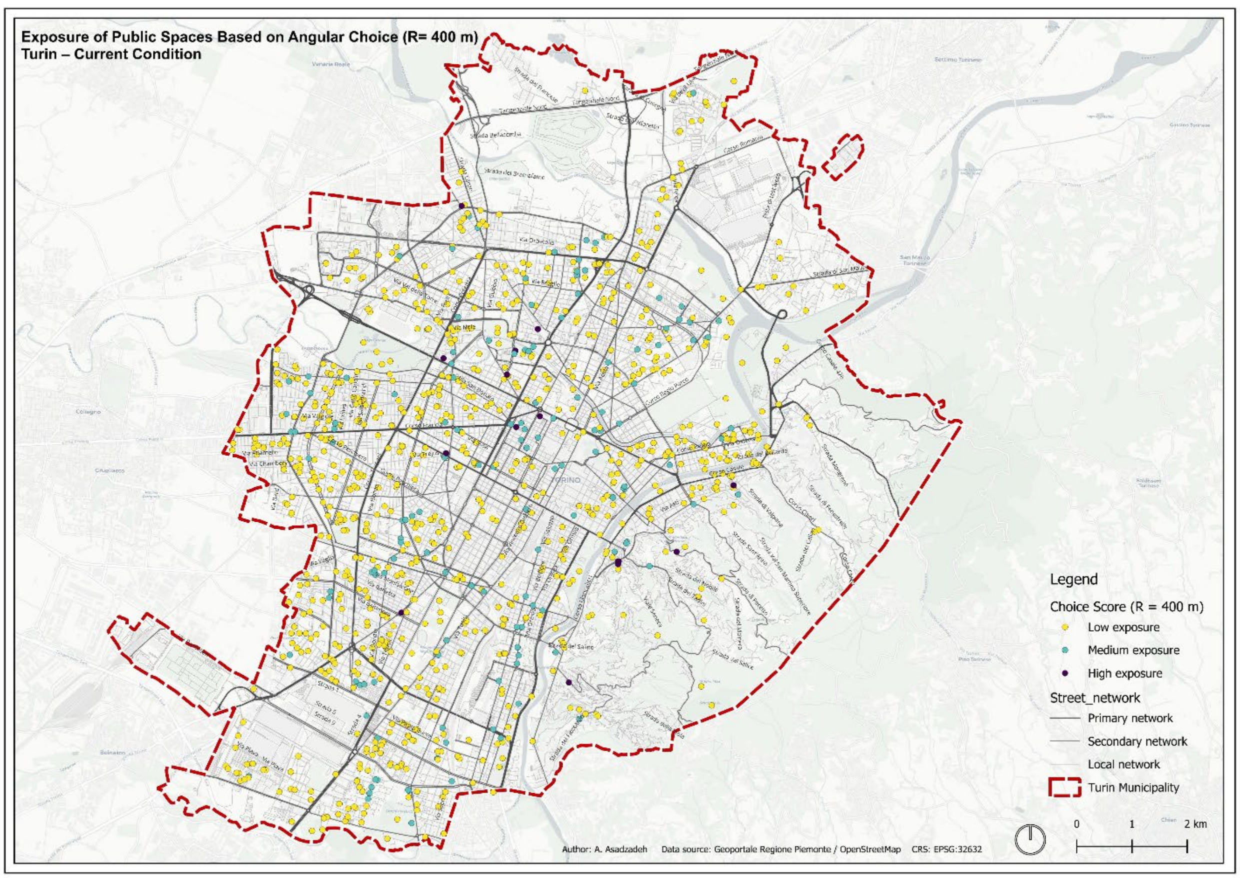


Figure 4-7 Exposure of Public Spaces based on Choice (R= 400m) – Turin Current Condition

At the neighbourhood scale, public spaces are in the low exposure category (74.3%), although this share is lower than at a 400 m radius. Medium exposure increases to 21.6%, indicating that more public spaces are located near streets that serve as neighbourhood-level movement corridors. High exposure also rises to 4.1%, mainly in spaces along major connecting axes. Overall, the 800 m analysis shows that potential exposure to through-movement becomes more widespread when accessibility is considered beyond the immediate local context.

Table 4-2- Exposure of Public Spaces based on Choice (R=800 m)

Exposure – 800 m	Percentage
Low exposure	74.3
Medium exposure	21.6
High exposure	4.1

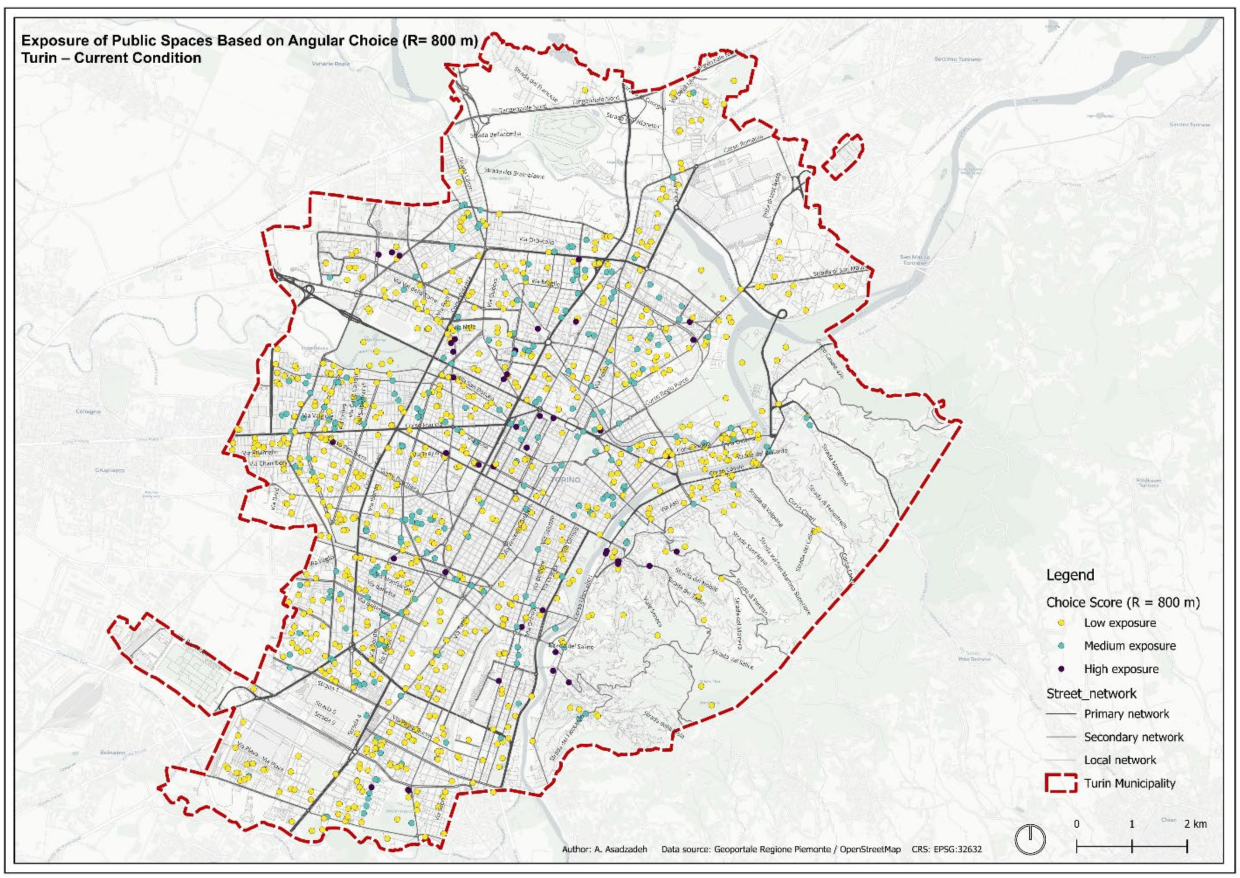


Figure 4-8- Exposure of Public Spaces based on Choice (R= 800m) – Turin Current Condition

4.1.2.2 Integration

Integration is a configurational measure that describes how easily different street segments can be reached within the overall street network. Streets with higher Integration values are more centrally positioned and accessible, while streets with lower values are more spatially segregated and harder to access. This measure is particularly relevant for understanding children's environments, as higher levels of integration generally indicate better accessibility to everyday destinations through the street network. In this section, Z-score normalised Integration maps are used to identify streets with different levels of spatial accessibility under existing conditions. These values are then linked to child-related public spaces to assess their accessibility and understand how their location relates to the surrounding street network. Z-score normalised angular Integration values are classified into five categories, ranging from **values below −1 to values above +1**. Based on these Integration scores, child-related public spaces are grouped into three accessibility levels**: low, medium, and high**. This classification allows the assessment of how the spatial location of public spaces relates to different degrees of network accessibility under current conditions

The map shows a clear central–peripheral gradient in Integration values across Turin at a 400 m radius. Streets with high Integration values are strongly concentrated in the central urban area, where the street network is denser and more interconnected. As the distance from the city centre increases, Integration values gradually decrease, indicating that streets in outer and marginal areas are more segregated and less accessible within the local network.

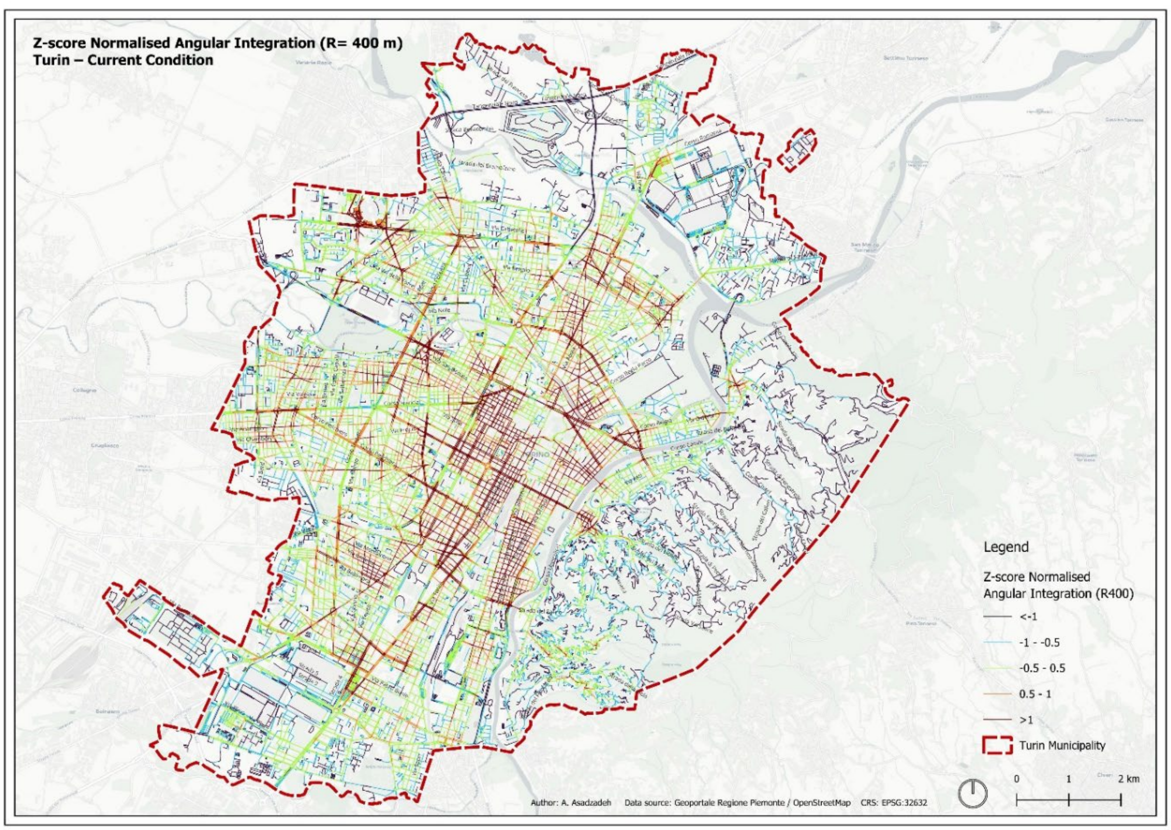


Figure 4-9 Z-score normalised Angular Integration (r=400m) – Turin current condition

At the 800 m radius, high Integration values extend beyond the city centre and form broader, more continuous corridors across Turin. Compared to the 400 m analysis, accessibility is less concentrated in the core and more evenly distributed across connected neighbourhoods. Marginal areas remain less integrated, but the overall pattern shows improved neighbourhood-scale connectivity within the existing network.

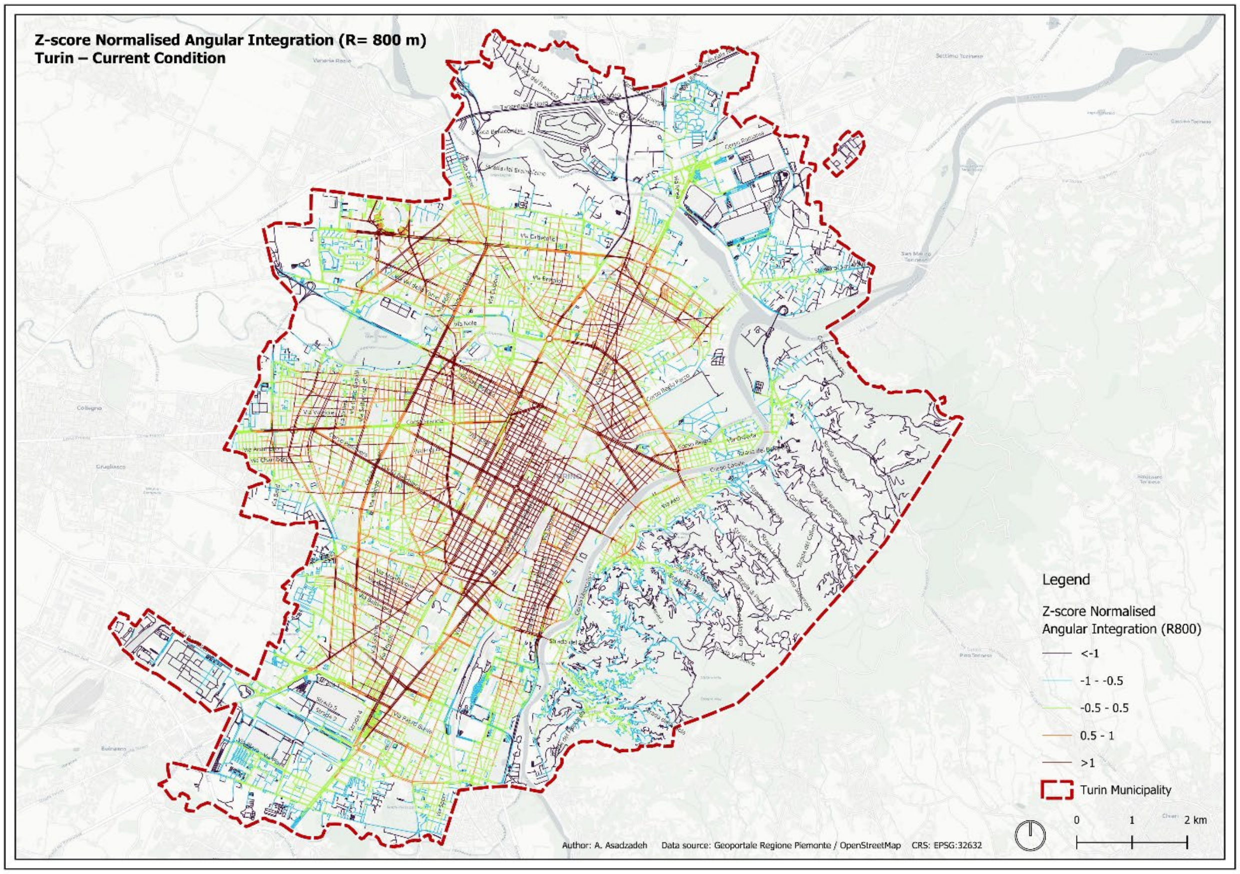


Figure 4-10 Z-score normalised Angular Integration (r=800m) – Turin current condition

Accessibility of public spaces based on integration

At the local level, child-related public spaces in Turin are most commonly characterised by medium accessibility (43.0%), suggesting a generally balanced integration into the street network. Nearly one quarter of these spaces (23.6%) are highly accessible and located in central neighbourhoods with a dense, well-connected street network. Conversely, 33.4% of public spaces show low accessibility, reflecting their location in more peripheral or spatially isolated areas. Overall, accessibility at the walkable scale varies noticeably across the city, favouring central areas over the urban periphery.

Table 4-3- Accessibility of Public Spaces based on Integration (R=400 m)

Accessibility – 400 m	Percentage
Low accessibility	33.4
Medium accessibility	43.0
High accessibility	23.6

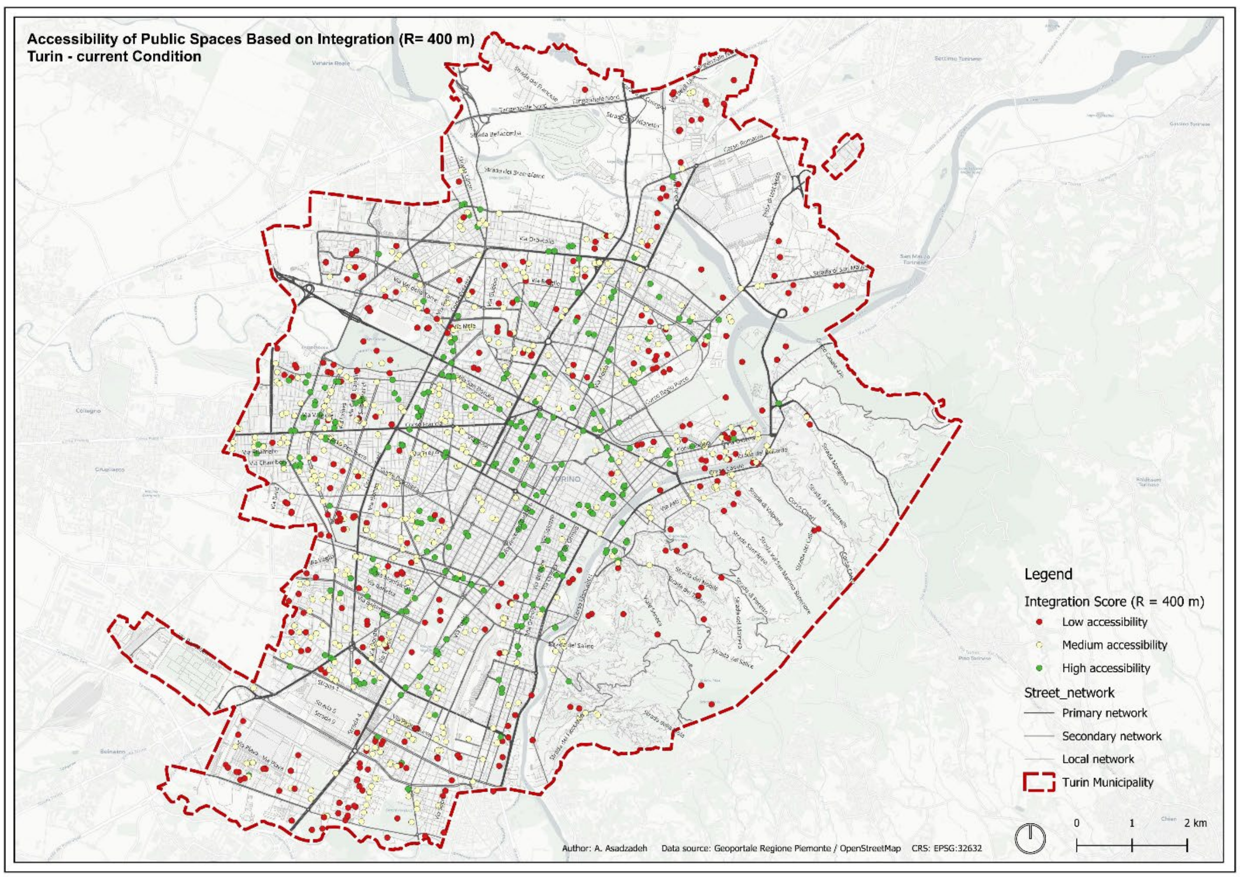


Figure 4-11 Accessibility of public spaces based on integration (R= 400 m) – Turin current condition

At the neighbourhood scale, most child-related public spaces in Turin are in medium accessibility (41.3%), while a substantial proportion (33.2%) are from high accessibility, reflecting their location along well-connected parts of the street network. Low accessibility accounts for 25.5% of public spaces and is mainly associated with areas that remain more spatially segregated. Overall, the results indicate a relatively strong level of accessibility to public spaces when connectivity is considered at the broader neighbourhood scale.

Table 4-4- Accessibility of Public Spaces based on Integration (R=800 m)

Accessibility – 800 m	Percentage
Low accessibility	25.5
Medium accessibility	41.3
High accessibility	33.2

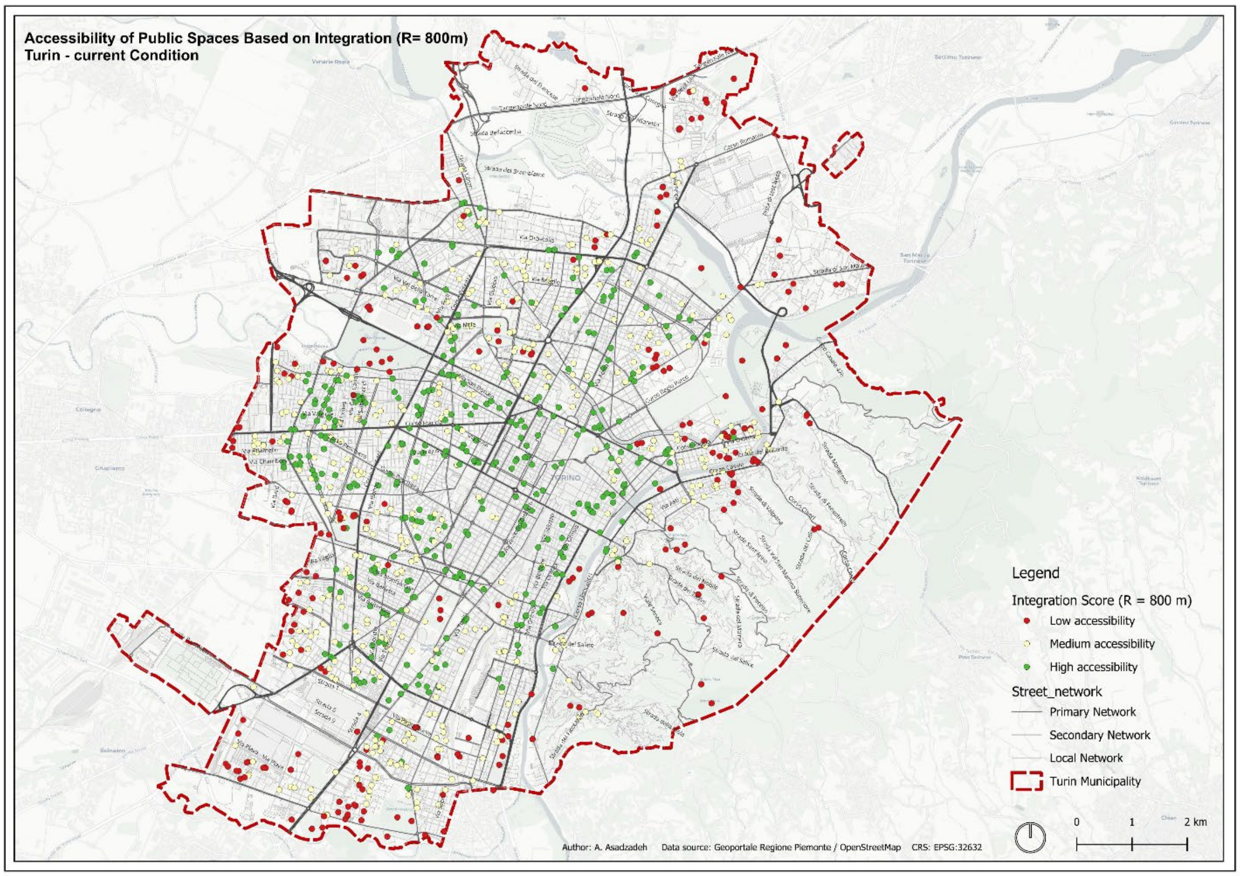


Figure 4-12- Accessibility of Public Spaces Based on integration (R=800 m) - Turin current condition

4.1.2.3 Composite quality accessibility

This section presents the overall results of the Integration and Choice analyses, combined into a single indicator referred to as Composite Accessibility Quality. The composite results are classified into five categories, ranging from very high (A) to very low (E) accessibility quality. This classification provides an integrated view of how children-related public spaces perform in terms of both network accessibility and potential exposure under current conditions. Public spaces with low or very low composite accessibility quality are of particular interest, as they represent areas where spatial conditions are currently less supportive of children’s independent access. These categories serve as a key reference for the subsequent.

At the local scale (R=400 m), most public spaces show medium to high composite accessibility, with the largest share falling in the high category (40.7%), followed by medium (25.8%). Very high accessibility (18.7%) is mainly found in central areas where the street network is more connected and supportive.
Lower composite accessibility levels are less common and are mostly located in outer and less connected neighbourhoods. Public spaces with low (14.2%) or very low (0.6%) accessibility tend to appear toward the edges of the city, where the network structure and movement conditions are weaker. These areas highlight locations with the greatest potential for improvement through future reconfiguration of the street network.

Table 4-5- Composite quality accessibility – (R=400 m)

Composite quality accessibility – 400 m	Percentage
A — Very high composite accessibility quality	18.7
B — High composite accessibility quality	40.7
C — Medium composite accessibility quality	25.8
D — Low composite accessibility quality	14.2
E — Very low composite accessibility quality	0.6

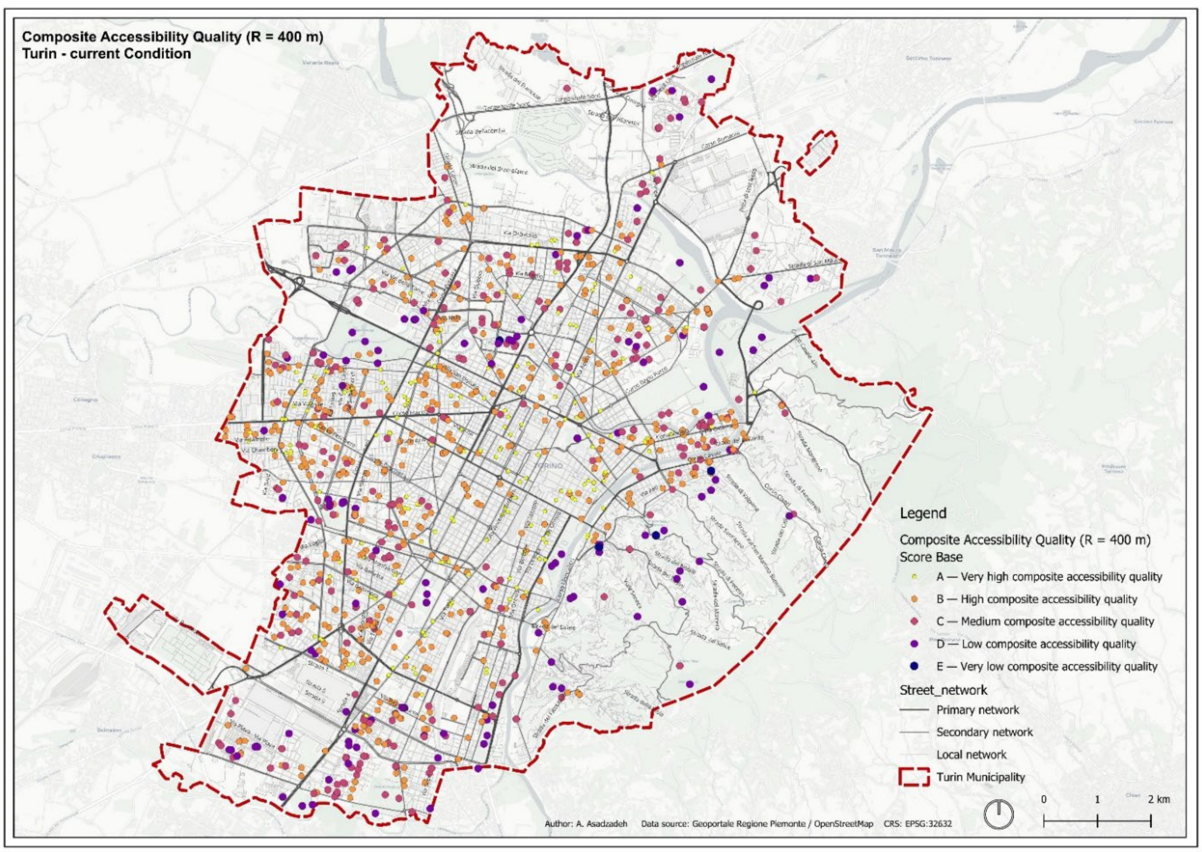


Figure 4-13- Composite quality accessibility – (R=400 m)

When accessibility is evaluated at the 800 m scale, a large share of public spaces shows strong overall performance. More than 60% of child-related public spaces are in the high and very high composite categories, indicating that many destinations are located within well-connected parts of the street network. A smaller portion displays medium accessibility, while only a limited number of public spaces are classified as low or very low, mostly in areas that remain weakly connected. This distribution suggests that, at the neighbourhood scale, accessibility to public spaces is generally supportive across much of the city.

Table 4-6- Composite quality accessibility – (R=800 m)

Composite quality accessibility – 800 m	Percentage
A — Very high composite accessibility quality	22.2
B — High composite accessibility quality	40.8
C — Medium composite accessibility quality	24.7
D — Low composite accessibility quality	11.4
E — Very low composite accessibility quality	0.9

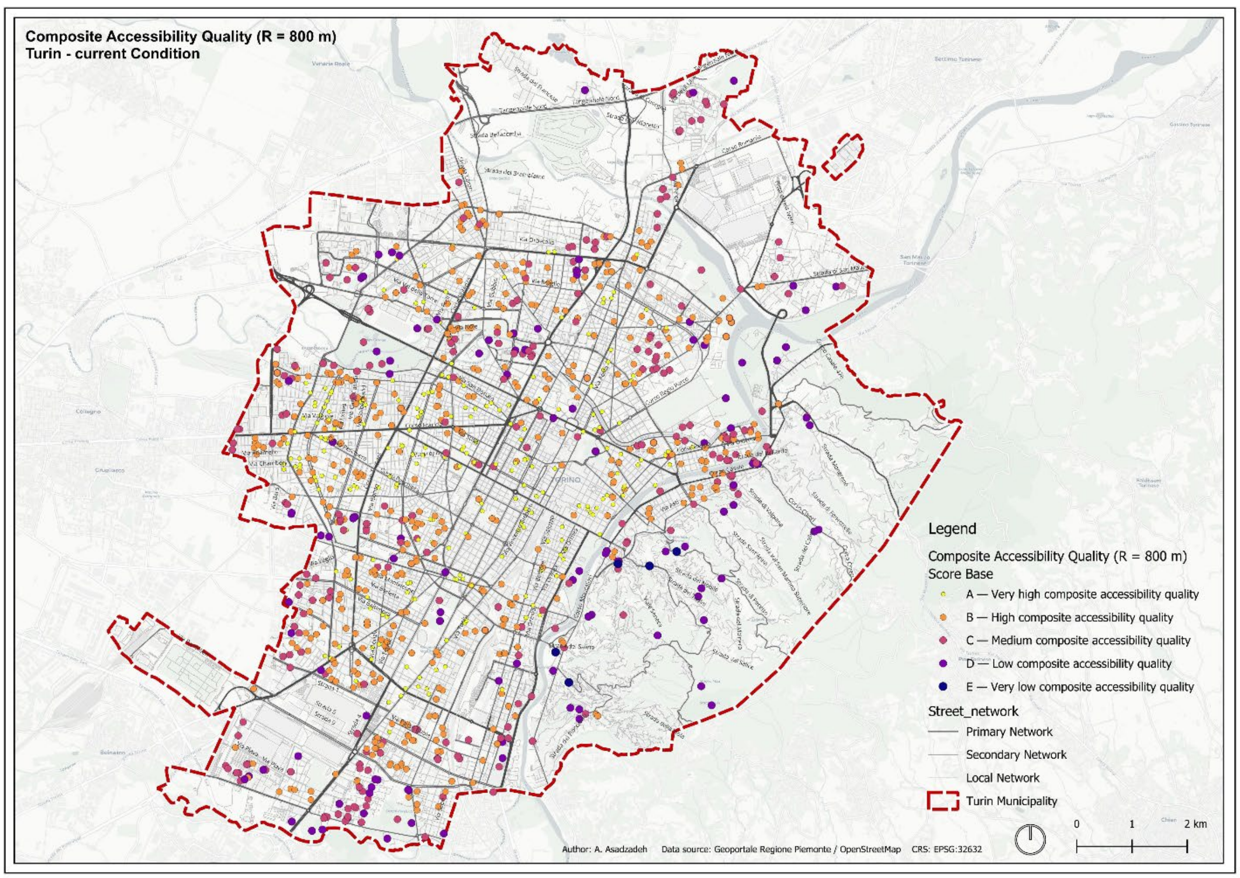


Figure 4-14- Composite quality accessibility – (R=800 m)

4.1.3 Superblock Scenario Definition and Network Reconfiguration

In this step, the Superblockify tool was applied to the existing street network of Turin to generate a reconfigured network structure based on superblock principles. The output was exported as a GeoPackage containing three main spatial layers: **nodes, edges, and Low Traffic Neighbourhoods (LTNs)**. Together, these layers show the reorganised street network and its partitioning logic.

The resulting map shows how the street network is divided into 637 partitions, each corresponding to a superblock. SPARSE streets, shown in black, represent the primary and high-connectivity streets that accommodate through-traffic. These streets are not included in any partition and instead function as structural boundaries separating neighboring superblocks. In contrast, the remaining streets are classified as residential and grouped into coloured partitions, each colour indicating a separate superblock generated through the network partitioning process.

Spatially, the partitioning pattern reflects the city's underlying structure. In the central areas, where the street network is denser and more regular, superblocks tend to be smaller and more compact, while in peripheral areas they appear larger and less uniform, following the coarser network structure. This configuration reduces through-traffic within residential areas while maintaining connectivity along major streets, establishing the spatial framework for evaluating post-intervention changes in accessibility and exposure in the following analyses.

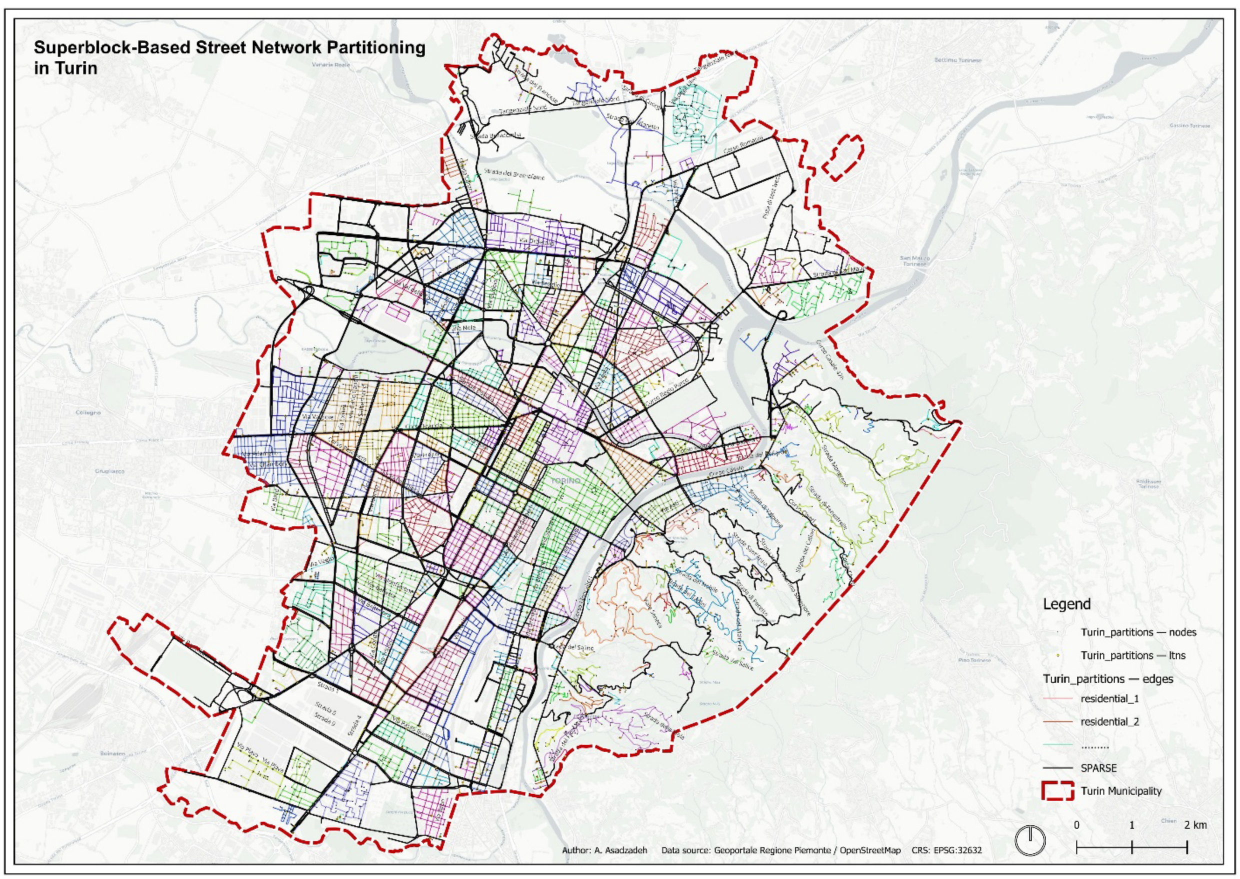


Figure 4-15- superblock-based street network Partitioning in Turin

4.1.4 Post-Intervention Accessibility Analysis

This section presents the accessibility patterns observed after implementing the superblock scenario. Using the transformed street network, accessibility to public spaces for children was reassessed to examine how spatial conditions and reconfigured network structures affect accessibility.

4.1.4.1 Choice

Following the same choice-based framework described in the baseline analysis, Z-score normalised angular Choice values are recalculated for the post-intervention network to assess changes in movement patterns and exposure levels. At a radius of 400 m, the results show that higher Choice values become more concentrated along selected main connectors, while many internal residential streets exhibit reduced through-movement potential. This pattern shows a clearer separation between streets that support neighbourhood-level movement and those that primarily serve as local streets within superblocks. In general, the post-intervention configuration represents a decrease in locally dispersed through-movement and the creation of calmer internal street environments, forming the basis for evaluating changes in the exposure of child-related public spaces.

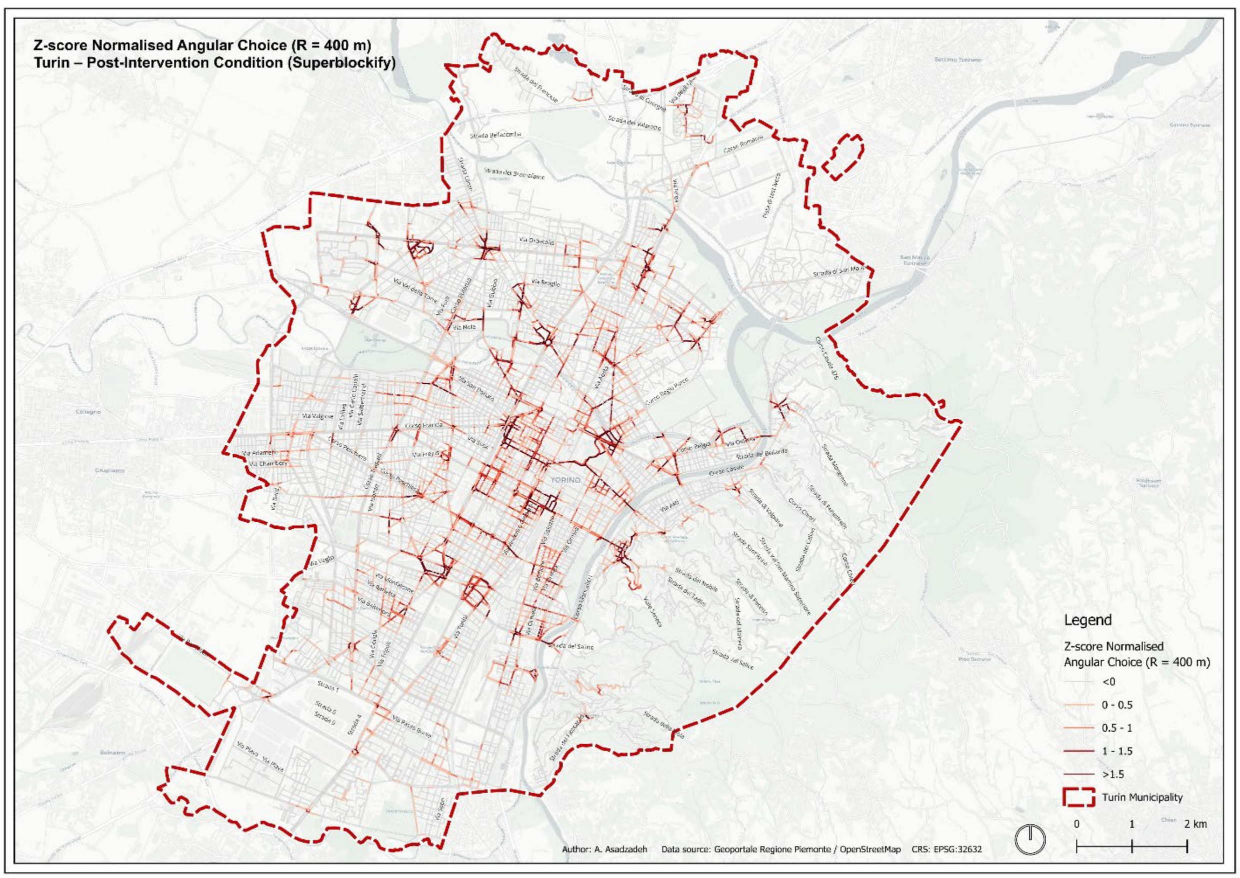


Figure 4-16 Z score normalized angular Choice (R= 400m) - Turin post intervention Condition

At the neighbourhood scale (R= 800 m), the results indicate a more selective distribution of through-movement, with higher Choice values largely confined to a limited number of main routes. These streets continue to play a key connective role at the city scale, while most internal streets exhibit lower Choice values.

In contrast to the pre-intervention condition, through-movement is less spread across the network and more clearly directed along primary corridors. This pattern shows the superblock's effect in separating strategic movement routes from internal residential streets. As a result, the post-intervention configuration suggests a network that is better suited to limiting exposure to through-movement within neighbourhood interiors, particularly in areas hosting child-related public spaces.

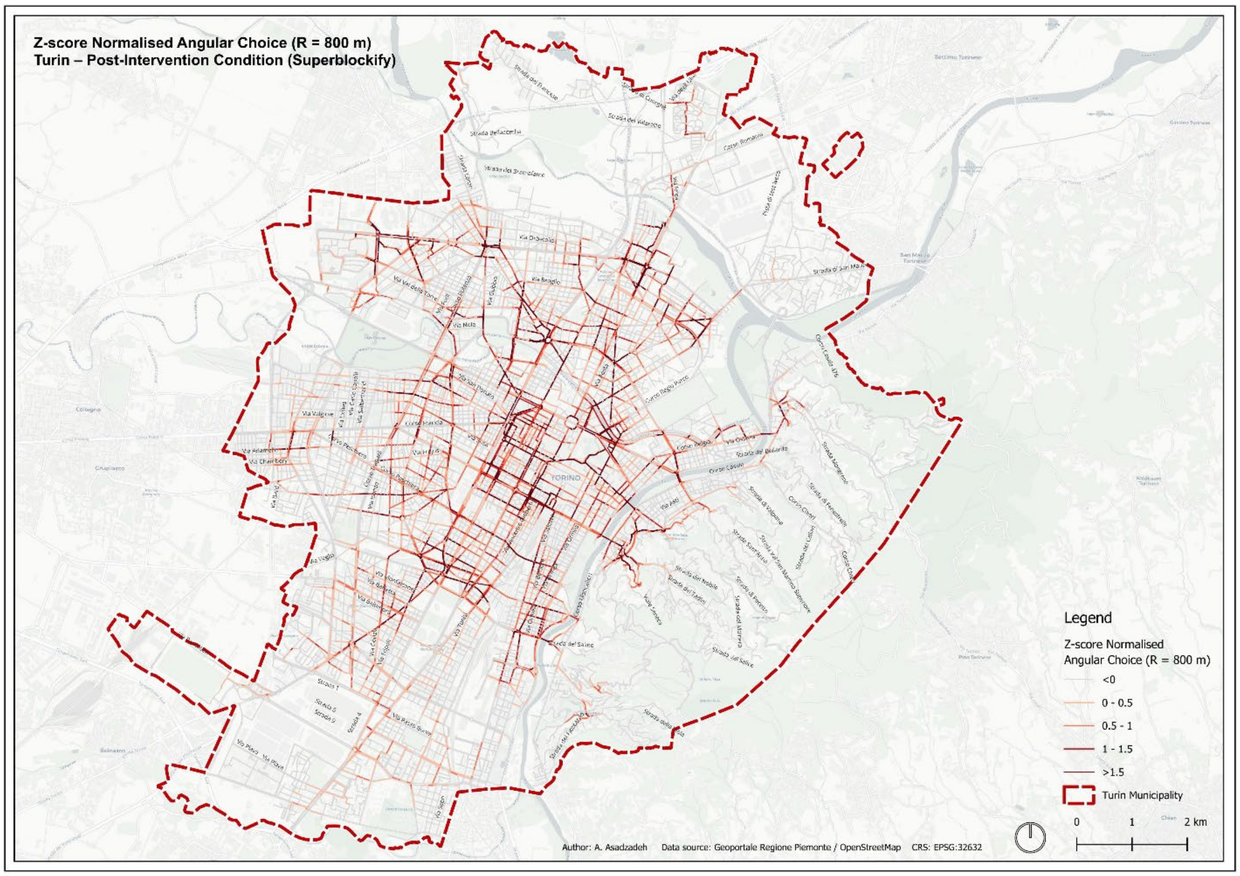


Figure 4-17- Z score normalized angular Choice (R= 800m) - Turin post intervention Condition

Exposure of Public Spaces based on Choice

At a 400 m radius, the overall exposure pattern of child-related public spaces remains broadly similar after the intervention, with the majority of spaces continuing to fall into the low exposure category. However, the maps show a slight spatial redistribution: some public spaces that were previously closer to higher-choice street segments are now more clearly fixed with calmer local networks. While the quantitative differences are limited, Map 4-17 indicates a slight reduction in the concentration of high-exposure locations along central.

Table 4-7- Exposure of Public Spaces based on Choice (R=400 m) – Turin -Post Intervention Condition

Exposure – 400 m	Percentage
Low exposure	81.13
Medium exposure	14.88
High exposure	3.99

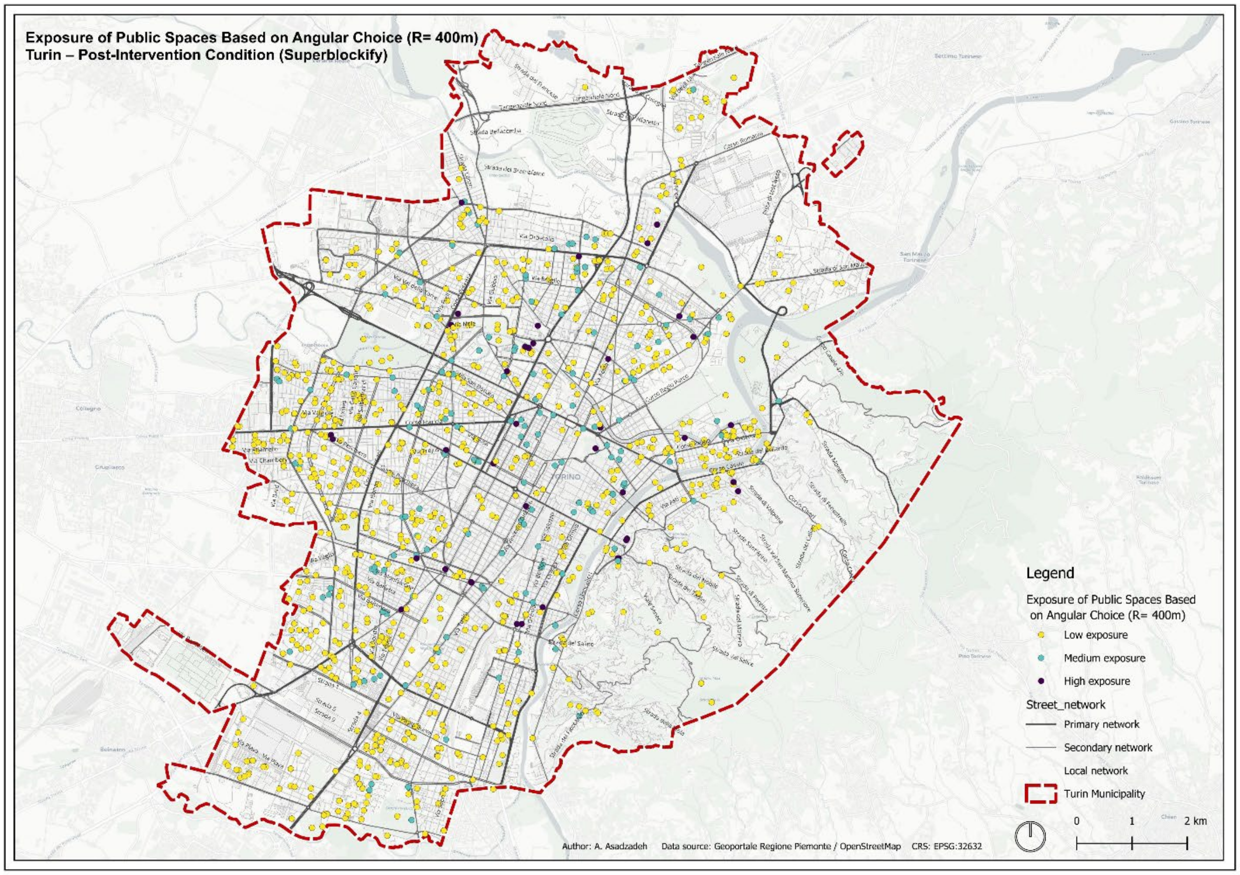


Figure 4-18- Exposure of public spaces based on choice (R=400m) – Turin Post Intervention condition

At the 800 m radius, the post-intervention results indicate that most public spaces stay within the low exposure category (70.79%), while medium exposure accounts for 21.38%, and high exposure increases to 7.83%. Spatially, higher exposure points are mainly aligned with the main structural corridors that remain active after the intervention, whereas the interior areas of superblocks show mostly low exposure. The overall pattern remains the same, but exposure becomes more clearly concentrated along primary routes, suggesting a clearer separation between through-movement corridors and calmer internal neighbourhood spaces.

Table 4-8- Exposure of Public Spaces based on Choice (R=800 m) – Turin -Post Intervention Condition

Exposure – 800 m	Percentage
Low exposure	70.79
Medium exposure	21.38
High exposure	7.83

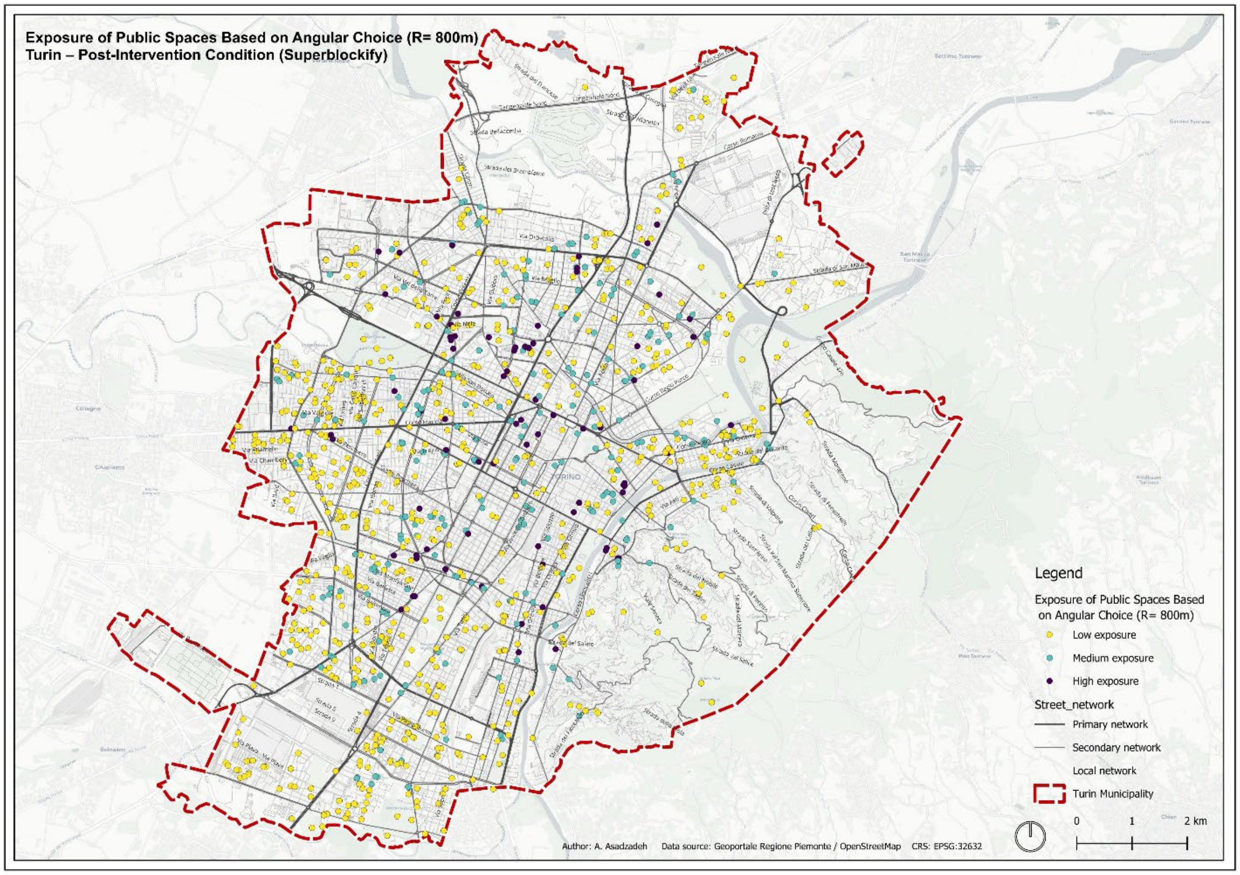


Figure 4-19- Exposure of public spaces based on choice (R=800m) – Turin Post Intervention condition

4.1.4.2 Integration

The Map 4-19 shows that high integration values remain concentrated in the central areas of Turin, where the street network is denser and more continuous. However, compared to the baseline condition, integration becomes more evenly distributed across neighbourhoods. Some Marginal and Residential areas display slightly improved integration, indicating better local connectivity following the superblock-based reconfiguration. Although the number of highly integrated street segments decreased after the intervention, medium-integration values have become more widespread across the network. This indicates a more balanced spatial structure.

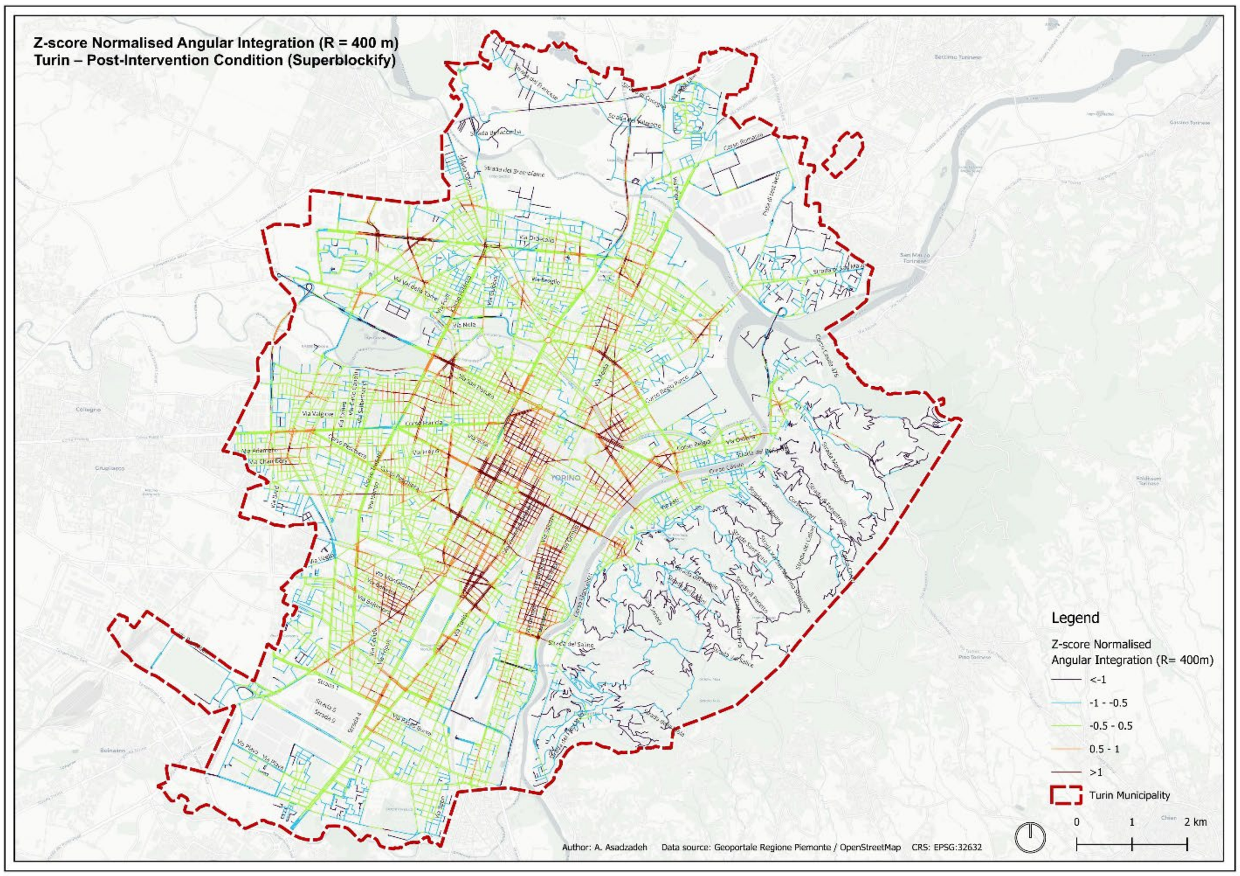


Figure 4-20- z score normalised angular Integration (R= 400m) – Turin- Post intervention

In Map 4-20, the highest integration values remain concentrated along the main city core and primary corridors, but their spatial extent is reduced compared to the current condition. Marginal streets show a shift toward intermediate integration ranges, while strongly segregated values become less dominant. The numerical distribution indicates a decrease in extreme integration contrasts and a smoother gradient from central to outer areas, suggesting a more balanced large-scale accessibility structure after the superblock intervention.

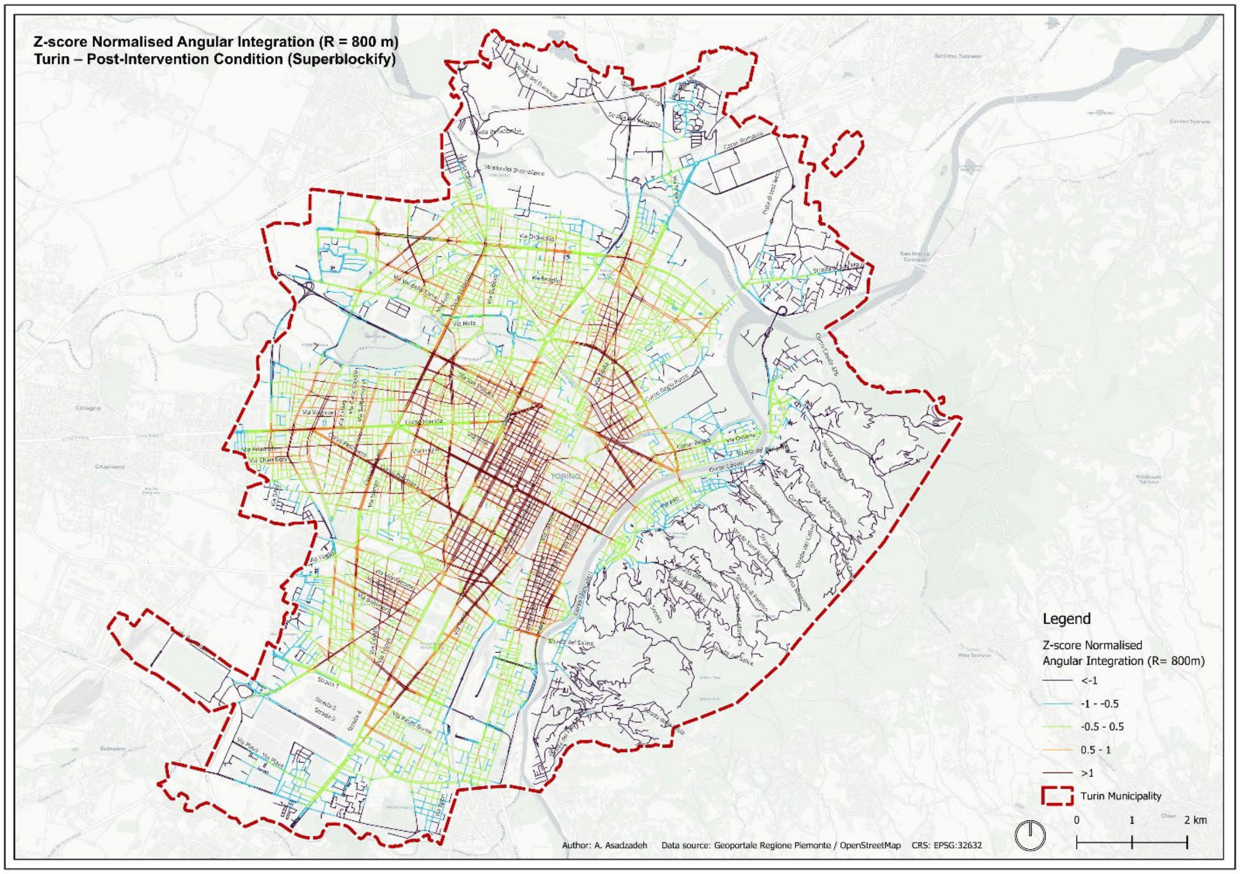


Figure 4-21- z -score normalised angular Integration (R= 800m) – Turin- Post intervention

Accessibility of public spaces based on integration

Map 4-21 shows that public spaces with higher accessibility are mainly clustered within inner neighbourhoods and areas connected to dense local street grids. These spaces are fixed in streets that stay good local continuity and short-distance connectivity. Public spaces with medium accessibility are more widely distributed across the urban fabric, indicating a relatively even local embedding across many residential areas. In contrast, low-accessibility public spaces are predominantly located along peripheral zones, fragmented edges, and areas adjacent to major infrastructures or natural barriers, where local street connectivity is weaker. The pattern shows a locally more coherent and neighbourhood-oriented accessibility structure, with a reduction in fragmentation inside residential areas.

Table 4-9- Accessibility of Public Spaces based on Integration (R=400 m)

Accessibility – 400 m	Percentage
Low accessibility	31.17
Medium accessibility	54.82
High accessibility	14.02

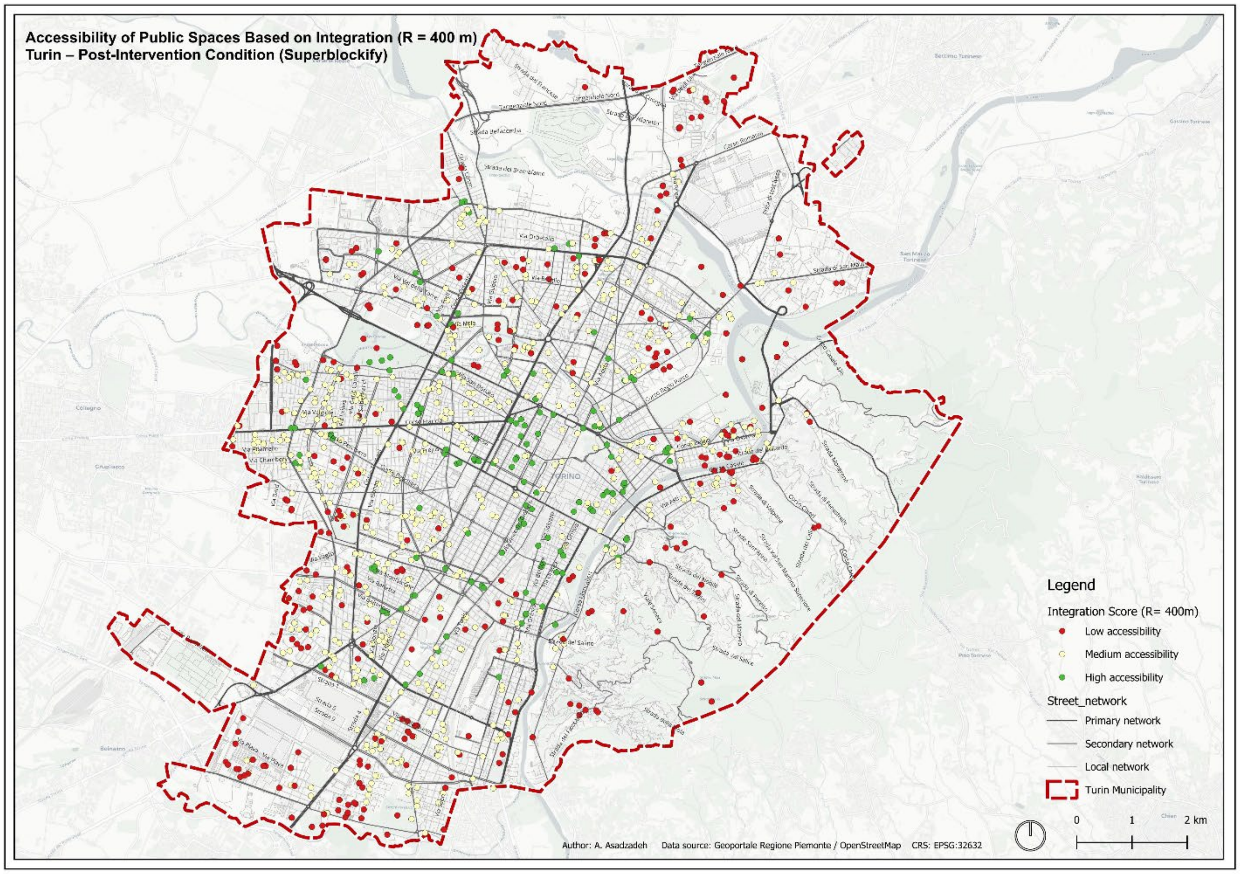


Figure 4-22- Accessibility of public spaces based on integration (R=400m) – Turin Post Intervention Condition

At the neighbourhood level (R = 800 m), the post-intervention map shows a more balanced spatial spread of accessible public spaces across the city. Areas with stronger accessibility are following the main urban structure and very good connection with residential districts, while moderately accessible spaces appear throughout both central and intermediate zones. Locations with weaker accessibility are mainly at the urban edges and in areas where the street network becomes less continuous.

Table 4-10- Accessibility of Public Spaces based on Integration (R=800 m)

Accessibility – 800 m	Percentage
Low accessibility	33.12
Medium accessibility	40.96
High accessibility	25.92

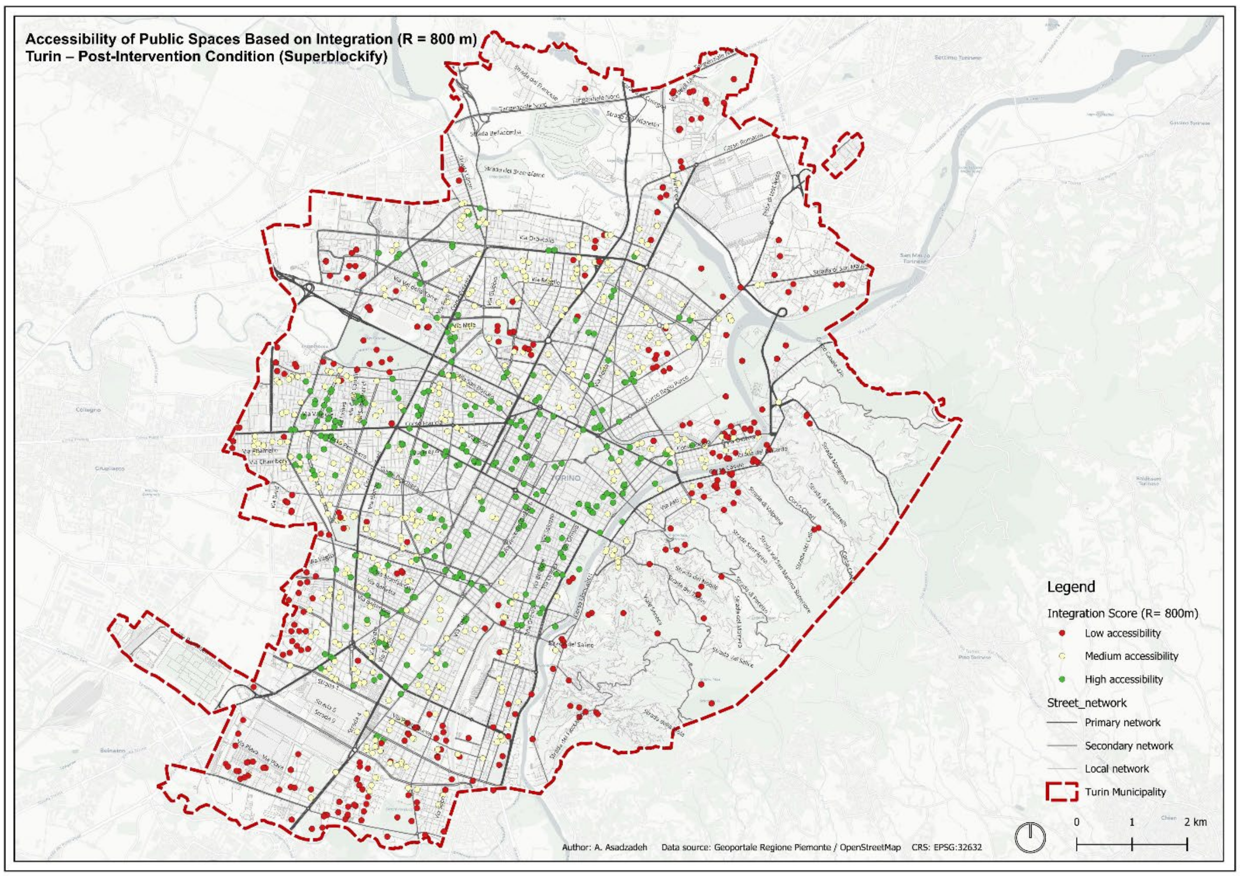


Figure 4-23- Accessibility of public spaces based on integration (R=800 m) – Turin - post-intervention Condition

4.1.4.3 Composite accessibility quality

Map 4-23 presents the combined results of Integration and Choice through a composite accessibility quality (R=400). The spatial distribution of scores indicates that more than 80% of Public spaces are in the medium to high composite quality categories, reflecting a simultaneous improvement in local connectivity (integration) and a reduction in dominant through-movement pressure (choice) in their surroundings. Higher scores are mainly observed in areas with a more regular and legible street structure, while lower scores are largely confined to marginal zones and areas with more fragmented spatial configurations.

The findings represent that, compared to the current condition, the general accessibility situation has been improved, the share of low-quality areas has decreased, and a more balanced and good accessibility pattern has emerged across the city.

Table 4-11- Composite quality accessibility – (R=400 m)

Composite quality accessibility – 400 m	Percentage
A — Very high composite accessibility quality	5.8
B — High composite accessibility quality	51.1
C — Medium composite accessibility quality	32.3
D — Low composite accessibility quality	10.5
E — Very low composite accessibility quality	0.3

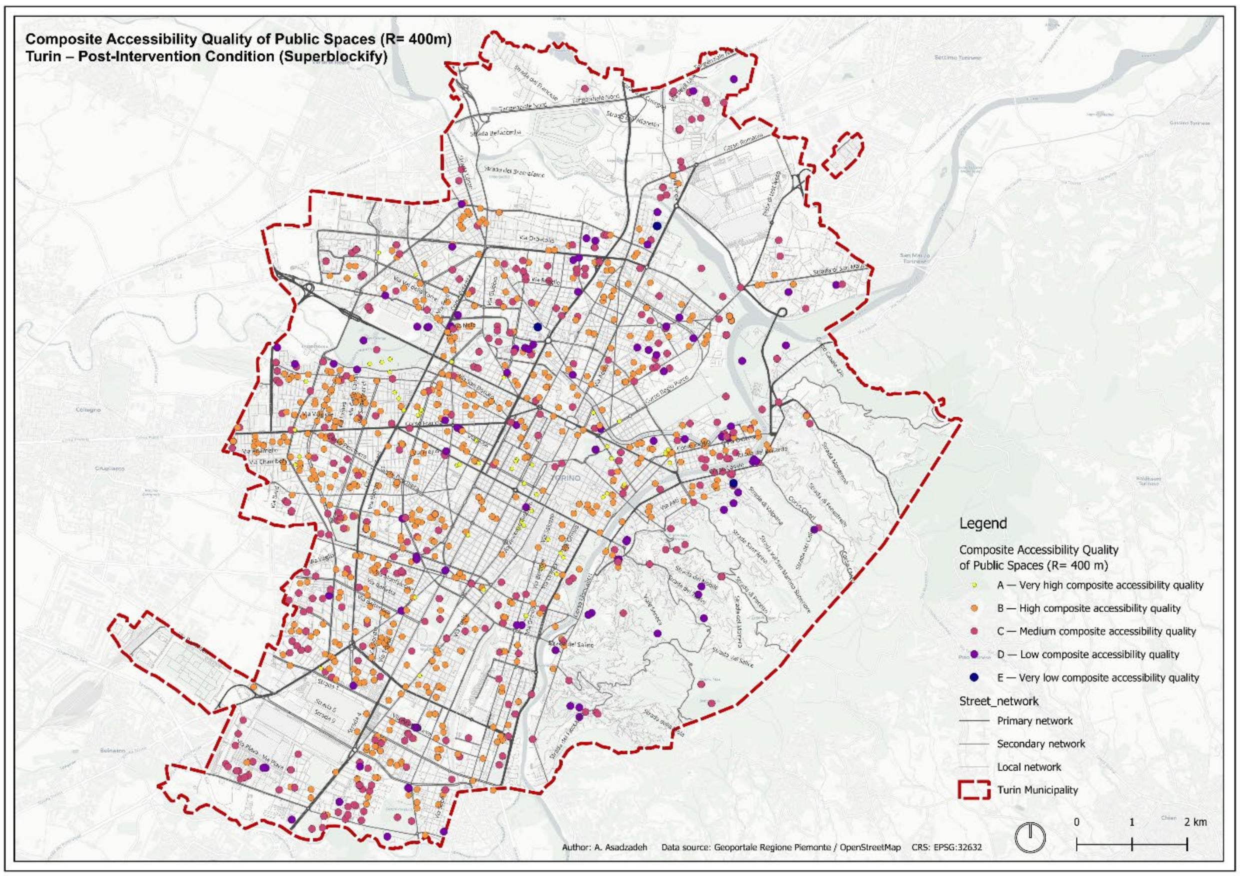


Figure 4-24- Composite Accessibility Quality (R=400 m) – Turin - post-intervention Condition

The map below shows that most public spaces fall within the high (36.8%) and medium (26.8%) composite accessibility categories, indicating that a large share of locations are reasonably well connected to the wider street network at this distance. A smaller but still notable proportion is classified as low composite accessibility (21.8%)**,** while very low accessibility remains limited (1.5%) and appears mainly in more marginal areas and north of Turin. The results represent a generally moderate-to-high level of composite accessibility across the city, with lower-quality scores concentrated in specific, spatially constrained zones rather than being widespread.

Table 4-12- Composite quality accessibility – (R=800 m)

Composite quality accessibility – 800 m	Percentage
A — Very high composite accessibility quality	13.1
B — High composite accessibility quality	36.8
C — Medium composite accessibility quality	26.8
D — Low composite accessibility quality	21.8
E — Very low composite accessibility quality	1.5

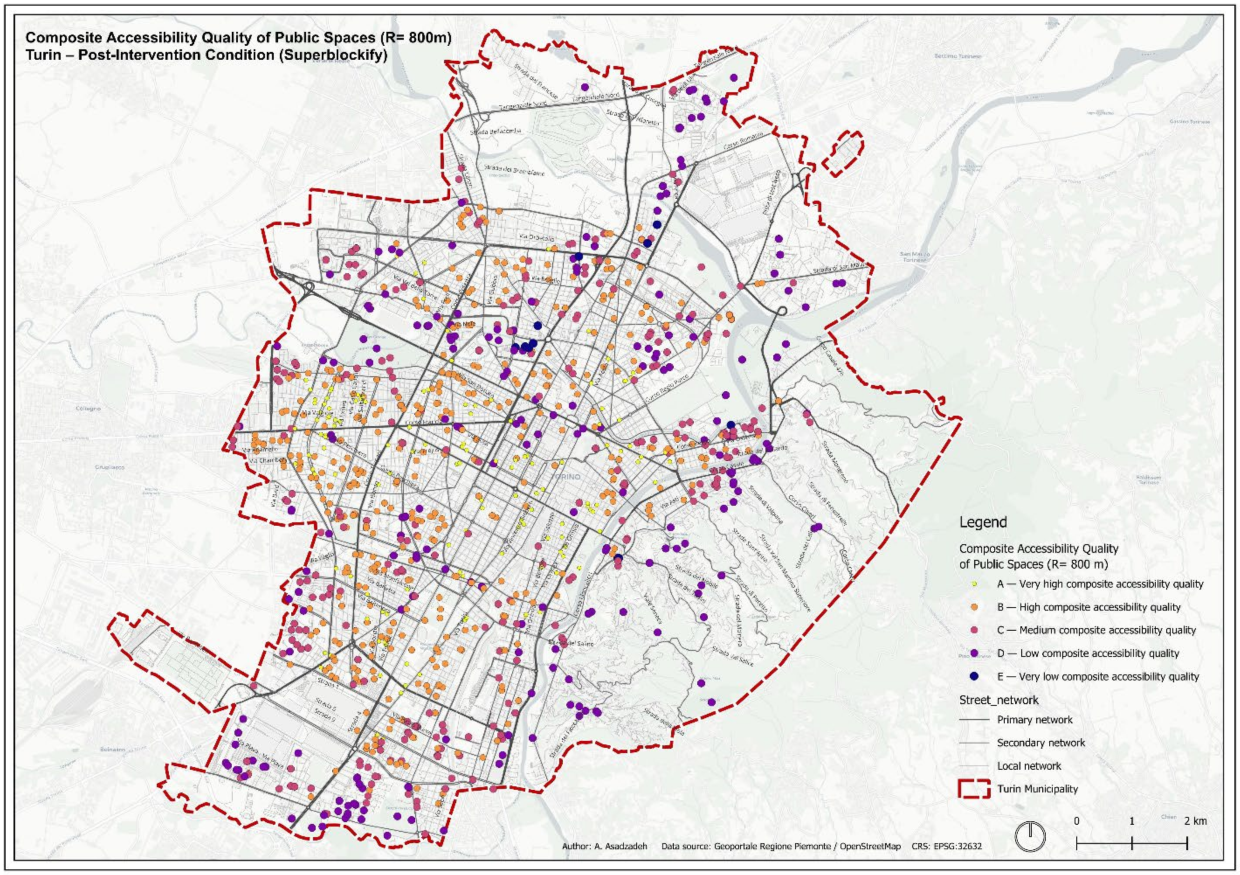


Figure 4-25- Composite Accessibility Quality (R=800 m) – Turin - post-intervention Condition

4.2 Braga

4.2.1 City Overview, Street Network Configuration, and Distribution of Child-Related Facilities

4.2.1.1 City overview

Braga is a city and a municipality, capital of the northwestern Portuguese district of Braga and of the historical and cultural Minho Province. Braga Municipality had a resident population of 201,583 inhabitants (in 2023), representing the seventh largest municipality in Portugal by population. Its area is 183.40 km2. Its agglomerated urban area extends to the Cávado River and is the third-most-populated urban area in Portugal, behind the Lisbon and Porto Metropolitan Areas (Wikipedia). Braga has a compact urban and residential core, whereas most of the surrounding areas are composed of dispersed housing, open land, and rural or semi-rural uses.

Figure 4-26- Pictures of Braga Municipality

Map 4-25 illustrates the geographical context and administrative position of the Municipality of Braga across different spatial scales. The left panel presents the national context of Portugal, highlighting the Braga District within the country's administrative division, which comprises 18 districts in total. This panel situates Braga within the northern part of Portugal. The top-right panel shows the location of the Municipality of Braga within the Braga District, emphasizing its position relative to the surrounding municipalities. Finally, the bottom-right panel depicts the administrative boundary of the study area, which corresponds to the Municipality of Braga, outlined with a dashed line to clearly distinguish the area selected for spatial analysis.

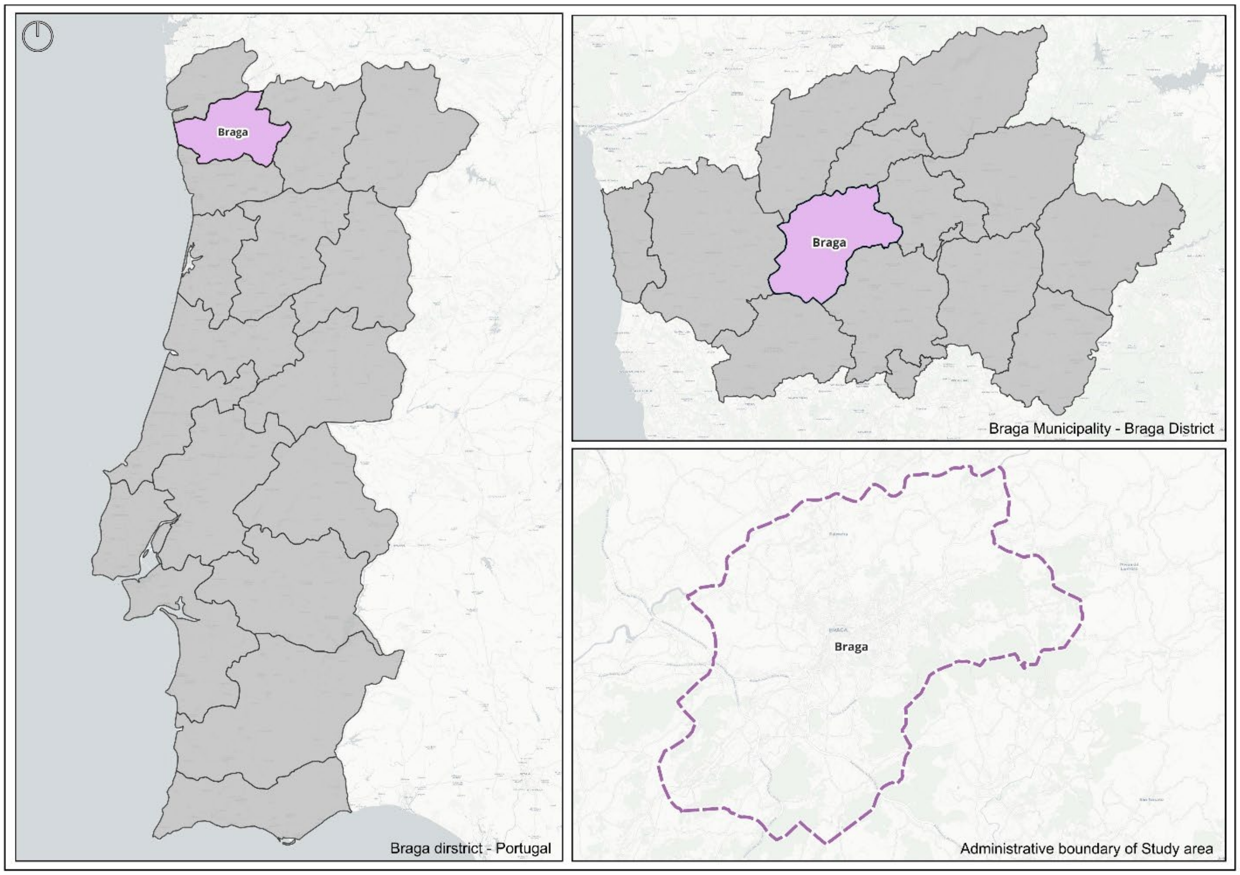


Figure 4-27- situation of the Municipality of Braga

4.2.1.2 Current Stret Configuration in Turin

The layout of Braga's streets reflects both its historical Roman origins and the demands of today's city life, featuring a compact, walkable historic center with narrow, winding streets (like in Maximinos, Sé, Cividade) filled with cafes and shops, connecting to a wider system for efficient traffic flow, incorporating elements like covered market streets and elevated paths for connectivity, all within a landscape shaped by surrounding mountains and valley.

The map below shows the street network of Braga in Current Condition, classified into Primary network (Including: RedeSupramunicipal and ViaEstruturantePrincipal), Secondary network (including: ViaEstruturanteSecundaria and ViaEstruturanteLocal), and Local network (including: ViaAcessoLocal and ViaAcessoLocal-TransitoCondicionado).

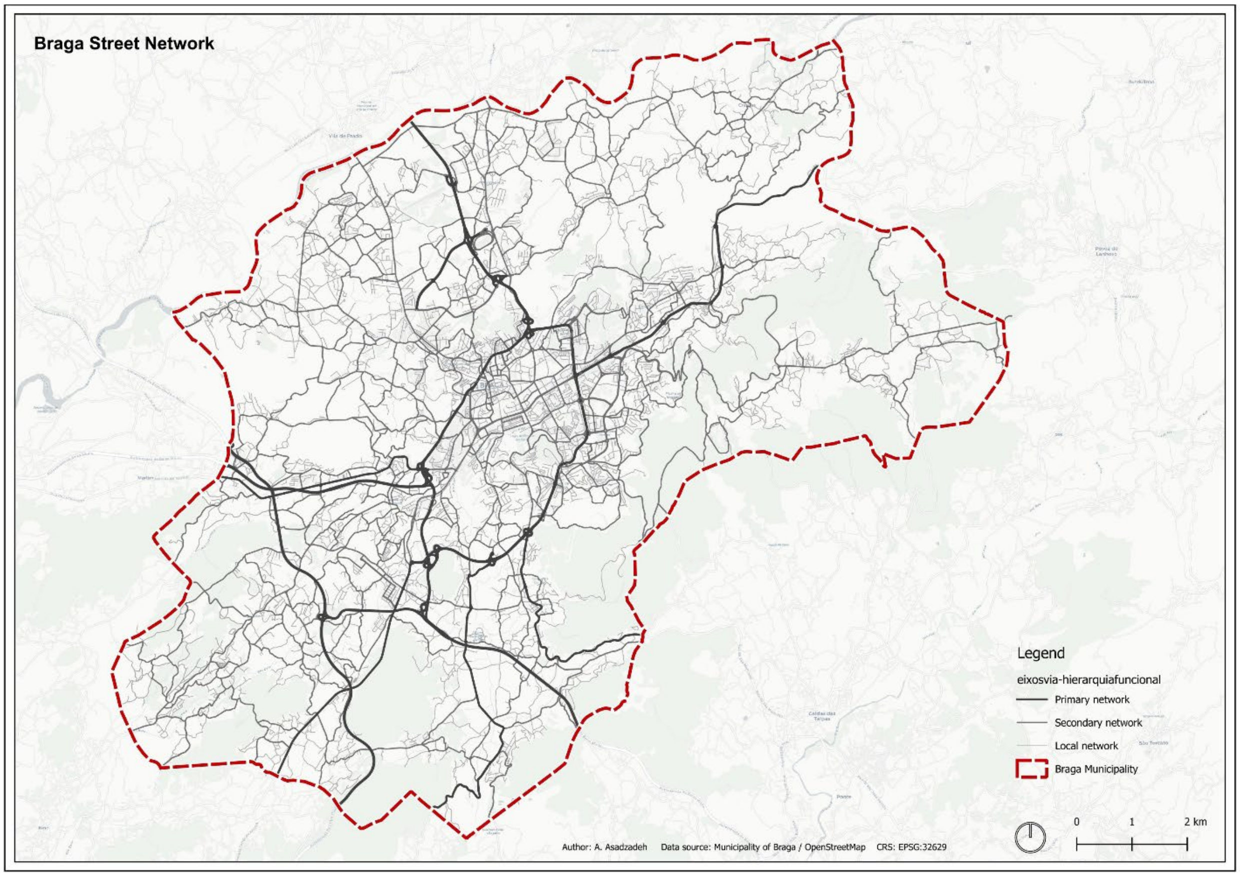


Figure 4-28- Street network – Braga Current Condition

4.2.1.3 Public Spaces (Parks, Playgrounds, and Schools)

The map 4-27 shows a total of 279 child-related public spaces in Braga, including 100 parks and green areas, 16 playgrounds, and 163 schools and kindergartens. These facilities are unevenly distributed across the municipality, with a clear concentration in the central urban area, where the street network is denser and urban functions are more compact. Schools and kindergartens form the largest share and are strongly clustered around the city centre, reflecting residential density and service accessibility. Parks and green areas are more spatially dispersed, extending toward peripheral zones and playgrounds are fewer in number and mainly located within consolidated neighbourhoods.

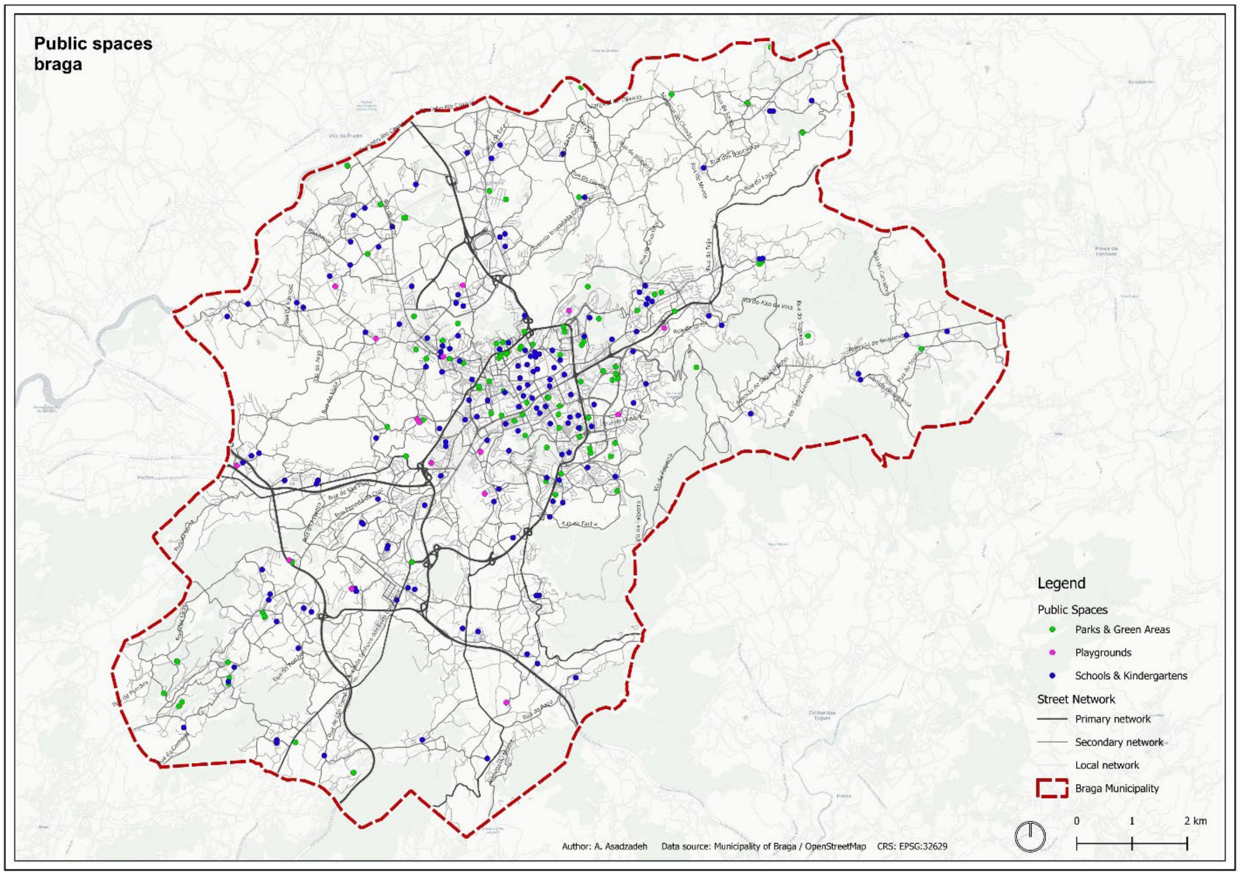


Figure 4-29- Public spaces – Braga Current condition

4.2.2 Baseline Spatial Analysis – Current Condition

For the Braga case study, the same baseline analytical framework adopted for Turin is applied without modification. The street network is analysed using an identical segmented representation, and the same Space Syntax metrics and radii are employed. Integration and Choice values calculated at 400 m and 800 m are linked to public spaces for children to assess accessibility and exposure under current conditions.

4.2.2.1 Choice

Map 4-28 shows that higher Choice values are limited and scattered geographically throughout Braga. Elevated scores are observed along a few key connecting corridors near the central urban area, indicating localized concentrations of through movement at the walkable scale. Conversely, the majority of street sections exhibit minimal Choice values, mostly in topographically areas with limitations, reflecting a network that primarily supports local movement rather than continuous through-routes. In general, there is a locally oriented street network, with through movement limited and movement patterns mostly neighbourhood-based.

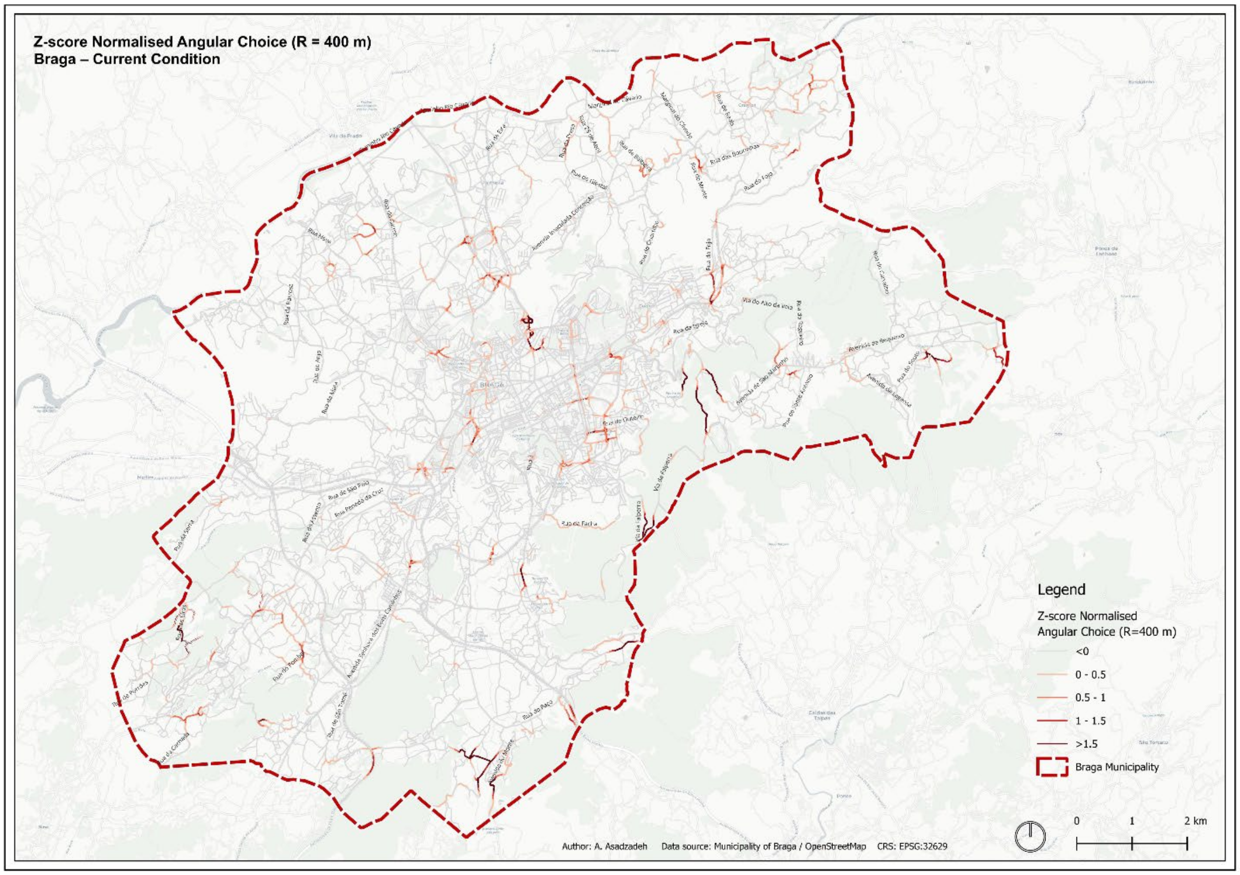


Figure 4-30- Z-Score Normalised Angular choice (R=400 m) – Braga Current Condition

Map 4-29 reveals a selective distribution of higher Choice values within Braga's street network. Segments with elevated scores are mostly focused around the central urban area and along a limited number of connecting axes, indicating that through-movement at the neighbourhood scale is channelled through specific corridors rather than being widely dispersed. Outside these areas, the network is characterised by mostly low Choice values, especially in outer and topographically constrained zones.

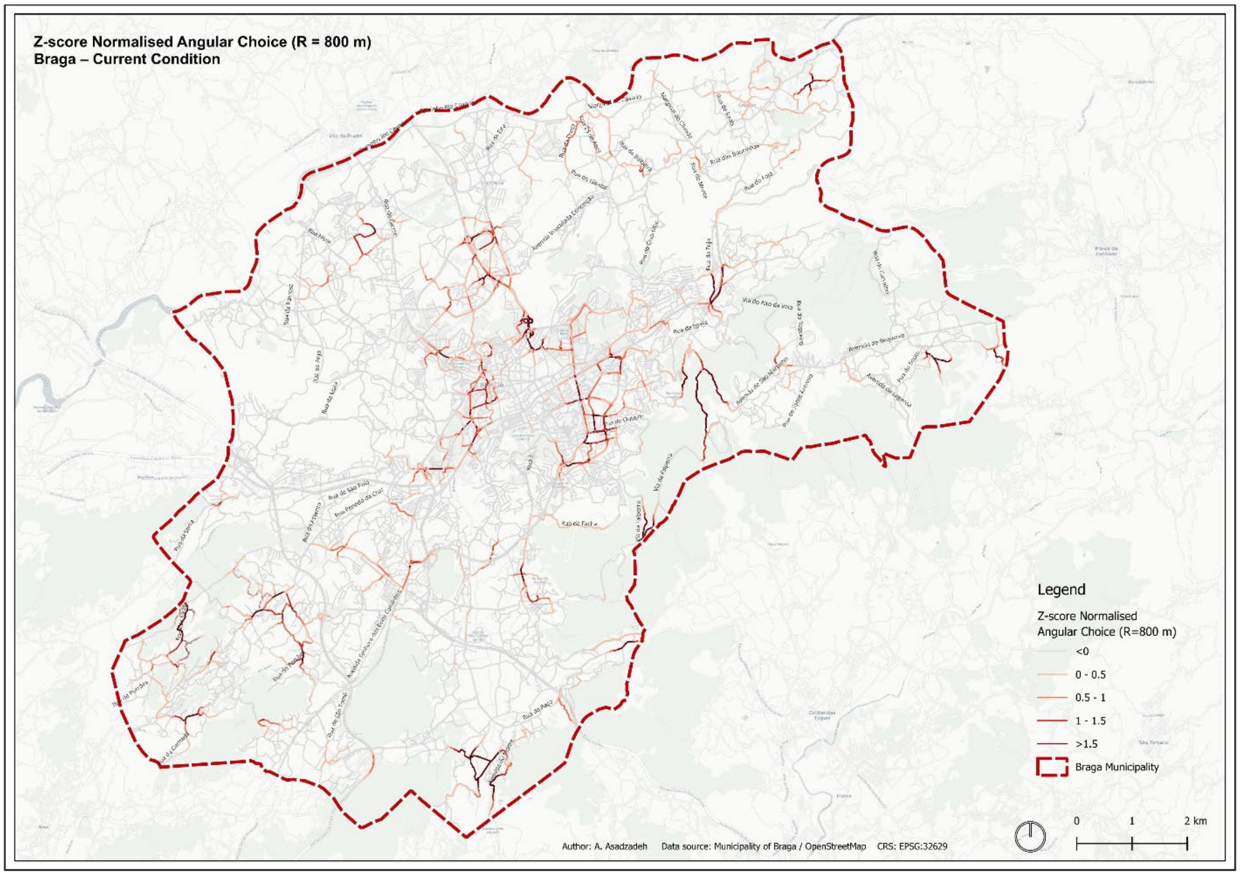


Figure 4-31- Z-Score Normalised Angular choice (R=800 m) – Braga Current Condition

Exposure of Public Spaces based on Choice

Map 4-30 indicates that most public areas are considered to have low levels of exposure (90.6%), indicating limited association with through-movement at the local scale. Medium exposure are 9.1%, while high exposure is virtually insignificant (0.3%), showing that the most public spaces related to children are located along streets, primarily supporting local rather than through movement.

Table 4-13- Exposure of Public Spaces based on Choice (R=400 m)

Exposure – 400 m	Percentage
Low exposure	90.6
Medium exposure	9.1
High exposure	0.3

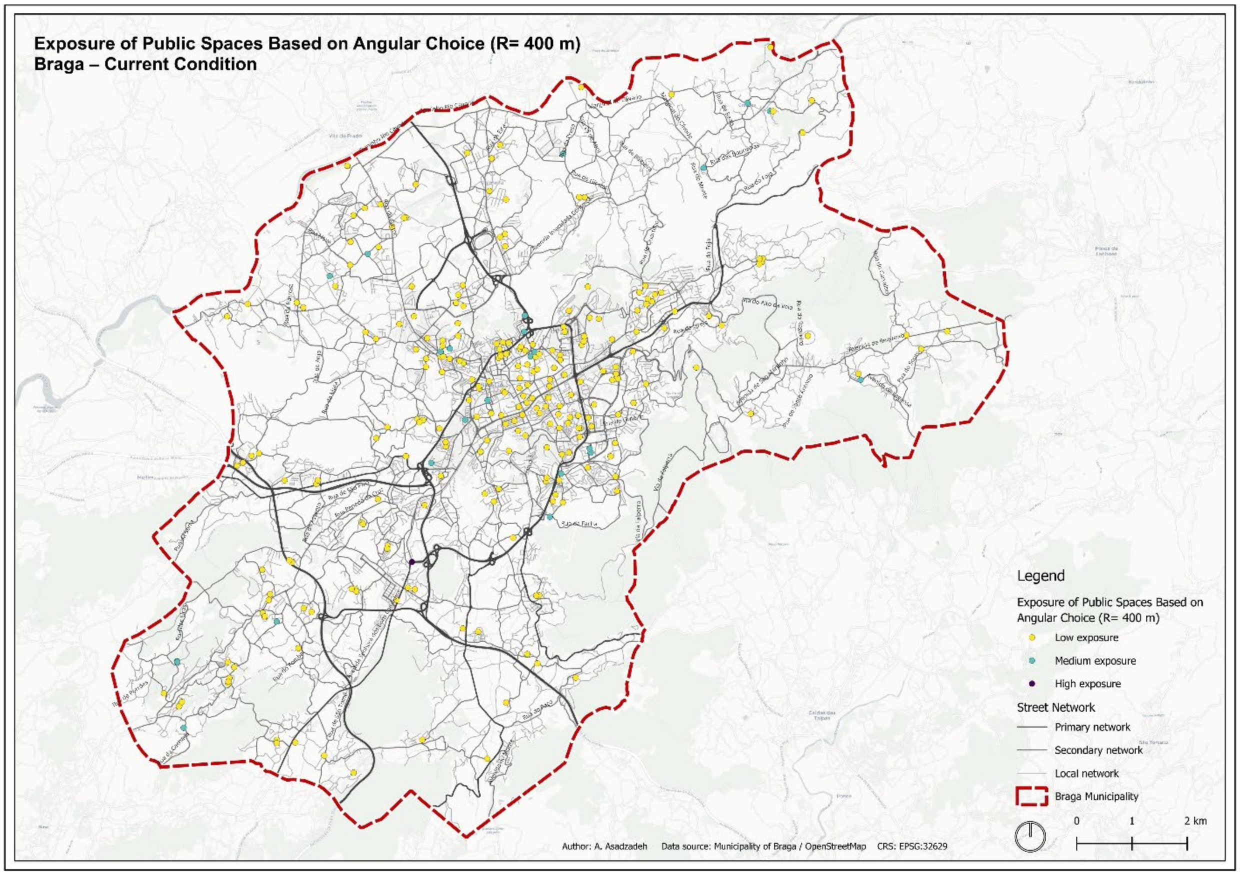


Figure 4-32- Exposure of Public spaces based on angular choice (R= 400) – Braga Current Condition

Map 4-31 and the accompanying table illustrate that most public spaces are in the low exposure category (83%), indicating limited alignment with streets that concentrate through-movement even at the broader neighbourhood scale. Medium exposure increases to 16.4%, reflecting a stronger influence of main connectors around the central urban area, while high exposure remains marginal (0.6%). Overall, the pattern suggests that child-related public spaces in Braga are largely in locally oriented networks, with only a small share located along streets with higher through-movement potential.

Table 4-14- Exposure of Public Spaces based on Choice (R=800 m)

Exposure – 400 m	Percentage
Low exposure	83
Medium exposure	16.4
High exposure	0.6

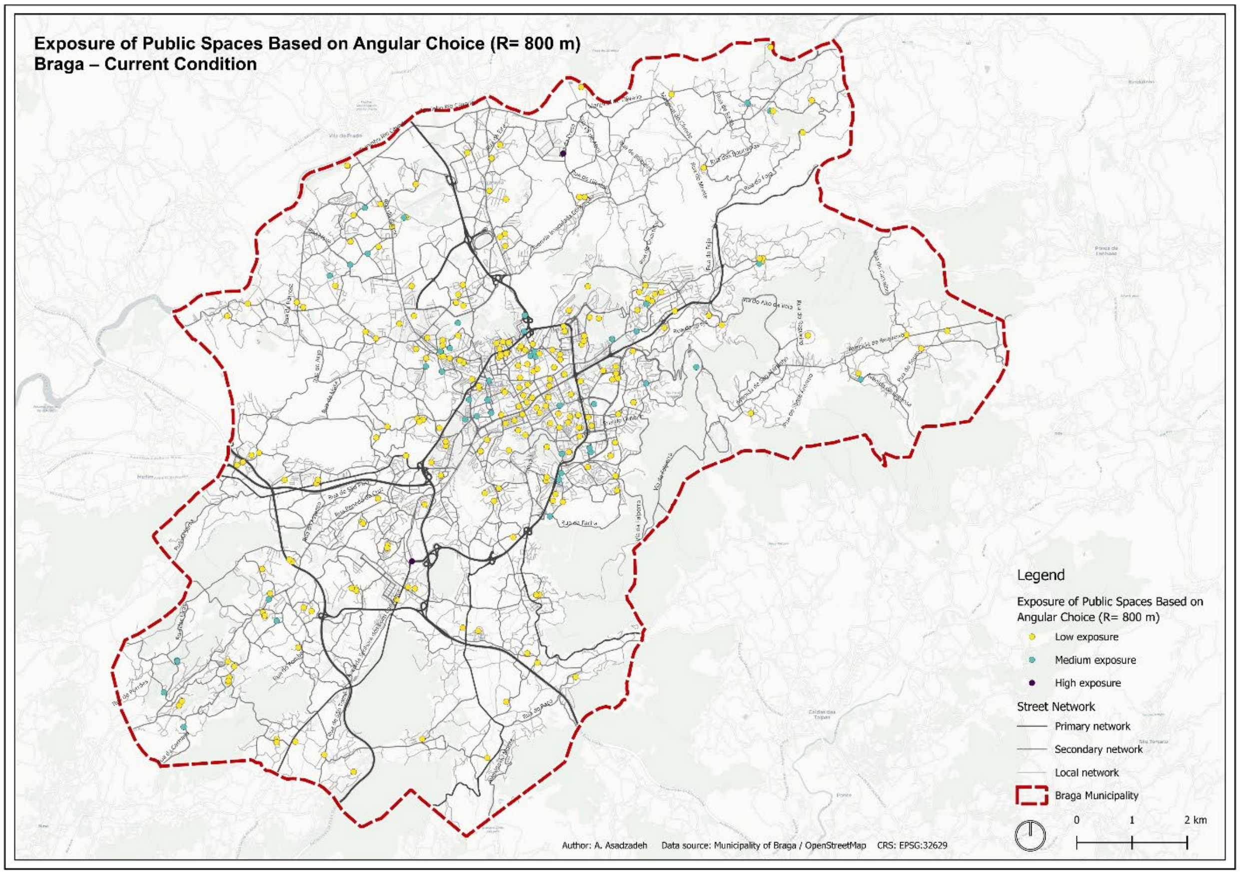


Figure 4-33 – Exposure of Public spaces based on angular choice (R= 800) – Braga Current Condition

4.2.2.2 Integration

The map below presents Z-score normalised angular Integration at a 400 m. The network is dominated by medium integration values (around the central Z-score range), indicating that most streets operate as locally connected routes rather than strong attractors of movement.

There is no very low integration for streets across the whole municipality; only in some primary streets in the south is integration more accessible, as shown in darker colors.

In general, the map shows a largely uniform and weakly differentiated pattern, indicating a locally flat spatial structure with no clearly dominant or highly integrated urban core.

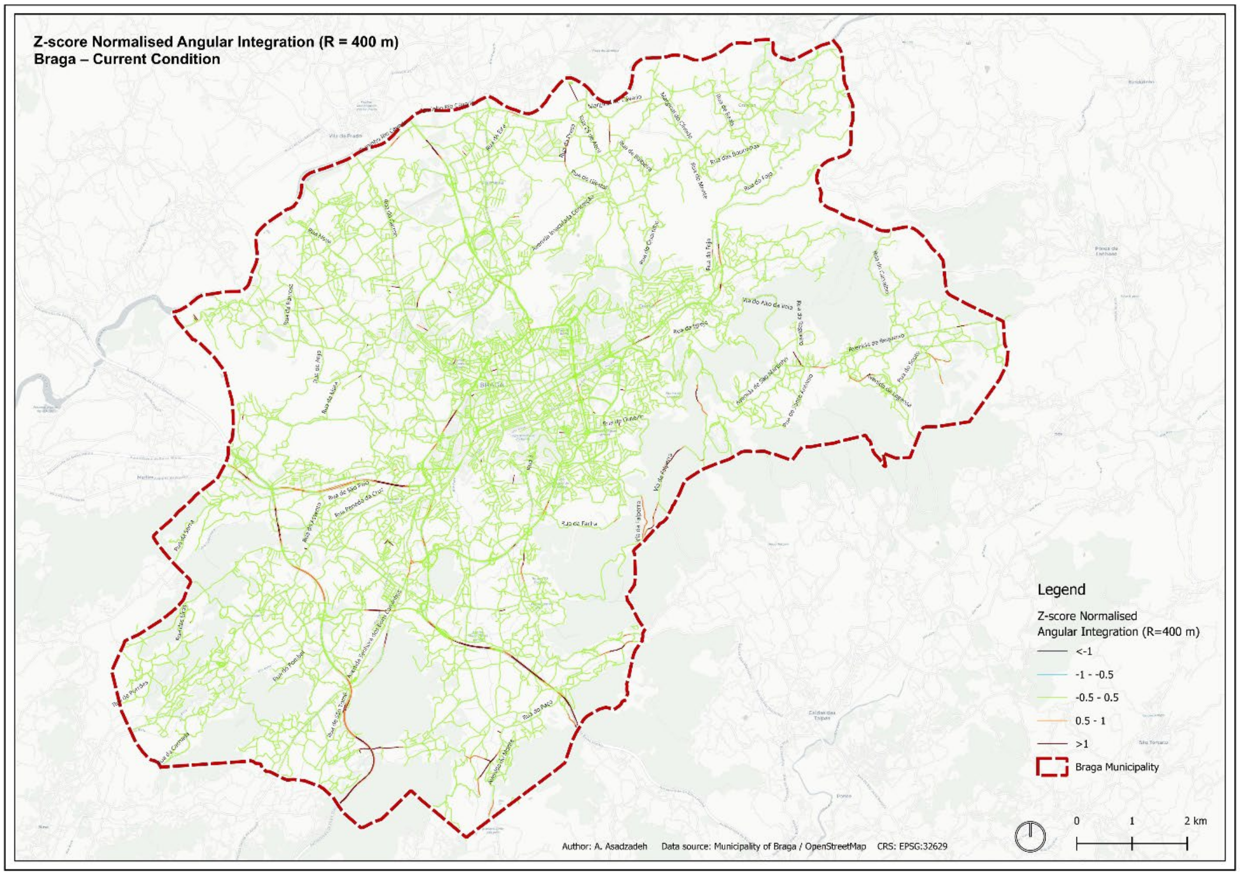


Figure 4-34- Z-score normalised angular integration (R=400 m) – Braga Current condition

Map 4-33 shows that, most of the network shows similar, medium integration values, the central area of Braga are a little in higher integration, forming a weak but clear core. This indicates that movement accessibility is somewhat concentrated in the historic/central fabric but overall accessibility is evenly distributed across the municipality rather than concentrated in a single central area.

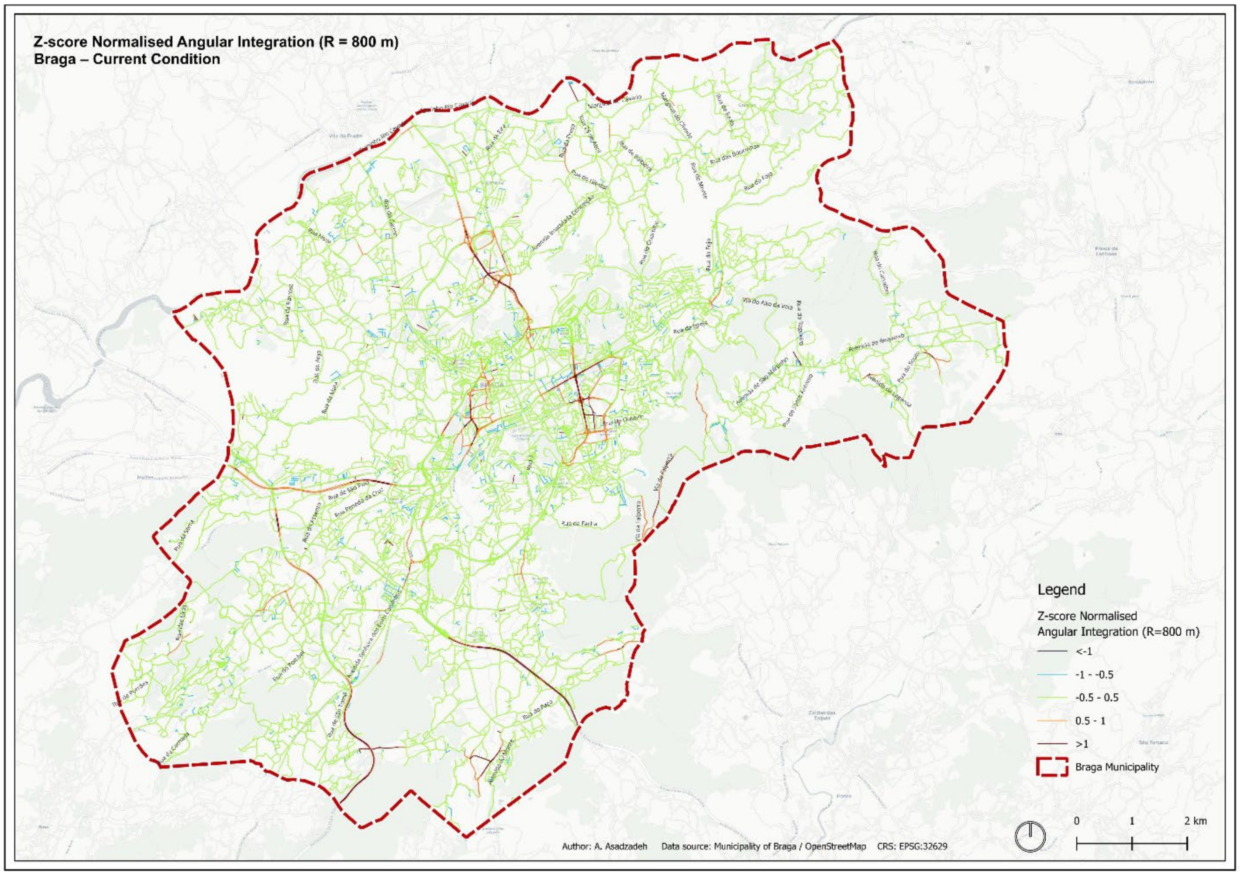


Figure 4-35- Z-score normalised angular integration (R=800 m) – Braga Current condition

Accessibility of public spaces based on integration

Map 4-34 shows that Most public spaces in Braga show moderate and fairly even accessibility at the 400 m scale. Almost all locations are in the medium accessibility category, which means that public spaces are generally easy to reach within short walking distances. There are no clearly isolated areas, and only a small number of spaces stand out as highly accessible, mainly along the most connected streets near the primary network. Overall, the map shows a balanced local accessibility pattern, where public spaces are well integrated into the everyday street network rather than concentrated in a few highly connected locations.

Table 4-15- Accessibility of Public Spaces based on Integration (R=400 m)

Accessibility – 400 m	Percentage
Low accessibility	0
Medium accessibility	99.1
High accessibility	0.9

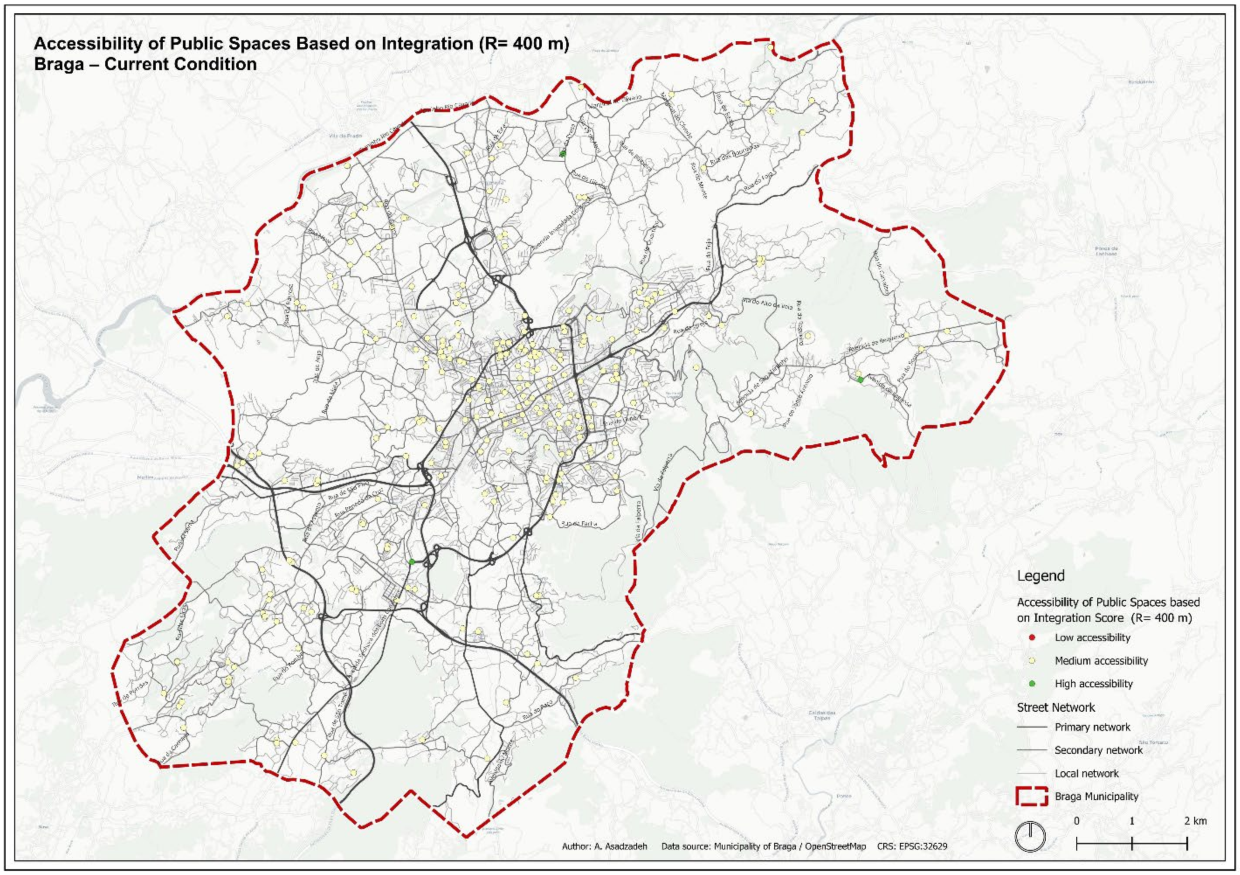


Figure 4-36- Accessibility of Public spaces based on Integration (R= 400m) – Braga Current Condition

In the Map of Accessibility for public spaces based on integration with an 800 m radius, public spaces in Braga remain mostly within the medium accessibility range, indicating that most locations are reasonably connected at the neighbourhood level. A small share of low-accessibility spaces appears mainly in peripheral and less connected areas, while high accessibility is limited and concentrated along the main structural corridors near the urban core. In summary, the map shows a generally coherent but not highly polarized accessibility structure, with extended-range access present but only a few public spaces benefiting from very strong network integration.

Table 4-16- Accessibility of Public Spaces based on Integration (R=800 m)

Accessibility – 400 m	Percentage
Low accessibility	7.9
Medium accessibility	87.8
High accessibility	4.3

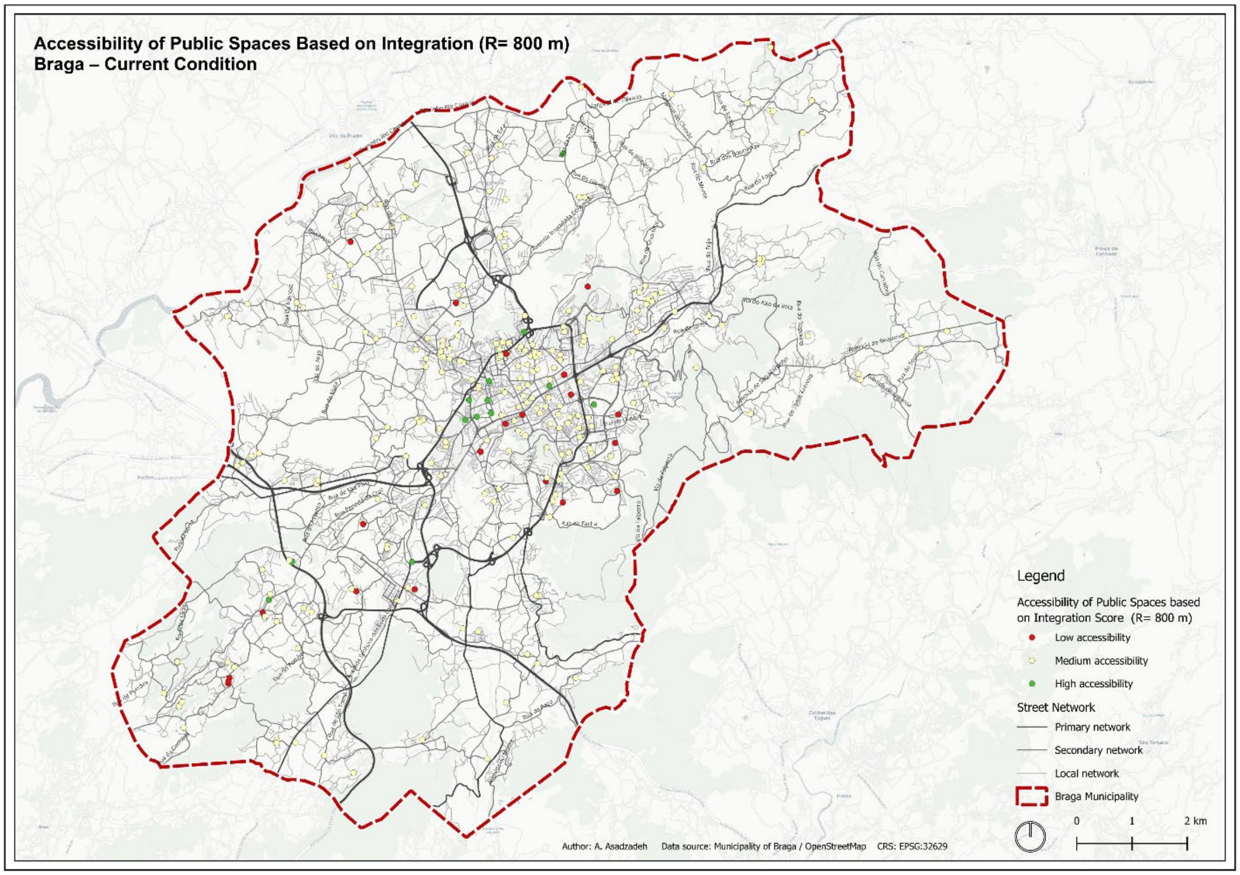


Figure 4-37- Accessibility of Public spaces based on Integration (R= 800m) – Braga Current Condition

4.2.2.3 Composite accessibility quality

The composite map for radius 400 m, puts together local accessibility and exposure conditions for giving a general evaluation of how good public areas are for kids.The findings indicate a clear prevalence of high composite accessibility quality, with the vast majority of public spaces classified in category B, indicating favourable local access combined with limited exposure to through-movement. Medium and low composite categories are very few and are distributed unevenly across the area , mainly outside the most consolidated urban areas. The absence of very low and very high extremes suggests a balanced and stable local accessibility structure, where most child-related public spaces benefit from adequate network integration without being located on highly exposed routes. The map reflects a generally supportive local environment for everyday child-oriented activities at the 400 m scale.

Table 4-17- Composite quality accessibility – (R=400 m)

Composite quality accessibility – 400 m	Percentage
A — Very high composite accessibility quality	0
B — High composite accessibility quality	91.2
C — Medium composite accessibility quality	7.9
D — Low composite accessibility quality	0.9
E — Very low composite accessibility quality	0

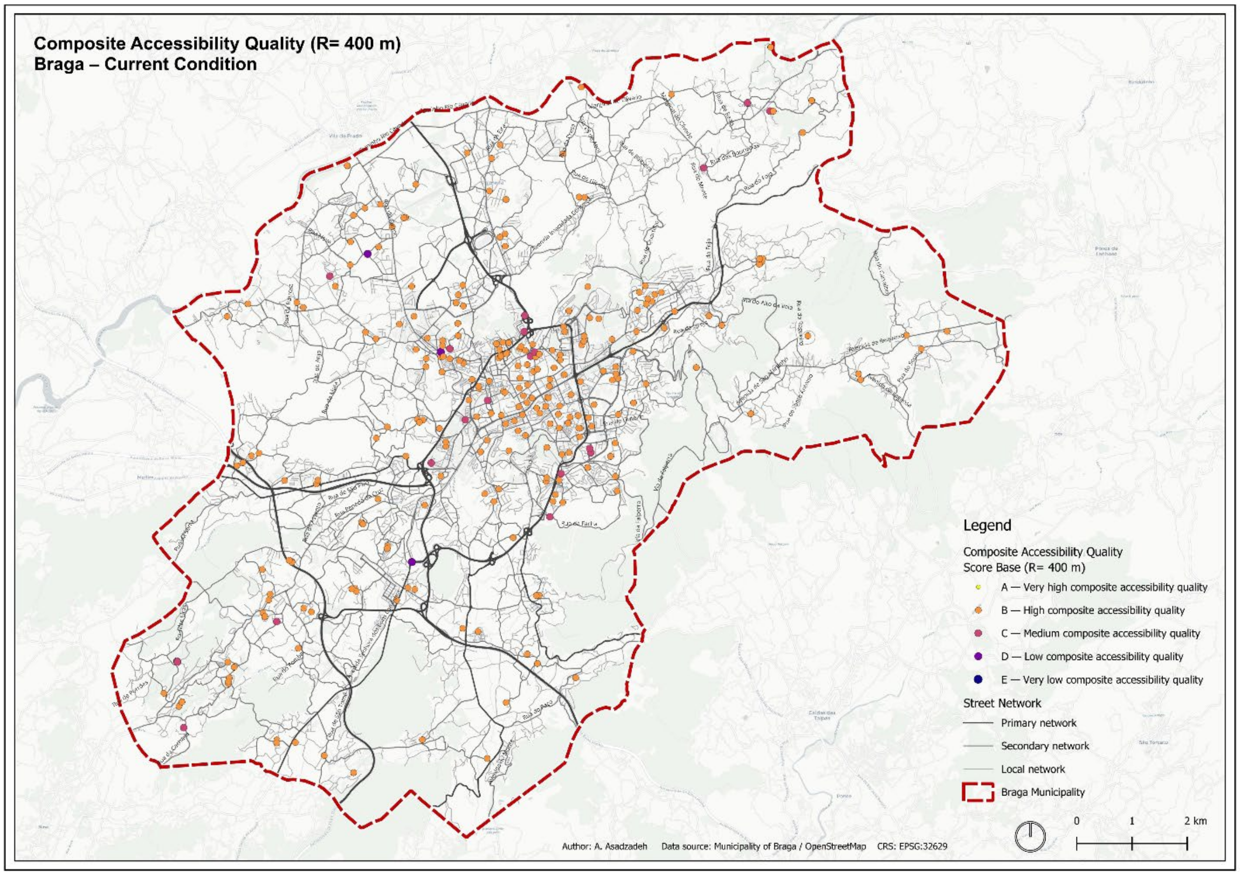


Figure 4-38- Composite quality Accessibility (R=400m) – Braga Current condition

Map 4-37 presents the composite accessibility quality of public spaces at the 800 m scale under current conditions. Most public spaces fall within the high composite accessibility category, showing that they are generally well connected at the neighbourhood level. A smaller part is classified as medium accessibility, indicating some variation in how easily spaces are reached across the wider urban area. Very high and low accessibility conditions are rare, and very low accessibility is almost absent. Spatially, higher-quality public spaces show to be clustered in and around the more consolidated urban core, while medium and lower values appear more scattered toward peripheral areas. Overall, the map in current condition is generally balanced and good accessibility pattern at the broader spatial scale, with limited problematic conditions.

Table 4-18- Composite quality accessibility – (R=800 m)

Composite quality accessibility – 800 m	Percentage
A — Very high composite accessibility quality	1.
B — High composite accessibility quality	76.6
C — Medium composite accessibility quality	21.0
D — Low composite accessibility quality	1.2
E — Very low composite accessibility quality	0

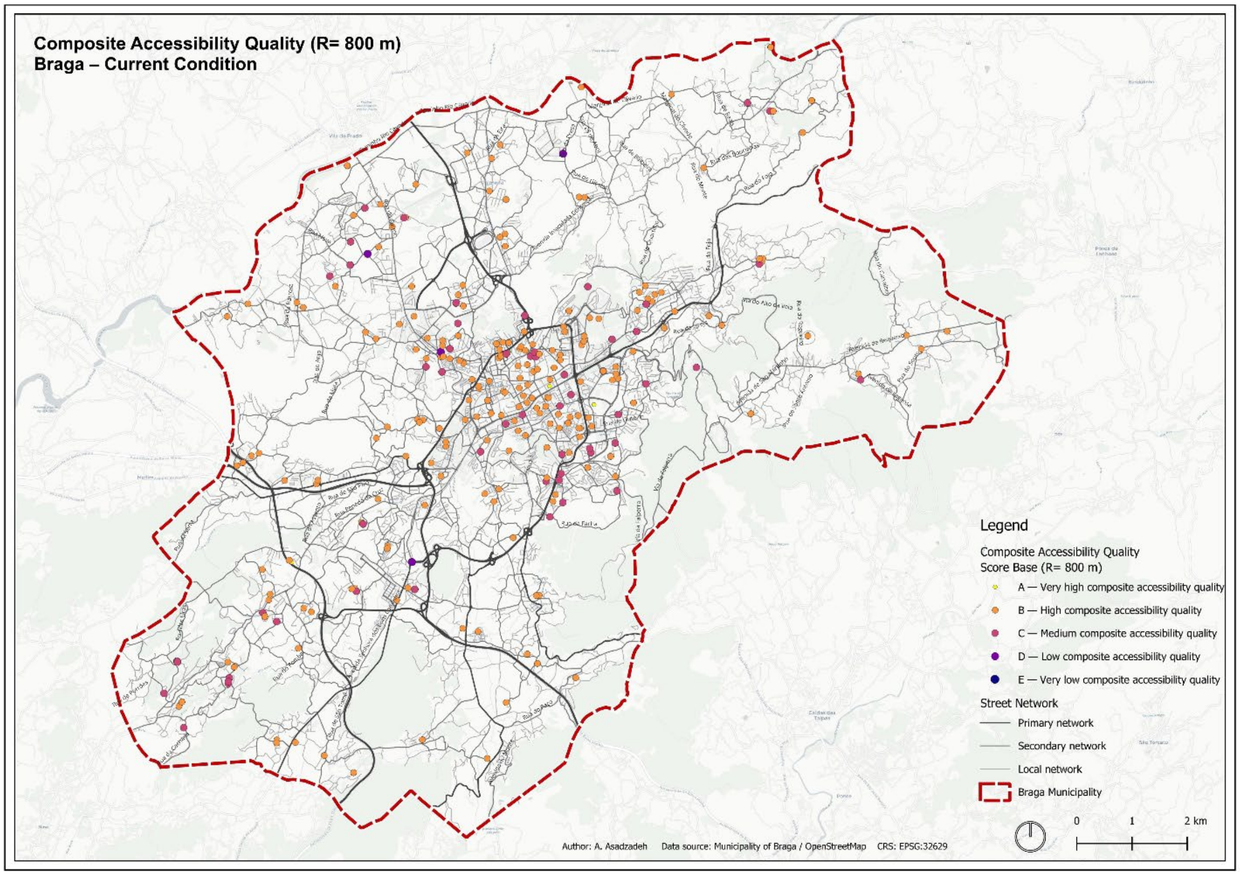


Figure 4-39-Composite quality Accessibility (R=800m) – Braga Current condition

4.2.3 Superblock Scenario Definition and Network Reconfiguration

The Superblockify tool has been applied to the current street network of Braga in order to reorganise the network into functional units based on connectivity and movement hierarchy. Through this process, the street network was partitioned into 530 distinct superblocks, each representing a cluster of local-access streets bounded by higher-order roads.

In the resulting map, SPARSE streets (shown in black) are the structurally important parts of the network. These streets accommodate through-movement and act as boundaries between superblocks, remaining outside the partitioning process. In contrast, the coloured street segments represent residential and local streets, which are grouped into different partitions. Each colour belongs to a separate superblock, illustrating how local street networks are internally connected. Spatially, smaller and more compact superblocks are concentrated in the central urban area, where street density is higher. Toward the peripheral and semi-rural areas, superblocks become larger and more irregular, reflecting lower street density, longer block lengths, and a more fragmented urban structure. The results are more meaningful in the central urban area of Braga, where the dense street network allows for coherent superblock formation, but in marginal zones characterised by rural and agricultural land uses, the partitioning is less reliable and less impactful; however, since the entire municipal boundary was included in the Superblockify process, these outer areas were nonetheless partitioned. This variation highlights how the Superblockify approach adapts to different urban morphologies rather than imposing a uniform pattern.

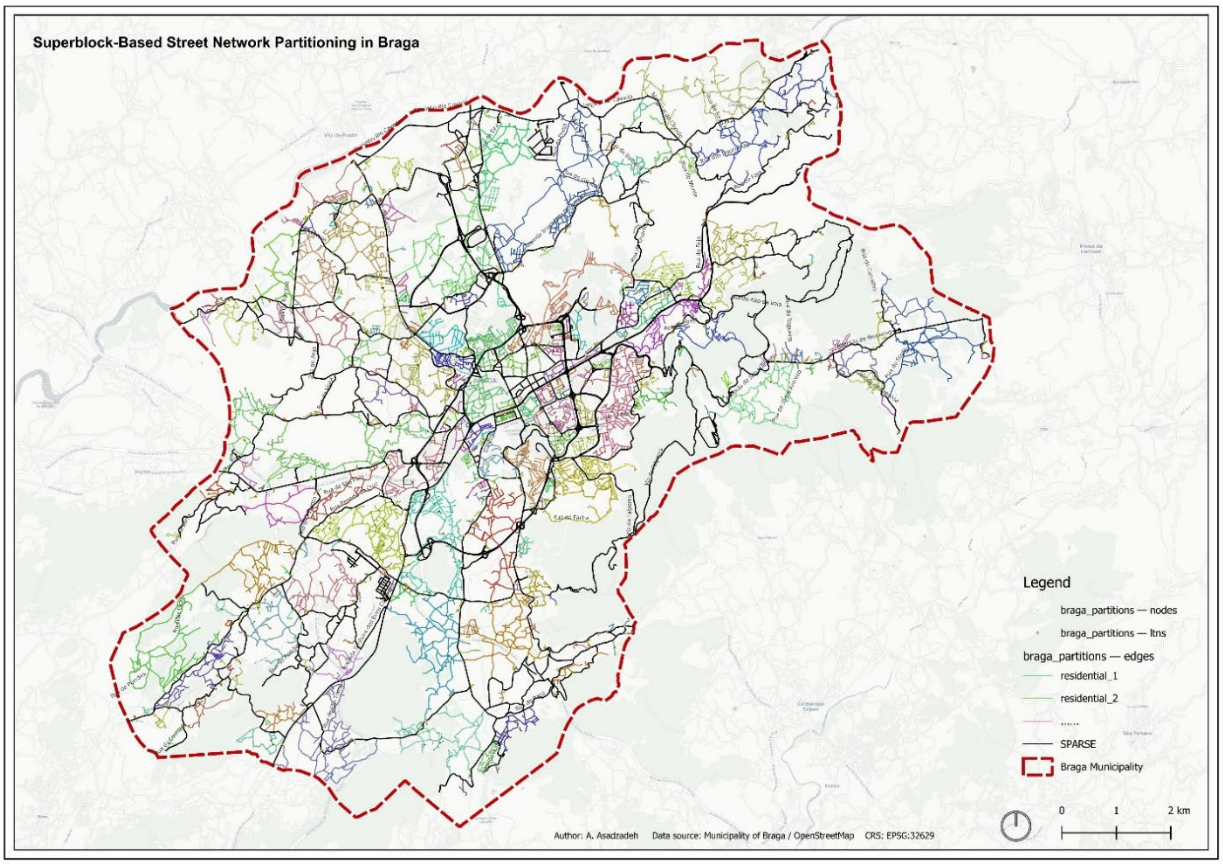


Figure 4-40- Superblock-Based Street Network Partitioning in Braga

4.2.4 Post-Intervention Accessibility Analysis

This section presents the post-intervention maps for Braga, generated after applying the Superblockify approach, in order to examine how the spatial configuration and accessibility patterns differ from the current condition.

4.2.4.1 Choice

Map 4-39 shows a clear departure from the previously uniform and weak through-movement pattern observed under current conditions. After the application of Superblockify, Choice values become more spatially differentiated, with higher through-movement potential increasingly concentrated along a limited set of structurally continuous corridors, primarily within the central urban area and selected connecting axes.

In contrast to the earlier condition where low Choice values were widely and evenly distributed, the post-intervention configuration reduces diffuse through-movement across local streets. Overall, the network structure becomes more hierarchical and less uniformly spread across the urban fabric.

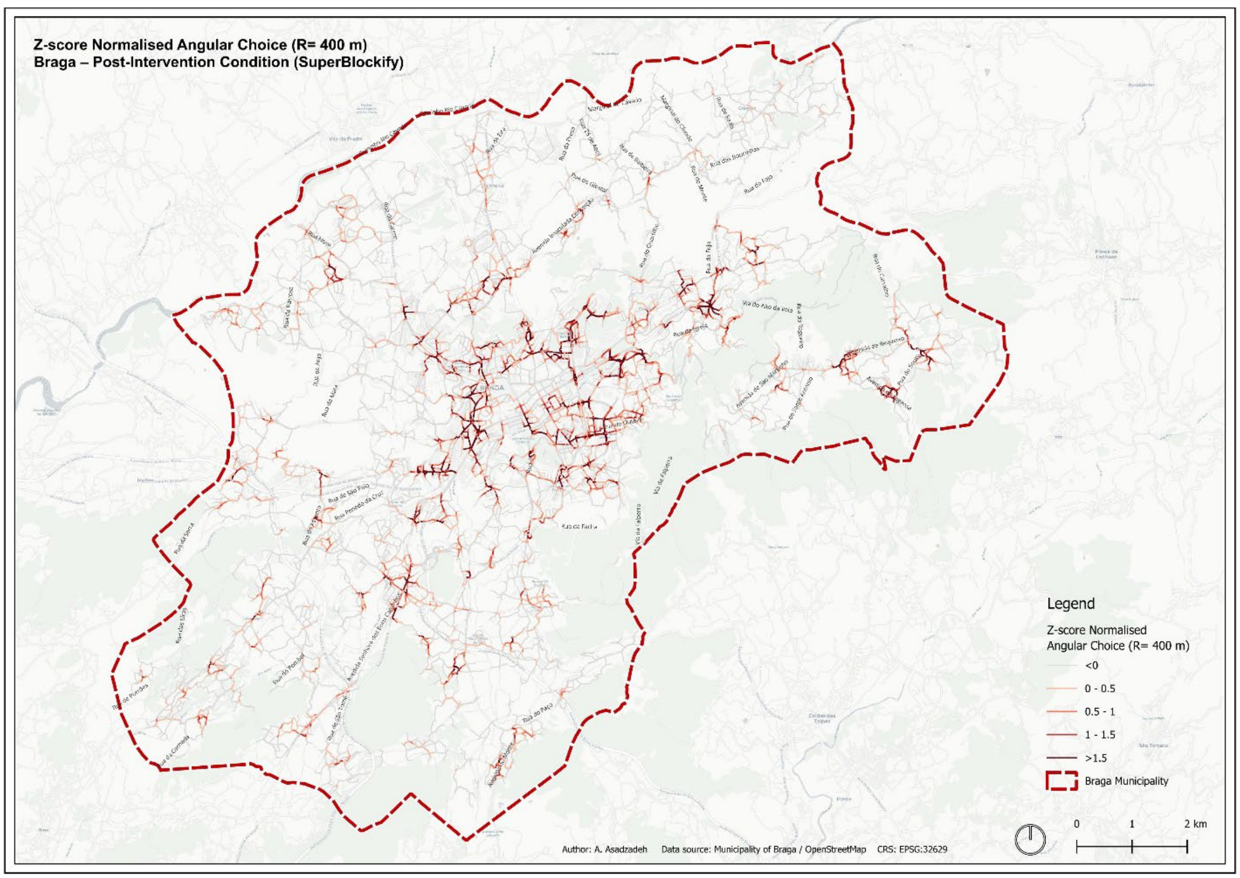


Figure 4-41- Z-score normalised Angular choice (R=400 m) – Braga Post intervention Condition

The post-intervention angular Choice map at R = 800 m shows a clearer concentration of through-movement on a limited number of main routes, mostly in central urban areas. Compared to the more even pattern observed before, higher Choice values are now less dispersed and tend to follow structurally continuous streets, while many peripheral and local roads display lower values. This indicates that longer-distance movement is being channelled more selectively through the network, reducing the role of minor streets as pass-through routes and reinforcing a clearer functional hierarchy at the neighbourhood scale.

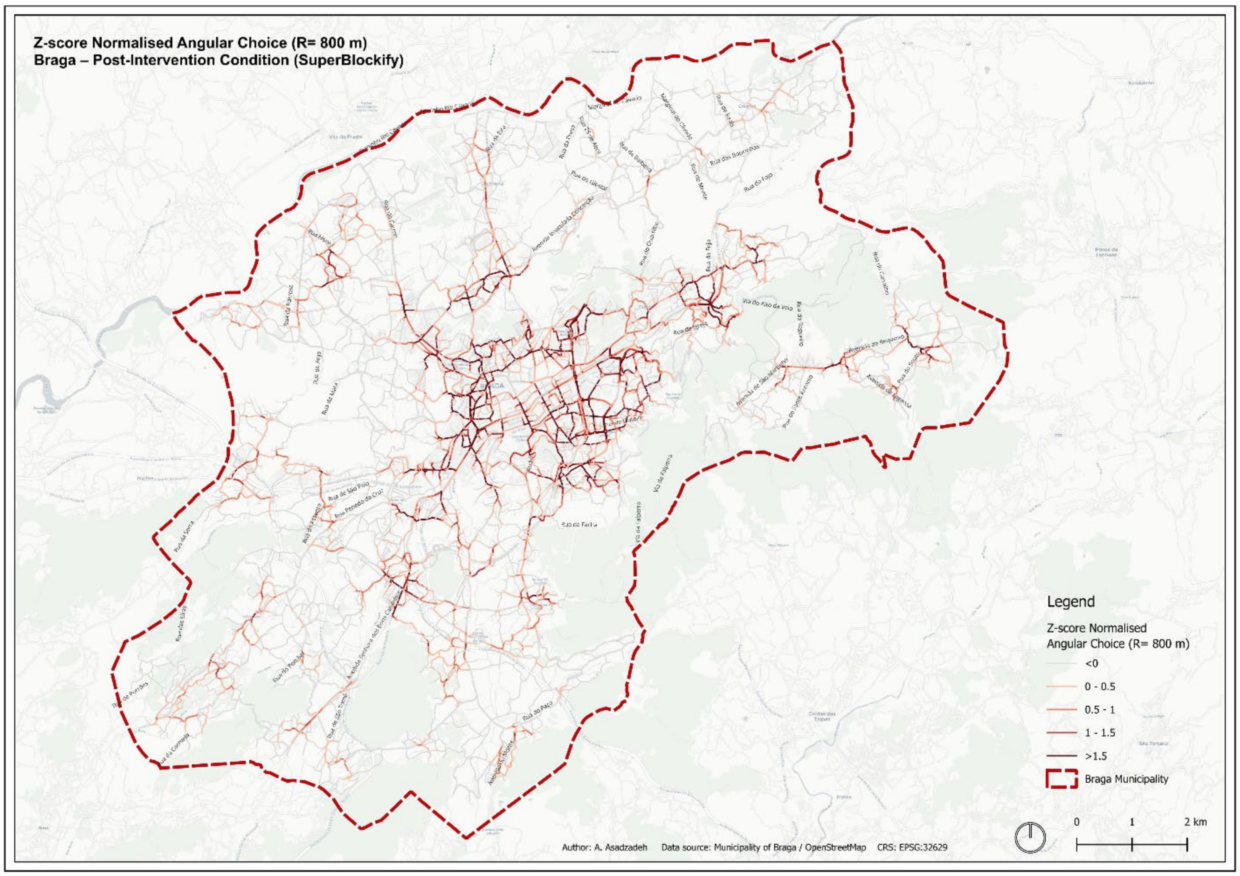


Figure 4-42- Z-score normalised Angular choice (R=800 m) – Braga Post intervention Condition

Exposure of Public Spaces based on Choice

Map 4-41 indicate that the majority of public spaces (76.9%) are located on streets with low Choice values, suggesting limited exposure to passing traffic at the local scale. Medium exposure spaces account for 15.2% and are mainly concentrated in the central urban area, where local connectivity remains relatively higher. Only a small share (7.9%) of public spaces falls within the high exposure category, typically aligned with a few structurally important streets. From a child-oriented perspective, this spatial pattern is generally favorable, as the dominance of low-exposure public spaces indicates reduced interaction with through-traffic, creating safer and more comfortable environments.

Table 4-19- Exposure of Public Spaces based on Choice (R=400 m)

Exposure – 400 m	Percentage
Low exposure	76.9
Medium exposure	15.2
High exposure	7.9

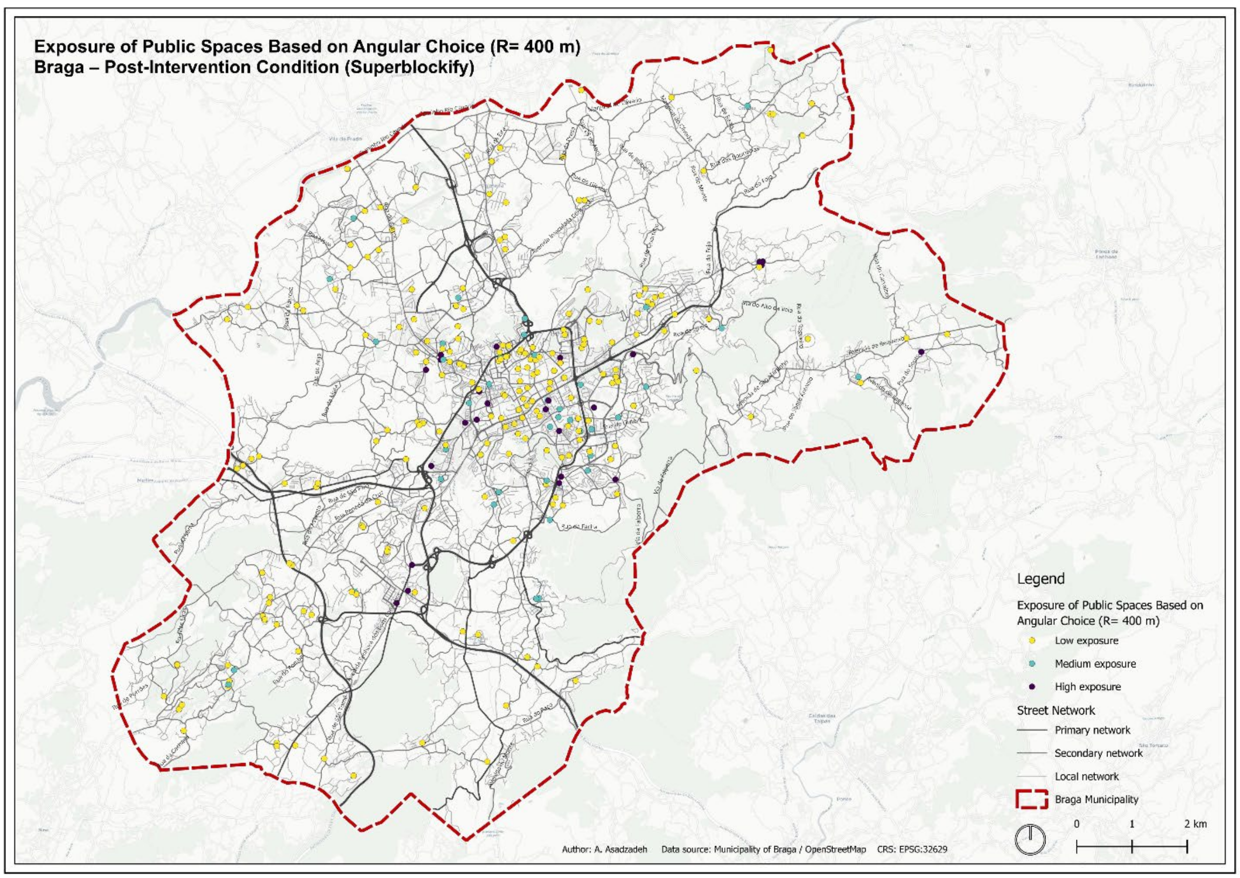


Figure 4-43- Exposure of Public spaces based on angular choice (R=400m) – Braga Post Intervention condition

Map 4-42 and show the exposure of public spaces to through-movement at the 800 m scale under the post-intervention condition. The results indicate that most public spaces remain within low to medium exposure levels (65% and 23.7%), while a smaller share is associated with high exposure (11.2%). Spatially, higher exposure points are mainly concentrated along the main structural corridors and central routes where the Choice number has been increased, whereas peripheral and residential areas continue to host public spaces with lower exposure. Even at a bigger radius, the pattern is a balanced distribution where the majority of child-related public spaces are not strongly affected by through-traffic.

Table 4-20- Exposure of Public Spaces based on Choice (R=800 m)

Exposure – 400 m	Percentage
Low exposure	65
Medium exposure	23.7
High exposure	11.2

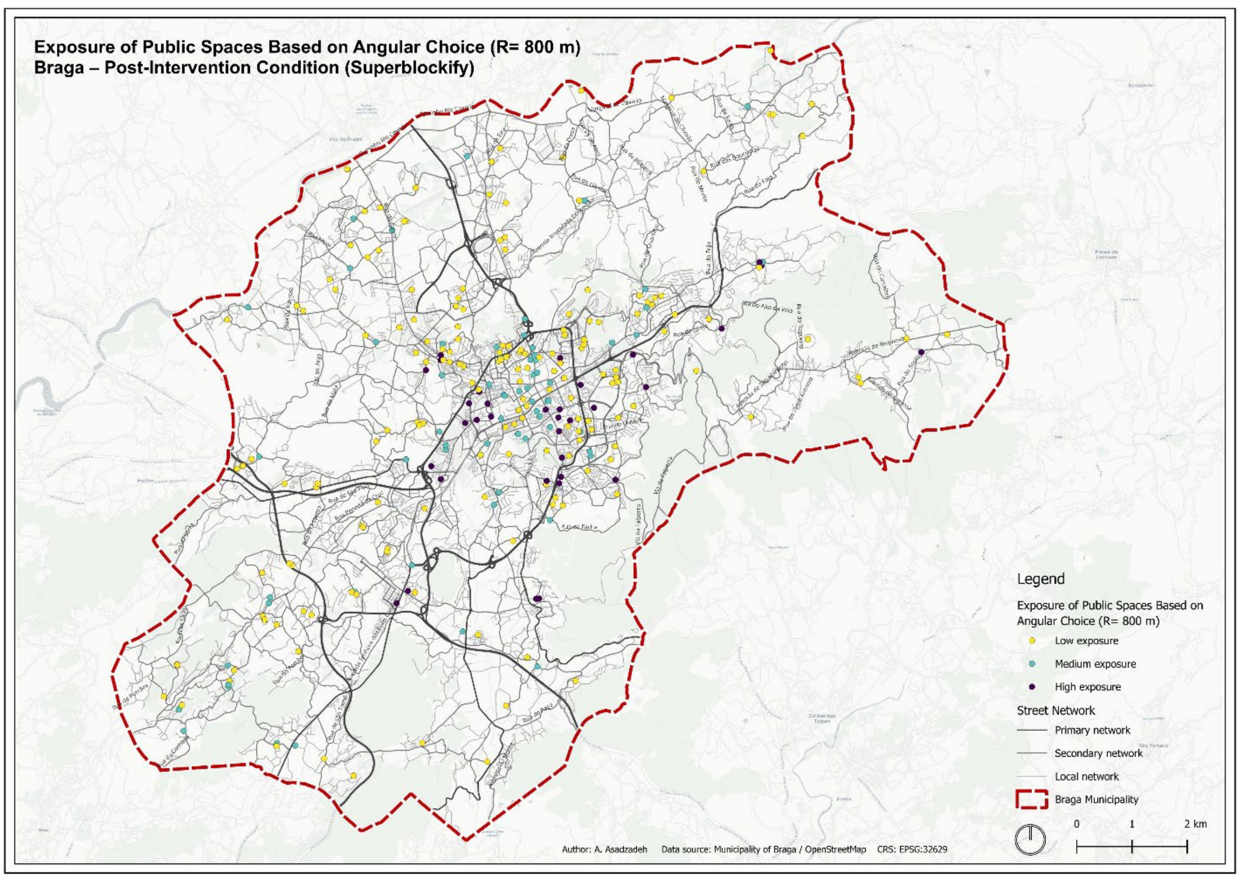


Figure 4-44- Exposure of Public spaces based on angular choice (R=800m) – Braga Post Intervention condition

4.2.4.2 Integration

Compared to the initial condition, where angular integration values were largely concentrated in the medium range, Map 4-43 shows a more articulated spatial structure. Higher integration values are now more clearly concentrated in the central urban core and along key connecting corridors, while peripheral and residential areas display lower to medium integration. This indicates that the street reconfiguration has reduced the overall uniformity of the network and strengthened the distinction between highly integrated central routes and quieter local streets, resulting in a more structured and hierarchically organised accessibility pattern.

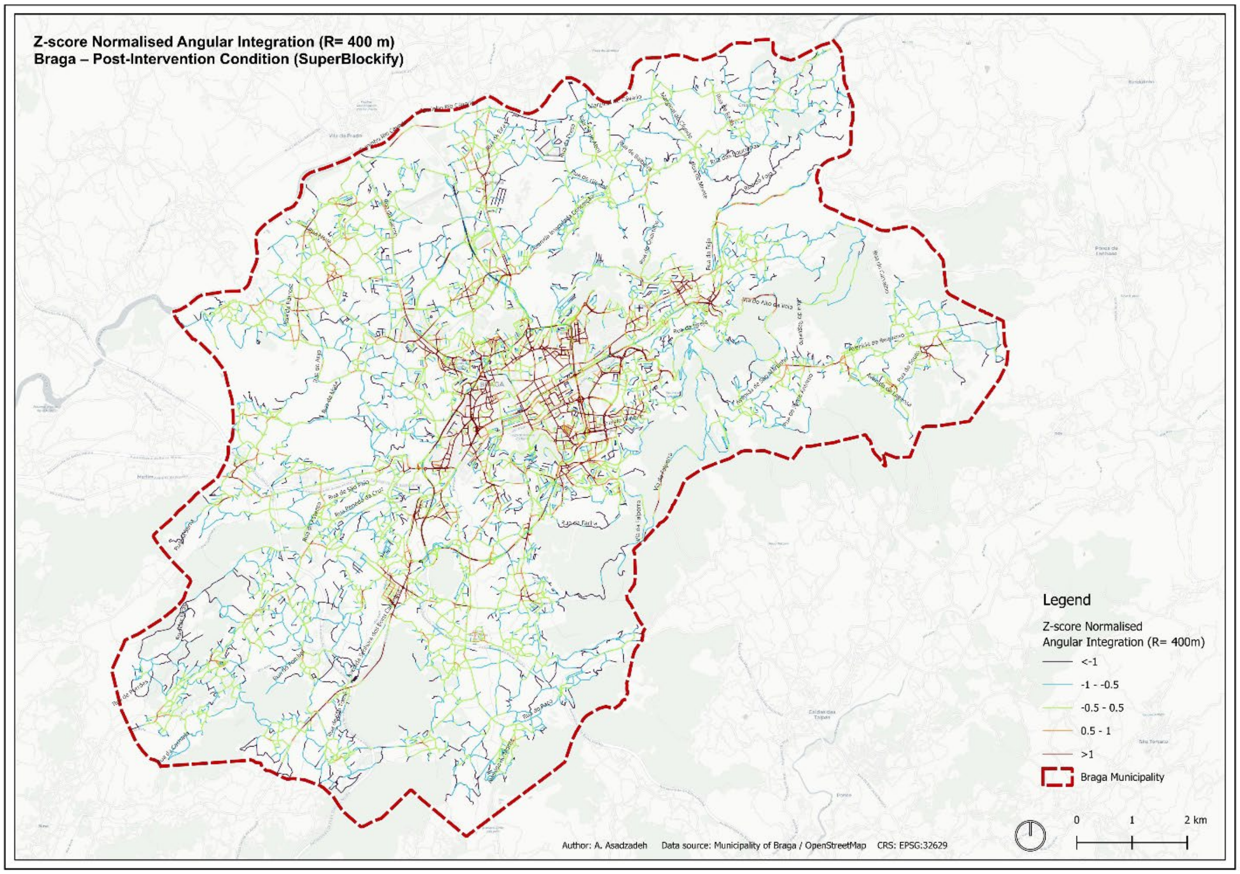


Figure 4-45- Z-score normalised angular Integration (R=400m) – Braga post-intervention condition

The post-intervention angular integration map at the 800 m radius highlights a more differentiated and legible accessibility structure across Braga. Higher integration values are strongly concentrated in the central urban area and along a limited number of strategic corridors, reflecting their continued role in city-wide connectivity. In the other hand, large portions of the peripheral and residential network display low to medium integration values, indicating reduced global accessibility and a stronger local character. In general, the intervention reinforces a hierarchical network structure by consolidating integration within the urban core while limiting excessive connectivity in outer areas, contributing to a more balanced and readable city-scale movement pattern.

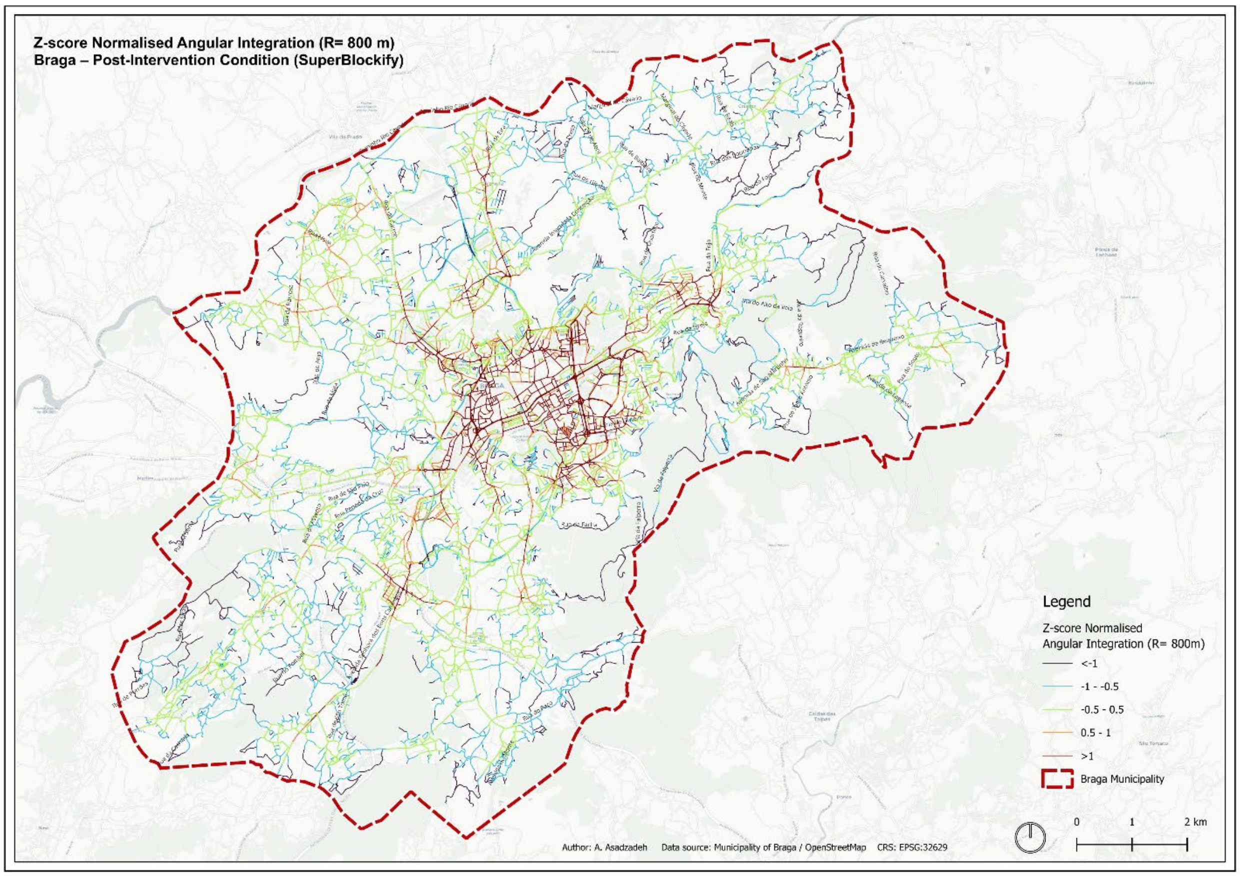


Figure 4-46- Z-score normalised angular Integration (R=800m) – Braga post-intervention condition

Accessibility of public spaces based on integration

The post-intervention accessibility map at the 400 m radius (Map 4-45) shows a more choral local accessibility pattern across Braga. Public spaces with high accessibility are mainly clustered within the central urban area, where the street network is denser and more interconnected, supporting short walking trips. Medium-accessibility spaces form a surrounding belt, indicating reasonably good local access within residential neighbourhoods. In contrast, low-accessibility public spaces are more circulated toward the less urbanised areas, where the street structure is sparser and connections are weaker.

Table 4-21- Accessibility of Public Spaces based on Integration (R=400 m)

Accessibility – 400 m	Percentage
Low accessibility	31.6
Medium accessibility	41
High accessibility	27.4

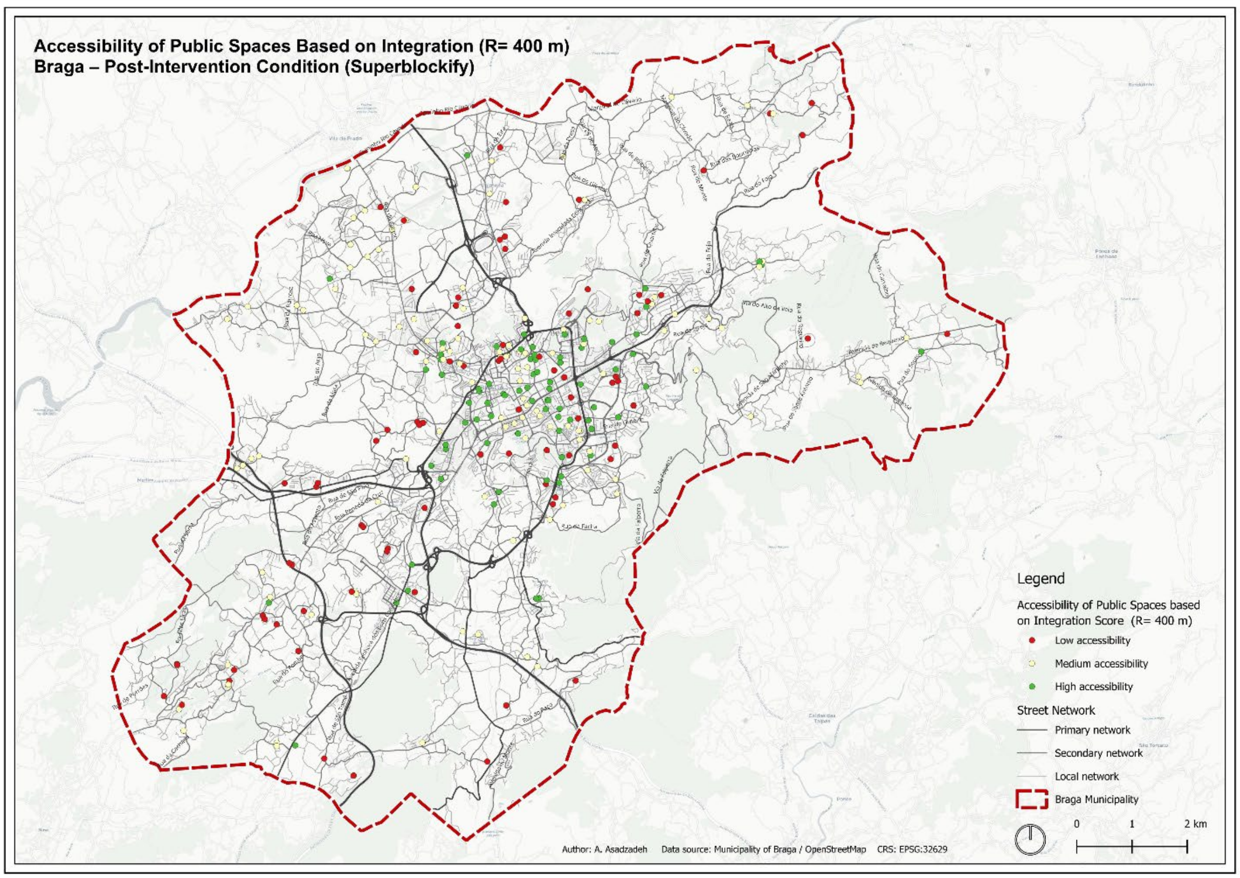


Figure 4-47-Accessibility of Public Spaces based on Integration (R=400 m) – Braga Post Intervention Condition

At the 800 m scale, the post-intervention accessibility shape highlights a wider spatial reach of the street network in Braga. Public spaces with high accessibility are mostly concentrated in and around the central urban area, where longer-distance connections are more continuous and direct. Medium-accessibility spaces extend outward from the core, indicating improved neighbourhood-level reach within the wider urban fabric. Low-accessibility public spaces are still located in less urbanised zones, where network density and continuity remain limited. Overall, the map suggests that at this larger radius, the intervention supports a more balanced distribution of accessible public spaces.

Table 4-22- Accessibility of Public Spaces based on Integration (R=800 m)

Accessibility – 400 m	Percentage
Low accessibility	25.5
Medium accessibility	39.8
High accessibility	34.7

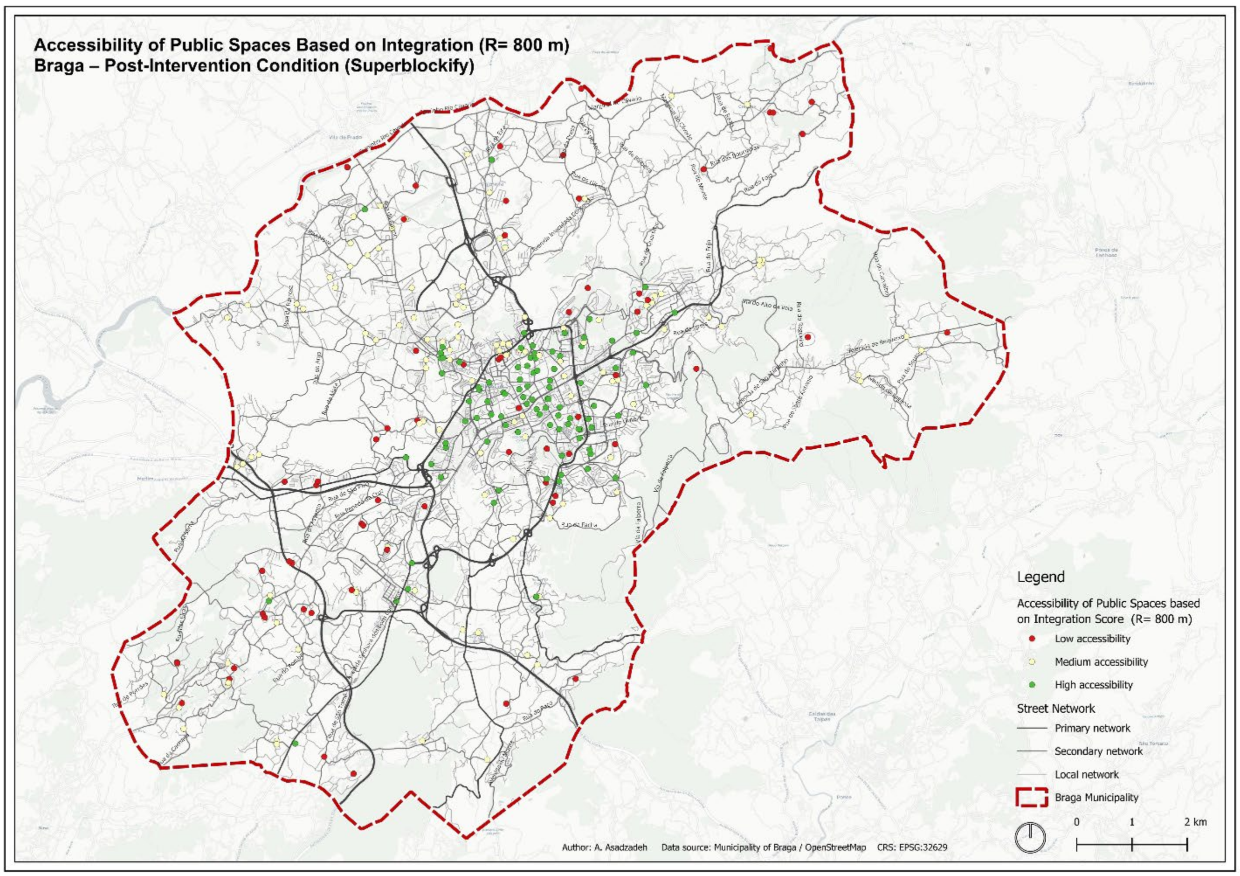


Figure 4-48- -Accessibility of Public Spaces based on Integration (R=800 m) – Braga Post Intervention Condition

4.2.4.3 Composite accessibility quality

The composite accessibility quality at the 400 m scale indicates that most public spaces in Braga are located in areas with high overall accessibility. A significant amount is in the high to medium range of composite quality classes, showing that accessibility and exposure conditions tend to be evenly distributed throughout the city. Public spaces with very high accessibility quality are present, though more limited in number, and are mainly concentrated within the central urban structure. Low composite quality areas exist but are dispersed and not dominant, while very low accessibility conditions are absent. Overall, the spatial pattern represents that public spaces are largely fixed within accessible and well-connected neighbourhoods at the local scale.

Table 4-23- Composite quality accessibility – (R=400 m)

Composite quality accessibility – 400 m	Percentage
A — Very high composite accessibility quality	14.9
B — High composite accessibility quality	37.7
C — Medium composite accessibility quality	24
D — Low composite accessibility quality	23.4
E — Very low composite accessibility quality	0

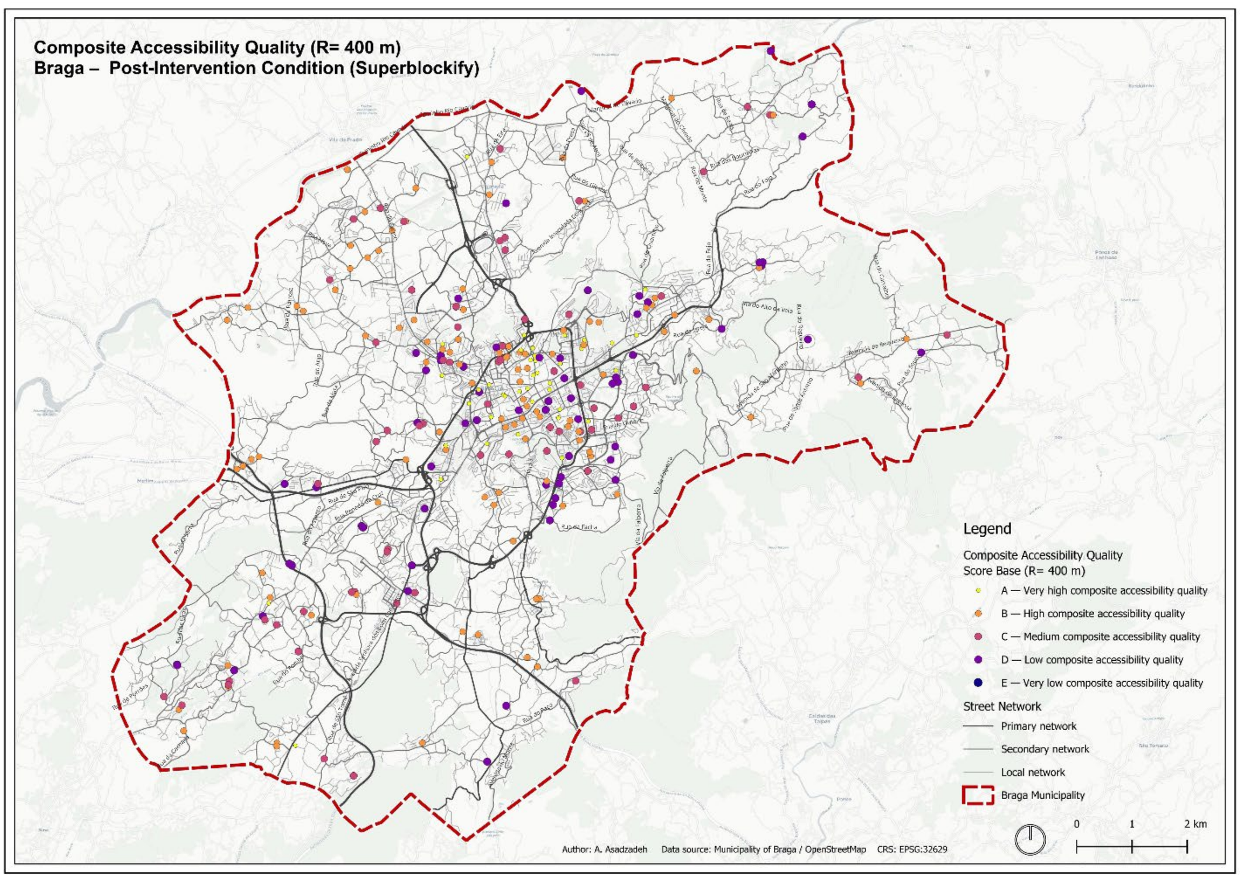


Figure 4-49- Composite quality accessibility (R=400 m) – Braga Post Intervention condition

Map 4-48 shows a Mostly positive overall condition. A substantial share of public spaces are in the high and medium composite accessibility classes, indicating that many locations benefit from a balanced combination of network accessibility and limited exposure to through-movement at the neighbourhood scale. Very high composite accessibility areas are present and are mainly clustered around the more consolidated urban structure. Low and very low composite quality spaces represent a smaller proportion and are generally scattered.

Table 4-24- Composite quality accessibility – (R=800 m)

Composite quality accessibility – 400 m	Percentage
A — Very high composite accessibility quality	16.7
B — High composite accessibility quality	36.5
C — Medium composite accessibility quality	27.1
D — Low composite accessibility quality	18.5
E — Very low composite accessibility quality	1.2

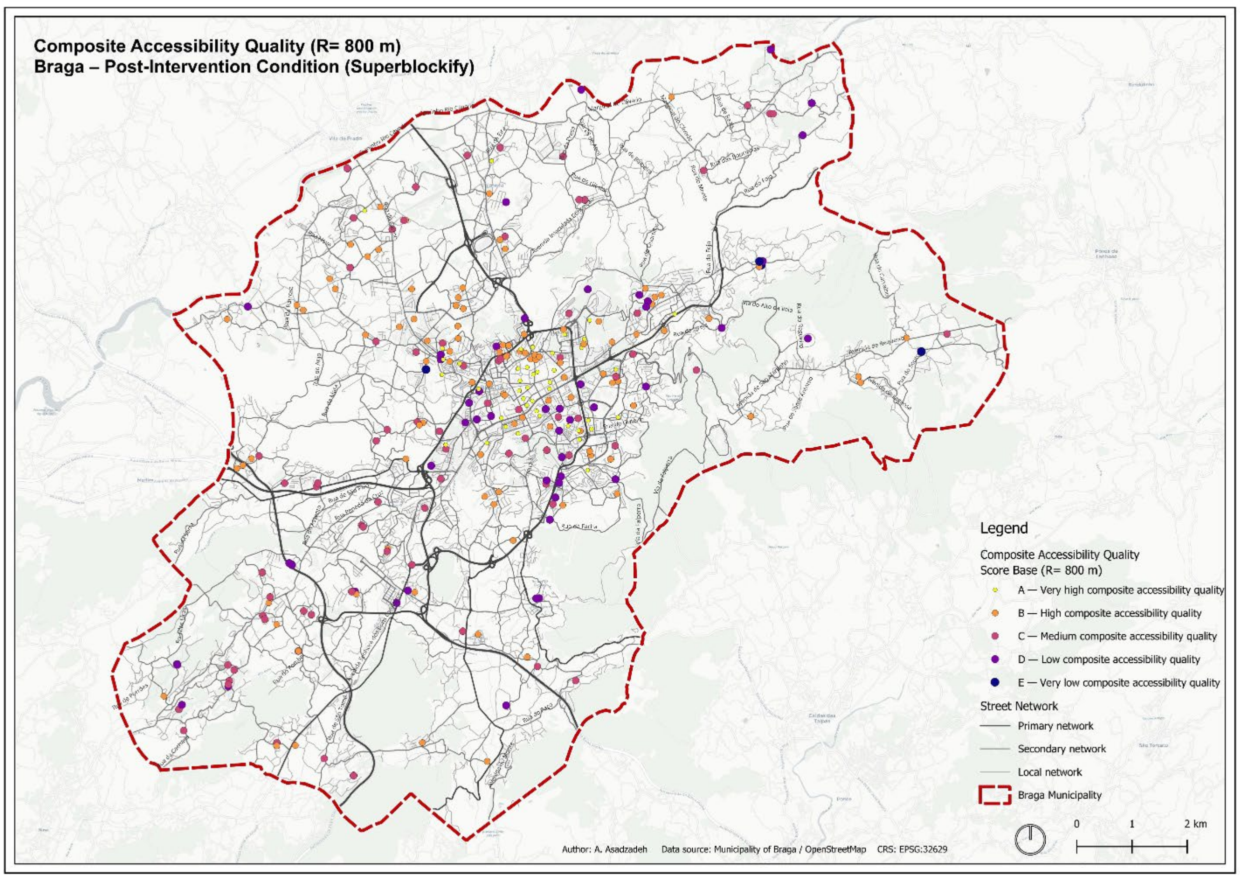


Figure 4-50- Composite quality accessibility (R=800 m) – Braga Post Intervention condition

This chapter examined the two case studies under both current and post-intervention conditions based on superblockify tool. Using a logical analytical framework, the spatial configuration of the street network and its relationship with child-related public spaces were assessed through integration, choice and composite accessibility indicators at multiple spatial scales. The results provide a detailed understanding of how accessibility and movement patterns are structured before and after the application of the superblock strategy. Building on these findings, the following chapter focuses on a comparative assessment, to highlight the impact of the superblockify intervention and evaluating whether and to what extent it produces which outcomes for children’s accessibility and exposure conditions across the two case studies.

Chapter 5: Discussion: Comparative Analysis

After examining both case studies of Turin and Braga before and after conditions of superblockify, this chapter discusses 3 comparative analyses:

- Municipality of Turin (Current Condition vs. Post-Intervention Condition)
- Municipality of Braga (Current Condition vs. Post-Intervention Condition)
- Comparative Analysis of Turin and Braga

First, the impacts of the intervention are analysed separately for each city in order to understand how superblockification affects different urban contexts. Then, a comparative analysis between Turin and Braga is presented to highlight how variations in urban morphology and network structure influence the effectiveness of the intervention. Finally, the implications of these changes for children's accessibility to public spaces are discussed.

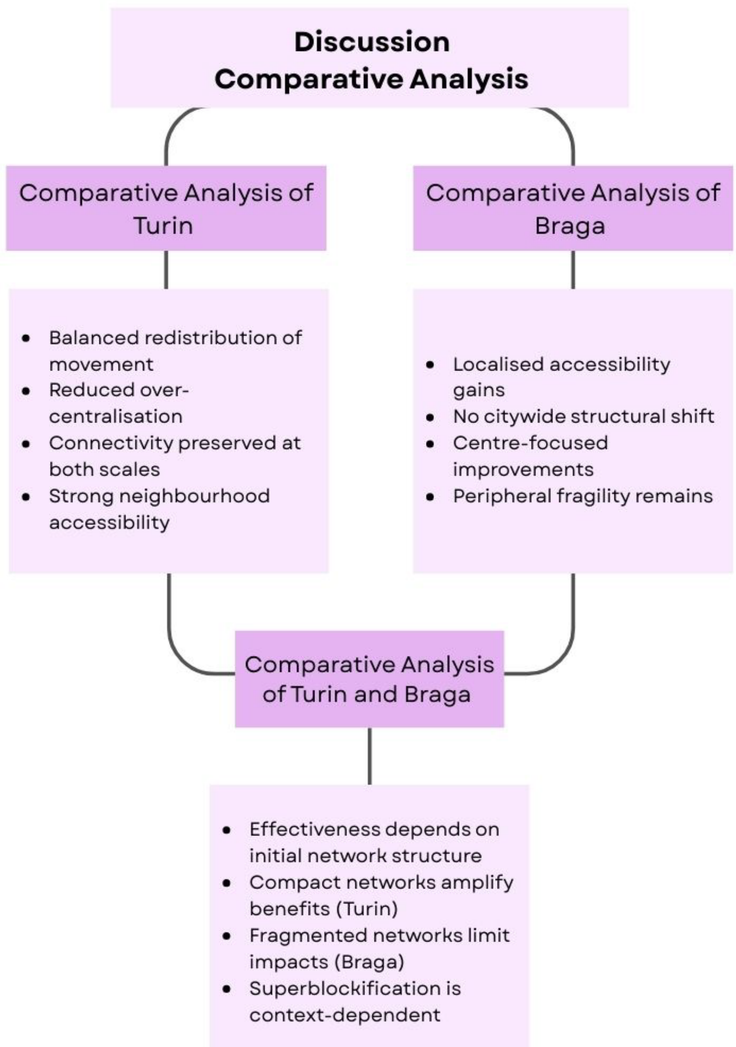


Figure 5-1- Discussion diagram (Elaborated by author)

5.1 Comparative Analysis of Turin (Current Condition vs. Post-Intervention Condition)

The superblockification in Turin results in noticeable, yet measured, shifts in how the street system functions and how easily places can be reached.
The analysis of Choice (movement exposure) shows that after superblockification, the ratio of public spaces with low exposure decreases, while medium and high exposure categories slightly increase. This change is modest at the 400 m scale, which reflects local, everyday movement, and becomes more evident at the 800 m scale, where neighbourhood-level accessibility is captured. The findings suggest a shift in the distribution of movement rather than an overall intensification, suggesting that through-traffic is reduced within local streets without disrupting broader connectivity.

From an Integration perspective, public spaces in Turin shift from highly integrated positions towards more medium levels of integration, particularly at the 400 m scale. This indicates a shift from accessibility being overly focused in central areas to a more distributed model that emphasizes local neighbourhoods. Importantly, this change does not limit public spaces within the wider network; instead, it preserves worldwide connections while lessening over-reliance on just a few, closely linked roads.

The Composite Accessibility results augment this interpretation. After superblockification,The way accessibility is spread out changes, shifting from a highly centralized system with very high peaks to a more balanced distribution across high and medium accessibility areas. At the local scale, accessibility becomes more neighbourhood-based and homogeneous, while at the 800 m scale the intervention reduces over-centralisation without weakening overall urban accessibility. In Turin, the superblock approach essentially serves to optimize the urban network. It aims to create improved equilibrium and spatial fairness instead of simply increasing the number of connections.

5.2 Comparative Analysis of Braga (Current Condition vs. Post-Intervention Condition)

Because Braga has a less robust and more disjointed street layout, the impact of superblock implementation there differs significantly from what has been observed in Turin.
Before the intervention, movement patterns In both 400 and 800 m radii are characterised by low and discontinuous Choice values , with most public spaces exhibiting very low exposure. Following superblockification, movement spreads out more uniformly and becomes more interconnected within local areas. Nevertheless, this also results in greater vulnerability in specific spots, suggesting a more delicate process of reallocation.

The Integration analysis shows that, before intervention, Braga’s network is dominated by medium integration values in both local and neighborhood level, with very few highly integrated streets in 800 m radius. After superblockification, the number of highly integrated segments increases, but these improvements are concentrated in specific central locations rather than extending across the entire network. As a result, the spatial logic of the city remains largely unchanged.

One of the important things in shaping the outcome is the spatial distribution of public spaces across Braga. As shown in the Braga maps at both 400 m and 800 m radii, a large share of public spaces is concentrated in and around the central area, where accessibility levels are generally higher both before and after the intervention. Following superblockification, some of these central locations experience a shift toward higher composite accessibility classes, reflecting localized improvements in integration and exposure conditions.

At the 400 m scale, changes are limited and highly fragmented, while at the 800 m scale accessibility improvements tend to concentrate along a few main corridors rather than spreading across the wider network. This results in an uneven spatial pattern, where central areas benefit more from superblockification, whereas peripheral public spaces show little or no improvement.

In the existing situation, public spaces are mostly located within medium or high levels of composite accessibility quality across the entire municipal boundary. After the intervention, low-quality accessibility classes become visible at both radii. Although some public spaces in the central area of Braga shift toward very high accessibility quality after superblockification, this does not indicate a substantial overall improvement. At the same time, the number of public spaces with lower accessibility increases. the intervention results in slight improvements in the city centre, while other areas, particularly marginal and edge zones, show little change or may even experience a decline in accessibility.n Overall, the composite accessibility results show that in Braga, the benefits of superblockification are limited by the city’s marginal areas and because of that do not lead to a consistent improvement in accessibility across the whole city.

5.3 Comparative Analysis of Turin and Braga

Comparing Turin and Braga demonstrates how a city's existing layout significantly impacts the success of superblock implementations. Despite Turin and Braga employing the same superblock strategy and methods, the results diverge significantly because of their differing urban layouts. Turin benefits from a dense, compact, and well-integrated street network, while Braga is characterised by a more fragmented structure with strong centre–edge contrasts. These variations in urban design are readily apparent in the composite accessibility patterns observed before and after the intervention, resulting in distinctly varied spatial patterns from city to city.

In Turin, composite accessibility is already high and spatially continuous in the pre-intervention condition, particularly within the central and semi-central areas. After superblockification, accessibility remains strong at both the 400 m and 800 m radii, but its internal distribution becomes more balanced. The strategy reduces accessibility clustering downtown, improves accessibility in local communities, and maintains the network's connections. Significantly, the surrounding districts do not show evidence of general decline, indicating that superblockification in Turin functions as a refinement of an already robust network.

In contrast, Braga begins with a less stable and more disparate accessibility framework. Before intervention, composite accessibility is strongly concentrated in central areas, while peripheral and edge zones exhibit weaker conditions. After superblockification, some central public spaces shift toward higher accessibility levels; however, this improvement is not consistent across the municipality. At both radii, new areas of lower composite accessibility emerge, and peripheral public spaces remain weakly connected or experience limited change. This results in a more fragmented and spatially uneven accessibility pattern.

Across both scales, the comparison demonstrates that superblockification improves equilibrium and ease of use in Turin, while in Braga it leads mainly to localized and partial adjustments. In a compact, grid-based city like Turin, the intervention fine-tunes movement and accessibility patterns without disrupting connectivity. In a more fragmented and edge-oriented city like Braga, the same intervention lacks the structural capacity to generate citywide improvements and may even reinforce existing spatial inequalities.

In general, the comparative analysis affirms
that superblockification is not a universally transferable solution. Its effectiveness depends strongly on pre-existing network integration, urban density, and the spatial embedding of public spaces within the street network.

5.4 Impact on child- accessibility

How superblocks affect children's ability to get around differs significantly depending on their age, how they travel, and the city they live in. For children (3–14 years old) who mainly rely on short, accompanied trips, the 400 m radius is the most relevant scale. Within this specified scope, Turin exhibits more pronounced enhancements following the implemented changes, as the dense, well-connected street network enhances walking and low-speed cycling access to nearby public spaces. In Braga, however, improvements at this scale remain limited and largely confined to the central areas. At the same time, peripheral and semi-urban neighbourhoods show little or no change because they are not part of urban morphology; rather, they are more semi-rural places.

For older children (ages 7–14), who have greater freedom of movement and frequently alternate between walking and biking, the 800 m radius becomes more meaningful. At this scale, Turin again benefits more from the intervention, as superblockification reinforces already strong connections and supports safer and more continuous routes across neighbourhoods. On the other hand, Braga's disconnected system structure, especially along the urban edges, limits the intervention's effectiveness, resulting in uneven accessibility gains and, in some cases, no visible improvement for children living farther from the centre.

While superblockification can enhance children's daily accessibility in Urban areas that are space-efficient and cohesively planned, like Turin, it is beneficial for walking, and cycling are far less consistent in cities such as Braga, where peripheral, semi-urban, and rural conditions limit the potential for meaningful accessibility improvements across different age groups.

Conclusions & Recommendations

This chapter presents the recommendations and findings for Turin and Braga regarding the Strategic Spatial Recommendation Maps for both designated areas. It outlines maps indicating where accessibility improves post-intervention, where movement management is needed, and where superblocks should not be implemented due to poor street layouts. By connecting analytical insights to practical planning results, this chapter seeks to clarify the conditions under which superblocks can enhance children's accessibility and identify the most suitable areas for the superblockify tool.

6.1 Urban planning and policy recommendations

In this section, we can see four strategic spatial recommendation maps that are presented for Turin and Braga at two spatial scales (R = 400 m and R = 800 m). These maps summarise the results of the before and after superblockification analysis and translate the accessibility findings into planning insights.
At the local scale (R = 400 m), the maps show where superblocks improve child-oriented accessibility and where movement management is needed due to high exposure. In general, these maps focus on local accessibility for children. At the district scale (R = 800 m), the maps emphasize how accessibility is more broadly re-distributed along key structural routes, identify key network nodes, and indicate areas where superblock implementation is not recommended due to marginal or semi-rural conditions. These maps present a neighbourhood-level accessibility for children. Overall, the maps support a context-sensitive approach to superblock planning rather than a uniform application across the entire city.

This map presents strategic spatial recommendations for Turin at the local scale (R = 400 m). The main city center stands out as a dense area of improved local accessibility, where the street network shows the highest levels of accessibility and movement intensity. In this area, children can more easily walk or cycle to public spaces and daily destinations, making it the most suitable context for positive superblock effects. Although some levels of exposure remain within the city centre, this condition is partly expected given the overall intensity of urban activities. Surrounding this core, several child-priority movement zones are identified, corresponding to areas where superblock implementation has shown clear positive effects after the intervention and is therefore highly recommended. In addition, specific movement management areas are highlighted at key interfaces between local streets and the main structural network, where higher exposure levels indicate the need for targeted traffic calming and access control measures. The blue arrows also show that the distribution of area is toward the city center after the superblockify intervention. Marginal and semi-rural areas are classified as not recommended for superblock implementation, as the analysis indicates limited or even negative effects due to weaker and less connected network structures.

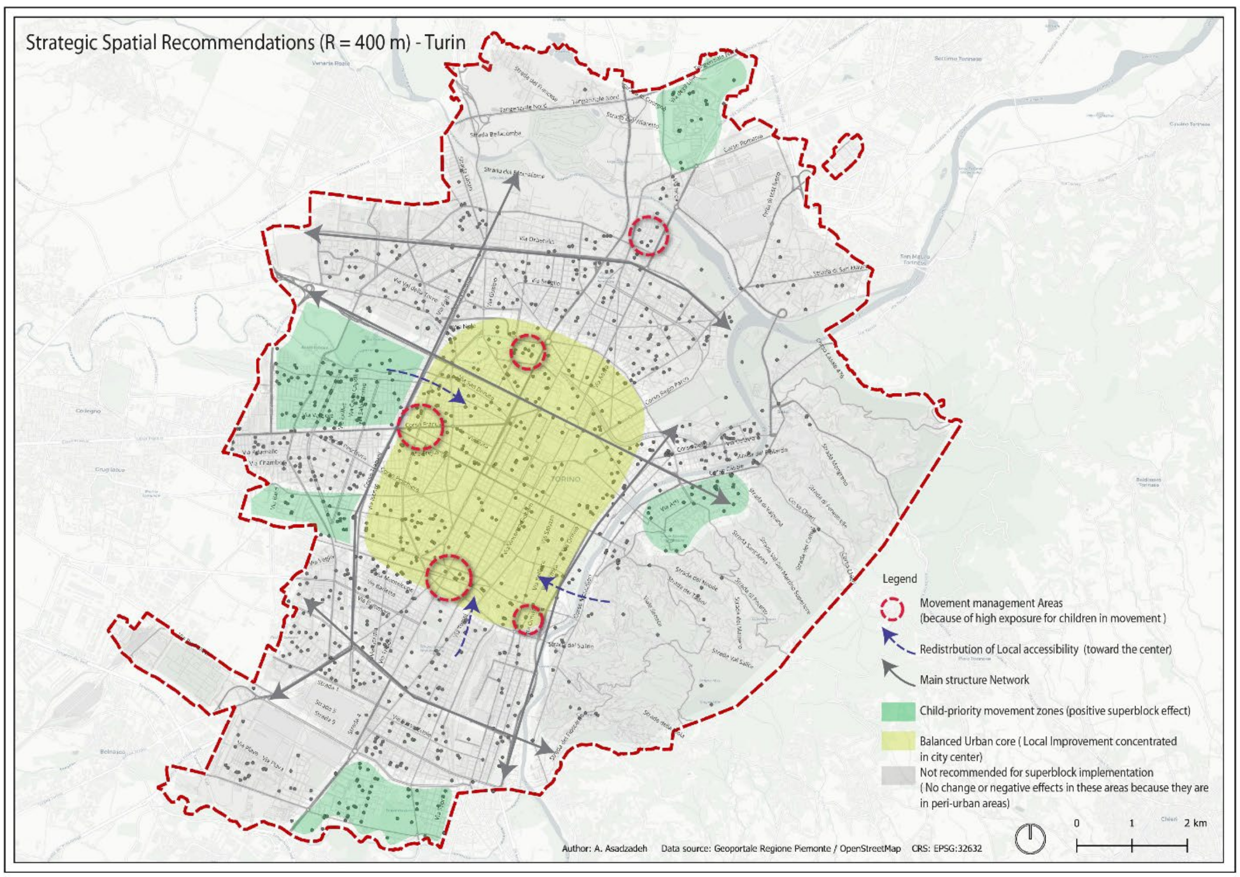


Figure 6-1- Strategic Spatial Recommendations (R=400m) – Turin

Map 6-2 presents strategic spatial recommendations for Turin at the district scale (R = 800 m) and should be read in direct relation to the previous local-scale map (R = 400 m), which focused on children's everyday walking environments. The 800 m scale reflects broader mobility patterns, including secondary-level children who travel longer distances, often by bicycle or accompanied by adults. At this scale, the balanced urban core remains generally in agreement with the more localized examination, confirming its central role as the main concentration of accessibility and urban activities. Beyond the core, the map highlights major structural corridors and strategic network nodes that mark important connections between neighborhood streets and major transportation routes. These crucial locations serve as central connection points, facilitating a seamless transition from neighborhood roads to wider area transit as traffic concentrates there.

Areas compatible with superblock implementation at the district scale are identified along these corridors, where network continuity and connectivity support larger-scale interventions both in 400 m and 800 m. Areas at risk of district-scale fragmentation do not perform poorly at the local level. In fact, at a 400 m radius, superblock interventions often improve neighbourhood walkability and reduce children's exposure by making strong local street networks. However, when considering an 800 m radius, these zones tend to have less robust links to the larger city. Limited links to main structural corridors, physical barriers, or low network continuity prevent local accessibility gains from extending beyond the neighbourhood. Creating superblock-like structures can make getting around locally easier daily. However, if the main road network isn't improved at the same time, this can also make it harder to access different parts of the wider area. Several gray areas were also highlighted as not recommended because they have no change due to semi-urban areas after the intervention of superblockify.

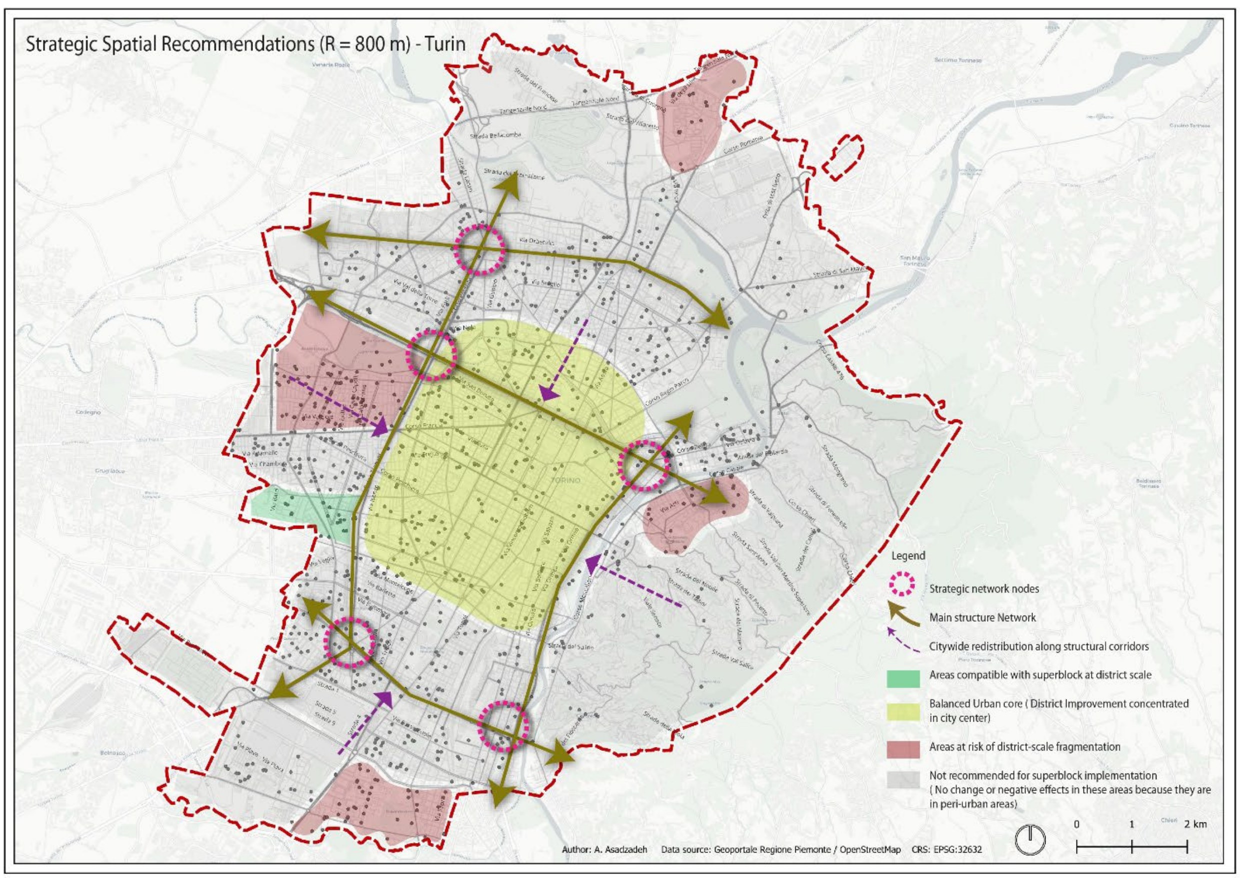
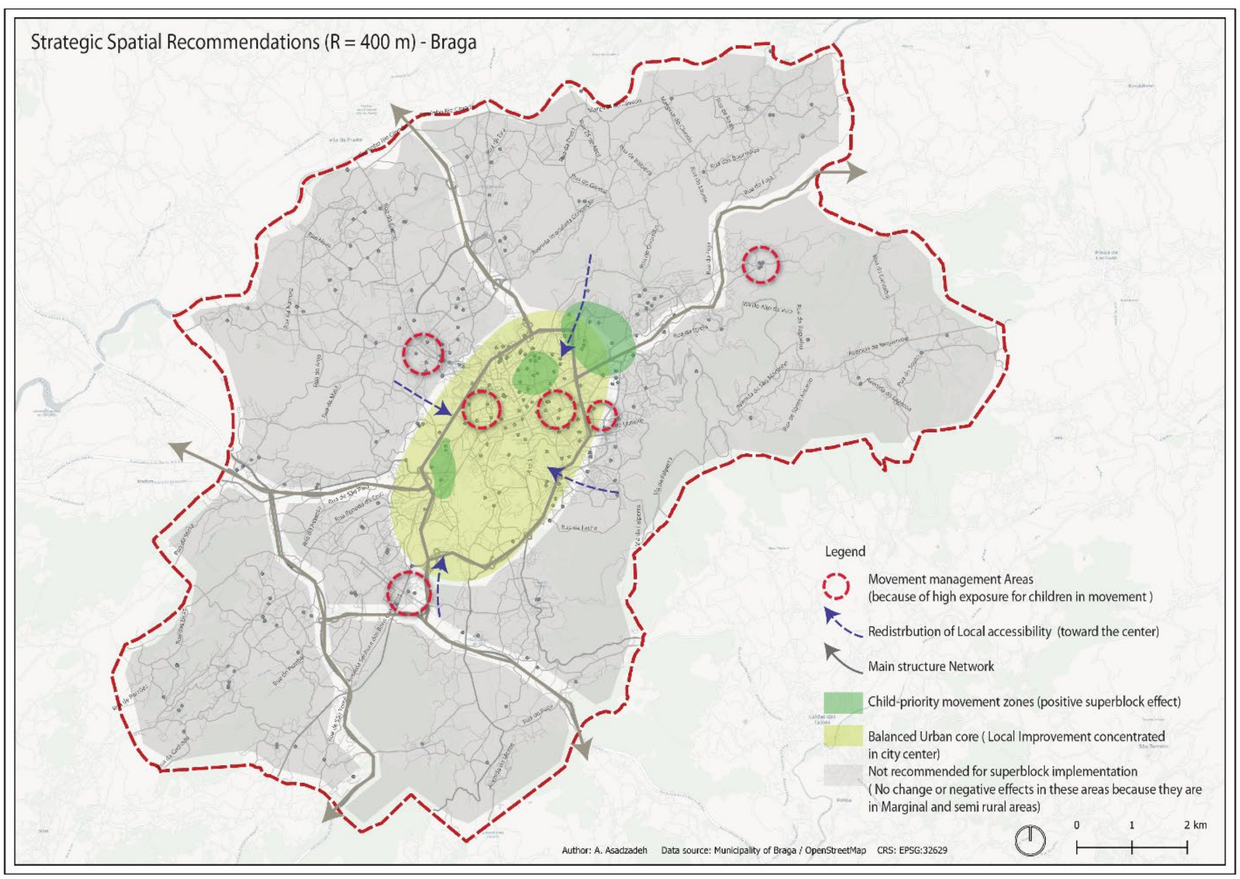


Figure 6-2- Strategic Spatial Recommendations (R=800m) – Turin

Map 6-3 shows the strategic spatial recommendations for Braga at the local scale (R = 400 m). The balanced urban core, marked in yellow, is the zone where local accessibility is most prominent and where superblock implementation leads to the most evident improvements after the intervention.This central area features a closely spaced network of streets, and public spaces are more common, and children can more easily walk or cycle to daily destinations, even though some levels of exposure remain typical of central urban areas.

The green areas indicate child-priority movement zones, where superblockification shows positive results by improving local accessibility and creating safer environments for children's everyday movement. Shifting from the city center out to the surrounding suburbs, accessibility decreases, reflecting a more rural or semi-rural character with fewer public spaces and weaker local networks. Consequently, these outer areas are categorized as not recommended for superblock implementation. The intervention for the appears to have had little to no positive impact, according to the analysis.

The map also highlights movement management areas (red dashed circles), which correspond to locations with high exposure for children in movement, typically at interfaces between local streets and the main structural network. These areas require targeted traffic management measures rather than full superblock application. Finally, the dashed arrows illustrate how local accessibility shifts to the city center. This indicates that accessibility, which was once more evenly distributed, becomes more focused in the central urban area following the implementation of the superblock.



sFigure 6-3- Strategic Spatial Recommendations (R=400m) – Braga

Map 6-4 highlights larger-scale travel behaviors that extend beyond routine, local trips. The yellow area represents the balanced urban core at the district scale, which remains the primary focus of accessibility following superblock implementation, confirming the central role of the city centre in structuring movement and access to public spaces. On this level, the primary infrastructure network gains greater significance, as shown by the highlighted corridors connecting the urban core to surrounding districts and municipal edges. The identified strategic network nodes correspond to key intersections where major routes converge and where accessibility redistribution is most evident. Although these nodes are not child-oriented destinations, they are strategically important because they connect enhancements at the neighborhood level with the broader urban infrastructure and influence exposure and route continuity for longer trips.

The map also identifies areas compatible with superblock implementation at the district scale, mainly located around the urban core, where network continuity and redundancy can support larger-scale reorganisation. In contrast, areas at risk of district-scale fragmentation that limit connections to the main structural network prevent local accessibility gains from scaling up, potentially isolating neighbourhoods within the wider urban structure. Peripheral and semi-rural zones are therefore classified as not recommended for superblock implementation, as the analysis shows limited or even negative effects at this scale. In general, the key spatial trends identified in Braga remain quite similar whether considering smaller or larger areas (R = 400 m and R = 800 m). Gains are mainly focused within and near the city center, while outlying regions experience very little positive impact.

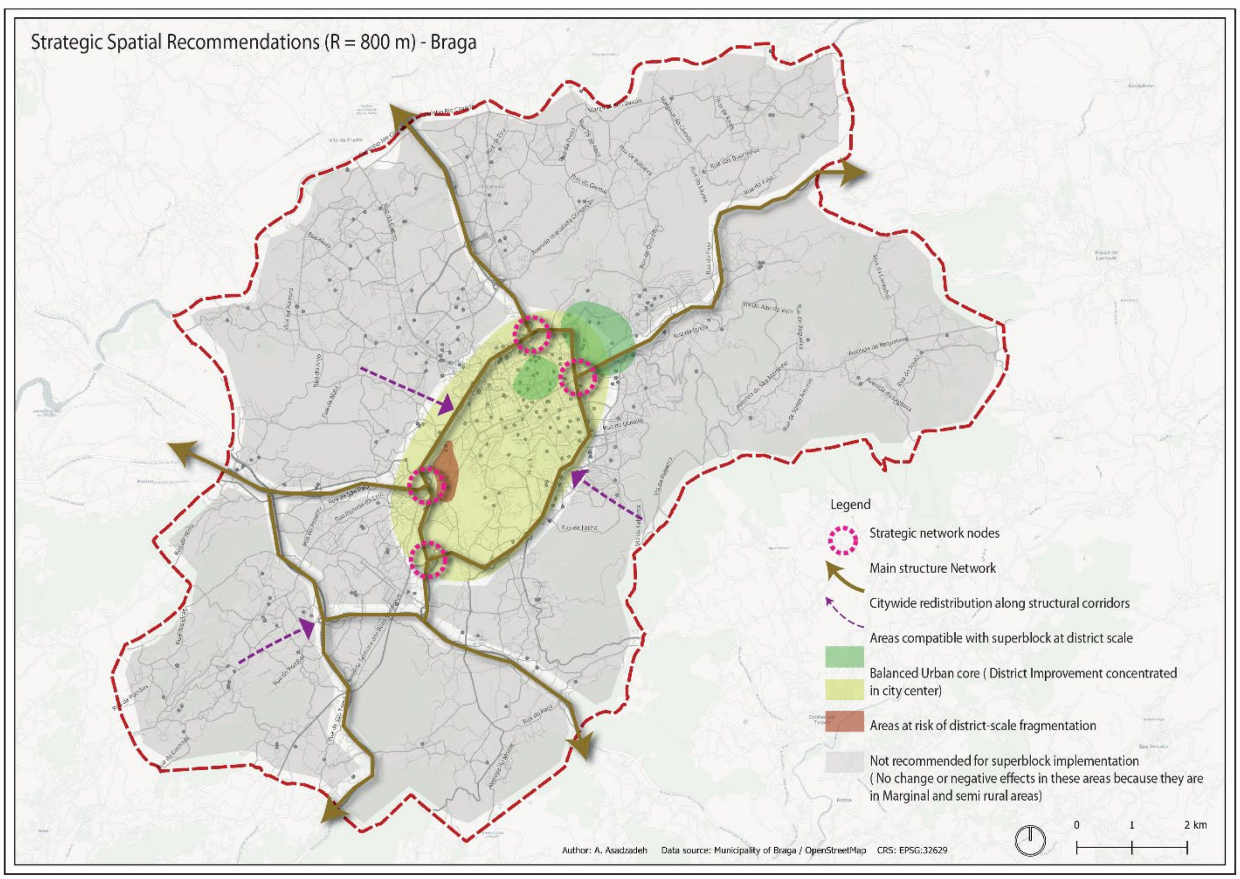


Figure 6-4- Strategic Spatial Recommendations (R=800m) – Braga

6.2 Summary of findings

This thesis explores how children's access to public spaces is shaped by the structure of street networks, rather than by distance or land-use distribution alone. By comparing conditions before and after the introduction of superblocks in Turin and Braga, the study investigates how changes in network configuration affect everyday accessibility and exposure. The results emphasise that superblock-based restructuring can make better access for children, but only in certain urban contexts.

In Turin, the street network is dense, continuous, and strongly interconnected. Within this setting, superblockification helps redistribute movement more evenly across the network. Highly centralised flows are reduced, while overall connectivity is preserved. This shift allows access to parks, playgrounds, and schools to become more closely tied to neighbourhood routes. In general, everyday walking and cycling environments are safer and more manageable for children, without limiting accessibility at the city scale.

The situation in Braga is different. The street network is more fragmented, with several semi-urban areas. While the compact urban core shows some local improvements after the intervention, these changes do not extend consistently across the wider municipality. In outer and marginal areas, weaker network continuity limits the benefits of superblockification, and in some cases, overall accessibility is slightly reduced.

These outcomes suggest that superblockification should not be applied as a standard solution. Its effects depend heavily on existing street structures, urban form, and the location of child-oriented public spaces. For this reason, superblock strategies need to be carefully adapted to local conditions and supported by spatial analysis, especially in areas with weaker networks. From a child-oriented planning perspective, this study emphasises accessibility as a spatial equity issue, where the design of street networks plays a key role in supporting safe, independent, and inclusive daily mobility for children.

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