The Søsterhagen Project: An Explanation of Urban Planning and Space Syntax Analysis

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Abstract

This research explores the relationship between urban design and pedestrian dynamics in Skarnes, Norway, using space syntax approach. The study integrates quantitative spatial analysis with qualitative data through community engagement survey and expert interviews to develop a comprehensive urban design framework. This research applied a mixed-method approach through the application of: (1) the mathematical street network modelling approach with Space Syntax, (2) Stakeholder workshop and interviews, (3) Scenario development for Skarnes, (4) survey with locals, (5) personal perspective of the author through photographic survey of the study area (Søsterhagen), and (6) Pedestrian movement data from sensors. The findings reveal that Skarnes is not pedestrian-friendly in many parts of the town. Disconnected roads, missing sidewalks, urban barriers such as regional through roads (E16) with high volume of motorized traffic, and complex spatial situations such as roundabouts and tunnels, are the cause of fragmented pedestrian movement network. However, Skarnes` residents perceive it to be a safe town for walking during daytime. During the night with little to no light, poor street lighting and heavy traffic, the town is perceived as unsafe for walking. Following, three scenarios (with stakeholders and based on citizens perceptions) were developed and tested with space syntax to create a solution fostering pedestrian movement through an urban development and grid intensification strategy. The study adds to the existing literature by offering practical strategies for integrating pedestrian infrastructure in smaller towns. It underlines the importance of community involvement in the whole process of urban planning. This research is fundamental for urban planners, urban designers, and policymakers who seek to build a more pedestrian friendly, sustainable, and socially vibrant urban environment.

Keywords: Space syntax, Urban design, Pedestrian Movement, Community engagement, Mixed-method approach, Master Plan, Connectivity, Locals safety perspective, Urban Planning.

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1. Introduction

Urban regions and cities are intricate systems shaped by both the physical environment and human activity. The organization of a city's streets, plazas, and buildings significantly impacts how people perceive and navigate these spaces, influencing mobility patterns and social interactions. Understanding these dynamics is crucial for urban planners and designers aiming to create functional, safe, and socially vibrant environments. This research investigates the relationship between a place's physical layout and the ways in which people move and interact within it. By examining this connection, the study seeks to provide insights that can inform the design of urban spaces, enhancing their utility and fostering community engagement.

To achieve this objective, the study employs the method and theory of space syntax, a comprehensive analytical framework developed by Bill Hillier and his colleagues in the late 1970s. Space syntax theory proposes that the spatial arrangement of a place has a direct impact on social interactions, mobility patterns, and perceptions of safety. This perspective challenges the traditional view of space as merely a passive backdrop to human activity, suggesting instead that the physical layout actively shapes human behavior (Batty, 2007). By utilizing space syntax, the study aims to quantify and analyze the configuration of urban spaces, revealing how different spatial elements such as streets, and buildings—connect and interact to form a cohesive network. This approach provides a deeper understanding of the underlying order in seemingly random patterns of movement and interaction, offering valuable insights for urban planning and design.

The space syntax theory examines the intricate connection between how a space is organized and how people move and interact in it (Hillier B. , 2007). This idea contends that a space's architectural layout actively shapes human behavior rather than serving as just a setting for activities. The fundamental idea behind space syntax is "configuration" (Hillier B. , 2007), which describes how various space elements—like rooms, hallways, streets, and plazas—connect and diverge to create a network. Space syntax employs a range of analytical tools to quantify this arrangement and its effects on mobility and social interaction.

Integration and choice are the two important measures for space syntax analysis (Hillier B. , 2007). Integration assesses the simplicity with which you can move from one location in a building to another, for example from your office to the cafeteria. A highly integrated location provides a direct and easy pathway, whereas a less integrated space may have more dead ends or complex pathways. This can have an impact on how long you commute and how easy it is to navigate. Choice, on the other hand, refers to the number of various routes accessible for travel between locations. A highly integrated environment may have just one obvious path, whereas a location with a high choice may provide several routes from point A to point B.

Last is the depth analysis; In architectural and urban design, depth analysis plays a significant role in determining the accessibility of different areas within a space (Hillier B. , 2007). A shallow space would have most areas easily reachable from any starting point, while a deep space might require traversing long distances to reach certain areas. This can affect the sense of isolation and the ease of access for emergency services.

Designers can use space syntax to foresee how people will move and interact in a building or urban setting (Hillier B. , 2007). This understanding is an effective tool for directing design decisions, allowing architects to construct building layouts that promote smooth circulation, stimulate social interaction in specified areas, and make vital places easily accessible. Similarly, urban planners may employ space syntax to improve pedestrian movement in cities, resulting in a more efficient and user-friendly experience for inhabitants and tourists. It deconstructs the seemingly random movement of people in a location, revealing the underlying order determined by its layout. Understanding these linkages allows us to create environments that not only suit our utilitarian requirements, but also generate a feeling of community.

In the field of urban planning and design, space syntax theory has found many uses. Some key applications include:

- Pedestrian oriented urban planning and analytical design: Space Syntax identifies walking-friendly regions in a city based on integration and choice values. This information is essential for building sidewalks, plazas, and other public places that promote walking and social interaction.
- Urban regeneration: Space Syntax is also helpful for analyzing existing urban areas and pinpointing areas with limited accessibility or poor connectivity. This knowledge can inform regeneration projects that improve connections, enhance public spaces, and revitalize underutilized areas within a city.
- Building design: The concept of Space Syntax can be utilized to examine a building's interior design and assess how user-friendly it is. This can be especially beneficial in designing public buildings, hospitals, and educational institutions that prioritize clear and intuitive wayfinding for their users (Hillier B. , 1996).

However, some critics argue that the theory may overlook the impact of social and cultural factors on human movement within cities, as it primarily focuses on physical arrangement (Yagi, 2022). Additionally, the use of specialized software and complex mathematical calculations can be perceived as a hurdle for those who are not experts in the field to effectively engage with the theory. Advocates of Space Syntax contend that the theory can complement other methodologies such as social surveys and user experience studies, resulting in a more comprehensive comprehension of urban environments (Varoudis, 2013,). Additionally, there are ongoing endeavors to produce simplified tools and visual aids, making Space Syntax more accessible to a broader range of professionals in the planning and design fields.

1.1. Case Study

The town of Skarnes, located on the banks of the Glomma River, serves as the administrative center of Sør-Odal Municipality in Norway. Its spatial layout reflects its history, function, and environment. The village's placement along the river influenced its original design, as rivers were primary transportation routes. Although Skarnes does not have a well-documented specific emergence date, it likely developed gradually over several centuries, like many small towns in Norway. Its growth was significantly influenced by its strategic location along the Glomma River, which served as a vital transportation route.

The Kongsvingerbanen railway line, which includes Skarnes Station, opened in 1862 and runs through the village. Skarnes likely emerged as a stop for travelers and traders, resulting in a linear layout along the riverbank with buildings oriented towards the waterway. Important structures, such as docks and warehouses, were situated closest to the river, followed by commercial areas serving travelers. Residential areas extended behind the commercial center, forming a basic grid or organic layout depending on the terrain (see chapter 3 for details). The 2.43-square-kilometre (600-acre) village has a population (2021) of 2,557 and a population density of 1,054 inhabitants per square kilometer (2,730/sq mi).

As Skarnes grew into more than just a small riverside stop, its layout likely shifted to accommodate its changing role. Given Sør-Odal's agricultural roots, it's possible that Skarnes evolved into a local hub for trade. This could have led to the creation of a central marketplace, or square, around which shops and other commercial buildings were built. To efficiently move goods and people, transportation routes may have been designed to radiate outward from the marketplace and connect with nearby farms.

It's unlikely that Skarnes' layout was rigidly planned, but rather developed over time in an organic manner. Narrow and winding streets may have originated as historic pedestrian pathways, while wider streets could have been added later to accommodate carriages or automobiles. Public spaces like parks and playgrounds may have been incorporated into the village as it grew, providing areas for residents to relax and enjoy themselves.

Skarnes' current spatial arrangement likely results from a combination of its history and modern influences. While the historic center might maintain its traditional charm, newer residential areas could incorporate more contemporary designs, featuring wider streets and carefully plan green spaces. Ensuring easy pedestrian flow and accessibility throughout the village remains a top priority for both residents and visitors alike. To fully grasp the essence of Skarnes' spatial identity, one must go beyond a mere map analysis. To fully grasp the essence of Skarnes' spatial identity, it is essential to look beyond a mere map analysis. According to (Hillier B. A., 2007), cities have a dual nature comprising a foreground (global) and a background (local) street network. The foreground network, consisting of main routes and longer streets, facilitates efficient movement and connectivity across the city. In contrast, the background network, typically composed of shorter, residential streets, reflects cultural patterns and influences the spatial identity of a place.

In Skarnes, the foreground network includes the main streets and transport routes like E16 that connect the village to its surroundings, ensuring accessibility and movement efficiency. Meanwhile, the background network, formed by residential areas and local streets, embodies the cultural and historical aspects of the village. These local streets, with their distinct architectural styles and building materials, contribute to the village's unique spatial character (see chapter 3. Figure 2, 3, and 4).

Therefore, understanding Skarnes' spatial identity requires an in-depth exploration of both its foreground and background networks. By examining local photographs, architectural studies, and conducting on-site surveys, one can gain a deeper appreciation for how the spatial layout and connectivity, as described by (Hillier B. A., 2007), shape the village's cultural and historical identity. Through a combination of digital map analysis and on-site surveys, we can uncover the network of streets, plazas, and pedestrian walkways in Skarnes. Utilizing space syntax software, we can generate axial maps that reveal the longest and most direct lines of sight within these pathways, offering insight into potential pedestrian movement options.

The spatial arrangement and network design of Skarnes directly relate to several key issues faced by the municipality. The village must be preserved as it is now and provide safe walkways to schools within which the boundaries may be motor traffic free. Measures to promote the use of bicycles and buses and walking would facilitate the minimization of the use of cars, particularly for journeys by parents to take children to schools Additionally, the design of public meeting places, with universal access in mind, can help reduce social exclusion and provide essential amenities for the elderly, children, and other vulnerable populations. Efficient employee parking and its management are the other major concerns for the economic sustenance of the municipality's operations. In the meanwhile, all these measures will help the city to improve the quality of life of every resident and visitor.

A recent incident underscores the urgency of these issues. Figure 1. shows the accident news and the location of the accident on 15-01-2024 near the pedestrian roundabout where a school kid was hit by the car. Probably he was walking through the roundabout without realizing the pedestrian tunnel. The roundabout is situated on the E16 road and is only for motorized traffic. But maybe the kid mistakenly put the foot on the road without releasing the tunnel. The news is in Norwegian, and it translates as:

"***A student at Skarnes upper secondary school was hit in a pedestrian lane this afternoon."***

"We were notified of the incident afterwards where a high school student was hit in a pedestrian lane. We have been in dialogue with the boy's mother and have received feedback that there will not be serious injuries, says task leader Ove Stian Ovrum of the police in Innalndet.

The parties talked together at the scene, before the driver drove on, but we want to map out what has happened and talk to those who were involved."

So, this news correlates with the response in Figure 31. And Figure 35. Shows a clear image of the site's location, that is a very busy area, because of buses and every kind of traffic, so there is a dire need to propose some intervention in the area. Despite people feeling safe while walking (fig. 30) but this research got some very strong evidence that the E16 possesses a threat to pedestrians and their feasibility to walk around the area.


TRAFIKK SØR-ODAL POLITIET I INNLANDET

Skoleelev påkjørt i gangfelt

Av Benedicte Bratås Publisert: 15.01.24 15:37

En elev ved Skarnes videregående skole ble i ettermiddag påkjørt i et gangfelt.

For abonnenter

– Vi fikk melding om hendelsen i etterkant, hvor en videregående-elev ble påkjørt i et gangfelt. Vi har vært i dialog med guttens mor, og har fått tilbakemelding om at det ikke skal være alvorlige skader, sier oppdragsleder Ove Stian Ovrum i politiet i Innlandet.

– Partene pratet sammen på stedet, før bilkjører kjørte videre men vi ønsker å kartlegge hva som har skjedd og prate med de involverte.

Trafikkuhell

Mandag ettermiddag ble en skoleelev påkjørt i gangfeltet ved E16.

Les mer om: Trafikk Sør-Odal Politiet i Innlandet

Figure 1. Accident News about the Study Area. Near Pedestrian Roundabout.

Despite numerous researches, most existing literature focuses on major urban areas, leaving a significant gap in understanding the challenges and opportunities for improved walkability in smaller towns like Skarnes. Previous studies have extensively used space syntax analysis in urban settings to assess objective metrics like pavement widths, traffic volumes, and the spatial configuration of streets. However, these analyses often overlook the subjective experiences of pedestrians, which are critical for creating truly pedestrian-friendly environments. This study addresses this gap by applying a broader range of methods, including photographic surveys, local interviews, and space syntax analysis, to understand pedestrian experiences and mobility in Skarnes. By focusing on a smaller town and incorporating both quantitative and qualitative data, this research aims to provide a comprehensive view of pedestrian-friendly urban design and its impact on community well-being.

2. Theoretical Background

Walkable cities have been a major focus for urban planners in their quest to create vibrant, sustainable, and healthy communities. The effectiveness of several urban design initiatives in promoting pedestrian activity has been assessed by recent empirical studies. This review centers on research pertaining to pedestrian safety and accessibility, as well as the effects of design components on foot traffic.

When it comes to encouraging walking, safety should always be the first priority. According to Ewing (Ewing, 2010), there is a substantial link between car-centric design and pedestrian mortality. Interventions that prioritize pedestrians, such as complete streets and lower traffic speeds, have been shown to considerably reduce pedestrian injuries (Wang, 2017). These findings highlight the necessity of putting pedestrian safety first in urban planning. Similarly, One important element in encouraging pedestrian activity is accessibility. Sarkar (Sarkar, 2017) found that preserving sidewalks in excellent shape, having enough lighting, and making sure crossings are accessible are all essential for promoting walking, especially among older people and those with disabilities. The creation of walkable spaces that are beneficial to all users requires the use of inclusive design principles.

Beyond safety and accessibility, several design elements can significantly affect pedestrian activity. Speck (2018) found that visually appealing businesses, street trees, and broader sidewalks all encourage more foot traffic. Handy (2002) supports this by demonstrating mixed-use construction may be a potent walking inducement since it offers a range of attractions close by. These results highlight the need to include design features that guarantee accessible and safe walking while also producing a pleasant and interesting pedestrian experience.

The design of public spaces has a big impact on community development. Studies by (Carmona, 2003). indicate that well-planned pedestrian zones, parks, and plazas may serve as vibrant hubs for social interaction, attracting people and fostering a feeling of community. Coutts (2015) add that green infrastructure such as street trees and green areas can make pedestrian pathways more appealing, encourage physical activity, and improve mental health.

Numerous studies show that thoughtfully planned urban improvements significantly increase pedestrian activity. By emphasizing pedestrian safety, accessibility for all, and the incorporation of design features that promote walking, urban planners may build vibrant and healthy communities. Investing in pedestrian-friendly streets and public spaces has the potential to increase physical activity, lower population levels and enhance the general standard of living for city dwellers. (Ewing, 2010) accurately observe that "Walkable communities are not just a physical design; they are a lifestyle."

2.1. Urban Mobility and Pedestrian Dynamics

The flow of people through a city is essential to its operation and liveliness. Pedestrians are at the center of urban mobility and have the closest interactions with the city's infrastructure, even though other forms of transportation do play a part. Comprehending pedestrian dynamics and fostering walking are essential for developing urban landscapes that are sustainable, socially cohesive, and healthy. The ease and safety with which pedestrians may move about a city - walkability is impacted by a number of variables including; roadway connections, the width of sidewalks, traffic volume, and the availability of pedestrian street furniture like benches, trees, and crossings (Litman, 2015). Promoting walkability in cities necessitates deploying resources on pedestrian infrastructure, such as well-kept sidewalks, designated pedestrian zones, and secure pedestrian - crossings.

Prominent urban theorists: Jan Gehl and Jane Jacobs have fought for the importance of walking in urban planning. Gehl's landmark 1971 book "Life Between Buildings" emphasizes how important it is to plan cities with people in mind rather than solely around vehicular mobility. He contends that making pedestrian traffic a priority may improve social interaction, foster a feeling of community, and eventually raise the standard of living in a city. In a similar context, Jacobs' seminal book "The Death and Life of Great American Cities" (Jacobs, The Death and Life of Great American Cities. Random House., 1961) highlights the importance of designing vibrant and colorful streetscapes with a variety of uses at street level. She contends that busy pedestrian streets boost safety by the Principe of keeping "eyes on the street" and which allows for unplanned encounters and conversations among city residents hence strengthening a city's social fabric.

The movement of pedestrians is greatly impacted by a city's layout. Studies show that walking is more common in towns with a grid-like layout, varied land use, and shorter block lengths (Marshall, 2004). Walking is encouraged by this kind of urban architecture, which provides several route alternatives, reduces travel times between locations, and fosters unplanned meetings. However, large suburban developments that prioritize cars and have far-flung services from one another discourage walking, which results in a decrease in physical activity and social isolation (Ewing, 2010).

Promoting walkability has advantages beyond the health benefits of physical activity. It encourages communication amongst people and a sense of belonging. It promotes friendly interactions with store owners, other pedestrians, and among neighbors. These interactions can strengthen a person's sense of pride and belonging in their community and add to its social capital (Handy, 2002). Additionally, pedestrian-friendly streetscapes offer chances for people-watching, which may improve a city's feeling of safety and vibrancy.

Furthermore, walking-friendly communities may greatly improve the sustainability of metropolitan regions. Generally speaking, motorized vehicles produce higher amounts of noise and air pollution than pedestrians. A city's overall environmental well-being may be strengthened by encouraging the adoption of more environmentally friendly modes of transportation like cycling and public transportation, which can be achieved through the development of walkable communities (Newman, 1998).

Understanding pedestrian dynamics and promoting walkability is a crucial component for developing active urban areas. Prioritizing pedestrian infrastructure and creating walkable cities may enhance quality of life, encourage social interaction, and contribute to the development of more sustainable urban areas. According to Gehl (Gehl, Cities for people. Island press., 2013), "The city is primarily a place for people"; making walkability a top priority ensures that our cities genuinely cater to the people who call them home.

2.2. Theories of Social Interaction in Public Spaces

Public spaces are not just empty physical locations; they are living, breathing social ecosystems where people interact with each other and the city itself. The way these spaces are used generally reveals a city's distinct personality. Understanding the psychological and social elements that influence people's conduct in public settings. By doing this, we may provide environments that encourage constructive social interactions, improving the hospitality, inclusivity, and enjoyment of these spaces for all users.

Urbanist Kevin Lynch emphasizes the use of mental maps in his well-known book "The Image of the City" (Lynch, 1964). The mental maps that people make of their surroundings are cognitive representations that are shaped by the urban landscape's imageability, readability, and connection. He further explains that public spaces with well-defined concepts, easily remembered imagery, and effective linkages are more likely to be included into these mental maps, which encourages individuals to use them (Lynch, 1964). He further explained that pathways, edges, landmarks, nodes, and districts are the five key elements that make a city understandable. These components are frequently seen in public areas, which are essential to determining the personality of a city. A well-marked walkway in a park, for instance, can help pedestrians find their way about, and a notable structure or monument can serve as a distinguishing landmark that helps people navigate the urban environment. A bustling square or plaza may serve as a hub, attracting people and fostering conversation. When these components are expertly combined, public areas become more than just tourist attractions; they become vital components of the mental map of a city, promoting discovery and social engagement.

William H. Whyte explores the social dynamics of public spaces in his seminal work "The Social Life of Small Urban Spaces" (1980). Whyte discovers crucial architectural aspects that either encourage or inhibit social interaction via careful observation of people interacting in urban settings. He emphasizes the value of "triangulation," in which groups are seated so that there is easy eye contact and communication amongst them. Whyte also emphasizes the significance of "passive provision," which describes elements like landscape, street furniture, and microclimates that obliquely entice people to remain and socialize (Whyte, 1980). Whyte criticizes the aesthetics-first approach taken in the design of many modern public areas. He further explains that large, open plazas frequently don't encourage social connection, which makes people feel alone even when there are many people around. Conversely, well-planned plazas including water features, covered spaces, and seats grouped in smaller clusters become lively community centers. People feel more at ease and engaged with their environment when these design decisions foster a feeling of ownership and social connections.

Though the effects of design on public areas are widely recognized, psychological factors that influence social interaction should also be considered. Robert Sommer explored the concept of "personal space" in his 1969 book "Personal Space," which refers to the unseen circle that individuals keep around themselves. He explains that when personal space is not respected and allowed in public areas, urban spaces can seem crowded and unwelcoming, which discourages people from interacting with each other. However, subtle personal space boundaries can be created by design features like plants and well-placed furniture, which promotes comfortable social engagement and a sense of security (Sommer, 2002).

Territoriality – which is defined as the attempt by an individual or group to affect, influence and assert some control over a geographic area, is an additional and a very important psychological factor. Public areas that people feel like "theirs"—places that are secure, comfortable, and give them a feeling of belonging—are places where people are more inclined to interact and spend time. Public spaces may create a feeling of territory and in turn increase social interaction by encouraging community ownership through user-designed components or local participation activities.

In order to design public areas that foster social interaction, designers need to use a variety of strategies. Lynch's concepts of legibility and imageability should be taken into consideration to guarantee that locations are included in mental maps. Furthermore, as Whyte's research indicates, adding components that support triangulation and passive provision might boost social interaction even more. Through a comprehension of the psychology of space and the integration of features that address individual space requirements as well as communal ownership, we may augment the feeling of safety and inclusion, which in turn promotes social engagement.

In nutshell public areas serve as potent social catalysts and are much more than just physical structures. Through an understanding of Lynch and Whyte's sociological and psychological underpinnings of space utilization, we may create public places that encourage social interaction. These vibrant areas foster a feeling of shared experiences, community, and belonging, which enhances the health and vitality of our cities.

2.3. Space Syntax

Space syntax theory and its relationship with urban space is thoroughly explained by Yamu (Van Nes A. &., 2021) in her book. According to Yamu, Space syntax provides a theoretical framework and methodology for accurately characterizing and measuring the spatial characteristics of the constructed environment that influence socio-economic activities. Key figures in comprehending the connection between the physical aspects of urban environments and social dynamics are Jane Jacobs (1960) and Jan Gehl (1971).

Jacobs explores the significance of pedestrians in creating vibrant urban environments in her book, *The Death and Life of Great American Cities.* She proposes using physical indicators to determine the type of spatial framework that creates vibrant and secure cities. Her work encompasses an analysis of urban blocks, surveillance of public spaces (eyes on the streets), distinct separation between public and private areas, and the integration of various activities (Van Nes A. &., 2021).

In his 1971 work "Livet mellem husene" (Life between buildings), Gehl examines the specific activities that contribute to the vitality of urban spaces. The author's classifications of activities as necessary (such as going to work or school), optional (such as strolling), and social (such as playing, meeting people, and playing sports) are derived from his study conducted in the 1960s and subsequently implemented in his architectural work. Gehl argues that optional activities enhance the experience of life in urban spaces and are heavily influenced by the physical characteristics of the built environment (Van Nes A. &., 2021).

Jacobs and Gehl offer an understanding of how the level of urban liveliness is connected to the spatial characteristics of public space. However, didn't have a consistent way to measure the conditions needed for liveliness of an urban space and how safe a city should be. Only through this quantification will it be feasible to understand the spatial circumstances that are crucial for vibrant street life and urban safety (Van Nes A. &., 2007). Building upon the research conducted by Jacobs and Gehl, space syntax offers a set of tools for examining urban space and evaluating urban design choices with the aim of fostering vibrant cities and communities (Van Nes A. &., 2021).

Space Syntax Theory, first raised and considered in 80’s, is a very innovative method of urban analysis. It was developed by Bill Hillier and his colleagues at the Bartlett School of Architecture, University College London (Hillier B, 1984). In contrast to conventional urban analysis that considers space as a passive, static scenery, Space Syntax Theory ascertains a strong correlation between the spatial environment layout and the social activities that occur within them. Such an outlook, therefore, has very important insights for urban designers and planners aiming to create more functional and socially dynamic cities.

At the heart of Space Syntax Theory is the idea that the arrangement of buildings, streets, and other urban elements significantly influences how people navigate and interact with space. It stresses the importance of "configuration," analyzing the connectivity and integration of different parts of the environment (Hillier B. , 1996). By examining this connectivity, Space Syntax can reveal the ease or difficulty of movement and the potential for encountering others within the urban fabric. This approach provides an innovative way to understand the relationship between built environments and human behavior, which can inform more effective urban design and planning decisions.

The idea makes use of a number of analytical methods to break down urban landscape into a web of interconnected areas. These methods frequently rely on movement patterns and sightlines. Axial analysis is a particular approach that finds the longest continuous lines of sight in a given area. Highly integrated areas are said to be easier to navigate and foster an open feeling since they have many deep axial lines. On the other hand, areas with brief and disjointed sightlines are seen to be less connected and may impede mobility or foster a feeling of seclusion (Hillier B. , 2007).

Space Syntax goes beyond mere visual analysis. It utilizes metrics like integration and choice to quantify the relationships between spaces. Integration reflects the ease of reaching different parts of the network, while choice refers to the number of alternative routes available for movement between any two points (Hillier B, 1984). These metrics provide a data-driven approach to understanding how spatial configurations influence human behavior.

The significance of Space Syntax lies in its ability to unveil a hidden layer of meaning within urban landscapes. This theory posits that spatial configurations can be linked to various social phenomena. For example, studies have shown correlations between highly integrated spaces and increased levels of pedestrian activity, social interaction, and economic vibrancy (Carmona, 2003). Conversely, poorly integrated spaces may be associated with higher crime rates and a sense of fear (Mara, 2022).

The theory of *natural movement (economic process)*, space syntax-based, is the argument that the spatial configuration of urban areas significantly affects the movement patterns and the distribution of economic activities. This type of forecasting likely functioning of urban designs when it is in place has to deal with the space changes and requires comprehensive baseline analyses of current contexts. Space syntax is effective in the prediction of potential socio-economic impacts. Nevertheless, it cannot override social rationality or the cultural context, nor can it inform the optimal design solution. Instead, it tests several spatial options through the scenario analysis, answering the question "What happens if.?" and showing the result. This theory concentrates on an understanding of the local culture, laws, and regulations, considers priority to be given to pathway networks in planning, and uses simple language in visuals so that information findings can be communicated to stakeholders of any background to guarantee that the urban environment is working effectively (Van Nes A. &., 2021).

By understanding these correlations, Space Syntax empowers urban designers and planners to make informed decisions for a city's functionality and social well-being. For instance, analyzing existing urban layouts with Space Syntax tools can reveal areas with poor connectivity and limited pedestrian movement. This information can then be used to inform design interventions that improve integration, such as creating pedestrian walkways, plazas, or opening up vistas that enhance visual connection between spaces. By incorporating these principles from the outset, designers can create urban layouts that promote social interaction and pedestrian movement. This can be done by ensuring high levels of integration within a development and providing diverse pathways for movement, encouraging a sense of exploration and discovery within space.

Critics of the Space Syntax theory argue that the theory ignores the impact of social and cultural elements on urban behavior in favor of concentrating exclusively on physical layout (Yagi, 2022). Additionally, the use of specialized software and complex mathematical calculations can be perceived as a hurdle for those who are not experts in the field to effectively engage with the theory. Space Syntax Theory is nevertheless a useful tool for urban studies in spite of these drawbacks. Its capacity to measure the connection between spatial arrangement and social phenomena can provide important new perspectives on how to build more socially and functionally dynamic cities. Space Syntax offers a distinctive viewpoint for comprehending the intricate interactions between space and society, which are becoming more and more important as urban designers look for data-driven solutions.

2.4. Gaps in Literature

Pedestrian-friendly design is a crucial aspect of constructing walkable cities, offering numerous benefits including improved public health, reduced traffic congestion, and enhanced social interactions. Despite the growing body of research on this topic, much of the existing literature focuses on major urban areas, leaving a significant gap in understanding the unique challenges and opportunities for improving walkability in smaller towns such as Skarnes.

Previous studies have extensively applied space syntax analysis to urban settings, primarily evaluating objective metrics of pedestrian activity like pavement widths, traffic volumes, and the spatial configuration of streets. While these analyses provide valuable insights, they often overlook the subjective experiences and perceptions of pedestrians, which are critical for creating a truly pedestrian friendly environment. For instance, research by Follestad (Follestad, 2018) concentrates on urban densification in a specific urban area (Skjoldskiftet) and its implications for urban planning. It employs methods like Space Syntax, Space Matrix, and Kevin Lynch to analyze the street network and building morphology. In contrast, this research explores pedestrian-friendly design in the smaller town of Skarnes, incorporating a broader range of methods, including photographic surveys, local interviews, and space syntax analysis to understand pedestrian experiences and mobility in a rural context.

Staahl's (Erland, 2013) work focuses on the movement and quality of urban spaces in a waterfront context, emphasizing the role of natural elements and the attractiveness of the sea. The study uses Space Syntax and other spatial analysis methods to measure visibility and movement, along with observational data. This research, on the other hand, addresses pedestrian mobility and safety in a small town, examining how physical layout and infrastructure impact pedestrian experiences and proposing specific interventions to enhance walkability.

Thesis by Ladehaug (Ladehaug, 2018) focuses on the impact of bypass roads on the commercial and spatial dynamics of small towns. The study uses space syntax to analyze changes in the location pattern of shops and urban functions before and after the construction of bypass roads. This research differs by focusing on the pedestrian-friendly design and urban health in Skarnes, specifically looking at how space syntax and other methods can be applied to improve pedestrian safety, mobility, and overall urban quality in a rural town setting.

The application of space syntax in a Norwegian context, specifically in rural towns near Oslo, is somewhat limited. That is, integrating urban health considerations with pedestrian-friendly design and urban development is underdeveloped. This gap is relevant to the social dynamic, infrastructure, and economic factors of a rural town like Skarnes. This study closes that gap through space syntax analysis and qualitative assessments of pedestrian experiences in Skarnes. The study, therefore, examining unique characteristics of Skarnes and its nearness to Oslo, endeavors for social improvement for pedestrian friendly smaller Norwegian towns. The mixed method used in this research combines quantitative spatial analysis with data from pedestrian surveys, expert interviews, and qualitative data for a comprehensive view of pedestrian-friendly urban design and its impacts on community well-being.

2.5. Research Questions

1. To what extent is pedestrian-friendly, inclusive accessibility realized in the town of Skarnes?

1.a. What kind of features are hindering pedestrian movement in Skarnes?

1.b. To what extent do pedestrians perceive it to be safe to walk?

- This question will be answered through a built environment audit, looking into the elements such as availability of sidewalks accessibility features and road design. The study will utilize current space syntax model, photographic illustrations, surveys, and expert interviews. By conducting a survey with locals in Skarnes this research aims to improve their perception of safety and comfort while walking.

2. Which spatial development strategy creates an inclusive, pedestrian-friendly built environment and adds socio-economic value to future Skarnes?

- To address this question, First, the current state of Skarnes will be assessed using a combination of methods. A detailed space syntax analysis will evaluate the town's spatial configuration, focusing on key metrics such as connectivity, integration, and pedestrian movement patterns. A photographic survey will document the existing pedestrian infrastructure, highlighting areas needing improvement. Pedestrian surveys will be distributed to residents to gather qualitative data on their perceptions of safety, comfort, and accessibility. Additionally, semi-structured interviews with urban planners, local government officials, and other stakeholders will provide expert insights on the current pedestrian infrastructure.
- Second, the existing master plan by architect for Skarnes will be critically analyzed with space syntax analysis using “Choice”. This involves reviewing the master plan to identify provisions for pedestrian-friendly infrastructure and socio-economic goals. The plan will be assessed using space syntax analysis to evaluate its proposed spatial configurations, comparing these metrics with the current state.
- Third, two alternative design scenarios will be developed through workshops with urban planners, architects, and local stakeholders. Each scenario will be evaluated using space syntax

to assess potential impacts on pedestrian movement and connectivity. These Scenarios will also be analyzed through space syntax analysis and syntactic values.

- Finally, a final scenario will be developed by author, combining the best elements of the current state, the existing master plan, and the expert-developed scenarios. This scenario will be evaluated both quantitatively, using space syntax analysis, and qualitatively, through follow-up pedestrian surveys and expert interviews. The integrated analysis will inform specific need for a new master plan by author and design interventions, such as new street profiles, pedestrian pathways, and public spaces, tailored to the unique context of Skarnes.

By following these steps, the study will provide a comprehensive, data-driven analysis of how to create an inclusive, pedestrian-friendly environment in Skarnes. The proposed strategy will be informed by both quantitative spatial analysis and qualitative insights from local residents and experts, ensuring a holistic approach to urban development that enhances walkability and socio-economic value.

This study attempts to highlight the pedestrian experience in Skarnes through evaluation of the spatial layout, urban design components, and user experiences. This study aims to offer recommendations for making Skarnes more walkable, inclusive, and vibrant by assessing both objective design elements and subjective opinions about safety and user experience. It is expected that this research will yield valuable insight not only into walkable city planning in general but also for smaller communities and can guide future developments in Skarnes while inspiring similar efforts in other towns.

2.6. Importance of Space Syntax Approach for Skarnes

Space Syntax is a useful tool for revealing the level of integration in Skarnes' street network. This information is crucial for locating areas that have poor connection, as it may discourage walkability/pedestrian mobility. Space Syntax can accurately identify regions where improving its connections might boost the movement of pedestrians by analyzing integration metrics and axial lines in great detail (Hillier B, 1984).

Skarnes is a town with a lot of potential to improve its walkability. Space Syntax can help identify regions where pedestrians are likely to be active. This spatial layout study can assist identify specific regions that could benefit from interventions like pedestrian-only zones or improved street facades. By focusing on specific improvements, Skarnes can make the town more pedestrian-friendly and encourage both inhabitants and visitors to explore it on foot. (Hillier B. , 2007) highlights the possible advantages of such treatments in his study on the subject.

The Space Syntax analysis may efficiently identify issue spots in a spatial design that may restrict pedestrian mobility. The barriers that can be detected include dead ends, unconnected roadways, large crossroads and many more. With this knowledge, design methods may be recommended to reduce these barriers and increase pedestrian safety, such as building pedestrian crossings or improving sightlines, which would eventually promote and encourage walking (Carmona, 2003). The Space Syntax Theory offers a useful framework for understanding the relationship between spatial structure and social behavior in urban environments (Hillier B, 1984). The layout of streets and buildings may influence pedestrian movement and encourage social contact, which is essential for designing cities that value human experience (Carmona, 2003).

In this study on Skarnes, this research intend to use Space Syntax analysis to make important contributions to the fields of urban planning and space syntax approach. The goal is to investigate the link between physical space and social interactions in urban areas, as well as how this influences the overall operation of cities. Using Space Syntax analysis, this study aims to provide insights into how urban layout affects social and economic connections, pedestrian mobility, and accessibility, allowing for the creation of more successful urban planning strategies. By filling the gap in the existing literature, this study can demonstrate how to make use of Space Syntax in a smaller town context. The study aims to promote the wider use of Space Syntax in similar urban environments by showcasing how effective it is in guiding pedestrian-friendly design decisions for smaller towns like Skarnes.

Although space syntax is deniably important in urban planning but as mentioned earlier it ignores social and cultural considerations. However, a mixed-methods approach that includes both Space Syntax analysis and qualitative data collecting can help to address these constraints. Previous studies, like Penn's (2013) (Varoudis, 2013,) have shown how useful this method is for improving our comprehension of urban environments by integrating user experience with spatial - geographical analysis.

The research's mixed-methods approach can help provide a more thorough knowledge of pedestrian friendly urban space. The link between spatial arrangement and real-world experience can be better understood by combining data on pedestrian perceptions (questions on safety and user experience) with Space Syntax analysis. This can inform future research by highlighting the importance of user-centered design in space syntax applications. Skarnes' results can spur additional investigation in other small towns with distinct spatial arrangements. By proving the utility of Space Syntax in examining pedestrian potential within a given context, this study can help to design context-sensitive planning techniques for enhancing walkability in a variety of urban settings.

Space Syntax Theory is a great tool for studying how urban architecture influences human behavior. By combining Space Syntax analysis with my study on Skarnes, I hope to not only design focused solutions to improve the town's walkability, but also contribute to the larger field of urban planning. This research has the ability to demonstrate the efficacy of Space Syntax in smaller cities, close the gap between theory and reality, and emphasize the relevance of user experience in space syntax apps. Finally, it can help to create more walkable, sustainable, and human-centered cities in the future.

3. Case Study

3.1. Location and connections of Skarnes with nearby cities

Skarnes is situated in the Sør-Odal municipality along the Glomma river. It is roughly an hour's drive from Skarnes to Oslo. Conversely, Kongsvinger is about a 20-minute drive away, and the Swedish border can be reached in approximately 50 minutes. The Gardermoen airport is also about 50 minutes' drive from Skarnes. The L14 train line operates from Asker through Oslo S to Skarnes, continuing towards

Kongsvinger. Direct trains from Oslo S to Skarnes typically take 1 hour and 4 minutes, with services running hourly. Sør-Odal functions as a commuter municipality where a significant portion of the workforce commutes out; 60% of the 3,900 working residents (as of 2018) primarily travel to Kongsvinger, though many also head to Oslo, Nes, and Ullensaker. About 40% of jobs in the municipality are filled by commuters coming predominantly from Kongsvinger. Figure 2 shows the lay out and connections of Skarnes with nearby areas.

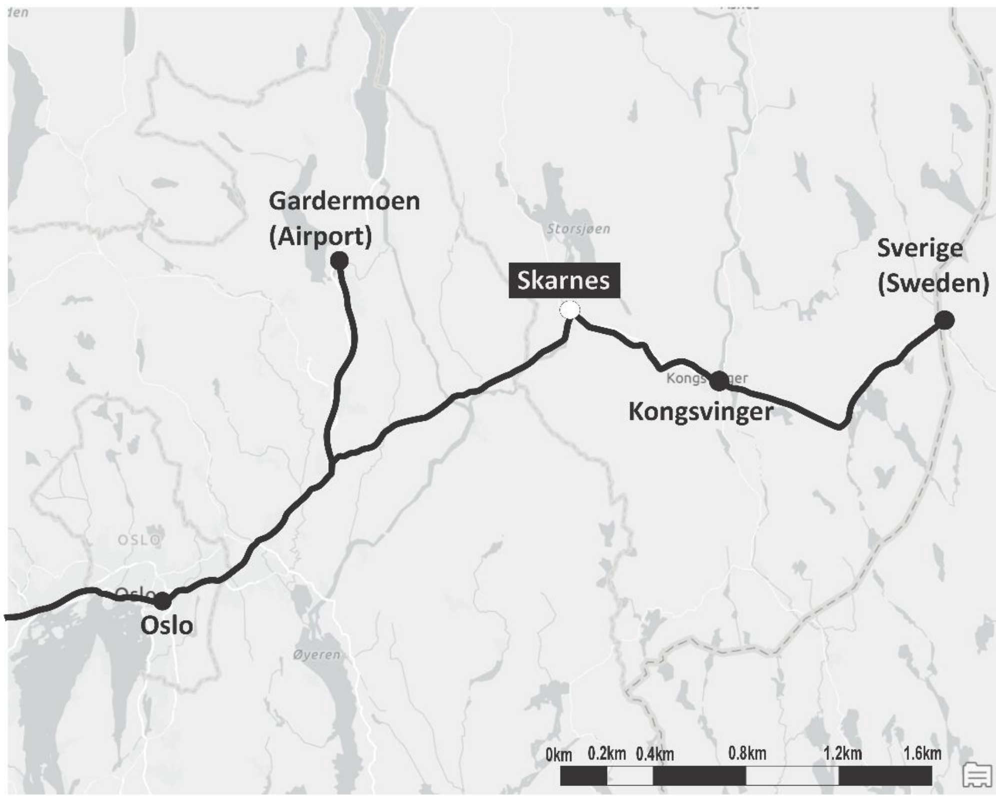


Figure 2. Location and connections of Skarnes with nearby cities.

3.2. Overall Skarnes Landscape

The town of Skarnes is broadly segmented into three distinct areas. Central Skarnes, nestled on a cape encircled by the Glomma River, hosts key facilities such as the railway station, town hall, and the main commercial center. To the south lies Tronbøl, predominantly a residential zone characterized by detached homes where a majority of Skarnes' population resides. Across the Glomma, Korsmo is linked to Skarnes by both a pedestrian and a vehicular bridge. Right here in the community, it has got everything important close by - that includes both schools and places where our seniors can live comfortably.

Figure 3 illustrates that Skarnes is well-connected by major transport routes; European route 16 (E16) links it westwards to Oslo and eastwards to Kongsvinger and Sweden, running along the river by Korsmo. Additionally, County Road 24 extends north from Skarnes towards Nord-Odal, while County road 175 traces the river's south bank.

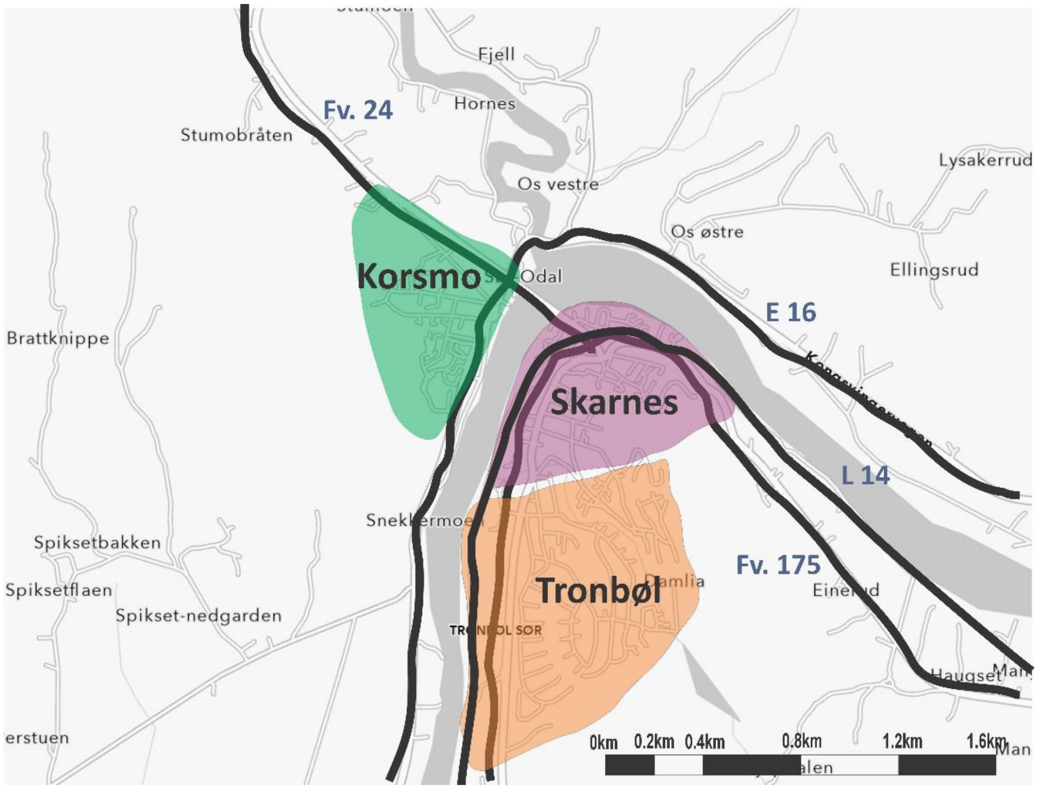


Figure 3. Overall Skarnes Landscape.

3.3. Søsterhagen Planning area

The planning area for the Søsterhagen residential area is located in the northern part of Korsmo (Fig. 4). The Søsterhagen residential area, covering approximately 350 decares, is strategically located in the northern part of Korsmo, bordered by E16 to the east, county road 24 to the north, Lehmann's road to the south, and the wooded area around Spigsetberget to the west. Right here, schools, parks, hospitals and homes blend together in a perfect mix that just makes life easier. Key landmarks such as Bøssmyra and Søsterhjemmet stand alongside prominent educational institutions including Glommasvingen School and Skarnes Upper Secondary School. Around here, you'll find everything from sports facilities to a swimming hall. Plus, the Korsmo bus terminal is right on our doorstep, making it super easy for schoolkids to get around. Healthcare amenities are predominantly located towards the west end of Korsmo, close to the nearest kindergarten. A brand-new underpass now links Øgårdsvegen with Bruvegen, making it an even more attractive spot to live thanks to better connections. These components illustrate the region's comprehensive mix of educational, recreational, healthcare, and residential offerings, all situated in an environment that prioritizes nature and accessibility.

The planning area covers the northern part of Korsmo and is approximately 346 decares (about 85.5 acres) in size. Within the planning area, 5 project sites have been defined for the Søsterhagen residential area, which are currently municipally owned. The municipality wishes to sell these to private developers. The five sites are:

- Søsterhjemmet, 4.1 decares (about 1.01 acres)
- Sykehusvegen, 9.0 decares (about 2.22 acres)
- Graner, 22.7 decares (about 5.61 acres)
- The old Sør-Odal secondary school, 22.4 decares (about 5.54 acres)
- Bøssmyra, 32.9 decares (about 8.13 acres)

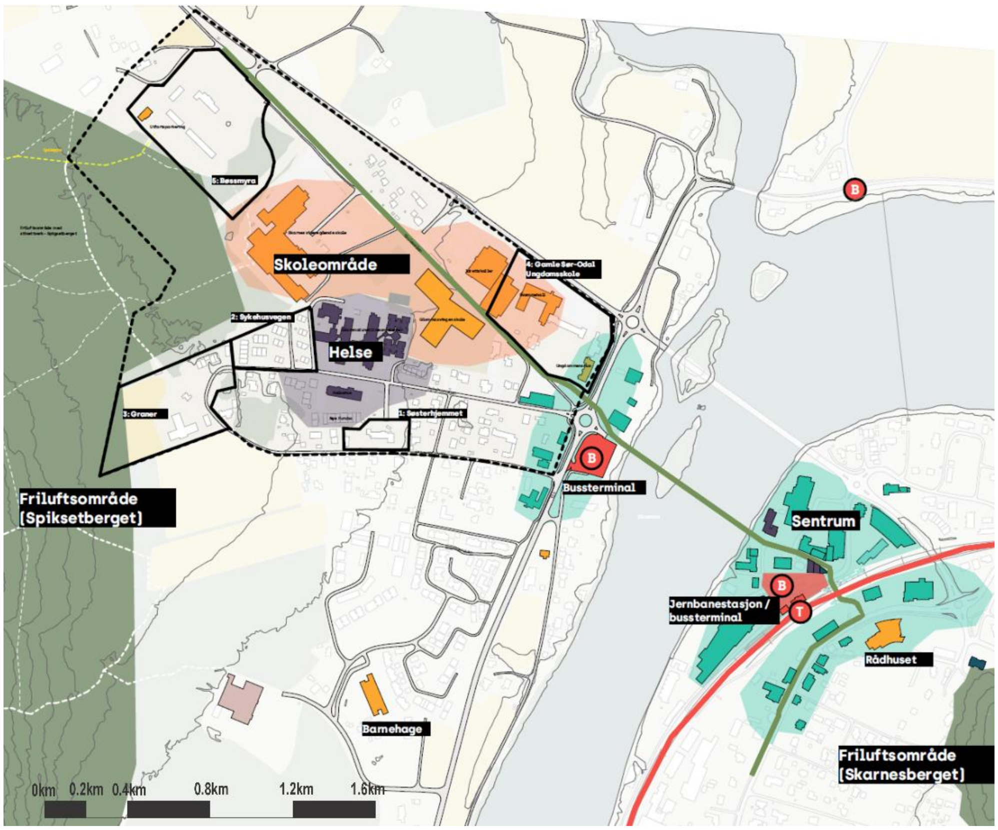


Figure 4. Søsterhagen Planning area (image by Søsterhagen boligområde Report).

4. Methodology

4.1. Mixed Method Approach

Three research methodologies are utilized in the field of social sciences: The three main research methodologies are qualitative, quantitative, and mixed approaches (Tashakkori, 1998). Mixed method approach is the combination of both quantitative and qualitative data for complex research topics for better results and outcomes. It employs both statistical methodologies and in-depth interviews to provide a more comprehensive perspective on the research subject. This method is valuable since it enables researchers to investigate and validate various facets of a phenomenon, hence enhancing the reliability and comprehensiveness of the findings.

This section outlines the methodological approach for investigating the redevelopment of the Søsterhagen area in Skarnes, focusing on enhancing pedestrian connectivity and urban integration. The methodology is designed to address research questions and municipal challenges through the application of space syntax analysis.

4.2. Space Syntax

Space syntax is a theory and method for analyzing spatial interactions that was developed in the 1970s by Bill Hillier and his colleagues at The Bartlett School of Architecture, University College London. In a broader perspective, space syntax is a collection of approaches that may be used singly or in various combinations. The use of these various analytical tools is determined by the study of urban design and planning question(s) for one or more urban systems under consideration. The space syntax technique is essentially concerned with computing configurative spatial connections in the constructed world. Hillier and Hanson recognized early in the method's development that space syntax can provide a spatial understanding of the social organization in settlements from different cultures by demonstrating how buildings and settlements play a role in social relations (Van Nes A. &., 2021).

Space syntax techniques are based on two basic concepts: integration and choice (also known as potential to movement and potential through movement). The topological centrality of a particular region within a city network is described by its integration. The greater the integration value of a particular place, the more accessible (to movement) and connected it is within the urban network. This selection indicates how likely a particular area is to be used when moving between two points within a city network (through movement). The terms integration and selection correspond to two fundamental parts of any journey: the selection of a destination from a starting point (integration) and the selection of a route between the starting point and the destination (choice). They may thus be used to forecast the possibility of specific metropolitan locations attracting pedestrian or vehicular traffic, as well as a variety of other social activities (Aleksandrowicz, 2018).

The spatial analysis was carried out through Depth map software, applying NACH (Normalized Angular Choice) Analysis. This process involved normalizing the values with a specific formula (see methods) to ensure comparability across different scales. To assess pedestrian feasibility, the study focused on three different measures of accessibility. Global Accessibility was examined through Log Choice N, while pedestrian accessibility for more localized movement was studied using two radii: an 800m radius representing a 10-minute walk (Log Choice 800m), and a 1200m radius for a 15-minute walk (Log Choice 1200m). This approach using multiples scales provided a comprehensive view of the navigational potential for pedestrians in the study area.

Normalized angular choice (NACH) has been implemented since 2012 (Hillier W. R., 2012). Currently, the computer application Depth map enables the normalization of angular segment choosing and angular segment integration studies using metric radii immediately within the software following graph processing. The values were normalized using a specific formula to ensure consistency in the analysis.

Equation 1. Formula for Normalizing Angular Choice.

$$NACH = \log(Choice(r) + 2)$$

This normalization formula is highly robust and effectively functions for all categories of built environment. This formula is useful for comparing one map of a city with another map when the axial maps are not georeferenced. If the maps are If all the maps are georeferenced using the same units, there is generally no requirement to normalize the values (Van Nes A. &., 2021).

To understand the spatial dynamics of the Skarnes city and to pinpoint areas for potential development of pedestrian friendly and walkable centers, a strategic map was created using a systematic approach rooted in space syntax methodology. To check the overall efficiency and accessibility of the area three strategies were developed.

1. An existing strategic map was devised to encapsulate the entire network of Skarnes, incorporating axial lines that represent both pedestrian pathways and vehicle-centric roads, to evaluate the city's overall accessibility (Figure 5).
2. An existing car-based map was crafted, this time excluding the pedestrian bridge and focusing on the highway bridge, while also omitting walk-only paths, to assess the infrastructure tailored specifically for vehicular access (Figure 5).

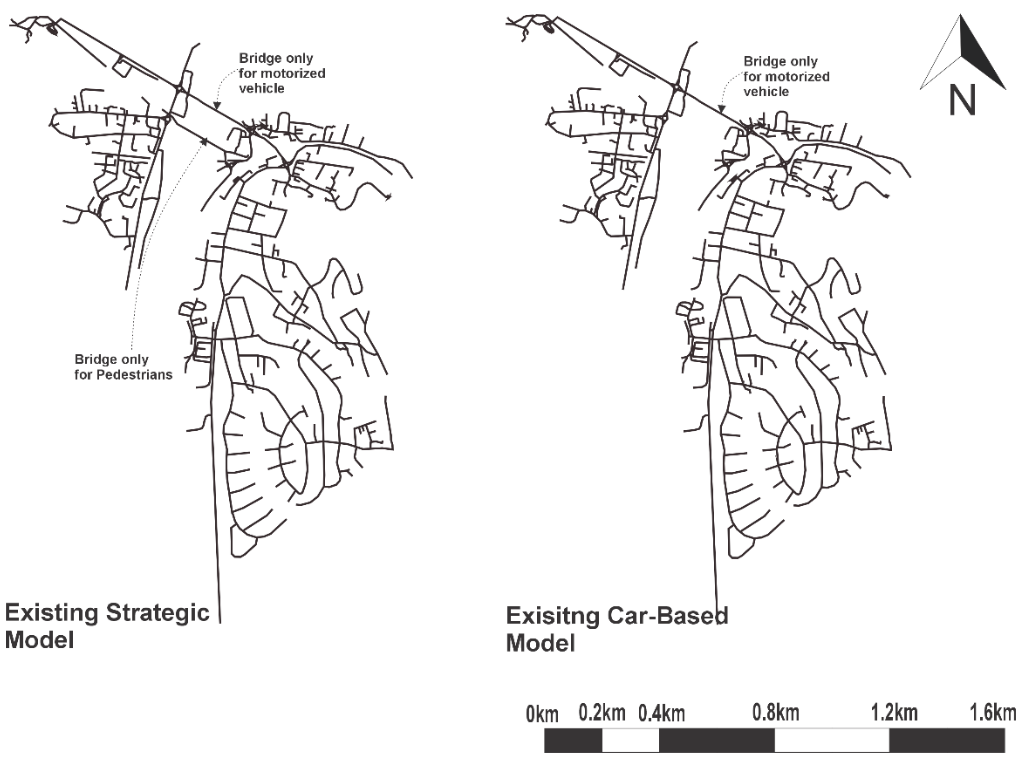


Figure 5. Unprocessed Axial Map of Strategic and Car Based Model Respectively.

3. An existing pedestrian-centric map was developed, omitting highways while incorporating a walking bridge that connects one side of Skarnes to the Søsterhagen area, emphasizing pedestrian mobility (Figure 6).
4. An existing proposed master plan by the architect from Sør-Odal municipality was georeferenced and integrated into the pedestrian-focused map. This approach enabled us to evaluate the overall effectiveness of the proposed plan from the area planner, assessing its potential to enhance pedestrian-friendly spaces in the region over time (Figure 6).

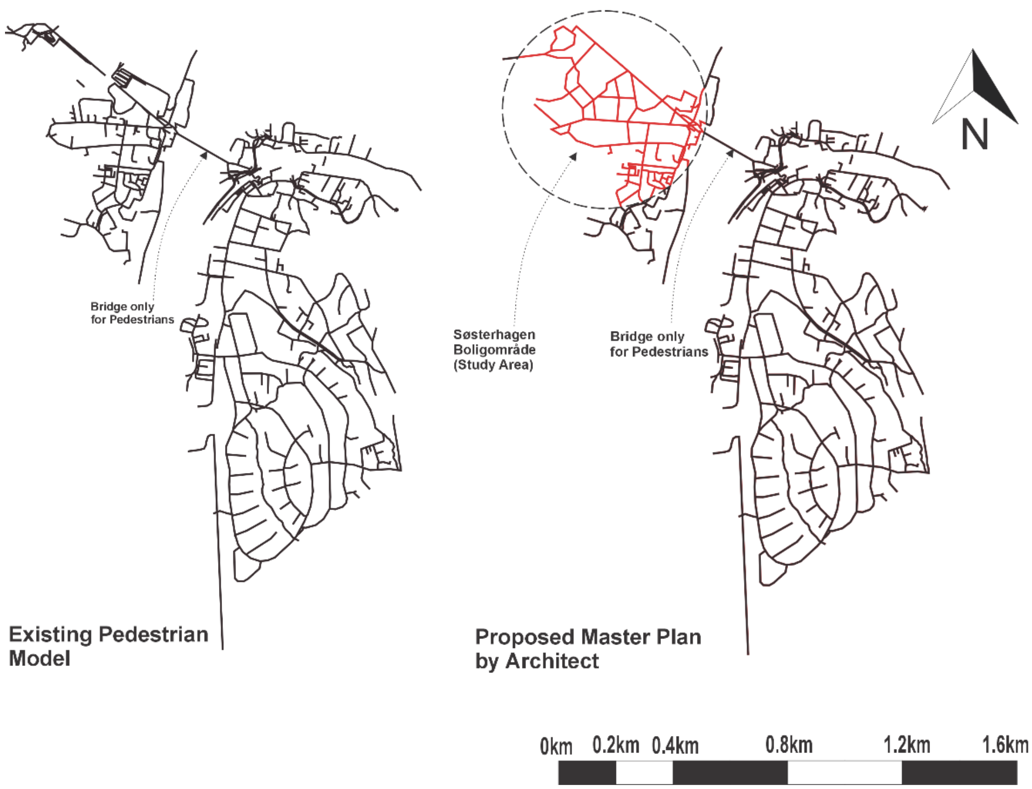


Figure 6. Unprocessed Axial Map of Existing Pedestrian Model and Proposed Model by Area Planner respectively.

4.3. Stakeholder workshop and Expert Interviews (qualitative)

The participant took part in a conference organized by the Sør-Odal municipality, which was aimed at addressing the spatial challenges faced by Skarnes. The event saw the involvement of 20 participants from 9 distinct municipalities. The conference was centered around several key objectives:

Problems (by municipality in conference)

- To ensure safe route to school
- Contribute to less driving by parents with children to school, encourage bicycle and public transport
- Reduce social exclusion with universal design of meeting places, benches and light seating for elderly, children, vulnerable people and local population

- Less motorized traffic
- Facilitate for elderly
- Ensure good financial operations
- Manage parking for employes in local area

During the conference, a space syntax workshop was conducted with GIS experts and area planners to reevaluate the proposed plan from Sør-Odal municipality's area planner. The objective was to develop solutions aimed at improving accessibility and facilitating pedestrian navigation within the Søsterhagen area. The workshop was organized into two groups, culminating in the creation of two new maps. These maps presented innovative approaches to reconfiguring the layout of the Søsterhagen area to better support pedestrian movement. Below (Fig. 7) are the images of workshop and discussion for the new development of Scenarios by experts.

(a) Development of Scenario 1-by experts

(b) Development of Scenario 2-by experts

(c) Discussion about approach towards developing scenarios 1

(d) Discussion about approach towards developing scenarios 2

Figure 7. Stakeholder Workshop Images.

4.3.1. Approach Towards Development of Scenario 1 (By Experts)

- Tried to separate the pedestrian/bicycle paths from cars.
- Adding walking/cycling green areas in the existing green area (straight lines/line of sights).
- Connecting walking and cycling paths with entrances of videregående and living areas (direct connections).
- Arranged shorter walking paths for recreational purposes around institutions and health areas.

4.3.2. Approach Towards Development of Scenario 2 (By Experts)

- Change direction of the buildings in Bøssmyra so that it's easy for the people, coming from center, to navigate towards-around the area.
- Direct walking link with videregående with the skolevegen.
- Created a direct better connection with sykehus.
- Søsterhjemmet was detached from the rest of the Korsmo area so making a better connection with søsterhjemmet.
- Creating a shortcut from walking bridge and roundabout (in sport center) towards skolevegen.

4.3.3. Approach Towards Development of Final Scenario (By Author)

- Created a Grid and Graner and Bøssmyra area for better connection and movement.
- Created a overall better connection of Garner Area with Bøssmyra Area.
- Added one more direct link between Lehmanns veg and Sykehus Vegen (Hospital Road).
- Make a through connection of Skolevegen (School Road) with Bøssmyra area also with vidregående skole (High school) and Sykehus (Hospital)
- Removal of the roundabout in front of pedestrian bridge for better flow of foot traffic.

Figure 8. Illustrates the changes in the study area with the development of new Scenarios by experts and final Scenario by the Author.

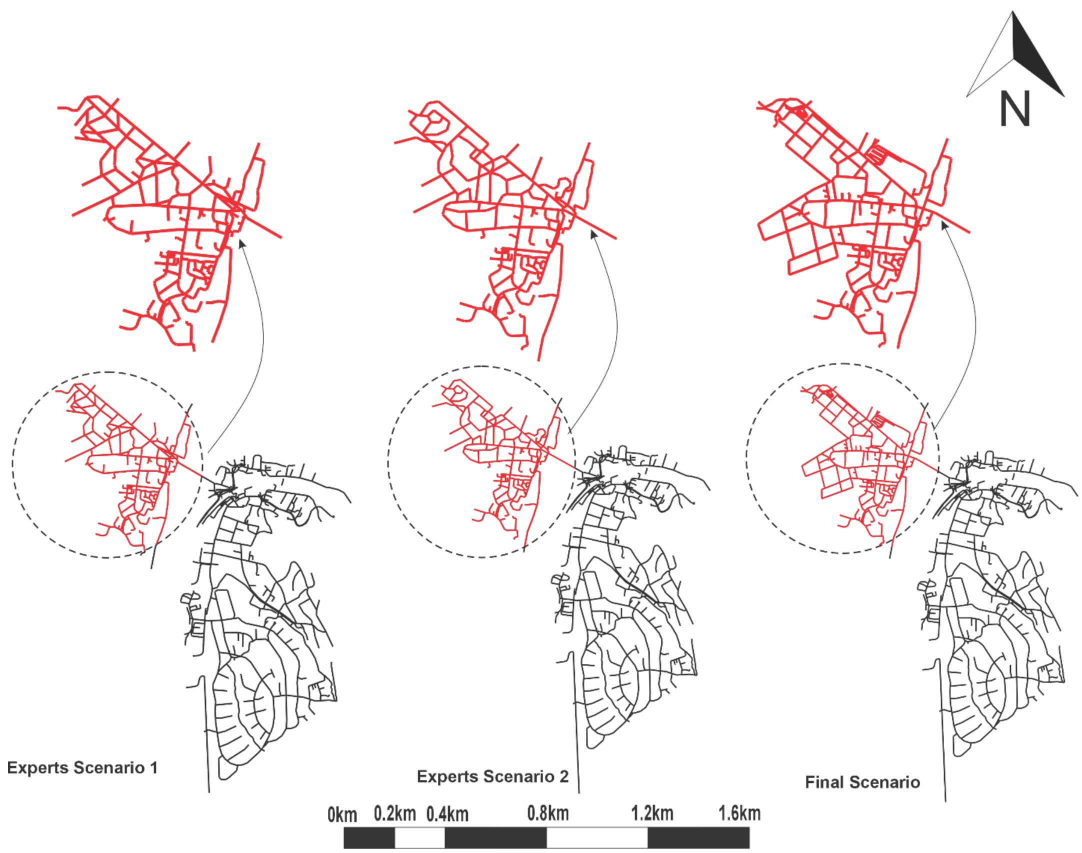


Figure 8. Unprocessed A Maps of Expert Scenario 1, 2 and Final Scenario respectively.

4.3.4. Expert Interviews (Qualitative)

The semi-structured interviews conducted to obtain qualitative information from professionals involved in municipal operations with respect to the comprehensive study of urban planning and development in Skarnes were held during a workshop on 5th March 2023. These proved to be very effective for the evaluation of the applicative value of space syntax in urban planning, perceptions about inclusive accessibility, and priorities in the urban development of Skarnes. The discussion section was carried out by two female urban planners, one male GIS analyst, one male urban planner, and a male land measurer. The ages of the participants ranged from roughly 31 years to 60 years. Their perspective thus gave a mature and experienced team. Interviews were held in English, and the responses to some inquiries were in Norwegian, then translated to english for proper accuracy and context; these are summarized in the result section (chapter 5.6 Analysis of Expert interviews). The key issues discussed include the utility of space syntax for planning and defining and enhancing inclusive accessibility and strategic urban development needs specific to Skarnes.

An opinion divide appeared around whether one or two local centers or any pedestrian-friendly infrastructure can be incorporated on an everyday basis into the overall urban aesthetics and practicality that best serves the community. Information from these interviews provides key insight into professional standards and descriptions of what is expected for urban planning in Skarnes with respect to both consensus and divergences in expert opinion. This is qualitative data that builds up the thesis, because it treats pedestrian dynamics and urban accessibility, therefore giving grounded and practical views from those in charge of shaping up the townscape.

One of the interviews addressed the issue of the demand for one or two local centers in Skarnes. One argument was made in favor of establishing a center in Skarnes, citing commercial sustainability issues as the primary reason.

P1: “Skarnes only needs one center.

It is difficult to keep stores that are not grocery stores.

Søsterhagen is to be a residential area.”

Conversely, it was seen that the Glomma River naturally divided Skarnes into two sections, allowing for the differentiation of centers to occur, and perhaps even making it unavoidable.

P2: “Skarnes doesn't need two centers but natural border –

The Glomma River splits town in to parts and this can't be changed easily.

It's better to find some advantages in that.”

Ultimately, it was decided that a single facility could be established, with the potential to provide enrichments that would enhance local life and foster community relationships.

P3: “Skarnes need only one local center,

but under given conditions a sort of coffee shop, lunch bar,

corner shop who offers a place to would be great.

This may also be a place maker for the area.”

Overall, the experts emphasized the importance of enhancing the attractiveness and vibrancy of Skarnes. The main recommendations include reducing reliance on cars, enhancing infrastructure for pedestrians and cyclists, and reconfiguring major highways such as E16 to better align with the specific requirements of the local community. Prioritizing sustainable and long-term urban improvement and community-enhancing areas was crucial. These changes were incorporated into the final Scenario (see chapter 4.3.3., figure 8) which are clearly visible in in the Master Plan (see chapter 7.6., figure 46) with the recommendations of experts.

4.4. Survey (qualitative and quantitative)

The Skarnes Community Engagement Survey was designed to elicit specific feedback on the Skarnes local populace's input and observations regarding urban and pedestrian dynamics. It was designed to obtain direct feedback from both permanent and regular Skarnes visitors on their perceived safety, mobility behaviors, and recommended interventions for the future. This elaborate and elaborate survey methodology was implemented to obtain feedback that would provide insights into the various aspects of pedestrian safety, accessibility, and overall livability in Skarnes. This public was asked about their average walking behaviors, perceived safety while walking, and aspirations for Skarnes' future growth, emphasizing the need for pedestrian-friendly infrastructure and communal spaces. This survey methodology included an elaborate questionnaire prepared through a link and a QR code. It comprised sections of questions designed to obtain the participants' statistical data, assess their average walking behaviors, rate their perceived safety at various times of the day, and elicit their suggestions for improvements. To ensure inclusivity, the survey was prepared wholly in a way that engaged participants of all experiences, and the inquiries were adequately created to provide the researcher with participants' preferences. Additionally, the survey comprised map-based questions that elicited spatially critical findings; these questions provided the local community with an effective understating of spatial trends and challenges. Map questions presented in the survey establish areas within Skarnes that survey takers viewed as safe or risky and points that would require considerable attention to enhance urban mobility settings. This approach is critical in providing an all-rounded landscape of pedestrian dynamics in Skarnes, thereby enabling a focused study that considers the statistical and spatial patterns of urban pedestrian dynamics and community engagement. I used this data to suggest evidence-based urban development processes aimed at making Skarnes safer, more accessible, and vibrant.

4.5. Empirical Data Collection (Photographic Illustration-Spatial Data)

The aforementioned method was supported by a photographic survey (Figure 9) of the Skarnes area. This methodological strategy involved taking a series of photographs in different parts of Skarnes to create a visual record of my own perception of the current urban environment and pedestrian conditions. More pointedly, the method sought to seek visual evidence of the current infrastructure, conditional mobility facilities in the Skarnes area and the overall spatial set-up therein. As a result, the photographs allowed me to specifically draw attention to features which eased or hindered the pedestrian experience in the Skarnes neighborhood. The visual survey was instrumental in providing qualitative background information to the statistical analysis of the Skarnes statistics. The written observations allowed me to integrate my overall perspective on some of the critical areas that could be explored more in-depth in the context of additional research and the possibility of improving the Skarnes neighborhood in terms of urban interventions to enhance the provision of the quality pedestrian environment. Therefore, this method played a crucial role in enabling the collection of first-hand insights into the Skarnes pedestrian everyday realities and experience.

Figure 9. Photographic Illustration of Eight Selected Sites within the Study Area.

Table 1. Observations After Photographic Survey of Søsterhagen area.

Road Segments	Observations					
	Side Walks	**Presence of Shops**	**Presence of Pedestrians**	**Sence of Security due to Traffic**	**Presence of Meeting points**	**Types of Buildings**
Segment a	Yes (But only one side)	No	Yes	No	No	Detached Houses, SOAS, Healthcare
Segment b	No	No	No	No	No	Detached Houses
Segment c	No	No	Yes	No	No	Detached Houses
Segment d	Yes	No	Yes	Yes	Yes	Detached Houses and Education Buildings
Segment e	No	No	Yes	No	No	Detached Houses
Segment f	Yes	Yes	Yes	No	Yes	Detached Houses
Segment g	Yes	No	Yes	Yes	No	No
Segment h	Yes	Yes	Yes	Yes	Yes	Detached Houses

4.6. Pedestrian Data from Sensors

The Muncipality has places 7 sensors on different sections of the Roads in Korsmo Area (Figure 10). These sensors can take the observations such as detect either the thing that has passed the sensor is either the pedestrian or the cyclist. They can calculate more things such as the speed, Direction, Weather conditions, temperature, humidity. The locations for the sensors are as follows according to the ID from 1 to 7. Ungdomskole (High School), Sykehusvegen (Hospital Road), SOAS (Social Housing), Vidregående skole (College), Joker (Grocery store on E16), Lehmanns veg and Brua (Pedestrian bridge) respectively.

The data provided by the municipality was for 6 months from July-December 2023. The data was divided into 3 sections according to the months that is Summer (July, August), Autumn (September, October, November) and winter (December). Data was further cleansed in excel and obtained to total no. of pedestrian passing through each sensor for each season. After gaining this information we took the analysis and made graph bar chart and also an image with geographical locations of the sensor in ArcGis for the better visualization of the pedestrians and color code them accordingly from red to blue according to high pedestrian traffic and low pedestrian traffic. After this pedestrian forecast happened with correlating the space syntax results of the same roads for measure choice 800m with the current pedestrian data and got the forecasted pedestrian data.

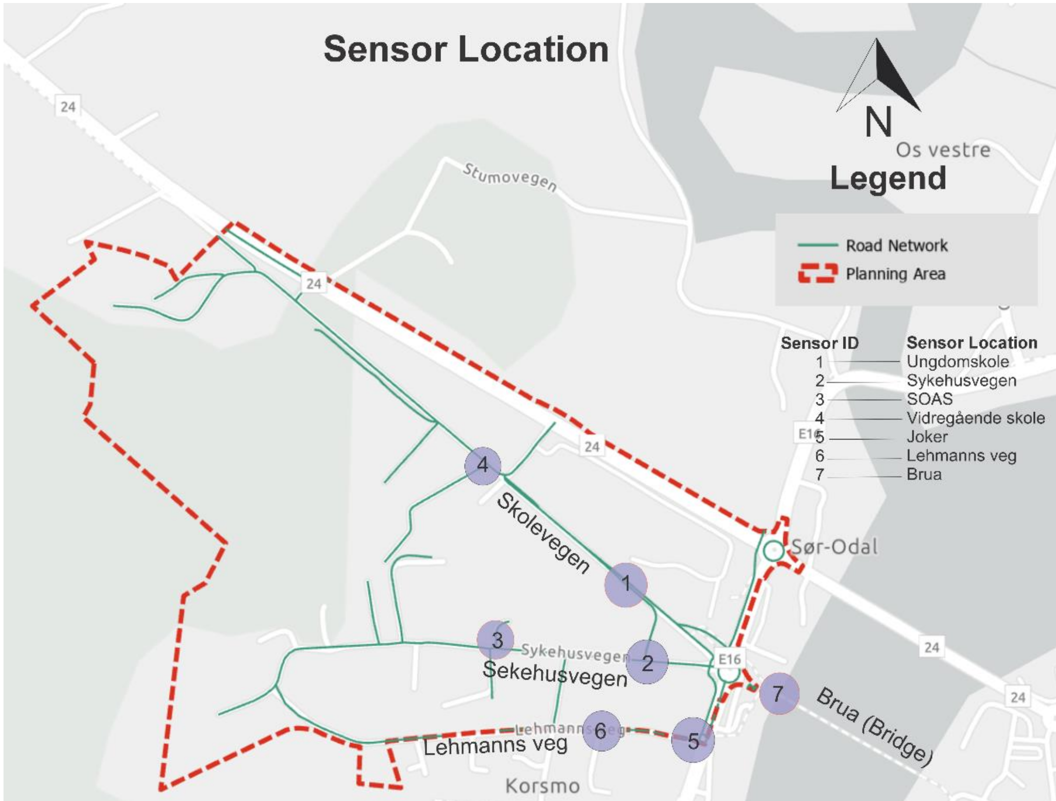


Figure 10. Sensors Location.

4.7. Primary and secondary data

To collect primary and secondary data to support investigation into the research questions, the study employed various methods. Space syntax analysis, survey, expert interviews, and photographic illustrations of the study site were used to collect primary data, providing an in-depth understanding of the built environment and pedestrian experience. Additionally, the sensor data provided secondary data of pedestrian movement obtained from the municipality, who had deployed sensors strategically located in the movement parts of the area. The secondary data assisted in supporting the primary data collected using direct observation and interaction.

Summary

The study used a mixed-method to address the research questions and the challenge specific to the municipality concerning the redevelopment of the Søsterhagen area in Skarnes. Therefore, the mixed method combined the use of both qualitative and quantitative data. Additionally, the mixed method utilized the use of statistical methodologies through interview methodologies offering an all-understanding integration and understanding of pedestrian connectivity and urban integration. For spatial analysis, the study used space syntax, which is an architectural theory that was developed in the 1970 s to analyze spatial interactions in the neighborhood. The space syntax focused on the two critical consideration integrations, which refers to accessibility within the urban network and the choice, which refers to the ability and possibility of movement between two points. It evaluated the spatial configuration of Skarnes using DepthMap software and applied the normalized angular choice, which is also abbreviated as NACH, which helped in the assessment of pedestrian feasibility in various scales (RN, R800m, R1200m). Three strategic maps were developed: the city-wide considering both pedestrian pathways and vehicle-centric road and a pedestrian-centric and car-centric map without highways and the pedestrian bridge. Additionally, the area planner's master plan was converted into a space syntax model to analyze its effectiveness in developing pedestrian-centric spaces. A survey was conducted with the residents that helped to establish their perception of safety, mobility behavior, and aspiration in the future Skarnes. Additionally, the residents were subjected to map-based questions that required the identification of safe and risk areas. Semi-structured interviews with the experts helped to gather data concerning the application of space syntax, inclusive accessibility, and the priority of urban development. The Sør-Odal municipality organized a workshop that had 20 participants from nine municipalities. The workshop focused on the spatial challenge to develop solutions that would aid in improving pedestrian navigation in Søsterhagen. Two scenarios were developed and analyzed, leading to the third scenario, which was developed using the two scenarios' best aspects. The pre-existing urban environment and pedestrian condition were documented using photographic services that offered a detailed qualitative analysis background to support the likely quantitative results. The study retrieved the secondary data from the sensors placed by the municipality to measure the pedestrian's movement along the marked paths. The secondary data covered six months and was grouped into seasons. The study sought to determine the correlation between the sensor data, and the space syntax resulted and forecasted the likely movement and mapped the high and low pedestrian movement areas using ArcGIS. Primary data sourced for the study involves space syntax analysis, survey, expert interview, and photographic illustrations that offered an extensive understanding of the building environment and pedestrian experience. The secondary data enhanced the primary data and offered illumination on the pedestrian movement.

5. Analysis and Results

5.1. Existing Situation - Space Syntax Results

5.1.1. Choice Radius N

The space syntax analysis of the "Choice" measure, often referred to as "Natural Movement" or "Through Movement" in space syntax terminology (Van Nes A. &., 2021).This measure helps to identify which streets are likely to attract more movement based purely on their spatial configuration, without considering other attractors like shops or destinations. Below is figure 11. Shows the depicts the existing situation of Skarnes including Existing strategic, car-based and pedestrian models of space syntax analysis with choice N. The accessibility levels, marked by colors on the map (Figure 10), would give an immediate visual indication of the impact each scenario has on different areas of Skarnes. High accessibility areas are likely to coincide with main roads and bridges which are red in color, while low accessibility areas might be more isolated or residential, marked by blue tones. Figure 10 provides a magnified view of all the scenarios to enhance the visualization of the research area, Søsterhagen.

The strategic model map (Fig. 11, 12) illustrates the existing layout of the area with the natural movement patterns highlighted. Highways are clearly indicated in red, showing their prominence in the area's overall connectivity. Secondary streets in orange also stand out, indicating that they too are significant for movement but to a lesser extent than the highways. This baseline strategic model represents the city of Skarnes with both pedestrian and motorized vehicle bridges, showing the integrated nature of the transport network. The motorized vehicle bridge in this model appears highly central and accessible, signifying its importance in the city's transport network. The Strategic map indicates that the motorized bridge is a significant connector in the city, supporting the car-based nature of Skarnes.

The car-based map in (Fig. 11) with the pedestrian bridge removed, emphasizes the car-based infrastructure of Skarnes. The motorized traffic bridge remains central, but the removal of the pedestrian bridge likely increases the centrality of motorized paths and potentially decreases the overall accessibility for pedestrians, particularly between Korsmo and Tronbøl areas. This scenario reflects the reliance on vehicles and demonstrates reduced connectivity for non-motorized movement.

The existing pedestrian model (Fig. 11) after removing the car-based bridge and other highways like E16 highlights the pedestrian bridge as the primary connector, suggesting a shift in centrality towards pedestrian movement. The pedestrian bridge's centrality indicates its role in linking various parts of the city, supporting non-motorized transit, and encouraging foot traffic between Korsmo and Tronbøl. With the shift of centrality towards the Tronbøl area This map shows an increased accessibility for pedestrians and a decrease for vehicles, compared to the strategic model.

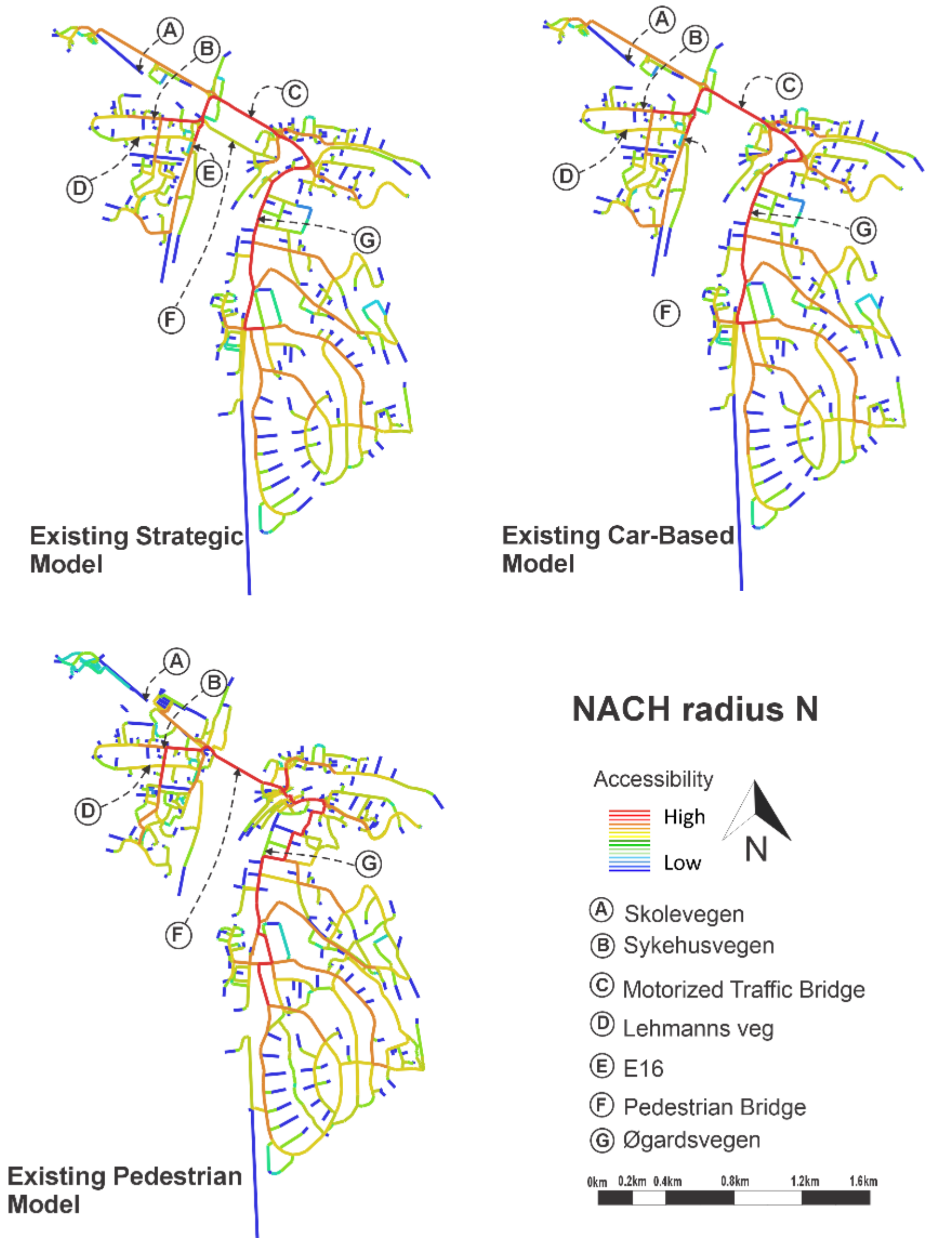


Figure 11. Skarnes's Existing Situation, NACH Radius N.

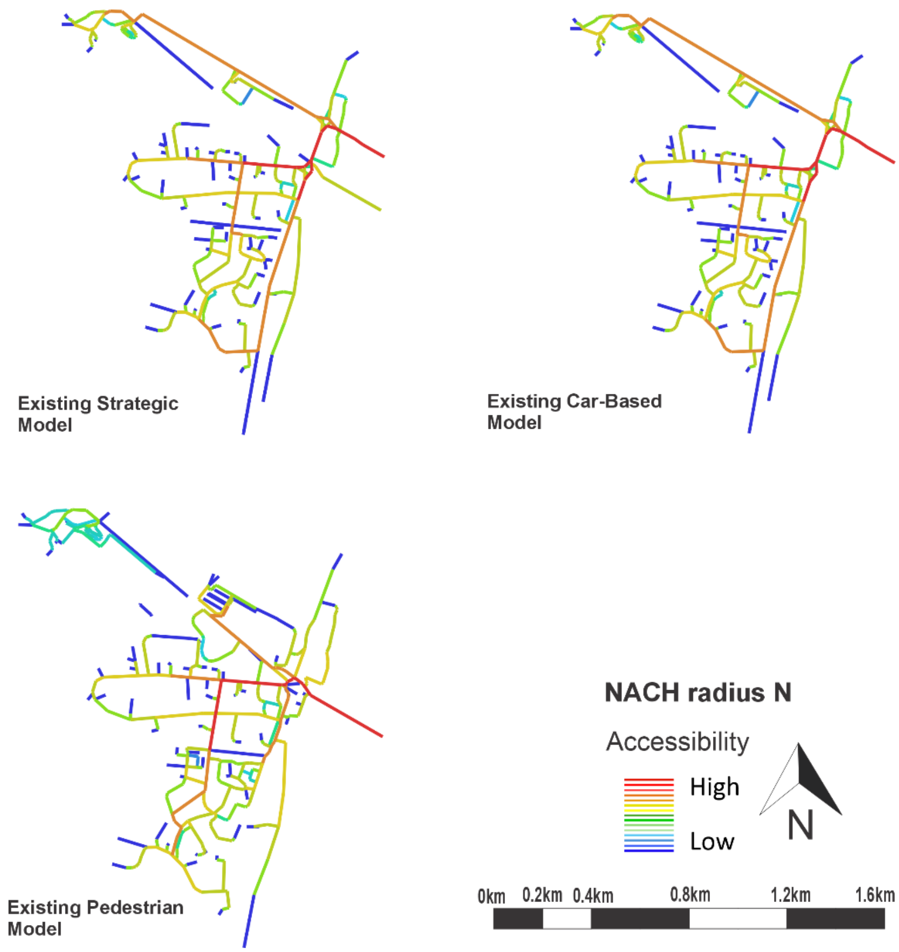


Figure 12. Søsterhagen Area. NACH Radius N. (Section of Study Area)

5.1.2. NACH radius 800m

Choice 800 meters in space syntax analysis measures the potential pedestrian and vehicular movement along streets within an 800-meter walking distance of 10 min, predicting which paths are more likely to be chosen for through movement. The analysis focusing on through movement, which measures the potential for pedestrian and vehicular traffic within a given radius, shows that the strategic model and the car-based model prioritize vehicular flow. Below is figure 13. depicts the existing situation of Skarnes illustrating Existing strategic, car-based and pedestrian models, respectively, of space syntax analysis with choice 800m.

When analyzing the 800m radius space syntax models (Fig. 13, 14) show that, Skarnes remains predominantly car-oriented in both the strategic and car-based models. This implies that current infrastructure and urban planning heavily favor vehicular movement over pedestrian circulation. The pedestrian model shows a slight improvement in walkability along Skolevegen with orange color, indicating an increase in pedestrian accessibility, yet this change is not substantial.

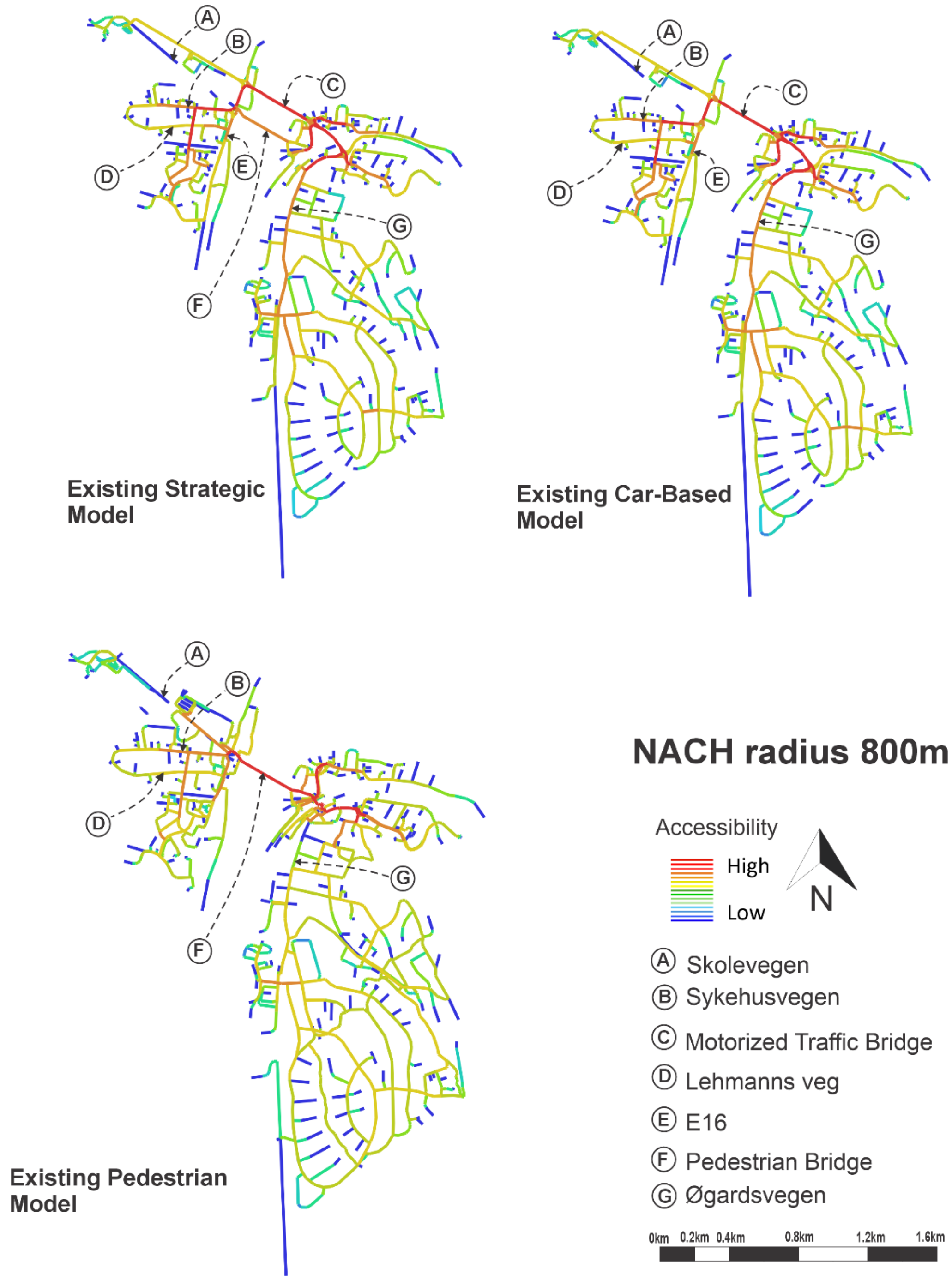


Figure 13. Skarnes's Existing Situation, NACH Radius 800m.

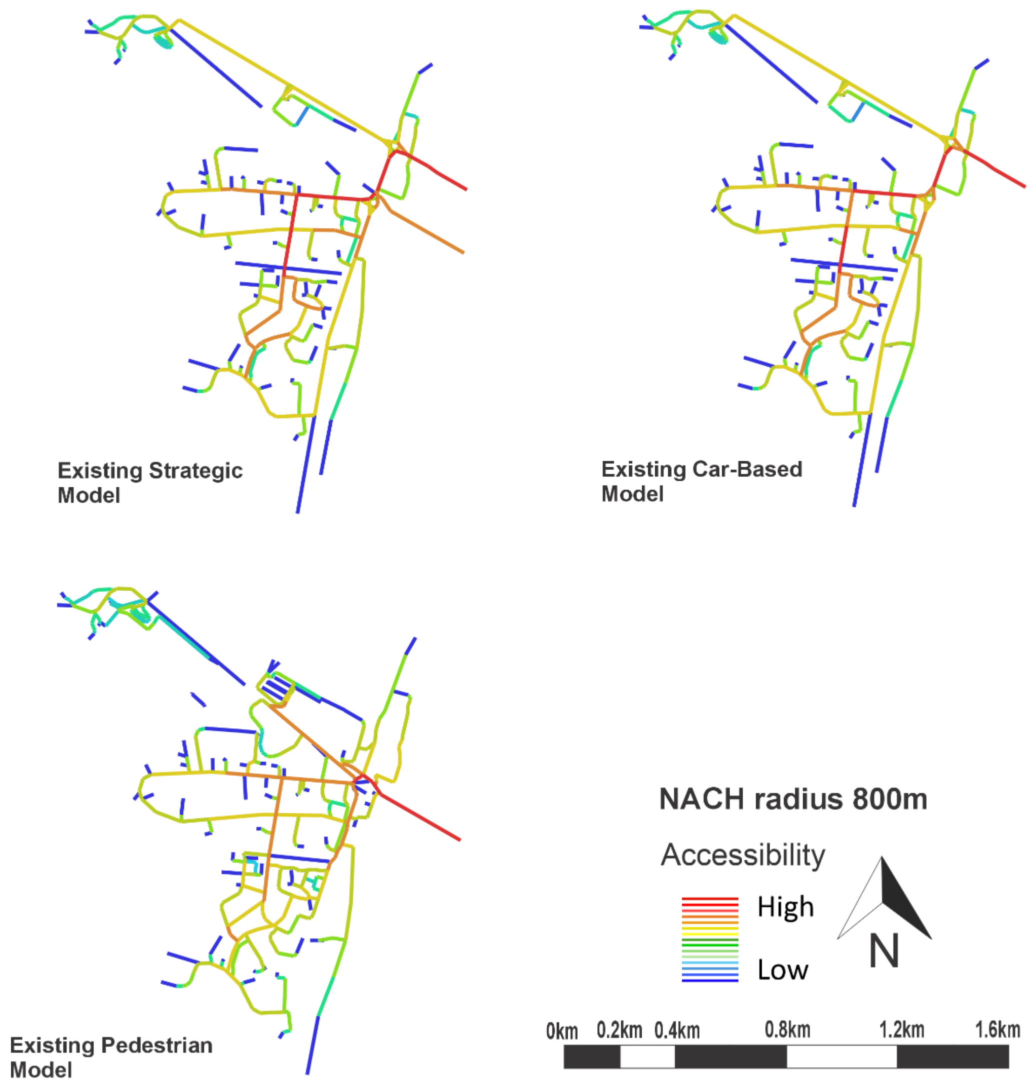


Figure 14. Søsterhagen Area. NACH Radius 800m. (Section of Study Area)

5.1.3. NACH radius 1200m

Choice 1200 meters in space syntax refers to a measurement of potential movement along streets within a 1600-meter range, roughly equivalent to a 15-minute walk. This measure helps to understand how well a street or area is connected within a local urban context, indicating the likelihood that it will be a preferred path for pedestrians and vehicles moving through a neighborhood. Below is figure 15. Shows the existing situation of Skarnes including Existing strategic, car-based and pedestrian, respectively, models of space syntax analysis with choice 1200m.

In (Fig. 15, 16) space syntax model of Skarnes, the 1200-meter radius measure offers a broader view of pedestrian accessibility, focusing on a 15-minute walk from any point in the area. Observations highlight that the strategic and car-based models prioritize highways, retaining high accessibility at this radius. The pedestrian model, along with the proposed plan by the area planner, shows a spillover effect, which, while modest in the Søsterhagen area, enhances movement in the Tronbøl area. It suggests that although direct changes in the Søsterhagen area are insignificant, they contribute to improved accessibility and pedestrian experience in the neighboring Tronbøl area, evidencing a beneficial spillover effect.

The models, specifically strategic and car-based, tend to be biased on the side of the vehicular traffic. From the comparison, it comes out that the 1200 meters have high access to the highways. Generally, the Pedestrian Model tends to be less effective on its own. This becomes important in making sure that their experience is, in the near future, as accessible as that of the vehicular one.

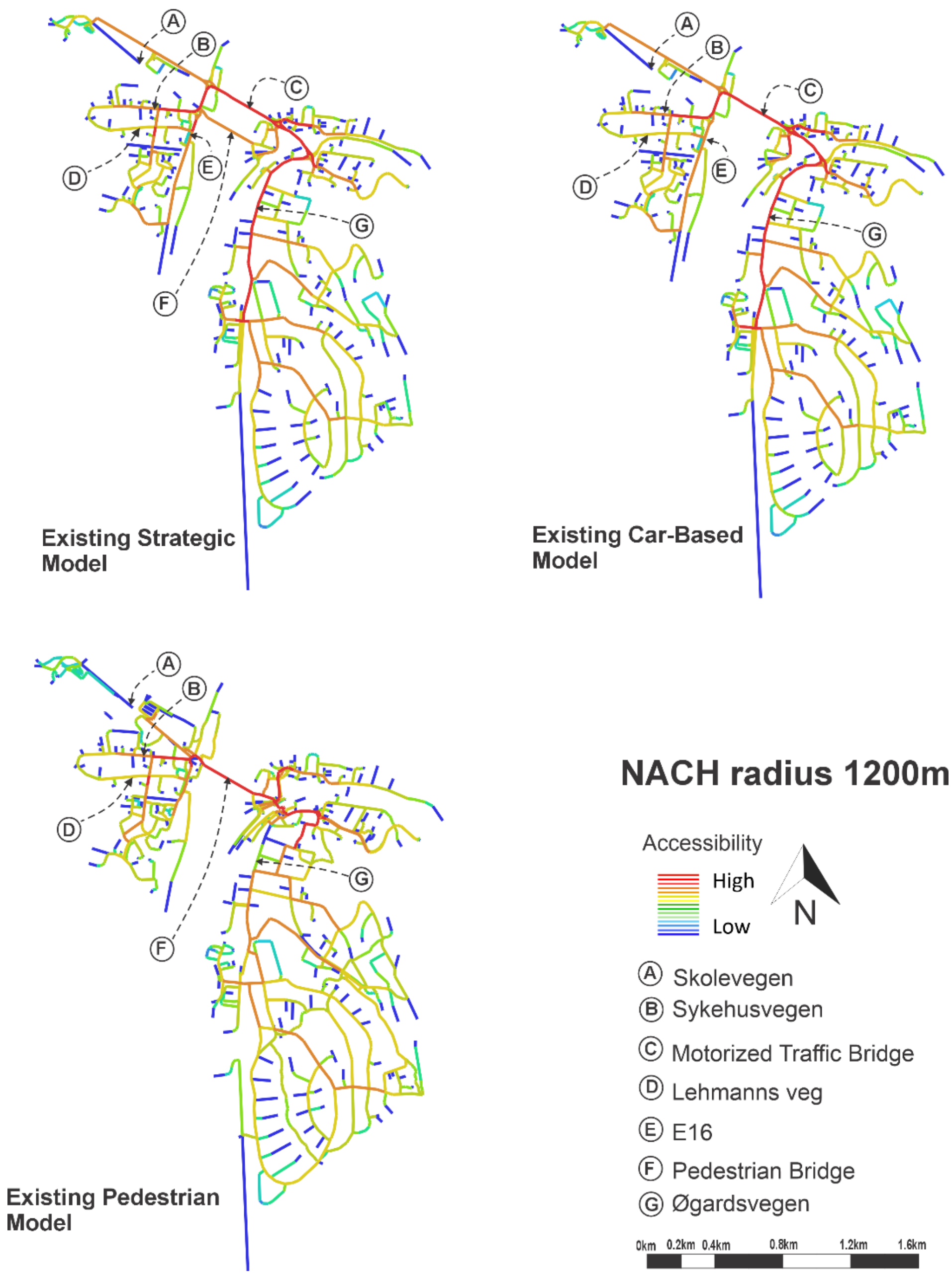


Figure 15. Skarnes's Existing Situation, NACH Radius 1200m.

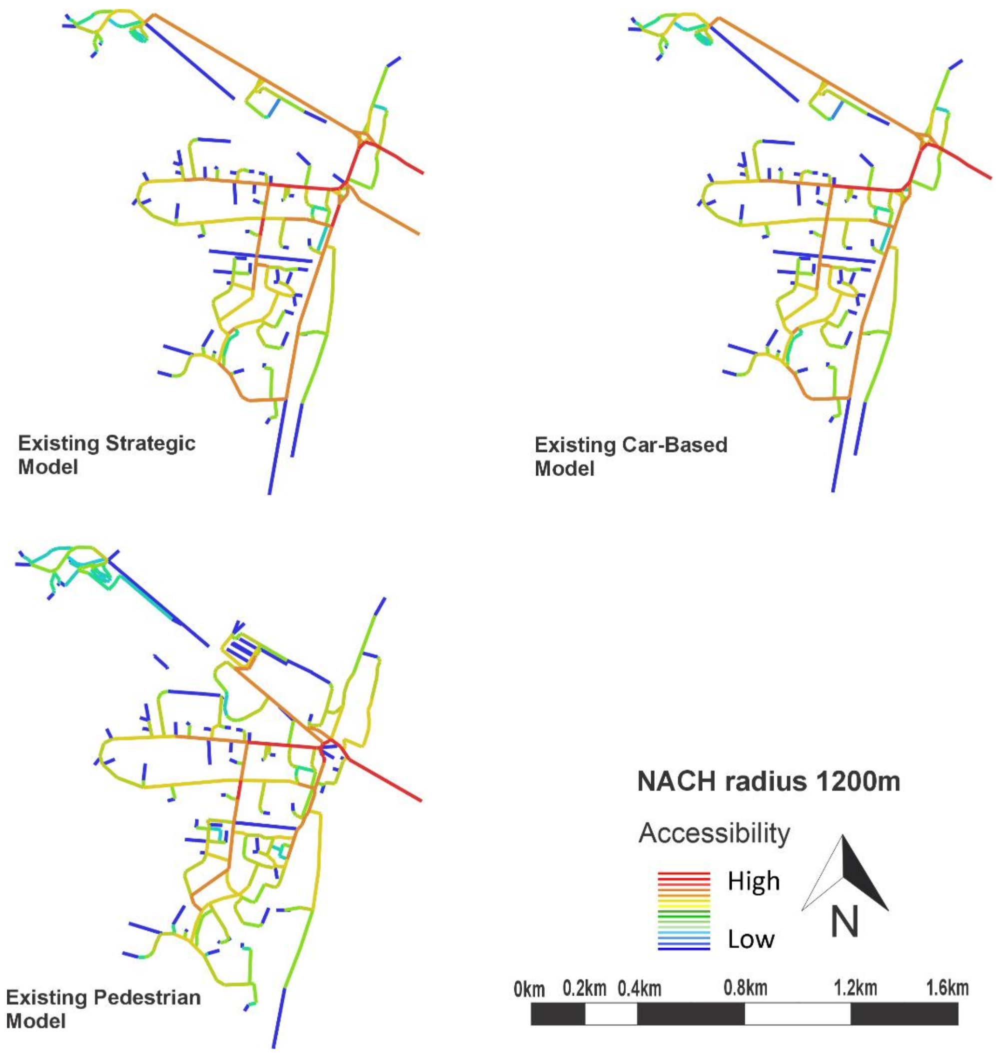


Figure 16. Søsterhagen Area. NACH Radius 1200m. (Section of Study Area)

5.2. Proposed Master Plan by Architect

The proposed master plan by architect of choice N in (Fig. 17, 18) includes changes to the existing network in krosmo area that result in a more fragmented patter. This fragmentation means reduced directness and efficiency in the network, potentially lowering the potential for connectivity between the two main roads. This shows that the new plan does not significantly affect the centrality compared to the existing pedestrian model, which indicates a lack of substantial improvement in accessibility from the proposed changes.

Comparing these scenarios reveals how the presence or absence of pedestrian infrastructure impacts the overall accessibility of Skarnes. The Strategic Model provides a balanced approach to accessibility for both cars and pedestrians. The Car Based Model demonstrates the city's car dependency and how removing pedestrian options can limit accessibility for non-vehicle users. The Pedestrian Model shows how pedestrian infrastructure is crucial for non-motorized centrality and accessibility. The Proposed Model indicates that new planning efforts may not offer significant improvements to the pedestrian network and could lead to a more disconnected urban fabric. This comparison serves as a framework for understanding the trade-offs between different modes of transportation in urban planning. The analysis suggests that enhancing pedestrian infrastructure in car-dominated cities like Skarnes could lead to a more equitable and balanced accessibility network. However, it also highlights the challenges in modifying entrenched car-based systems and the need for careful planning to ensure proposed changes genuinely benefit urban connectivity.

For Choice measure 800m the proposed master plan introduced by the architect should ideally enhance pedestrian connectivity, but it appears to suffer from fragmentation, particularly beyond the pedestrian roundabout, where the continuity of accessible routes breaks down. This suggests that the master plan does not significantly enhance pedestrian experience and could potentially worsen it compared to the existing pedestrian framework. The lack of integration within the proposed model may undermine the goal of creating a pedestrian-friendly environment.

The current strategic and car-based models (figure 15, 16) have a clear vehicular traffic bias, such as high highway accessibility, with a specific concentration within the 1200-meter radius. The existing pedestrian model, however, is relatively ineffective in most parts of the county to achieve this all-round connectivity. It is paramount to address this disparity to be at par with vehicular traffic. These shortcomings are put into consideration in the proposed masterplan, whereby even though the changes in the Søsterhagen area are not significant, they significantly improve access and connectivity in Tronbøl.

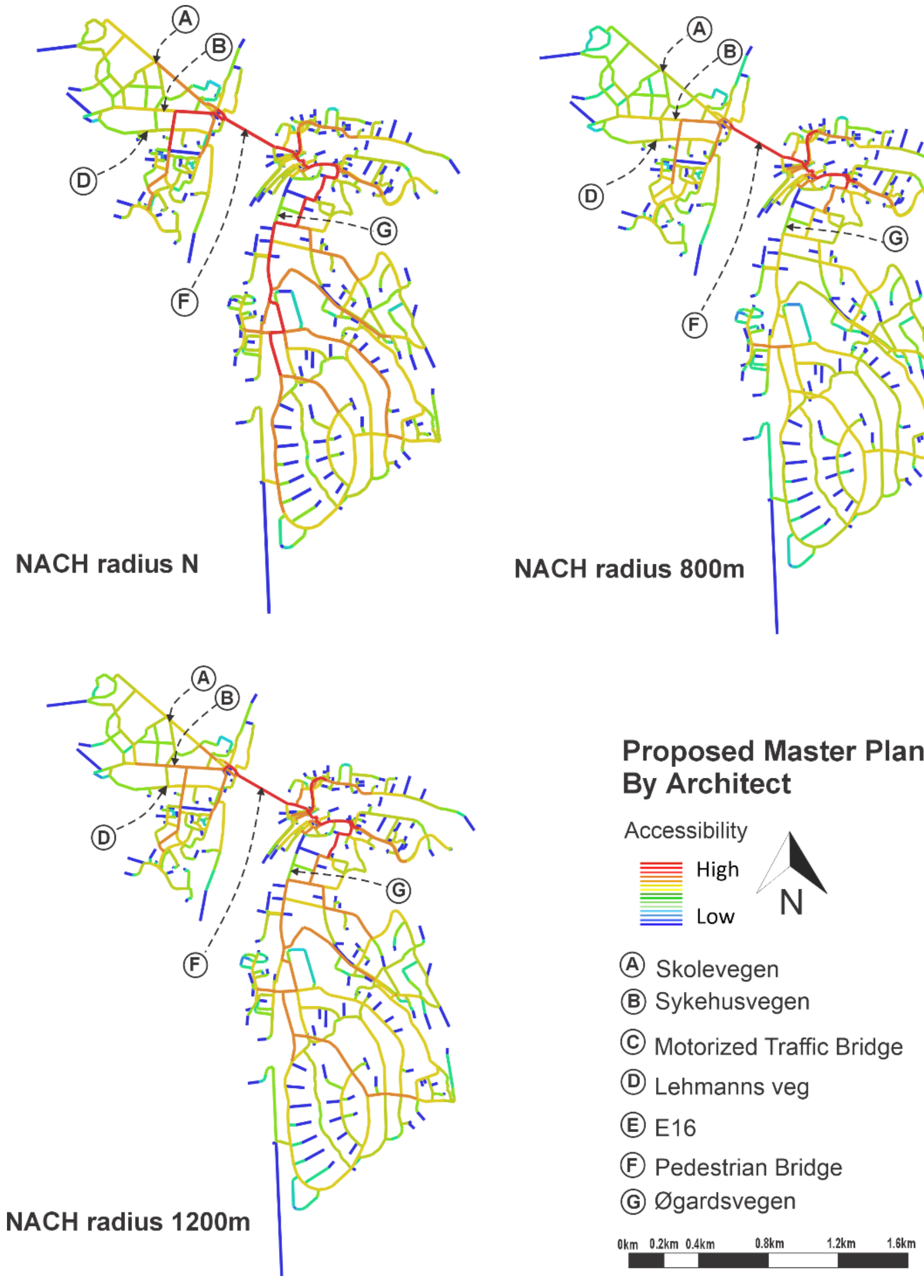


Figure 17. Proposed Master Plan by Architect with all Choice measures.

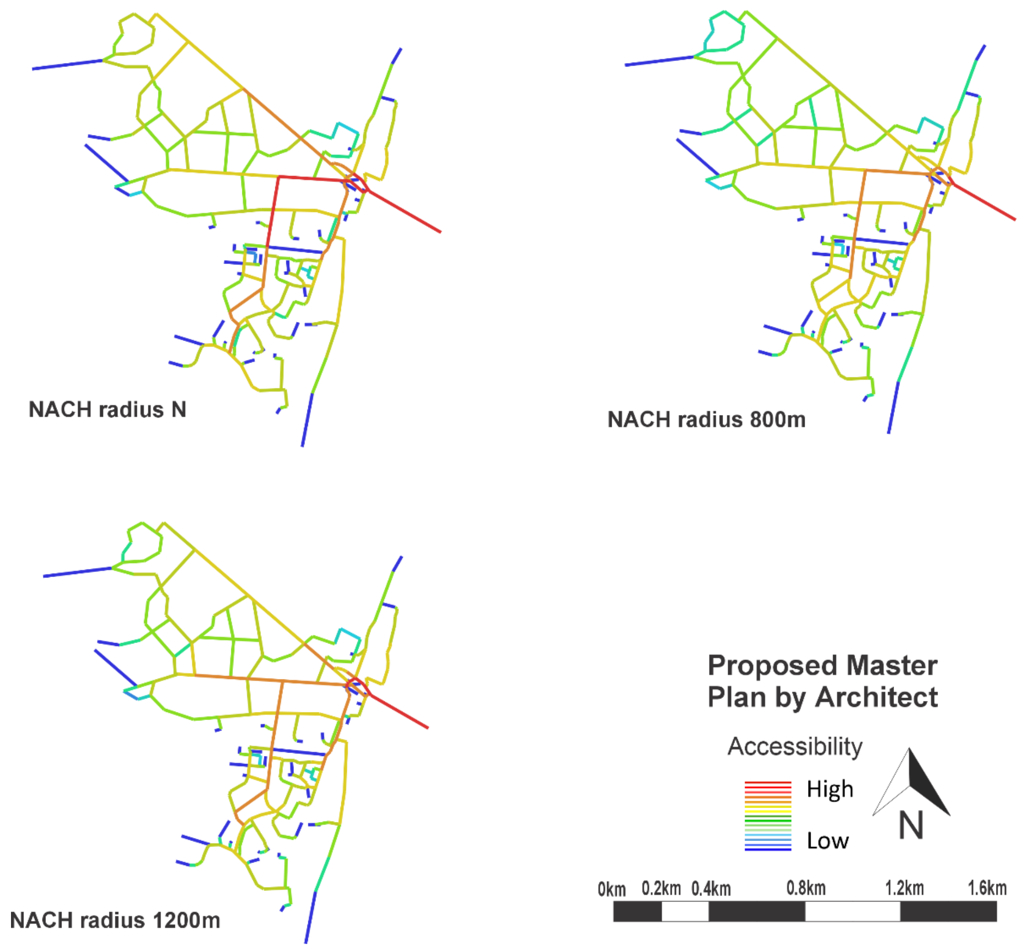


Figure 18. Magnified Images of Søsterhagen Area of Proposed Master Plan by Architect.

5.2.1. Syntactic Values

When evaluating the overall performance of the aforementioned models, below in (Table. 2), the NACH (Normalized Accessibility) is consistently maintained at a minimum value of 0.301 for all models. This serves as a reference point, indicating that no additional accessibility improvements can be achieved by any of the urban design strategies.

The System Average values of all the Scenarios shows that the Existing Pedestrian Model illustrates the highest average accessibility at the RN level (3.53) and at 1200m (3.18). This would indicate that this model consistently gives the most accessible routes for pedestrian passage. The Proposed master plan by the architect averages a 1200m (3.23) of accessibility, which is slightly better but, in general, comparable with the Car-Based Model. The Proposed master plan suggests specific enhancements to accessibility on a larger scale throughout the city. These improvements are likely to prioritize the demands of both vehicles and pedestrians more effectively compared to the other three models.

Upon checking the system maximum (Table. 2), in the current pedestrian model at RN (6.14) and 1200m (5.47), this indicates that some routes are highly optimized for pedestrian movement. The Proposed Master Plan also realized high accessibility, especially at the proposed RN (6.10) and 1200m (5.43), realizing that the redesign would maintain or slightly change the routes of high accessibility without much compromise.

The proposed master plan has shown a remarkable improvement, indicating that NACH values at all scales increased and hence accessibility improves for Skolevegen, which can benefit the foot traffic.

As regards the Sykehusvegen, the Proposed Master plan brings a slightly reduced level of accessibility when compared to the Existing Pedestrian Model. This is due to the repositioning of space and the prioritization of other routes.

All the values in the proposed master plan, by the arcitect for Lehmanns veg, show a deviation. The existing pedestrian model registers slightly higher values than the proposed master plan, indicating that the changes in the new plan do not favor accessibility.

The strategic model shows significantly lower values for the pedestrian bridge compared to the pedestrian model, highlighting the car-based nature of the area. In the existing pedestrian model, the values remain high compared to those in the proposed plan. Specifically, at RN, it drops from 6.65 to 5.83. This indicates that the pedestrian bridge in the area planner's map is struggling to achieve high values that would attract foot traffic. Øgardsvegen, experiences a drop in accessibility in the Proposed Master Plan, likely reflecting a de-prioritizing in relation to other routes.

In the Proposed master plan, the number of both axial lines and segments is cut down to the number existing in the model for pedestrians. This seemingly simplification in the network might show a type of attempt to streamline traffic flow or to reduce navigational complexity. The existing Pedestrian Model appears most permissive of pedestrian movement, especially with the Average and Maximum Accessibility Values. Therefore, the proposed master plan seems to be striking a balance between high accessibility on major routes while, with high certainty, reducing pedestrian priority on the rest.

Table 2. Comparison Syntactical Measures and street measures.

		NACH											
		Existing Strategic Model			**Existing Car Based Model**			**Existing Pdestrian Model**			**Proposed Master Plan from Architect**		
		RN	**800m**	**1200m**	**RN**	**800m**	**1200m**	**RN**	**800m**	**1200m**	**RN**	**800m**	**1200m**
	Syetem min	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
	System avg.	3.37	2.71	2.95	3.36	2.69	2.93	3.53	2.96	3.18	3.23	3.004	3.23
	System max.	5.89	4.78	5.08	5.89	4.78	5.07	6.14	5.16	5.47	6.1	5.16	5.43
A	Skolevegen	0.301	0.301	0.301	0.301	0.301	0.301	3.7	3.32	3.62	4.97	3.69	4.25
B	Sykehusvegen	5.06	4.19	4.52	5.06	4.15	4.47	5.27	4.36	4.76	5.02	4.01	4.57
C	Motorized Traffic Bridge	5.82	4.52	4.52	5.82	4.51	5.06						
D	Lehmannsveg	4.38	3.76	3.94	4.38	3.71	3.91	4.15	3.91	4.15	4.09	3.71	3.86
E	E16	5.41	3.95	4.55	5.37	3.89	4.5						
F	Pedestrian Bridge	4.2	3.94	4.21				6.65	4.88	5.43	5.83	4.82	5.32
G	Øgardsvegen	5.86	4.12	4.75	5.86	4.12	4.76	4.06	3.42	3.72	4.73	3.33	3.72
	Total no. of Axial Lines	840			837			1217			1112		
	Total no. of segments	1462			1454			2035			1886		

Note: NACH stands for Normalised angular choice

5.3. Scenarios – Space Syntax Results

5.3.1. Choice Radius N

Expert Scenario 1 in (Fig. 19, 20) Focuses on separating pedestrian and bicycle paths from car traffic, enhancing safety and creating more dedicated spaces for non-motorized users. Adds green areas and direct connections to schools and healthcare facilities, aiming to improve both the environmental quality and practical usability of walking and cycling paths.

In (Fig. 19) A (Skolevegen) and B (Sykehusvegen) show an increase in accessibility, due to the implementation of more direct and segregated pathways. The map indicates improved pathways connecting different sections of the town, particularly around areas D (Lehmanns veg) and G (Øgardsvegen). These improvements are likely aimed at reducing travel distances and improving direct access to various urban amenities. Expert Scenario 1 enhance pathways linking residential areas with key facilities such as the area around F (Pedestrian Bridge) and central hubs.

After Comparing the Scenario 1 with existing pedestrian map, Scenario 1 provides a clear improvement over the existing map by focusing on safety and recreational enhancements, directly addressing the limitations of the existing pedestrian infrastructure.

In Scenario 2 (Fig. 19) The map suggests changes in the direction of buildings in the Bøssmyra area (near area A), aiming to make them more accessible and easier to navigate from the town center. This reorientation is likely intended to streamline pedestrian flows and enhance the visual and physical connectivity of the space. Significant direct links have been added, such as the path between the videregående (high school) and Skolevegen (A), which seems to have been straightened and made more direct. This enhancement aims to reduce travel times and increase safety for pedestrians, especially students. There is a newly created pathway connecting the hospital (Sykehus) more directly with surrounding areas (near area B), which is essential for ensuring quick and easy access for emergencies and daily visits. The connection to Søsterhjemmet from the Korsmo area (near area G) has been improved to integrate this isolated area better with the rest of the town, potentially enhancing community integration and access to services. The scenario introduces shortcuts, such as the one from the walking bridge and roundabout (near area F) towards Skolevegen, which can significantly reduce walking distances and improve the functional connectivity of pedestrian paths.

When comparing Scenario 2 with Scenario 1, Experts Scenario 1 Prioritizes safety and the integration of leisure spaces within the urban fabric, making it ideal for recreational users and improving general livability. Scenario 2, Shifts focus towards improving navigation and functional connectivity, especially by enhancing the accessibility of important urban areas and reorienting building layouts for better pedestrian flow. Introduces more direct pathways and removes navigation barriers, potentially making pedestrian movement more efficient than in Scenario 1.

The Final scenario (Fig. 19) shows a more structured network, with a grid-like pattern particularly visible in the central areas around Skolevegen (A) and Sykehusvegen (B). This grid structure supports easier navigation and potentially distributes pedestrian and vehicular traffic more evenly, reducing congestion in critical areas. There is enhanced direct connectivity between major areas such as Skolevegen, Sykehusvegen, and the areas surrounding Lehmanns veg (D) and E16 (E). The removal of the roundabout near the Pedestrian Bridge (F) implemented in this scenario, would typically reduce the segmentation of pedestrian flows and enhance direct line-of-sight travel paths. Improved pathways leading to and around the hospital (Sykehusvegen) and educational institutions (Skolevegen) ensure that critical services are more accessible to the public. This setup not only supports daily commuting needs but also enhances emergency response efficiency.

When Comparing final Scenario with Scenario 2, Scenario 2 Focuses on targeted improvements to facilitate easier access to key urban areas and streamline pedestrian routes. Final Scenario Incorporates the strengths of both previous scenarios and introduces a comprehensive grid system that significantly enhances connectivity across skolevegen and sykehusvegen. Along with this, it also Optimizes pedestrian traffic flow by removing major barriers (roundabout) and creating additional direct links.

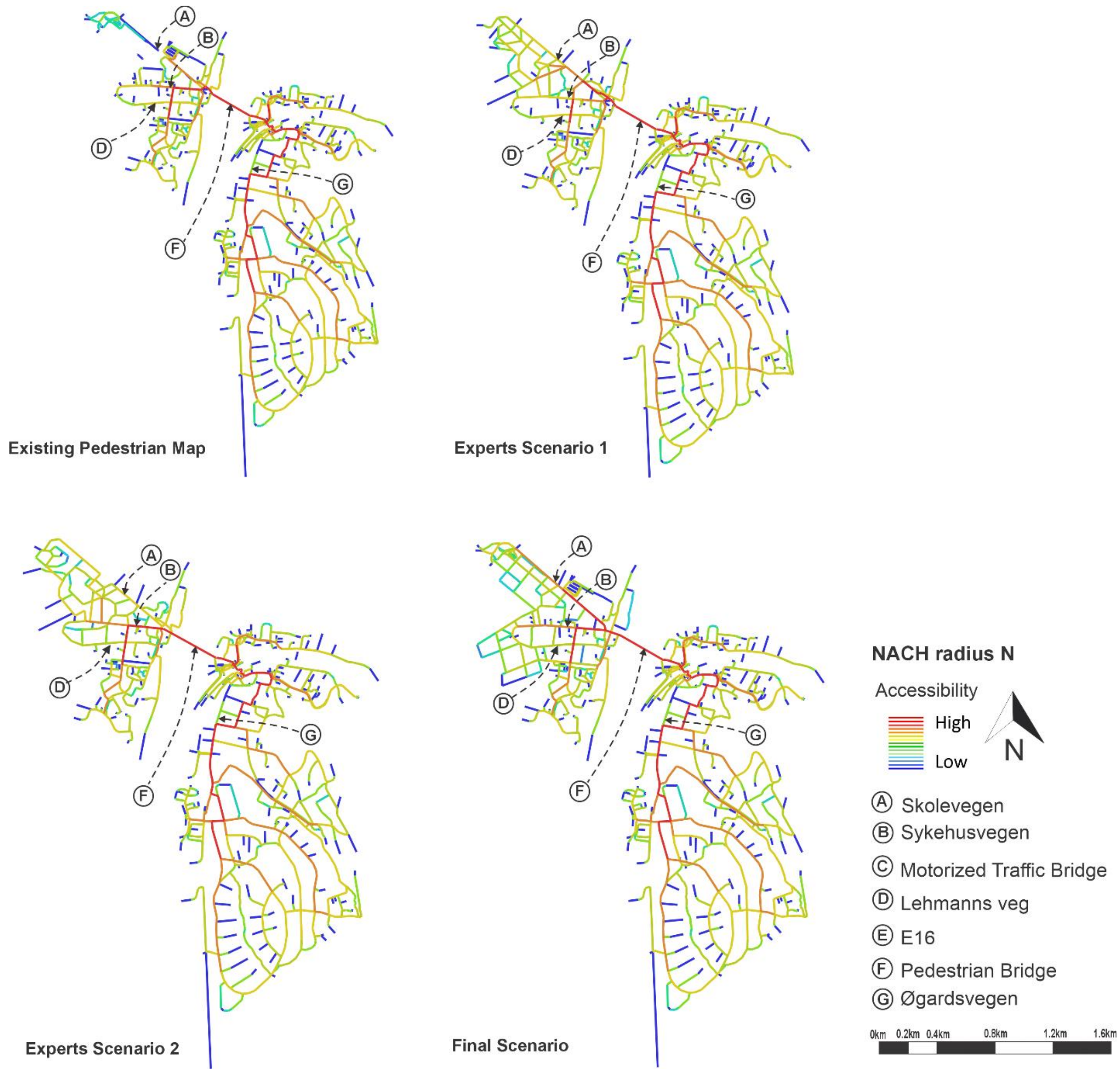


Figure 19. NACH N, Comparison of all the Scenarios with Existing Pedestrian Map.

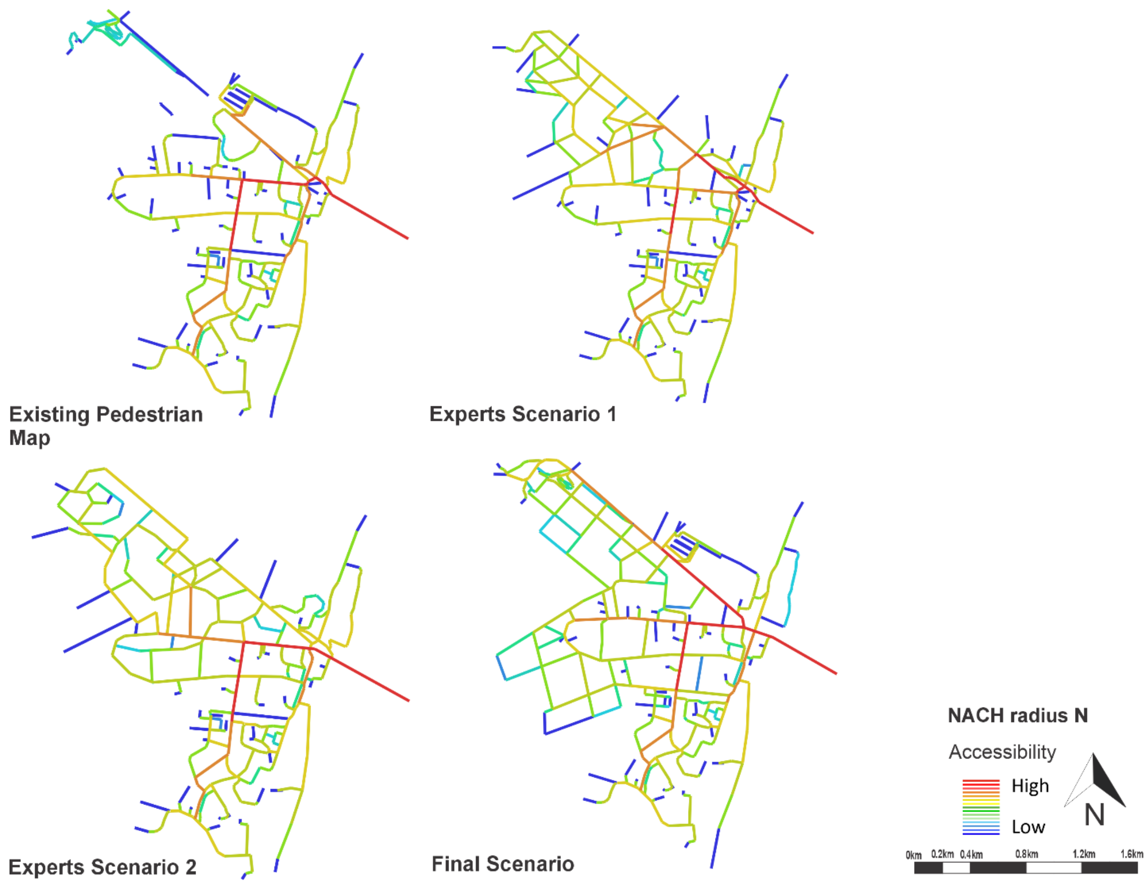


Figure 20. NACH N, Magnified image of all the testing Scenarios.

5.3.2. NACH radius 800m

Syntax analysis measuring the movement of pedestrians and vehicles along streets within a 10-minute walking distance of 800 meters in space predicts which paths are most likely to be selected by movement. The main pedestrian routes in Experts Scenario 1 (Fig. 21, 22), such as those along Skolevegen (A) and Sykehusvegen (B), are highlighted in yellow, indicating higher accessibility compared to the existing pedestrian map. New or improved connections between residential areas and key facilities (schools, hospitals) are visible. The scenario integrates strategic pathways to connect major nodes like educational institutions and healthcare facilities directly with residential zones. This integration not only enhances accessibility but also encourages walking and cycling by providing shorter and more direct routes. Expert Scenario 1 succeeded to achieve better visualization of color i.e. green and yellow towards Bossmyra area.

The modifications in Expert Scenario 1 aim to significantly enhance pedestrian movement within an 800m radius, promoting a shift towards more sustainable urban mobility by improving local connectivity and accessibility.

The scenario reflects a well-thought-out approach to urban planning where pedestrian needs are prioritized, potentially leading to a decrease in car dependency for short distances, improving overall urban livability and public health.

When Comparing Scenario 1 with Existing Pedestrian Map, the existing map shows a basic setup with moderate accessibility, focusing on key arteries but lacking in broader connectivity for pedestrians. Scenario 1 enhances the pedestrian experience by integrating green areas and improving direct pathways to essential services like schools and hospitals, making it superior in promoting healthier and more sustainable urban movement.

The expert's scenario 2 (Fig. 21) establishes a more straightforward routing between significant points such as Skolevegen (A) and Sykehusvegen (B), reducing turns and intersections that could slow down pedestrian movement. These paths are marked in yellow, indicating better accessibility as compared to existing map of pedestrian's accessibility. Adjustments in the direction of buildings along Bøssmyra are aimed at facilitating more intuitive navigation from the town center, which can encourage walking by making the path seem more direct and simpler. Sykehusvegen (B) sees the addition of more direct routes connecting it with adjacent residential and institutional areas. This is evident from the more streamlined paths connecting different sectors, designed to facilitate easier access to the hospital and surrounding amenities. The creation of shortcuts from the walking bridge near the sports center directly towards Skolevegen (A) integrates recreational spaces with residential and educational pathways, likely to boost local foot traffic.

When comparing the current scenario with Expert Scenario 1, Scenario 2 makes significant changes by reorienting building directions for better navigation and creating direct pathways that enhance practical connectivity to and from major community points. This scenario might be viewed as more dynamic in facilitating movement, especially for newcomers or visitors navigating the area.

The final scenario (Fig. 21) demonstrates significant enhancements in connectivity, especially around central hubs like Skolevegen (A) and Sykehusvegen (B). The pathways appear more direct and integrated, linking major areas with fluid, efficient routes marked in visible orange color. The removal of the roundabout near the Pedestrian Bridge (F) simplifies the traffic flow, reducing congestion and enhancing safety for pedestrians. New links between Lehmanns veg (D) and Sykehus Vegen (B) facilitate direct access to essential services and can decrease travel times for both pedestrians and cyclists. This integration supports a more cohesive urban environment where key services and residential areas are linked more seamlessly.

When comparing the Final Scenario with all the models, it is clear that the Final Scenario builds upon this by removing physical barriers such as roundabouts and further enhancing the grid layout. This scenario provides the most comprehensive connectivity improvements, making it the best option for overall accessibility across different parts of the town within 800m.

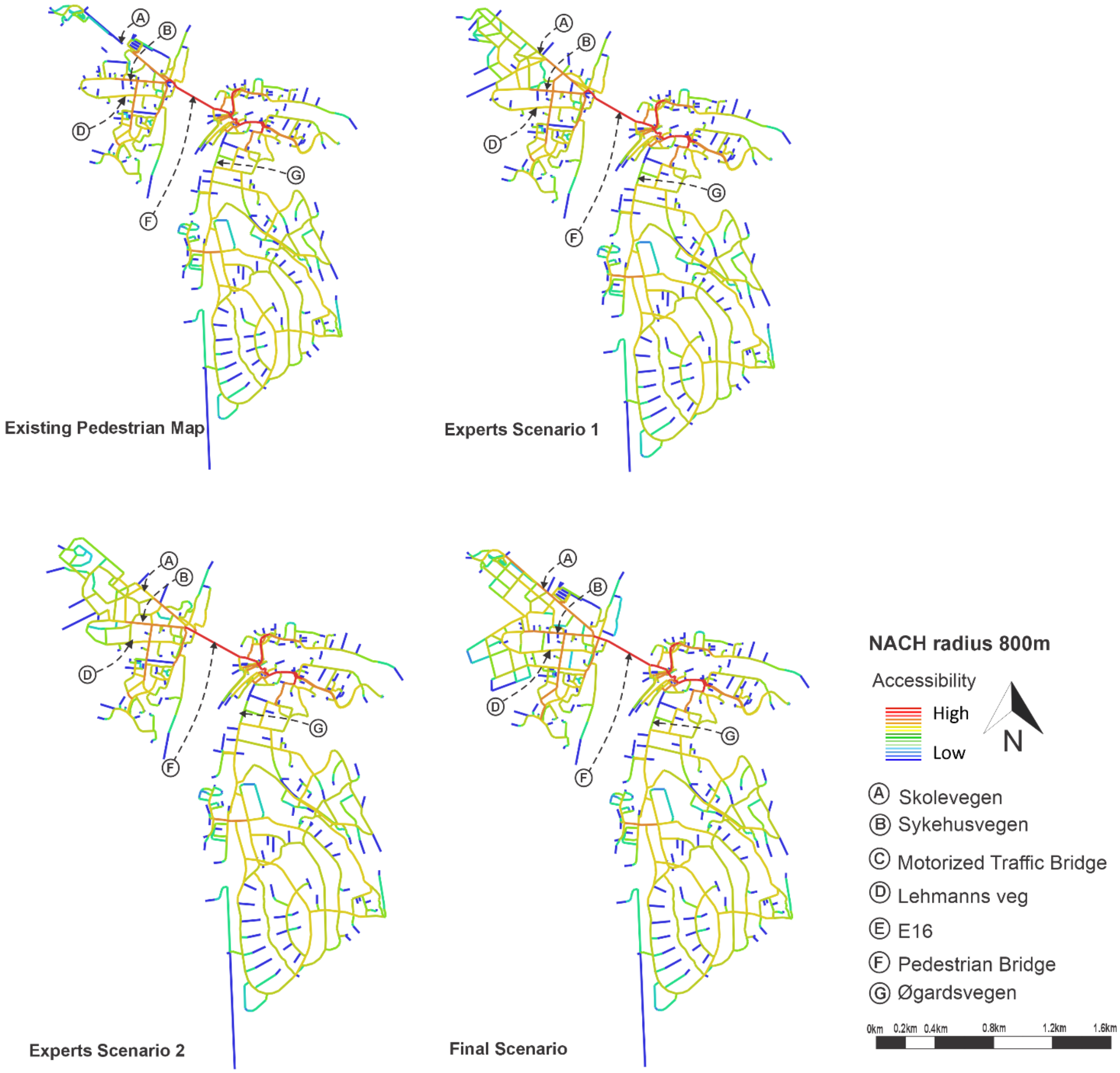


Figure 21. NACH 800m, Comparison of all the Scenarios with Existing Pedestrian Map.

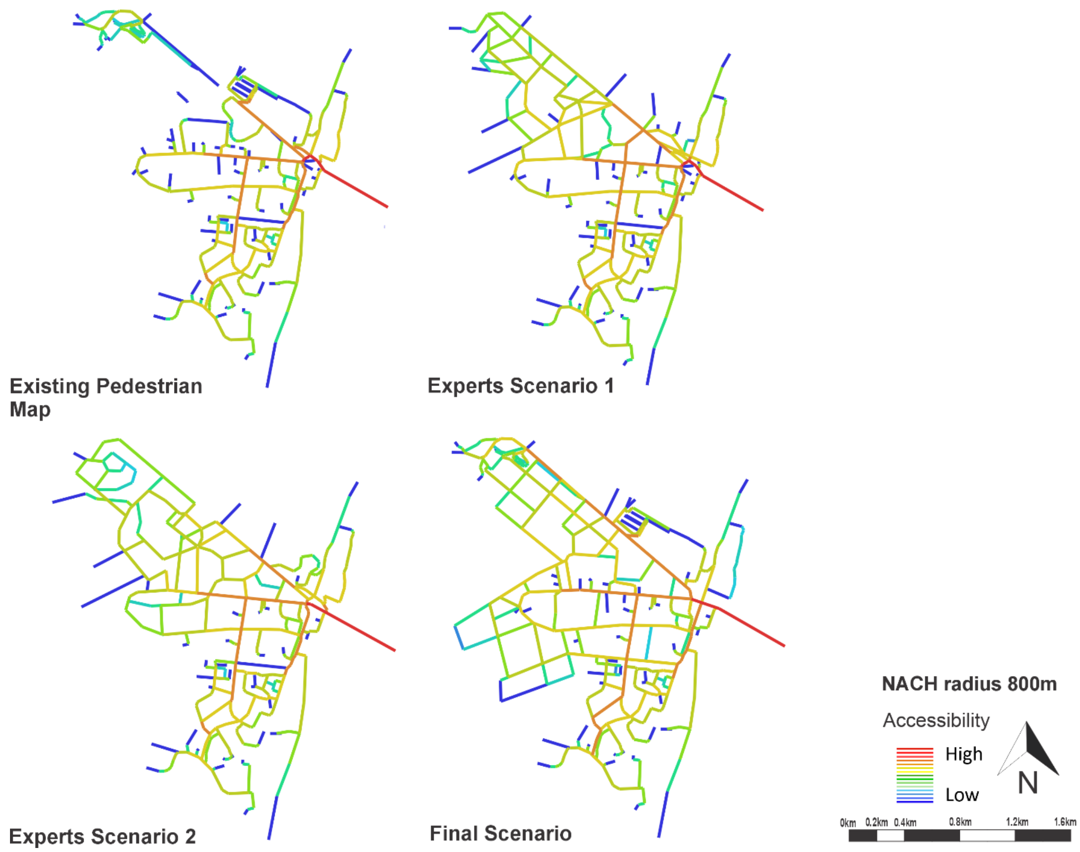


Figure 22. NACH 800m, Magnified image of all the testing Scenarios.

5.3.3. NACH radius 1200m

In the space syntax approach, the NACH 1200m (Normalized Angular Choice to 1200 meters) metric is used to evaluate the accessibility of various parts of an urban network within a 1200-meter radius, roughly equivalent to a 15-minute walk. This metric helps to understand how pedestrian movements are facilitated or hindered by the urban layout, providing a global view of connectivity and accessibility. Higher NACH values indicate higher potential for movement, suggesting routes that are more likely to attract pedestrians due to their directness and integration within the network.

The Existing Pedestrian Map (Fig. 23, 24) shows that most routes have fair accessibility, but the few highly accessible routes (marked in red) are concentrated mostly around central areas like Skolevegen. The pathways are fragmented and cause inefficiency in pedestrian movement.

Expert Scenario 1 dramatically improves connectivity along Skolevegen (A), indicated by vibrant red and orange pathways. This represents a focused effort to enhance pedestrian accessibility within a 15-minute walking radius, especially along key routes. It also integrates peripheral areas, connecting them through more direct and accessible paths.

Expert Scenario 2 clearly emphasizes the linkage along and between Sykehusvegen (B) and Lehmanns veg (D), marked by a pronounced red path. This scenario prioritizes strategic routes that facilitate easier movement between major urban spaces, improving directness and likely reducing travel times for pedestrians.

The Final Scenario outperforms all previous models in terms of accessibility. The area around Skolevegen (A) is extensively highlighted in red, indicating high accessibility and likely serving as the main arterial route for pedestrian traffic. This scenario optimizes the pedestrian network by enhancing connectivity not just along the main routes but also extending to peripheral areas. The enhancements along Sykehusvegen (B), characterized by redder and orange pathways, suggest improved connectivity with surrounding areas, including Lehmanns veg (D). This strategic design choice aims to disperse pedestrian traffic more evenly across the network, potentially reducing congestion in overly busy areas and enhancing the accessibility of services. The overall connectivity in this scenario suggests a holistic urban planning approach where both main and peripheral routes are emphasized, creating a balanced urban mobility framework that supports both dense urban centers and less central areas.

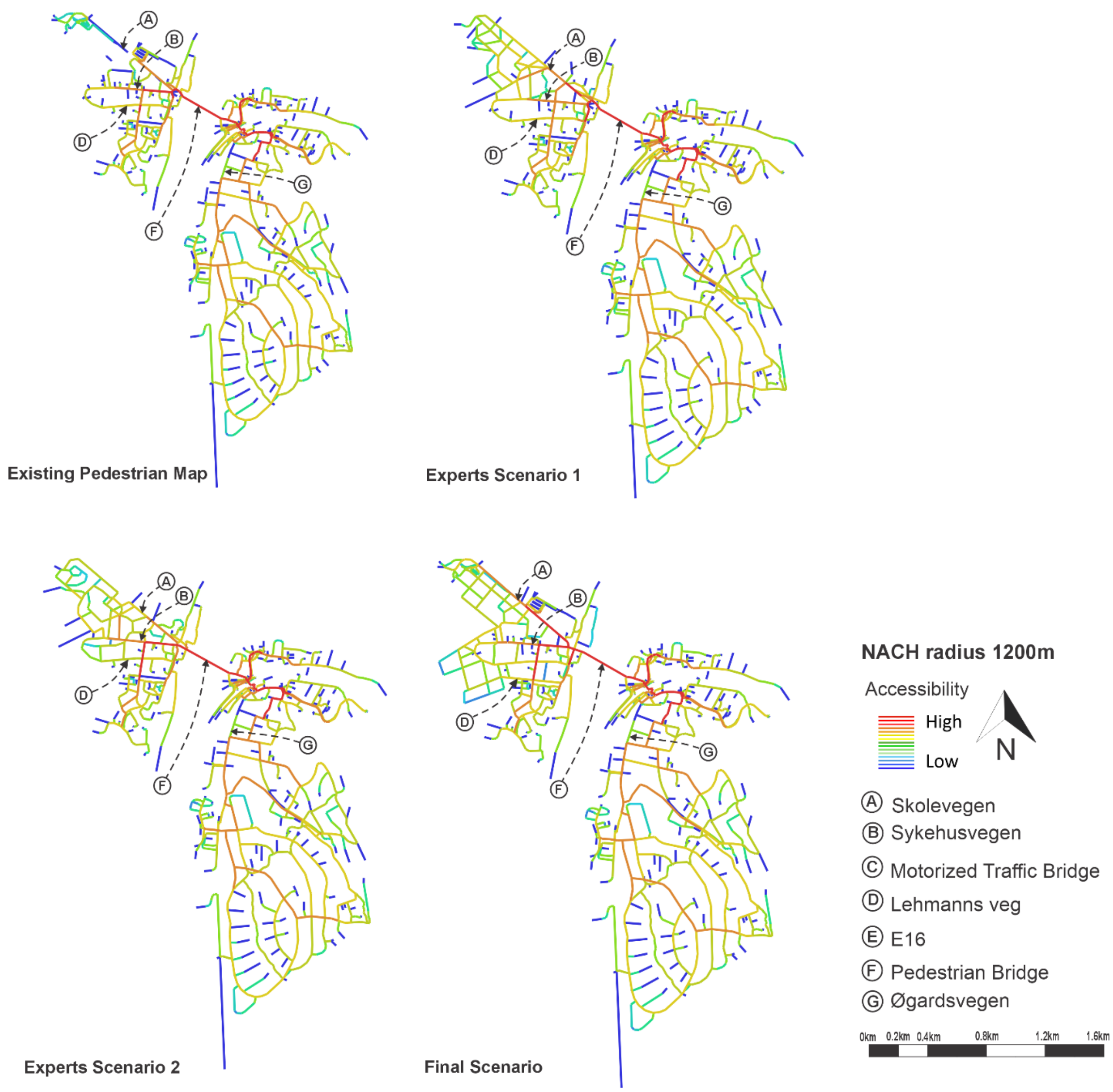


Figure 23. NACH 1200m, Comparison of all the Scenarios with Existing Pedestrian Map.

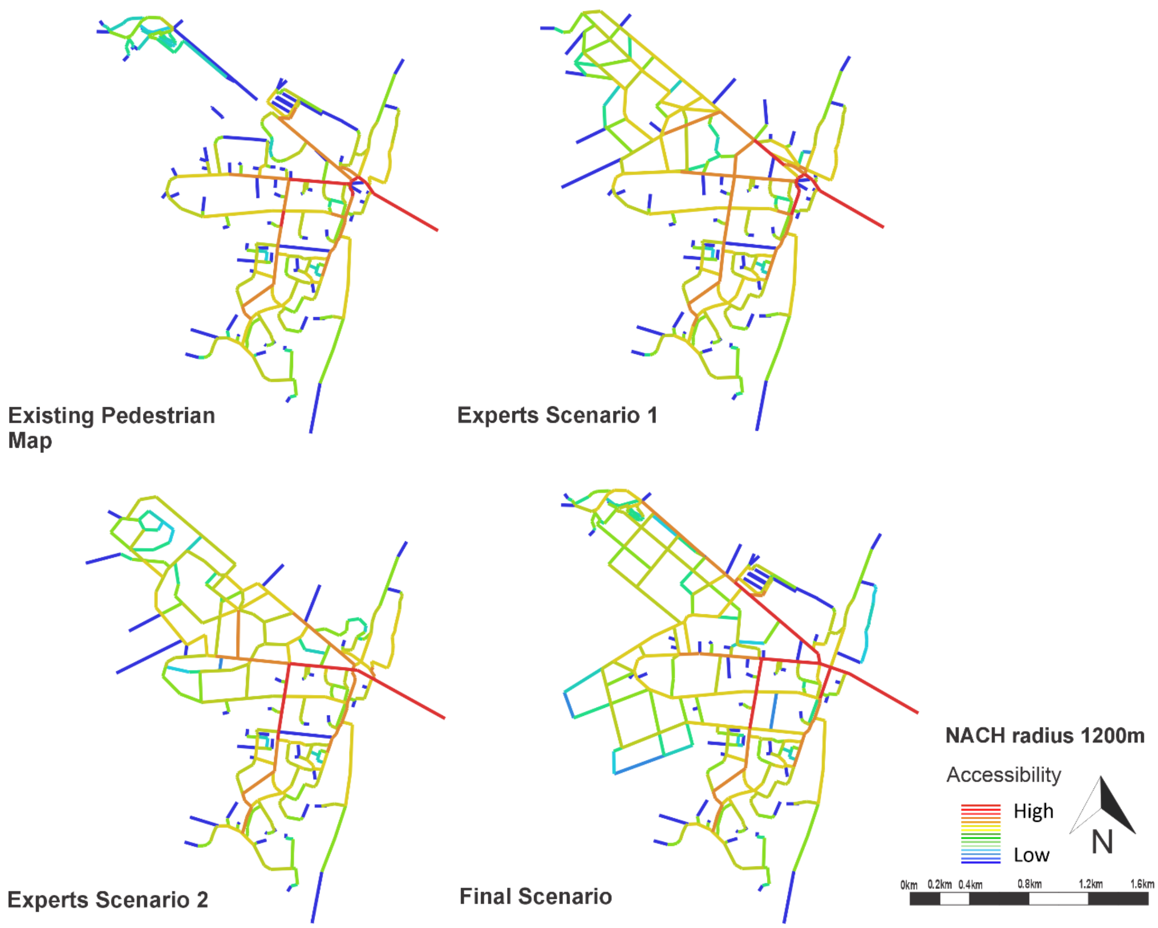


Figure 24. NACH 1200m, Magnified image of all the testing Scenarios.

5.3.4. Syntactic Values

In the below Table, (Table 3) the system minimum is still consistent like all the previous models, at 0.301 for all model Scenarios and radii, indicating that there is a uniform baseline accessibility maintained in every scenario.

For system average the Existing Pedestrian Model shows good average accessibility at RN (3.53) which slightly decreases in larger radii. The Proposed Master Plan by Architect shows a slight decrease in average accessibility at 800m (3.004) but remains stable at other radii. Experts Scenario 1 presents the highest average at RN (3.63), suggesting this scenario offers the most overall connectivity at a city-wide scale. Experts Scenario 2 and the Final Scenario show a general decline in average accessibility, with the Final Scenario showing the lowest averages at 800m (2.99) and 1200m (3.21), indicating a possible reduction in overall connectivity.

For the system maximum the highest values are noted in the Final Scenario at RN (6.18).

Skolevegen (A) Sees gradual improvement across scenarios, peaking in the Final Scenario at RN (5.51), which suggests targeted enhancements to make this street more accessible.

Sykehusvegen generally high values are maintained across all scenarios, with a notable peak in Final Scenario at RN (5.5), indicating it is a vital artery in urban connectivity.

Lehmanns veg shows slight variability, with the highest connectivity in Final Scenario at RN (4.58). Scenario 1, however, shows a slight reduction with RN (4.55).

Pedestrian Bridge exhibits its highest accessibility in the Existing Pedestrian Model at RN (6.65) and shows a consistent decrease in later scenarios, indicating a shift in focus or reallocation of resources.

Øgardsvegen increases in accessibility in the Proposed Master Plan but shows decreases in later scenarios, suggesting changes in prioritization or connectivity patterns.

The number of axial lines varies slightly across models, peaking in the Existing Pedestrian Model (1217) and decreasing in the Final Scenario (1197). The number of segments peaks in the Final Scenario (2095), indicating an increase in pedestrian pathways or complexity in the urban grid.

The Existing Pedestrian Model provides the highest systemic averages, particularly beneficial for pedestrian accessibility. The Final Scenario, despite having higher maximum values, shows lower average values, which suggests that it has optimized certain routes for high connectivity.

The variations in connectivity and focus from one model to another indicate shifting priorities in urban planning, possibly reflecting a trade-off between enhancing major routes (like in the Final Scenario) and maintaining overall pedestrian-friendly environments.

These syntactical measures underscore the impact of different planning approaches on urban mobility. Higher connectivity in specific areas (like Skolevegen in the Final Scenario) may be aimed at boosting economic activity or reducing traffic congestion, which must be balanced against the broader need for equitable urban access.

Table 3. Comparison of Syntactical Measures of all Scenarios and Street Measures.

		NACH														
		Existing Pdestrian Model			**Proposed Master Plan from Architect**			**Experts Scenario 1**			**Experts Scenario 2**			**Final Scenario**		
		RN	**800m**	**1200m**	**RN**	**800m**	**1200m**	**RN**	**800m**	**1200m**	**RN**	**800m**	**1200m**	**RN**	**800m**	**1200m**
	Syetem min	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
	System avg.	3.53	2.96	3.18	3.23	3.004	3.23	3.63	3.02	3.25	3.62	3.03	3.25	3.581	2.99	3.21
	System max.	6.14	5.16	5.47	6.1	5.16	5.43	6.17	5.16	5.46	6.14	5.15	5.45	6.18	5.14	5.46
A	Skolevegen	3.7	3.32	3.62	4.97	3.69	4.25	5.05	3.88	3.81	4.53	3.94	4.25	5.51	4.32	4.79
B	Sykehusvegen	5.27	4.36	4.76	5.02	4.01	4.57	4.94	4.32	4.32	5.12	4.33	4.91	5.5	4.42	4.97
D	Lehmannsveg	4.15	3.91	4.15	4.09	3.71	3.86	4.55	3.97	4.01	4.08	3.81	3.93	4.26	4.01	4.18
F	Pedestrian Bridge	6.65	4.88	5.43	5.83	4.82	5.32	6.07	4.87	4.87	6.01	4.77	5.36	6.1	4.75	5.41
G	Øgardsvegen	4.06	3.42	3.72	4.73	3.33	3.72	4.87	3.42	3.77	4.52	3.5	3.83	4.58	3.41	3.98
	Total no. of Axial Lines	1217			1112			1153			1158			1197		
	Total no. of segments	2035			1886			2009			1983			2095		

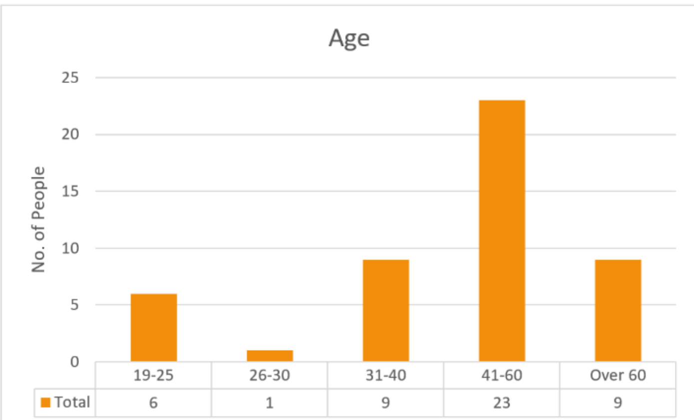
Note: NACH stands for Normalised angular choice

5.4. Data Collection Results

5.4.1. Survey Results

The survey results are shown in the images below (Figure 25). The survey was conducted using the Maptionnaire platform, which is an effective community engagement tool for collecting data and especially useful for gathering map data.

A total of 174 individuals participated in the survey. However, 126 were bounce visitors, leaving 48 who completed the survey. Figure 22 illustrates the demographics of these respondents. The age group 26-30 had the fewest respondents, with only 1 response, whereas the 41-60 age bracket had the most, with 23 respondents. The pie chart in Figure 21 displays the nationalities and genders of the respondents. Most respondents were European, with only one African male. Females were the most numerous, with 34 respondents, followed by 13 European males.



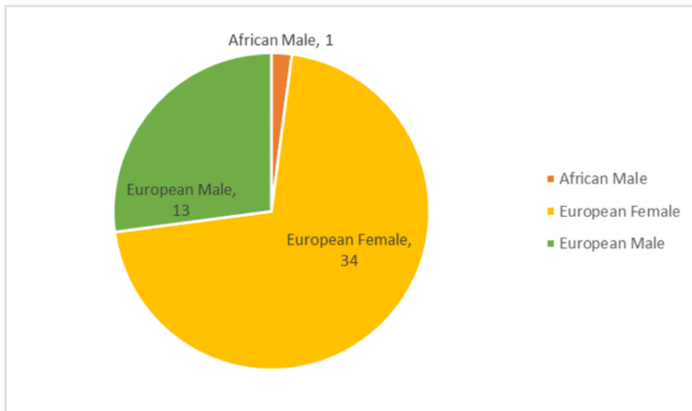


Figure 25. Information about Demographics of Respondents.

Skarnes was divided into two principal areas. Zone 1, the Korsmo Area, also served as the focus of the research, while Zone 2 comprised the Tronbøl area (Figure 26). Most respondents were from Zone 1, totaling 14, with an additional 12 from Zone 2. Other areas where people reside and commute to Skarnes for work are depicted in the images below (Fig. 27), for example, from Kongvinger, Råholt, Årnes and Eidsvoll. It was crucial for this survey and the research to ask this question to ensure the data collected was of high quality and obtained from individuals who directly experience the issues by living in or commuting to these areas daily.

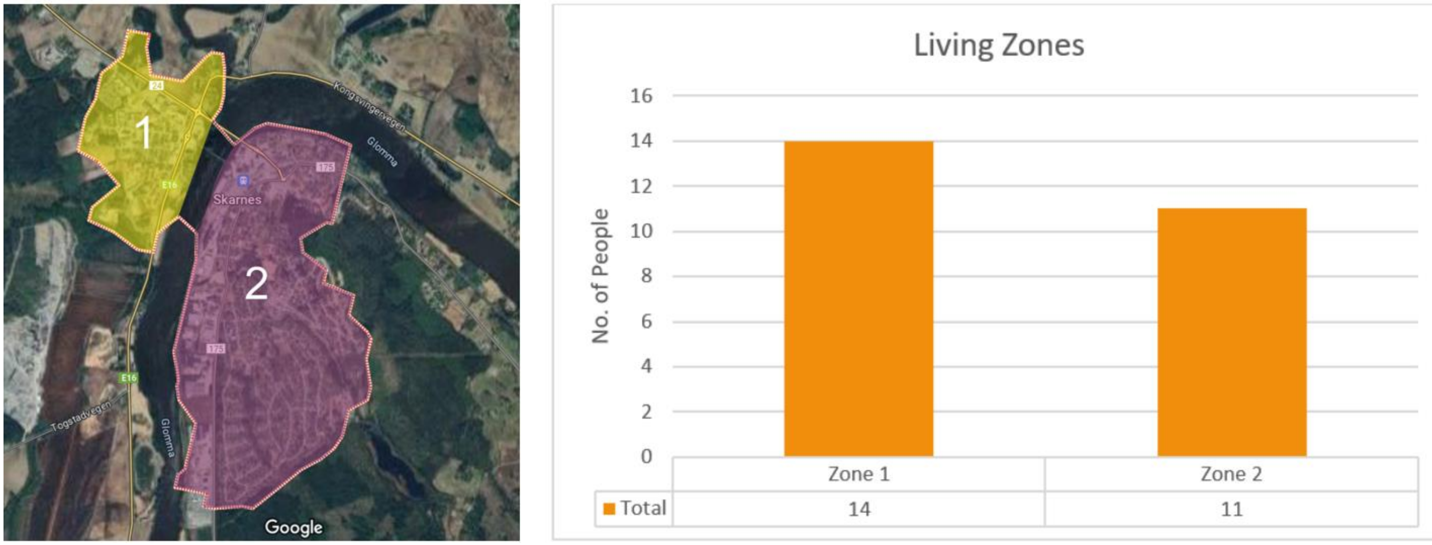


Figure 26. Area of Living.

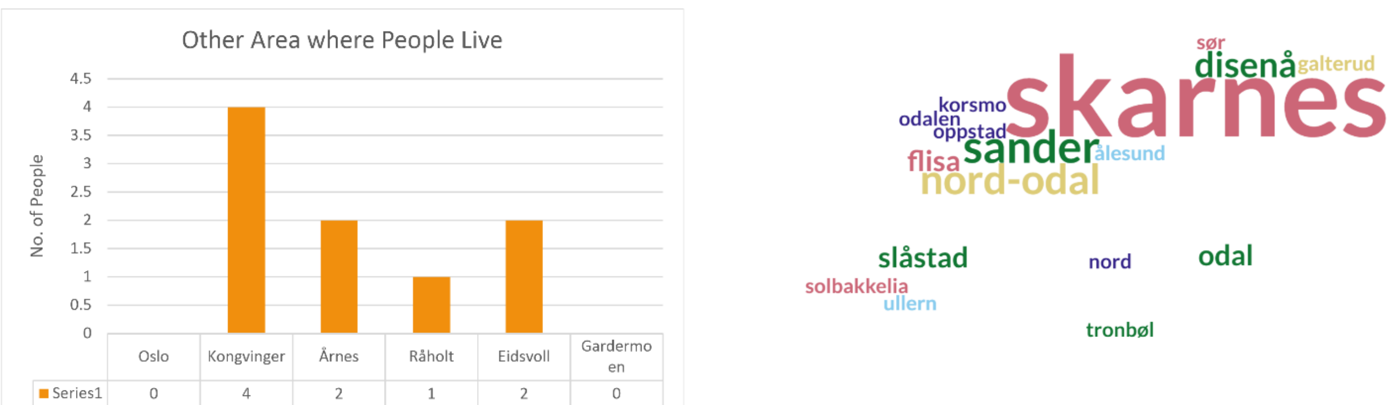
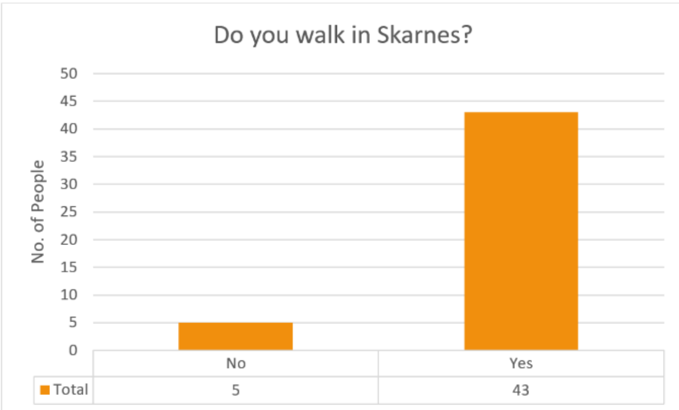


Figure 27. More Areas Where People Live.

The bar charts below illustrate the walking experience and choices of the respondents in Skarnes. Figure 28 shows that out of 48 respondents, 43 engage in walking activities within the town. The bar chart also details their perception of safety; notably, only 2 individuals reported feeling unsafe while walking in Skarnes. Figure 25 presents the reasons for walking, indicating that most people walk for grocery shopping (28 respondents) and general activity (26 respondents). Additionally, Figure 29. Shows that 13 respondents walk to work, and 3 use walking as a means to reach bus stops or train stations. This segment of the survey was crucial for understanding the walking experience and the respondents' feelings of safety while walking in Skarnes.



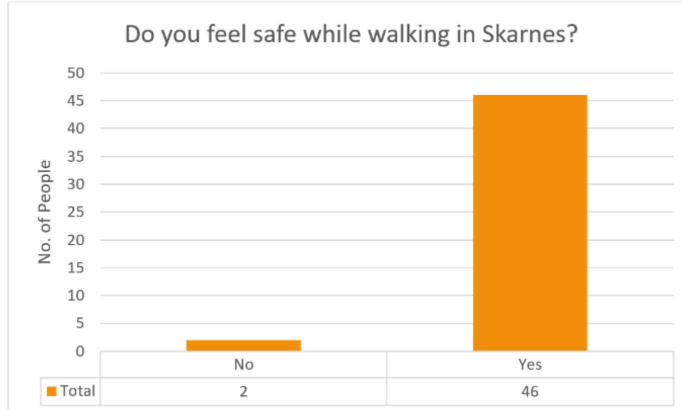


Figure 28. Walking and Safety Perspective of Respondents.

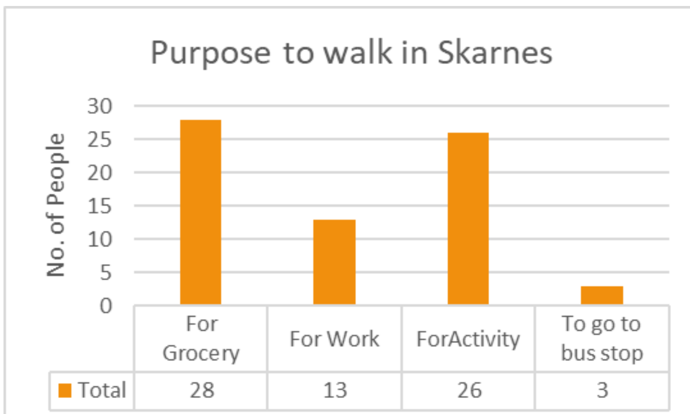
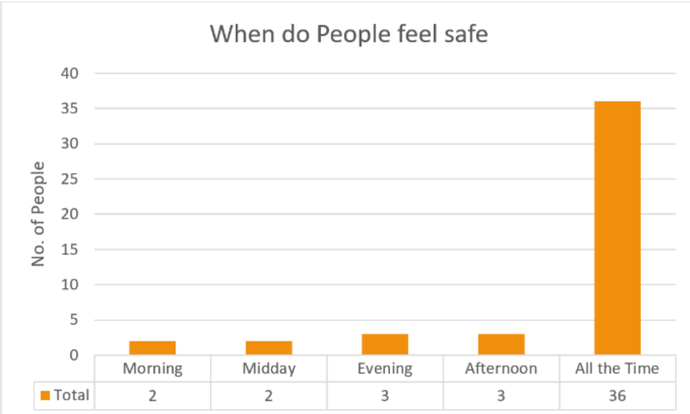


Figure 29. Reasons to Walk in Skarnes.

The bar charts below (Fig. 30) display people's perceptions of safety throughout the day in Skarnes. The majority, with 36 respondents, indicated that they feel safe all the time. Three individuals feel safe during the afternoon and evening, while two feel safe in the morning and midday. The reasons for feeling safe, detailed in the subsequent bar chart, show that 27 people find it easy to walk around Skarnes, 23 cite the low traffic levels, 21 mention the presence of streetlights, and 17 note that visible people in the streets contribute to their sense of safety. This survey section allowed respondents to select multiple reasons for their perceptions of safety, reflecting the varied factors that contribute to their comfort.



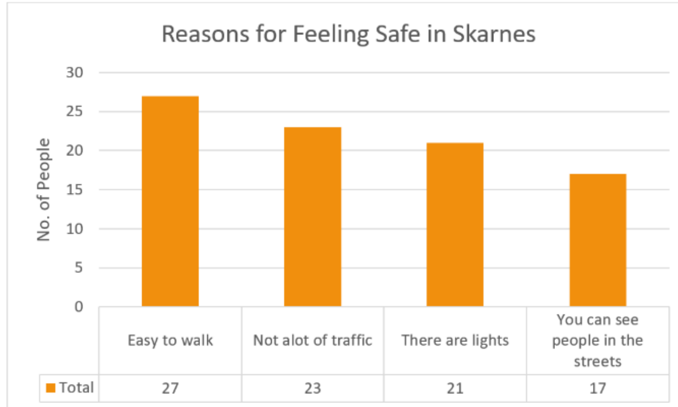


Figure 30. When do People Feel Unsafe and Why.

Below in Figure 31, the graph displays responses regarding when people feel safe throughout the day, correlating their perceptions of safety with feelings of unsafety. Twenty-five respondents feel safe at all times. However, the majority feel unsafe during the night, with 15 individuals expressing this concern, and four feeling unsafe in the evening. Only 18 out of 48 respondents provided reasons for feeling safe, potentially because they had already mentioned feeling safe all the time in Skarnes in a previous question. Eight people attribute their feeling of unsafety to the darkness in Skarnes, possibly due to a lack of street lighting. Additionally, five respondents pointed out the absence or narrowness of sidewalks and excessive traffic as reasons for feeling unsafe. This graph indicates that, overall, most people in Skarnes feel safe.

There is a contradiction, with the responses of feeling safe and unsafe, since a large group of respondents would feel safe all the time, yet a subset would somehow feel unsafe at some times, especially at night. This contradiction can be understood by considering the context of the respondents' experiences. While 75 percent feel safe all the time in Skarnes their perception significantly shifts towards feeling unsafe at night by 31 percent and decreases to 52 percent (Figure 31) from 75 percent (Figure 30). This indicates that safety perceptions are not static and vary with time, person to person and specific conditions. The overall perception of safety is influenced by factors such as ease, light conditions on the road and traffic conditions, which are less favorable at night and leading to heightened feelings of safety during these times.

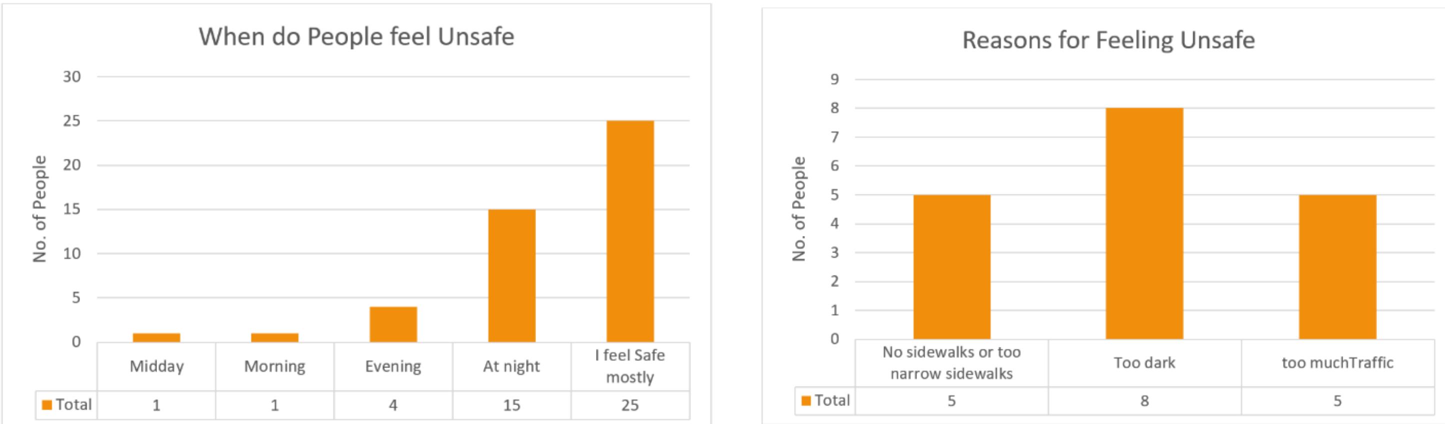


Figure 31. When do People Feel Unsafe and Why.

The Heat map below with the title, "Heatmap of Places where People Feel Safe", Fig. 31 is the image of Heatmap analysis of the places that people pointed out on the map where they feel safe. The dashed line labeled 'Skarnes_Boundary' outlines the geographical scope of the map, and the 'Skarnes_Buildings' are highlighted with yellow patches indicating built-up areas. The central regions near Sykehusvegen, train station and the area extending towards Korsmo and E16 show very dense concentrations of safety perceptions of the locals. This is due to the presence of healthcare facilities, busy commercial areas and also better lighting. To the south and the northeastern parts of Skarnes, the safety perception is moderate to sparse. These areas are less populated and have no public amenities, which could contribute to a lower sense of safety.

Figure 32. Heatmap of Safe Places.

The map shown below as Figure 33, titled "Heatmap of Places Where People Feel Unsafe," identifies areas in Skarnes where residents have reported feeling unsafe. The sense of danger is primarily concentrated around major roads, such as E16, and intersections. This is due to the heavy traffic on E16 and its conflict for pedestrian to walk around this road. Additionally, some respondents have pointed that the bridge designed primarily for vehicular traffic poses risks for pedestrians. There's also a specific mention of a perceived unsafe area to the west of Lehmanns veg. This region is a large empty spaces with low population density, which can feel be perceived as unsafe to individuals walking there at night. Also, this is the same area marked for new development, known as the Graner Area.

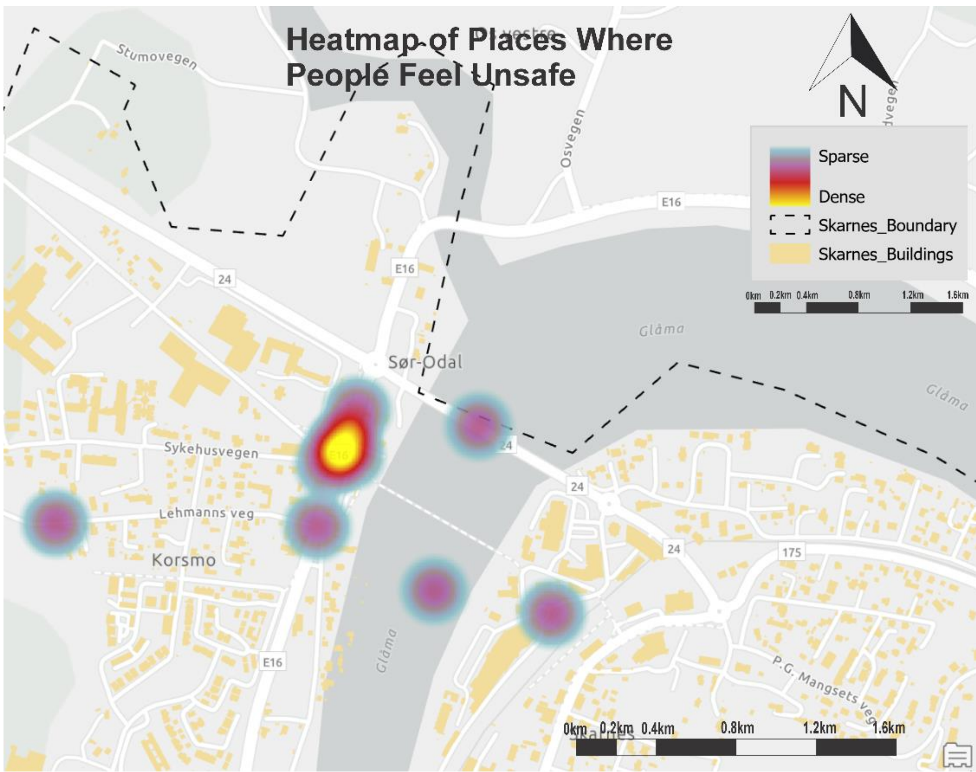


Figure 33. Heatmap of Unsafe Places.

Figure 34 below illustrates additional significant reasons mentioned by respondents in the survey regarding why they feel unsafe while walking in Skarnes. One primary concern is the crime rate in the area, with specific references to groups of boys or gangs contributing to a threatening environment. Another critical safety issue is the conflict between pedestrians and the traffic on E16. A notable point raised was the presence of a pedestrian tunnel under E16, which serves as the sole pedestrian access from the bridge to the Korsmo Area. This tunnel can be particularly confusing for children and first-time visitors to Skarnes, potentially leading them mistakenly onto the E16 roadway, posing serious risks of accidents and danger.

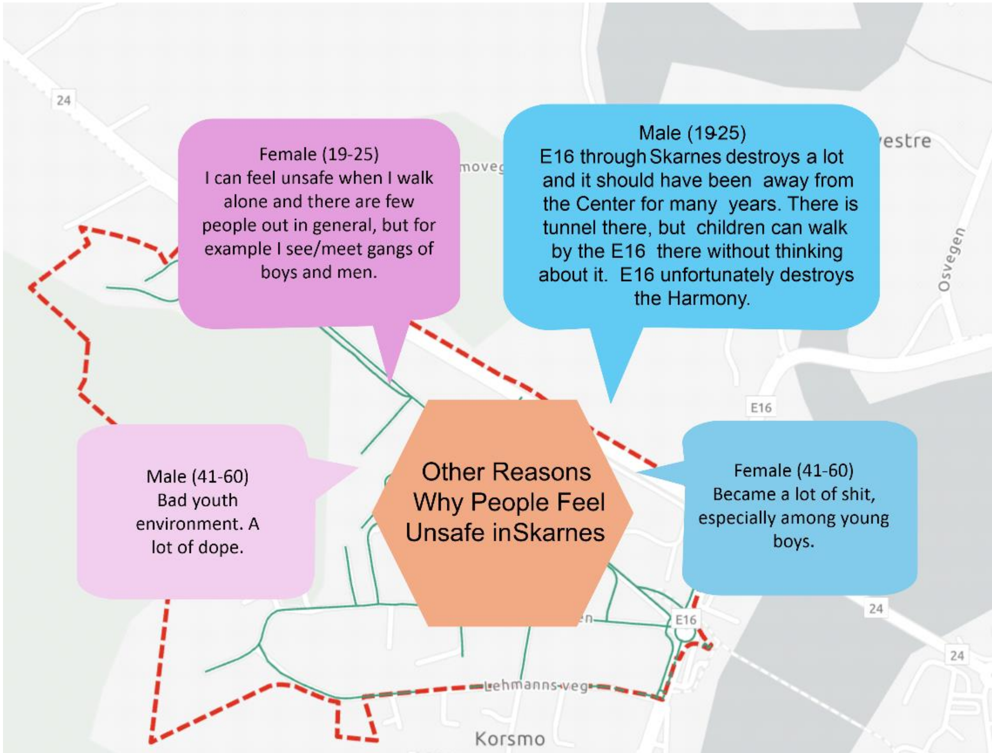


Figure 34. Various Other Reasons to feel Unsafe.

The image below (Fig. 35) displays a walking bridge and tunnel, with image *(labelled as a)* highlighting the conflict faced by pedestrians using the bridge. The E16 road carries heavy traffic, including buses, trucks, and cars. To the west, there's a bus junction *(labelled as b)* where school children from Skolevegen must navigate the tunnel to access the bus stop or cross the bridge. Notably, there is no zebra crossing on the E16, likely due to the heavy nature of the traffic. The images *(labelled as c)* illustrate the tunnel's openings from the bridge side and the Skolevegen side *(labelled as c).* This area requires serious reconsideration and a new design intervention to resolve these conflicts effectively.

(a) Illustration when you pass the pedetrian bridge

(b) Bus stop - on the left side of the bridge and E16

(c) Entrance of the tunnel for foot traffic

(d) Illustration of the other side of bridge - towards skolevegen

Figure 35. Illustration of the Bridge and Walking Tunnel.

The aim of this research was to transform Skarnes into a pedestrian-friendly and livable area. To gather insights on how people envision the future of Skarnes, a critical question was included in the survey. This question helped consolidate all research efforts to propose a new master plan for the Korsmo area. It was a multiple-choice question, allowing respondents to select as many options as they desired. The choices were inspired by the book "Walkable City Rules, 101," (Speck, 2018) which then guided the options provided to the participants. In the graph below (Fig. 36) The majority, with 38 responses, expressed a desire for more parks and meeting places in Skarnes. Thirty-three people noted a lack of benches for sitting outdoors, while 30 respondents want more family-oriented places for activities. Twenty-seven participants believe that proper street lighting would brighten Skarnes' future, and 24 emphasized the need for proper sidewalks. Twenty people expressed a wish for more spaces for physical activities and sports, and 13 advocated for proper zebra crossings to prevent traffic accidents.

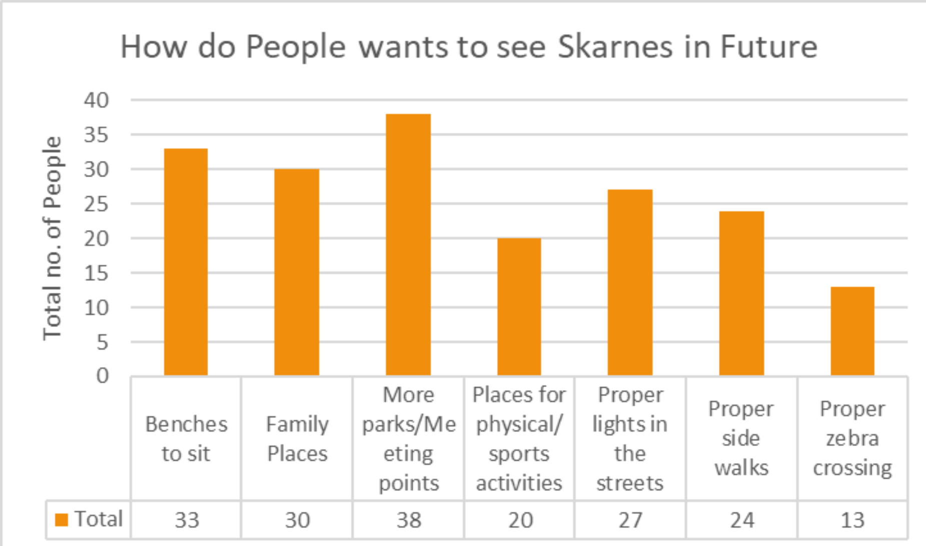


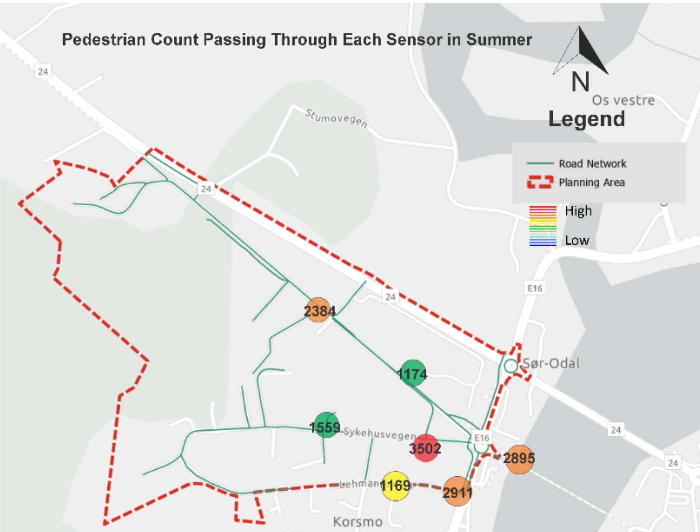
Figure 36. How People want to see Skarnes in Future.

5.4.2. Pedestrian Data Results

Table 4. Below displays the total number of pedestrians detected by each sensor during the months of July and August. Each sensor is assigned a unique ID based on its location by the Municipality. The bar chart in Figure 34 illustrates that the most frequented sensor during the summer was located at Sykehusvegen, with a total count of 3502 pedestrians. The least utilized sensor was situated on Lehmanns veg. The second most active sensor was at the Joker grocery store, registering 2911 pedestrian movements. Close behind, the Brua (Bridge) sensor recorded 2895 passes, making it the third most frequented spot by pedestrians. The fifth and sixth positions were held by the SOAS and Ungdomskole (High School) sensors, with counts of 1559 and 1174 respectively. The geographical location and usage frequency of each sensor are clearly indicated with color coding in Figure 37.

Table 4. Total no. of Pedestrians Walking Through each Sensor in Summer.

Sensor ID	Sensor Location	Class	Total no. of Pedestrian
1	Ungdomskole	pedestrian	1,174
2	Sykehusvegen	pedestrian	3,502
3	SOAS	pedestrian	1,559
4	Vidregående skole	pedestrian	2,384
5	Joker	pedestrian	2,911
6	Lehmanns veg	pedestrian	1,169
7	Brua	pedestrian	2,895



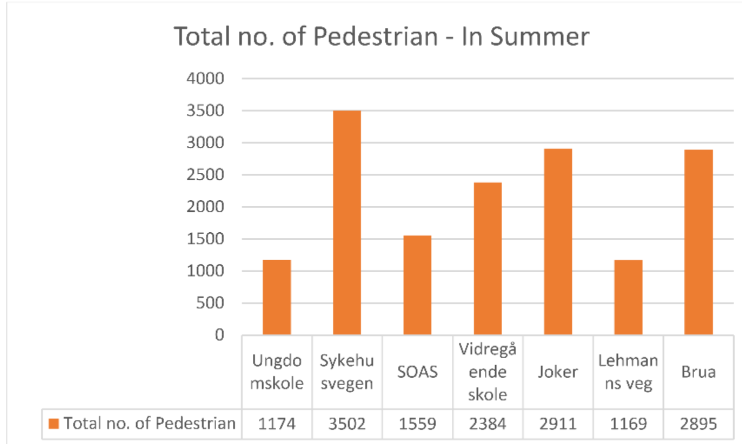


Figure 37. Total no. of Pedestrian Walking Through Each Sensor in Summer.

Based on the existing pedestrian space syntax model, the map in Figure 38 overlays pedestrian counts from sensors for both 800m and 1200m radii. This helps to understand the relationship between predicted accessibility and actual pedestrian usage and validate the model's predictions. For example, Sykehsvegen (sensor 2) has the highest pedestrian count of 3,502 representing moderate to high accessibility. This demonstrates that this road is frequently visited and serves as a beacon of the spatial model. In a similar fashion, the Joker location (sensor 5) sees the second highest count of 2,911 pedestrians; the space syntax model labels this location highly accessible. The bridge (sensor 7), with a count of 2,895, is portrayed as the most accessible location in the space syntax model, highlighted in red, and its usage validates the model's representation of the main pedestrian routes. However, some discrepancies can be observed from the pedestrian counts of the Ungdomskole (sensor 1) and SOAS (sensor 3) sensors, which see less counts of 1,174 and 1,559, respectively, albeit with moderate-to-high accessibility. These results indicate that additional factors, such as the presence of attractions and amenities in a location and potentially the quality of pedestrian environment strongly influence choice. Therefore, it can be concluded that the spatial model effectively identifies potential pathways, but accounting for additional factors like (attractors and generators) is necessary to fully understand pedestrian movements in Skarnes. For example, the results of pedestrian count for sensor 4 do not align with the space syntax results.

Sensor ID's and pedestrian count are mentioned in the legend with the color coding according to high and low pedestrian traffic.

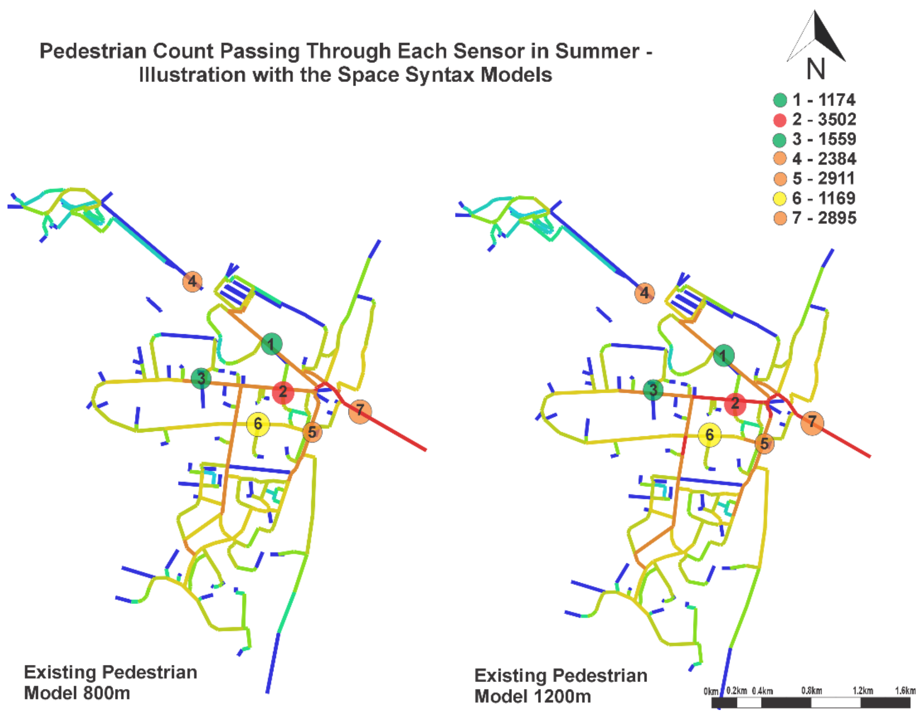


Figure 38. Overlay of Pedestrian Count with Exiting pedestrian Space Syntax Map.

Table 5. presents data from the Log Choice 800m analysis for the Final Scenario, combined with pedestrian data collected through sensors. This analysis is designed to forecast pedestrian movements and assess whether the new urban design will improve walkability and attract more pedestrians in Skarnes. Notably, data from Sensor 5 was excluded due to the removal of E16, which affected the ability to evaluate pedestrian flow in front of the Joker store. There was an increase in pedestrian counts at Sensor 1, from 1174 to 1528, and at Sensor 4, from 2384 to 3102. However, there was a slight decrease at Sensor 7, with counts dropping from 2895 to 2818, likely due to design changes in the final scenario, such as the removal of a nearby roundabout. These trends are clearly depicted in the bar graph shown in Figure 39.

Table 5. Forecast no. of Pedestrian Passing Through Each Sensor in Summer.

Sensor ID	Sensor Location	Exisitng Pedestrian Model (NACH 800m)	Current Pedestrian Flow	Final Scenario (NACH 800m)	Forecasted Pedestrian Flow
1	Ungdomskole	3.32	1,174	4.32	1,528
2	Sykehusvegen	4.36	3,502	4.42	3,550
3	SOAS	4.36	1,559	4.42	1,580
4	Vidregående skole	3.32	2,384	4.32	3,102
5	Joker		2,911		
6	Lehmanns veg	3.91	1,169	4.01	1,199
7	Brua	4.88	2,895	4.75	2,818

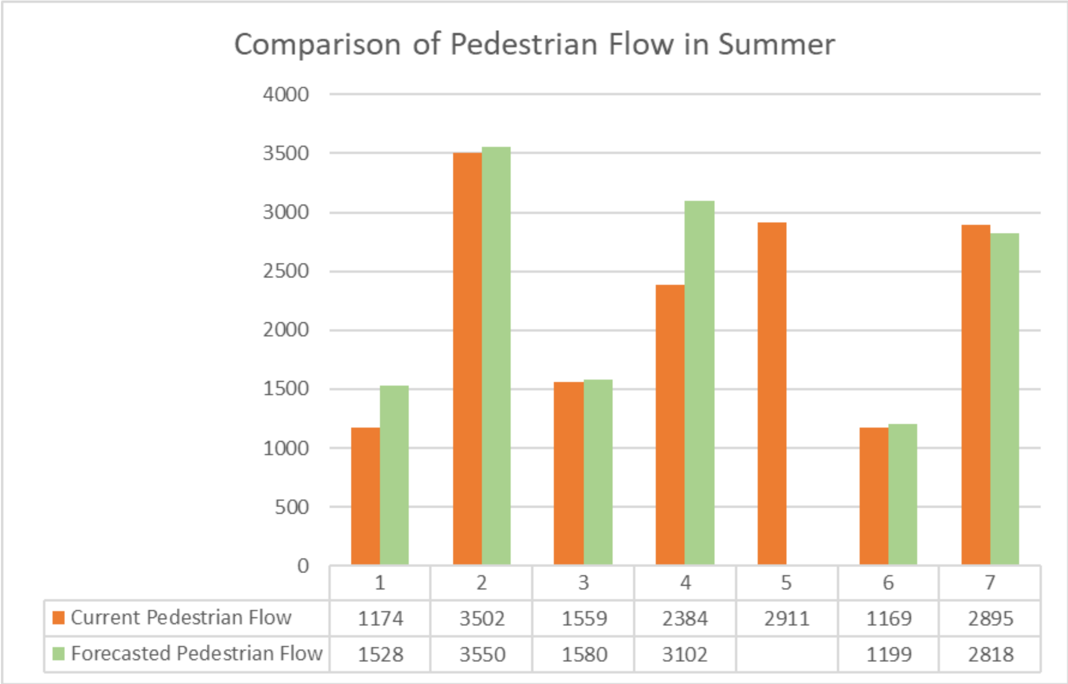
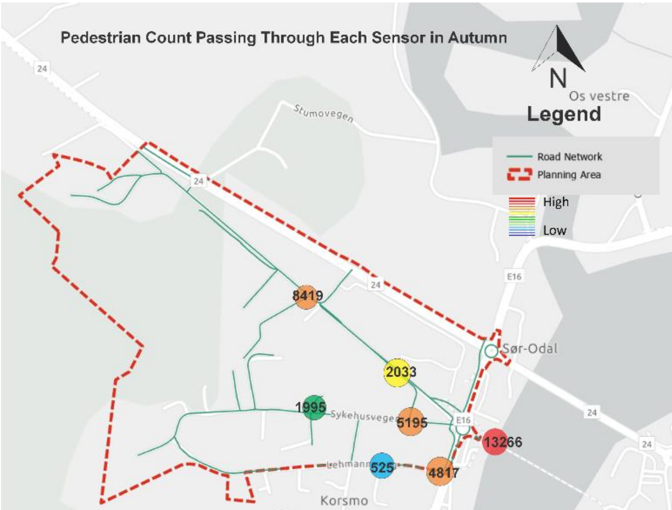


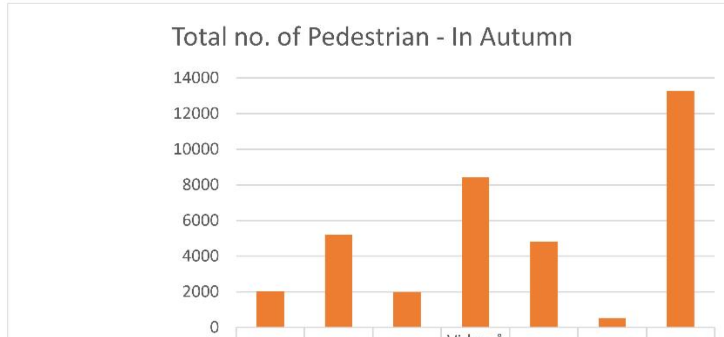
Figure 39. Changing Trends and Current and Forecast Pedestrian Movement in Summer.

Table 6. Below displays the number of pedestrians detected by sensors during the autumn months (September, October, November). This table spans the maximum duration of three months, accounting for the highest pedestrian counts compared to the summer and winter seasons. The highest pedestrian traffic, totaling 13,266, was recorded by sensor 7 at Brua. Following this, Vidregående Skole, sensor 4, recorded 8,419 pedestrians, and Sykehusvegen, sensor 2, noted 5,195. Not far behind, sensor 5 at Joker tallied 4,817 pedestrians. The lowest count was observed at Lehmanns veg, with only 525 pedestrians, which is significantly lower than the other locations. The graph below (Fig. 40) illustrates the trends of pedestrian traffic through each sensor, providing a clearer visualization of the highest and lowest counts. Additionally, the geographical location and usage frequency of each sensor are clearly marked with color coding, as shown in Figure 40.

Table 6. Total no. of Pedestrians Walking Through each Sensor in Autumn.

Sensor ID	Sensor Location	Class	Total no. of Pedestrian
1	Ungdomskole	pedestrian	2,033
2	Sykehusvegen	pedestrian	5,195
3	SOAS	pedestrian	1,995
4	Vidregående skole	pedestrian	8,419
5	Joker	pedestrian	4,817
6	Lehmanns veg	pedestrian	525
7	Brua	pedestrian	13,266





	Ungdomskole	Sykehusvegen	SOAS	Vidregående skole	Joker	Lehmanns veg	Brua
Total no. of Pedestrian	2033	5195	1995	8419	4817	525	13266

Figure 40. Total no. of Pedestrian Walking Through Each Sensor in Autumn.

The Pedestrian count in autumn analysis is shown in Figure 41. overlaid with the space syntax model describes several observations. First, established in the 1200m space syntax model, the Skarnes Bridge (sensor 7) records the highest count of pedestrians, with 13,266 counts, imitating the highly accessible route, red, in the model. The Vidregående skole (sensor 4) registered the second highest counts 8,419, which does not correspond with its space syntax model definition of accessibility. The third highest count of pedestrians at Sykehsvegen (sensor 2) with 5,195 pedestrians, which correlates the moderate-high accessibility of the space syntax model. It is interesting to note that the sensor at Ungdomskole (sensor 1) comprises less counts of pedestrians 2,033 despite the area meeting the yellow-Moderate accessibility model. Sensor locations 3 and 6 with moderate accessibility (orange and yellow), however, achieved less count of pedestrians see the count details, 1,995 525, revealing that the accessibility standard does not define the pedestrian preference spread out. Thus, these cases outline the critical dependence on other factors contributing to the pedestrian outreach within the Skarnes area.

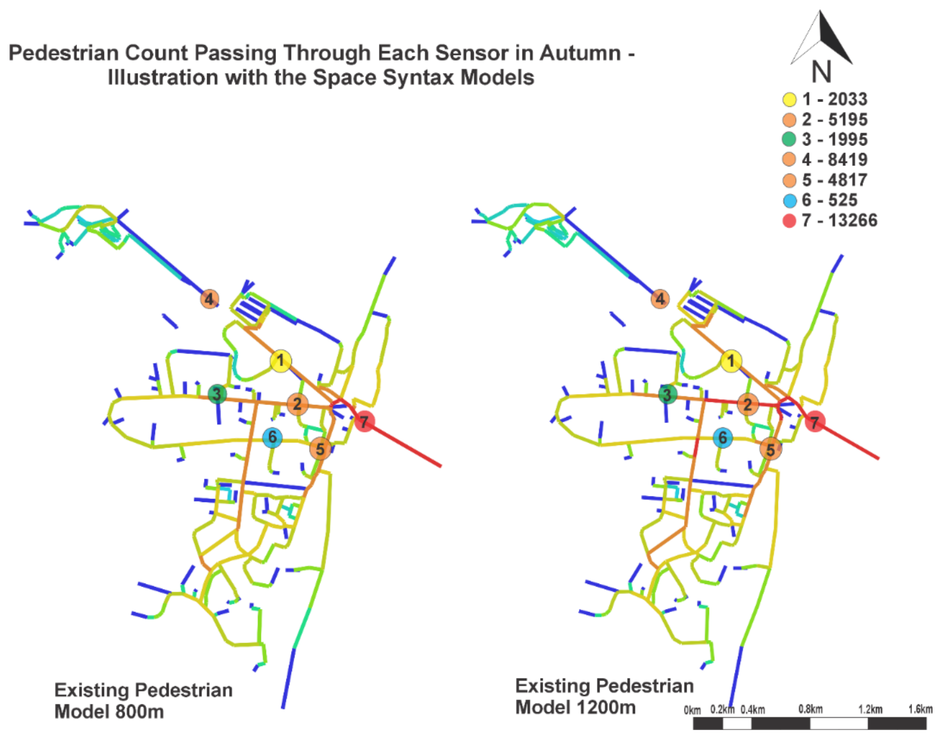


Figure 41. Overlay of Pedestrian Count with Exiting pedestrian Space Syntax Map.

Table 7. illustrates the forecasted flow of pedestrian traffic for each sensor during autumn. Sensor 5 is excluded due to the removal of E16, as mentioned previously. A significant decrease is observed at the Vidregående skole location, sensor 4, with counts dropping from 8419 to 1055. Similarly, there's a reduction at Brua, sensor 7, from 13266 to 12913. Conversely, a slight increase is noted for Lehmanns veg, sensor 6, from 525 to 538. These changes in pedestrian traffic trends are clearly depicted in Figure 42 below. All sensors are showing improvements in pedestrian counts except for Brua, where numbers are declining.

Table 7. Forecast no. of Pedestrian Passing Through Each Sensor in Autumn.

Sensor ID	Sensor Location	Exisitng Pedestrian Model (NACH 800m)	Current Pedestrian Flow	Final Scenario (NACH 800m)	Forecasted Pedestrian Flow
1	Ungdomskole	3.32	2,033	4.32	2,645
2	Sykehusvegen	4.36	5,195	4.42	5,266
3	SOAS	4.36	1,995	4.42	2,022
4	Vidregående skole	3.32	8,419	4.32	10,955
5	Joker		4,817		
6	Lehmanns veg	3.91	525	4.01	538
7	Brua	4.88	13,266	4.75	12,913

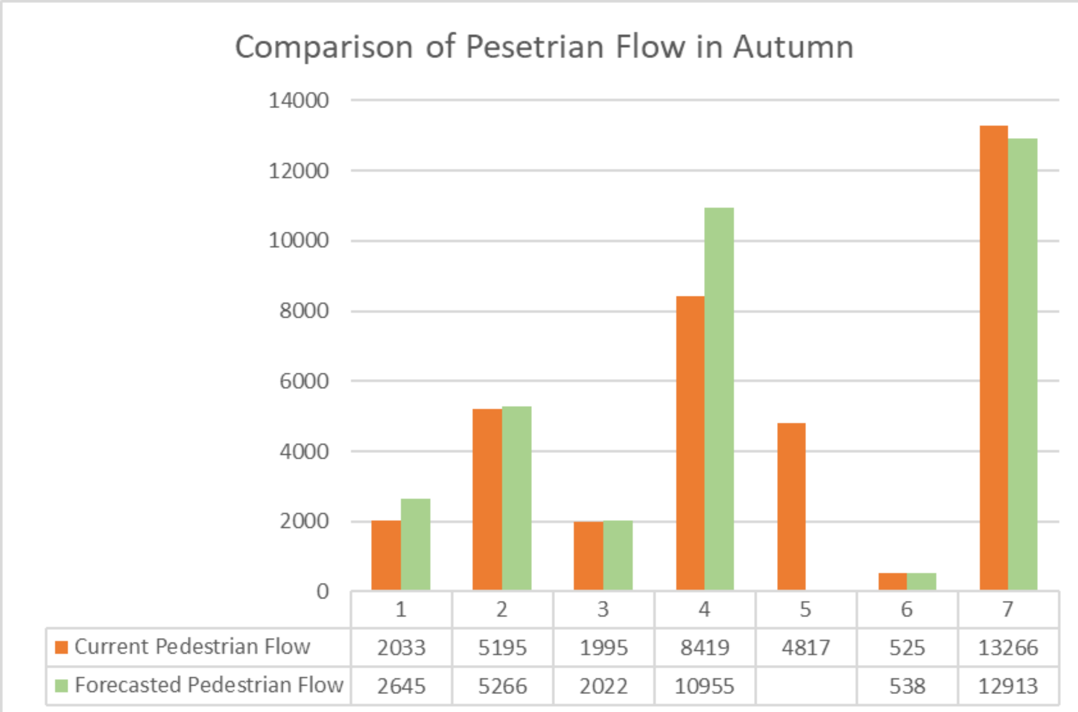
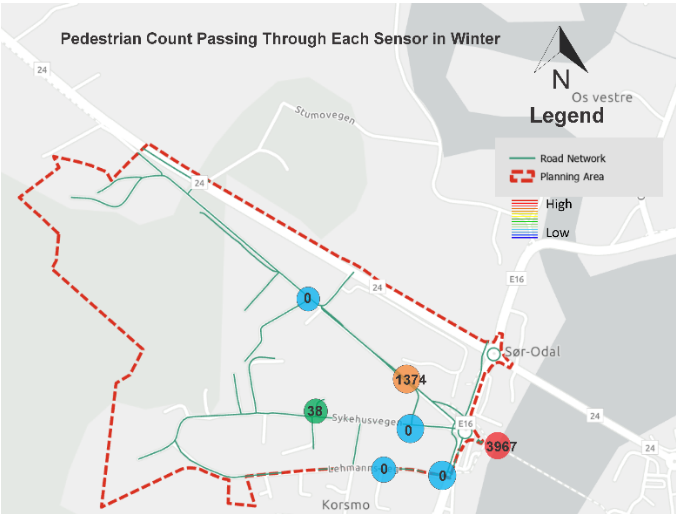


Figure 42. Changing Trends and Current and Forecast Pedestrian Movement in Autumn.

Table 8. Below presents the results from the data collection of sensors during the winter. Winter data is available only for December, during which there was minimal to no pedestrian movement across most sensors, this might be due to the technical issue with the sensors. With the exception of sensors 1 and 7. The highest number of pedestrians was recorded at sensor 7, Brua, totaling 3967. These trends are clearly visible in Figure 43.

Table 8. Total no. of Pedestrians Walking Through each Sensor in Winter.

Sensor ID	Sensor Location	Class	Total no. of Pedestrian
1	Ungdomskole	pedestrian	1,374
2	Sykehusvegen	pedestrian	0
3	SOAS	pedestrian	38
4	Vidregående skole	pedestrian	0
5	Joker	pedestrian	0
6	Lehmanns veg	pedestrian	0
7	Brua	pedestrian	3,967



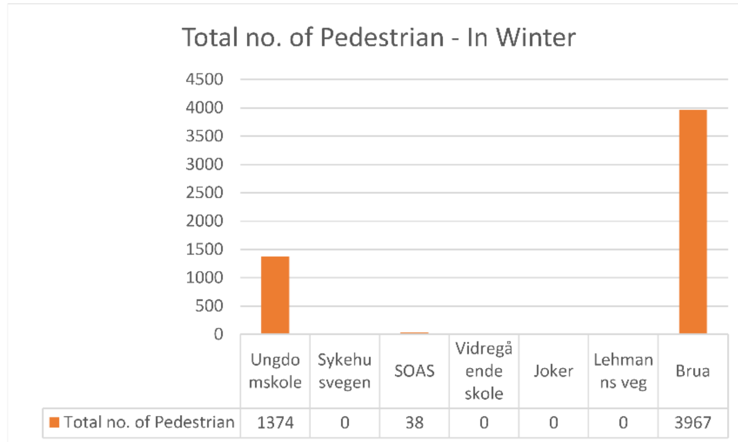


Figure 43. Total no. of Pedestrian Walking Through Each Sensor in Winter.

Below Figure 44 is the image overlaying pedestrian traffic with the space syntax model for winter. As previously mentioned, the sensors were out of order for most of the winter season, and the data is limited to only December. Consequently, there is not much foot traffic, and this limited data does not provide a clear view of space usage in winter. Despite this, the sensor on the bridge recorded the highest pedestrian count of 3,967, followed by the Ungdomskole (Sensor 1) with 1,374 counts. These two sensors align with the space syntax spatial analysis, indicating high and moderate accessibility according to the space syntax models for choice radii of 800m and 1200m.

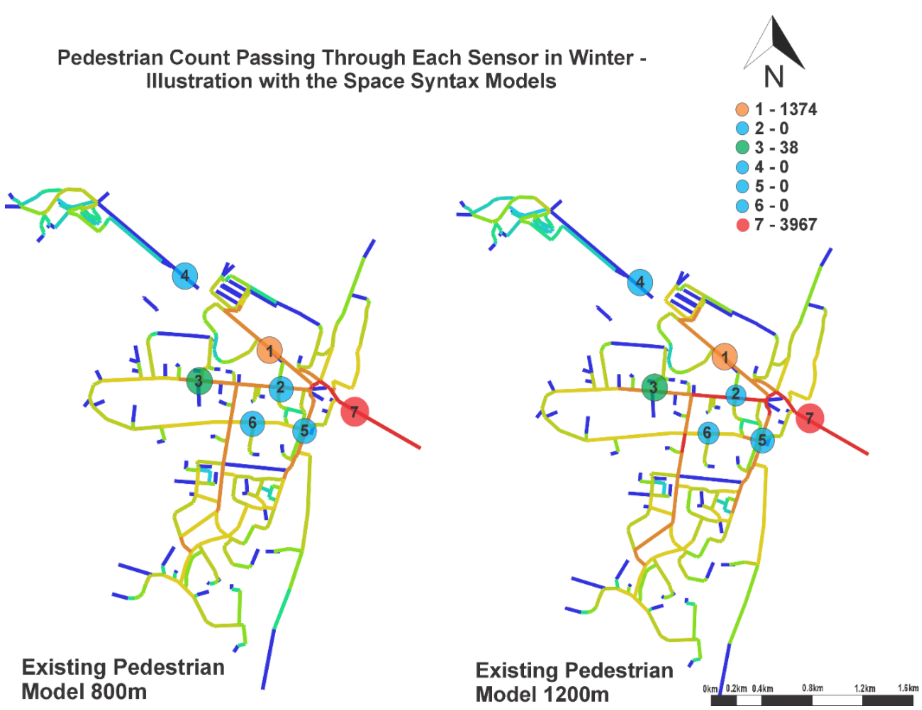


Figure 44. Overlay of Pedestrian Count with Exiting pedestrian Space Syntax Map.

Table 9. below illustrates the changes in current pedestrian traffic and forecasts for the winter season. For sensor 2, there is a minimal change from 38 to 39. A more significant change is observed for sensor 1, where the count increases from 1374 to 1788. Additionally, the number of pedestrians passing through the pedestrian bridge shows a slight decrease from 3967 to 3861. These trends are depicted in Figure 45.

The overlap image of the pedestrian count with space syntax results provides some interesting insights (Figure 38, 41, 44). Examining the attractors and generators surrounding the sensors. Because for some sensors, specially sensor 4, the results do not overlap with the space syntax models. It may be because of the attractors and generators. Recognizing the attractors and generators helps to understand the discrepancies between space syntax predictions and actual pedestrian counts. Considering the functional role of urban areas, in addition to their spatial configuration, is critical for facilitating pedestrian movement. These findings will allow more targeted and effective urban planning interventions to enhance pedestrian accessibility and connectivity in Skarnes.

Table 9. Forecast no. of Pedestrian Passing Through Each Sensor in Winter.

Sensor ID	Sensor Location	Exisitng Pedestrian Model (NACH 800m)	Current Pedestrian Flow	Final Scenario (NACH 800m)	Forecasted Pedestrian Flow
1	Ungdomskole	3.32	1,374	4.32	1,788
2	Sykehusvegen	4.36	0	4.42	0
3	SOAS	4.36	38	4.42	39
4	Vidregående skole	3.32	0	4.32	0
5	Joker		0		0
6	Lehmanns veg	3.91	0	4.01	0
7	Brua	4.88	3,967	4.75	3,861

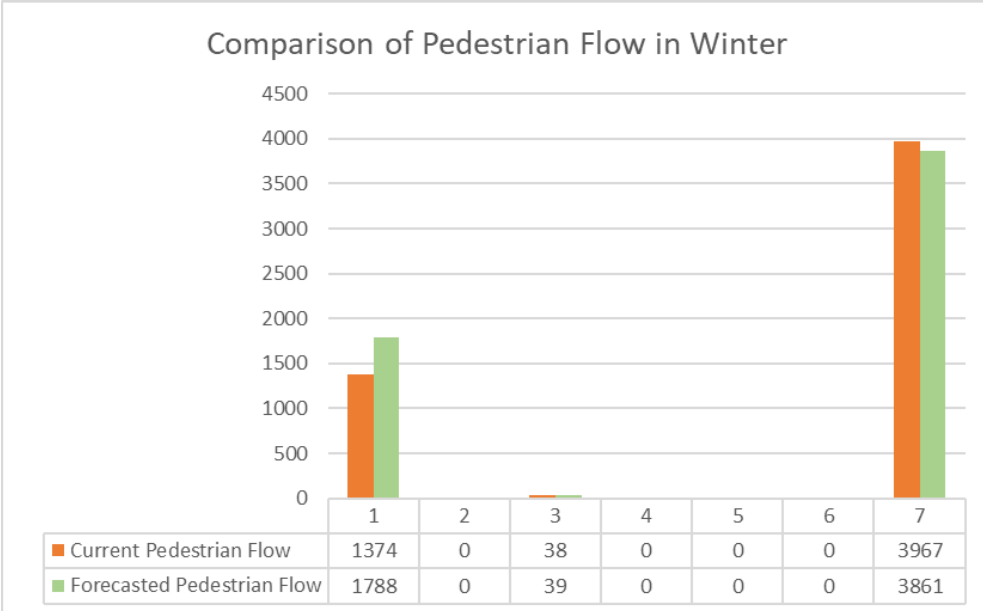


Figure 45. Changing Trends and Current and Forecast Pedestrian Movement in Winter.

5.4.3. Analysis of Expert Interviews

Semi-structured interviews made it possible to receive highly informative responses, shedding light on several critical points of Skarnes urban planning that relate to the utilization of space syntax, inclusivity in accessibility perceptions, and strategic requirements for urban development. Original answers are provided in the Appendix. B. First, the opinions regarding the viability of space syntax among the interviewees were mixed. For instance, one respondent, an urban planner, argued that space syntax provides a perspective broader than plain mobility. It seems that the theory introduces a multidimensional understanding of planning, which is beyond doubt useful. At the same time, one GIS analyst explained that space syntax ensures the provision of data-driven models as a supplement to traditional planning principles, which also seems to be beneficial. However, it is noted that some respondents struggle to understand the theory and its practical outputs, therefore the theory requires some clear articulation of how it may be beneficial. Another concept that I probed the interviewees concerning was that of inclusive accessibility. While the answers varied to some extent, they all seem to focus on the idea of making urban spaces available, functioning, and meaningful to people, including those with disabilities. Indeed, the concept of “inclusive accessibility” seems redundant to the Norwegian one – “universell tilgjengelighet,” – universal accessibility and “inkluderende planlegging,” inclusive planning. Thus, inclusivity may be identified with the need to create spaces where all people can move freely, irrespective of abilities and age. Certain components were named that seemed to help in creating this access, such as combined parks that are kids’ play zones and communal green spaces, calm zones for urban recreation isolated from sound and opened to sunlight, and park systems or walking streets that form connections between important urban elements like schools and public squares. The interviews also showed that memorable and logical routes were mentioned that indicated the importance of designing an urban area that orients people without issues. One of the interviews covered the question of local centers' desiredness and count in Skarnes. On the one side, it was argued that one center was needed in Skarnes due to commercial sustainability problems. On the other, it was noted that the Glomma River naturally separated Skarnes into two parts, which made centers' differentiation possible or even inevitable. Ultimately, it was agreed that one single center could be launched with enrichments possible for enhancing local life and community connections. In general, the experts underlined the need for making Skarnes appealing and alive. Key suggestions involved decreasing car dependency, intensifying pedestrian, and cyclist spaces, and restructuring big roads like E16 to fit with local needs. Sustainable and long-term urban improvement and community-enhancing spots' prioritization was also essential.

6. Discussion

Skarnes has demonstrated significant growth potential, but now faces the critical challenge of reconciling its car-centric infrastructure with the increasing demand for a pedestrian-friendly environment. This research has conducted a thorough analysis of pedestrian accessibility and safety in Skarnes, utilizing space syntax analysis to evaluate various urban design scenarios and a community survey to gather insights into residents' walking habits and safety concerns.

The space syntax analysis of Skarnes clearly shows a town that is highly focused on car-based mobility. Both the existing strategic model and the car-based model prioritize vehicle traffic, with highways consistently having high accessibility across all measured radii (5.1.1, Fig. 11, 12). This emphasis aligns with the survey results, which indicate that a significant number of respondents live in Zone 1 (Korsmo) near the E16 highway (5.5, Fig. 26). The prevalence of car-centric design suggests a potential over-reliance on private vehicles for daily commutes, even for short distances. This dependency on cars could lead to various negative effects, such as increased traffic congestion, air pollution, and decreased physical activity levels.

The space syntax analysis of Skarnes reveals its car-centric nature, but it also highlights the potential benefits of dedicated pedestrian infrastructure. The pedestrian model consistently shows higher accessibility for pedestrians in the study area, especially along key routes such as Skolevegen and Sykehusvegen (5.1.2, Fig. 13, 14). These findings are further supported by the survey results, which indicate that 90% of respondents walk for errands and leisure activities (5.5, Fig. 28, 29). The presence of the pedestrian bridge also emerges as a significant factor influencing pedestrian movement patterns in the existing pedestrian model (5.1.2, Fig. 13). Overall, these findings suggest that residents are open to walking and cycling as viable transportation options, provided there is a safe and well-connected network.

The architect's proposed masterplan aims to improve pedestrian accessibility, but the space syntax analysis reveals limitations in the design. The model creates a fragmented pedestrian network, especially beyond the pedestrian roundabout, which could reduce overall connectivity compared to the current pedestrian model (5.2 figure 17, 18). This fragmentation may result in longer routes and discourage walking, ultimately undermining the model's effectiveness in promoting pedestrian mobility.

The space syntax analysis also indicates potential shortcomings in the proposed masterplan overall system measures (5.2.1, Table 2). While the model improves accessibility on specific routes (proposed RN at 6.10), the average accessibility across the network slightly decreases compared to the existing pedestrian model. This suggests that the proposed changes may prioritize certain high-traffic routes at the expense of overall network connectivity.

The survey results offer valuable insights into how residents perceive safety while walking in Skarnes. Most respondents feel safe during the day (5.4.1, Fig. 30), but there are concerns at night, especially in unlit areas and near major roads with heavy traffic (5.4.1, Fig. 31). This aligns with the space syntax analysis, which shows that areas dominated by cars often lack pedestrian infrastructure such as wider sidewalks and proper lighting, particularly near busy roads (4.5, Fig. 9, Table 1). Prioritizing car traffic can create safety risks for pedestrians, especially at night when visibility is limited. The integration of space syntax analysis and survey results highlights the necessity for a more equitable approach to mobility in Skarnes.

After introducing the final scenario and analyzing the syntactic values (5.3.4, Table 3) of all five models (existing pedestrian network, proposed master plan, expert scenarios 1 and 2, and the final scenario), it is evident that the final scenario outperforms all others. This is particularly true for the Choice 1200m measure, which represents a 15-minute walk analysis. The Global Choice (NACH RN) indicates that the roads benefiting most in terms of accessibility are Skolevegen, Sykehusvegen, and Øgardsvegen. For Local Choice (NACH 800m), the streets Skolevegen, Sykehusvegen, and Lehmanns veg show superior accessibility compared to all other scenarios and the proposed model, as they exhibit higher values. The NACH 1200m measure proves to be the most effective for the Søsterhagen area, as accessibility improves significantly for all major roads. These include Skolevegen, Sykehusvegen, Lehmanns veg, the pedestrian bridge (Brua), and Øgardsvegen. This comprehensive enhancement in accessibility highlights the final scenario's effectiveness in creating a well-connected and pedestrian-friendly urban environment.

This is later supported by pedestrian counts from sensors when the pedestrian forecast was conducted for each road using the NACH 800m measure. This forecast and the overlap of pedestrian counts with space syntax analysis are clearly illustrated in Figure 38, 41, 43. The figure shows roads such as Skolevegen, which has two sensors, 1 and 4. There is a clear increase in pedestrian count by 30% for sensor 1 and by 31% for sensor 4. Sykehusvegen also has two sensors, 2 and 3, where the pedestrian count has increased by 1.3% on both sensors. On Lehmannsveg, sensor 6 shows a pedestrian count increase of 2.5%. However, the pedestrian count on the bridge, monitored by another sensor, has decreased by 2.6%. This decrease is attributed to the removal of the pedestrian roundabout in the final scenario, aimed at better distributing foot traffic flow. Hence, it is evident that the street that is most benefiting from the introduction of final scenario is Skolevegen.

While a complete departure from car-centric design may not be practical or ideal, a gradual transition towards a more balanced approach that prioritizes pedestrian accessibility can yield significant advantages and results. This could entail the implementation of traffic calming measures on main thoroughfares, the creation of dedicated pedestrian lanes and broader sidewalks, and the establishment of designated areas with reduced speed limits to enhance pedestrian safety.

The constraints of the proposed master plan by architect, in the space syntax analysis underscore the significance of a well-integrated pedestrian network. It is crucial for future urban planning initiatives to focus on establishing a seamless network of pedestrian pathways that link residential areas with essential destinations such as schools, workplaces, and shopping centers. This may entail the removal of physical obstacles like roundabouts (as indicated in the final scenario of the space syntax analysis) and the creation of more direct pathways to enhance overall connectivity and promote pedestrian mobility.

The survey results have identified specific areas where safety concerns are particularly high. These areas, especially those near major roads (E16) and unlit pathways (Lehmannsveg) (Figure 33), should be prioritized for safety enhancements. Implementing improved street lighting, increasing police presence in high-risk zones during nighttime hours, and installing traffic management features such as crosswalks with pedestrian signals can greatly improve pedestrian safety, especially for vulnerable groups such as children and elderly residents.

Encouraging a culture of walking extends beyond just infrastructure improvements. Public awareness campaigns that emphasize the health, environmental, and community benefits of walking can play a critical role in changing attitudes. Additionally, incorporating elements such as public art installations, street vendors, and green spaces along pedestrian routes can make walking a more enjoyable and engaging experience.

Improving pedestrian accessibility and safety in Skarnes requires a comprehensive strategy that takes into account various factors. Through the analysis of space syntax data and gathering feedback from residents, this research has pinpointed specific areas in need of improvement. It is vital to gradually transition towards a transportation system that gives equal importance to pedestrian infrastructure, network connectivity, and targeted safety measures. Encouraging a culture of walking and fostering community involvement are also crucial in creating a lively and healthy urban environment in Skarnes. As Skarnes continues to develop, prioritizing the needs of pedestrians will not only enhance safety and quality of life but also contribute to a more sustainable and fair future for the town.

7. Conclusion

The study aimed to explore the relationship between urban design and pedestrian dynamics in Skarnes, a small town in Norway, utilizing space syntax theory. The objective was to enhance pedestrian connectivity and social interactions by analyzing spatial configurations and incorporating empirical data. This research adopted a mixed-methods approach, blending quantitative space syntax analysis with qualitative insights from surveys and expert interviews. The goal was to propose a comprehensive and practical urban design framework that promotes walkability and community engagement.

7.1. Key Findings

Choice Radius N highlighted the natural movement patterns within Skarnes, showing that the strategic model map, which includes both pedestrian and motorized vehicle bridges, presented a balanced approach to accessibility. The existing pedestrian model shifted centrality towards pedestrian movement, emphasizing the importance of the pedestrian bridge in linking various parts of the town. The proposed plan by the architect showed reduced directness and efficiency, indicating potential fragmentation in the pedestrian network.

NACH radius 800m analysis, focusing on a 10-minute walking radius, revealed that Skarnes remains predominantly car-oriented. The existing pedestrian model showed slight improvements in accessibility, but the proposed master plan was fragmented, potentially worsening pedestrian experience.

NACH radius 1200m, the 15-minute walking radius analysis indicated modest improvements in pedestrian movement in the Tronbøl area due to spillover effects, although direct changes in the Søsterhagen area were insignificant. The strategic and car-based models showed high accessibility for highways, reflecting a car-biased infrastructure.

The space syntax analysis reveals multiple physical barriers for pedestrian movement, including unconnected roads and roundabout tunnel, as well as areas with questionable sidewalks and crossing. Due to which pedestrian movement is often uncomfortable and constrained by the car-dominated urban environment. The analysis reveals a pedestrian bridge over the E16 road, which has high traffic, among the most significant barriers. Additionally, the bridge is not designed comfortably for school children, who must navigate through a pedestrian tunnel.

When compared the original master plan by the municipality (proposed master plan by architect), with the existing situation, it highlighted significant emphasis on balancing accessibility for both vehicles and pedestrians. The proposed model by the area planner includes specific enhancements to accessibility on a larger scale throughout the city, suggesting a comprehensive approach to urban development. This model shows slight improvements in overall accessibility compared to the existing pedestrian and car-based models, particularly on major routes such as Skolevegen and Sykehusvegen (Table 2). However, some areas, like Lehmanns veg and the pedestrian bridge, show reduced accessibility in the proposed master plan compared to the existing pedestrian model. This indicates prioritizing certain routes over others.

The development of three spatial space syntax scenarios through stakeholder workshop provided actionable strategies for improving pedestrian movement. The final scenario offered the most promising results. Separating walkers and cyclists from cars in Scenario 1 created a safer network, weaving in greenspace benefited all users. Scenario 2 reimagined buildings' positions, stitching walkways between them for direct routes. The final scenario merged these approaches. By thoughtfully arranging a grid accommodating multiple modes of transport, the final scenario transformed Skarnes into a cohesive, pedestrian-friendly community through varied yet well-integrated paths linking with other important roads.

On the one hand, in expert scenario 1, the pathways were "intensified," connecting residential areas with the most significant facilities, such as Skolevegen and Sykehusvegen. This led to an improvement in accessibility, as the focus on safety and recreational elements eliminated the constraints of the existing pedestrian infrastructure. On the other hand, in expert scenario 2, introduced more direct pathways and removed navigation barriers, making pedestrian movement more efficient. As a result, not only did the reorientation of buildings eliminate obstacles but the creation of direct links assisted in clear and direct navigation. Thus, the final scenario outperforms the previous models in terms of patterning accessibility – it structured pedestrian movement by eliminating major hurdles and creating new direct links. Overall, this would facilitate easier navigation and allow for the more systematic spread of pedestrian and vehicle traffic.

The comparison of the proposed master plan with the other scenarios (Table 3), the architect's master plan generally aims to balance accessibility improvements across the city. While it does not achieve the highest system averages compared to the Existing Pedestrian Model or Expert Scenario 1, it provides targeted enhancements to specific streets such as Skolevegen and Sykehusvegen. However, the master plan does show some limitations when compared to the more focused enhancements seen in the Final Scenario. the proposed master plan works effectively to improve accessibility in critical areas, but it may not provide the same level of overall connectivity as other scenarios. This reflects a strategic approach to urban planning, where the architects plan aims to enhance specific routes while maintaining a balanced and functional urban environment. These insights into the master plan's performance underscore the need for a holistic approach to urban design that considers both localized improvements and broader accessibility goals.

This mixed-methods approach, which involves survey and expert interviews providing qualitative data, served to confirm the need for user-centered design. Information gathered from the Skarnes residents proved invaluable in understanding their daily experience of walking, preferences, and identification of places that need improvements. The photographic surveys reinforced the spatial analysis when it came to the visual documentation of the current states and areas of pedestrian needs, for example, the roundabout and the Sykehusvegen.

Survey response highlighted the areas where people feel unsafe due to poor lighting, traffic volumes, and improper pedestrian infrastructures. These perceptual barriers, though purely psychological, need to be addressed to make people feel safe while walking and improve the overall safety experience for pedestrians. Heat maps showed that people feel safe near Sykehusvegen and the central parts of Skarnes due to adequate lighting and a good view of public amenities. In contrast, the areas lacking both felt more dangerous.

7.2. Addressing Research Questions

1. To what extent is the potential of pedestrian-friendly, inclusive accessibility realized in the town of Skarnes?

According to this study, Skarnes has the potential to become a pedestrian-friendly town. For example, by developing the street profiles and introduction of proper sidewalks and pedestrian crossings. The current dominance of vehicle infrastructure poses significant challenges for walking and will require considerable changes. The study revealed several gaps, like the roundabout in front of pedestrian bridge and lack of sidewalk on Lehmanns veg, sykehusvegen and improper pedestrian infrastructure on E16, that hinder pedestrian movement. Although people generally feel safe in Skarnes, the local environment needs to become more inclusive and comfortable for pedestrians. Enhancing the pedestrian infrastructure will necessitate addressing these barriers and implementing comprehensive urban design strategies to prioritize pedestrian infrastructure.

1.a. To what extent do pedestrians perceive it to be safe to walk?

Overall, the survey results reveal that 75% respondents feel safe walking in Skarnes, particularly during the daytime. However, 31% of participants indicated that safety levels at night are compromised by poor lighting and high traffic, which makes the situation uncomfortable. To improve the overall safety perception, it is crucial to enhance pedestrian-friendly infrastructure, increase street lighting, and implement traffic calming measures. These interventions will help always create a safer and more welcoming environment for pedestrians.

1.b. What kind of spatial features are hindering pedestrian movement in Skarnes?

The research identified several features that hinder pedestrian movement in Skarnes. Key obstacles include unconnected roads, the confusing roundabout tunnel, and a lack of pedestrian infrastructure like sidewalks and zebra crossings. The pedestrian bridge and tunnel at E16 were highlighted as significant barriers, particularly for school children. These findings underscore the need for targeted interventions to improve connectivity and safety for pedestrians. Addressing these issues will be essential to enhance the pedestrian experience and ensuring that walking becomes a more viable and attractive option for residents and visitors.

2. Which spatial development strategy creates an inclusive, pedestrian-friendly built environment and adds socio-economic value to future Skarnes?

The study has emphasized the importance of stakeholder involvement in creating effective spatial solutions. Collaboration with locals, GIS specialists, and municipal planners highlighted various aspects to enhance pedestrian mobility in Skarnes. This research presents spatial strategies envisioned through expert scenarios and supported by community perspectives. Key strategies include developing a grid-like pattern for better connectivity, enhancing pedestrian infrastructure, and improving safety measures. These strategies aim to create a comprehensive Master Plan (Figure 46) for a more livable and socio-economically successful walkable future for the inhabitants of Skarnes. Active stakeholder engagement will be crucial to ensure that the proposed interventions are practical, effective, and aligned with the community's needs and aspirations.

7.3. Research Contributions

This study is thus of much importance in current knowledge about urban pedestrian mobility, as it wedges the Space Syntax Theory with community engagement qualitative data. This provides a wide perspective for analyzing and enhancing pedestrian connectivity in small towns. It is more pragmatic and applicable to Urban Planners and Designers in which practical insights and strategies for pedestrian infrastructure improvement are incorporated. It guides the policy makers and municipalities in making decisions to bring about walkable urban environments and empowers local groups with data and strategies to advocate for better pedestrian amenities. Additionally, this research contributes by providing a guideline to a robust methodology for combining spatial analysis and community feedback, which can be applied in different urban contexts.

7.4. Research Limitations

Notwithstanding the valuable insights put forward by this research, some limitations may be admitted. In relation to the survey response, the study revealed that the number of people who participated was only 48, while Skarnes has a population of 3000. Such a low rate of response brings about bias because the findings will not be able to represent the perspective and experience of the broad community. The pedestrian sensor data is inconsistent and non-homogenous for different seasons.

Another limitation of this research is the reliability of the sensor data for pedestrian count. For the summer, the only available data was for July and August, while for the fall there was data for three months and for winter, data was only recorded for December. There are also indications that the sensors may have been malfunctioning in December, so confidence in the winter pedestrian count data is low. On the other side, the research was carried out in a constrained time frame, which restricted the capacity to capture long-term trends and seasonal variations comprehensively. The short period of the study may not fully capture the dynamic nature of pedestrian movement throughout the year. Overreliance on the already installed sensor infrastructure brought with it several challenges which were attributed to malfunctions and spaces that had missing data. Alternative methods, for instance, gate count may be more appropriate for the study since they give the primary data while the sensor data used in this case was secondary. This technological shortcoming interfered with the completeness and accuracy of pedestrian movement data, particularly during the winter period.

7.5. Future Research

Future research should include continuous data collection through all four seasons in a study conducted over one year will unveil seasonal differences and trends in pedestrian movement. This way, the data is representative and comprehensive, capturing variation across the year.

More robust efforts to ensure high survey participation to cover for all varieties of people through different outreach means will ensure the study is more representative with minimal bias in responses.

Advanced sensor technologies should be considered to work hand in hand with manual gate counts for increased accuracy and consistency in pedestrian data. Inclusive accessibility for people with disabilities, the elderly, and children must be considered to provide specific barriers associated with the three groups.

Pilot projects to test the adopted spatial strategies will help in practical learning. Comparative studies in small towns will help find the best practices that can be designed for replication in Skarnes. A tool that creates digital means of community engagement and real-time feedback for further continuous data collection and resident participation.

A study of the socio-economic impacts of better pedestrian infrastructure will make a stronger case for investment. Integration of urban design sustainable principles with improvements in pedestrian infrastructure will help in creating a more livable and resilient urban setting. In particular, Space syntax analysis can relate to the socio-economic benefits. The overlay of the to-movement and through-movement analysis enhances the quality of space use, Space syntax can indicate the best land for active use. This approach demonstrates the socio-economic context of the space syntax: how better pedestrian infrastructure can drive economic activity and hence improve community vitality. Integrating the outlined analytical measures in space syntax would be significant towards a comprehensive understanding of socio-economic impacts for urban planning that is more effective, inclusive, and sustainable in Skarnes and other similar communities.

7.6. Recommendation – Master Plan

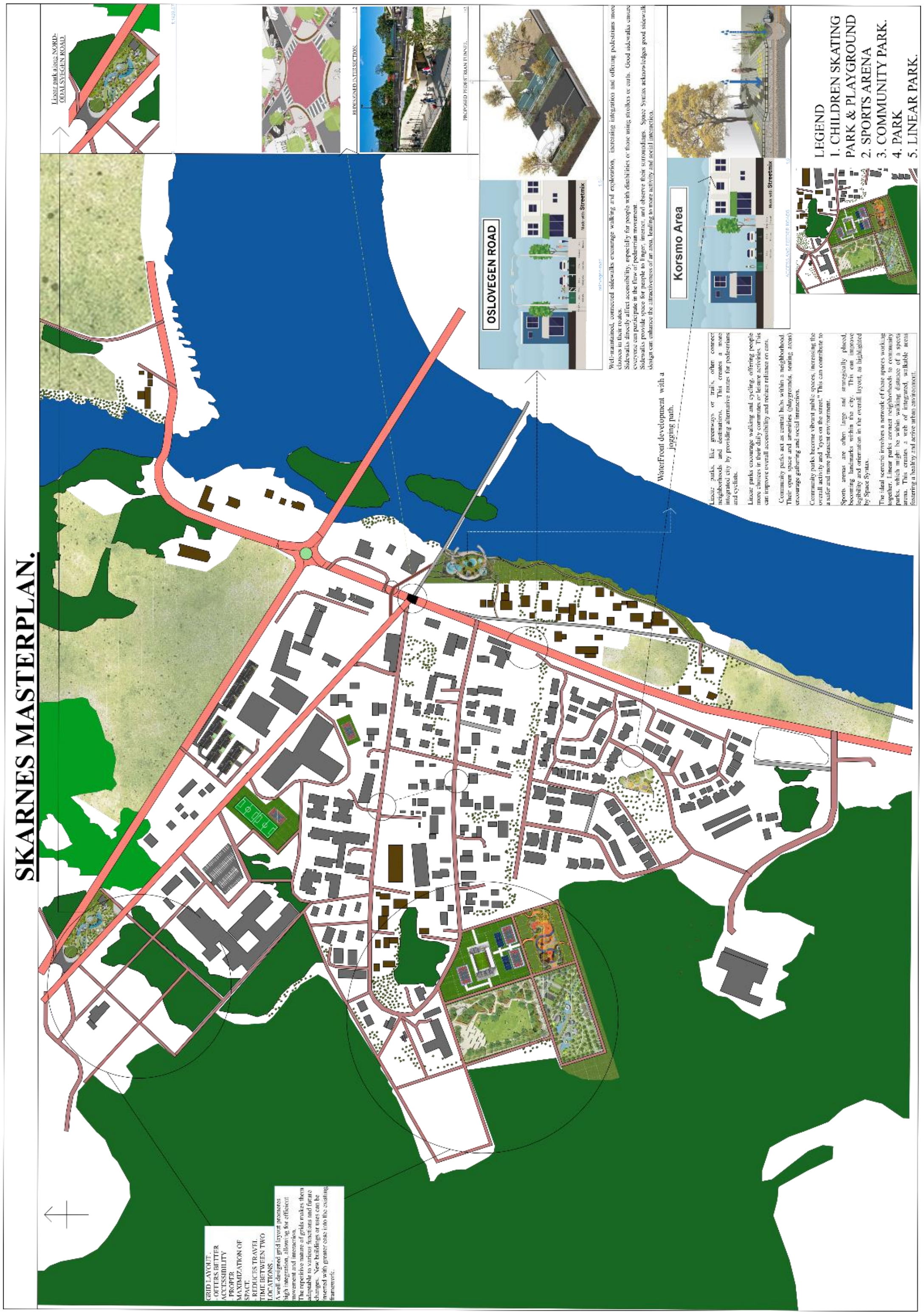


Figure 46. Master Plan, Skarnes.

Below Figure 47. Is a magnified image of the master plan (Figure 47) is the image of Grid structure into the Bøssmyra area and Graner area. Grid layout offers better accessibility, Proper maximization of space, reduce travel time between two locations. A well designed grid promotes high integration and allows for efficient movement and interaction. The repetitive nature of the grid makes them adaptable to various functions and future changes. New building and uses can be inserted with greater ease into the existing framework.

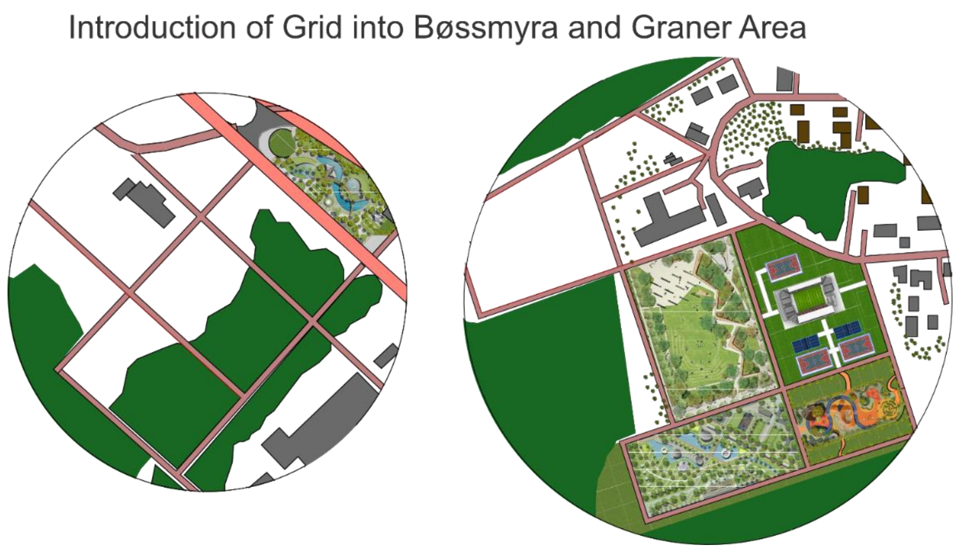


Figure 47. Grid Structure.

The magnified image from the master plan, is the image of linear park (Figure 48). Linear parks like greenways and trails often connect neighborhood and destinations. This creates a more integrated city by providing alternative routes for pedestrians and cyclists. Linear parks also encourage walking cycling. Offering people more choices in their daily commutes or leisure activities. This can improve overall accessibility and reliance on cars.

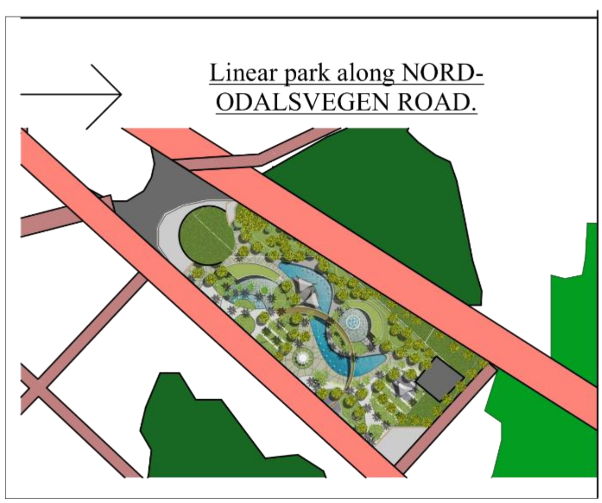


Figure 48. Introduction of Linear Park.

Below (Figure 49) is the image of the newly introduced intersection after removing the roundabout in front of the pedestrian bridge. This image is a bird view of the area. The new intersection will be expected to be favorable for pedestrians coming from Tronbøl area to Korsmo area. With signals the traffic can be controlled, and pedestrians can walk safely on the zebra crossing. This new intersection should be expected to enhance and encourage cycling and walking.

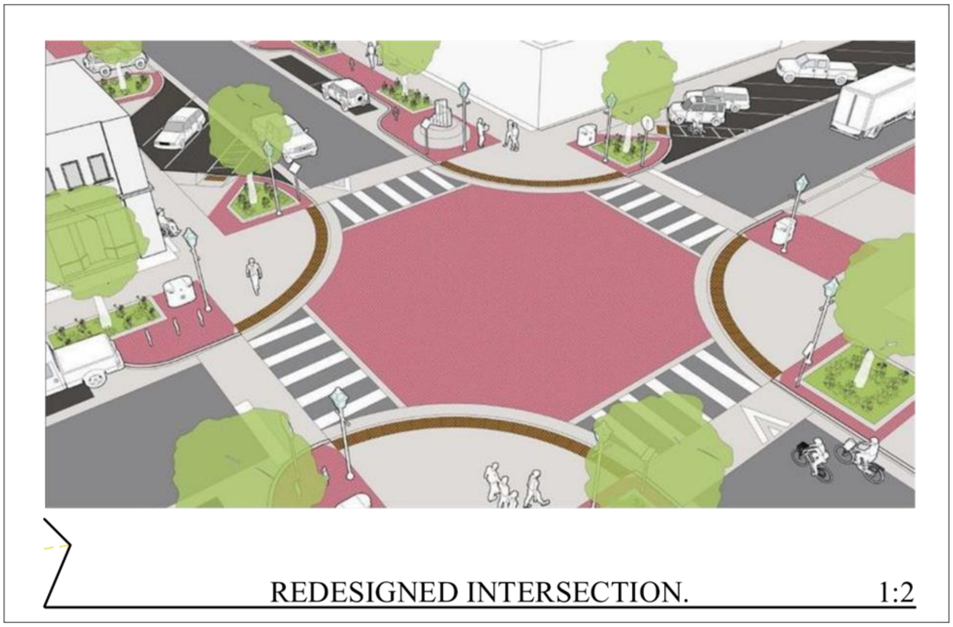


Figure 49. Intersection in front of bridge.

Figure 50. is the elevation and 3D model of street profile of the main E16 road (Oslovegen road). Well-maintained connected sidewalks encourage walking and exploration, increasing integration and offering pedestrians more choice of routes. Sidewalks directly affect accessibility, especially for people with disabilities or those using strollers or carts. Good sidewalks ensure that everyone can participate in the flow of pedestrian movement. Sidewalks provide space for people to linger, interact and observe their surroundings. Space syntax approach also acknowledges that good sidewalks designs can enhance the attractiveness of an area, leading to more activity and social interactions.

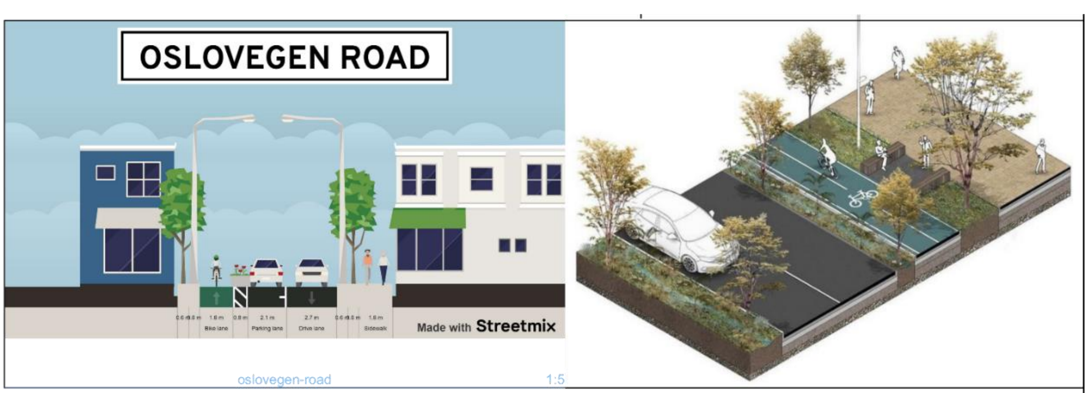


Figure 50. Street profile of Oslovegen Road.

The image (Figure 51) below shows the Graner area with the grid structure and street profiles of the streets in Korsmo area for busy roads like sykehusvegen and Lehmanns veg. There is an introduction of the community park into the Graner area . Community parks acts as central hubs within a neighborhood. Their open space and amenities (play ground, seating area) encourage gathering and social interactions. Community parks become the vibrant public spaces, increasing the overall activity and "eyes on the street." This can contribute to the safer and more pleasant environment for a small area like Korsmo. According to the peoples perspective of what they want to see in Skarnes, sports places were also highlighted in Skarnes's Future development. Keeping in mind that there is also a sports Arena. Sports Arena are often large and strategically placed, becoming landmarks within the city. This can improve legibility and orientation in the overall layout, as highlighted by space syntax.

The ideal scenario involves a network of these spaces working together. Linear parks connect neighborhood to community parks, which might be within walking distance of a sports arena. This created a web of integrated, walkable areas fostering a healthy and active urban environment.

Figure 51. Street Profile of Korsmo Area and Grid.

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8. Appendix

8.1. Appendix A

Table A1. 1 Describes Participants Demographic.

ID	Gender	Age	Role In Municipality
P1	F	41-60	Urban Planner
P2	F	41-60	Urban Planner
P3	M	31-40	GIS-Analyst
P4	M	31-40	Urban Planner
P5	M	41-60	Land Measurer

8.2. Appendix B

Semi-Structured Interview Guide.

Semi-structured interviews were conducted in the workshop on 5-03-2023. These interviews conducted in English but some of the answers I got were in Norwegian that was later on translated.

About you

What is your Gender? Age?

Where do you live?

What is your role in the Muncipality?

Questions and Answers

1. Do you find space syntax useful for the planning and design of Skarnes?

P1: «Det gir flere perspektiver enn bare mobiltet»

P2: “Yes it can be useful, but a lot more in combination with a study of the actual space”

P3: It proves what can be assumed from known planning princibles in a data driven model

P4: It gave a focus on movement and location, but also difficult to understand the theory and output in it.

2. How do you define inclusive accessibility?

P1: "Hm, do you refer to the norwegian word ""universell tilgjengelighet""? Or “inkluderende planlegging"". With both of these terms I think of (how to make) spaces available, functional and meaningful to humans within all ages and with all kinds of disabilities."

P3: Accessibility in regard to different abilities and needs when it comes to getting around freely, thus implementing a design suited for different use and user case scenarios.

P4: Everyone should have good access to public space and infrastructure, so that everyone feels included in community as well as others.

P5: Easy and safe to move around, all year, for virtually everyone.

3. Describe a little what makes these spaces inclusive.

P1: It has been suggested that the municipality can create a park here that can function as a playground, but also as an additional outdoor area for the school.

P2: "School yard would double up as both activity sone outdoor for the school and a public park with a little mixed use in which areas are connected through pass through pedestrian paths. Between e16 and the school there is a probable zone for urban recreation protected from noise and wind and open towards the south. An added urban square at the bus terminal area would link up a continuous pedestrian zone with different function them between. Parks may be located in more silent areas or as a feature along the riverside where islands could be added with raised pedestrian paths."

P3: Way is easy to remember and easy to plan.

P4: It's close to something (schools, activities), maybe areas of crossing directions.

4. Does Skarnes need one or two local centers? Why? Explain with a few sentences.

P1: Skarnes only needs one center. It is difficult to keep stores that are not grocery stores. Søsterhagen is to be a residential area.

P2: Skarnes doesn't need to center but natural border - The Glomma River splits town in to parts and this can't be changed easy. It's better to find some advantages in that.

P3: Skarnes need only one local center, but under given conditions a sort of coffee shop, lunch bar, corner shop who offers a place to would be great. This may also be a place maker for the area.

5. What do you think is important for Skarnes urban development?

P1: It is important that Skarnes develops into an attractive place. It is important to facilitate less car use.

That readability may be increased for how anyone perceives the town. That the big picture and the micro context coexist in a way tha enhance both. Pedestrians and cyclists get prioritized so that personal preferences turn towards more walking and cycling. There is also a need for reprogramming the E16 for the realities when the main road becomes a local main street with services-oriented activity locally than a road access point of fuel and road-food oriented approach. Also, there is a need for incremental improvements through prioritized growth, zoning and focus areas that establishes improvements to the overall features of the town.

P2: I think it's most important to figure out an improvement of the center of Skarnes (Stasjonsvegen, Bruvegen og gangbrua).