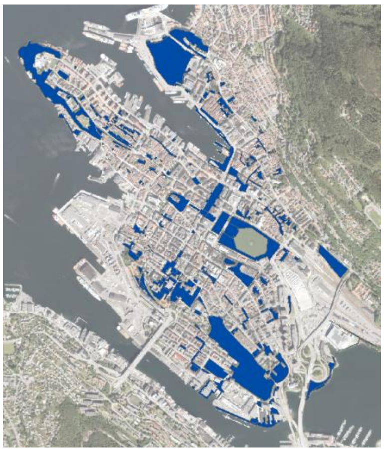
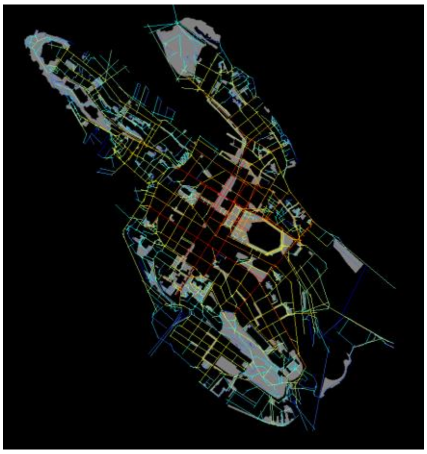
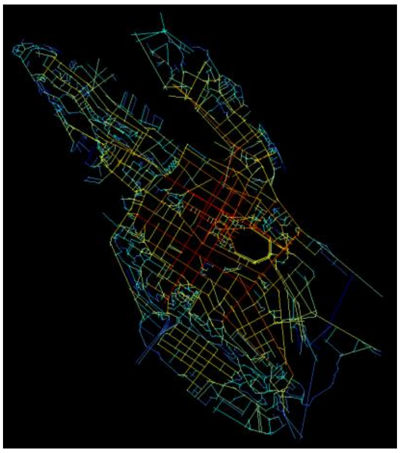
“I Need Some Space!”

Combining Digital and Traditional Methods in the Planning of Public Open Space

Kari Elida Eriksen

Department of Geography, University of Bergen

2017

"I Need Some Space" – Combining Digital and Traditional Methods in the Planning of Public Open Space

Master's thesis

Kari Elida Eriksen
Department of Geography, University of Bergen

Project carried out under the supervision of SpaceLab – Spaces of Climate and Energy Laboratory at University of Bergen

Executive Summary

This thesis explores the use of multiple methods, or triangulation, in the planning of public open space (POS). The focus is on how the Space Syntax method of *integration analysis* can be combined with other GIS methods, and the more traditional method of observation. The study uses the city of Bergen, Norway as a case, on three different scale levels, from the individual POS to the city centre as a whole.

The main objective of the study is to explore what makes a good public open space, and how planners best can combine GIS, Space Syntax and traditional methods to plan it. The study has shown that there are a number of different ways to use the methods, and a number of criteria by which one can evaluate the quality of public open spaces. The study has also shown that different types of POS should fulfil these criteria in different ways to be successful, especially on the subject of their location in highly or poorly integrated streets.

Furthermore, this study demonstrates that there is an element of scale to be considered when using Space Syntax in physical planning, where the level of detail in the axial maps should differ when working on different scales of the city. If on the right scale, integration analyses can be used to show potential flows and paths through spaces for pedestrians or motorised vehicles. If scaled incorrectly, integration analyses may display potential flows incorrectly.

The method triangulation of the thesis has found that combining integration analyses with GIS and observation may uncover inconsistencies and shortcomings in the methodologies used. Viewshed analyses showed that in areas with uneven terrain, axial lines may not correctly represent sight lines. Combining integration analyses with observation may uncover meanings and uses of spaces, verify if spaces amount to their potential, and help explain why they do or do not. This is something the digital tools can not.

The thesis further discusses these topics, and suggest ways to integrate Space Syntax with GIS and observation, for use in planning of public open spaces.

Acknowledgements

Hvis noen hadde sagt til Kari, 15 år, at hun om ti år skulle sitte og skrive en masteroppgave i geografi, om *dataprogrammer og kart*, da hadde hun ledd høyt. Høyt og lenge. Men her sitter jeg da. Med en nesten ferdig masteroppgave i geografi, om dataprogrammer og kart!

Å skrive denne masteroppgaven har både vært noe av det morsomste og noe av det mest frustrerende jeg har gjort i mitt liv. De lange timene i GIS-bunkersen på instituttet har absolutt vært noe for seg selv. Arbeidet har vært langtekkelig, men verdt det. Nå som jeg har kommet så langt er det en rekke mennesker jeg vil takke.

Først og fremst vil jeg takke mine veiledere, Gidske Leknæs Andersen og Håvard Haarstad, for å ha hentet meg inn fra de teoretiske og metodiske viddene ved mer enn én anledning. Uten dere, og uten innspillene, hjelpen og diskusjonene om hvordan man strukturerer en tverrfaglig masteroppgave, hadde det ikke vært noen tverrfaglig masteroppgave å vise til.

Jeg vil også takke alle som har hjulpet meg underveis i arbeidet. Blant dem spesielt Ben Robson som har vært min GIS-guru, og Akkelies van Nes, som har hjulpet meg med både Space Syntax og hyggelige samtaler. Alle dere på GIS-kontoret og i SpaceLab, som har bidratt med gode diskusjoner og praktisk hjelp, min informant hos Bergen Kommune, samt Jan Espen Vik som har lånt meg figur Figure 2-5. Og ikke minst Marta og Tove i SV-kantina, som har foret meg med koffein, mat og oppmuntring i fem år.

Studietiden i Bergen har vært den mest sosiale tiden i livet mitt, og en tid jeg aldri vil glemme. Det gir mange mennesker som har gitt meg motivasjon og støtte til å skrive denne oppgaven. Leiligheten i Sandviken Seniorsenter, dere er flotte. Alle naboene våre og alle som har bodd hos oss, vært på besøk og spist vafler og drukket valgfrie drikker, dere er flokken min. Alle på lesesalen som har lært meg nye språk, kastet papirfly, gjort pranks, sendt videoer på Youtube og fått meg til å le, dere har gjort dagene lysere. Og sist, men ikke minst, fortjener familien min, Tora og Vilbjørg en spesiell takk for å ha holdt ut med nerding og klaging konstant de siste to årene. Tusen takk.

Og til alle bergensere jeg har møtt som møter oppgaven min med "Åja, du jobber med offentlige rom? Vi burde legge tak over Torgalmenningen!": Jeg lover å foreslå det så fort jeg blir sjefsplanlegger i Bergen kommune.

Kari Elida, august 2017

Content

List of Tables, Images and Figures

Table of figures

Table of tables

Table of images

Appendixes

1 INTRODUCTION

Public space is, and has always been, important for inhabitants of cities. From the marketplaces of Ancient Greece and traditions of picnics in public parks and riverbanks across the world, to Occupy Wall Street and the Tahrir Square demonstrations during the Arab Spring in Egypt, 2011, public space has played a role in the life of people.

In this thesis, I will discuss the meaning and importance of the public space (or *public open space*, a term which I will get back to), and explore how analysing potential movement through street networks (so-called *integration analyses*) in GIS and other computer programs can be useful in public open space planning. The study focuses on the centre of the city of Bergen, Norway, and combines both digital accessibility analyses and the more traditional observational research to enlighten different sides of the public space.

1.1 Public Space

In Ancient Greece, the *Agora* was the space of social encounters and political discourse. It was also the marketplace, the central public space in cities and surrounded by buildings with public functions (Store Norske Leksikon, 2011). It is frequently portrayed in movies as a bustling place full of people and exchanges. But since this classical era, there have been radical changes to both society and cities. The public space of today is in many respects different from the agoras of Ancient Greece. But that does not mean it is not still important.

Today, the public space still serves the same purposes, as a space for shopping, social interaction and democratic activity. It is the space where people can, or at least should be able to, move freely and interact. As seen during for example the Tahrir Square protests in Egypt in 201, or the Occupy Wall Street movement the same year, it is also a space where people gather, demonstrate and exchange opinions. And it is a place where one can encounter other opinions than one's own, without actively seeking them out.

Defining the public space is not always easy. It can be many things, depending on who you ask. Some may say it is a physical space, indoors or outdoors, like the agora. Others would say it is the abstract space of public opinion, like the internet or the free press. And yet others would say it is a social dimension in which people act and interact (Carmona et al., 2010).

In many ways, the public space can be all of these things at once. One could say that the one definition has no meaning without the other. Would for example Tahrir square have been the breeding ground for the Arab spring if there was no social dimension to the space, and no people around to watch the protests? Would it still have been the place of one of the biggest social movements in modern history, if it were not for its place in people's consciousness and its symbolic role in the media? And would the protests have been as big and had as much impact, if they were not physically in one place, so sympathisers could join freely and create new social networks and interactions? Probably not.

The public space can take on many forms. Public buildings like libraries, streets and roads, parks, squares and marketplaces are all different public spaces. In this thesis, the focus is on outdoor public spaces, that are not roads, and that are more or less planned to have a democratic or social function (see definition used in this thesis in chapter, p. 14). These are also called *public open spaces* (POS hereafter).

The democratic function is merely one example of the prominence of public space in society. Having good public open spaces in a city has also been proven to increase walking and physical activity, drive sustainable urban growth, and increase urban dwellers' well-being (Ståhle, 2008, Taylor et al., 2011, Sallis et al., 2016). The United Nations Human Settlements Program (UN Habitat used hereafter) has recommended cities have 15-20% public open space (UN Habitat, 2014, UN Habitat, 2015). This is especially important in the face of growing urbanisation and urban population growth.

For societies to benefit from these positive effects, public open spaces have to be accessible and in use. There are a number of theories on how public spaces should look and be located in order to be used by people. Some of the most mentioned criteria for good POS are:

- Accessibility for all user groups
- Central location
- Feeling of openness
- Enough seats
- Enough people using it and passing through
- Attractions and activities in the space
- Safety

(Gehl, 1980, Lorange, 1984, Whyte, 1988a, Jacobs, 1992, van Nes & Nguyen, 2009, Carmona et al., 2010, UN Habitat, 2013).

A POS' integration in the street network is a particular aspect that has often been overlooked in the theory on the topic, and is one of the main foci for this study. A POS's location can affect its use, and it is important that people can see it and get to it easily (Whyte, 1988). This is directly affected by the configuration of the street network. Ståhle (2008) found that the number of directional changes through the street network is directly relevant for how much a green space is in use, and that POS that are well integrated in the street network are more likely to be in use than POS that are not (Ståhle, 2008, Asplan Viak & Spacescape, n.d.).

1.2 Methods for Planning and Studying Public Open Space

For city planners and politicians, protesters and regular people, the question is how to best plan these spaces and how successfully to integrate them in cities. Many cities see a continual work to improve public spaces to be functional and safe places that people want to use, which then can benefit societies in the best way.

In order to speak about the planning of public open space, it is necessary to explain the concept of planning. It is a term that is widely used in academia, with many different definitions and approaches (see e.g. Hall & Barrett, 2012). I have based my understanding of planning in this thesis on a paragraph from the UN Habitats Report on the State of the World's Cities:

«UN-Habitat's reinvigorated notion of urban planning involves sustainable use of, and equitable access to, the 'commons' through appropriate policies and schemes. It also gives any city tighter public control over the use of land, and contributes to the change in form and function of cities based on sustainable development principles. [...] urban planning can identify strategies and plan for optimal production of public goods, in the process contributing to social capital, enhancing sense of place, safety and security, integrating social groups (e.g., youth), and increasing the economic value of the areas where these goods are provided.» (UN Habitat, 2013).

To specify it further, the focus of this thesis is on how the chosen methods in this thesis can help secure people's access to good public open spaces. Accessibility to good public open spaces is seen here as a public good, as it has been shown to have positive effects for urban inhabitants (Ståhle, 2008, UN Habitat, 2013). I do not focus specifically on how different user groups (public/private planners or the public) can use the methods, but on how the methods themselves can be used in planning. The focus on sustainability and sustainable development principles is one of the base premises for the thesis, since access to public open spaces promotes walking (Sallis et al., 2016) and drive further sustainable growth (Ståhle, 2008).

There are many methods that can be used in planning public open spaces, depending on the types of POS, their uses, and what one needs to study in order to inform their planning. Some POS may require counting users to determine its level of use (Gehl & Svarre, 2013). Others may require observing or interviewing people to determine how they are used (Clifford, French & Valentine, 2010). And yet others may require use of digital and quantiative tools like geographical information systems (GIS) to analyse street networks, spatial distribution of POS or the physical condition of a POS (Herold, Couclelis & Clarke, 2003, Edwards et al., 2013).

One of the most well-used and efficient traditional, qualitative methods to study public open spaces is observation. Researchers, architects and activists like Jan Gehl, William H. Whyte, Eric Lorange and Jane Jacobs have all used observation in their research. Observation is cost-effective and flexible (Kearns, 2010), and will yield information that can complement digital analyses.

The UN Habitat has published a report named “Global Public Space Toolkit: From Global Principles to Local Policies and Practice” (UN Habitat, 2015). Here they list a number of tools (or methods) available to plan public open spaces. 5 out of 61 case studies mentioned using digital tools in the planning process. In 2 cases they were used as a means of planning, and in 3 cases for communication between planners and users and not directly for planning. This shows a general trend in the planning literature: non-digital, more traditional, methods are well covered, but there is much less literature on using digital methods in planning.

Combining traditional and digital, and qualitative and quantitative, methods in planning builds an entirely different base of knowledge than using only one or the other, and is common in in methodological research (see eg. Srivastava & Narayan, 1974, Jick, 1979, Ståhle, 2008, Lindau, 2015). Cross-reference of results from different analyses, so-called *between-method triangulation* (Jick, 1979) is perhaps the best way to properly evaluate the validity of results of different methods. Triangulation is especially important when working with public open spaces, as they have both a physical and a social dimension, and may require different methods to be adequately analysed (Carmona et al., 2010).

When triangulating methods, each method should contribute something unique to the project (Clifford, French & Valentine, 2010). Thus, using digital tools for mapping and analysis will give you information on the physical dimension of a POS, the quality and location of the space. Traditional methods like observation can then inform the study with information that the digital methods cannot provide, on the social interactions and activities happening in the POS, the POS’ meaning for people, or what kind of exchanges of opinion that happen there. And whether or not people use it the way it was intended (which they may very well not, being acting subjects with a free will), or if they even use it at all.

One type of digital method, and one of the main methods used in this thesis, is *integration analysis* within the field of Space Syntax. Space Syntax is a theory and method developed since the 1980s, based on empirical studies of cities (Hillier & Hanson, 1984). The theory is focused on the spatial form of cities, and how people and place relate to each other and shape each other. It is primarily concerned with the layout of the street network and open spaces in the city. Integration is a measure of how well-connected streets are within the street network, and how likely a street is to have human movement through it (UCL Space Syntax Glossary, 2017f).

Using integration analyses in planning, one can for example determine suitable locations for various types of public open spaces, based on the street network. In an already developed city it may sometimes be difficult to change the street layout or create new public spaces, integration analyses, in combination with other methods, may uncover potential areas for development. Furthermore, using integration analyses on zoning plans, planners have a unique potential to plan the street network according to movement and POS principles to ensure the best possible flow of people through space.

In this project, integration analyses can analyse the configuration and integration of street networks, potential flows through a space and can rate the potential movement from high to low. Integrating these in a GIS gives opportunities for cross-verifying the results through other analyses. In this case, I use a viewshed analysis in a GIS to complement. Observation and other qualitative methods like interviews can help explain why one gets the result one gets from the analyses, and explain coherences and discrepancies between results and reality, and can uncover activities, uses and relationships that may never be visible in a computer analysis. For that reason, this thesis combines the use of Space Syntax integration analyses with GIS analyses, and with direct observation of a public space.

There are many computer softwares developed based on Space Syntax, which map and run analyses on street networks and open spaces in cities. The different softwares and tools handle different information, but they all analyse varieties of connections, distances and directional changes in street networks. Space Syntax softwares and methods are increasingly being taken into use by planners and local municipalities (see e.g. Vik, 2010, Asplan Viak & Spacescape, n.d.).

The softwares and method is quantitative, in that it works with a physical and quantifiable data material. The method is well tested on street networks and within individual POS (see eg. the Trafalgar Square case showed in Carmona et al, 2010), and as local municipalities across the country are expressing interest in using this method, it is highly pertinent to test the uses of different Space Syntax analyses on different types of urban spaces. In this thesis, I therefore set out to investigate the uses of integration analyses from the field of Space Syntax on public open spaces and pedestrian movement to them.

The software I have chosen to use in this thesis is the UCL DepthmapX software, developed at the University College of London (UCL). This method and software has some shortcomings that will be discussed further in chapters (2, 3 and 5.1). I therefore integrate the analyses in a geographical information system (GIS) to further analyse them and combine them with more geographical information, and then run a GIS based viewshed analysis to complement the Space Syntax output.

1.3 Case Study: Bergen

The study area for this thesis is Bergen, Norway. Bergen is Norway's second biggest city and is located on the west coast. The city is known as «the city between the seven mountains». It is known for its topography, where the city is both built on several mountain sides and along the sea. The city centre, which is the main study area for this thesis, borders the sea on three sides and a mountain on the fourth (see Figure 1-1).

Bergen's city centre is compact and rather small compared to the size of the city. It takes approximately ten minutes to cross the most central part of the city centre by foot, and the study area as a whole can be crossed in approximately thirty minutes by foot in any direction.

The main public open space in Bergen, and also the main shopping street and economic centre is Torgalmenningen. From Torgalmenningen it is easy to reach a number of other central and well-used POS, like Bryggen, Fisketorget and Festplassen. From Festplassen there is an almost straight line to both Fløibanen and Johanneskirketrappen, and this axis (from Johanneskirken to Vågsalmenningen) is one of the main foci of this thesis (see Figure 1-1).

Looking at the configuration of the city and the street network, Bergen is a varied city. The city centre has been developed partially over centuries, and the building structures and street networks therefore vary throughout the city.

As can be seen from (Figure 1-1 and Figure 1-2), the areas of Nøstet, Klosteret, Bryggen and Vågsbunnen are populated with low wooden buildings and narrow streets. This is the oldest building development in the city centre and has existed since the 1600s, even though houses were rebuilt several times during the 18the and 19th century, due to large fires.

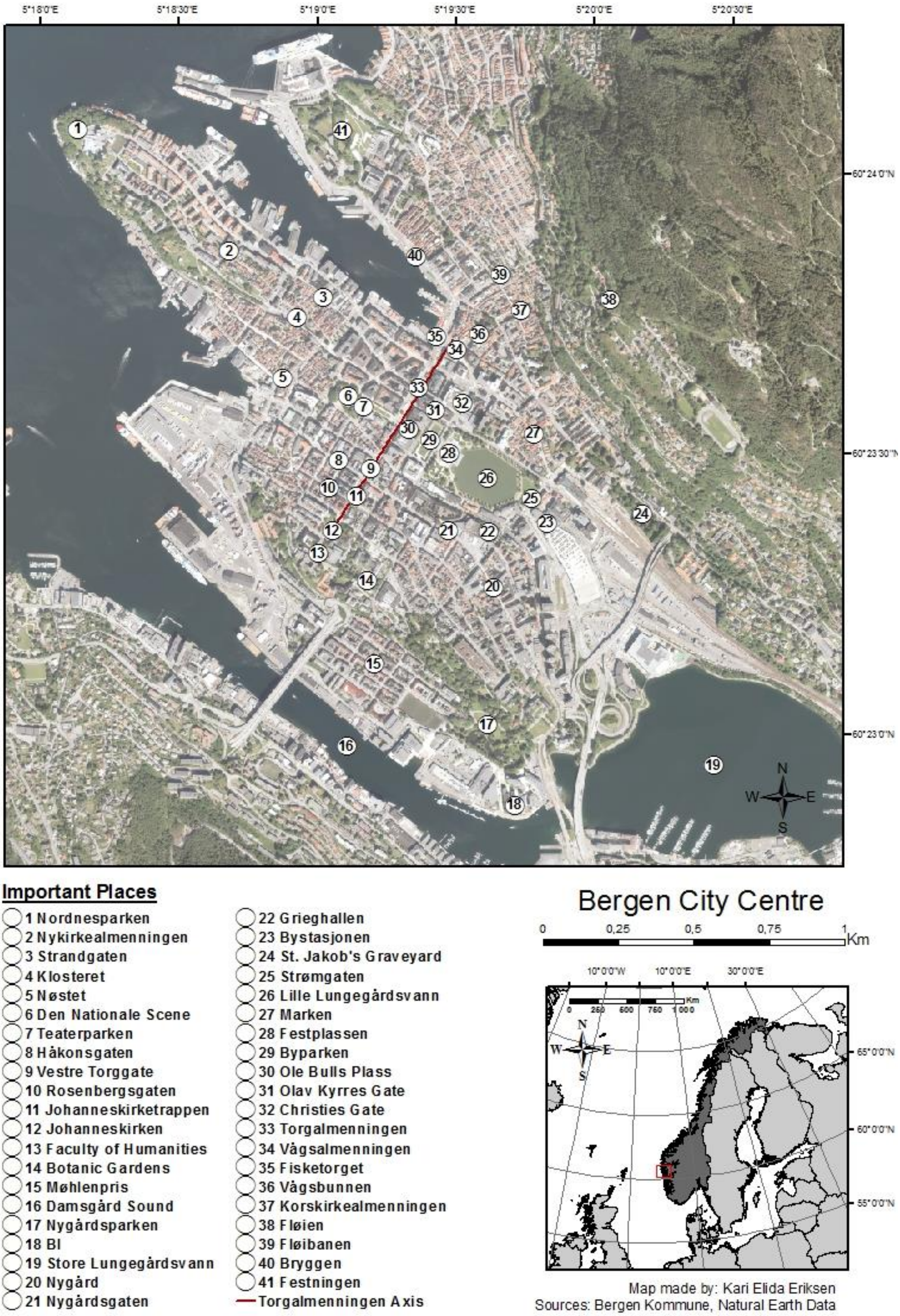


Figure 1-1: Map of Bergen, main public open spaces and main streets

On the other hand, areas like Nygård, Møhlenpris and around Torgalmenningen is newer (late 1800s and onwards), and is characterised by higher residential blocks in concrete and wider streets accessible for cars.

The street network has been continually developed since at least the 1640s, and a law passed in the middle of the 1800s to cement a grid-like street structure in the main part of the city centre. The same law demanded wide fire gates at strategic locations, because of a number of large city fires in the preceding centuries. These fire gates are called *allmenninger* today, and some of them function as large public open spaces today (Roald, 2010). Not all parts of the city centre have the grid-like structure, mostly due to them not having burnt down and been replaced with newer buildings in the 1800s (Roald, 2010). This has resulted in Bergen having a number of streets so narrow that they have to be one-way, or are even inaccessible to cars.

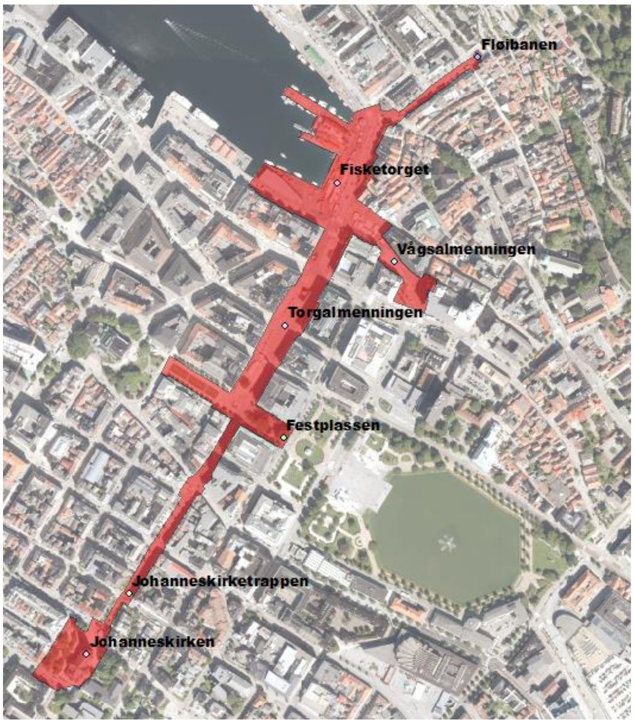


Figure 1-2: The public open space axis from Johanneskirken to Fløibanen

There are a few urban studies of Bergen, and some are focused on public open spaces (see eg. Vik, 2010, Asplan Viak & Spacescape, n.d.). One report, *Uterom i tett by*, has shown that urban dwellers in the city centre want more street-facing shop fronts on street level, a larger variety in shops, restaurants and culture, more public open spaces (and especially child friendly ones), and for it to be easier to walk and cycle in the city centre (Asplan Viak & Spacescape, n.d.). These are all considerations that the local municipality and planners should take into consideration when planning further in the city centre.

Furthermore, planners analysed integration and access to public open spaces in seven study areas in Bergen. They found a lack of public open spaces and connections between them in all study areas except for the city centre. According to the report, the city centre had a lack of POS (<5%, compared to the 15% recommended by the UN Habitat (2015)), but good connections between them (Asplan Viak & Spacescape, n.d.). However, maybe surprisingly, none of the respondents in the survey reported feeling like they have bad access to public open spaces.

The report also showed that there is a large amount of POS with «hard surfaces» in Bergen, and less POS with soft surfaces like grass or sand (Asplan Viak & Spacescape, n.d.). This could be related to the fact that Norwegian authorities demand private or semi-private outdoor space to be accessible for dwellings. In densely built neighbourhoods, local municipalities often allow this outdoor space to be partly covered by existing or new-built public open spaces (Kommuneplanens arealdel, 2010, §10).

That means many POS in Norwegian cities are planned in relation to buildings rather than in relation to key streets and nodes in a neighbourhood, and may be an explanation as to why the *Uterom I tett By* report found a lack of connections between spaces (Asplan Viak & Spacescape, n.d.).

However, contrary to the findings of the *Uterom i tett by* report, I have found that the city centre has a high number of public open spaces. Some POS types have good connections between then, some do not. The high number of POS means the city centre is a good place to test softwares for analyses of pedestrian accessibility to POS. It is also known as a city with a lot of hills, and it can therefore be interesting to use topography as a factor in the analyses, and compare results with actual use in steep areas.

The study area is studied on three scales. Firstly, I study the overall location and integration of public open spaces in the entire city centre. Then I focus more specifically on the axis from Vågsalmenningen to Johanneskirken (the *Torgalmenningen axis*) and run integration analyses on that area, and finally I combine the integration results from the Torgalmenningen axis with observing in Johanneskirketrappen, a POS at the south edge of the axis (see Figure 1-1).

1.4 Objective and Research Questions

To research this topic, I have formulated one main objective, and three research questions that will help illuminate the topic.

The main objective is to *explore what makes a good public open space, and how one can best combine digital and traditional methods to plan it, using both the field of Space Syntax and social science theories, on a case study of Bergen, Norway on three different scale levels.* The digital methods used are geographical information systems (GIS) analyses and Space Syntax integration analyses. This is because GIS is already commonly used in planning, and personal communication with planners and researchers in various cities has indicated that Space Syntax is something several local municipalities in the country is looking into using in their planning.

The research questions are:

1. How can Space Syntax integration analyses be used in the planning of public open spaces?
2. How do the results of these integration analyses compare to the actual use of public open spaces in Bergen, and why does it or does it not compare?
3. How can combining the different methods and types of knowledge in this project be a strategy in the planning of public open spaces?

The thesis is built up around these questions and seeks to answer them. It will first discuss the theoretical foundation of public space and public open space, street networks and Space Syntax, and some theory on social interaction and action. Then it will go into further detail on the methods used, the data material and discussions on these. Finally it will present the results of the accessibility analyses, and discuss them in light of findings from observation and theory. Finally, in the last section of the thesis, I will attempt to adequately answer my research questions and make some final remarks and conclusions.

2 THEORY AND BACKGROUND

What is really a public space, and how does a space become public? What criteria does a space need to fulfil to become an attractive destination for people? And how can you study the public space using quantitative, digital tools, when the people using it are free and thinking actors that may act as they please?

In this chapter I will discuss what a public space is and different criteria for its attractivity and use, what Space Syntax is and its uses, if space can condition free-willed actors' behaviours, and how one can really study the public space.

2.1 Theories on Space

The history of public spaces goes back thousands of years, to the agoras[1] of ancient Greece, the spaces of public discourse, trade and social activity (Store Norske Leksikon, 2011). Since then, public spaces have been important arenas for democracy, politics and social life, as well as integral parts of the urban layout and life in cities. To discuss what the *public open space* is, one first needs to discuss what *space* is. In academia, there are a number of approaches to understanding it. The boundaries between the different approaces are often blurred, as many are both similar and related, and there are many ways to group them. Here, I group them into quantitative and qualitative understandings.

The *quantitative understandings* of space in geography and planning are usually associated with the *spatial science theories* in the 1950s and 60s, when there was a belief that people's actions were determined by the physical environment they lived in (Holloway & Hubbard, 2001). Spatial scientists measured people's actions numerically and statistically and assumed people to be rational spatial users. Much like the well-known "economic man"-principle in economics (Malecki, 2015). Places and urban spaces were merely conceived as physical surfaces, where qualitative features were not important[2], and there was no regard for construction of meaning within space. This is also the way space is represented in a GIS (Heywood, Cornelius & Carver, 2011). Put in the words of Haggett (1990), paraphrased by Holloway and Hubbard (2001):

[1] Public spaces that doubled as places for political and social gatherings, and marketplaces (Store Norske Leksikon, 2011).

[2] An example: the statistical model of movement between an urban settlement and a recreational area made by Coppock and Duffield, 1975 (referred to in Holloway & Hubbard, 2001, p. 11).

“*In the abstract and highly stylized models developed by spatial scientists, places are, in effect, effaced, replaced by a geometrical matrix of movements, channels, hierarchies, nodes and surfaces.”* (p. 11)

The same trains of thought can be found in the *modernist* architecture from the same time, with architects like Le Corbusier planning for positive social change, and where architecture to a certain degree followed the same ideals as science: geometry, movement and linearity (Cresswell, 2013).

The structuralist view of space is slightly different from spatial science. There are many branches of structuralism, but many structuralist social theories seem to understand physical space as a result of how social structures determine people’s actions. Physical space is thus a physical manifestation of social structures, and will by its physical form, structure people’s movement and actions within it (Lévi-Strauss, 1967, Hillier & Hanson, 1984, Cresswell, 2013). Every society has its own, distinct structures, meaning that every society has different-looking spaces and practices within them. However, space is also a physical structure in itself, and may to a certain degree affect how people move and act in space (Hillier & Hanson, 1984, Cresswell, 2010).

The more *qualitative understanding* of space can be found in for example humanistic geography, post-modernist and post-structuralist theories, and focus more on people’s relation to and in space, and space as meaning.

Humanistic geographers in the 1970s focused on people’s relationship with spaces, and how their experiences of and in them made them prominent in people’s minds as *places* rather than *spaces*, and how people use them to constitute their own identities (Relph, 1974, in Carmona et al, 2010, Holloway & Hubbard, 2001). These understandings are more preoccupied with the different meanings of space.

In post-modernist theories, theories on space are often focused on and experiment with elements of its social dimension, such as commodification, production and its politicisation., rather than its physical structure. In architecture and design, one has moved away from the modernist ideas of using space to create social change, but rather experimented with form and structure (Cresswell, 2013).

Extending from post-modernism, there are *post-structuralist* scholars arguing that the concept of space includes the relations that create it and is thus a relational entity. Space is more than just its physical layout, it is also a set of relations and cultural structures, and has an inherent social dimension, that can be continually reproduced and changed. The layout of spaces often differ between cultures because of different social and cultural relations to and in spaces. This is to a certain degree similar to the view of space found in structuralist theories (Hillier & Hanson, 1984, Murdoch, 2005). The difference between the two seems to be that structuralist theories place a larger emphasis on space's ability to *determine* people's actions, where post-structuralist theories might point to space's potential to *impact* people's actions, but not determine them (an example can be found in chapter 2.6).

However, there is also a certain middle ground that combines the qualitative and quantitative views. One example is *Space Syntax* theory, that encompasses elements from many of these theories, such as a (partial) reduction of space to "geometrical matrixes of movement" and spatial relationships, the humanistic notion that people interact with space and the post-structuralist idea that space is relational and the urban layout is relationally and culturally contingent (Hillier & Hanson, 1984). The Space Syntax notion of urban space is that it is a system, much like a language[3], that consists of a network of streets and open spaces, framed by buildings and private spaces (Ståhle, 2008, van Nes, 2014). In "The Social Logic of Space", they argue that it does not make sense to divide the physical and social aspect of the city, as society has an inherent spatiality, and space has a social dimension. Space Syntax has thus become a way to understand "the social content of spatial patterning and the spatial content of social patterning" (p. x-ix).

Much like many structuralist theories, Space Syntax sees space as shaped by inherent social structures, that results in different societies' cities taking on different spatial forms. In Space Syntax theory, society and space are mutually dependent on each other, and neither exists independently of the other. Since the theory has similarities with many other theories in social science, it can be used in conjunction with a large variety of theories from different theories, and can be combined with a variety different understandings of space.

Drawing on these understandings of space, Carmona et al. (2010) use the concept of the *public realm*, and its interdependent physical and social dimensions, to develop theory on what the *public space* is. In their framework, the public space has a *physical dimension*, which is the collection of physical spaces, such as public buildings, streets and town squares, that facilitate

[3] From where I assume it has also copied the notion of "syntax" as the coherence between entities in the system (Hillier & Hanson, 1984, ch. 1)

social interaction and public life (see also Taylor et al., 2011; Edwards et al., 2013, Gehl & Svarre, 2013). At the same time, it has a *social dimension*, which encompasses all the social relations and democratic activity that happens in the physical space (see also Habermas, 1962, and Bannerjee, 2001, both referred to in Carmona et al., 2010, Holm, 2006, Cresswell, 2013, Gehl & Svarre, 2013).

The physical dimension can, according to Carmona et al., be divided into two types: *movement spaces* and *social spaces*. *Movement spaces* are public spaces such as roads, pavements and other public spaces that has considerable human movement through it. *Social spaces* are public spaces that provide opportunities for interactions and exchanges of an economic, social or cultural character, such as town squares and parks (Carmona et al., 2010). Social spaces are important in a city, to stimulate social interaction between inhabitants and facilitate social life, and it is this type of space that is referred to as *public open space h*ereafter[4].

A *public open space* (POS) is more, however. The definition used in this thesis is that it is an open, public space that functions as a social space (or was planned with an intention of being one). It is outdoors, open, and has no or very few barriers for access for the public. It is free of charge to use, and has no or very limited motorised vehicle traffic (because that would make it primarily a movement space). It is a space primarily for pedestrians and cyclists. It may be located on either private or public land, as long as it gives the impression of being a publically accessible social space (definition based on e.g. Ståhle, 2008, Edwards et al., 2013, Low & Smith, 2013, UN Habitat, 2013, Bodnar, 2015).

2.2 Space Syntax and Public Open Spaces

Space Syntax is both a theory and a method, concerned with analysing the structure and configuration of space and how it affects human movement (van Nes, 2014). Like already mentioned, it has a particular way of understanding and representing public open spaces. It operates within Carmona et al.'s physical dimension of space, and represents space as geometric figures. It is based on an assumption that urban space consists of a network of streets and open spaces, framed by buildings and private spaces (Batty 2008, referred to in Ståhle, 2008, van Nes, 2014). Space Syntax analyses supposes that the terrain is completely flat, and that axial (sight) lines will be the same regardless of a person's height above the ground.

[4] When speaking of the system of all open, public spaces, including both movement and social spaces, I will use the term *public space*.

The Space Syntax method is based on analysing relations between streets in the urban environment and how it affects and is affected by human movement. Space Syntax analyses include a number of different spatial analyses called *accessibility analyses* (see chapter 2.3). In this thesis, the main focus is on *integration* analyses, which are performed on axial lines.

Integration is in the Space Syntax field defined as *"[…] a normalised measure of distance from any a space of origin to all others in a system* […] it calculates how close the origin space is to all other spaces" (UCL Space Syntax Glossary, 2017f). It is a measure on how well-connected a street is, analysing how connected a street is to all other streets in the street network. The integration value of a street says something about how likely the street is to have human movement through it, i.e. its *potential movement*.

In Space Syntax, one represents open space in two ways: as one-dimensional lines and as two-dimensional open spaces. Any open space in the city can be represented as a series of *axial lines or convex spaces*, which are two types of geometric shapes used to represent physical space (Ståhle, 2008, UCL Space Syntax, 2017, Asplan Viak & Spacescape, n.d.).

A network of open spaces in a city, or a street network, will usually be made up of a seies of convex spaces. A *convex space* is a space where all parts of the space are intervisible and can be seen from every other part of the space. Every segment of the street that is completely intervisible is one convex space, and an adjoining POS or another street segment is another convex space (UCL Space Syntax Glossary, 2017c).

An *axial line* is a one-dimensional straight-line representation of streets, or movement spaces. The axial line is "*the longest line that can be drawn through an arbitrary point in the spatial configuration*" (Turner, Penn & Hillier, 2005, p. 426). Easier said, the axial line is the longest possible line of sight through an open space in the street network, and thus the longest straight line one can follow through a street. Two people standing on opposite ends of an axial line should be able to see each other (Hillier, 2007, Baran, Rodriguez & Khatta, 2008). A map where all streets and open spaces are represented as axial lines is called an *axial map*.

In an axial map, all axial lines must be connected to at least one other axial line, in the same way all streets in a street map is connected to at least one other street. This connection is called an *axial link*, and the directional change between two axial lines is called an *axial step*.

2.3 Street Networks and Accessibility

A street network (or *open space system*, as it is called in Ståhle, 2008) is the network of *movement spaces* that traverse a city. Street networks can have different configurations, from a linear grid structure found in cities like Barcelona, to a twisting tree-type structure typically found in suburban residential areas, or something in between (Carmona et al., 2010). The configuration of the street network inherently affects movement through cities, both by leading traffic onto certain paths, and by affecting the localisation of economic activity (Ståhle, 2008, van Nes, 2014).

There are many ways of analysing *distance* in a street network. They are based on different measures of distance and what methods are available for analysis. Space Syntax uses three types of distance: *straight-line*, *topological/walking* and *axial line step distance* (Ståhle, 2008). All of these can be analysed metrically (counting the metrical distance between features) and topologically (using the relationship between features).

Figure 2-1 illustrates the difference between topological and metrical analysis in a large street network, and its configuration affects the potential distances travelled using these two distance measures. In all these illustrations, the thick black line is the starting point. The *radius* value (R=2 or R=3) refers to units of measurements. In topological analyses, this refers to number of turns in the network. In metrical analyses, it refers to a defined unit of measurement, for example meters.

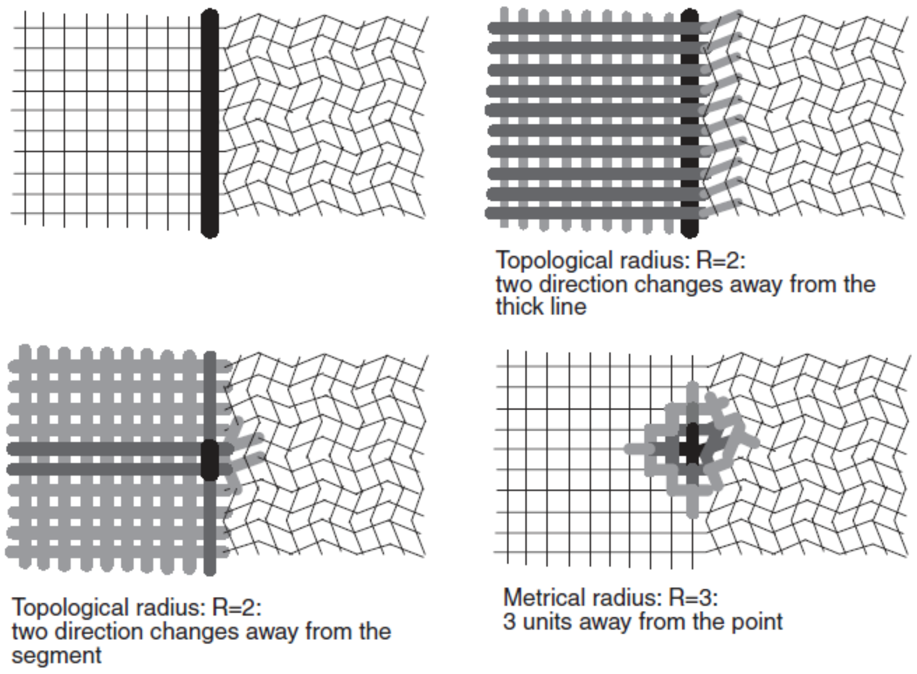


Figure 2-1: Distance (here "radius" or "R") measured as topological and metrical distance in different street networks. All images have a linear street network to the left of the black centreline and a non-linear street network to the right. The dark grey lines represent R=1 (one turn/unit of measurement), the light gray lines represent R=2 and R=3 (2 and 3 turns/units of measurement). Figure from van Nes, 2014, p. 245.

The figure shows that using a topological radius in a linear grid street network (left in the images in Figure 2-1) allows a person to move further than in a non-linear street network. Using metrical radius will get you equally far in both cases. This shows that there can be a discrepancy between topological distance and actual distance a person would have to move, depending on the configuration of the street network (Ratti, 2003, Oh & Jeong, 2007).

There three types of distance used in Space Syntax (Ståhle, 2008):

Straight-line distance is a simple Euclidean distance, or air line distance between two points. It is often used in buffer analysis in GIS and metric distance analysis in the DepthmapX software. It is not affected by the configuration of the street network, and it does not account for people's behaviour or cognition. (Ståhle, 2008) (see image A in Figure 2-1). Straight-line distance is usually measured metrically.

Walking distance is based on topology. *Topology* is the geometric relationship and connectivity between objects (Heywood, Cornelius and Carver, 2011). A street network is a good example of topology, as the network of streets is what connects and creates a spatial relationship between buildings and locations. Topological (or walking) distance is thus the distance a person would have to move in the street network, following the network's paths and turns (Ståhle, 2008) (see image B in Figure 2-3). In a GIS this can be measured by using network datasets. Walking distance can be measured both metrically and topologically.

Axial line step distance is a distance measure that is unique to Space Syntax, based on directional changes along axial lines in axial maps (Ståhle, 2008, see also chapter 2.2). Axial line step distance is the number of times one changes axial line directions, and is a topological measure of distance. Each directional change creates a new axial line. Space Syntax theory assumes that people usually choose the path with the fewest number of axial line changes. This is not something commonly done in a GIS, but is the foundation for all axial analyses in The DepthmapX software (see image C in Figure 2-3). Axial line step distance is usually topological, but one can also analyse it metrically.

Looking at this on a larger scale, one can compare the three types of distance (air line, walking, axial). Oh and Jeong (2007), demonstrate that there are potentially very big differences in results when using straight-line distance and walking distance. Different configurations of the street network affect how big a difference there is between distances measured in air line, topology and axial line steps. A linear grid configuration will often yield different results than a less structured grid.

Figure 2-3 illustrates the difference, with a POS (in grey, marked with a red dot) located in the backyard of a building (marked with a red dot) in the Klosteret neighbourhood (see location of area in Figure 1-1). This demonstrates that public open space can be close to a building in straight-line distance (see A), but be difficult to access through the pedestrian network, because of the configuration of the street network or obstacles like other buildings (see images B & C).

In the same way, the number of axial line changes required to reach a POS can be high, meaning the space is less likely to be used than if the number of steps were lower. Like showed in images C and D, this is dependent on its location in relation to the street network.

If the block in Figure 2-3 had a linear street grid instead, the gray POS would most likely be placed on the other side of the block, adjacent to the main street (instead of in a backyard), and substantially fewer meters and axial line changes would be necessary to reach it (see D). This is because it is easier to reach, and it is visible to everyone moving past on a main street, than a POS placed in a backyard (Whyte, 1988a). There would also be a shorter metric distance to travel from the building to the POS than it is today.

Relating that to Figure 2-2, a person living in the building where these analyses originate would be more likely to use the bench in the public open space across the street (following the black line in Figure 2-2) than the one in their backyard (red/blue lines). This is because it is closer, both in air line distance (52m), topological distance (also 52m, no turns) and axial line step distance (one axial step). It also has the advantage of being visible from the doorstep and possibly windows, and therefore exists in this hypothetical person's consciousness.

However, it is not always that simple. Ratti (2003) also has a discussion of how far people are willing to travel in metric distance, and still be within a set number of axial line changes. In the example of New York, a city with extremely long, straight streets and a grid-like street structure, measuring distance in walking/topological distance or axial line changes may not be useful.

If one is to measure the distance between Washington Square Park and Marcus Gavey Park in Manhattan, one will find that no axial line changes are necessary (as the parks are located on each end of an axial line). This means the topological and straight-line distances are the same. According to Google Maps, the walking distance between the two parks is approximately 9km, which would take almost two hours to walk by foot. Even though 5th Avenue would be represented by one single axial line in integration analyses, and probably have a high integration value due to the high number of crossing streets, one can safely assume that very few pedestrians would walk between the two parks (see Ratti, 2003).

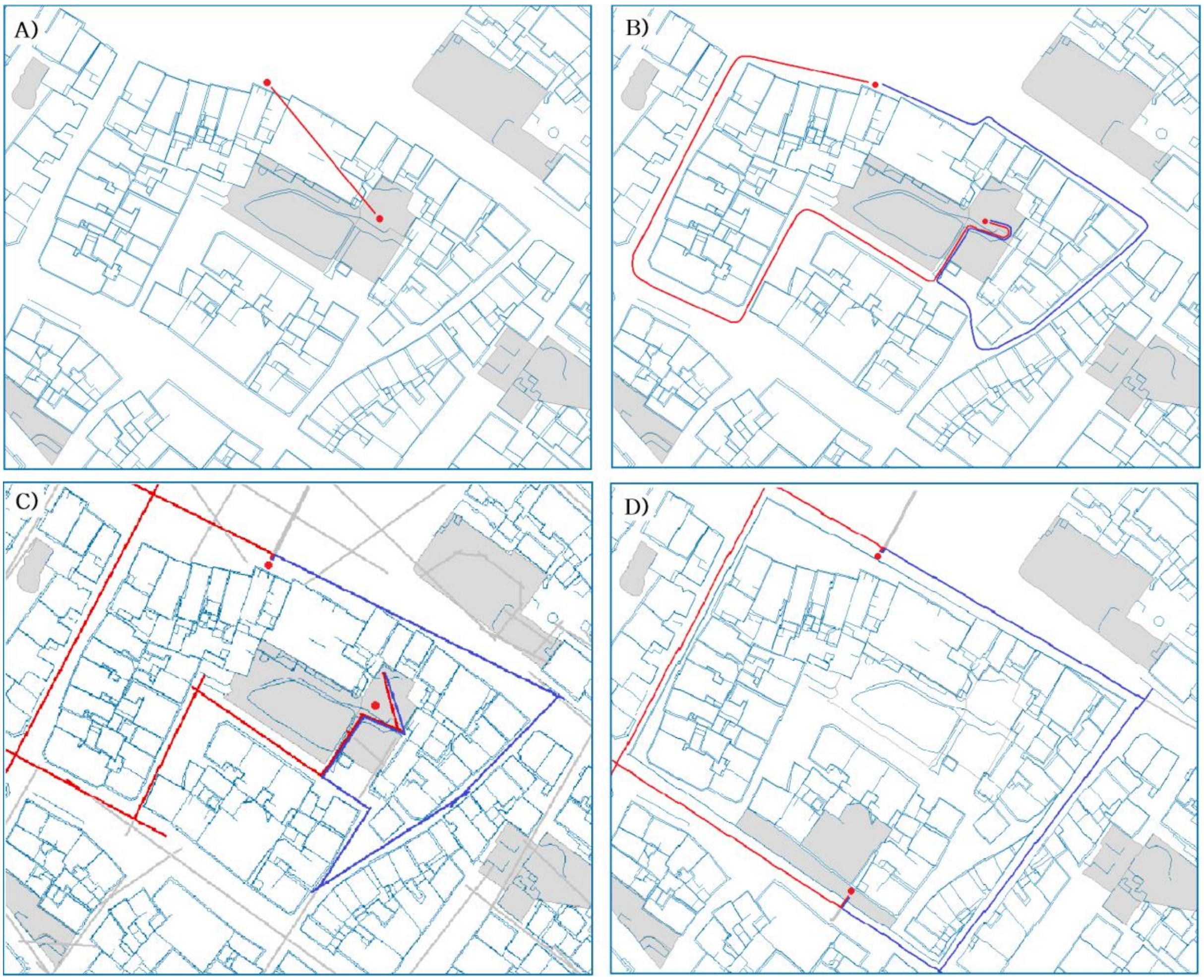


Figure 2-3: Distance from a front door (red dot) to a bench in a POS (red dot in grey field) measured with three types of measurements.
*(**A**) Airline distance, 52m. (**B**) Walking distance, 256m (red) or 213m (blue). (**C**) Axial line distance. 9 axial line changes (red), or 8 axial line changes (blue). (**D**) Axial line distance if street network was linear and POS placed by the street. 5 axial line changes from entrance to bench in both directions, or 189m (red)/242m (blue).*

These examples demonstrate what is known as *accessibility*. The space across the street is more *accessible* for the person in the marked building than the space behind their house. Accessibility is defined by the Oxford English Dictionary online as "the quality of being able to be reached or entered" (Oxford English Dictionary Online, n.d.), and is here defined as the ease with which people can access a street or public open space.

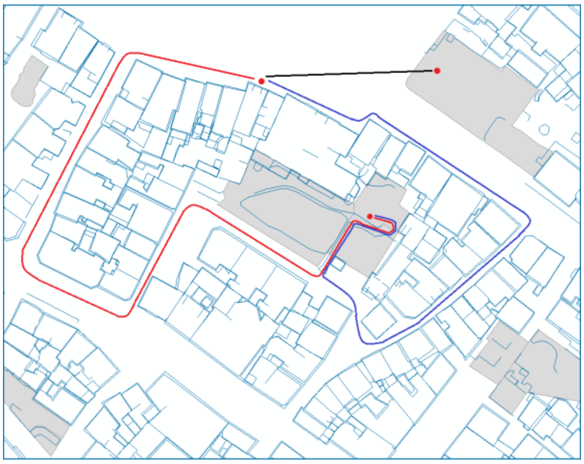


Figure 2-2: Distance to the space across the street (black line). 52m airline and topological distance, no turns, one axial step.

In Space Syntax, *accessibility analyses* are different ways of analysing the street network of a city, with regards to how streets are connected to each other. The geometric representations of space in Space Syntax are tied to different types of accessibility analyses, where *integration* is the the most commonly used. Integration analyses have been shown to correlate well with real-life data on what streets are most and least used (van Nes, 2014).

Well-integrated streets have a number of social advantages, and poorly integrated streets have a number of disadvantages. A well-integrated street will usually have both more people and more businesses than a less well-integrated street. This is a mutual relationship where people attract shops and shops in turn attract people. It will also have an equal distribution of male and female travellers, and be more in use generally (Whyte, 1988a, van Nes & Nguyen, 2009, Carmona et al., 2010, van Nes, 2014).

A poorly integrated street tends to be more at risk of burglary, crime and social segregation, and will more often have an overweight of male travellers. This last point can be due to safety, or perceived safety (van Nes, 2014).

In the same way, a POS that is well-integrated in itself or is located within accessible distance from a well-integrated street is more likely to be in use than a less well-integrated POS. The accessibility and integration also affect the kind and density of activities that happen there (Whyte, 1988a, Hillier, 2007, Ståhle, 2008, Carmona et al., 2010, van Nes, 2014). High integration means good accessibility, which usually means more use of a street or space. Integration is therefore an important and useful measure for examining the spatial configuration and social spaces of a city.

However, like the example of Manhattan shows, a location may be deemed accessible within one measure of distance (for example axial step distance), but not another (metric distance). One can assume that how far people are willing to travel to a location depends on many factors, for example the attraction at the location, the time they have available and what means of transportation they are using.

2.4 Integration Analyses

What Space Syntax attempts to analyse with axial lines is a person's cognitive environment, and how the configuration of the street network affects people's movement through cities (Hillier & Hanson, 1984, Hillier, 2007, Carmona et al., 2010). There is an inherent idea that people are most likely to follow straight lines when moving though cities, and are more likely to use streets that are connected to many other, than streets that are segregated. This is to a certain degree true, where some studies have shown a positive correlation between high integration and walking trips for necessary reasons (going to work, shopping, or the likes), but not for leisure walking (Baran, Rodriguez & Khatta, 2008).

Integration analyses are run on *axial maps*. Axial maps can take on different forms. In this sub-chapter I will elaborate on the two types of axial maps that exist (*all-line* and *fewest-line* maps) and how they are used as a basis for integration analyses.

The *all-line map* is in essence a map where open spaces in a street network are covered by all possible sight lines, on every side of every physical feature (Turner, Penn & Hillier, 2005, Batty & Rana, 2003) (see Figure 2-4c). Hillier (2007) call all-line maps *visibility* maps, as they in essence show all the possible sight lines in an open space. The number of axial lines in an all-line map is in theory infinite, although softwares rarely can handle that amount of information and therefore calculate a manageable subset of the number of lines, and run analyses with that (Turner, Penn & Hillier, 2005).

The *fewest-line map* is the map with the least number of axial lines needed to cover and connect all the open spaces in a study area (Figure 2-4b) (Hillier & Hanson, 1984, Turner, Penn & Hillier, 2005). It is thus the simpler version of the all-line map. Put in the words of Hillier (2007, p. 271): "*[…] it is clear that, by definition, axial maps are subsets of the lines that make up the 'all-line' visibility map*". It is also the map that is referred to as the *axial map* in this thesis.

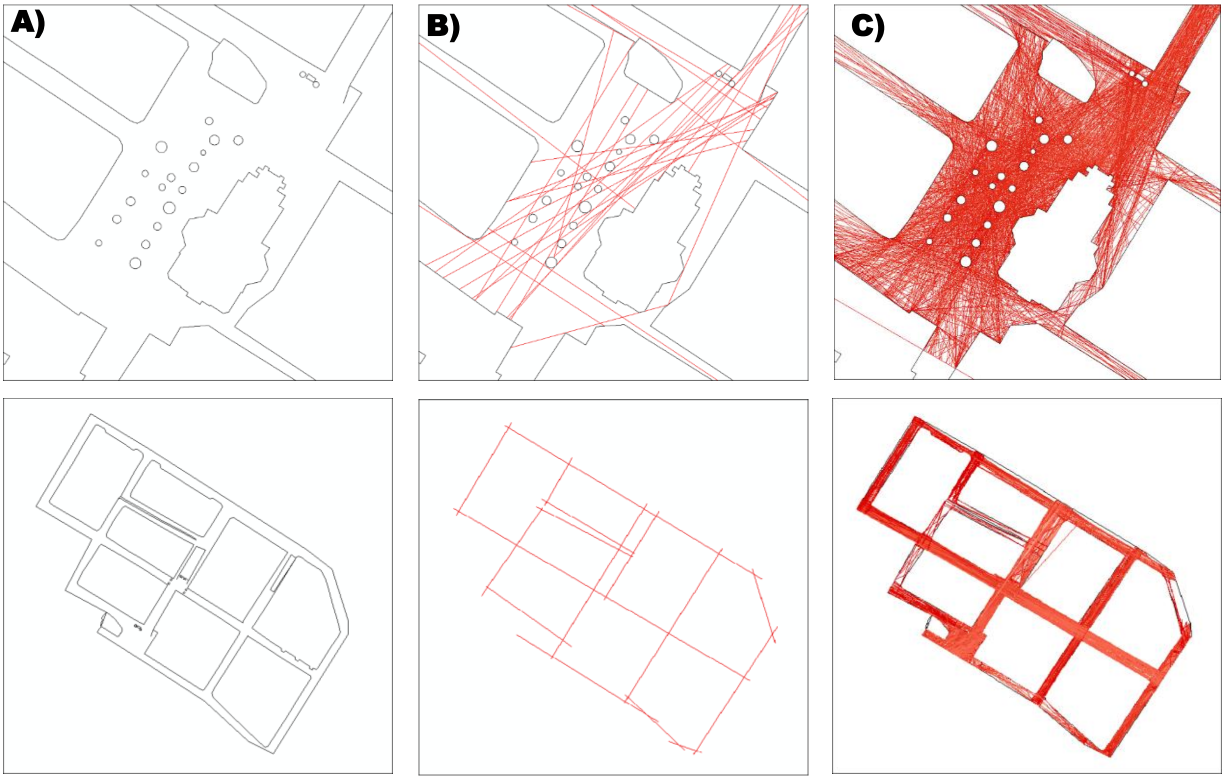


*Figure 2-4: Open space system (**A**), axial map (**B**) and all-line map (**C**). The circles in the top row images represent trees.*

To make it, an algorithm in the chosen software takes an all-line map, removes lines that duplicate the axial links[5] of another, longer axial line, until only the minimal number of lines needed to cover a system remains. To eliminate lines, the programs keep every line that is connected to a line that its neighbouring lines is not, and delete the rest. Then, if two or more lines are connected to the same lines, the algorithm removes the shortest of these and keeps the longest.

It is important that all axial links are made and that all convex spaces are covered by at least one axial line (Turner, Penn & Hillier, 2005). If one draws the fewest-line map by hand (which is the usual practice, as most computers have trouble reducing this amount of information) one should follow the same drawing rules, but one does not have to draw the all-line map first. One can draw the axial map directly. Studies have shown that hand-drawn and computer calculated maps are near identical (Turner, Penn & Hillier, 2005).

The *integration analysis* (see definition in chapter 2.2) is the axial accessibility analysis used in this thesis. A reason for that is that integration is one of the accessibility analyses that is the most well-knows, and can easily be combined with social science theories on public space. Integration analyses are run on axial maps.

Integration is a way of calculating how well-connected a street is to all other streets in the street network. It can be *global* or *local*. Global integration measures the integration of every street in the system to every other street in the system, and is usually related to car-based traffic. Local integration measures the integration of every street within a pre-determined number of axial line changes, and will usually display local centres and potential pedestrian movement in a neighbourhood (Penn, Hillier, Banister & Xu, 1998, Hillier et al., 1998, referred to in van Nes, 2014, Ratti, 2004). According to Akkelies van Nes, professor at the Bergen University College, one usually uses a radius of 3 axial line changes as the catchment for local integration in European cities (personal communication in lecture, 09.09.16).

I will not go into detail on how integration is calculated in this thesis, but it is based on the concept of *depth* in a street network. *Depth* is the number of axial steps from a street to other streets, and occurs when one will have to move through several convex spaces to get from one place to another (UCL Space Syntax Glossary, 2017d).

[5] *Axial links* are the connections or crossing of axial lines. See Turner, Penn & Hillier, 2005 for further explanation.

Every street in the network has its own depth, called *step depth*. That is the number of axial steps from the selected street to every other street (van Nes, 2014, UCL Space Syntax Glossary, 2017h). A long street will usually have a lower step depth than a shorter street, as it usually has more connecting streets and fewer axial line changes are necessary to get to any given point in the network. This is the same for integration values, where a well-integrated street has a lower step depth than a poorly integrated street, meaning it is easier to get to from any given point.

To calculate integration for the street network, one calculates the average step depth for every street and then normalises the result based on the number of streets in the network as a whole, using several different calculations[6]. Streets are then classified into one of ten classes ranging from high to low integration, using an equal interval classification. The range of values and their classification depends on the number of streets in the network. A street with a step depth of 15 in a small street network and a street with a step depth of 345 in a larger network can both be in the highest integration class, even if their step depth is fundamentally unlike. This is because integration is a measure that will always be relative to the street network it is run on.

There are also some considerations to make when using integration analyses. Like already mentioned, long streets will often be more highly integrated than shorter streets. When using global integration, and especially on small-sized datasets, central streets in the dataset are more likely to be highly integrated than streets on the edges of the dataset. This is called the *edge effect*, and occurs because streets on the edges of the dataset are not connected to as many streets as the ones in the centre (UCL Space Syntax Glossary, 2017e). The edge effect can occur naturally because of *natural edges* (like the sea, which is the case on three sides of the axial map of Bergen), or because of *artificial edges* (where one has chosen to end the study area, which is the case on the north-east side of the axial map of Bergen).

2.5 What Is a Good Public Open Space?

Not all public open spaces work well as social spaces. There have been conducted numerous studies on public open spaces and what makes them successful. Much of the literature points to the same criteria, which I have grouped into five main categories: location, shape and size, design, attractivity and attractions, and safety (Gehl, 1980, Lorange, 1984, Whyte, 1988a, van Nes & Nguyen, 2009, Carmona et al., 2010).

[6] For an explanation, see Turner, Penn & Hillier, 2005 or van Nes, 2014.

2.5.1 Location

The location has to do with how and where the space is located. A good public open space should have an overlap with, or close proximity to, a movement space (Whyte, 1988a, Carmona et al., 2010). In other words, a good POS should be located on or near a street, and preferably in a central location such as a main street, which usually have high integration. It should be accessible. This is because the social dimension of a POS is dependent on people actually being in the space to perform social activities (Whyte, 1988a, Ståhle, 2008, Carmona et al, 2010, van Nes, 2014).

A POS should also be *visible*, meaning that people should be able to see it. This means it should be located where it can be seen, and not be too closed off by fences and hedges. For example, in flat terrain, a POS should be located on street level, or no more than approximately one metre above or below. If they are too elevated or sunk, people don't notice them: "*Sight lines are important. If people don't see a space, they will not use it*" (Whyte, 1988a, p. 128-129).

2.5.2 Shape and Size

The perception of *shape and size* of an open space is defined by its spatial boundaries. Lorange (1984) discusses how the ground ("floor"), the the facades of adjacent buildings ("walls") and the sky ("roof") affects people's perception of width, length and height of a space, and how the combination of these elements affects people's experience of the space as a whole (Lorange, 1984, Carmona et al., 2010). But what is the ideal relationship between these elements?

Much literature suggests that a 3:1 or 6:1 relationship between floor width and building height is ideal. 3:1 for enclosed spaces, and 6:1 for very open spaces, where the floor space is 3 or 6 times the height of adjacent buildings. (see Asplan Viak & Spacescape, n.d.). One has often thought that people avoid long, narrow spaces, but Whyte (1988) found that people were as likely to use open squares as they were to use long, narrow spaces. The shape of the space was less important than the other factors mentioned here.

2.5.3 Design

There are several design features that can elevate the attractivity of a public open space, but aesthetics is not the most important. The most important ones are openness, sun and light, shielding from the weather, seating and sound.

A good public open space should have few physical or visual barriers towards the street, and should *invite people in* (Whyte, 1988a). It should also have logical and intuitive paths running through it, that allow people to move through the space rather than around it (Hillier, 1996). It should have adequate amounts of *sun and light*, which is affected by the width-height relationship of the space mentioned above, and the size and shape of the roof in particular (Lorange, 1984, Gehl Architects, [no date, b]).

Shielding the POS from the weather is especially important in northern countries. People in Nordic countries are more likely to sit down in direct sunlight and in places that are somewhat shielded from wind and rain (by for example niches or overbuilds), than people at lower latitudes (Whyte, 1988a, Gehl & Svarre, 2013, Asplan Viak & Spacescape, n.d.). This is probably because of low temperatures in the north, where wind chill or shadow can make a space cold and unfriendly. At lower latitudes, people are more likely to seek sitting in the shadow.

Adequate *seating* is one of the most important resons why people use a public open space (Whyte, 1988a, Whyte, 1988b). The ideal amount of seats is approximately ten percent of the space's floor area. Chairs or movable benches is preferred to fixed seating, as it allows people to create a social distance between themselves and other groups of people. People are as likely to sit on edges and ledges (of a 30cm to 1m height) as they are on benches, and people will very often sit on steps of stairs, as they offer seating variations and the possibility of social distance (Whyte, 1988a). People are also more likely to sit down where pedestrian flow directly crosses seating options (Whyte, 1988a).

Water is a good design option, in that it masks the sounds of traffic and other people's conversations and allows for private conversations and a certain social distance. It can also be an attraction in itself, if it is in such a form that people can use it to dip their feet or play on (Whyte, 1988a).

2.5.4 Activity and Attractions

Equally important as the physical layout of a space, is the activity that happens there. The primary activities happening in a public space is walking, standing, sitting and playing (Gehl & Svarre, 2012). These are activities that anyone can do, at any time. However, to attract people to a space, there is often a need for other activities and attractions happening outside of the individual itself.

Ståhle (2008) uses the concept of "attractions" when describing what may entice people to use a public space (both POS and streets). Attractions are features that attract people to a space, like businesses (e.g. shops or cafés), events and public transportation. Close proximity to them is important for successful POS, because attractions give people a reason to go to or stop in the space. Lorange (1984) even claims that activity on street level is so important that it can to some extent compensate for a lack of physical critera like light and a view of the sky (p.61).

One attraction is a business. Businesses are most likely to locate themselves on main streets, because they need to be in spaces where there are people (Vik, 2010, van Nes, 2014). In return, more people are likely to use the main streets because there are attractions there for them. In the same way, people are more likely to use a POS if there are attractions like workplaces, restaurants and shops nearby. There is an especially strong correlation between the number of food businesses and the number of people using a space (Whyte, 1988a, Ståhle, 2008).

Kart 22: Butikkfasader og integrasjonsverdi i dag.

Figure 2-5: Integration values and shop fronts in 2010 (Vik, 2010, p. 94). Comparing with Figure 4-3 and Figure 4-4, a pattern shows where shop fronts correlate with high integration values. Areas with shops facing the space are more likely to attract people.

Other activities, like music, performing art, temporary or fixed art installations may or may not draw people to a space, depending on the situation (Whyte, 1988a). And in some cases the POS itself can be an attraction. That is typically the case with parks, which people use even if they defy most of the criteria for location and attractions that a good POS should have (see chapter 0). Flowers and water are attractions that people can study and play with, and something which will often entice people to stop and engage with a space (Whyte, 1988a, 1988b)

When it comes to the activities that *people do themselves* in spaces, Jan Gehl has developed a methodology that focuses on observing and analysing people's behaviour in public places, to see how they relate to their surroundings, and to understand why people do or do not use public open spaces (Gehl & Svarre, 2013).

The activities people usually perform in public spaces are arranged along an axis from optional to necessary activities, and then further divided into activities people do while walking through the space, or while they spend time in the space while stopping there or sitting down (Gehl & Svarre, 2013). On the left side of the figure, we find optional activities like taking a stroll or

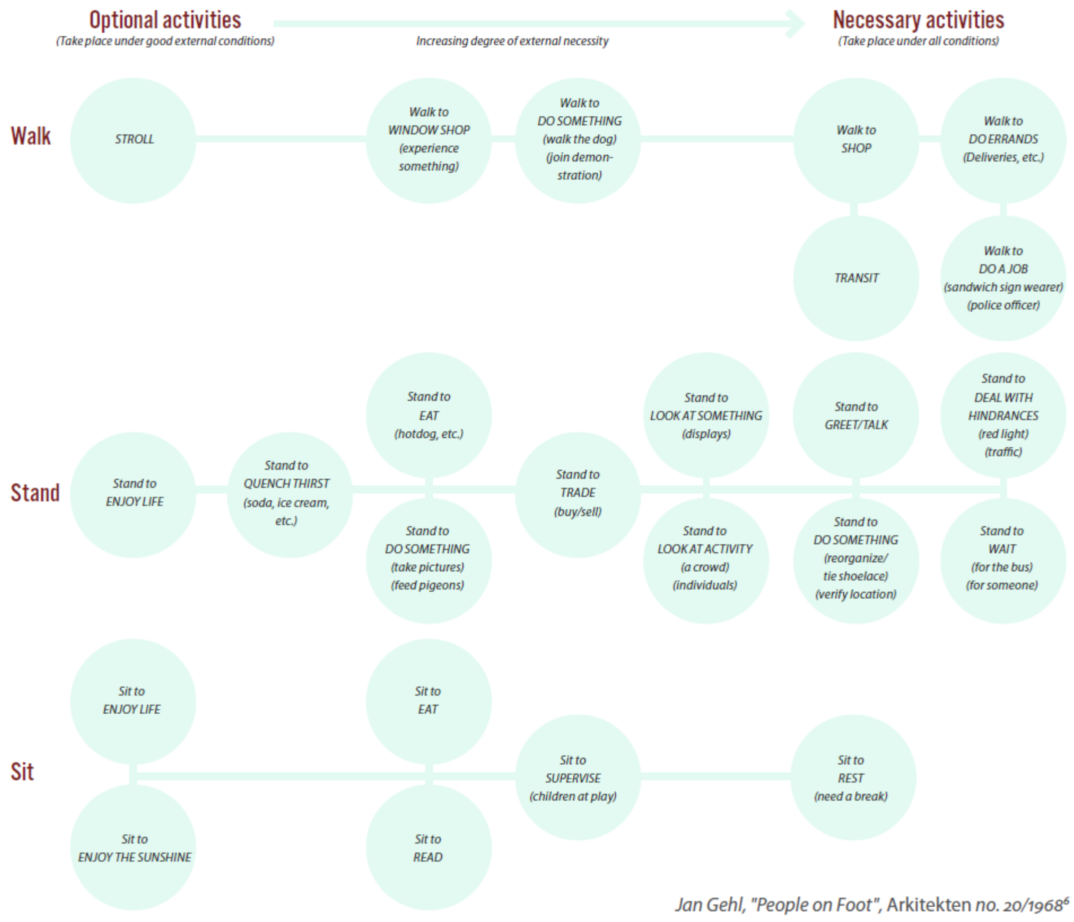


Figure 2-6: The Gehl framework (Gehl & Svarre, 2013, p. 16)

stand to enjoy life. On the opposide end of the figure, we find activities like walking to run errands and standing to deal with a hindrance, like a red light or traffic.

Gehl (1980) notes that there is more activity in a good space than in a bad space, and a good space will have more optional activities than a bad one. If the physical environment is bad, most of the activity will be necessary activities. If the physical environment is good, both the number of optional activities and the number of users in general will increase.

2.5.5 Safety and Social Control

A good public open space should also be a safe one. Fear of crime makes people avoid public spaces (especially streets), which in turn makes them more unsafe. Jacobs (1992) describes this as "*an intricate, almost unconscious, network of voluntary controls and standards among the people themselves, and enforced by the people themselves*" (p. 40). This is also known as *informal/positive social control*, where people through interaction with each other reinforce positive social norms and habits (Østerberg, 2003). Positive social control is part of the social dimension and social practices in a space, and contributes to keeping the public space safe.

A good measure of how safe a space is, is the ratio of female to male travellers in the space. Safe streets usually have an equal number of female and male travellers, whereas unsafe streets are more male dominated (van Nes & Nguyen, 2009). Safety also correlates with integration values, where well-integrated streets are usually less affected by criminal behaviour than less-well integrated streets, and also have a more equal gender ration of travellers (van Nes & Nguyen, 2009).

One way to achieve safety when planning streets and public open spaces, is to locate building entrances directly onto the street or POS, and to achieve a certain amount of intervisibility between buildings on both sides of the street. That way the people living around the space will both see and use it daily, which contributes to developing the social dimension and the positive social control of the space. This is also called "eyes on the street" (Jacobs, 1992, van Nes, 2014).

However, as we will see later, the relationship between all these criteria is not always as easy as simple as it may seem. For example, different types of areas may benefit from different types of public open spaces, or some POS are better suited in some areas than other. Like shown by Oh & Jeong (2007), the visitors of parks in residential areas are mostly local residents, while visitors of parks in business areas are mostly workers and visitors. Therefore, they require different integration values. Furthermore, Baran, Rodriguez & Khattak (2008) show that in certain types of neighbourhoods, low local integration correlates with higher numbers of leisure walkers – which in extension may lead to higher use of local, poorly integrated POS.

2.6 The Social Dimension of Space

Much like in the discussion on what the public space is, academics have different views on the social dimension of space and the degree to which the built environment can condition people's behaviour (see Carmona et al, 2010).

In the urban design field, one view is that a public open space's design creates opportunities for people to perform certain actions. That means physical planners could have an intention of how a POS is to be used, and design it to encourage people to act according to their intentions (Carmona et al., 2010). A similar view is the Space Syntax idea that the configuration of the street network will affect people choices on which streets to move through (Hillier & Hanson, 1984), or the idea that if a POS fulfils all the criteria of a good public open space, it will be in use – and in the way the planners intended.

These ideas are rather deterministic in their view of space and society, in the way that they assume that the configuration of space is the prime driver for people's behaviour in space. On the other hand, they are not completely off base. The configuration of space and people's behaviour can be seen as a reciprocal process, where the physical and social dimensions of space mutually affect and produce each other (Hillier & Hanson, 1984). That means that the design of the street network and public open spaces may structure and restrict the social processes, and vise versa, but not fully determine them.

To explain this further, let's use an example: Benches. There are many benches in Bergen city centre, for example along Torgalmenningen. The intention of these benches is to provide seating for people, and one can assume that planners intended them to be used for sitting.

At the same time, benches also provide obstacles and possibilities for movement. When finding a bench in one's path, one will have to circumvent it in some way. The most common response is perhaps to walk around it (or sit down on it, if that is what one wishes). However, one could also climb over it, roll under it, jump over it on a bike, or skateboard across it. In this way the bench will structure one's movement, in that one will have to reflect on the fact that it is there and circumvent it in some way, but it cannot determine what way one moves past it[7].

One of the premises for both this thesis and Space Syntax is the fact that people are living, acting subjects with a free will. Put in the words of Bill Hillier: "*[society] is a system composed of large numbers of autonomous, freely mobile, spatially discrete entities calles individuals*" (Hillier & Hanson, 1984, p. 32). This means people may not always act as they are intended to, or in the way physical space is structured to encourage them to. They may choose to skateboard on the bench, rather than use it to sit on. In the same way, people may not choose to walk on the most well-integrated streets, or use a public open space, even if it fulfils all the critera of a good POS. Or they may use it in a different way.

In the wake of the structuralism mentioned in chapter 2.2, the british sociologist Anthony Giddens developed a theory called structuration theory, where he discusses the relationship between social structure and individual actions, and how these two continually create and reproduce each other. This is a reciprocal process creating social practices, where people act and relate to each other, dependent on both the social structure around them and their individual

[7] Here is the main difference between structuralist and post-structuralist and post-modernist views of space: the extent to which the bench can determine people's movement around it or not.

will. The structure structures people's actions, but actions also create and reproduce the structure (Nygaard, 1995, Østerberg, 2003).

This is what Carmona et al (2010) refers to as "the social dimension" of a space. Carmona et al. believe the social dimension of a space is the set of social relations and activities that happen in the social space. However, unlike Giddens, Carmona et al. include a relation to space in their definition. They claim the social dimension is produced through social, economic and environmental processes (Carmona et al, 2010, see also Murdoch, 2005), and impacted by physical space. Space may thus be part of structuring people's behaviour, but will not be its only determinant.

The social practices in the social dimension take place between individuals and groups, and may be similar in similar contexts (Nygaard, 1995). However, as the processes influencing the social practices may differ even in similar contexts, social practices may also differ in similar contexts. An example can be found in Bergen, where the use of the park Nygårdsparken was split in two for more than forty years. One part was dominated by students and families, whereas the other was dominated by drug addicts (Åkernes & Edvardsen, 2015). One could expect both parts of the park to show patterns of similar behaviour, but for many years there were two completely different sets of social practices that dominated the two parts of the park.

Thus, if one accepts the premise that social practice is a self-reproducing process that happens in the relation between people, that is influenced by a set of other processes, and the premise that people are free-willed actors that may or may not be affected by their physical environment, then one should also accept the premise that people's actions may not always be in accordance with what one intended in a public space (Gehl & Svarre, 2013).

The social dimension of a space will then be a process that may structure whether people are more likely to walk around the bench, or circumvent it in some other way. Or, perhaps Different user groups may also solve the situation in different ways. My own daily walks across Torgalmenningen have shown that where adults are most likely to walk around, children can frequently be seen climbing over or under them, or even walking on top of them. In the same way, skateboarders sometimes use the benches as skating paths. This means that benches may structure and restrict movement, but they may also expand movement for certain user groups, depending on the social practices of that group or space.

Another example of how the use of a space may differ from the intention can be found in the large public open space outside of the Gallery of Modern Art in Glasgow, Scotland (see Image

2-1). This is a large open space with few features, except for a large statue and a set of steps leading up to the entrance of the gallery. Due to the space's design, one can assume that the social actions intended by the planners would be activities like walking, sitting on the gallery steps or stopping to look at the statue.

Contrary to expectation, an activity that is frequently observed is people climbing the statue and giving it a traffic cone for a hat (See image 2-1). The statue is now famous for it, although the local council has expressed wishes that the practice is discontinued and have considered raising the statue's plinth to make it more difficult to climb (Hall, 2013). It is clear that there is a continually reproducing social practice taking place in the space, that was not intended in the planning of the space. Furthermore, the practice is unwanted by some user groups (the local

Image 2-1: Glasgow POS and statue
*(**A**) Left to right is Queen Street, the POS with a statue, and The Gallery of Modern Art. Seen from above. ©Google Maps, 2017 [Screenshot taken 31.01.16]. (**B**) The statue and its hat in August 2015. Own image.*

council), but wanted by other user groups (the "vandals"). When a social practice like this reproduces and manifests itself in a space over time, one can start talking about social practices or habits[8] reproducing in space.

Changing these social practices and habits may not be immediate. To change social practices, the actors involved in reproducing the practices and structure needs to develop new practices and habits. That may take time. Gehl (1980) points to this as an explanation for why many new property developments have no life in the public spaces between the buildings: there is not

[8] A habit is an established and repeated behaviour (Ordnett.no, 2017)

enough activity happening yet to attract more activity, meaning that there is not enough social life to create common social practices and habits of use.

3 METHOD

Three main methods have been used in this thesis: aerial photo interpretation, integration analyses and observation. The aerial photo interpretation of the city centre resulted in the set of classifications of public open spaces, and the location of different POS. The integration analyses have been performed on two different datasets on two different scales (city centre and Torgalmenningen axis), and have resulted in axial and all-line maps. Finally, the observation was done in Johanneskirketrappen, the third scale level used in the thesis. In this chapter, I will further detail the process followed and the choices made, and their basis. I will also shortly discuss method triangulation and the softwares used.

3.1 Research Design and Triangulation

The thesis has been designed using an *intensive research design,* which is where one attempts to describe one or a few cases with as much detail as possible (Clifford, French and Valentine, 2010). This is commonly used for case-studies and in-depth analyses. In this case, the focus is on describing and analysing the particular context of Bergen, and the use of accessibility analyses on public open spaces here. The analyses used in this thesis were performed to investigate how integration analyses perform in this local context and on the specific area categories of POS. Some of the results may however be generalisable.

As my research questions are wide and different, but all contribute to enlighten the subject of integration analyses in planning public open spaces, I have used several strategies and methods to answer them. This is known as *triangulation* (Denzin, 1978, in Jick, 1979, p. 602-603). When triangulating, one chooses theories and methods that complement each other in respect to what information they can provide, and on how to create a bigger picture of a certain case than can be done with one single method (Jick, 1979).

There are many ways to triangulate. I have used theory triangulation and method triangulation (Denzin, 1978, in Jick, 1979, p. 609, Hoque, 2006). The theory triangulation is done between the "soft" social science theories of eg. Gehl, Whyte and Jacobs, and the "hard" science approach of Space Syntax with its mathematical calculations and different theory of space. The method triangulation is between observation, GIS and Space Syntax methods.

The reason for triangulating these methods in particular is that there is some information that the digital integration analyses cannot give us. They show the *potential* use of a space, but they do not show its *actual* use. To do that, one would have to collect data through for example observation. Integration analyses can correlate with actual flows through a space (eg. Hillier et al., 1998, referred to in van Nes, 2014, Ståhle, 2008), but not whether or not people are likely to stop there, or want to spend time there. They do not show what kinds of activities happen in the space, and they do not give information of the social character of the space: does it put people in contact with each other? Do people meet and interact there?

In this thesis, I therefore combine Space Syntax methods with observation, and integrate the results in a GIS, something which is known as a *between-method triangulation*. This puts my thesis in what Jick (1979) would call a complex triangulation design, where I attempt to both investigate the validity of my quantitative results from the Space Syntax and GIS analyses, and also attempt to provide a more complex description and explanation of why the results are the way they are.

3.2 Softwares and Workflow

I have used three different softwares.

The first is ESRI's ArcGIS software, versions 10.1, 10.4 and 10.5. This is a GIS software that I have used to map public open spaces and run Viewshed analyses, draw all the map layers used in the Space Syntax analyses, interpret outputs from DepthmapX and to design maps.

The second software is the UCL DepthmapX software, version 0.50 ("DepthmapX" used hereafter). It is an open source software based on Space Syntax theory, developed at the University College of London. This software runs axial and all-line integration analyses.

The third software is QGIS 2.14. This is an open source GIS that I have used to convert files between ArcMap and DepthmapX file formats for the Space Syntax analyses, a very time-consuming process.

Finally, I have also used online services like Google Maps and Google Street View in support of the interpretation of aerial photos and classification of POS.

A graphical representation of the workflow can be seen in Figure 3-1. On the digital side, I have interpreted a georeferenced aerial photo (orthophoto) from 2014 to classify POS, hand-drawn axial maps and computer-drawn all-line maps on which I've run integration analyses. I have also run a viewshed analysis from Johanneskirketrappen. On the traditional side I have used classifications and observation that have mutually affected each other throughout the project. I have then run analyses, classified and observed on three levels: the city centre, the Torgalmenningen axia and Johanneskirketrappen.

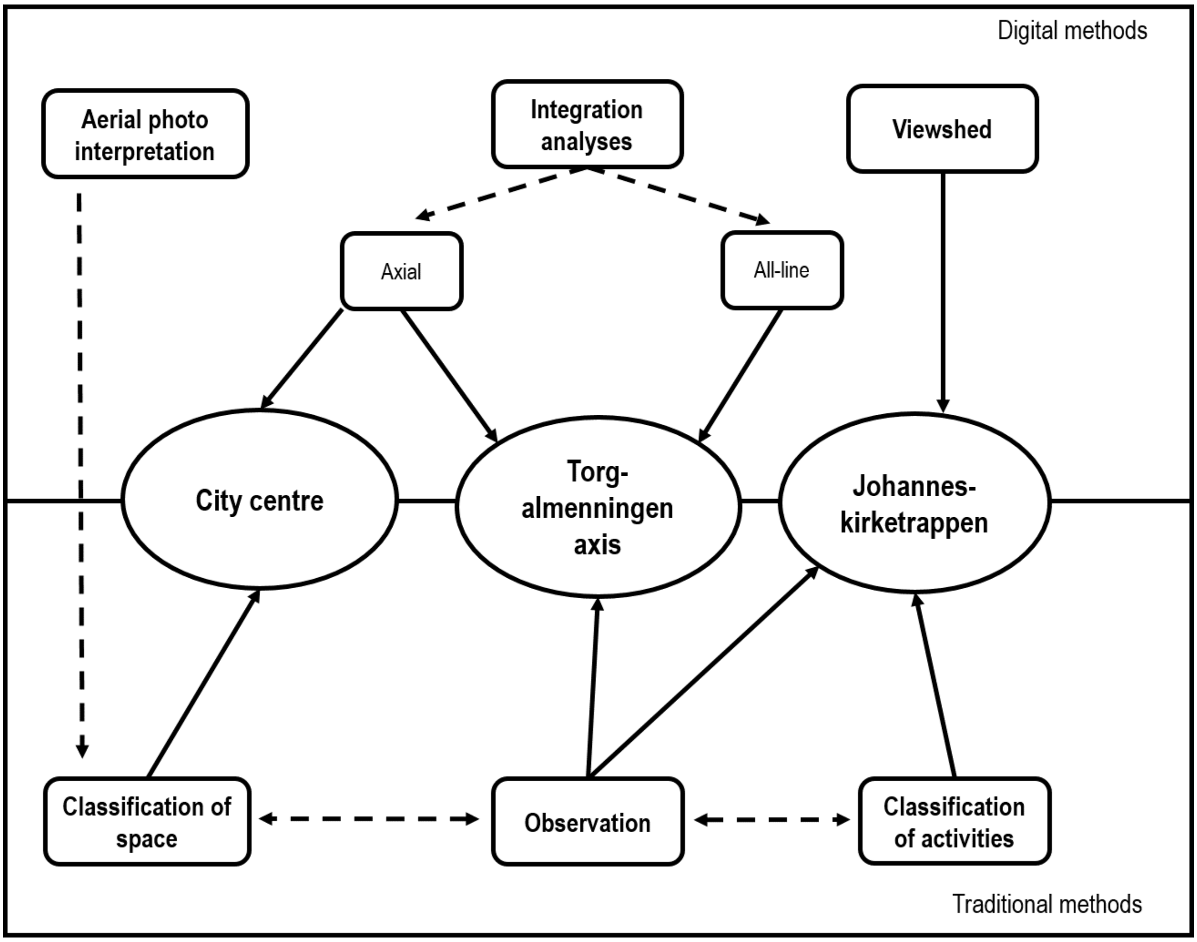


Figure 3-1: Graphical view of method use. Dotted line shows workflow between methods, full line shows workflow of methods used on field areas.

3.3 Study Area

To test the use of integration analyses and Space Syntax on pedestrian movement and public open spaces in the particular context of Bergen, I have used three study areas on three different scales. The largest area is Bergen city centre, the middle-sized area is the Torgalmenningen axis (from Vågsalmenningen to Johanneskirken) and the smallest is the Johanneskirketrappen POS.

I chose the city centre, and not a newer neighbourhood or a neighbourhood under development, as the first study area for several reasons. The most important reason was that it is a rather small city centre, and is naturally delimited by the sea on three sides and a mountain on the fourth. That would make both mapping, classification of POS, and ground verification an easier task than if the city was of a bigger size. Using natural boundaries also makes the results of the analysis more reliable than if the boundaries were artificial (which may result in problems like the edge effect, discussed later in this chapter). I also know the city centre well after having lived there for several years, something which usually makes maps more accurate (Srivastava & Narayan, 1974).

In addition, it is an area that is already developed. It is comprised of neighbourhoods from different eras, with different planning and building styles, different street networks and different functions. That gave an opportunity to compare POS and POS accessibility for vastly different neighbourhood types and street networks.

To delimit the study area, I used the natural border towards the sea on three sides, and by administrative circuits (*"grunnkrets"*) on the north side (see Figure 3-2). This was to include a little more than just the economic centre of the city along the Torgalmenningen axis, like parks, and residential areas with little economic activity. That gives more grounds to compare results across space. Using an already developed area also allows analysing if there is potential for improvement.

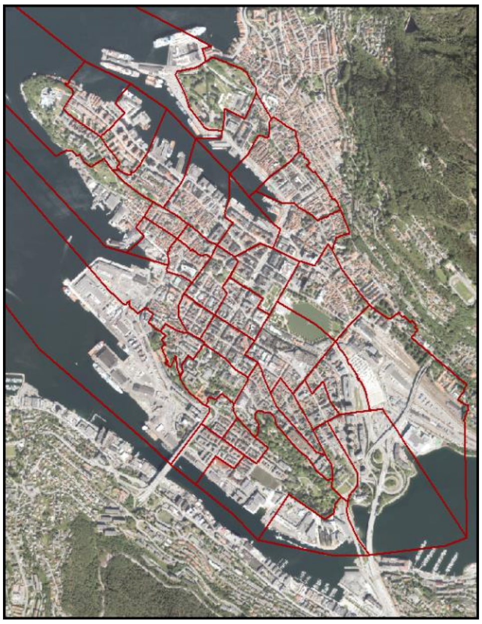


Figure 3-2: Delimitation of study area. Red line indicates grunnkrets, all areas within the red line are part of the study area.

The second study area is the Torgalmenningen axis. Torgalmenningen, the main shopping area and economic centre, is located in the middle of a long, highly integrated axial line that also covers three other POS: Johanneskirketrappen, Vestre Torggate and Vågsalmenningen (see Figure 1-1, Figure 4-3 and Figure 4-4). Large parts of the axis is visible from the Johanneskirketrappen POS, and comparison of the use of spaces along the axis is therefore possible. The axis is intersected by a number of streets.

To include these in the analysis and get integration results, but not have to run the entire dataset, I created a 150m buffer zone around the Torgalmenningen axis. That included approximately three parallel streets in every direction from the axial line. Three streets were chosen because that is also the number of directional changes used for local integration.

The third study area is the Johanneskirketrappen POS, located at one end of the Torgalmenningen axis (see localisation in Figure 1-1). It was chosen for several reasons:

- One has a view of the rest of the axis, allowing comparison.
- It is located on a hill, and it is therefore be possible to consider whether topography plays a role in its use.
- It is located at the edge of an axis and not in its most central part, allowing comparison.
- It is newly redeveloped from a street into a POS, and is planned specifically as a public open space. That means planners would have had an intention of facilitating social interaction.
- It is not too big, allowing a single person to observe it.
- Two separate planners from the local municipality mentioned it in informal conversations as an interesting space because it was so new.

The Johanneskirketrappen POS was redeveloped in 2015 with money from the local municipality, as part of a public space renewal project (interview with planner in Bergen Local Municipality, 21.09.16). Before the renovation, it was a street with roadside parking, and two run-down staircases on each side, and had presumably looked the same since at least 1912 (see image 3-1).

Today, the space itself consists of two parts: a large staircase at the bottom of the hill, and a large open square approximately halfway up the hill (see Figure 3-3Image 3-2). The *staircase* is divided into three parts, with one narrow, regular staircase on each side, and a broad, sitting-

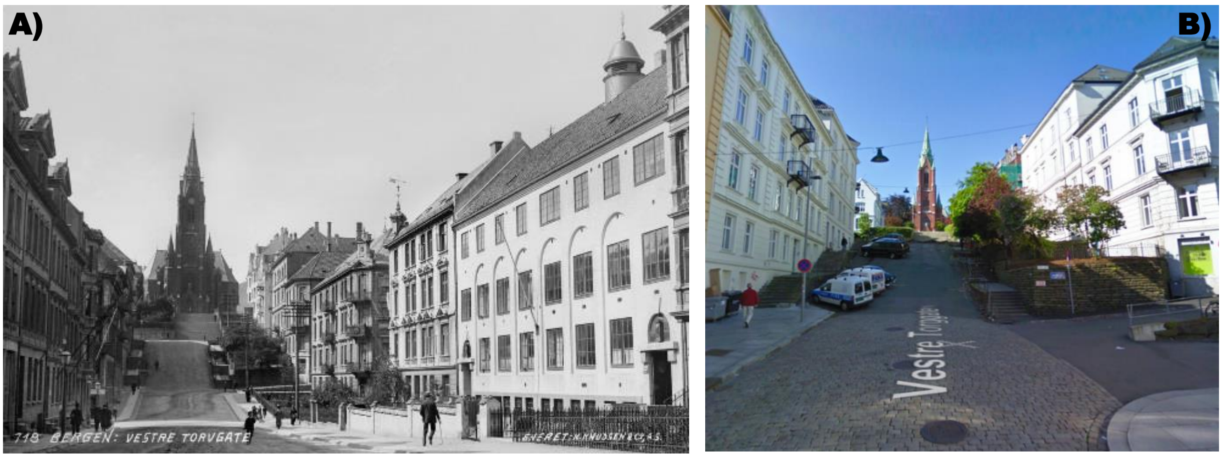


Image 3-1: The old layout of Johanneskirketrappen.
*(**A**) Vestre Torggate in 1912. The hill is where Johanneskirketrappen is today. (©K. Knudsen & Co/Marcus UiB)*
*(**B**) Johanneskirketrappen in 2009, seen from Vestre Torggate (©Google Street View, 2009).*

friendly staircase in the middle, with a bench, a fountain, some water features and a some flower pots.

The buildings surrounding the space are residential dwellings. There are a few businesses on the same block, but outside the borders of the POS (see Figure 2-5). The stairs are approximately 45m long from the bottom to the top, and 7m wide.

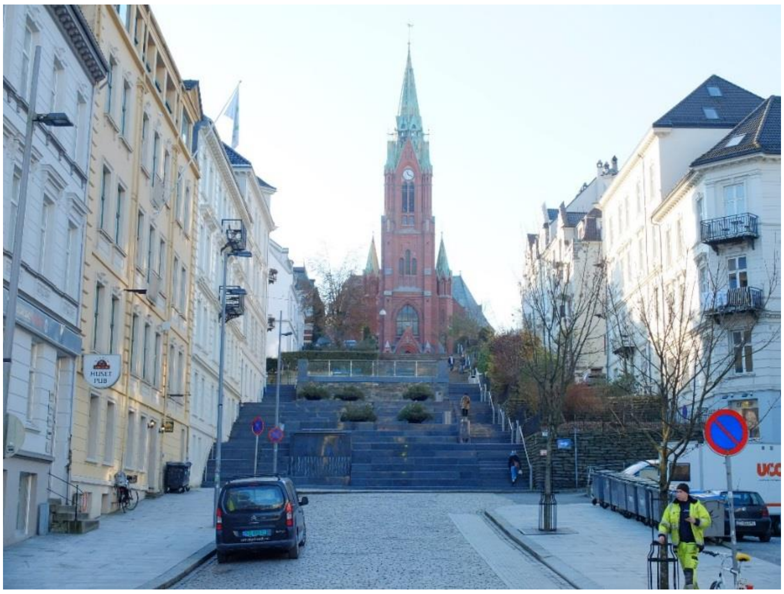


Image 3-2: Johanneskirketrappen from below. (Mark features mentioned in text above.)

The *open square* is large and open, with few features in it. All features, such as benches, a fountain and flower beds with sittable ledges, are placed around the edges of the space. Cars are allowed to drive through, but the entry to the space is narrower than the adjoining road, and only one car can drive through at once. The space is paved, in contrast to the adjoining tarmac of the street. There are two benches in front of a glass railing, very close to a fountain, and two ledges between the benches and the two stairs, and one bench at the back of the space, towards a wall.

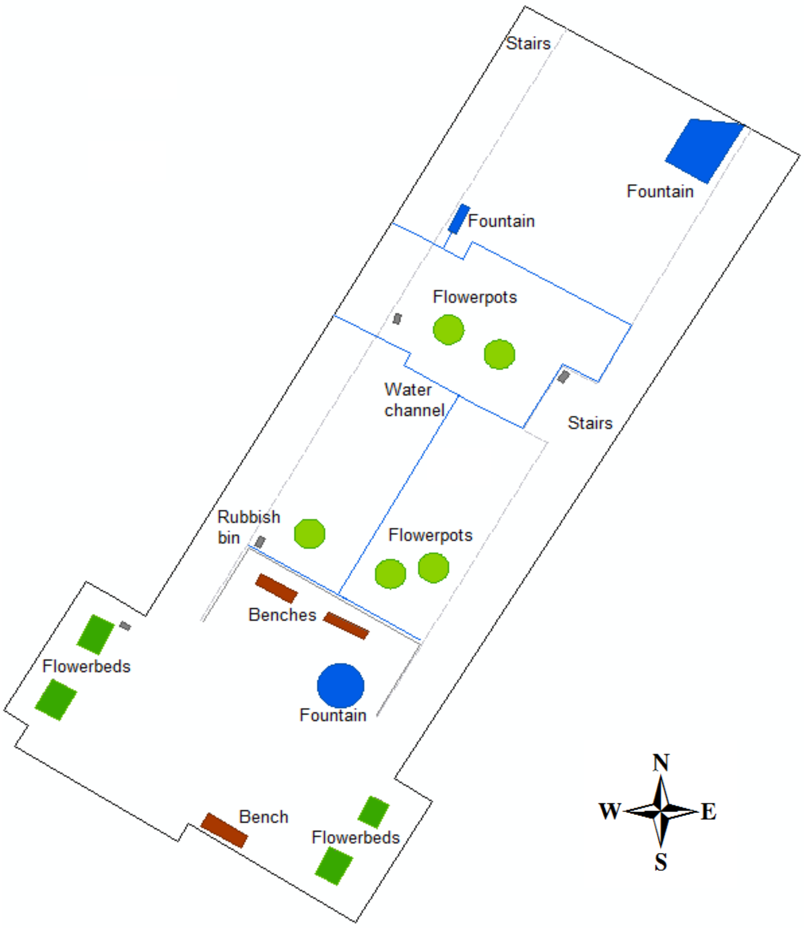


Figure 3-3: The new layout of Johanneskirketrappen. See larger version in appendix A.

The stairs are 23m long and 14m wide, with building facades of 15m. However, including the open space on top and the semi-private gardens on the east side of the stairs, the actual open space 45m long and 23m wide. The height of adjacent buildings is approximately 15m.

Image 4: Johanneskirketrappen today
*(**A**) Upwards from the open space*
*(**B**) Seeing the open space from the stairs in image A.*
*(**C**) The open space seen from the west.*
*(**D**) The main stairs seen from above, east.*
*(**E**) The main stairs seen from below, west*

3.4 Image Interpretation and Classification

To identify and classify public open spaces, I have interpreted aerial photos. I decided on manual interpretation because there are few accurate methods of automatically extracting information on public spaces from aerial photos, and it has been proven to be an accurate method of data extraction (Srivastava and Narayan, 1974, Morgan, Gergel and Coops, 2010).

The aerial photo I have interpreted is an "orthophoto type 10" from the Norwegian Mapping Authority (Kartverket) from 2014. It is an RGB colour image, and has a ground resolution of 0.1 meter, with a spatial precision of ± 0.35m (Kartverket, 2016). That means it is a very fine-grained image with a high spatial precision.

Though I am not a trained professional in manual image interpretation, I have lived within the field area's boundaries for several years and know the area well. This local knowledge helped me to quicker assess whether a space could fall within the classifications or not and what feature I was looking at. I also used Google Street View, photographic sources (eg. Google Images, MarcusUiB) and ground verification to verify the spaces I was unsure of.

The classifications in Table 3-1 were created through a combination of examining the aerial photo and local land use maps, and reading theoretical literature on what a public space is. I did not find any classifications that included all public spaces, and simultaneously distinguished between different subtypes, and therefore made my own (see e.g. Srivastava & Narayan, 1974, Hagen et al., 2016). The classification is split into four over-arcing types (green spaces, open spaces, sports and play, and pathways), with 13 subtypes.

The classifications are not based solely on physical criteria (the physical dimension of space), but also on what the social dimension of a space is. It may, for example be difficult to distinguish *greenery* (see Table 3-1) from the area category *vacant land* (now removed, referred to open spaces that were not in use). In this case, they have many of the same physical criteria (small, green or otherwise open spaces, not a planned park with paths and a purpose, can have an un-ideal location). The difference between them is that what is here classified as *greenery* has potential for being in use (I have either seen people use it, or its location, shape and size is of such a dimension that it seems likely people will use it), whereas *vacant land* does not (small green spaces on steep slopes, isolated by walls, next to motorway etc). In the same way, *quays* that were either closed to the public, or that had docking and loading of ships as their only activity were not mapped in the *quay* class, as their social function was being a workplace, and not being a place for public exchange and social life.

A planner in the local municipality revealed that there is widespread use of streets (movement spaces) as public open spaces in the field area, especially by people with kids. This is probably connected to a lack of POS in close vincinity of one's dwelling. However, it is difficult to distinguish between streets that have a distinct social function and streets that don't from an aerial photo, and time constraints made it impossible to walk every street in Bergen to look for visual clues of a street's social dimension. The regular street as a social space was therefore excluded from this thesis. Within the field area, pedestrian streets, walking paths and shared spaces often had different ground cover and could therefore be identified from aerial photos and verified on the ground.

While mapping, I frequently found features that had "fuzzy" boundaries or could fall into two classifications at once (Heywood, Cornelius & Carver, 2011). These cases included a nursery school surrounded by a forest with no discernible fence, a schoolyard that doubled as a parking lot, and a large open space that included both a quai, a square and a walking path. Where there was doubt, I checked the spaces, either in person or on Google Street View, determined its boundary or primary function and classified it accordingly. If different parts of the space seemed to have different primary functions, I split the space into several polygons with different classifications.

This verification was also useful for building sites in the ortophoto. After verifying what was there today, all building sites that have later become POS were mapped. Johanneskirketrappen was one of these sites.

Table 3-1: Classifications of public open spaces. Some categories are self-explanatory and therefore have no examples.

Type of space	**Definition**	**Subtype**	**Description and examples from dataset** (see Figure 1-1 for location)
Green spaces	Open green spaces that are or can be in use by people	Cemetery	Graveyard *St. Jakobs graveyard*
		Greenery	Open green spaces that don't have the character of a park, often in conjunction with buildings or parks, but that can be used by people
		Park	Open green space planned as a park, or with park-like features such as benches, paths and flowerbeds *Nygårdsparken, Nordnesparken*
Open spaces	Open spaces that have a social function as a meeting place, market place or similar.	Allmenning	Specific area type for Bergen. Orginally designed as firebreak in the city, often same function as place/square *Vågsallmenningen, Torgallmenningen*
		Square / Place	Open spaces that have or have had a function as a market place or meeting place. Can be in relation to a building *Fisketorget, Festplassen*
		Stairs	Large, outdoor staircases that are also intended for recreational use. *Johanneskirketrappen*
		Quay	Built structure where boats can dock. Usually industrial area, in Bergen also used for recreation. *Bryggen*
Sports and play	Open spaces developed for sports or play	Playground	Open spaces with installations like swing sets, climbing frames and the like, intended for children
		Sports field	Fields for playing football, handball, basket, skating etc.
		Schoolyard	Same definition as playgrounds, but in conjunction with schools or nurseries
Pathways	Paths or streets not intended for motorised traffic	Pedestrian street	Streets where cars cannot normally drive, pedestrians have right of way *Marken, Strandgaten*
		Walking path	Pedestrian walking paths, not planned so cars can use them *Around Store Lungegårdsvann*
		Shared space	Streets that have no markers for whether pedestrian or vehicle traffic has right of way, or "gatetun" *Møhlenpris*

3.5 Data Preparation and Analysis

Integration analyses require some preparation. One first needs to identify all the open spaces that people can move through in the study area, such as streets, public open spaces and walking paths, then draw axial lines through them, and lastly run integration. Axial maps require all open spaces to be covered by a single axial line. This is usually drawn manually for larger street networks, as the DepthmapX software struggles when it is faced with large areas and too many axial lines (GitHub, 2015). Drawing the axial map and the open space layer for the all-line map is rarely done in the DepthmapX software, as it is more easily done in drawing softwares or a GIS.

All-line maps are calculated by the DepthmapX software, which requires all open spaces to be drawn as a single, closed polygon, in a single polyline format (van Nes & Song, n.d.). Any open space is calculated as part of the street network, and the data layer therefore cannot have any dangling lines or unclosed building polygons (see Figure 3-4).

Both axial maps and open space outlines can be drawn by tracing open spaces with axial lines or as polygons on top of aerial photos, road maps or building maps (see Figure 3-5). The most common base layers for axial maps are road maps. They are less detailed than for example building maps and easier to use when mapping large areas. When analysing pedestrian accessibility or smaller areas, however, one could argue that it is better to use building outlines, as they give a more detailed image of pedestrian accessibility. Batty and Rana (2003) put this down to a question of scale, where an analysis at a larger scale calls for a more detailed axial map than an analysis at a smaller scale (or a larger area).

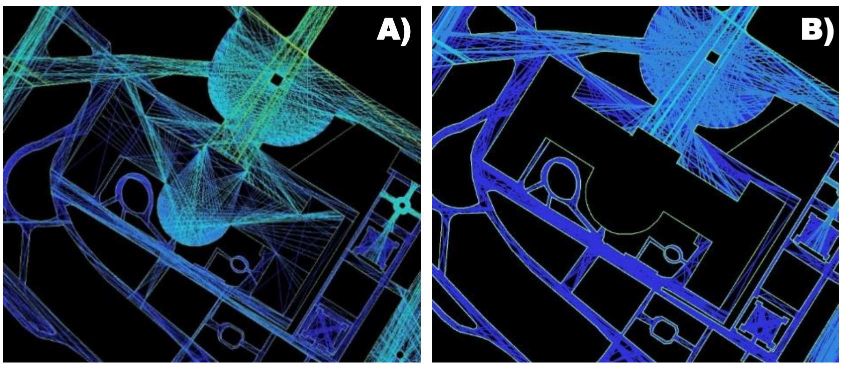


Figure 3-4: The Museum of Natural History and the open spaces around it.
*(**A**) With an unclosed polygon. (**B**) Result after closing the polygon.*

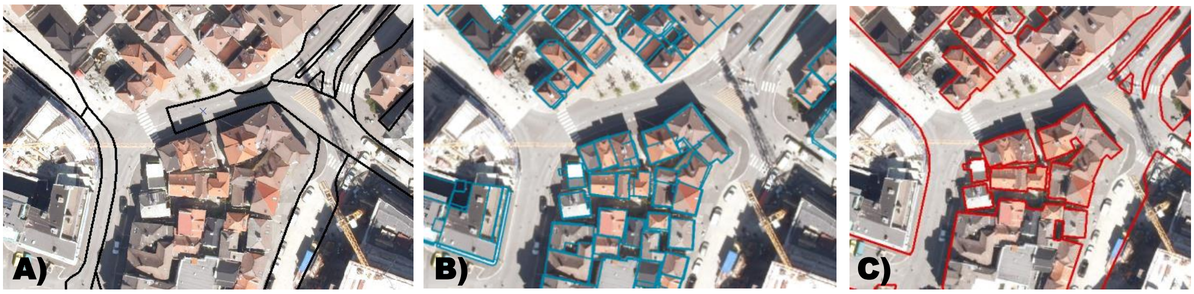


Figure 3-5: Base layers
*(**A**) Road outline layer, where main streets are not connected. (**B**) Building outline layer showing all possible paths.*
*(**C**) Combining the road and building data with aerial photo.*

All-line integration analyses are not commonly performed for very large areas. This is because it is not necessary to run them for large areas like the city centre, since the simpler version of it, the axial map, will get the same integration values (see chapter 2.4 for explanation). Since all-line integration analyses are best used on smaller areas and larger scales, they can be very detailed and include other features than buildings, such as trees and benches.

To make these maps, I had access to road and building data in vector-format from Felles kartdatabase (the official national map database, the abbreviation *FKB* used hereafter). This is the most detailed map data available for Norwegian cities (Kartverket, n.d.). I could not use the FKB data directly for any of the analyses.

The road data did not include pedestrian paths or sidewalks and displayed every street as a separate polygon. Maps based on this data would be missing axial lines, and have most lines cut shorter than they should be (see Figure 3-5 A). The building data was too detailed for the DepthmapX software, and would have included axial lines in-between outlines of buildings that are in reality connected to each other (see Figure 3-5 B). Both layers also had a considerable amount of unclosed polygons, which meant many buildings would have been counted as open spaces by the DepthmapX software during an analysis.

Figure 3-6: The open space layer for the entire study area.

I therefore drew my own map of the open spaces in the city to use as a basis for the analyses, using a mix of road and building outlines where they complemented each other, and then verifying it with the aerial photo from 2014 (see Figure 3-5 C and Figure 3-6). I then drew axial lines based on it, and used the area of the Torgalmenningen axis and its 150m buffer to run the all-line analysis.

I ran a topological test in ArcGIS to ensure all polygons were closed. 150 errors were corrected by manually connecting all unclosed polygons. The process of creating the layer included running all-line analyses on the layer in the DepthmapX software, inspecting the output for errors, fixing the errors in ArcGIS and redoing the analysis several times.

When drawing the open space map, there were some issues with what features to include or exclude, and some boundary issues such as roads that have several lanes divided by fences, and how to treat the issue of grass and non-paved passages. The issues and solutions can be seen in

Table 3-2.

Table 3-2: Issues in mapping open spaces

Feature	**Issue**	**Solution**	**Reasoning**
Features in roads	All objects in a convex space should be mapped. Should road dividers at junctions or in lanes be mapped?	Mapped: fences and dividers that - divided one road from another - separated one-way-streets from two-way streets Did not map: features that divided separate lanes of the same road.	Axial maps do not require axial lines for each road lane, thus I only used one axial line per street.
Lawns/grass and non-paved passages	People can walk across grass. Should it be mapped as possible paths or open spaces or not?	I did not map grass as paths or open spaces if there were no walking tracks visible in aerial photos. If there were footpaths, it was mapped as path.	If there are no tracks, it indicated that the grass is not habitually used as a path, and it is therefore not an important part of movement in the area.
Passages under buildings	Some buildings have passages under or though them. You cannot see them in aerial photos. Do you map them?	I mapped passages if I knew they were there or if I could see them using Google Street View or by going there myself.	It is open, and people can use it. Therefore you map it.

3.5.1 Integration Analyses

The integration analyses were run on two datasets: an axial map of the entire city centre, and an all-line map of the Torgalmenningen axis (with its 150m buffer zone). There are two ways of making these maps: drawing them by hand or having the DepthmapX software draw them.

I hand-drew the axial map of the entire city centre. I first drew it based simply on recommendations from others who have worked with axial maps and some theoretical literature. It did not completely follow the drawing rules mentioned in chapter 2.2. These drawing rules includes drawing every line around every feature and including all features like benches and flowerbeds (see Turner, Penn & Hillier, 2005). An illustration of an axial map following all these rules can be seen in Figure 3-7 A, where I have had the DepthmapX software reduce an all-line map to an axial map.

I therefore later edited it to comply more with these rules. I ran some tests on smaller areas in the city, and found that single lines did not affect integration of nearby streets to any significant degree. Due to the results of this test, and to the medium scale of the map, I deemed it unnecessary to edit all of it to comply completely with the drawing rules and include all features (Batty & Rana, 2004). I therefore only edited the main paths through most open spaces, to make these comply with the rules (see illustration in Figure 3-7 B). This is consistent throughout the

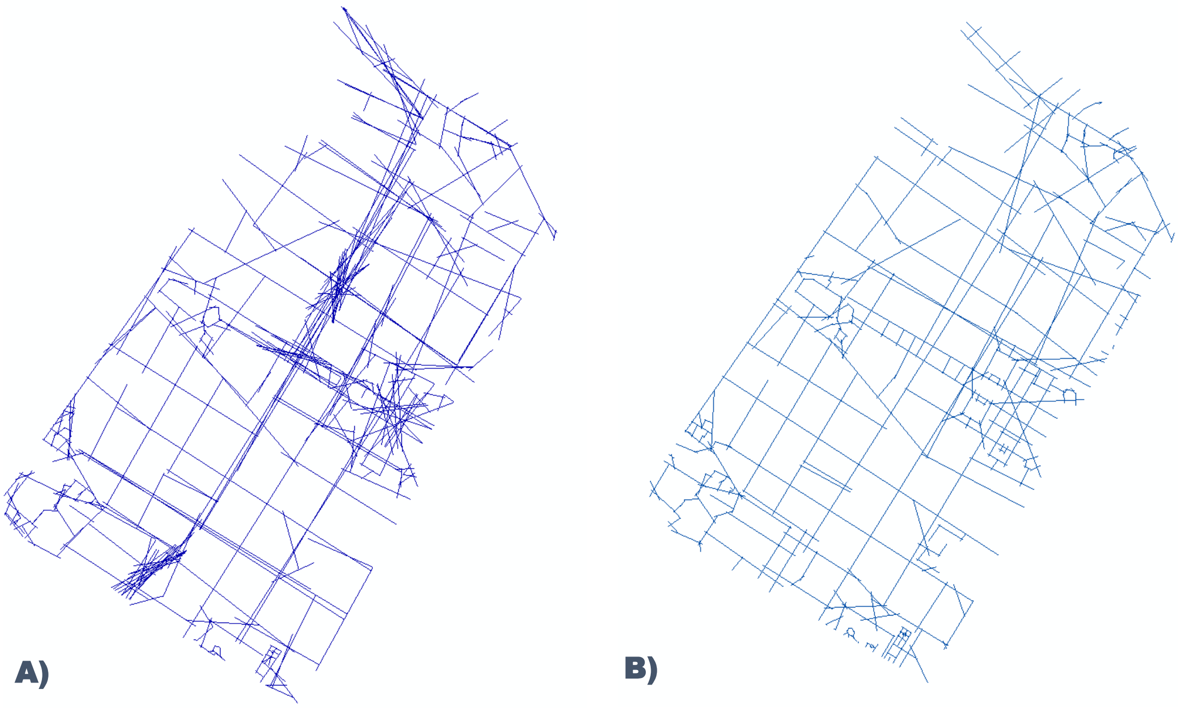


Figure 3-7: Two different axial maps.
*(**A**) Automatically reduced axial map following drawing rules. (**B**) Hand-drawn axial map of Torgalmenningen area*

dataset, and the results of the analysis can therefore be relied on to also be consistent throughout the analysis (ref. Batty & Rana, 2004).

The all-line integration analysis was also calculated for both global and local measures, and was based on the Torgalmenningen axis open space layer. The analysis was run in DepthmapX, calculating all possible sight lines through the open space. The open space layer used for this was more detailed, and included features like fences, benches, flowerbeds and trees. The result was thus also more detailed, which is also pertinent due to its larger scale.

The local integration values were set to 3 in the axial integration analysis, according to advice from Akkelies van Nes, professor at the Bergen University College (personal communication in lecture, 06.09.16). However, for the all-line analysis, I have chosen only to include the result of the global integration. This is because the results of the global and local integration were different (with local integration only showing values in the bottom 7 classes, and the global in all 10), but when run as axial analyses they were very similar (values in all 10 classes, and similar results). This is an anomaly that I cannot explain, and I therefore opted not to include the analysis in the results and discussion.

In this thesis, I use the term “high” integration for the three highest classes of integration values, “medium” or “middle” for the four middle classes and “low” integration for the classes with the lowest integration when discussing the results.

3.5.2 Edge Effect

The edge effect is the effect where streets on the edges of the study area are more likely to be less well-integrated than streets in the middle of the study area, due to being connected to a lower number of streets (Ratti, 2004, Space Syntax Glossary, 2017e). In this study, the city centre is cut off from the main roads leading into the centre, which could mean the analysis would look different and with different global integration values if one were to include accessibility out of the city.

On three sides, Bergen has a natural edge towards the sea, meaning there is a “natural” edge effect. These natural edges do not affect integration results in the same way as artificial edges, as they are physical boundaries that are in place at all times. Integration results affected by natural edges therefore represent actual integration.

3.5.3 Viewshed analysis

Viewshed analyses are not normally used in the Space Syntax method. In this thesis it is included because it complements the integration analyses by including criteria that Space Syntax does not, namely on topography and the viewer's height above the ground. It can therefore say something about the actual visibility along axial lines.

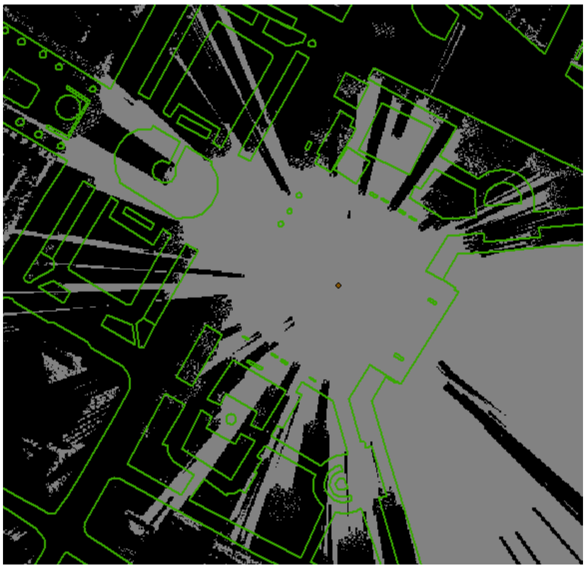


Figure 3-8: Illustration of a viewshed analysis of Festplassen.

The viewshed analysis is a raster based analysis that calculates what pixels will be visible from a chosen point in space, based the slope and elevation of the terrain (see Figure 3-8) (ArcGIS Resources, 2012). It is based on a Digital Terrain Model (DEM), a 3D model of the earth's surface, which is made from LiDAR-data obtained from Bergen kommune. The DEM has a spatial resolution of a 0,5m.

In a viewshed, one can decide a height above the ground from which to calculate visibility. I therefore made a point in the middle of the square at Johanneskirketrappen that I offset from the ground by 2 metres, from which I calculated the viewshed. 2m was chosen because it was the closest whole number to an approximate average height of people in Norway of 1.75m, derived from statistics about height of young people liable for military service (Statistics Norway, 2012).

3.6 Observation

Observation is defined in the Oxford English Dictionary "*the careful watching and noting of an object or phenomenon in regard to its cause or effect, or of objects or phenomena in regard to their mutual relations*" (Oxford English Dictionary Online, n.d.). It is in essence a way of studying life in spaces, and not just physical spaces themselves (Gehl Architects, n.d., a). It is also therefore an efficient way of studying how people relate to space (Gehl & Svarre, 2013). Crang (1997, in Hay, 2010) points to the fact that observation can be to actively take "*part in the world, not just representing it*" (p. 242), by which it complements GIS-based methods, as they mainly *represent* the world (Heywood, Cornelius & Carver, 2011).

There is no specific method or formal steps to follow for observation (Laurier, 2010). Any given situation merits its own methods and strategies, dependent on what questions one wants to answer (Kearns, 2010, Gehl & Svarre, 2013). I based the observation in this thesis on the Gehl framework presented in chapter 2.5.4 (Gehl & Svarre, 2013).

This method is based on systematic or semi-controlled direct observation of people and their actions in public spaces. People are observed and counted according to pre-defined categories, and factors like the time of day, weather and other relevant factors that may affect the observation are thoroughly noted (Gehl Architects, n.d., a).

A framework like this is useful when analysing the activities of public open spaces, since a good POS is more likely to have a higher number of users doing optional activities than a bad POS (Gehl, 1980, Carmona, 2010). Categorising what types of activities people do in a POS *may* give an indication of how the space is perceived by people. The presented framework was made in 1968, and Gehl & Svarre (2013) note that if it had been made today, it would also have included activities like using a mobile phone, smoking or different types of exercise.

The reason for using observation to complement a GIS analysis is that it is one of the main traditional methods for studies of the social dimension of public space, and observations can uncover activities and structures that accessibility analyses can not (Gehl & Svarre, 2013). It is also a way to evaluate the results of the accessibility analyses, especially when testing integratin analyses on areas with varied topography. A further discussion of the implications of this method and possible issues can be found in chapter 5.

3.6.1 My observation

The observation for this thesis was a semi-controlled direct observation that differed slightly from the Gehl methodology mentioned in chapter 2) (Kearns, 2010). I spent time in the public open space and recorded what activities people did and the general trends of movement, observed social interactions and how the use of the space changed throughout the day. I explored the range of activities and social interactions that happened, and observed at different (pre-determined) times of the day and in different types of weather, to see if observations differed.

My observation was carried out in Johanneskirketrappen in late September and early October 2016. The original plan was to do it in August, since people tend to spend more time outdoors in the summer, but it got delayed. However, September and October were possibly more interesting than August, since the tourist season was over and one would be able to evaluate local's use rather than tourists'.

I kept the Gehl methodology in mind while noting observations, but without using it directly to fill in and count observations. I always noted factors like weather, temperature and time of day. But as the field area is an outdoor space, I could not control the observation parameters, as one would in a laboratory or research lab, and I did not count observations of pre-determined categories, like the Gehl methodology demands, I merely explored the activity and noted some general trends of use in the space and along the Torgalmenningen axis.

Loosely basing observation on the Gehl framework gave me a basis from which I could build upon when it came to noting observations. Deciding to observe during different hours of the day and in different weather conditions, over several weeks, allowed me to observe, later analyse observations, and then go back and verify or test ideas and theories.

I did not follow a rigid time schedule for observation, but tested a few different strategies like sitting there for long periods of time, or being there for half an hour at a time, every hour. I also observed at different times of the day, to explore if there was a considerable difference in activities. The times and days of observation can be summed up in table Table 3 and the following list:

- 7 days, 13 hours in total. Day and afternoon on weekdays, day and night on weekend
- 4 days during lunch time (11.30 to 12.30 or 13.00) – both weekdays and a Saturday
- 2 days between 14 and 16.30 (weekdays)
- 3 days at some point between 16.00 and 19.30 (weekdays)
- 1 evening (21.00 to 01.00 (Saturday)

I mostly chose weekdays, because they are the days that show daily use of the space, but also one Saturday to compare, and a short observation on a Sunday to test the hypothesis that people would sit down if it was hot (but no sun). The weather was either sunny and warm (most of the time), sunny and not so warm, or rainy and cold. However, as Bergen is known for being a rainy city, the days of observation were mainly chosen because of the weather.

It is possible that the choice of season affected my results. In late September and early October, it is possible that people have spent a summer outside and are now in work mode. It is possible that if the observation had been done in May or June, that more people would be sitting outside in general, as it is the beginning of summer. But I don’t really know this.

Table 3: Times of observation. Every cell represents 30minutes. Where start and end times are not noted, observation took place for thirty minutes from the hour to half past. Note that the days are chronological, but not days in a row.

Date:	**15.09.2016**	**16.09.2016**	**17.09.2016**	**23.09.2016**	**25.09.2016**	**26.09.2016**	**04.10.2016**
Time / Day	Thursday	Friday	Saturday	Friday	Sunday	Monday	Tuesday
09.00		09:10-09:30					
10.00							
11.00		11:20	11:20				
	11:45						
12.00	12:15	12:20					
			13:00				
13.00							
14.00							
		14:35					
15.00							
		15:30					
16.00							
17.00							
18.00							
19.00					19:05		
20.00							
21.00							
22.00							
23.00							
00.00			00:15				
			01:00				
01.00							
Number of hours	0,5	2,25	3,75	4		1,5	1
TOTAL HOURS	13						

3.6.2 Conversation

I have also conducted one field conversation. It was a planned meeting with a planner in the local municipality, in the beginning of the period of observation. I did not use an interview guide, but had written down a few questions to the planner beforehand (not in order of asking). I asked many other questions and follow-up questions during the conversation, but did not write these down.

- Are there any areas or public open spaces in the city centre that the local municipality would be interested in me looking at?
- Do you use Space Syntax in your planning?
- Do you see any challenges with using Space Syntax in planning?

- What do you think about my classifications for public open spaces, does anything look wrong or is anything missing?

The most notable outcome of the conversation, though not mentioned elsewhere in the thesis, was the affirmation that Johanneskirketrappen was a relevant public open space to study, and that Space Syntax is a tool that is currently being taken into use by local municipalities and is therefore useful to test.

Most of the information from the interview was used to explore ideas and themes, verify my findings and to locate sources and points of investigation.

3.7 Discussion of Methodological Choices

All research has a certain amount of considerations and issues to be discussed with regards to validity and academic rigour. This thesis also has some considerations and points of discussion, on two levels: that of the data material and analyses, and that of my position as a researcher during observation.

With regards to the data material there is especially the drawing and conversion of the axial map that may have affected the results of the integration analyses. As mentioned in chapter 3.5.1, the drawing of the axial map did not always follow the drawing norm. There were also cases of axial lines being split up in several segments, axial lines that were not extended as far as they could, and axial lines that were not drawn around all features in open spaces, only some (further discussed in chapter 5.1).

The mapping of public open spaces was not completely consistent. After finishing the analyses, I have for example discovered a number of the "gatetun"/shared space type, that were not mapped. Combining that with a comment from the *Uterom I tett by report* claiming that people in Bergen have had a tradition of using streets as a public open space, I believe the number of spaces people use as POS is higher than what is mapped in this thesis (further discussed in 5.2.1). Combining this with claims that people often take the street into use as a social space (Carmona et al., 2010), one can assume that the access to public open spaces is substantially higher in Bergen than this analysis shows.

Considering the observation, there is both the issue of perception of me as a researcher by users of the space, and the question of safety. In the first few days of observation, I sat on various benches in the space for long periods of time, with a book and a notebook. The result was that people noticed me sitting there, which may have encouraged others to sit down. After a few days, however, I switched between sitting and leaning against a ledge, writing notes on my phone. That drew less attention to me and I could observe more freely.

I observed one evening and early night. I was alone, in an area that is known for public intoxication and fighting among people, which could have been a risk for my own safety. Also, several people noticed me sitting alone in the space. Some commented on it to their friends (mostly women), others sat down and/or talked to me (only men). However, there was a large number of both people and police around, and strangers surprisingly both talked to and helped others who seemed to be in trouble around me. I still decided to stop the observation around 1 o'clock, as I feared I would draw too much attention to myself by being alone later during the night.

However, there were not many big ethical issues related to the field work, as I did not talk to people, take pictures where people were included, or in any way recorded anything that could identify anyone.

4 RESULTS

In this chapter, I will present the results of the POS classification and accessibility analyses. These results will be further discussed and compared with observation results in the discussion chapter. The chapter begins by analysing the POS maps, the axial integration maps, and the combination of the two, for the entire city centre. Then I will present the results of the all-line analysis for the Torgalmenningen axis.

4.1 Image interpretation and classification

The results of classifying and identifying public open spaces yielded the results seen in Table 3-1. As can be seen there, the localisation of public open spaces in the city centre has a distinct spatial arrangement, depending on the type of space and the type of building structures in the neighbourhood.

Looking at the different categories of spaces and their distributions, a few patterns emerge. See Figure 1-1 for place names.

There are 52 *parks or park-like green spots*, of many sizes (see Figure 4-1 A). The large ones (Nygårdsparken, Nordnesparken and Festningen) are located at the edges of the study area, generally bordering to water, main roads or industrial areas. The smaller parks or green areas (Bryggeparken, Teaterparken, Festplassen, Lille Lungegårdsvann, Botanisk hage) have more central locations. Except for Teaterparken, Byparken and Lille Lungegårdsvann (which are all located close to each other), there are few parks in the middle of the city centre.

There are three *allmennings*[9] and 89 *places* (see Figure 4-1 B) in the dataset. These are largely located in the centre of the study area rather than around the edges. The biggest open spaces are along the axis from Torgalmenningen to Bryggen, including Ole Bulls plass, Torgalmenningen, Fisketorget, Vågsalmenningen and Bryggen. Worth mentioning is also Festplassen and the open square in front of Grieghallen, two large open spaces. They are all among the biggest open spaces in the city centre, and they are all located close to the main streets and shopping areas.

There are 10 *playgrounds* in the study area, but none of them located in the middle of the centre (see Figure 4-1 C). There are 12 *schoolyards* or kindergartens where children can play instead, some of them in the centre. Children frequently play in other spaces as well, like a fountain in Ole Bulls plass or in Byparken.

[9] There are several more allmennings in Bergen, but they are all roads or parking spaces today and are therefore not included in the dataset.

The six *pedestrian streets* are all located in the northern part of the study area (in some of the oldest areas of the city centre, see Roald, 2010), whereas the eight *shared spaces* are all in the southern part of the study area, stretching towards Damsgårdssundet, in areas that were built slightly later (Roald, 2010) (see Figure 4-1 D).

Except for the three largest parks, all the largest POS are located in the area between Fisketorget and Grieghallen (north-south) and Den Nationale Scene (DNS, the theatre) and Bystasjonen (shopping centre and bus station) in a west-east direction. This is also the area with the most economic activity, where you find shops, restaurants, bars, and buildings with public functions (see Figure 2-5).

Looking at the *building mass and its function*, one can see that different types of building mass and functions have different types of public spaces in their vicinity. In the neighbourhoods with the oldest building mass (dating back to between the mid-1500s and 1800s), like in Vågsbunnen and Nøstet, one generally finds dwellings and little economic activity. These areas have many small public open spaces in-between houses (Skreien & Haaland, 2009, Roald, 2010)

The areas that were developed slightly later (mid 1800s to mid 1900s) with a building mass consisting of apartment blocks, like Møhlenpris, Nygård and Torgalmenningen, have no planned POS in-between them (Skreien & Haaland, 2009, Roald, 2010). But these areas are generally in the vicinity of larger spaces and also contain economic activity (see Vik's map of businesses, Figure 2-5). The spaces in these areas are thus bigger and further apart than in the older building mass. In Møhlenpris (which has little economic activity), some of the streets have been turned into shared spaces ("gatetun") that are shared equally between cars and pedestrians.

Adding them all to the same map and not differentiating gives the result seen in Figure 4-2. Here one can see that the high number of POS in Bergen city centre means it is possible to move across the city centre walking almost exclusively through or next to different types of POS. For example from Torgalmenningen to Nordnes, from Torgalmenningen to Festningen and from BI to UiB's Faculty of Humanities.

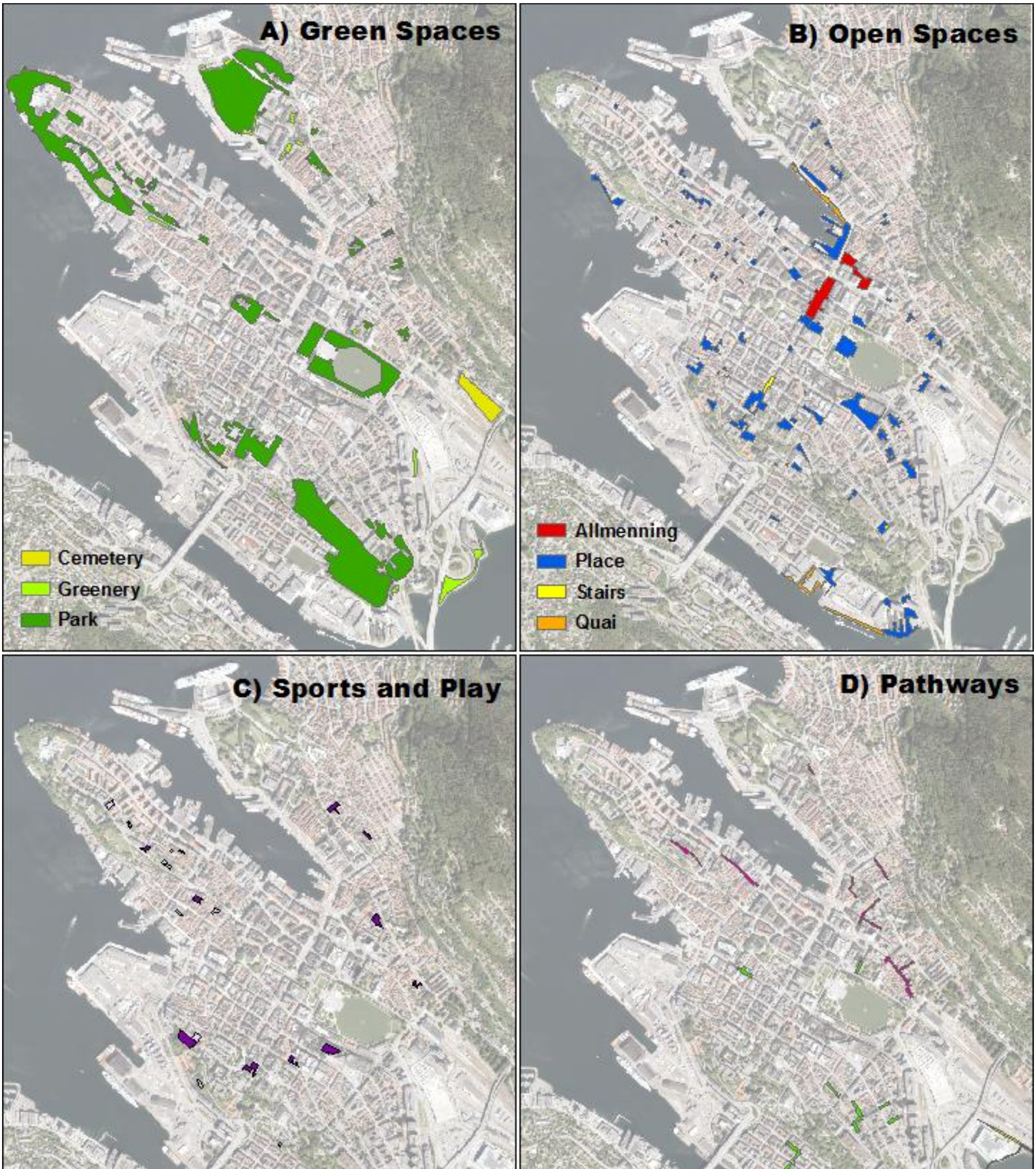


Figure 4-1: Distribution of POS in Bergen. Larger versions can be found in Appendix B and C.

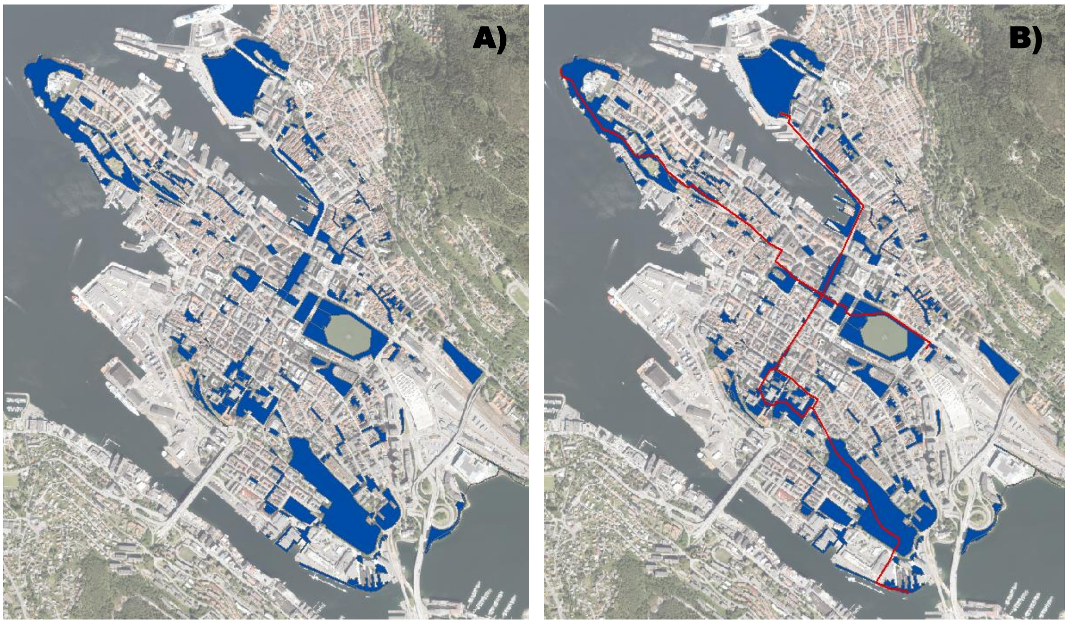


Figure 4-2: POS and paths
*(**A**) All POS in Bergen. (**B**) Potential paths through the centre moving through POS.*

4.2 City Centre

One of the main findings of the integration analyses was that there was not much difference between local (pedestrian, R=3) and global (car-based, R=n) integration (see explanation in chapter 2.4). That means that areas with similar street networks and building types have approximately the same values both locally and globally.

4.2.1 Global integration

Figure 4-3 shows the result of the global integration analysis of Bergen city centre, with labels from Figure 1-1. The streets with the highest integration values are in the centre, and the integration values decrease gradually towards the edges of the area. The longest streets typically have higher integration than shorter streets. The longest straight streets are also the roads most used for motorised traffic though the city centre, like Christies gate (32), Olav Kyrres gate (31) and Nygårdsgaten (21).

Looking at building typology, the areas built with small wooden houses, like Nøstet (5), Klosteret (4) and Marken (27) typically have medium to low integration values. Residential areas with apartment block structure, like around Rosenbergsgaten (10), Nordnes (1) and Møhlenpris (15) have all ranges of integration values, depending on where in the city they are located. Residential apartment block areas on the edges of the study area have lower integration values than the same building structure in the centre.

The areas of the city with business or public service functions and apartment block buildings are typically highly integrated, or in the top classes of the medium range. These areas include streets like Torgalmenningen (30), Vestre Torggate (9), Fisketorget (35) and Bryggen (40), and are amongst the most central streets of the city. This also means that shops, cafés and entertainment are located in the most integrated streets of the city.

4.2.2 Local Integration

Looking at Figure 4-4 of local integration (N=3), it shows the same trend as the global integration: streets with high integration in the middle, and streets with low integration at the edges. However, the gradual change is not as strong as with global integration, and the trend where long streets have higher integration and short streets have lower, is slightly more obvious.

Christies gate (32), Olav Kyrres gate (31) and Nygårdsgaten (21) come out very strongly integrated here. There is presumably most pedestrian traffic there as well, not the least because the two first streets are the main axes for public transportation, and where most of the bus stops are located.

There is a very slight tendency for local clustering, where you see long streets in Nordnes (1) being more strongly integrated locally than globally, and Møhlenpris (15) has higher integration values. You also see a tendency for division, where for example Møhlenpris is separated from the Nygård area (20) by the poorly integrated Nygårdsparken (17).

With regards to building typology and economic activity, the same trend emerges: economic activity and public services are on well-integrated streets, and areas that are mainly dwellings are moderately to less well integrated.

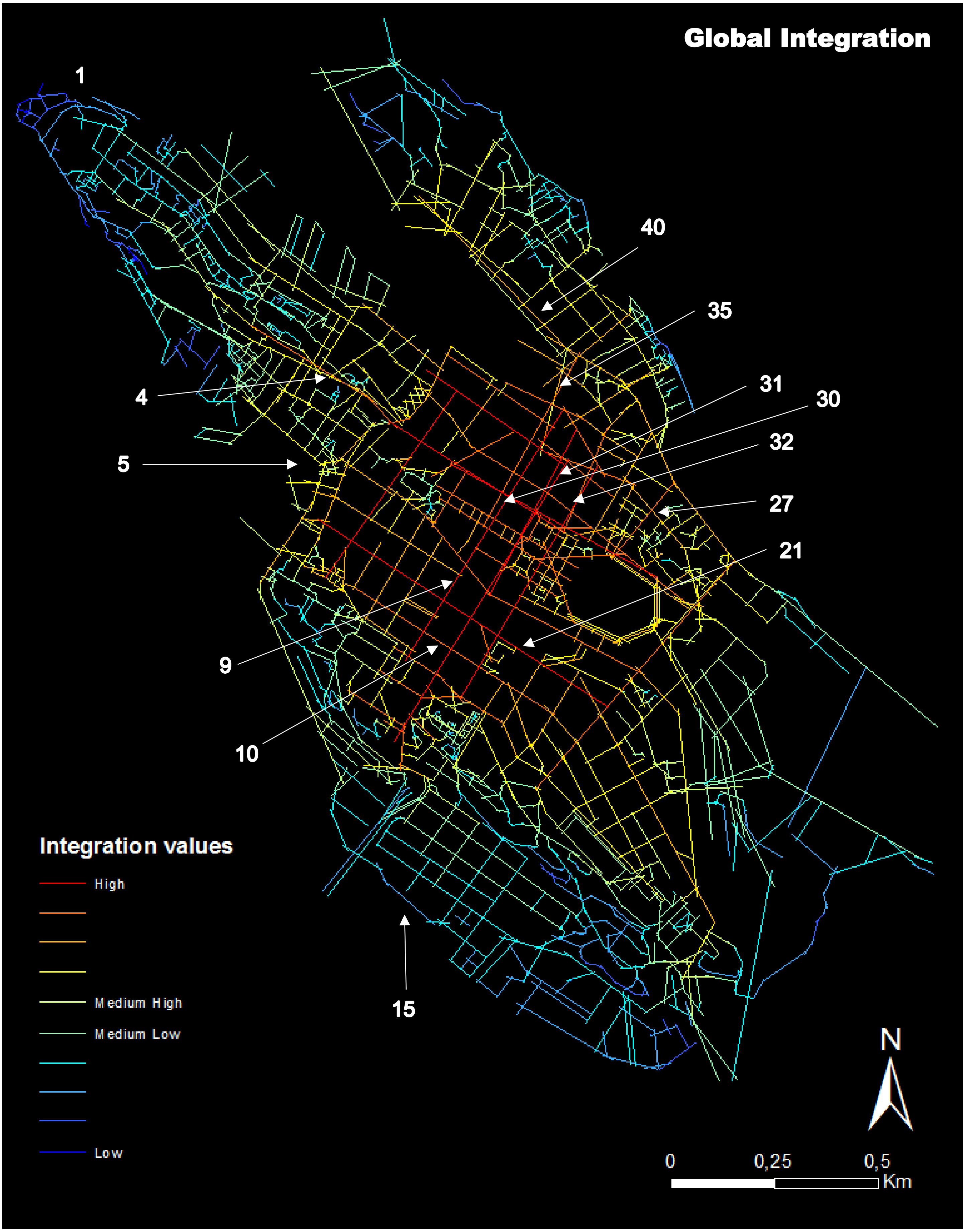


Figure 4-3: Global integration (R=n). See version without labels in appendix D.

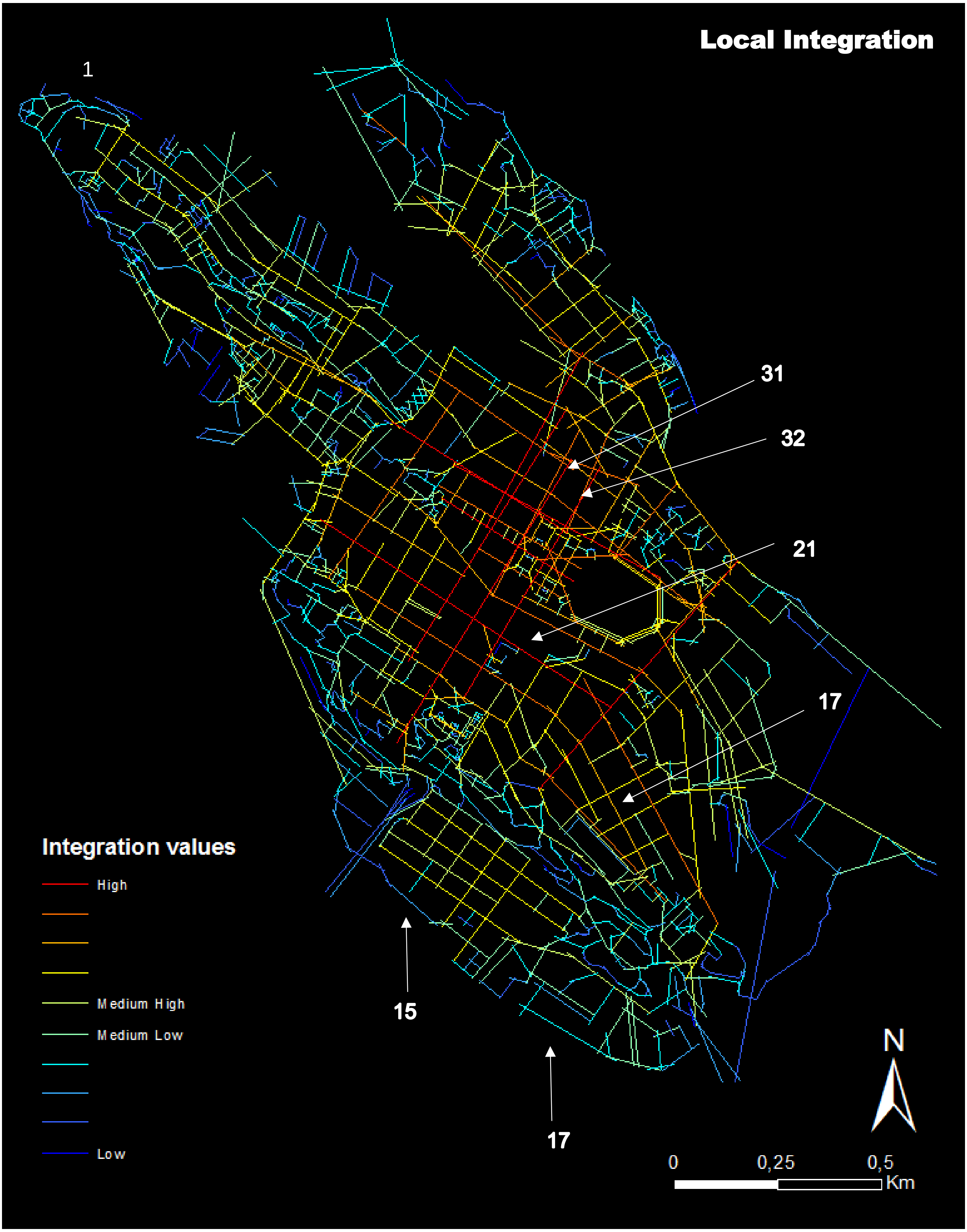


Figure 4-4: Local integration (R=3). See version without labels in appendix E.

4.2.3 Integration and Public Open Spaces

Overlaying the map of all types of public open spaces on the integration analyses, a few trends emerge. Looking at image A in Figure 4-5 (global) and Figure 4-6 (local), one sees that most parks have one or more medium- or well-integrated streets leading *to* the park, but not many compared to how many axial lines enter each park. The global integration analysis has more medium-well integrated streets leading to parks, than the local integration analysis. Walking paths *within* parks are poorly integrated both globally and locally. Most of the paths in the park are in the lower five classes. Other had varying integration values.

Image B shows allmenning, place, stairs and quays. Here another trend emerges; all of the largest public open spaces (Torgalmenningen, Fisketorget, Festplassen, Grieghallen) are located on or near very central axes. It seems that the closer to a well-integrated axis (both globally and locally), the larger the public open space. The Torgalmenningen axis is also distinct here, as it crosses five separate POS, and is highly integrated both locally and globally.

The schoolyards, playgrounds and sports fields in image C are all located outside of the most integrated parts of the city centre. They are generally medium to highly integrated globally, but medium to low locally. Pedestrian streets, walking paths and shared spaces (image D) are generally medium integrated both globally and locally, with little change in classification.

Combining all the beforementioned analyses (classification of POS, global and local integration values and its relation to location of POS) a pattern emerges. Neighbourhoods with a grid-like street configuration and long streets usually have buildings of the apartment block type (areas like Nordnes, Vestre Torggate, Rosenbergsgaten, Møhlenpris). They are all within the five top integration classes, with the exception of Møhlenpris neighbourhood, which has low integration. The most well-integrated of these areas also have a considerable business activity (areas like Torgalmenningen, Festplassen, Bryggen, Lille Lungegårdsvann). Public open spaces in these neighbourhoods are of a medium and large size (when comparing all POS in the study area with each other), where the largest POS are located where there is business activity.

In contrast, neighbourhoods with a more curved street configuration, or where streets are generally short and frequently change directions, is usually populated with small wooden houses of 2-3 stories. There is generally little business activity in these areas. Integration values are over the entire spectrum, but is mostly in the medium and low range. POS are generally smaller here than in the rest of the study area. Examples of areas are Nøstet, Klosteret, Marken, Vågsbunnen.

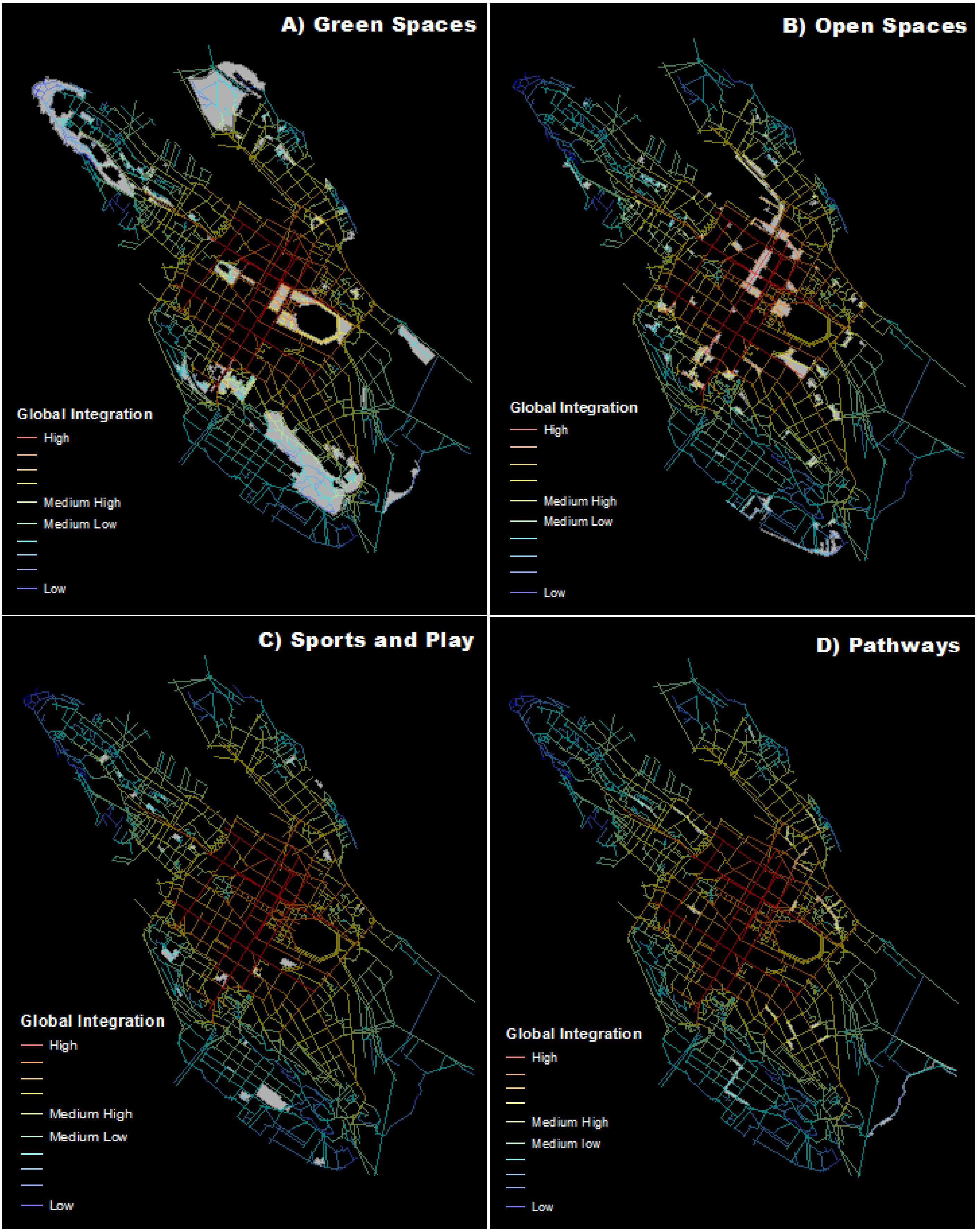


Figure 4-5: Global integration and public open spaces. Larger versions can be found in Appendix F and G.

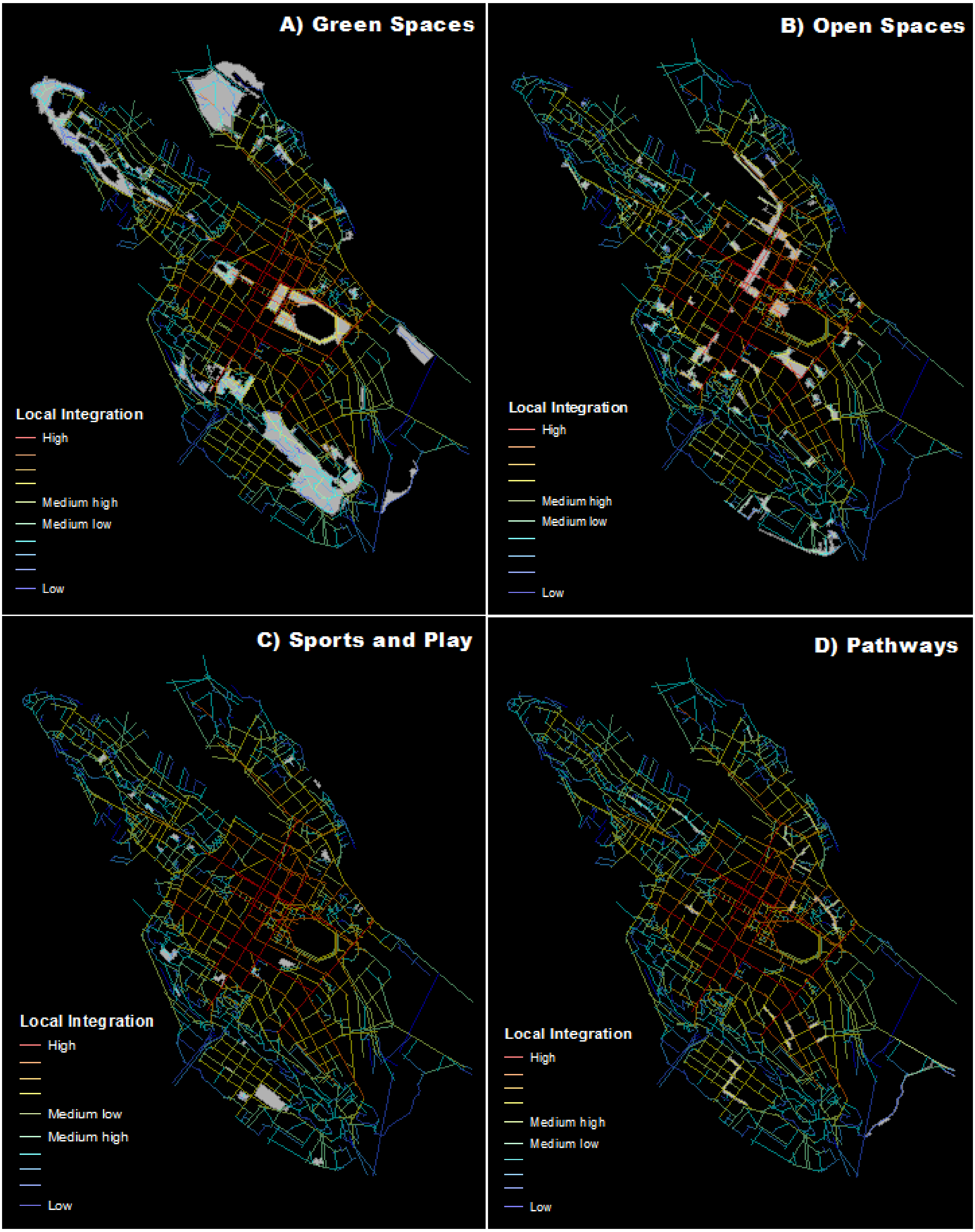


Figure 4-6: Local integration and public open spaces. Larger versions can be found in Appendix H and I.

4.3 Torgalmenningen Axis

In the axial integration analyses, the Torgalmenningen axis comes out as highly integrated, both locally and globally. As does its surroundings.

For the all-line integration I only show the result for the global analysis, as mentioned in chapter 3.5.1. Looking at Figure 4-7, one can see that the highest integration values are found along the Torgalmenningen axis itself, and not in the parallel or crossing streets, even if they are almost

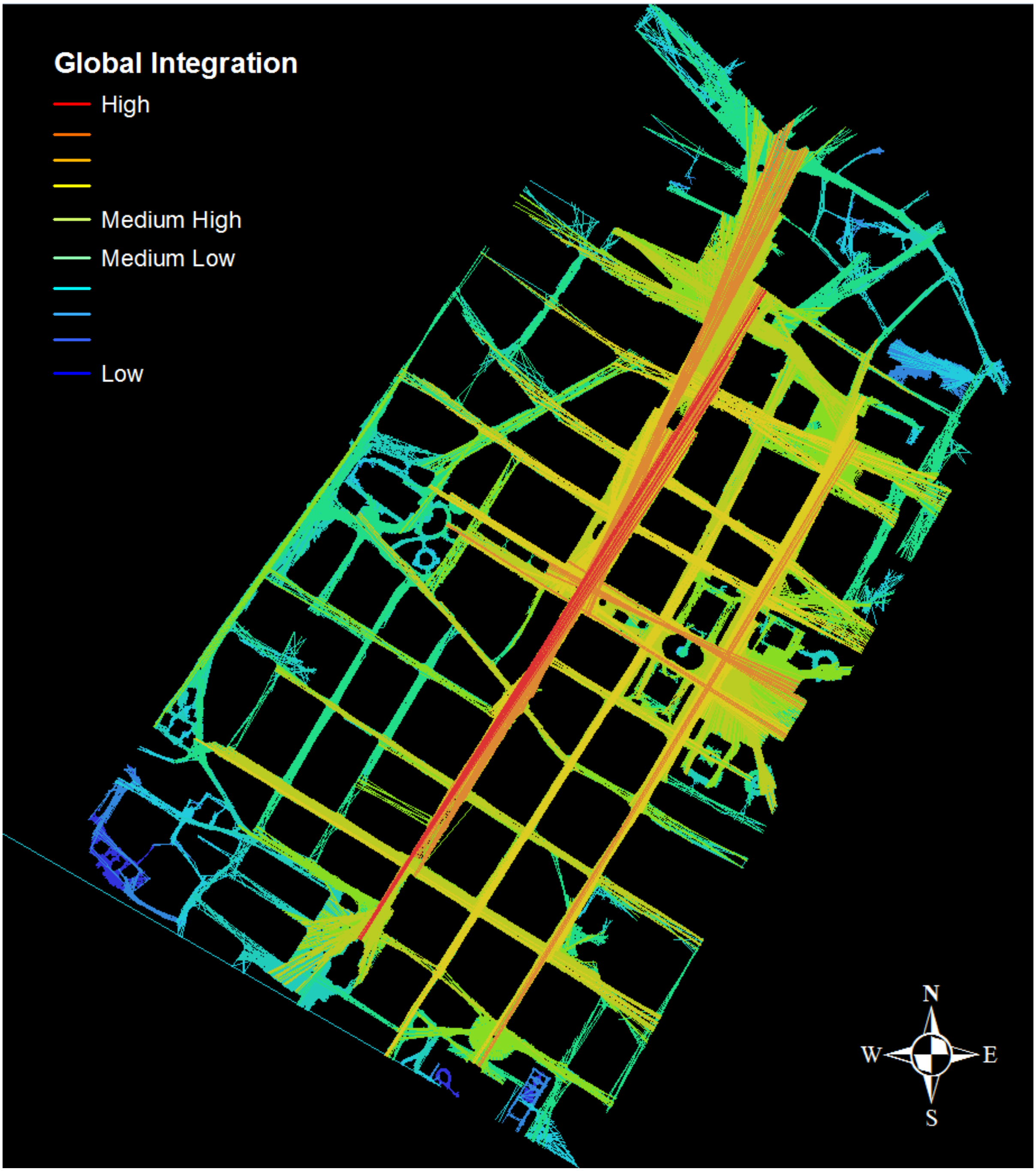


Figure 4-7: Global integration on all-line of Torgalmenningen axis. In convex spaces like Festplassen this analysis shows all possible walking paths and their potential attractivity..

the same length. Due to the edge effect, spaces closer to the edges of the study area, and especially in the corners, have lower integration.

Looking at the axis itself, integration is highest on the the east side of Torgalmenningen, moving diagonally to the west side of the street when it reaches Johanneskirketrappen. It is also very high diagonally across Torgalmenningen from the north to the south. That means people are most likely to follow those paths when walking through the space. Crossing the Torgalmenningen axis is most likely to happen in the middle, in Ole Bulls plass.

During observation it became clear that a space may have the same integration value and potential use, without being equally used by people. There would usually be few people in Johanneskirketrappen, but the POS in Vestre Torggate would be well-visited and often filled with people (which is possible due to its small size), and there would be even more people in Torgalmenningen.

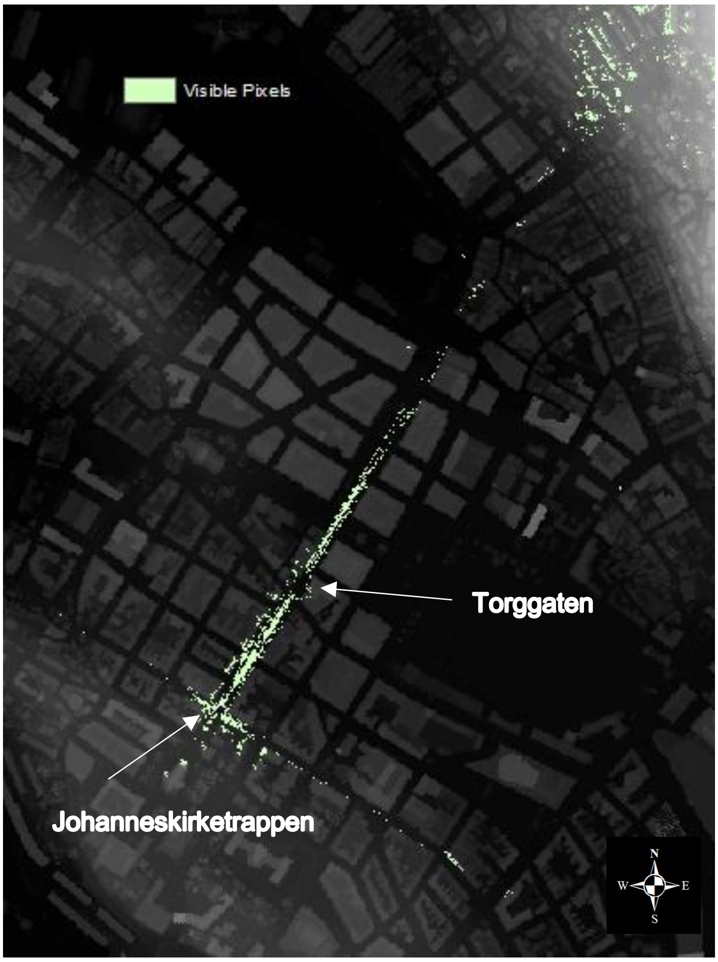


Figure 4-8: Viewshed analysis of visibility from a 2m height in Johanneskirketrappen.

Although axial lines are supposed to be sight lines (Hillier, 2007), observation and Viewshed analysis showed that in a city with hills, like Bergen, one cannot always see the entire length of the axial lines, as the theory supposes. This was confirmed by the viewshed analysis. Looking at Figure 4-8, the viewshed shows that one can see approximately one block to the west, three blocks to the east and one block south. One can see the street in approximately six of the nine blocks along Torgalmenningen, but they are not continuous due to an away-facing slope in Torggaten.

4.4 Johanneskirketrappen

The results from Johanneskirketrappen came from axial and all-line integration analyses in chapters 4.2 and 4.3, and observation.

The *integration results* for Johanneskirketrappen showed that the space is well integrated both globally and locally, and located in close proximity to the most central part of the city centre. The integration analyses show that people are more likely to walk through the space going up or down the stairs (north-south) than to follow Rosenbergsgaten across the space (east-west). The all-line integration also showed that people are slightly more likely to walk up or down the stairs on the west side of Johanneskirketrappen, than on the east side. People are also less likely to walk up the middle than on the sides. All of these results were confirmed by observation.

Looking at the *shape and size*, the space is 23m wide and 45m long, with building heights of 15m. If one measures width (23m) to height (15m), the space has a 1:1,5 width to height ratio. This means that the space does not have the ideal ratio. But, the space still gives the impression of being a quite open space.

The *design* of the space was illustrated in . The stairs are partly shielded from the wind and rain by the buildings facing the space, and there is sun at least for a few hours every day. Most of the space made for sitting in Johanneskirketrappen (the middle stairs and benches) is in the middle of the stairs, with walking stairs on the east and west sides. There are also benches in the open square on top of the stairs, and flowerbeds with sittable ledges lining the open square. The seats on the stairs and benches are all to the side of the pedestrian flow, whereas the flowerbeds are in the middle of the pedestrian flow.

People who sat down on the benches or on the stairs seemed to make a conscious decision to sit down, and often sat for a while, whereas people who sat down on the flowerbeds seemed to sit down without thinking much about it, and were often waiting for someone. All in all, fewer people sat down on the flowerbeds than in the rest of the space.

However, more important than the opportunities for sitting, was the weather. Whether or not people sat down seemed to be dependent on temperature and sun conditions. If it was warm and sunny, or warm and overcast, people would sit everywhere in the space. If it was sunny but warm, people would sit in the sun. If it was neither sunny nor warm, people would avoid sitting down, even if they were waiting for someone. If it rained, people would avoid stopping at all.

The POS has building entrances facing directly onto the space on the east side, and semi directly (through a garden) on the west side. All buildings have many windows, and there is good intervisibility between buildings. However, from observation it seemed that most of the people using the space did not live in any of the buildings facing the POS. Most of the traffic was through-traffic originating in different places.

Johanneskirketrappen has a lack of *activities and attractions*. The surrounding blocks are mainly by apartment blocks with flats. There are few attractions in or facing the space, but there are shops on the next block (in Vestre Torggate). The only permanent attractions found in the space are two fountains and a channel for running water, which attracted mainly children and tourists. There are also some flowerpots that were frequently photographed, and the view, which many people stopped to admire.

The activities that people do themselves can be put in the into the Gehl framework in Figure 2-6. The result can be found in Figure 4-9. Here, I have put activities into the same categories as Gehl, or a category I found comparable[10].

Most of the recorded activities are on the necessary side of the spectrum, and these were also the activities most commonly performed in the space. It was my impression that more people used the space for necessary activities than for optional ones. I did not do a formal count, but I would estimate that during my observation, more than ¾ of people used the space for necessary activities, where most of them walked through in one way or another.

With regards to *who* used the Johanneskirken POS, there were mostly adults, and some children accompanied by parents or teachers. Listening to conversations revealed that most people using the space were Norwegian speaking, although there were some international students and a few tourists (the number of tourists is probably much higher in the tourist season). There seemed to be an equal distribution of men and women, suggesting that this is most likely a *safe* POS (van Nes, 2014, Gehl & Svarre, 2013).

An important point to make when discussing use of Johanneskirketrappen, is that some user grops rarely moved according to expectation or theory on Space Syntax and movement in cities in general.

[10] As the Gehl framework was created in 1968, certain activities (like using one's phone) did not have a category. These activities were classified according to similar activities found in the framework. Using one's phone is very likely to be for some kind of communication, and was therefore classified as a necessary activity.

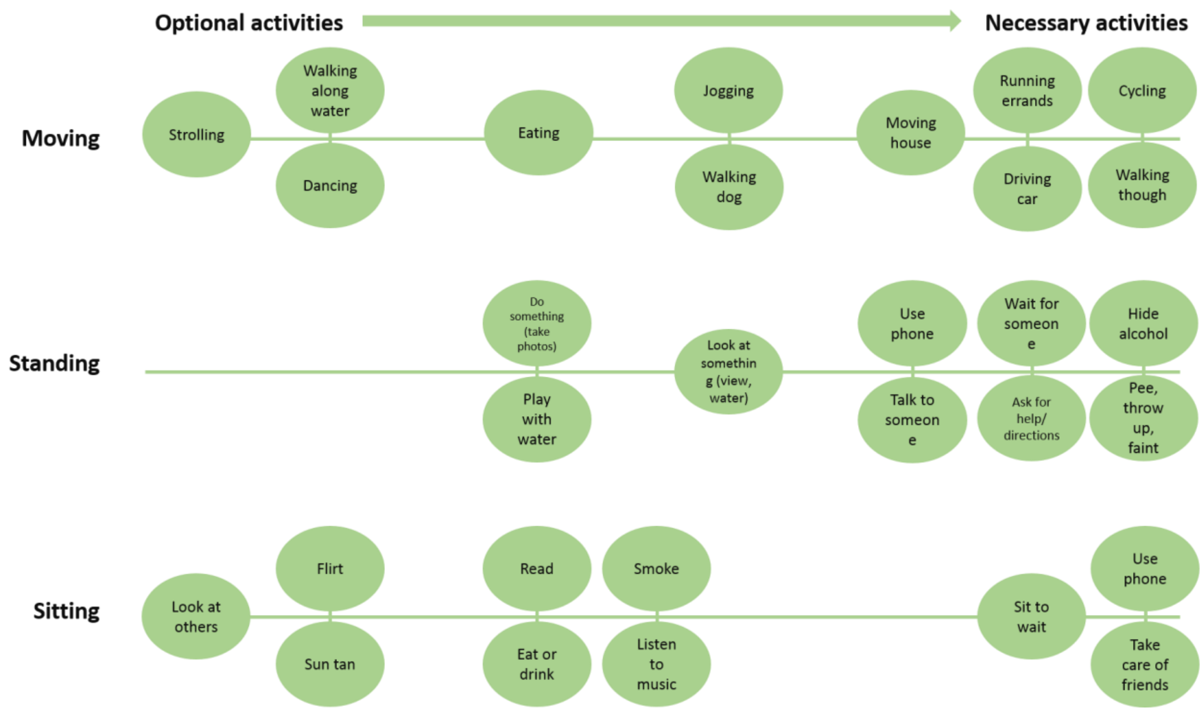


Figure 4-9: What do people do in Johanneskirketrappen? Figure after Gehl & Svarre, 2013.

Children observed in Johanneskirketrappen did not seem to care the least about following the straightest path from A to B (unless led that way by their parents), and if left in charge of the path through the space, would criss-cross it in different ways, often choosing to follow the water channel running down the steps. They would also often be attracted to the water fountains or the flowerbeds, walking purposively towards them to investigate, or suddenly run off to one side to look at something.

Another interesting group were cyclists, who could not cycle up the staircase, and would either carry their bikes up take a different path. People in wheelchairs are in the same situation, where topography and stairs are obstacles that require taking different paths (Moe & Algerøy, 2015).

5 DISCUSSION

In this chapter, I will discuss the various methods I have used, their validity and use, how the different results relate to each other, and how these results and analyses best can be combined with each other and contribute to the planning of public open spaces.

5.1 Discussion of Methods and Datasets

To answer research question 1 about how integration analyses can be used in the planning of public open spaces, I will first discuss the methods (with their advantages and shortcomings) and the datasets used for the analyses in this thesis.

5.1.1 Classifications

Interpreting aerial images and classifying public open spaces was more difficult than expected, especially when encountering spaces that fit into several area categories, or spaces that had an unclear purpose. This means a large part of the image interpretation and accompanying ground verification was based on my subjective judgement. However, Srivastava & Narayan (1974), conclude that interpretation done by someone who knows the area is one of the most accurate methods of classification, and this subjective judgement was based both on interpretation of aerial photos, use of digital tools like Google Street View and ground verification where I visited and explored all unclear spaces.

Combining image interpretation with ground verification has been common practice for many years when determining land use (Srivastava & Narayan, 1974). However, in this case the ground verification served not only to get a clearer view of the physical dimension of the space and to determine POS class. Observation also aided in determining if there was any kind of social dimension of the spaces, which was important for distinguishing between POS classes. Visual clues like children playing, toys lying around or drug addicts hiding behind rubbish bins, helped determine if a space was in use, and how. Other visual and auditory clues, like steep slopes, tall walls or a substantial amount of heavy traffic passing a very small space, often gave clues if space was unlikely to be in use and therefore should not be mapped.

The classifications used for the mapping was developed throughout the mapping process. It started as a mix of classifications from other research projects, but was modified and changed continually throughout the mapping process, to include and logically group all POS types in Bergen city centre. Doing this allowed me to specify what POS types exist in Bergen, how they are different from each other, and probably contributed to making the map more detailed.

Some difficulty arised when different POS types have the same function but are inherently different in character, like *pedestrian streets* (that are lined by shops and buildings), and *pedestrian walking paths* (that are away from buildings and closer to nature). Or in the case of *allmenning*, where an allmenning can be both a public open space (Torgalmenningen, Vågsalmenningen), or it could be a zigzagging street on a hill, with small slices of greenery in between (Nykirkealmenningen, Korskirkealmenningen). A number of these considerations were made throughout, and each case was classified and included or excluded separately. Using larger classes that incorporated more spaces in one could have eased the mapping, but would also have given less detailed information about the geographical spread and accessibility of different POS types.

The *Uterom I tett by* report did not include pedestrian streets. This was partly because they were difficult to distinguish from regular streets in maps, and partly because people also use perfectly regular streets as POS, and that is impossible to know from a map or an aerial photo (Asplan Viak & Spacescape, n.d.). All the streets mapped in the pathways category of this thesis were mapped because I knew they were pedestrian, or because I stumbled upon them while doing field work. I therefore missed a number of streets used as POS and shared spaces that I did not know about (but found by chance after finishing the analyses). Checking if there existed a register of pedestrian streets and shared spaces before mapping would have increased the validity and usefulness of the mapping of these types of POS. If I had had the time and resources, mapping streets that showed characteristics of being used as POS could have been an interesting supplement.

5.1.2 Integration Analyses

Results of integration analyses are mainly dependent on two factors: the parameters of the analyses and the configuration of the data layers used. This means there are a number of methodological choices that have to be made in order to run integration analyses. In this section I will go through and discuss them, their validity and potential sources of error, and how they can contribute to the planning of public open spaces.

5.1.2.1 Axial Integration and Data Layers

The results of the integration analyses on axial maps are mainly dependent on three things: how many streets are in the dataset, their location in relation and in connection to each other, and the configuration of the street network. In this thesis there are two main points of discussion in regards to the number of streets and their relations, both related to how the axial data layers were created.

The first main point of discussion is what street network layer one uses to draw the axial map. This is discussed in chapter 3.5, where I made the choice to use building outlines to complement road data, to include streets only accessible for pedestrians. That meant the number of streets in my dataset was higher than if I had used road data. It also meant I included several open spaces in the city that were in-between buildings and not in the road network (see Figure 5-1).

Figure 3-5 shows examples of differences in open space using the road network and building outlines. Figure 5-1 shows a similar example from Nøstet, where the number of axial links is higher than what the road network suggests. Using buildings therefore gives a number of new connections between public open spaces that are not present in the road layer. Having lived in the area myself, and frequently went walking here, I know that people use these narrow pathways that are not mapped in the road layer. They thus have a function for people, and including them increases the validity of the dataset.

However, if one is creating axial maps for larger areas than in this thesis (for example large cities), it may be too time consuming to include every possible path. And since these pedestrian paths are often short and poorly integrated, they are unlikely to have a big effect on overall accessibility. In that case, using road data is likely to be the best option.

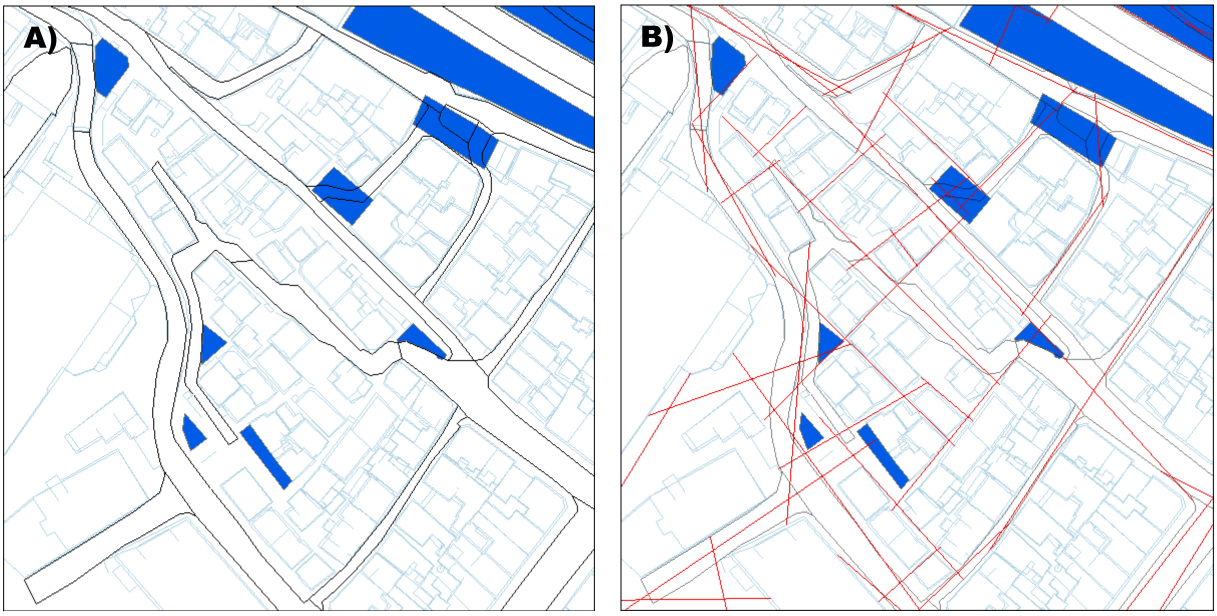


Figure 5-1: Differences in accessibility
*(**A**) POS (coloured squares) overlaid on road layer. (**B**) POS and axial lines overlaid on road layer.*

The second main point of discussion is whether or not one includes all axial lines around all features or not. The Space Syntax drawing rules state that one should draw every line on every side of every feature in space (Turner, Penn & Hillier, 2005). However, neither road nor building layers include features like rubbish bins, flowerbeds or fences. That means one may have to use for example aerial photos to fill in these features and draw axial lines around them.

Including every feature in space, and drawing axial lines around every feature can be extremely time consuming in a large dataset. That is why, for this data layer, I only drew the main axial lines through spaces, not including ones around for example benches and rubbish bins. This is in accordance with Batty & Rana's discussion of the scale or resolution of the data (2008). My own tests also showed that changing only a few axial lines in the dataset did not change the integration values by more than a class or two up or down, and I have been consistent throughout the dataset. Including all lines would therefore have had little effect on the outcome.

When determining how to draw the axial map, one should consider what the use of the axial map is – and what analyses one wants to run on it. If one is looking at motorised traffic, including benches is not necessary. If one is analysing general pedestrian accessibility of a large area, drawing the main axial lines crossing a space may be enough, as one is looking at accessibility through a bigger area. However, if one wants to analyse smaller spaces and how people can potentially move through a single space or a number of smaller spaces, including all axial lines around all features is likely to be necessary. Unless one chooses to use an all-line map.

The configuration of the street network has an effect on the outcome of all axial analyses (integration, step depth, etc,). Since axial lines are straight lines, every turn in the street requires drawing a new axial line. This means that long, straight streets get long, straight axial lines, and are likely to be crossed by more streets than streets that bend and require several axial lines. This means cities and neighbourhoods with a block structure or grid street network and long, straight streets are more likely to be highly integrated than cities and neighbourhoods with curved and shorter streets.

That is why integration analyses should be combined with other urban analyses, such as where attractions and important functions are, where people live, and what one wants to achieve with the analysis. For example, if one wants to plan a small, secluded POS (like the ones mentioned in chapter 5.2.1), they should be planned on streets that are not highly integrated. It then does not matter if long streets are generally more highly integrated.

This is visible in the street network of Bergen. The neighbourhoods with a grid-like street network (for example the most central areas) are more highly integrated than the neighbourhoods with curved and short streets (like Nøstet). It is especially visible in parks. The walking paths within parks are very curved and comprised of a high number of axial lines, which means they get low integration values. That is one of the reasons why parks in Bergen have low integration values, and why they are less well-integrated than the POS in the open space class. Another reason for this (and also another thing that may create bias in the analysis) is the edge effect.

5.1.2.2 All-line Integration

There are a number of potential uses for all-line integration maps compared to axial maps. All-line analyses are especially useful for analysing openness and flows through spaces, by analysing the number and integration of axial lines entering and crossing a space.

Spaces that are visible to people are more in use than spaces that are not (Whyte, 1988a). Running all-line analyses on a POS will show how many entrances there are to a space, how wide these entrances are, what paths run through the space, and from what directions people are most likely to see it and enter it. If one is developing a new space, an all-line analysis can help in deciding what way to face features in the space due to what directions people are most likely to come from, or to identify planned or existing features that may inhibit the flow through the space because of their location or shape.

Furthermore, all-line analyses can say something about the potential flows through the space. Festplassen does not have any features in the middle, ensuring that people can walk in straight lines across it. Figure 5-2 shows an all-line map (without integration values) of Festplassen. It shows that it is a very open space, with many potential entrances, but that people are most likely to see and enter it from the west side, as this is the most open side (towards the theatre and Torgalmenningen). If one were to develop it further, ensuring that the visibility from that side is maintained can be important.

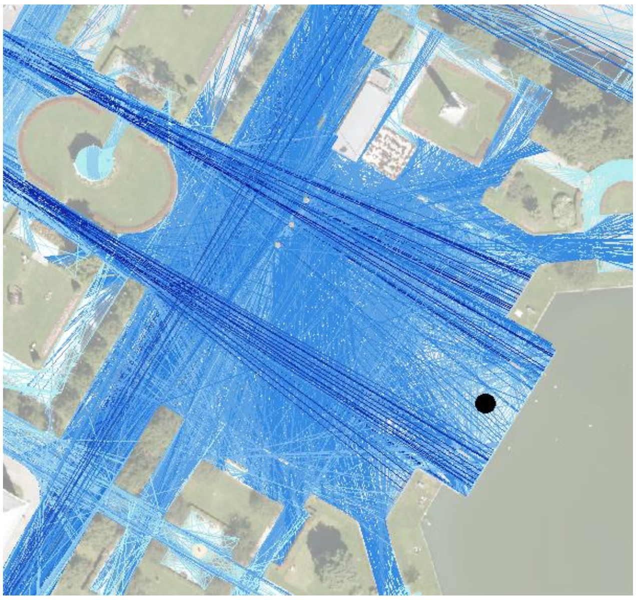


Figure 5-2: All-line map of Festplassen and Festparken. The black dot marks the part of the space where concert stages are usually placed, with the back to the water. Colour scale here represents length of lines, not integration values.

However, keeping entrances from all sides is fundamentally important. This is something that is tested by for example Hillier (2007), who found that centrally placed open spaces, that were accessible from all sides, were more connected and more highly integrated than peripherally placed POS that were not accessible from all sides.

If one were to close Festplassen on one or more sides, both accessibility and visibility would decrease. It is perhaps for that reason that when there are outdoor concerts in the space, the stage is always placed on the east side of the square, with the back to the water (see Figure 5-2). Doing so ensures natural movement through the space during the time when the stage is rigged up and down, and also makes the stage an attraction that is visible from other well-integrated streets (Torgalmenningen and Olav Kyrres gate), that may attract people.

5.1.3 Observation

The observation had the double intention of uncovering the social dimension of the Johanneskirketrappen POS and the actions that took place there, and act as a cross-reference for the results of the integration analyses of the Torgalmenningen axis.

Using a pre-defined framework, but only keeping loosely to it was very beneficial in this study. As the Gehl framework was from the 1960s, sticking completely to it would have meant only noting activities within the existing categories, and not noting activities like using phones or listening to music. It would also mean not being open to observations that did not fit in a category, like observation of how different groups behaved.

Observing on different days and different times of the day allowed for the observation of a larger range of activities. In Johanneskirketrappen, different activities and behaviours took place during daytime and night time, although that is not used for further analysis here [11].

A factor be aware of when observing social phenomena is that the observer may interpret social situations and actions differently than the actors performing them (Kearns, 2010). It is therefore necessary to be aware of one's interpretations while observing, and open for alternative explanations than what may immediately seem to be happening.

While observing in Johanneskirketrappen, I did not delve deep as into the social dimension, interactions and relations of the space as originally intended, and potential wrongful interpretation of actions was therefore not a big issue. I rather sought to describe and identify

[11] Activities are not separated by time of day in the results as it is not necessary to answer the research questions

(rather than interpret) activities and social practices relating to the use of the space. This resulted in the activities presented in Figure 4-9 and the patterns of use presented in chapter 4.4.

To complement this analysis further it could have been useful to talk to users of the space, for example to ask them why they do or do not use the space or to ask for comments about the space's design. Talking to passers-by inhabitants of nearby buildings, asking about uses of the space, if they observed any patterns or habits in people's use and how they found the quality of the space could have shed further light on the social dimension of Johanneskirketrappen.

It is the same if one intends to use observation in planning public open spaces. Planners could then benefit from talking not only the people who will be using the POS in planning, but to users of similar spaces elsewhere. That will complement the planner's own observation, descriptions and interpretations, and there is potential to evaluate whether experiences from one space can be used in the development of another.

5.1.4 Method Use and User Groups

An important point to make about integration analyses on both axial and all-line datasets, is that they are not suitable when planning for all user groups. Some groups do not move according to expectation, while others are restricted from doing so by the physical environment.

An example is children, who rarely followed the straightest path but were unusually attracted to attractions (see chapter 4.4). Although the data material on this is too small to draw any definitive conclusions, my results suggest that integration analyses are not a suitable tool when planning for children.

Another group that integration analyses are not necessarily suitable for, is people moving on wheels. Cyclists would have to carry their bikes or take a longer path to avoid the stairs of Johanneskirketrappen, or any stairs or steep slopes. The same problem will arise for example for people in wheelchairs (who usually cannot carry their chair, but could be carried by someone else) and people with babies in prams. The two-dimensional representation of axial lines and shortest paths does not account for topography and ground cover, and will therefore have to be combined with other analyses to accommodate the needs of these user groups.

Looking back at chapter 2.6, one may realise that axial maps do not account for alternative movement besides walking or driving. Axial lines are always drawn around features, not across them. Like in the example of the benches, user groups like children, cyclists and skateboarders, or even parkour artists and urban climbers, could absolutely move across the benches (or other features in space, like fences, statues and the likes) in different ways than the axial maps suggest. One could argue, however, that since most people are not skateboarders or urban climbers, that integration analyses are useful for mapping the potential movement of large populations moving in conventional fashions (walking, driving). And, unfortunately, less suited for groups with unconventional movement patterns.

When planning for user groups that do not move according to theory, planners could benefit from downplaying the role of integration analyses, and to put more weight on other methods that are more suitable for said groups.

5.2 Discussion of Results

In accordance with research question 2, one can say that the results of the integration analyses (axial and all-line integration) in some cases compare well with each other and with actual use, and in some cases do not.

5.2.1 City Centre

The integration analyses of Bergen city centre correlate well with reality. The area with high integration locally and globally is the middle of the city centre, and is the area with the most traffic, both pedestrian and motorised. It is also the main public transportation node (see chapter 4.2). It is also the area with the highest frequency of economic activity (see Figure 2-5). The streets with the highest integration in both the global and local analyses are the main transportation axes of the city (Torgalmenningen axis, Nygårdsgaten, Olav Kyrres gate, Christies gate and Strømgaten, see Figure 1-1).

The results did not show much difference between global (R=n) and local integration (R=3). Many streets retained the same integration value in the two analyses, or changed only one or two classes up or down in terms of integration value (see Figure 4-3 and Figure 4-4). Running these analyses on bigger datasets usually yields results where streets get vastly different values with global and local integration, where global integration correlates with city-wide motorised traffic and local integration with localised pedestrian traffic (see eg. Penn, Hillier, Bannister & Xu, 1998, Carmona et al, 2010).

This is very likely due to a combination of the small size, the natural borders to the sea and the partly grid-structured street network in the city centre. This combination means one can get through much of the city centre with only three axial line changes, and it seems it is for this reason that the differences between the two datasets is small.

The classification of public open spaces showed a spatial pattern. When analysing the street network configuration and building typology in the city centre, I found that areas with grid-like street networks tend to have apartment block buildings and large POS. The economic centre of the study area is located in such an area. There are few POS in these areas, but the ones that are there are fairly large. On the other hand, areas with less grid-like street networks, lower wooden houses and less economic activity seem to coincide, and have more and smaller POS.

This is most likely due to the idea of architecture and POS in the time period the different areas were developed. The areas with large POS were developed in a time when public spaces were imagined to be grand places, well designed and impressive (Roald, 2010). They were seen to be important for people's well being and for the image of the city. It is highly likely that "visitors" (i.e. people travelling through but not living in the area) stand for most of the use of these large POS (Oh & Jeong, 2007).

In contrast, the older neighbourhoods with wooden buildings were not as meticulously planned as the apartment block neighbourhoods (to the degree they were even planned at all). The POS in these areas may therefore have appeared more or less by chance during the rebuilding of houses (Roald, 2010). The POS that exist there today were most likely not part of any kind of grand plan from the local municipality's side, an assumption that can be strengthened by their small size, and sometimes inconspicuous and rather hidden location in-between buildings.

However, they have most likely been intended to, and probably also have, a function as local POS for residents in the area, much like small, local parks in Seoul, and their use is presumably mostly comprised of local residents (Oh & Jeong, 2007).

POS types *playground, schoolyard, sports field, pedestrian street, walking path and shared space* are all located outside of the most integrated part of the city centre. This is most likely due to the most integrated part of the centre being well-covered by *parks, greenery, allmenning, place, stairs and quays*.

The *Uterom i tett by report* concludes that:

"*The hierarchy of outdoor spaces in the areas is not well enough connected to the pedestrian network of the city. […] Shopping streets, squares, allmennings and parks need better connections to pedestrian paths and streets where people actually move.*" (p. 228, own translation).

The results of my analysis show the opposite. I found that most of the big open spaces in the city centre (*allmenning, place, stairs and quay*) are well connected to the pedestrian network, as are many of the medium and small sized green spaces (see Figure 4-5). The frequency of POS is so high that one can cross the city centre and move almost continually through POS or pedestrian streets (see Figure 4-2).

However, it is clear that the study area in my study is bigger than the study area in the *Uterom I tett by report* (see Asplan Viak & Spacescape, n.d., p. 79 and 85). That, in addition to the inclusion of pedestrian and shared space streets means that the overall number of POS included in the study is also higher.

The three largest parks (Nordnesparken, Nygårdsparken and Festningen) are all poorly integrated (within the lowest three classes). This is mainly due to two factors: the configuration of the street networks around the parks, and the edge effect, since they all border to the sea or are fenced off.

When the weather is good, the parks are filled to the brim with people, regardless of not being highly integrated. That may indicate that parks are attractions in themselves, perhaps to a higher degree than other POS types that require a certain proximity to people to be in use. In addition, one should remember that the axial line step distance that determines integration is not the same as walking distance. Parks in Bergen are poorly integrated, but one can reach all of them within 20minutes of walking from Torgalmenningen (as calculated by Google Maps). Most people living within the study area then live closer than 20minutes walking from a park, which may explain part of their attraction.

One can also point to the fact that Baran, Rodriguez & Khattak (2008) found a negative correlation between local integration values and leisure walking. That means that streets with low local integration values are more likely to be used as a path for leisure walking than streets with high local integration values. They point to lack of car-based traffic as a possible explanation. As the large parks are generally poorly integrated (both locally and globally) in Bergen city centre, this could be one explanation for their use.

Comparing with building typologies, integration analyses show the pattern where the older neighbourhoods are medium to poorly integrated, while the newer neighbourhoods are highly integrated, both globally and locally. This means that a lot of the smaller POS in Bergen are located in areas that potentially has a low number of pedestrians, except for people living there. But that is not necessarily a bad thing. The size of the POS and the number of seating places and activities that can be performed there delimits how many people can use the space at one time. Many of the POS in the Klosteret and Nøstet area are, for example, small and may only hold a bench or two, or a small playground.

Perhaps, then, one could say that the size of the POS should stand in relation to the demand from its surroundings. A large POS may feel empty and out of place in a neighbourhood with low integration and consequently little pedestrian traffic and few people – and a small POS may become overused and subject to substantial degradation if located in a well-integrated area that is well frequented. At the same time, the slightly more secluded location and less traffic of the small POS, or the business of the larger POS, may be attractions in itself (Baran, Rodriguez & Khattak, 2008).

5.2.2 Torgalmenningen Axis

As shown in Figure 4-3 and Figure 4-4, the Torgalmenningen axis is in the highest integration class. Figure 4-7 further shows that the pedestrian flow along the Torgalmenningen axis is likely to be highest on the east side of Vågsalmenningen and Torgalmenningen, and on the west side between Ole Bulls plass and Johanneskirken.

I do not have results from observation to affirm this. However, observation showed that, contrary to what axial lines may indicate, the actual use varied along the axis. Users were clustered in certain areas (Vågsalmenningen to Vestre Torggate, and especially in Torgalmenningen), and less in other areas (Vestre Torggate to Johanneskirken). The part of the axis with the most use is the area in Torgalmenningen with the most economic activity, which is closest to public transportation nodes and other highly integrated streets. Whereas the part with less use (including Johanneskirketrappen) had less or no economic activity, no public transportation and is surrounded by streets with medium or poor integration values.

During observation, there were always more people in the POS' in Vestre Torggate and Torgalmenningen than in Johanneskirketrappen. The POS in Vestre Torggate and Torgalmenningen also saw most people just walking through, but both also had a larger portion of optional activities; particularly people sitting down. The POS in Vestre Torggate is much smaller than Johanneskirketrappen, but had more people sitting down at all times. Torgalmenningen is larger than both of the two others, and had the most people out of the three spaces at all times.

These two spaces are closer to the middle of the axis, have a number of attractions facing them (a number of different types of businesses and cafés), are in closer proximity to public transportation, and are surrounded by several streets with high integration. They also both have a lot of seating, all in the middle of pedestrian flow, which may encourage people to sit down there.

In contrast, Johanneskirketrappen does not have a single business facing it directly, is further away in walking distance (and uphill) from public transportation and the most used part of the axis, and is surrounded by streets with lower integration values. Therefore, people are less likely to use this POS as an attraction in itself, and also less likely to walk through it on their way to another attraction nearby.

Both Vestre Torggate and Torgalmenningen have food businesses facing them on several sides, something which has been shown to attract people (Whyte 1998a, Ståhle, 2008). They are also closer to other highly integrated streets and other attractions. Johanneskirketrappen is located on the same highly integrated axis, but is lacking in attractions that may entice people to spend time there. A reasonable explanation then, could be that people are more likely to choose to move through Johanneskirketrappen on their way to somewhere else, than the surrounding (less well-integrated) streets, but the space itself does not have a strong enough attraction to act as a destination where people stop or sit down (Ståhle, 2008). Unlike the two other POS on the axis.

5.2.3 Johanneskirketrappen

Going through the methods and criteria for good public open spaces in order, a few trends emerge in Johanneskirketrappen. *Integration results* showed that people were more likely to walk through the space in a north/south direction (up/down) than east/west (following Rosenbergsgaten). They are also more likely to walk up or down the stairs on the west side of the space than the middle or the east (see Figure 4-7).

Observation showed the same result: most people walked up or down, and most people walked on the west side of the space. This is very likely due to that being along the longest straight line one can walk through the Torgalmenningen axis, unlike the east side that requires a directional change at one point or another, or the middle part which has high steps meant for sitting on and not walking (see Figure 4-7). The number of people seen walking through the space horizontally, through Rosenbergsgaten, was substantially lower *than* people walking up/down the stairs, like integration results also showed.

Looking at the physical dimension of Johanneskirken, its *shape* does not fulfil the floor width to building height ratio. But the space still feels open, and there are three factors that may help explain why. The first is that the west side of the space is lined by gardens, thus making the open space between the buildings wider than the width of the actual POS (see chapter 3.3). The second is that the top of the space is open and not lined by buildings, which means the sun shines through the space parts of the day. The number of hours of sunlight varies with the season. The third factor is that Johanneskirketrappens location on a slope may make the buildings around the space seem lower. From the open space at the top of the stairs, one is at level with the second and third floor of the buildings at the bottom of the space (see Figure 5-3), something which means that there are no looming walls around a person using the space, and one has a clear view of the sky in all directions, even straight ahead (see Figure 5-3).

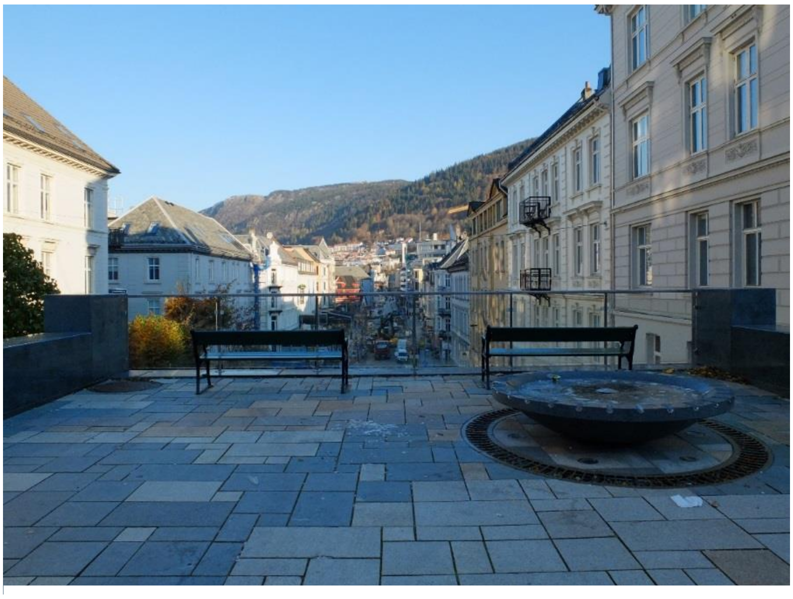


Figure 5-3: View from the open space at Johanneskirketrappen.

The *activities* observed in Johanneskirketrappen were mostly of a necessary character (see Figure 4-9). Both the number of activities that fell on the necessary side of the spectrum, and the number of people doing these activities were higher than the optional activities. Most of the activities were done while moving, and the activity most performed was simply walking through the space. Comparing this to theory, a good public space will usually have a high frequency of optional activities, whereas necessary activities happen in all types of spaces (Gehl, 1980). This is likely to be because many types of good POS are located in central locations, with a large flow of people moving through.

Johanneskirketrappen is located at the end of a highly integrated axis, but a few blocks outside of the main business area of the city centre. It feels open, but does not have the ideal dimensions of size mentioned in chapter 2.5.2. It has a high number of seating options, but few attractions apart from the water, flowers and view. No shops, street performers or other activities. There is intervisibility between buildings on each side of the POS, but there does not seem to be a particularily well-developed social dimension. The POS is mainly a path that people walk through. That means that Johanneskirken only fulfils about half of the criteria for a good POS, and particularily prominent is the lack of a social dimension.

But that does not necessarily mean it is is not a good space. A POS that is considered a good space in terms of design can be placed in a bad location and therefore be subject to a lacking social dimension and lack of use. A POS that is considered a bad space in terms of design and activities can be frequently used if it is in a good location (Whyte, 1988).

There are a number of possible explanations for why people don’t stop or sit down in Johanneskirketrappen. I have outlined three main explanations: climate, design, and the social dimension and attractions.

Firstly, it is possible that it is related to the weather and climate. More people sat down on warm or sunny days than on cold or overcast days. And Bergen is famous for its rain. It could also be the times of the day or week of observation, or the autumn season itself that affects people’s desire to sit down. Or it could be the fact that one will have one’s back to the sun almost wherever one sits in the space.

Secondly, and related to where one sits, it is possible that it is the location and design of the seating that inhibits spontaneous sitting. Whyte (1988) found that people were the most likely to stop to talk or sit down in the middle of pedestrian flow. People in Johanneskirketrappen would stop to talk in the middle of the open square or in or right at the top of the walking stairs on the east and west sides (see Figure 3-3 for the layout of the space). Few people sat down. It is possible that the location of the seating (the benches in the open square and the sitting steps in the middle of the stairs), that requires stepping to the side and out of the pedestrian flow to sit down, discourages people from sitting down. Sitting down consequently becomes a conscious choice where one has to step out of one’s path.

In addition, the type of stone that lines the outside of the steps dries much slower than the rest of the stone used (see Figure 5-4). Bergen is a city where it often rains, and so this extends the period of time one would have to wait after a rain shower before one can sit down without getting wet.

Figure 5-4: Stone types, in dry weather

The flowerbeds in the open space in Rosenbergsgaten, however, are in the middle of pedestrian flow. According to theory, people should be more likely to sit down there than on the benches and stairs. Contrary to theory, fewer people sat down on the flowerbeds. However, as there is a lower number of people walking through Rosenbergsgaten in general (see chapter 4.4), that is not an observation that I have put much weight on.

The third, and possibly most likely, explanation relates to the attractions and social dimension of the space. If one looks away from the shape (as that is less important than the other criteria, see Whyte, 1988), and the slightly-off location of the seats, what is mainly lacking in Johanneskirketrappen is related to the social dimension.

Social practices and the social dimension of a POS is produced between people, constituted in spaces, and may endure over time. The traffic cone hat in Glasgow is an example of that. In this case, Johanneskirketrappen was a street and parking lot from at least 1913 until it reopened as a POS in 2015 (see chapter 3.3 and Image 3-1). For more than a hundred years, it was not a social space, but a movement space. It is therefore reasonable to believe that if any social practices were tied to the space before, they were most likely not relating to a social space or recreation, but to movement.

Attractions and activities, use and and more optional activities are all POS criteria that depend on people using a space. And, since Johanneskirketrappen is newly redeveloped, it may take a few years before people internalise the habit and social practices of using it as a social space, increasing the number of optional activities performed there (see Gehl, 1980). The third, and possibly most important, possible explanation for why people don't use the space, is therefore that it is not yet established in their minds as a social space, and they don't yet have the habit of using it, because of a lack of attractions drawing them there (Gehl, 1980).

Two examples from observation may strengthen this hypothesis. The first example happened on the only occasion when there was activity in the space. On a Saturday during observation, a film crew from Bollywood were filming in Johanneskirketrappen. A big film crew was in action, there were numerous cars, technical equipment, a group of dancers and music in the space. During the filming, bypassers would stop and watch every time cameras rolled and there was action in the space. As soon as a take ended, people would leave. This pattern continued throughout the hours of filming.

The other event took place a few days before, when a young woman walked past with her friend. They clearly didn't pass through the space too often, because when they were in the middle of it, one of them looks surprised and says "*This place has become really nice! […] let's come here one day […] and have a coffee and enjoy the view of the city!*". They were not the only pair of passersby who showed pleasant surprise when walking though the POS.

This illustrates that activity and people attract people, and maybe more attractions, more often, is what Johanneskirketrappen needs to draw people there and develop a social dimension (Whyte, 1988a, Whyte 1988b).

But again, maybe not. The social practices, economic activity and attractions, and the physical layout and the integration of spaces all work together as a whole and may entice individuals to *choose* to use a space. It will not necessarily mean they *will* choose to use it for anything but necessary activities, even if the POS fulfils all the necessary criteria. So if most people show a tendency to merely walk through a space, it is not necessarily because it is a bad space in itself.

5.3 Combining Methods and Knowledges in Planning Public Open Spaces

There are many ways in which combining, or triangulating, different methods and types of knowledge can be used in the planning of public open spaces. Triangulation is a very useful technique to explore and validate findings in research.

There are both advantages and challenges to triangulating methods. General advantages can for example be a stronger confidence in results if several methods yield the same results, possibility of uncovering explanations that could not be uncovered with other methods, and the possibility of testing other theories and methods. Challenges can be that it is difficult to replicate (especially if one uses qualitative methods), that mixing methods may not be useful for all types of research questions, and that some methods may have the same weaknesses or may not be suited to the phenomenon one is studying (Jick, 1979).

On the theoretical side of this project, combining different theories on space and public open space may offer the opportunity to provide different models of explanations for actions in and design of public open spaces. One could for example explain the lack of use of Johanneskirketrappen with it being lacking in attractions and proximity to other well-integrated axes (like Ståhle, 2008). Or one could explain it with people not having the habit of using it as a social space yet, after at a least a hundred years of not using it (like Gehl, 1980). Or one could assume it is an interplay of these explanations, and possibly other (yet uncovered) explanations.

In this case, the two types of theory complement each other and provides different explanations on different scales. The Space Syntax is a structural explanation of the effect of the physical street network and provision of attractions, while the habits-explanation points to social structures and individual actors' effect on people's actions. Combining theories in this can can provide a more comprehensive understanding of a phenomenon.

Of course, one can never know if one has uncovered all, or even the main, explanations by using only theory. That is why combining theory with methods is important, so one can test or cross-verify assumptions. In this study, I have for example found that the Space Syntax theories, and indeed the method itself, is not suited for investigating the social dimension of space, and it does not apply to all users of a space.

That means that using both digital tools like integration analyses and other GIS analyses, and combing them with more traditional and qualitative methods like observation, planners and others can examine the interplays between the physical and social dimensions of public open space. Looking not only at how the physical or social environments affect people, but how the interplay of the two affects people. In Johanneskirken, there is not much of a social dimension yet, and few attractions that draw people there. The physical design of the space is good in some ways (the space is open, has sun, shields from the wind and has a lot of seating), and not so good in others (the seating is perhaps not ideally placed, the shape is not ideal, and the location is uphill at the less-integrated en of an axis). It is pertinent to assume that the lack of use and lack of optional activities in the space is due to a combination of these factors.

5.3.1 Within-Method and Between-Method Triangulation

Method triangulation can be divided into *within-method* and *between-method* (Jick, 1979). Using the *within-method* approach, I have combined two different Space Syntax analyses to investigate the localisation and use of public open spaces[12]. That has included using axial integration on the city centre to investigate the location of different types of spaces, and all-line integration analyses to determine walking paths within the smaller study area of Johanneskirketrappen. It is the same analysis, but on different datasets.

In the analyses in this thesis, the axial integration showed that the Torgalmenningen axis and Johanneskirketrappen is highly integrated. The all-line integration showed that it is the east side of Torgalmenningen and the west side of Johanneskirketrappen that is the most integrated, and that the horizontal Rosenbergsgaten is only medium well integrated. The Space Syntax analyses show internal coherency. Both axial and all-line integration analyses show that

[12] One could also combine different Space Syntax softwares to run other analyses, something which I have not done here.

Johanneskirketrappen is most highly integrated in a north-south direction (up/down), and less in an east-west direction (see Figure 4-3, Figure 4-4 and Figure 4-7).

Checking these results with the *between-method* approach (Jick, 1979), showed both coherency and contradictions. Observation verified the results of the axial integration and all-line integration, with regards to where people walk. However, both observation and viewshed analysis disagreed with the fundamental Space Syntax presumption that axial lines are sight lines. There is nowhere along the Torgalmenningen axial line that one can see the entire length of the axis.

This is due to slopes that are not accounted for in the two-dimensional integration analyses, but that are both visible in viewshed analyses and that inhibit sight lines in real life. In cities with varied topography, one cannot always see the entire length of the axial line, or even the end points. One can then ask to what extent axial lines serve a purpose in cities with varied topography and hills, and if people's perceptions of their environment changes with topography. Perhaps axial analyses are less suited in these cities? That would be an interesting point for further research.

This internal coherency and external contradictions show the value of mixing methods, where using different data layers (vector vs. raster) and different methods of analysis (integration vs. viewshed vs. observation) can either verify or disprove the results of a method.

5.3.2 Integrating Space Syntax, Observation and GIS

The between-method approach also has other advantages in the planning of public open spaces. Integrating Space Syntax in a GIS, for example, opens up a new range of potential analyses. There are several computer programs and plug-ins that run accessibility analyses and that are directly compatible with a GIS[13].

The first and easiest integration is overlaying and integrating Space Syntax results with other datasets, as I did in this thesis by overlaying the maps of different POS on integration analyses (Ståhle, 2008). One can use the same method for other types of information, like bus stops, schools or public services, pedestrian streets or anything else that one would like to compare.

A GIS can also use multiple factors in the analysis, including (but not limited to) where entrances are located, how many people live in the area as a whole or in a specific building, how the street network is structured, where there are road crossings or one-way streets, and can

[13] Examples are the Urban Network Analysis (plugin for ArcGIS), QGIS Space Syntax Toolbox, Confeego and Axwoman.

weight streets against each other (Oh & Jeong, 2007, Ståhle, 2008, Sevtsuk & Mekonnen, 2012). The DepthmapX software used in this project can not do that, as it is a much simpler program. This probably makes it an easier software to use for basic analyses, but also strongly limits its uses as a tool in itself for POS planning.

A plugin-tool for ArcGIS 10.1 that works very similarily to the DepthmapX software used in this thesis, is the Urban Network Analysis (UNA) (Sevtsuk & Mekonnen, 2012). It is a tool based on analysing street networks, that does not use streets or open spaces as the measure of accessibility, but buildings (Sevtsuk & Mekonnen, 2012, City Form Lab, n.d.). It is also possible to weight the buildings by various measures, like size or population. Using land registry and population data for different streets in Bergen, it could have been possible to weight the axial lines in my analysis by population, to look for population patterns in relation to the streets' integration and the size of public open spaces in the area. Combining this with for example information on the average age of dwellers, it could be used to determine if a POS should be large or small, be particularly adapted for children or the elderly, if it should be open or enclosed, how much sun it gets and the likes (the criteria derived from Gehl, 1980, Lorange, 1984, Whyte, 1988, Baran, Rodriguez & Khattak, 2008, Carmona et al., 2010, Gehl & Svarre, 2013).

One can use an axial integration and POS map to determine the location of other features in space such as public transportation nodes, public services or shops. These should preferably be located in highly integrated locations, or in close proximity to these. Locating attractions in close proximity to a middle- or highly integrated POS will be beneficial for both the use of the POS and the attractions (Whyte, 1988a, Ståhle, 2008).

All of these potential combination analyses can be used to inform planning processes. And not just for planning POS themselves, but also for the planning of new buildings or extensions to buildings which will increase the number of residents in an area. Local municipalities have individual demands for a certain area of mandatory outdoor space per housing unit in the building in their municipal plan (Kommuneplanens Arealdel). In many cases, this outdoor space can be covered by already existing public open spaces (Kommuneplanens arealdel, 2010, §10).

At the moment, there are four planned property developments within the borders of the study area in Bergen. One in Nygård (Bergen Kommune, 2017b), two in Nøstet (Bergen Kommune, 2015a, Bergen Kommune, 2015b) and one in Kong Oscars gate (Bergen Kommune, 2017a). Judging by the zoning plans and plan proposals available from Bergen local municipality, all of these will need to have all or some of their outdoor space covered by already existing public outdoor spaces.

Using a mix of POS typology, integration analyses, GIS and observation, one can evaluate whether or not this is advisable, and if there are adequate POS nearby to cover this outdoor space. An analysis of this type could combine information such as:

- The type and number of nearby POS, and their quality (based on the criteria of location, shape and size, design, attraction and safety)
- Paths between the POS and the building developments, the metric distance in the street network, and if there are any particular hindrances for certain user groups in the path (hills, roads, physical barriers)
- The integration values of these paths
- The number of inhabitants in the area
- The number of inhabitants in buildings that also have part of their mandatory outdoor space covered by the same POS
- Number of actual users and activities in the POS throughout the day

Using a mix of methods such as these will ensure that mandatory outdoor spaces are localised where inhabitants are likely to use them, and are not overcrowded if they are located in dense areas.

In the same way, if a city centre wants to become car-free or make more streets pedestrian, one can use the same method to identify what streets to make pedestrian. One can convert the axial integration map into a network dataset (.ND file) showing traffic flow directions to locate one-way streets, and/or combine it with a dataset showing which streets are the most frequented by cars (for example transport per day (døgntransport)) (Oh & Jeong, 2007). Then, using this information in conjunction with one another, one can see if there are streets that are less frequented by cars, but are highly integrated that could be potential pedestrian streets (Baran, Rodriguez & Khattak, 2008).

One can also use integration analyses on their own, to analyse connections between POS, and make sure there are accessible corridors between them and for people living in the vicinity (Oh & Jeong, 2007).

All of these methods can be used further in conjunction with qualitative methods like observation or cognitive mapping. Observing, as has been shows in this thesis, can be useful to verify analysis results. It can also be used to set the parametres of the different analyses, like I did when setting a height for the viewshed analysis, since the viewshed output did not concur with observation of sight (see chapter 3.5.3). Observation can also be combined with a more Gehl-esque method of counting observations, like counting the number of people using a POS at different times of the day, or doing different activities. That can be useful for example in a planning process.

Cognitive mapping, where people draw their perception of their environment and what streets and POS are prominent in their daily life, or where they walk or sit in a POS, and why, can be compared (as done by Lynch, 1960). Then one can ensure the validity of the analyses in that particular urban context, and integrate it with qualitative information on what spaces people use and when, why, what activities they do there and what they think of the space. That would make for a very comprehensive study of public open spaces.

Finally, integrating all these methods can help determine on what scale analyses should be performed. As discussed in chapter 3.5, axial maps and analyses should be scaled to according to their use. Integrating the different methods, and especially observation and integration analyses, will help planners in determining what is the most important features to map and include, how many streets and how big an anera to allow in the datasets, and whether or not outcomes are relevant for what one is studying.

6 CONCLUDING REMARKS AND RECOMMENDATIONS

The objective of this thesis was to explore what makes a good public open space, and how one can best combine digital and traditional methods to plan it, using both the field of Space Syntax and social science theories, on a case study of Bergen, Norway, on three different scale levels.

Using methods from social science, Space Syntax and GIS, I have approached the subject of public open spaces from various angles. There is a high degree of coherency in and between the different theories with regards to how good public open spaces should look and function. The general criteria is that it is located on suitable streets (integration values depending on the type of space and its purpose), is open and invites people in, has enough light and shielding from wind and rain, has attractions and activities enticing people to use it, is safe, and has a social dimension where people use the space.

Integration analyses have been demonstrated to be both useful and accurate in many ways, for example when mapping overall accessibility to POS in the city centre, or predicting where through a POS people are most likely to walk. That is if the data is scaled according to the area and research questions. But between-method triangulation has shown that axial integration may have a disadvantage on three points in particular.

The first is that observation and viewshed analyses showed that axial lines do not necessarily correspond with sight lines in cities with a varied topography. Sight lines there may be shorter or longer than axial lines, or they may be discontinuous. This should both be accounted for in analyses, and is an interesting point for further research on using Space Syntax on cities. The second point is that integration analyses are not useful in planning for all user groups, and especially not for children. When planning for children and other groups that do not move according to theory, the role of integration analyses should be downplayed and more weight should be put on other methods. The third is that integration analyses cannot be used to analyse the social dimension and actual use of a space, and should be combined with other methods if used to plan public open spaces.

Combining Space Syntax and integration with observation, like in this project, one can make comprehensive studies on both the physical and social dimension of public open spaces, and examine the interplays between the physical and the social dimensions of space. This can further be used in planning, especially in the cases where new developments are to have their outdoor areas covered by existing public open spaces, or when determining where to locate a space, how to shape it, and what strategies to use to attract people to it.

7 LITERATURE

ArcGIS Resources (2012) *Using Viewshed and Observer Points for Visibility Analysis* [Internet]. ESRI. Available from: <http://resources.arcgis.com/en/help/main/10.1/index.html#//009z000000v8000000> [Read: 07.11.16]

Asplan Viak & Spacescape (n.d.) *Uterom I Tett By* [Internet]. Available from: <https://www.bergen.kommune.no/bk/multimedia/archive/00261/UTEROM_I_TETT_BY_261049a.pdf> [Read: 11.01.17]

Batty, B. & Rana, S. (2004) The Automatic Definition and Generation of Axial Lines and Axial Maps. *Environment and Planning B: Planning and Design*, 31, p. 615-640.

Bergen Kommune (2015a) *BERGENHUS. GNR 165 BNR 574 M.FL., NØSTEGATEN* [Internet]. Available from: <http://www.bergenskart.no/braplan/planInnsyn.jsp?planid=64310000&kildeid=1201> [Read: 14.07.17]

Bergen Kommune (2015b) *BERGENHUS. GNR 165 BNR 555 M.FL., DIKKEDOKKEN* [Internet]. Available from: <http://www.bergenskart.no/braplan/planInnsyn.jsp?planid=63850000&kildeid=1201> [Read: 14.07.17]

Bergen Kommune (2017a) *BERGENHUS. GNR 166 BNR 520 M.FL., KONG OSCARS GATE 22 - 24* [Internet]. Available from: <http://www.bergenskart.no/braplan/planInnsyn.jsp?planid=65170000&kildeid=1201> [Read: 14.07.17]

Bergen Kommune (2017b) *BERGENHUS. GNR 164 BNR 948 M.FL., NEDRE NYGÅRD, DELER AV KVARTAL 16C* [Internet]. Available from: <http://www.bergenskart.no/braplan/planInnsyn.jsp?planid=65060000&kildeid=1201> [Read: 14.07.17]

Bodnar, J. (2015) Reclaiming Public Space. *Urban Studies*, 52, 2090.

Carmona, M., Tiesdell, S., Heath, I. & Oc, T. (2010) *Public Places – Urban Spaces: The Dimensions of Urban Design*. Oxford: Elsevier Ltd.

City Form Lab (n.d.) *Urban Network Analysis Toolbox for ArcGIS* [Internet]. Cambridge: City Form Lab. Available from: <http://cityform.mit.edu/projects/urban-network-analysis.html > [Read: 05.05.16]

Clifford, N., French, S. & Valentine, G. (2010) *Key Methods in Geography*. *Second edition*. London: SAGE Publications Ltd.

Cresswell, T. (2013) *Geographic Thought: A Critical Introduction*. Wiley-Blackwell.

Edwards, N., Hooper, P., Trapp, G.S.A., Bull, F., Boruff, B. & Giles-Corti, B. (2013) Development of a Public Open Space Desktop Auditing Tool (POSDAT): A remote sensing approach. *Applied Geography*, 38, 22-30.

Gehl, J. (1980) *Livet mellem husene: udeaktiviteter og udemiljøer*. Copenhagen: Arkitektens Forlag.

Gehl Architects [no date, a] *Approach* [internet]. Available from: <http://gehlarchitects.com/approach/> [Read: 06.05.16]

Gehl Architects [no date, b] *Professor Jan Gehl on making life visible* [video]. Available from: <http://gehlarchitects.com/film/professor-jan-gehl-on-making-life-visible/> [Seen: 06.05.16]

Gehl, J. & Svarre, B. (2013) *How To Study Public Life*. Island Press.

GitHub (2015) *SpaceGroupUCL/Depthmap* [Internet]. Available from < https://github.com/SpaceGroupUCL/Depthmap> [Read: 10.07.17]

Google (n.d.) *Google Maps* [Internet]. Available from: https://maps.google.com [Read: June 2016 - June 2017]

Hagen, A.L., Andersen, B., Brattbakk, I., Dahlgren, K., Ascher, B.E. & Kolle, E. (2016) *Ung og Ute. En Studie av Ungdom og Voksnes Bruk av Uterom*. AFI Rapport 6. Oslo: Arbeidsforskningsinstituttet.

Hall, J. (2013) 'An iconic part of local heritage': Glasgow Council drops £65,000 plans to raise Duke of Wellington statue that regularly has traffic cones placed on its head. *The Independent* [internet], 12.11.13. Available from: <http://www.independent.co.uk/news/uk/home-news/an-iconic-part-of-local-heritage-glasgow-council-drops-65000-plans-to-raise-duke-of-wellington-8934642.html> [Read 12.05.17]

Hall, T. & Barrett, H. (2012) *Urban Geography*. 4th edition. Oxon: Routledge.

Hay, I. (2010) *Qualitative Research Methods in Human Geography*. Canada: Oxford University Press

Herold, M., Couclelis, H. & Clarke, K.C. (2003) The Role of Spatial Metrics in the Analysis and Modeling of Urban Land Use Change. *Computers, Environment and Urban Systems*, 29, p. 369-399.

Heywood, I., Cornelius, S. & Carver, S. (2011) *An Introduction to Geographical Information Systems*. Fourth Edition. Essex, Pearson Educated Limited.

Hillier, B. (2007) *Space is the Machine. A Configurational Theory of Architecture* [Ebook]. London: Space Syntax. Available from: http://spaceisthemachine.com/ [Read: 29.05.17]

Hillier, B. & Hanson, J. (1984) *The Social Logic of Space*. Cambridge: Cambridge University Press.

Holloway, L. and Hubbard, P. (2001) *People and Place. The Extraordinary Geographies of Everyday Life*. Harlow: Pearson Education Limited.

Holm, E.D. (2006) Offentlig Rom. Vox Publica [internet]. Available from: <http://voxpublica.no/2006/offentlig-rom/> [Read: 2015]

Hoque, Z. (2006) *Methodological Issues in Accounting Research. Theories, Methods and Issues*. London: Spiramus Press Ltd.

Jacobs, J. (1992) *The Death and Life of Great American Cities.* New York: Vintage Books.

Jick, T.D. (1979). Mixing qualitative and quantitative triangulation in action. Qualitative Methodology. *Administrative Science Quarterly,* 24(4), 602-611.

Kartverket (n.d.) *FKB – Felles Kartdatabase* [Internet]. Available from: <http://www.kartverket.no/data/kartdata/Vektorkart/FKB/> [Read: November 2016]

Kartverket (2016) *Ortofoto* [internet]. Updated 28.04.16. Available from: <http://kartverket.no/geodataarbeid/Flyfoto/Ortofoto/> [read: 07.05.16]

Kearns, R. A. (2010) Seeing with Clarity: Undertaking Observational Research. In: Hay, I. ed. *Qualitative Research Methods in Human Geography*. Canada: Oxford University Press Canada, p. 241-258

K. Knudsen & Co (1912) *Bergen: Vestre Torvgate* [Digitized photography]. Available from: <http://marcus.uib.no/instance/photograph/ubb-kk-pk-0718.html> [Collected: 18.04.17]

Kommuneplanens Arealdel (2010) *Bestemmelser og Retningslinjer til Kommuneplanens Arealdel 2010.* Available from: <https://www.bergen.kommune.no/omkommunen/arealplaner/9268/9270> [Read: 23.06.17]

Laurier, E. (2010) Participant Observation. In: Clifford, N., French, S. & Valentine, G. ed. *Key Methods in Geography*. *Second edition*. London: SAGE Publications Ltd.

Lévi-Strauss, C. (1967) *Structural Anthropology*. New York: Anchor Books.

Lindau, M. (2015) *Identifying densification potential in urban areas. Development of a GIS-based methodology* [master thesis]. Trondheim: Norwegian University of Science and Technology.

Lorange, E. (1984) *Byen i landskapet – Rommene i byen.* Oslo: Universitetsforlaget.

Low, S. & Smith, N. (2013) *The Politics of Public Space*. Routledge.

Lynch, K. (1960) *The Image of the City*. USA: Massachusetts Institute of Technology.

Malecki, E.J. (2015) Economic Geography. In: Wright, J.D. ed. *International Encyclopedia of the Social and Behavioural Sciences. Second Edition.* Elsevier Ltd.

Moe, T.A., & Algerøy, Å. (2015) Rullestolbrukere raser mot den nye "Spansketrappen" i Bergen. *NRK* [Internet], 20.06.15. Available from: <https://www.nrk.no/hordaland/rullestolbrukere-raser-mot-_spansketrappen_-i-bergen-1.12419393> [Read: 16.07.17]

Morgan, J.L., Gergel, S.E. and Coops N.C. (2010) Aerial Photography: A Rapidly Evolving Tool for Ecological Management. *BioScience*, 60 (1), 47-59.

Murdoch, J. (2005) *Post-Structural Geography: A Guide to Relational Space*. [ebook] London: SAGE Publications Ltd.

Oh, K. & Jeong, S. (2007) Assessing the spatial distribution of urban parks using GIS. *Landscape and Urban Planning*, 82, 25–32.

Oxford English Dictionary Online (n.d.) *Accessibility* [internet]. Available from: <https://en.oxforddictionaries.com/definition/accessibility> [Read: 15.10.17]

Oxford English Dictionary Online (2004) *Observation* [internet]. Available from: <http://www.oed.com/view/Entry/129883?redirectedFrom=observation#eid> [Read: 08.07.17]

Roald, H.J. (2010). *Byplanen: En historie om utviklingen av Bergen by*. Oslo: Spartacus Forlag.

Sallis, J.F., Cerin, E., Conway, T.L., Adams, M.A., Frank, L.D., Pratt, M., Salvo, D., Schipperijn, J., Smith, G., Cain, K.L., Davey, R., Kerr, J., Lai, P.C., Mitáš, J., Reis, R., Sarmiento, O.L., Schofield, G., Troelsen, J., Van Dyck, D., De Bourdeaudhuij, I., Owen, N. (2016) Physical Activity in Relation to Urban Environments in 14 Cities Worldwide: A Cross-Sectional Study. *The Lancet*, 387, May/June, p. 2207-2217.

Sevtsuk, A., Mekonnen, M. (2012). "Urban Network Analysis Toolbox". *International Journal of Geomatics and Spatial Analysis*, vol. 22 (2), p. 287-305.

Skreien, N. & Haaland, A. (2009) Om Bergen, i: Bergen Byleksikon [internet]. Bergen: Bergen Byarkiv. Available from: < http://www.bergenbyarkiv.no/bergenbyleksikon/bergens-historie> [Read: 31.08.17]

Srivastava, R. and Narayan, L. (1974) An attempt towards mapping of land use of Dehra Dun city using aerial photo-interpretation techniques. *Journal of the Indian Society of Photo-Interpretation*, 2(1), p. 19-27.

Statistics Norway (2012) *108 Egenrapportert høyde og vekt for sesjonspliktige* [Internet]. Statistics Norway. Available from: <http://www.ssb.no/a/aarbok/tab/tab-108.html> [Read: 22.03.17]

Store Norske Leksikon (2011) *Agora* [Internet]. Available from: <https://snl.no/agora> [Read: 11.05.2017]

Ståhle, A. (2008) *Compact Sprawl: Exploring public open space and contradictions in urban density* [doctoral thesis]. Stockholm: Royal Institute of Technology.

Taylor, B.T., Fernando, P., Bauman, A.E., Williamson, A., Craig, J.C. & Redman, S. (2011) Measuring the Quality of Public Open Space Using Google Earth. *American Journal of Preventive Medicine*, 40, p. 105-112.

Turner, A., Penn, A. and Hillier, B. (2005) An algorithmic definition of the axial map. *Environment and Planning B: Planning and Design*, 32, p. 245-444.

UCL Space Syntax (2017) *Overview* [Internet]. Available from: <http://otp.spacesyntax.net/overview-2/> [Read: january 2017]

UCL Space Syntax Glossary (2017a) *Choice* [Internet]. Available from: <http://otp.spacesyntax.net/term/choice/> [Read: 26.05.17]

UCL Space Syntax Glossary (2017b) *Connectivity* [Internet]. Available from: <http://otp.spacesyntax.net/term/connectivity/> [Read: Read: 26.05.17]

UCL Space Syntax Glossary (2017c) *Convex Space* [Internet]. Available from: <http://otp.spacesyntax.net/term/convex-space/> [Read: january 2017]

UCL Space Syntax Glossary (2017d) *Depth* [Internet]. Available from: <http://otp.spacesyntax.net/term/depth/> [Read: Read: 26.05.17]

UCL Space Syntax Glossary (2017e) *Edge Effect* [Internet]. Available from: <http://otp.spacesyntax.net/term/edge-effect/> [Read: january 2017]

UCL Space Syntax Glossary (2017f) *Integration* [Internet]. Available from: <http://otp.spacesyntax.net/term/integration/> [Read: january 2017]

UCL Space Syntax Glossary (2017g) *Isovist* [Internet]. Available from: <http://otp.spacesyntax.net/term/isovist/> [Read: january 2017]

UCL Space Syntax Glossary (2017h) *Step Depth* [Internet]. Available from: <http://otp.spacesyntax.net/term/step-depth/> [Read: Read: 26.05.17]

van Nes, A. (2014) Space Syntax in Theory and Practice. In: Lee, J.D., Dias, E. & Scholten, H.J. eds. *Geodesign by Integrating Design and Geospatial Sciences*. Switzerland: Springer International Publishing, p. 237-257.

UN Habitat (2013) State of the world's cities. New York: UN Habitat. Available from: <https://unhabitat.org/books/prosperity-of-cities-state-of-the-worlds-cities-20122013/> [Read: 23.07.17]

UN Habitat (2014) *A New Strategy of Sustainable Neighbourhood Planning: Five Principles* [Discussion note]. Nairobi: UN Habitat. Available from: <https://unhabitat.org/wp-content/uploads/2014/05/5-Principles_web.pdf > [Read: 11.06.17]

UN Habitat (2015) *Global Public Space Toolkit: From Global Principles to Local Policies and Practice*. Nairobi: UN Habitat. Available from: <https://unhabitat.org/wp-content/uploads/2015/10/Global%20Public%20Space%20Toolkit.pdf > [Read: 10.04.17]

van Nes, A. & Nguyen, T.M. (n.d.) *Gender Differences in the Urban Environment. The Flâneur and Flâneuse of the 21st Century* [Conference Paper]. Proceedings of the 7th International Space Syntax Symposium.

van Nes, A. & Song, C. (n.d.) *Depth Map Manual for "DUMMIES" (….or for those of us with limited computer knowledge….)*. Version 12. [User manual]. Available from: <http://www.ia.arch.ethz.ch/wp-content/uploads/2013/09/DepthmapManualForDummies-v13.pdf > [Read: September 2016]

Vik, J.E. (2010) *Bystrukturens Forutsetning for Byliv – Bergens Historiske og Fremtidige Utvikling Diskutert Gjennom Space Syntax* [Master's thesis]. Ås: Universitetet for Miljø og Biovitenskap.

Whyte, W. H. (1988a) *City. Rediscovering the Center*. Philadelphia: University of Pennsylvania Press.

Whyte, W.H (1988b) *The Social Life of Small Urban Spaces* [film]. Available from <https://archive.org/details/SmallUrbanSpaces > [Seen October 2016]

Åkernes, H.L. & Edvardsen, A. (2015) Slik Blir Nygårdsparken. *Bergens Tidende* [Internet], 03.06.17. Available from: <https://www.bt.no/nyheter/lokalt/i/09WrM/Slik-blir-Nygardsparken> [Read: 10.05.16]