Urban Design of Winter Cities
Winter Season Connectivity for Soft Mobility

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Architecture
Urban design of winter cities: Winter season connectivity for soft mobility

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Summary

All over the world, the form of the built environment plays a key role as an enabler or inhibitor of urban outdoor activities such as soft mobility. The public realm can make it more attractive for people to be mobile outdoors and to participate in public life, or it can put people off venturing outside.

A key urban design challenge in winter cities is to create environments that encourage outdoor activity in both the winter and the summer. A closely related challenge is to understand how changes in weather due to climate change will influence people’s soft mobility choices.

The reason for studying this is the importance of understanding how the relationship between urban form, weather, seasonal variations, and climate change influences human outdoor activity. In this research, the focus on outdoor activity is problematised around the concern that people spend a low percentage of their time outdoors in winter conditions. For society, the problem is that this trend and the related low levels of physical activity are associated with a range of health issues.

To study this, the main question for this research is what attracts and hinders soft mobility during the winter season and how can this knowledge underpin new considerations about urban design for connectivity in winter cities? To address this, the research methods used are document studies, surveys, mental mapping, and photo elicitation.

The study works at three scientific levels. The first goal of the research is to clarify the relationship between the built environment and people’s outdoor soft mobility in winter. The second goal is to understand how connectivity for soft mobility in winter is affected by the season, climate, and weather. The third goal is to identify new ways of thinking about how the urban form can be conceived and designed to increase outdoor soft mobility in the winter season.

The conclusions and discussion focus on the argument that in winter settlements, the interaction between the urban form and winter season is an aspect of urban morphology and can be part of the process of shaping the public realm and its connectivity for soft mobility in winter. As the urban form is designed, recommendations for how to improve connectivity for soft mobility in the winter season are highlighted.
Sammanfattning

Över hela världen spelar den urbana miljöns form en nyckelroll när det gäller att möjliggöra eller försvåra för befolkningen av vara aktivt utomhus, såsom mjuk mobilitet. Utformningen av offentliga områden kan göra det attraktivt för befolkningen att förflytta sig och delta i det offentliga livet, eller så kan det få personer att avstå från att lämna hemmet.

En av stadsplaneringens huvudsakliga utmaningar i vinterstäder är att skapa miljöer som uppmuntrar till utomhusaktivitet alla säsonger. En närliggande utmaning är att förstå hur ändrade väderförhållanden på grund av klimatförändringar kan inverka på människors val av mjuk mobilitet.


Avhandlingens huvudsakliga forskningsfråga är: vad uppmuntrar och förhindrar mjuk mobilitet under vinterhalvåret och hur kan denna kunskap stödja nya överväganden kring stadsplanering för anslutningar för mjuk mobilitet i vinterstäder? De metoder som används för att belysa frågan har varit litteraturstudier, enkätundersökningar, kognitiv kartläggnings och fotoelicitering.

Det första målet är att klargöra samband mellan stadsmiljö och mjuk mobilitet utomhus på vintern. Det andra är att förstå hur förbindelser; de nätverk av vägar och stigar som möjliggör mjuk mobilitet, påverkas av säsong, klimat och väder. Det tredje är att identifiera hur den urbana formen kan planeras för att främja ökad mjuk mobilitet utomhus under vinterhalvåret.

I slutsatserna argumenteras det för hur interaktionen mellan urban form och vintersäsong är en aspekt av urban morfologi i vinterstäder, och hur det kan vara en del av processen kring hur den offentliga miljön formas. Slutligen ges rekommendationer som kan bidra till att förbindelser för mjuk mobilitet under vinterhalvåret förbättras vid planeringen av den urbana miljön.

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1 Mjuk mobilitet (engelska: soft mobility). Människors sätt att förflytta sig utan motordrivna fordon, tex genom att gå eller cykla, vilket har en relativt liten påverkan på miljön.
Acknowledgements

Many people have assisted in the development of this research. In particular, I would like to thank Kristina L. Nilsson, Agatino Rizzo & Agneta Larsson for their involvement.

On a personal note, I would like to thank my family and friends.
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Acronyms

ABE: Attractive Built Environments
CABE: Commission for Architecture and the Built Environment
Dfc: Subarctic climate (Köppen climate classification)
EAMQ: Environmental Analysis of Mobility Questionnaire
HCA: Homes and Communities Agency
IPCC: Intergovernmental Panel on Climate Change
LTU: Luleå University of Technology
RTPI: Royal Town Planning Institute
UCL: University College London
UNFCCC: United Nations Framework Convention on Climate Change
WCA: Winter Cities Association
WCI: Winter Cities Institute
WHO: World Health Organization
Glossary

**Connectivity:** The degree to which a place is connected by routes to other places and to which its own parts are connected to each other (Cowan, 2005, p.86).

**Public realm:** The parts of a village, town, or city (whether publicly or privately owned) that are available, without charge, for everyone to see, use and enjoy (Cowan, 2005, p.312).

**Soft mobility:** Human-powered, non-motorized ways of getting around, such as walking, cycling, rollerblading or skiing, that have relatively little impact on the environment. (Cowan, Dictionary of Urbanism, 2nd edition, forthcoming).

**Townscape:** Urban form and its visual appearance; the appearance of streets, including the way the components of a street combine in a way that is distinctive to a particular locality (Cowan, 2005, p.400).

**Urban grain:** The pattern of the arrangement and size of buildings and their plots in a settlement; and the degree to which an area’s pattern of street-blocks and street junctions is respectively small and frequent, or large and infrequent (Cowan, 2005, p.422).

**Urban structure:** The framework of routes and spaces that connect locally and more widely, and the way developments, routes and open spaces relate to one another (Cowan, 2005, p.427).
List of papers attached to the doctoral thesis

This document is a compilation thesis and consists of the following cover essay, four scientific papers, and a research report:


Introduction

All over the world, the form of the built environment plays a key role as an enabler or inhibitor of urban outdoor activities such as soft mobility. The public realm can make it more attractive for people to be mobile outdoors and to participate in public life, or it can put people off venturing outside.

Soft mobility in winter cities

A key urban design challenge in winter cities is to create environments that encourage outdoor activity in both the winter and the summer. A closely related challenge is to understand how changes in weather due to climate change will influence people’s soft mobility choices.

While there is no exact definition of a winter city, Pressman has suggested that winter cities usually satisfy five conditions. They commonly experience temperatures below 0 °C, the precipitation they experience is mainly in the form of snow, they have limited hours of sunshine and daylight and the preceding three conditions hold for several months in succession every year. The last condition is that their climate exhibits appreciable seasonal variation (Pressman, 2004). This definition of winter cities is used here in preference to definitions based on being located in Arctic or subarctic regions because many places that are considered to be winter settlements are located outside such regions.

In the context of sustainable urban development, good urban design is design that enhances connectivity for soft mobility activities such as walking, cycling or skiing. Furthermore, the weather is a major determinant of people’s decision-making about outdoor activities and soft mobility (Ebrahimabadi, Nilsson, & Johansson, 2015). Therefore, a key premise of this work is that the built environment and the weather play central roles in determining how people use the outdoor environment and the public realm.

A better understanding of the relationship between the built environment and the weather is needed to identify problems that discourage people from being active outdoors, for example by participating in mobility activities such as walking and cycling (Givoni, 1998). This is important because there is an
established connection between regular physical activity (levels of which are typically reported on a daily or weekly basis) and individual health and wellbeing (Kohl et al., 2012; WHO, 2017). As people are less likely to be physically active outdoors in winter time, this suggests that the urban environment of winter cities should enable and support soft mobility throughout the year rather than only during the summer or for leisure (Berglund, Tossavainen, Nilsson, & Kostenius, 2013; Ebrahimabadi, Johansson, Öberg, & Nilsson, 2011).

Problematising urban design for winter cities that promotes connectivity for soft mobility

The research focus on outdoor activity problematises the concern that people spend little time outdoors during winter (Westerberg, 2009). It is estimated that people spend only 10% of their lives outside (Evans & McCoy, 1998). The year-round problem of limited outdoor activity is exacerbated by the climate in winter settlements. For example, people in Finland spend as little as 4% of their time outdoors during cold periods (Mäkinen et al., 2006). These low levels of physical activity pose problems for societies because they are associated with a range of health issues (de Onis, Blössner, & Borghi, 2010; Faskunger, 2007; Piai, 2013; Robinson, Matsuda, Ciol, & Shumway-Cook, 2013; Shoshkes & Adler, 2009). The WHO states that a quarter of the global population is insufficiently active, and highlights the health and wellbeing benefits of physical activities such as walking and cycling (WHO, 2006; 2015; 2017). Consequently, a central focus of the WHO’s mission to promote individual physical activity is to encourage the creation of outdoor built environments featuring networks of connected streets and pathways that enable soft mobility (WHO, 2018). The organisation reinforces the need for physical activity by linking physical inactivity to 1.6 million deaths each year worldwide (WHO, 2017). The focus on outdoor activity is motivated by the fact that spending time in outdoor environments has additional health benefits, such as stress reduction (Lottrup, Stigsdotter, & Grahn, 2013; Tourula & Rautio, 2014; Tsunetsugu et al., 2013; Wheeler et al., 2012).
Background

This research was carried out at Lulea University of Technology’s (LTU) Architecture Group, which has focused on researching attractive settlements and outdoor environments that are comfortable in cold climates. The work presented here is aligned with the Joint Arctic Agenda (a strategic collaboration between LTU, Oulu University, University of Lapland, Tromso University and Umeå University). It also falls within LTU’s Attractive Built Environments (ABE) research area and connects with the Architecture and Health Sciences research programme’s focus of ‘Health on Thin Ice’.

I, David Chapman, have been visiting northern Sweden on a regular basis since 1996 and have been a member of the Architecture Group at LTU since 2013. By background, I am a trained architect and town planner. I received my Bachelor of Arts (Hons) in Architecture from The University of Huddersfield, England in 1994. This was followed with a Master of Architecture in 1996 from the Glasgow School of Art (GSA) and a Master of Philosophy in Town and Country Planning from the Bartlett School of Planning, University College London (UCL) in 2001. I have worked as a practitioner in the fields of architecture, planning and urban design for over fifteen years. During this period, I have worked in both the public and private sectors. As an architect and urban designer, my responsibilities were mainly at the city-wide or neighbourhood scale.

Between 2000 and 2014, I sat on a number of national and regional advisory boards for varying periods. In England, this included the Urban Renaissance Panel of Yorkshire Forward (a Regional Development Agency), the Design Code Enabling Panel and Delivery Panel of the Commission for Architecture and the Built Environment (CABE), and the Summer School of CABE. In Scotland, I was a member of Architecture + Design Scotland’s Enabling Panel and Design Review Panel.

My work in practice has received a number of design prizes including the Francis Tibbalds Award (Urban Design) for the Scotswood Expo Masterplan and 1st prize for the Concept plan competition for the West Kowloon reclamation area, Hong Kong. I have also been given awards for planning and regeneration from the Royal Town Planning Institute (RTPI) and Scottish Government. Further to this, I have authored a number of books including From Design Policy...
to Design Quality for the RTPI and Qualityreviewer: appraising the design quality of development proposals for the Homes and Communities Agency (HCA).

This background can be both positive and negative when it comes to being unbiased. My knowledge and experience in designing and delivering complex urban design projects can make it easier for me to understand the complexities of designing for winter cities. However, it also makes it difficult to distance myself from these projects, or to avoid having my judgment coloured by previous experiences and preconceived perceptions. For example, many of my projects focused on creating new neighbourhoods with defined streets, blocks, and plots and in general, I have supported this type of urban form and development pattern.

As the first author of the four papers and research report included in this thesis, I was responsible for conducting the empirical studies, presenting their results, and the main writing of the papers. The co-authors of these papers are my main and co-supervisors, each of whom contributed their views and recommendations on their design and helped improve both the research and the papers. I performed the extended literature and document studies.

Some of the research for this doctoral thesis was undertaken for my Master of Philosophy (Mphil) in Town Planning (Chapman, 2001). The associated article (Chapman, 2002) used this research as its basis. In particular, these studies utilise the literature review and semi-structured interviews from the Mphil. The PhD also takes advantage of case study work I was involved in for the Commission for Architecture and the Built Environment (CABE), UK; the results of that work are used as background material in the research report (Chapman, 2016).

My main supervisor for this PhD thesis was Professor Kristina L. Nilsson (Architecture Group). My co-supervisors were Associate Professor Agatino Rizzo (Architecture Group) and Dr. Agneta Larsson (Health Sciences). All are affiliated with Luleå University of Technology.

Policy context

For urban design, the overarching policy context is the Sustainable Development Goals set out by the United Nations (2015). Because this thesis deals with
connectivity for soft mobility in the built environments of winter cities, the main body of the work falls under Goal 11, which is to “make cities and human settlements inclusive, safe, resilient and sustainable.” However, since the research looks at soft mobility in relation to the human wellbeing benefits that can come from physical activity, it is also related to Goal 3 (“to ensure healthy lives and promote wellbeing for all at all ages”). Additionally, although the research does not address climate action, its background is informed by the need to “take urgent action to combat climate change and its impacts” (Goal 13).

Sustainable Development

The WCED report ‘Our Common Future’ (1987) and the Rio Earth Summit (1992) introduced the concept of sustainable development, which UN members have adopted as an overarching policy.

In urban design, the adoption of sustainable development as an overarching policy has seen a focus on urban forms that have a reduced impact on the environment. In many cases, such as within compact city policy, these urban forms have focused on soft mobility as a key design objective. Since the start of the 21st century, walkable communities – a prerequisite for soft mobility – have been a mainstream part of urban planning. Promoting soft mobility in the form of walking and cycling is considered to help deliver outcomes including social cohesion, resource efficiency, sustainability and better land economy (Carmona, Punter, & Chapman, 2002; Cowan, Adams, Chapman, 2010; Johansson, Lindelöw, & Rosander, 2017). Importantly, urban forms that support mobility without reliance on motorised vehicles are seen as helping to reduce emissions and pollution (Carmona, Tiesdell, Heath, & Oc, 2010; Jenks, Burton & Williams, 1996), which is vital for efforts to slow down climate change.

Climate Change

Global warming was first hypothesized (and disputed) in the 1930s, and is attributed to human activity by most researchers (IPCC, 2001; Davoudi, Crawford, & Mehmood, 2013; Miller, 2016). In brief, climate change is caused by the emission of pollutants known as greenhouse gases into the atmosphere; the magnitude of the change depends on the identity and quantity of the gases that
are emitted. One factor determining emissions is land use and land cover (Moss et al., 2008). Therefore, the planning, structure and form of our cities and their workings are determinants of gaseous emissions. The form of settlements and the mobility choices they facilitate influence transport emissions and therefore affect climate change.

The most important international agreement on climate change policy at present is the Paris Agreement, which was adopted under the United Nations Framework Convention on Climate Change (UNFCCC) on December 12, 2015 and came into force in October 5, 2016 (UNFCCC, 2018A). A main thrust of this agreement is the need to limit the increase in the global temperature:

’Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change’. (UNFCCC, 2018B)

This is important to this research because rising temperatures are likely to significantly affect the winter season: winters are expected to become warmer, with longer frost-free periods and more precipitation. The balance of precipitation between snow and rain is also expected to change (IPCC, 2007). Such weather changes are likely to influence people’s mobility choices.

Awareness of the impact of climate change on soft mobility is particularly important for winter communities. This is because over the last 50 years, Arctic temperatures have risen twice as quickly as the global average temperature (AMPA, 2017; Foreign and Commonwealth Office, 2018). Therefore, the effects of climate change are becoming apparent much more quickly in Arctic and sub-arctic regions.

**Wellbeing**

While urban design cannot be charged with delivering human health or wellbeing objectives, it can create places that are attractive and safe for outdoor
soft mobility. Such places can enable people to be more physically active by using active modes of transport that increase their metabolic rates, enhance their physical capabilities, and confer health benefits.

This is important, because recent decades have seen the emergence of links between non-communicable diseases and physical activity levels (U.S. Department of Health and Human Services, 1996; Lee et al, 2012). Consequently, there has been an increased emphasis on how the built environment can enable outdoor soft mobility and activity. In particular, there is an interest in promoting built environments that enable active forms of mobility such as walking or cycling (U.S. Department of Health and Human Services, 2015; WHO, 2018).
Research design

This chapter presents the rationale for the design of the studies included in the thesis, including the motivation for the use of specific methods. It is shown that the chosen methods support each other and enable triangulation that strengthens the conclusions of the studies.

Research rationale

The overarching goal of the work presented in this thesis is to address what Ebrahimabadi et al (2015) showed as the lack of knowledge about how the winter season affects connectivity for soft mobility. There is a great deal of academic and practical knowledge about the relationship between the built form, connectivity and soft mobility (Marshall, 2005). However, before this work was undertaken, little was known about how the winter season alters these relationships and the connectivity needed for soft mobility. It was therefore essential to better understand these relationships, and how they affect the field of urban design.

To this end, the first goal of the research is to clarify the relationship between the built environment and people’s outdoor soft mobility in winter. The second goal is to understand how connectivity for soft mobility in winter is affected by the season, climate, and weather. The third goal is to identify new ways of thinking about how the urban form can be conceived and designed to increase outdoor soft mobility in the winter season. Here the concepts of urban design and urban form relate to the design of buildings, their grouping, and the spaces and landscapes in between them (Cowan, 2005).
The research is grounded in a qualitative approach (Merriam, 2009) in which empirical data was interpreted qualitatively. Because the research questions relate to how the urban environment creates connectivity for soft mobility, the research is grounded in urban morphology.

**Aim and research questions**

Based on the problematisation and lack of knowledge within the field, the central research question is *what attracts and hinders soft mobility during the winter season and how can this knowledge underpin new considerations about urban design for connectivity in winter cities?* This is answered by considering four sub-questions:

- **Question 1:** What is the current state of knowledge and practice relating to the urban design of winter cities?
- **Question 2:** What attractors, promoters, and hindrances to connectivity for soft mobility can be created in the public realm of winter cities?
- **Question 3:** What climate- and weather-based barriers and enablers to connectivity for soft mobility are created in the public realm of winter cities?
- **Question 4:** How has connectivity for soft mobility been addressed in compact city policy?
**Thesis outline**

This thesis is divided into six sections: *background, research design, theory, results, discussion and conclusion*. Together, these sections address the overall needs and consequences of the urban form in relation to connectivity for soft mobility in winter.

The background section explains why the urban design of winter cities is important and what this work brings to society and academia by establishing how connectivity for soft mobility is related to the urban form and the winter season. This section is also used to highlight the connection between soft mobility and the health science discourse on physical activity and human wellbeing. Finally, it sets out the author’s personal background and initial understandings, as well as the research environment.

The research design chapter explains why the research methods of document studies and empirical research using case studies, questionnaires, mental mapping, photo elicitation, and semi-structured interviews were adopted. The chosen methods are described, and it is shown how they were combined to better understand how the winter season influences connectivity for soft mobility.

The theoretical framework chapter presents theories relevant to the research. This chapter focuses on the theories of urban morphology, urban space, connectivity and quality, human movement, and climate change.

The results section briefly summarizes the results presented in the four peer-reviewed articles and the research report included in the thesis. These works are in various stages of the publication process. Summaries of the papers are provided, outlining the research questions they addressed, the methods used to address them, the results that were obtained, and the conclusions that were drawn. This section sets out the results of the individual studies into the broader context of the work as a whole and elucidates synergies relating to the central research question. Copies of the four peer-reviewed articles and research report abstract are included as an appendix.

The analysis chapter reviews the research outcomes using the concepts outlined in the theoretical framework section. The outcomes presented in the four articles and the research report are discussed using theories of urban form,
urban morphology, public space, connectivity and quality, human movement and climate change. The chapter finishes with a discussion of urban design opportunities for winter cities.

The conclusion attempts to provide some answers to the main research question. The thesis ends with a discussion and some brief reflections and suggestions for further research. This section also highlights some outcomes that emerged during the work that are unrelated to the main research question and next steps.

**Research design table**

The methods used in each study were chosen to further the understanding of the ontology of connectivity for soft mobility in the winter season. A better understanding of this ontology will help improve urban design strategies for the winter season. To this end, it was necessary to gather data that could form a basis for answering the main and sub research questions.

The first step in this process involved conducting literature studies to review the existing knowledge base on connectivity for soft mobility and urban design in winter settlements. The second step involved gathering knowledge about people’s experiences of connectivity for soft mobility in the winter season.

It was therefore necessary to gather empirical data on how winter changes people’s understanding of places, and how people perceive barriers to and enablers of soft mobility in winter. Three participant-based research methods were used for this purpose: mental mapping, photo elicitation, and an Environmental Analysis of Mobility Questionnaire (EAMQ).

Previous studies were used as sources of background knowledge on connectivity for soft mobility in general. Specifically, four housing-led development projects conducted in the UK were used as case studies on connectivity for soft mobility in general. The developments were Accordia (Cambridge), Crown Street (Glasgow), Gun Wharf (Plymouth), and Upton (Northampton).

In addition, data from earlier literature studies, semi-structured interviews, and observational studies conducted in Britain and the Netherlands were used
as sources of background knowledge about connectivity for soft mobility in mainstream urban design.

The gathered data were used to discuss the central research question of what attracts and hinders soft mobility during the winter season and how can this knowledge underpin new considerations about urban design for connectivity in winter cities? The research approach is summarised in Table 1.

Table 1: Research design table.

<table>
<thead>
<tr>
<th>Sub-research question</th>
<th>Type of information required</th>
<th>Methods</th>
<th>Participants/materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the current state of knowledge and practice relating to the urban design of winter cities?</td>
<td>Academic books, peer-reviewed articles, design guides for winter settlements.</td>
<td>Literature Review: Documented principles of urban design for winter settlements.</td>
<td>35 (n) scholarly documents</td>
</tr>
<tr>
<td>What attracts, promotes, and hindrances to connectivity for soft mobility can be created in the public realm of winter cities?</td>
<td>Information on how a neighbourhood’s perceived connectivity for soft mobility can be altered by the winter season.</td>
<td>Mental mapping and photo elicitation: Mental maps of a case study neighbourhood in winter and summer. Photographic images of barriers and enablers to connectivity for soft mobility in winter.</td>
<td>12 (n) Residents</td>
</tr>
<tr>
<td>What climate- and weather-based barriers and enablers to connectivity for soft mobility are created in the public realm of winter cities?</td>
<td>Information on the perceived effects of the weather and winter season on soft mobility.</td>
<td>EAMQ-Climate: Questionnaire based on which public realm and weather conditions inhibit or enable soft mobility.</td>
<td>212 (n) Residents</td>
</tr>
<tr>
<td>How has connectivity for soft mobility been addressed in compact city policy?</td>
<td>Insight into how soft mobility was viewed by the planning industry under compact city policy.</td>
<td>Background research: Observational studies and semi-structured interviews for 4 case studies.</td>
<td>8 (n) Academics &amp; Planners</td>
</tr>
</tbody>
</table>
Case study

The case was selected strategically (Yin, 2003) based on the definition of a winter city as a city that experiences long snow-covered winters. Another criterion was practical: we needed to be able to follow a group of people in several workshops, so it was necessary to select a study environment reasonably close to the author’s base of operations. The city of Luleå has a long winter season and the university (LTU) at which the author worked is located in the city. Luleå is located 66.5622° N (latitude) and 22.1567° E (Longitude), and has a sub-arctic (Group D) climate belonging to the Dfc subcategory according to the Köppen-Geiger Climate Classification system. According to the National Weather Service (2011), regions in this subcategory have severe winters, no dry season, and cool summers. Temperatures in the city can reach +30 °C in the summer and -30 °C in the winter, and the sea is frozen for around 6-7 months per year. The average temperature is usually below 0 °C between mid-November and mid-March (Ebrahimabadi et al, 2015). The municipality of Luleå has a population of over 75,000 inhabitants, of whom around 45,000 live in the city itself (Luleå kommun, 2018).

Figure 2: Luleå, Sweden location in relation to the Arctic Circle.
The case study was conducted in the Mjölkudden neighbourhood of Luleå, which has a residential population of 3,491 with an average age of 46 years and a male to female ratio of 1708: 1783 (Luleå Kommun, 2014). The area is a mixed-use neighbourhood with accommodation including both single- and multi-family houses. Its societal services comprise a health care centre, pharmacy, dentist, and church, as well as an L School (F-3), a MH-school (4-9), a nursery school, and a care home. Commercial services in the area include a supermarket and leisure facilities such as a sports hall, football, hockey, and tennis pitches, an open-air pool, and a marina.

**Methods and implementation**

The methods used in the research included a literature review, mental mapping, photo elicitation, questionnaire, semi-structured interviews and observations.

![Diagram](image)

*Figure 3: The case study combined mental mapping, photo elicitation, & the EAMQ-Climate questionnaire to clarify how people perceive soft mobility in the winter season.*
Literature review

To get an overview of the state-of-the art in research on urban design and soft mobility in winter cities, a literature review was conducted using the Scopus and Web of Science databases, which were searched using various combinations of the keywords ‘winter cities’, ‘urban design’, ‘climate change’ and ‘health’. The number of hits obtained ranged from 233 hits when ‘winter cities’ and ‘urban design’ were used to six hits when all keywords were used. In total, 233 hits were obtained, of which 13 were identified as being relevant to the urban design of winter cities.

Reference and citation lists from these 13 documents were then used to identify an additional 22 relevant publications. In total 35 documents addressing various aspects of winter city urban design were included in the literature review. These documents comprised 22 journal articles, nine books, two urban design guides, and two academic theses. The 35 documents are listed and discussed in the results section.

The chosen documents were examined using qualitative content analysis (Graneheim & Lundman, 2004; Krippendorff, 2004). Relevant material from each document was identified and categorised using a stepwise approach (Mayring, 2000) whereby text was extracted from sentences and paragraphs based on keywords or themes. For weather conditions, these themes related to the conditions of sun, wind, snow, darkness, rain, cold, and snow- or ice-covered terrain. For aspects of the built form, the themes related to siting & layout, height & massing, façade & interface, and the public realm & landscape. A conventional qualitative content analysis based on the categories of weather and built form (Hsieh and Shannon, 2005) was used as the basis for text selection. The extracted text was then used to populate a matrix that juxtaposed information on climatic conditions against aspects of urban form.

The literature’s coverage of different aspects of urban form under different weather conditions was then ranked using a traffic light system: green was used to denote combinations that were discussed extensively, orange for combinations with moderate coverage, and red for combinations with little or no coverage. In this way, gaps in design policy coverage were identified.

Data on climate change were obtained from the IPCC and national and regional agencies in the Nordic countries. The national and regional documents
were used in discussions because they tailor global IPCC trajectories to local contexts.

The literature and document study aimed to explore available knowledge about the urban design of winter cities. As such, their purpose was to gather knowledge relating to the research question *What is the current state of knowledge and practice relating to the urban design of winter cities?* The results of this study are presented in the paper: Chapman, D., Nilsson, K. L., Rizzo, A., & Larsson, A. (in press). Updating winter: the importance of climate-sensitive urban design for winter settlements, *Arctic Yearbook* (accepted).

**Lynch analysis**

The mental mapping technique used in this work was that outlined by Kelvin Lynch in *The Image of the City* (1992). While other methods were considered, this method was chosen because it provided a way for people to illustrate their individual memory of a place. It is also a widely used method that is commonly understood in urban design research and originates from one of the most widely recommended urban design books at universities (Araabi, 2016).

To characterize the winter and summer connectivity of the studied neighbourhood (Mjölkudden), a series of workshops and sketch mapping exercises were conducted in 2017 and 2018. Because the objective was to understand how winter changed the neighbourhood, workshops were conducted during February and March. The participants were asked to draw their mental maps of the neighbourhood, and examples of other mental maps were shown. One researcher and one assistant led these workshops. Each participant was asked to:

1. Draw a quick sketch map of Mjölkudden showing the most interesting and important features, and giving a stranger enough knowledge to move about without too much difficulty and avoid major barriers.
2. Make a similar sketch of the route and events along a typical trip (either walking or cycling) from Mjölkudden to the City Centre.

Once collected, these sketch maps were combined by myself to give two resident maps of the neighbourhood, one in winter and one summer. The maps were all
redrawn to the same scale using Lynch's standard notation of Path, Edge, Node, District, and Landmark (Lynch, 1992).

A separate meeting was held with the local planning authority during which a planning officer familiar with the study area was briefed on the preparation of a Lynch type analysis for the neighbourhood. This officer made one diagram of the neighbourhood.

**Photo elicitation**

To deepen the results from the mental mapping exercise and gather specific knowledge about local barriers to and enablers of soft mobility in the case study area, the photo elicitation method was used (Harper, 2002; Ketelle, 2010). Photo elicitation is a method of visual sociology that uses participant photographs to obtain visual comments about a place and community.

In new workshops, a group of residents were asked to photograph physical aspects of the neighbourhood that they perceived as either facilitators of or barriers to their outdoor soft mobility. An introductory meeting was held with residents to explain this activity, and digital cameras were made available to participants. However, all participants instead chose to use the camera functions of their mobile phones. Over the following two-week period, they were asked to photograph ten physical aspects of the neighbourhood that facilitated or hindered outdoor soft mobility in winter. Participants were asked to email their photographs to the researchers before the second meeting so they could be printed.

During the second meeting, the participants were given a full set of prints of their photographs. Each of them was told to write a brief description of the photograph on its reverse and to then order them, placing the most significant barrier first and the greatest enabler (or smallest barrier if no enablers had been photographed) last. Each participant was then asked to describe his or her photographs and ranking. This prioritisation encouraged participants to identify the issues of highest importance.

These presentations formed the basis of discussions around each set of images. Within these discussions, the following questions were used:
• How would you broadly describe the barriers to walking and biking in winter in a physical sense?
• How can the local environment be improved to enable walking and cycling in the winter?
• Are there parts of the local area that you avoid using and how can they be improved?

The mental mapping and photo elicitation exercises were conducted to gather data relating to the research question *What attractors, promoters, and hindrances to connectivity for soft mobility can be created in the public realm of winter cities?* The results of this study are presented in the paper: Chapman, D., Nilsson, K. L., Rizzo, A., & Larsson, A. (forthcoming A). Climate-sensitive urban design; enabling connectivity for soft mobility in winter. *Urban Design International*, (submitted).

**Questionnaire**

A version of Patla and Shunway-Cook’s (1999) *Environmental Analysis of Mobility Questionnaire* ([EAMQ] Appendix A) that was tailored to winter conditions was used to investigate people’s movement behaviour and deepen the knowledge of soft mobility in winter. The original questionnaire was developed for physiotherapy and is an established method that focuses on community walking and provides insight into how the weather, ambient, and terrain conditions affect soft mobility.

The questionnaire made it possible to use a structured methodology to study the qualities that empower people to use and reuse the physical environment. The original EAMQ contained 37 questions divided into eight dimensions (distance, time, ambient conditions, terrain, physical load, postural transition, attention, and density) that address environmental conditions from a systems perspective. The questionnaire interrelates environmental factors with community walking (i.e. walking-related activities outside one’s property and in the community), individual capabilities, and human health.

The EAMQ was adapted to address the urban design of winter cities by focusing on the dimensions of distance, ambient conditions, and terrain. The questionnaire was expanded to address summer and winter soft mobility, and
the range of weather conditions experienced in winter (See Table 2). This made it possible to gather data on the effects of weather-related factors traditionally considered in winter city design (i.e. wind and snow) and the effects of other common weather conditions.

To differentiate this modified survey from the original and highlight its examination of a wider range of weather conditions, it was given the name EAMQ-Climate. EAMQ- Climate has twenty-two questions, eleven relating to encounters (e.g., *when you go into the community, how often do you walk on snow-covered surfaces?*) and eleven relating to avoidance (e.g., *when you go into the community, how often do you avoid walking on snow-covered surfaces*?). Five answers – Never, Rarely, Sometimes, Often, and Always – were possible for each question.

<table>
<thead>
<tr>
<th></th>
<th>Distance (D)</th>
<th>Distance – Summer (D)</th>
<th>Distance – Winter (D)</th>
<th>Dark (A)</th>
<th>Snow (A)</th>
<th>Rain (A)</th>
<th>Cold (A)</th>
<th>Wind (A)</th>
<th>Snow covered surfaces (T)</th>
<th>Ice covered surfaces (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAMQ</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAMQ-Climate</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

The questionnaire was pilot tested by students from the Architecture Engineering programme at Luleå University of Technology (LTU). The pilot study was conducted in spring 2016 and yielded 132 completed questionnaires. Its participants were people visiting the city centre of Luleå, all of whom gave informed consent for the use of their responses. Based on the pilot study’s results, the questionnaire was amended by adding items relating to the respondent’s gender and age in order to verify that the composition of the survey group reflects the general population.

The survey was repeated in the case study neighbourhood between the 20th and 23rd of June, 2016. The repeat was performed in the summer in an attempt to maximise the number of participants, who were recruited outside in the centre of the neighbourhood. In total, 212 people completed the questionnaire, all of whom were visitors to the neighbourhood’s centre (i.e. its shopping area)
during the four day period. All participants gave informed consent for the use of their responses. The survey results were then ranked in order of the reported barrier effects.

The EAMQ-Climate questionnaire was used to explore perceptions of different weather conditions as barriers to soft mobility in winter. As such, the responses relate to the research question: *What climate- and weather-based barriers and enablers to connectivity for soft mobility are created in the public realm of winter cities?* The results of this study are reported in the article *Climatic barriers to soft-mobility: Lulea, Sweden as case study*, which was published in the journal *Sustainable Cities and Society*, 35, 574-580 (2017).

**Semi-structured interviews**

Semi-structured interviews were held with professional planners and planning academics in relation to studies conducted in 2000 and 2001 in the Netherlands.

This approach was used due to the variety of projects discussed and the variety of roles held by the interviewees. The interviews focused on the underlying urban design necessary for successful implementation of a compact city policy:

- The procurement methods used to assemble land for redevelopment;
- Development density;
- The underlying urban design principles necessary to make high density living acceptable to residents; and
- The master plan constraints imposed to ensure design diversity.

**Table 3: List of interviewees, their occupations and employers, and the dates of the corresponding interviews.**

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Organisation</th>
<th>Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joep Boute</td>
<td>Physical Planning Department, Rotterdam.</td>
<td>Physical Planner</td>
<td>20 March 2001</td>
</tr>
<tr>
<td>Dr D. Drenth</td>
<td>School for Planning and Environment, University of Nijmegen.</td>
<td>Planning Academic</td>
<td>22 March 2001</td>
</tr>
<tr>
<td>Hein de Haan</td>
<td>School of Architecture, University of Delft, Delft.</td>
<td>Architect</td>
<td>19 March 2001</td>
</tr>
<tr>
<td>Dr D. Ipenburg</td>
<td>Department of Infrastructure, Transport and Spatial Organisation, University of Delft, Delft.</td>
<td>Academic Researcher (Spatial Planning)</td>
<td>17 March 2001</td>
</tr>
</tbody>
</table>
Observational studies

To characterize mainstream urban design qualities, observational studies were undertaken in 2009, focusing on four built housing-led development projects in the United Kingdom. The four projects reviewed were Accordia (Cambridge), Crown Street (Glasgow), Gun Wharf (Plymouth), and Upton (Northampton).

The criteria used to select cases for study were based on their urban design qualities, in particular their accessibility, flexibility, high-quality aesthetics, services and parking, legibility, distinct character and identity, liveliness, connectivity, and environmental sustainability. An extended list of potential case studies was drawn-up in collaboration with the CABE, which was also the client and publisher of By Design.

Design and Access Statements and other related design information were then obtained for these potential observational studies, and selected projects were visited in the company of representatives of the developer and local authority. An inclusivity expert and photographer attended each visit and observational study.

Once these observational studies were completed, their results were used to populate a matrix in which the observations of each scheme were weighed against the urban design objectives specified in By Design (Character, Continuity and Enclosure, Quality of the public realm, Ease of movement, Legibility, Adaptability, and Diversity). The outcomes in this matrix were written up in the form of a discussion.

The semi-structured interviews, and observational studies were used to evaluate the importance of connectivity for soft mobility in mainstream urban design. The resulting data relate to the research question How has connectivity for soft mobility been addressed in compact city policy? The results of this study

**Triangulation**

The results of the mental mapping, photo elicitation, and questionnaire were integrated by triangulation (Yin, 2003). The triangulation was methodological and the three methods were all used to gather data of the same matter: how soft mobility is perceived in the winter season. Triangulation was used to cross-check and validate the results obtained using the individual methods (Johansson, 2007), and to characterize connectivity for soft mobility from different perspectives. This yielded a more robust picture of connectivity for soft mobility in the winter season. Finally, the results of the different studies were analysed collectively to address the main research question.
Theoretical framework

The research focuses on how the urban form of winter cities can be improved to enhance connectivity for soft mobility in the winter season. To this end, it adopts a theoretical framework based on several concepts encompassing aspects of urban morphology, public space, connectivity and quality, human movement, and climate change.

Urban morphology

Urban morphology is the configuration of urban form, space and infrastructure (Hillier, and Hanson, 1984; Carmona et al., 2010). Here, ‘urban’ includes all human settlements despite size (i.e. it is not limited to cities), and ‘morphology’ means all urban forms (Kropf, 2009).

There are several commonly referenced schools of thought on urban morphology. Some, such as the Italian, British, and North American schools are associated with specific national identities, but others (such as space syntax) are grounded in specific methods. Each school has its own body of theory, preferred methods for collecting data and identifying patterns, change theory, and informal links. However, there is appreciable common ground between schools (Scheer, 2016).

Particularly relevant to this research is the urban morphology approach of searching for settlement patterns (Carmona et al., 2010; Hillier, and Hanson, 1984; Hillier, 2007; Kropf, 2014; 2017; Scheer, 2016). While these patterns vary in complexity, they all relate to how a spatial system and its movement system are produced. That is, they describe whether the buildings in a space define the space or are simply objects within it (Carmona et al., 2010). The areas over which searches for settlement patterns are conducted may be as small as a few blocks or as large as a region.

There is no general consensus between schools regarding the components of urban form, i.e. what makes up the urban form or its description. However, they all emphasise the importance of street patterns in relation to the built form (Gauthiez, 2004; Kropf, 2009; 2014; 2017; Jones, Isakjee, Jam, Lorne, & Warren, 2017). Street patterns and the configurations of space that streets create are
often seen as critical dimensions of the urban form (Kropf, 2009). Their spatial configuration defines the public realm network of a settlement and is the primary determinant of its connectivity.

The patterns of space created by these configurations of streets and other elements of the urban form are collectively known as the ‘urban grain’ (Caniggia & Maffell 1979). When studying urban morphology, this grain can be used to understand the spatial arrangement of a place and its connectivity for soft mobility. Importantly, it can also be used to see how space is defined or produced. Further to this, the streets and other elements of the urban form that comprise the urban grain are considered to have different rates of physical change. The street is seen as the least likely to change and is generally expected to outlive elements such as uses, buildings, and even plots (Carmona et al., 2010). In effect, this means the urban form and grain are always in a state of flux to some degree.

In urban design, urban morphology helps provide an understanding of how urban forms evolve (Sanders, 2013). It should however be noted that urban morphology focuses on the processes that shape these urban forms rather than the form themselves (Kropf & Malfroy, 2013). This is important; as Kropf & Malfroy (2013) note, while the planning and design of settlements is a conscious human activity, the forces that govern aspects of urban form include non-human forces (e.g., natural forces). Here it can be argued that some aspects of urban form are not consciously shaped, and that the impact of climate warrants study from a morphological perspective (Ding, 2013).

**Public space**

The concept of space can be described in many ways, and the question “what is space?” is rather open-ended (Madanipour, 1996; Hillier, 2007). Among other things, space can be seen as something abstract – an infinite container of all things – or an elaborate construction of physical, social and psychological dimensions (Hillier and Hanson, 1984; Hillier, 2007). Historically, the debate around the nature of space has evolved in several directions. Aristotle saw space as the container of all things, Newton saw space and time as real things with infinite duration, while Einstein said that the concept of space was a creation of the human imagination (Madanipour, 1996).
Other discussions present space as a virtual object that can express social structure (Lefebvre, 1991). Lefebvre dismissed the idea that space was just a container that is ordered by the built environment. Instead, he focused on studying space as a virtual object (Brenner, 2014; Fraser, 2008; McKeown, 1980; Mugavin, 1999; Pierce & Martin, 2015). For Lefebvre, this exploration was about the human relationship to space, necessitating an integration of mental, social, and physical dimensions (Bourdieu, 2018; Thompson, 2017). He suggested that this would make it possible to conceptualise ‘what space is’ (Brenner & Elden, 2001). Lefebvre identified three types of space: the conceived space, perceived space, and lived space (1991).

Conceived space is the representational space used to illustrate our built environment. Representations are drawings such as architectural and urban plans, elevations and sections (Lefebvre, 1991; Thompson, 2017). Perceived space is how space is understood in psychological terms. Here, Lefebvre’s idea was to focus on the perception of everyday space (the daily reality). Lefebvre saw this space as the outcome of many processes, both societal and historical (Madanipour, 2014; Merrifield, 2014; Pierce & Martin, 2015). Lived space is seen as the experienced space, which (according to Lefebvre) cannot be disaggregated from physical space and social circumstance (Madanipour, 2017; Pierce & Martin 2015; Fraser, 2008). Critical to Lefebvre’s analysis is the idea that these spaces cannot be considered in isolation, and that their properties depend on their inter-relationships (Hess, 2014; Lefebvre, 1991).

Like Lefebvre, Madanipour sought to find a meaning of urban space (1996). However, Madanipour offers a broader and less defined concept in which space is an objective, physical quantity with social and psychological dimensions (1996; 2017). While Madanipour’s definition of space is broader, he argues that the primary concern of urban design is the transformation of space and that we must try to understand space and the social processes behind it before we try to shape it (1996; 1997). He also argues that discussions of physical space are incomplete if they do not include time because space is constantly remade in the context of social circumstances (1996; 2013; 2017).

Lefebvre and Madanipour both contend that space can have non-physical dimensions that are perceived, and that space can be overlaid with meaning that can be perceived, read and understood. These ideas can be used in architecture and urban design to rethink the manifestations of urban space and its configuration (Lefebvre & Stanek, 2014).
Connectivity and quality

Connectivity is the degree to which a point or place is connected to other points and places, and is seen by many as a founding principle of good urbanism (Gehl, 2011; Jacobs, 2011[1961]; Madanipour, 2010). Connectivity is also a crucial component of sustainability for settlements, and one of the most important aspects for town planners to address (Stangl & Guinn, 2011; Stangl, 2011). In urban design, a place's connectivity for all modes of transport is often discussed in terms of networks of routes and links and their hierarchy (Marshall, 2005). The regularity of connections and the distances between them often form the basis of discussions about block size and connectivity (Stangl, 2014). Networks of routes and links with high degrees of connectivity (i.e. many connections) have been suggested to have positive effects on outcomes including economic activity and soft mobility (Hillier, 1996; Cowan et al., 2010). In general, places with high levels of connectivity and smaller block sizes are considered to enable soft mobility in the form of walking and cycling (Marshall, 2005).

While connections are a fundamental prerequisite for soft mobility, their ability to enable walking or cycling also partly depends on the quality of the routes. In 'Life between Buildings' (2011) Gehl defines three categories of activities performed in the public realm - necessary, optional, and social. Moreover, he argues that decisions to participate in optional and social activities is influenced by the quality of the public realm or space. This suggests that connectivity alone is not sufficient to enable connectivity for soft mobility; the built quality, the design and the materials of the links are also important (Carmona, 2010).

Human movement

While urban design is concerned with urban form, understanding how people move is a crucial aspect of medical science and physiotherapy. Enabling soft mobility can increase levels of physical activity, which in turn increases people's metabolic rates, physical capabilities, and general good health.
Central to this understanding is the concept of human motor control. Shumway-Cook and Woollacott have created a theoretical framework for movement that links three interacting factors relevant to this research: the individual (and their capacities, perceptions, and experiences), the task (for example walking), and the environment. Central to Shumway-Cook and Woollacott’s theory is that these factors constrain human movement. They argue that sensory and perceptual aspects affect individuals, and that the (built) environment is fundamental to understanding movement (Shumway-Cook and Woollacott, 2016). Their framework divides the environment into two ‘regulatory’ (physical) and ‘nonregulatory’ (non-physical) aspects.

**Climate Change**

The relationship between the state of the earth and human activity has been a subject of discussion throughout history. The aspect of this relationship relevant to this work is the link between human mobility and climate change.

A mainstream scientific argument that is widely accepted is the theory of coevolution. Here it is seen that human life and the environment have developed together over time and are linked by a causal relationship. The environment is seen as a coupled system that is shaped by life and vice versa (Kircher, 2002; Tyrrell, 2013). This argument is important in the context of this research because it suggests that humans can influence the environment, and that choices made during settlement and transport planning can thus have environmental consequences that influence climate change.

However, there are other positions including the argument that the earth’s environment is structured by natural forces driven by geological and astronomical processes. This approach, which is known as the geological hypothesis, sees humans as passengers on planet earth who have little or no influence over environmental change (Tyrrell, 2013). This theory, however, is not widely accepted today because it disregards the effects of human activity.
Results

The application of the chosen research methods generated a large body of empirical data that was used to address the research questions. This is graphically summarised below:

Figure 4: Main research question surrounded by sub-questions and key outcomes.

Summary of papers

Paper 1 *Updating winter: the importance of climate-sensitive urban design for winter settlements* addressed the research question; *What is the current state of knowledge and practice relating to the urban design of winter cities?* This
article has been accepted by the *Arctic Yearbook* and will be published by UArctic by the end of 2018.

To delineate the state-of-the-art in the urban design of winter cities, a systematic literature review of publications on this topic was undertaken. The review identified 35 documents covering various aspects of winter cities. The results were discussed in the context of rising outdoor temperatures due to climate change and their effect on winter weather conditions. The selected publications were also analysed in relation to human wellbeing and how connectivity for soft mobility can facilitate higher levels of physical activity and thus better health and wellbeing.

**Table 4: Publications selected for inclusion in the literature review, listed by date of publication.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Date</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1979</td>
<td>Bygg rätt för vädern och vind. Bästlägen och baklägen för tom och hus</td>
<td>Andbert, P. G.</td>
</tr>
<tr>
<td>3</td>
<td>1982</td>
<td>Settlement Planning under Arctic Conditions in Northern Norway</td>
<td>Børve, A.</td>
</tr>
<tr>
<td>4</td>
<td>1983</td>
<td>The liveable winter city (Canada)</td>
<td>Werier, V.</td>
</tr>
<tr>
<td>5</td>
<td>1983</td>
<td>Philosophy, Principles and Practice of Northern Latitude Urban Landscape Design</td>
<td>Pihlak, M.</td>
</tr>
<tr>
<td>6</td>
<td>1985</td>
<td>Reshaping winter cities: concepts, strategies and trends</td>
<td>Pressman, N. (eds.)</td>
</tr>
<tr>
<td>7</td>
<td>1986</td>
<td>Planning in cold climates: a critical overview of Canadian settlement patterns and policies</td>
<td>Pressman, N., &amp; Zepic, X.</td>
</tr>
<tr>
<td>8</td>
<td>1987</td>
<td>The future of winter cities</td>
<td>Gappert, G. (ed.)</td>
</tr>
<tr>
<td>9</td>
<td>1987</td>
<td>Hus og husgrupper i klimatutsatte, kalde strøk: utformning og virkemåte</td>
<td>Børve, A.</td>
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<td>10</td>
<td>1988</td>
<td>Cities designed for winter</td>
<td>Pressman, N. &amp; Mänty, J. (eds.)</td>
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<tr>
<td>11</td>
<td>1988</td>
<td>Design for northern climates: cold-climate planning and environmental design</td>
<td>Matus, V.</td>
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<td>12</td>
<td>1988</td>
<td>Klimatplanering, Vind</td>
<td>Glau mann, M., &amp; Westerberg, U.</td>
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<td>13</td>
<td>1988</td>
<td>Settlement and housing design with special regard to local climate conditions in cold and polar-regions – examples from northern Norway</td>
<td>Børve, A.</td>
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<tr>
<td><strong>14</strong></td>
<td>1988</td>
<td>Climate and Weather Protection Systems in Settlement Planning in the Arctic Regions of Northern Norway</td>
<td>Sterten, A.</td>
</tr>
<tr>
<td><strong>15</strong></td>
<td>1988</td>
<td>A climatic approach to town planning in the Arctic</td>
<td>Zrudlo, L. R.</td>
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<tr>
<td><strong>16</strong></td>
<td>1988</td>
<td>Developing Climate-responsive Winter Cities</td>
<td>Pressman, N.</td>
</tr>
<tr>
<td><strong>17</strong></td>
<td>1989</td>
<td>Final Report, UN/ECE Research Colloquium on Human Settlements in Harsh Living Conditions</td>
<td>Pressman, N.</td>
</tr>
<tr>
<td><strong>18</strong></td>
<td>1989</td>
<td>Harsh Living Conditions: A Research Agenda</td>
<td>Pressman, N.</td>
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<tr>
<td><strong>19</strong></td>
<td>1989</td>
<td>The Search for Northern Settlement Form</td>
<td>Pressman, N.</td>
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<tr>
<td><strong>20</strong></td>
<td>1990</td>
<td>Design Criteria for solar access and wind shelter in the outdoor environment</td>
<td>Westerberg, U. &amp; Glaumann, M.</td>
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<td><strong>21</strong></td>
<td>1991</td>
<td>Human Health and Social Factors in Winter Climates</td>
<td>Pressman, N.</td>
</tr>
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<td><strong>22</strong></td>
<td>1994</td>
<td>Climatic factors in play areas and public space</td>
<td>Pressman, N.</td>
</tr>
<tr>
<td><strong>23</strong></td>
<td>1994</td>
<td>Climatic factors in urban design</td>
<td>Pressman, N.</td>
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<td><strong>24</strong></td>
<td>1995</td>
<td>Northern cityscape: Linking design to climate</td>
<td>Pressman, N.</td>
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<td><strong>25</strong></td>
<td>1996</td>
<td>Sustainable winter cities: Future directions for planning, policy and design</td>
<td>Pressman, N.</td>
</tr>
<tr>
<td><strong>27</strong></td>
<td>2003</td>
<td>Potential of transferring car trips to bicycle during winter</td>
<td>Bergström, A. &amp; Magnusson, R.</td>
</tr>
<tr>
<td><strong>28</strong></td>
<td>2004</td>
<td>Shaping Cities for Winter</td>
<td>Pressman, N.</td>
</tr>
<tr>
<td><strong>30</strong></td>
<td>2009</td>
<td>The significance of climate for the use of urban outdoor spaces</td>
<td>Westerberg, U.</td>
</tr>
<tr>
<td><strong>31</strong></td>
<td>2012</td>
<td>Improvements in addressing climate factors in urban planning and design</td>
<td>Ebrahimabadi, S.</td>
</tr>
<tr>
<td><strong>32</strong></td>
<td>2015</td>
<td>Outdoor Comfort in Cold Climates: Integrating Microclimate Factors in Urban Design</td>
<td>Ebrahimabadi, S.</td>
</tr>
<tr>
<td><strong>33</strong></td>
<td>2015</td>
<td>The problems of addressing microclimate factors in urban planning of the subarctic regions</td>
<td>Ebrahimabadi, S., Nilsson, K. L., &amp; Johansson, C.</td>
</tr>
<tr>
<td><strong>34</strong></td>
<td>2016</td>
<td>Winter Design Guidelines, Transforming Edmonton into a Great Winter City</td>
<td>Edmonton.</td>
</tr>
</tbody>
</table>
Several important conclusions were drawn from the literature review. The main factors considered in publications regarding the urban design of winter cities were solar access, wind defence, and snow management (Andbert, 1979; Pihlak, 1983; Børve, 1987; Glaumann & Westerberg, 1988; Matus, 1988; Urbansystems, 2000; Pressman, 1989A; 1989B; 1989C; 1994A; 1994B; 2004; Ebrahimabadi, 2015; Edmonton, 2016). These urban design principles were mentioned in many of the reviewed publications, including those originating from Europe and North America.

It was also found that the number of publications dealing with urban design for winter cities peaked strongly between 1985 and 1989. This period broadly aligns with the founding and early years of the Winter Cities Association, Canada (WCA). Dr. Norman Pressman, a founding member of the WCA, was the first author of five of the 14 journal articles published during this period, and editor of two of the books. This is important because while the WCA and Pressman published their last book on winter cities in 2004, their publications are still some of the most widely cited documents on the subject. The Winter Cities Institute (WCI), which replaced the WCA in 2005, highlights Pressman’s books as a source of guidance on climate-responsive design (Davies, 2015; Winter Cities Institute, 2018).
The prominence of Pressman and the WCA in the discourse on winter cities is not a problem per se. However, there is a problem in that when their work ceased (in 2005 and 2004, respectively), research into winter cities slowed dramatically and may not have kept pace with problems that have since emerged. Notably, the literature review found that most articles and books published before 2005 did not mention the term sustainability even though the concept was introduced by the report “Our common future” in 1987 (WCED). However, Pressman’s last publications “Sustainable winter cities: Future directions for planning, policy and design” (1996) and “Shaping Cities for Winter, Climate Comfort and Sustainable Design” (2004) both discuss agendas related to sustainability, transportation, pollution, and mental health.

All the literature was also reviewed against source information from the WHO on the health benefits of physical activity, an issue brought to prominence in 1996 by the U.S. Surgeon General’s report on physical activity and health. In addition, they were reviewed against climate change scenarios, which became part of the international agenda in 1988 when the IPCC was established. Most of the documents said nothing about the health benefits that the WHO relates to physical activity. Moreover, few addressed the changes in winter weather conditions that are expected to result from climate change. In particular, the guidance rarely addressed issues relating to rain, darkness, ice, water or slush.

The literature review indicated that new research was needed to better integrate the agendas of ‘climate change’ and ‘physical activity’ into urban design for winter cities.

**Paper 2 Climate-sensitive urban design; enabling connectivity for soft mobility in winter.** This paper addressed the research question *What attractors, promoters, and hindrances to connectivity for soft mobility can be created in the public realm of winter cities?* It has been submitted to the journal Urban Design International.

This paper is based on empirical data gathered by mental mapping and photo elicitation, and uses urban morphology as its theoretical basis. It shows that seasonal climate variation can significantly alter connectivity for soft mobility at the neighbourhood scale. The participants’ mental maps of their neighbourhood in summer and winter were similar, but they differed noticeably with respect to the use of the sea. The summer maps of the water were free of interventions, but
the winter maps showed that the frozen sea offered varied opportunities for soft mobility.

![Winter Connectivity Map](image1)

![Summer Connectivity Map](image2)

Figure 6: Redrawn summaries of two mental maps submitted by a participant showing how the neighbourhood’s connectivity options for soft mobility in summer differ from those available in winter.

![Typical Mental Map](image3)

Figure 7: A typical mental map of the neighbourhood in winter submitted by a participant.
The presence of the ‘Ice Road’, which is a maintained leisure pathway on the frozen sea, was a clear difference between the winter and summer maps. This route was often drawn in more detail than other features, suggesting that it left a clear image in the participant’s minds. The results showed that frozen areas of water outside the ice road also facilitated soft mobility.

![Image: Luleå’s ice road facilitates walking, skating, skiing and kick sledding (Photograph, Jennie Sjöholm).](image)

The photo elicitation exercise focused on barriers to and enablers of connectivity for soft mobility. A theme that emerged during this process relates to how the urban form and the conditions of the winter season altered the public realm. The results showed that the winter season could change a neighbourhood’s local network of routes for soft mobility. In the main, the winter season was seen to reduce the number of routes available for soft mobility. One participant stated that in winter, ‘walkways through the forest disappear, and then you need to cycle on the roads’ and another said that ‘sometimes there are pathways, sometimes you have to make walkways yourself’.

The results also showed that in winter, build-ups of snow, ice, slush and water reduced the area of the public realm usable for soft mobility. One participant noted that in winter ‘everybody tries to stick to the same small dry patch of clear pavement’, and another said that ‘the slush is much more problematic than snow.’
You get stuck and wet, it’s horrible’. Participants suggested that the reduced area of the usable public realm that are created by the winter conditions could be a potential source of conflict because different users compete for those parts of the public realm in which the snow is adequately cleared.

Figure 9: A participant’s photograph shows that the usable pavement area can be greatly reduced in winter.

The winter season was also seen to alter the visual appearance of the townscape and the public realm. Here participants noted that the look of a neighbourhood ‘changes every week and it always looks different depending on the snow’. Build-ups of ice, snow, and slush were seen to create a ‘white-out’ effect in the public realm that made it difficult to identify different parts and uses of streets and spaces. For example, it became hard to see where the edge of the pavement was, where parking plots were located, or where cycle lanes were. Consequently, these elements of the public realm appeared to merge into a single area.
When asked about improvements for soft mobility in winter, participants stated that routes for walking and cycling in winter felt ‘improvised and not thought through’, and that in winter, ‘routes seemed to be planned in small sections and not connected’. In particular, participants felt that during the winter, cyclists ‘were forced to use the same space and routes as cars’. The participants suggested that walking, cycling, and skiing could be made into more practical modes of transportation in winter by creating better networks of usable and connected winter pathways within the area and between the area and its surroundings. Participants stated that better information on the usability of pathways for soft mobility would be helpful. In particular, it was suggested that a mobile phone app showing available soft mobility routes could be beneficial.
Figure 11: A participant used this photograph to illustrate how routes for soft mobility can just stop in winter.

Overall, the results indicated that winter can change connectivity for soft mobility in several ways. It can change the local network of streets and spaces, as well as the area's visual appearance in terms of the local townscapes and at the scale of streets and spaces. In addition, the winter could change the profile of the public realm, reducing the usable area for soft mobility.

This study showed that the winter mainly reduced connectivity for soft mobility by reducing the number of routes and pathways in the spatial network and limiting the usable space in those parts of the public realm that remained available. Overall, the study's results suggest that connectivity for soft mobility could be improved by creating winter soft mobility plans for cycling, walking and skiing that are grounded in an understanding of how winter changes the public realm.
Paper 3 *Climatic barriers to soft-mobility in winter: Lulea, Sweden as case study* addressed the research question *What climate- and weather-based barriers and enablers to connectivity for soft mobility are created in the public realm of winter cities?* It was published in Sustainable Cities and Society 35 (2017) 574–580.

This paper is based on data gathered using the EAMQ-Climate questionnaire. Its results show that people were slightly more reluctant to walk for more than a kilometre during winter than during summer. In addition, it indicated that the main barriers to soft mobility were icy surfaces and rain. Other important barriers were coldness, darkness, and wind. The barriers with the least impact on outdoor soft mobility were snow and snow-covered surfaces.

![Diagram showing avoidance by location](image)

*Figure 12: Avoidance: distance, ambient and terrain dimensions for the neighbourhood (n=212) and city centre (n=132) groups. Arranged in order of avoidance.*
Figure 13: Encounter: distance, ambient and terrain dimensions for the neighbourhood (n=212) and city centre group (n=132). Arranged in order of avoidance (Figure 4).

The responses to the questionnaire indicate that the traditional principles of winter city urban design should be expanded to include a wider range of weather conditions. While sun, wind and snow management will clearly continue to be important for soft mobility, urban designers and planners should also focus on weather conditions such as ice, rain, and darkness that can hinder soft mobility and other outdoor activities. In particular, the questionnaire showed that ice and rain are now important design considerations in winter.

The results were also discussed in light of how climate change could affect the case study location. Average temperatures in Norrbotten have been rising since the early 1980s. Before then, the area’s average temperature was usually around -2 °C. The average temperature now commonly fluctuates around 0 °C, and is
predicted to rise over the coming years (County Administrative Board of Norrbotten, 2016).

The questionnaire responses showed that climate change might be altering the weathers that must be considered when designing for the case study winter city. In particular, it was noted that since average temperatures are more commonly above or near to 0 °C, greater emphasis must be placed on barriers to soft mobility associated with these temperatures, such as extended periods of slush, rain in winter, and ice build-ups. Speaking generally, because global warming is expected to continue, urban design strategies for winter cities will have to adapt continuously to the challenges posed by changing weather.

**Paper 4 ’Compacte-stadsbeleid’ is dead: long live the Dutch compact city’** and the research report **‘By Design, from design guidance to built form’** both addressed the research question *How has connectivity for soft mobility been addressed in compact city policy?* The paper was published in MacJournal, 5, (2002) pp.48-57, and the research report was published by Luleå University of Technology (Chapman, 2016).

For ’Compacte-stadsbeleid’ is dead: long live the Dutch compact city, planning documents for compact cities were reviewed and eight semi-structured interviews were conducted with Dutch architects and town planners. The Dutch planning system was chosen as a case study because the Netherlands was one of the first countries to promote a policy of compact cities.

The document studies and interviews showed that Dutch compact city policy was a reaction to the previous policy of building satellite towns. This policy had resulted in the depopulation of urban centres, leading to economic stagnation. The results also showed that creating urban forms that supported connectivity for soft mobility was an important urban design objective of the Dutch compact city policy. Urban design objectives focused on placing pedestrians and cyclists first, redesigning public areas with pedestrians and cyclists in mind, and re-profiling roads and streets for pedestrians and cyclists. The policy also focused on changing car users’ behaviour by modifying parking policies and facilities (Bontje & Jolles, 2000; Chapman, 2002). Specifically, numbers of car parking spaces were reduced and parking charges were increased to dissuade people from travelling by car.
The research report (Chapman, 2016) sets out the state of the art in urban design knowledge in the year 2000, when *By Design* (2000) was published. This was done because between 1994 and 2010, English planning policy included a sustained commitment to regenerate English settlements and to urban design. *By Design* laid out the overarching national urban design policy for England, and promoted more compact development approaches, public transport, and soft mobility (walking and cycling).

Four significant UK housing-led development schemes that were planned and delivered during this policy era were then analysed against the urban design objectives specified in *By Design*. It was concluded that *By Design* created a step change in urban design policy. The analyses of the built schemes showed that the new neighbourhoods had been delivered with urban forms that were generally of higher density and less car-dependent, with increased accessibility and better layouts for soft mobility.

**Overall study results**

The results show some ways in which winter season can alter connectivity for soft mobility. In the main, they show that the winter reduces connectivity for soft mobility and creates more barriers to soft mobility than enablers.

The combined results from the mental mapping, photo elicitation and EAMQ-Climate studies indicated that people perceived connectivity for soft mobility as being created by the built environment and weather together. Here connectivity for soft mobility can be described as an outcome of interactions between the urban form, the winter season and the individual.

The participants did not limit their remarks to combinations of the winter and the weather alone; they often described these combinations in relation to the built environment and its design and maintenance.
One participant described how the area’s ‘Bear statues (traffic calming devices) meant that snow handling was not efficient and created narrow passages into housing blocks’. Another highlighted that piled snow could often ‘fill up important junctions, which reduces visibility and reduce vehicular noise’. Both issues were considered dangerous for soft mobility. It was also noted that the neighbourhood lacked adequate cycle parking, and that the available facilities were often unusable in winter.
This is an important result because it expands the discussion of connectivity for soft mobility in winter to include seasonal climate variation, the built environment, and the individual. This does not diminish the importance of the different weather elements of the winter season. Instead, it allows for a more elaborate discussion of how the urban form can better meet the challenges of supporting connectivity for soft mobility in winter season.

The studies highlight that connectivity for soft mobility in winter could be improved by adopting a more design-led approach to the public realm in winter. In particular, the results show that winter urban design plans and strategies should address the structure and function of a place when they become white due to snow and ice. Planners should seek to achieve an attractive built environment in which transport by walking and biking is prioritised and inviting as an everyday activity all year round. To achieve this, plans must include winter and summer connections, pathways, and soft movement and formal vehicular infrastructure; public space maintenance and management; and the outdoor winter environment.
Analysis

The research focused on the main research question *What attracts and hinders soft mobility during the winter season and how can this knowledge underpin new considerations about urban design for connectivity in winter cities?*

To address this question and improve our understanding of connectivity for soft mobility in the winter, an analysis is needed about what this research implies for urban design theory and practice. To facilitate such an analysis, it is useful to introduce the terms ‘bare-ground’ and ‘snow covered’. In winter settlements, ‘bare-ground’ is used to describe the built environment when it is not covered by snow or ice. The term ‘snow covered’ is used to describe the built environment when it has its winter cover that can include snow, ice, slush, water and maintenance materials.

Urban form

For this research, the urban form is described as the built urban form of a place, and the public realm is seen as the areas of the built environment that are there for everyone to see, use and enjoy (Cowan, 2005). The research presented in this thesis confirms that the winter season can change a place’s public realm but excludes the idea that it can alter the urban form of a settlement because the built form stays the same all year round. This is important because it shows that the winter season can alter the form of the public realm and its usability, and thereby affect people’s soft mobility choices (Chapman et al, forthcoming A). For the theoretical framework, this also shows that winter season can change the spatial arrangement of the public realm and the relationship between buildings, which are important considerations for urban morphology (Carmona, 2010; Marshall, 2005).
Figure 16: Photographs of the same place in winter and summer show how the winter can alter the form of the public realm.

The results also show that interactions between the urban form and the winter season in the built environment can alter an area’s urban grain, i.e. the spatial network that defines an area or place (Cowan, 2005). This is important because it shows that during the winter the networks of routes and pathways that make up an area’s spatial pattern and arrangement can change. In the main, the research shows that the winter season reduces the networks of routes and pathways for soft mobility. This implies that the interaction between the urban form and winter will produce a ‘coarser’ urban grain, reducing soft mobility options (Chapman, forthcoming A).

For the theoretical framework, this is important because this interaction between the urban form and the winter season can alter area wide spatial arrangements. Here the streets patterns of an area in relation to the built form that makes up the urban grain can change, which is an important consideration for urban design and urban morphology (Gauthiez, 2004; Kropf, 2009; 2014; 2017; Jones et al, 2017).
The main additional routes for soft mobility that appear in winter appear to be routes over frozen water, which is a traditional enabler of mobility in winter.
Here the research shows that these ephemeral winter routes offer opportunities to improve winter connectivity for soft mobility if they create connections between different parts of an area that feeds into the built networks of streets and pathways. These temporary routes can be important, because in the winter that can grow the soft mobility network of an area by providing new networks of routes and pathway that connect locations and create a ‘finer’ urban grain and route network, which in turn can enable soft mobility (Hillier, and Hanson, 1984; Scheer, 2016).

![Image of summer and winter season maps](image)

Figure 19: In the winter season, the frozen water can provide temporary soft mobility routes.

Equally, the research establishes that the winter season can change the visual appearance of the built environment. In particular, build-ups of snow and ice can alter views and vistas in a neighbourhood, and the ‘white-out’ effect of the winter season can mask elements of the public realm. This shows that the interaction between the urban form and winter season can change the visual appearance and townscape of an area (Chapman, forthcoming A). For the townscape of an area, the winter season alters the way the components of a public realm are understood and how there combination is perceived, which is an important urban design consideration (Cullen, 1983).
Public space

Because this analysis shows that the interaction between the urban form and winter season can alter a settlement’s urban morphology, it follows that the winter can affect the public space. It can also be argued that in summer, buildings and structures order the public space in the built environment (Hillier, 2007). However, in winter, the public space of the built environment can become ‘snow covered’ and is physically changed by the covers of the winter season. In winter, the public space of the built environment is thus ordered by both the urban form and the winter weather. Because winter gathers on the urban form, it is likely to reduce the amount of physically accessible urban space.

![Figure 20: Top image: Section through the urban form of the street. Middle: Section of the street including winter snow and ice deposits. Bottom: The remaining space comprising the public realm in winter.](image)

Equally, the perception of the space that remains is changed by the winter. The conceived space, which is the designed space was seen to be shaped by the winter season. At one level, this space could be looked at as part of the container, that with the built environment, physically orders the space of the winter season.

However, the winter season also alters how people perceive and live this space. Changes in the urban grain, the public realm and different climate
conditions alter how space is understood and used. As these are important aspects of the Lefebvre’s (1991) study of space as a virtual object (Fraser, 2008; McKeown, 1980; Mugavin, 1999; Brenner, 2014; Pierce & Martin, 2015), it suggests that space in the winter season is much more than just a container. The effects of the winter season on soft mobility can be preconceived, read and understood. As the first aspect of Lefebvre’s study is the conceived space, if also follows that these understandings can be influenced by design.

**Connectivity and quality**

The quality of the public realm in the winter season is important in enabling connectivity for soft mobility. This aligns with the majority of urban design research, which shows that the quality of the public realm is an important influencing factor for outdoor soft mobility (Carmona et al, 2010; Gehl, 2011; Marshall; 2005).

![Image](image.png)

**Figure 21:** The ‘bare-ground’ qualities of the public realm can be lost in the winter.

Here the winter season can alter the physical qualities of the public realm and create barriers to soft mobility (Chapman, Nilsson, Larsson, & Rizzo, 2017). This
is an important consideration when designing for winter settlements, because the built public realm will not be available for soft mobility throughout the whole year. Consequently, winter cities should be designed such that the built qualities of the public realm relating to connectivity and space for soft mobility are preserved to the greatest possible degree during winter (Chapman, forthcoming A).

**Human movement**

Like Carmona et al., (2010), Gehl, (2011) and Marshall, (2005), Shumway-Cook & Woollacott’s (2016) health science theory highlights the importance of the environment for human movement. Shumway-Cook & Woollacott describe human movement as emerging from interactions between the individual, the task and the environment. They also consider that each of these factors can be a constraint, and argue that it is important to understand the environment in which human movement occurs when studying human movement. In addition, they suggest that the shared perceptions and experiences of people in different communities can differ because each community has its own view of normality (2016). This is important because both urban design and health science theory suggest that our perceptions and understanding of the environment have important effects on human movement.

For winter cities, the research shows that most guidance does not address the health benefits of outdoor physical activity such as walking and cycling (Chapman, in press). The research also indicates that winter generally hinders soft mobility, makes the public realm hard to understand, and reduces its usability (Chapman et al, 2017).

To create built environments that enable the potential health benefits of regular physical activity (U.S. Department of Health and Human Services, 2015; WHO, 2018), the built environment of winter cities must be attractive for outdoor soft mobility in winter. This requires more than just designing for winter weather conditions; one must design for the winter season as a whole. In particular, it is necessary to design networks of streets and pathways that link parts of the settlements and neighbourhoods in winter. It is also important to ensure that streets and pathways are profiled for soft mobility and well delineated even when snow-covered (Chapman, forthcoming A).
Climate change

The research showed that much of the existing guidance for the design of winter cities says nothing about climate change (Chapman et al, in press). In addition, at the case study location, at least some of the weather conditions identified as barriers to soft mobility in winter are related to the warmer winter weather conditions attributed to climate change. There is clear evidence that winters in northern Sweden are getting warmer and wetter (County Administrative Board of Norrbotten, 2016), and this work shows that the conditions associated with warmer winters are perceived as creating barriers to soft mobility. In particular, weather and deposits associated with warmer conditions such as rain, ice, and slush are seen as significant barriers to soft mobility in winter (Chapman et al, 2017; Chapman, in press).

This is important because in Luleå, the case study location, warmer winter temperatures of around 0 °C are becoming more common, and the conditions associated with these temperatures were described as being the most prohibitive of soft mobility (Chapman, forthcoming A). Such winter temperatures were associated with precipitation in the form of rain, high levels of wind, and the melting of snow and ice into slush. These conditions were seen as major barriers to soft mobility and much worse than those experienced at lower temperatures. Like previous studies (Ebrahimbadi et al, 2015), this research established that temperatures below 0 °C with stable snow conditions can be more enabling for soft mobility. This is because at lower temperatures, the snow persists and gets compacted over time, providing a good stable surface for soft mobility.

Urban morphology

Seasonal interaction between the urban form and winter season are important for the discussion of urban morphology in a winter settlement.

Urban morphology was defined in the theoretical framework as the configuration of urban form, space and infrastructure (Carmona et al., 2010). The research presented above show that the interaction between the urban
form and winter season can alter the configuration of infrastructure. This interaction was seen to have a significant impact on the public space and the layout and form of the public realm.

Equally, it was established in the theoretical framework section that a common theme in urban morphology research is the search for settlement patterns and a focus on the production of spatial and movement systems (Hillier, and Hanson, 1984; Hillier, 2007; Kropf, 2014; 2017; Scheer, 2016). This analysis shows that interaction between the urban form and winter season can both alter the spatial and movement systems within a settlement. In particular, these interactions were seen to be capable of altering the urban structure; that is the network of routes and spaces of an area for soft mobility and the urban tissue; that is the relationship between plots, blocks and pathways. In these cases, the interaction between the urban form and winter season had a ‘reduction effect’ on the urban structure and urban grain by making some of the routes and pathways in the spatial network unusable.

At the level of the street, the discussion also shows that the interactions between the urban form and winter season can alter the space created by streets and their relationship to buildings. Similarly to the above, the interaction between the urban form and winter season had a reductive effect on the built environment by reducing the amount space and usable area of the public realm, and thus reducing capacity. This interaction was also seen to reduce the overall quality of streets and spaces for soft mobility in the winter season.

The visual appearance that is the ‘townscape’ of an area was also changed by interactions between the urban form and the winter season. The effects of this interaction were significant enough to change views in and around an area. It was also capable of masking the way in which components of the public realm are combined.

These relationships between streets and buildings and the patterns they create sit at the heart of the theory of urban morphology (Carmona, 2010). As such, it follows that because interactions between the urban form and winter season change these relationships in an identifiable way, their effect can be considered morphological. Importantly, these interactions create identifiable patterns that relate to the winter season (Collymore, 1994), coarsening the urban grain and shrinking the public realm.
While many of the processes that shape the urban form of a place are the outcomes of human activities, such as planning and design, these morphological outcomes are instead shaped by natural forces (Kropf & Malfroy, 2013). In this case, they are shaped by the seasonal climate variations that can be found in a winter city. These non-human forces, however, do still create identifiable morphological patterns that can be attributed to these interactions and these patterns can also be seen to be broadly repeatable over time (Madanipour, 1996). In this case, the interaction between the urban form and winter occur on a seasonal basis. As such, like man-made aspects of urban morphology, these non-human interactions have a ‘rate of change’ (Carmona; 2010), which is part of the ongoing morphological flux and development of a winter city. However, this morphological element of winter cities has two rates of change. The first is part of the seasonal climate, which means interactions are annual, and the second is part of climate change and global warming (Kircher, 2002; Tyrrell, 2013), which with natural climate evolution is altering the winter season. As these two rates of change are connected, the morphological patterns that are created by the interaction between the urban form and winter season are not stable and are changing over time. Importantly, while these patterns are the result of non-human and unconscious focuses, i.e. natural forces, global warming is linked to long-term human activity and in particular, it has been linked to town planning and land use (Moss et al., 2008).

**Opportunities for winter city urban design**

The empirical results were analysed to determine how interactions between the urban form and winter conditions affect connectivity for soft mobility.

With regards to urban design, the results indicate a need to re-balance design activities between ‘bare-ground’ summer conditions and ‘snow-covered’ winter conditions. When considering and designing for winter, we should seek to better understand a place’s townscape, urban structure, urban grain, and public realm in a variety of winter conditions. At the settlement or neighbourhood scale, designers should consider how outdoor soft mobility can be made attractive in winter. In particular, they should focus on:

- Ensuring the availability of a network of connected routes and pathways for soft mobility throughout the winter season.
- Ensuring that there is space available in the public realm for soft mobility.
- Ensuring people understand which areas of the public realm are for soft mobility.

The advent of climate change means that urban designers in winter cities must also consider the changing face of winter. The general scientific consensus is that global average temperatures are rising, winters are getting warmer in many parts of the world, and winter temperatures above 0 °C will become increasingly common even in formerly cold regions. In the future, design projects for winter cities will need to consider how warmer temperatures with increased levels of precipitation (more of which is likely to fall as rain) will alter mobility choices. In particular, designers may face the challenge of winter conditions that are around 0 °C. These conditions are particularly awkward because designers must be aware that precipitation may regularly fall as snow or rain, creating very treacherous surface conditions with a covering layer that may consist of snow, ice, slush, or frozen slush.
Conclusions

The literature review demonstrated that there is a large body of research dating back to the 1990s on designing for sun, wind, and snow in winter cities. Most of the available guidance and good practice for climate-sensitive urban design focuses on these issues. However, there is significantly less design guidance and good practice available for other aspects of the public realm or common weather conditions in winter settlements. In particular, the literature offers little guidance on dealing with weather conditions such as rain, slush, icy surfaces, and darkness. This is important because many of these conditions are associated with warmer winters and increased precipitation, both of which are predicted consequences of climate change.

In general, soft mobility in the built environment has been identified as an essential part of sustainable urban development. Compact city designs are considered to reduce the distances between residents’ destinations, enabling soft mobility by walking and biking. The studies conducted in the Netherlands and the UK demonstrate that a focus on creating networks of high-quality connected streets and pathways is needed to maximise opportunities for soft mobility. These networks should connect local and more distant destinations, and the grid size of streets and the urban grain should be relatively small to facilitate alternative route choices. The quality of these routes was also found to be critical for enabling soft mobility: the studies indicated that attractive public realms with landscapes and streets designed with pedestrians and cyclists in mind are important for enabling soft mobility.

Winter conditions can change settlement patterns and infrastructure because networks of streets and pathways can be transformed by snow piles, snow management regimes, and slippery surfaces. It was also found that the spatial configuration of the public realm (i.e. the way in which streets and pathways operate) can be changed by the same factors. Winter conditions generally reduce levels of connectivity for soft mobility in both street networks and the public realm by making certain streets and pathways unusable. This creates a ‘coarser’ urban grain for soft mobility that increases the distance between usable connections in the soft mobility network and reducing route choices. Winter also often reduces the usable space of the public realm, which again inhibits soft mobility.
However, winter can also provide high quality routes that are attractive for walking, cycling, and skating. For example, ice-roads’ can be seen as enablers and destinations for soft mobility. This indicates that we should focus on achieving similar qualities in the general streets and routes of settlements.

The research into the weather-based barriers to and enablers of connectivity for soft mobility confirms that the winter city urban design principles of solar access, wind reduction and snow management are important design considerations. However, it was also realised that a more extensive palette of weather conditions hinders people’s willingness to use soft mobility. It was also established that the worst conditions for soft mobility occurred when temperatures were close to 0 °C. At these temperatures, winter rain, slush, and water on ice are all common, all of which were perceived as major barriers to soft mobility. This is important because global warming is expected to make such conditions more common, which could become an important design consideration.

The aim of the research project was to determine “what attracts and hinders soft mobility during the winter season and how can this knowledge underpin new considerations about urban design for connectivity in winter cities?” Connectivity for soft mobility in wintertime is in part an outcome of the interaction between the urban form and the winter conditions. Within this context it is shown that this interaction can alter a settlement’s urban morphology and the patterns of streets and spaces that enable connectivity for soft mobility. This implication is crucial because the winter patterns created by these interactions affect people’s soft mobility choices, which in turn can affect levels of regular outdoor physical activity and the associated health benefits.

The research contributes to the science of urban design by clarifying that the interaction between the urban form and winter season is an element of urban morphology. Urban planning and design is an activity with human meaning that creates attractive and functional built environments. The morphological element to be explained here is the relationship between ‘the layout and spatial arrangements of settlements, structures, and open spaces and material character’ and ‘the factors that have created, expanded, diversified, and transformed them’. The research reveals ‘factors’ that include nonhuman actions and constraints on human actions. A notable nonhuman force is revealed by the way in which winter weather conditions with snow-cover, ice and slush can
change the visible view and function of the public realm, i.e. the legibility of a place and the purpose or connectivity of its street networks.

Designing for winter settlements is challenging because the outdoor conditions in these places vary greatly between seasons. The research therefore also contributes to practice by highlighting important factors to consider in urban design when seeking to create built environments that are useful and functional both when covered during winter and under bare-ground summer conditions.

The key conclusion of the research and analysis is that effective climate-sensitive urban design is paramount to delivering connectivity for soft mobility. In particular, urban design plans and strategies for winter cities should be created that address the structure, function, and design of public areas, spaces, streets and paths when they become white due to snow, slush and ice. These plans should seek to establish an attractive built environment where transport by walking and biking is prioritised and inviting as an everyday activity, all year round. Because the winter season is dark, these plans should also address the structure, function and design of the area’s lighting systems. At a technical level, these plans must address materials and the removal and storage of snow.

Figure 22: A mirrored view along the street in winter and summer shows how the seasonal climate can change a place's form.
Discussion

Designing for winter settlements is challenging because the outdoor conditions vary widely between seasons. Designing a built environment that works successfully in all seasons is very difficult, particularly because knowledge of designing for winter conditions is rarely presented in mainstream urban planning and design texts, and climatic understanding is rarely emphasised during the education of architects, planners and urban designers. The majority of books and publications on urban design place great emphasis on the qualities of successful outdoor areas and public realms, but few even mention how the climate can alter the entire built environment. This may be because most well-known books and journals on urban design originate from and relate to areas with temperate or warm climates.

Ebrahimabadi (2015) however shows that practitioners in cold regions have a great deal of tacit knowledge of designing for winter. The problem here is that little of this knowledge is available in the industry or represented in scientific publications. The reason for this is not clear, but it may simply be that most settlements around the world only really experience 'bare-ground' conditions, so most urban design and planning publications focus on such environments.

A major challenge for urban design is to plan for and create places that deliver attractive connectivity for soft mobility all year round. The physical environment must include for the combination of bare-ground and snow-covered conditions. We must therefore create guidance to help designers and planners achieve these goals. The research presented in this thesis shows that it will be better to adopt a qualitative approach to urban design guidelines that encourage consideration of the type of place to be produced and its qualities. For winter cities, such guidelines are likely to focus on the qualities of the public realm and green and blue areas of the outdoor environment that become white in winter season.

To improve the outdoor built environment, designers should also work with the winter season at a number of scales. Here are some examples found during the entire study or from the research environment.

Site location: The location is essential in terms of the microclimate. Higher, south facing sites have the distinct advantage that the landscape will help deliver direct sunlight and reduce the effects of cold air draining into the site.
**Urban form:** More compact development patterns can help facilitate soft mobility by positioning facilities and destinations closer together. However, urban forms cannot be imported directly from lower latitude areas that do not experience the same seasonal climates as winter settlements. Here the urban form and the urban grain of more compact winter settlements must maintain the networks of streets and pathways that enable soft mobility while accommodating the winter cover. Here it will also be important to consider how the relationship between the street, the plot and the building will operate in winter.

**Public space:** For many winter settlements, maintaining direct sunlight into public spaces in the winter is difficult due to the low sun angles. This often results in large public open spaces that are out of scale for the settlement. Here designers should look at the benefits of creating more, smaller connected public spaces that can benefit from direct solar gain over a large part of the year, while providing wind protection all year round.

**Networks of streets:** An areas network of streets can have a strong influence on soft mobility choices. Here designers should consider how the network of streets and routes could improve the microclimate. Irregular or broken street grid layouts and curved streets can significantly reduce wind and improve the pedestrian environment. Here winter street patterns can support soft mobility by connecting local and more distance destinations together while funnelling and blocking the wind from routes.

**Public realm:** Designing slightly larger streets and routes than those found in places that mainly experience bare-ground conditions will make it easier to accommodate soft mobility in winter. Wider streets will help ensure enough space is available for both the winter cover and movement. The section of the streets and public realm can also be designed to move rain, slush and snow away from the areas for soft mobility.

**Public realm legibility:** The winter tends to disguise the elements of the public realm. One way to overcome bare-ground details being hidden by winter season is to lift this information about the public realm, its networks, routes and designations off the ground level. This can help increase the legibility of the townscape and enable easier understanding of the area and its public realm.

**Building heights:** Building heights are an important consideration for wind. Here designers should consider how building heights that are out of context
with the surroundings are likely to increase the wind at ground level. Here buildings that are over twice the height of the majority can cause significant wind events at street level. If tall buildings are needed, designers should consider how the design could use features such as podium levels to reduce wind speeds on the ground.

**Building envelope**: High angled pitched roofs can throw snow and ice on the ground and people below. Here designers should consider how shallower roofs and overhangs or the use of canopies and arcades to protect pedestrians, from snow, rain and wind could help to avoid this. Intermediate (indoor-outdoor) spaces at building entrances should also be considered as these provide buffer zones in the winter. These spaces can help enable soft mobile by providing places for people to adjust from being outdoors. E.g. removing winter boats and clothing.

**Public realm management**: If we want to make it attractive for people not to use motorised transport in the winter, public realm management plans need to be prepared that prioritise the maintenance of the public realm for soft mobility. Here design strategies should focus on ‘designing’ the winter soft mobility networks and delivering a connected network of routes that link to local and more distant destinations.

**Water management**: With global warming, winter cities, like other cities, need more approaches, all year round, to designing for rain. Here designers need to consider how the winter public realms can manage high volumes of water. For building design, this may require new ways of on-site collection and temporary storage of storm water on site before discharge into the public realm. For the public realm this may also mean that streets and spaces should be designed to temporarily store water. However, this must be done in a way that is attractive and does not hinder movement.

**Methodological reflections**

As an urban design tool, a criticism of Kelvin Lynch’s method for analysing a place was that it focuses on a momentary snap-shot in time (Banerjee & Southworth, 1990). While this criticism of this tool was methodologically
important for the research, this weakness is common to many urban analytical tools.

It is common in urban design to produce a range of urban analytical drawings that study the patterns, forms, movement networks, and uses of a place. However, like Lynch’s method, most studies using these approaches capture a single snap-shot in time. This is important because many urban design decisions are based around these snap-shots. For places that experience significant seasonal variation in climate, it may be better to base designs on a series of analytical studies conducted at different times of year.

This suggests that standard urban analytical tools should be re-tooled for the urban design of winter settlements, to provide a better understanding about how a place is likely to function in different seasons. This will help guide decision making on built environment interventions that must work in both winter and summer.

The advent of climate change means that in future, we may also need to reconsider the definition of a winter settlement; many places formerly classified as winter settlements may no longer fit the definition. This could significantly affect the identity and character of such communities. Climatic warming means that the boundaries of the world’s sub-arctic regions are likely to be shifted northwards.

Further research

Because this work proposes the inclusion of the winter season as an aspect of urban morphology, it follows that future studies should test this proposition and, if appropriate, help build an evidence base for its inclusion.

This would necessitate gathering data on the forms of winter settlements and their spatial structures in winter and summer. If such data were available, it could be used to research and identify settlement patterns and spatial structures that can be better attributed to the winter season. Identifying such patterns would strengthen the case for including winter in theories of urban morphology.
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