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What moves us:

connections between urban mobility, travel emissions and wellbeing

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thesis submitted in partial fulfilment of a
Philosophiae Doctor degree in Environmental Studies

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Abstract

The thesis explores the connections between the urban environment, travel behaviour and wellbeing with a mixed methods approach, focusing on the Nordic countries. Despite being hailed as climate leaders, Nordic countries' travel footprints are exceeding levels for remaining below 1.5-degree Celsius temperature increase, while many people who meet the threshold today might belong to lower socio-economic groups. A large portion of the travel footprints stems from long-distance leisure travel and is partially driven by low climate concern. The thesis further focuses on a case study of Reykjavík, Iceland. Reykjavík urbanites express that they travel away from the city for their wellbeing, and the trips could be partially motivated by interactions with the broader urban environment. Activity spaces are used to explore this indication further. A correlation is found between high levels of urban mobility and engaging more in domestic leisure travel. Furthermore, there are indications of a lack of functioning public and active transport systems in Reykjavík. In daily urban mobility, exposure to green and grey spaces beyond one's neighbourhood could impact overall life satisfaction, although underlying socio-economic background is more relevant. What is more, exposure to green and grey spaces explains some of the leisure travel emissions, but personal attitudinal factors are more significant. The thesis highlights the importance of people-centric urban planning which considers the wellbeing and needs of residents. It also emphasises the need for rapid travel emissions reductions in wealthy countries while making sure socio-economically disadvantaged people do not get left behind in the transition towards sustainability.

Útdráttur

Ritgerðin kannar tengsl borgarumhverfis, ferðahegðunar og vellíðunar með blandaðri aðferð, og einblínir á Norðurlöndin. Þrátt fyrir að vera oft hyllt sem leiðtogar í loftslagsmálum hafa Norðurlöndin ferðafótspor sem fara yfir þau viðmiðunarmörk sem þörf er á til að haldast undir 1,5 gráðu hlýnunarmarka. Á sama tíma tilheyra margir sem uppfylla skilyrði um viðmiðunarmörk í dag lægri félags- og efnahagshópum. Stór hluti ferðasporanna stafar af lengri frístundaferðum og eru að hluta til knúin áfram af litlum loftslagsáhyggjum. Ritgerðin einblínir svo nánar á Reykjavík með tilviksrannsókn. Reykvíkingar segjast ferðast úr borginni sér til velferðar og að tenging við víðara borgarumhverfi geti verið hvati fyrir ferðalöngunum. Fylgni er að finna á milli mikils hreyfanleika í þéttbýli og þess að taka ríkari þátt í ferðalögum á eigin tíma innanlands. Jafnframt eru vísbendingar um skort á virkum almennings- og samgöngukerfum í Reykjavík. Útsetning fyrir grænum og gráum svæðum í daglegum ferðalögum innan borgarinnar borgarinnar út fyrir sitt nærumhverfi gæti haft áhrif á almenna lífsánægju, þó að undirliggjandi félagslegur og efnahagslegur bakgrunnur skipti þar meira máli. Samband við græn og grá svæði skýrir hluta af losun frá frístundaferðum, en persónulegir viðhorfsþættir eru mikilvægari. Í ritgerðinni er lögð áhersla á mikilvægi borgarskipulags sem er hannað fyrir fólk og hefur velferð og þarfir íbúa í huga. Í ritgerðinni er einnig lögð áhersla á nauðsyn þess að draga hratt úr losun tengdri ferðalögum í ríkum löndum og á sama tíma að tryggja að félagslega-efnahagslega illa settir einstaklingar verði ekki skildir eftir í umskiptum í átt að sjálfbærni.

Dedication

To my family.

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1. Raudsepp, J., Czepkiewicz, M., Heinonen, J., & Árnadóttir, Á. (2024). Travel footprints in the Nordics. *Environmental Research Communications*, 6(9), 095002. https://doi.org/10.1088/2515-7620/ad718d

2. Raudsepp, J., Árnadóttir, Á., Czepkiewicz, M., & Heinonen, J. (2021). Long-Distance Travel and the Urban Environment: Results from a Qualitative Study in Reykjavík. *Urban Planning*, 6(2), Article 2. https://doi.org/10.17645/up.v6i2.3989

3. Raudsepp, J., Thorbjörnsson, K. M., Hasanzadeh, K., Czepkiewicz, M., Árnadóttir, Á., & Heinonen, J. (2025). Activity spaces and leisure travel emissions: A case study in Reykjavík, Iceland. Travel Behaviour and Society, 38, 100896. https://doi.org/10.1016/j.tbs.2024.100896

4. Raudsepp, J., Hasanzadeh, K., Árnadóttir, Á., Heinonen, J., & Czepkiewicz, M. (2024). Does Higher Exposure to Green Spaces Lead to Higher Life Satisfaction and Less Leisure Travel? A Case Study of Reykjavík, Iceland. Urban Science, 8(4), Article 4. https://doi.org/10.3390/urbansci8040236

Contribution of the author

Article 1 (A1): **Conceptualization: JR,** JH, MC, ÁÁ; **Data curation: JR**; **Formal analysis: JR**, MC; **Funding acquisition:** JH, **JR**; **Methodology: JR**, MC, JH; Project administration: JH; Supervision: JH, MC, ÁÁ; Validation: JH, MC, ÁÁ; **Visualization: JR**; **Writing - original draft: JR**; and **Writing - review & editing: JR,** MC, ÁÁ, JH.

Article 2 (A2): **Conceptualization**, Á.Á., M.C., J.H. and **J.R.**.; **Data curation**, Á.Á. and **J.R.**.; **Formal analysis**, Á.Á., M.C., J.H. and **J.R.**; Funding acquisition, M.C. and J.H.; Methodology, M.C. and J.H.; Project administration, J.H.; Supervision, M.C., Á.Á. and J.H.; **Visualization**, Á.Á., M.C., **J.R.** and J.H.; **Writing—original draft, J.R.**.; **Writing—review and editing**, Á.Á., M.C., **J.R**. and J.H.

Article 3 (A3): **Conceptualization: JR**; **Data curation:** MC, JH, **JR**; **Formal analysis: JR**, KMT, KH; **Funding acquisition: JR,** JH, MC; **Methodology:** KH, **JR,** MC; Project administration: JH; Supervision: JH, MC, ÁÁ, KH; Validation: KH; **Visualization:** KMT, **JR**; **Writing - original draft: JR**, KMT; **Writing - review & editing: JR,** ÁÁ, MC, KMT.

Article 4 (A4): **Conceptualization, J.R.** and K.H.; **methodology,** K.H. and **J.R.**; software, K.H.; **formal analysis, J.R** and K.H.; **investigation, J.R.**, K.H., J.H. and M.C.; data curation, J.H., M.C. and K.H.; **writing—original draft preparation, J.R.**; **writing—review and editing**, K.H., J.H., M.C. and Á.Á; **visualisation, J.R.**; supervision, J.H. and Á.Á; **project administration, J.R.** and J.H..; **funding acquisition,** J.H., **J.R.,** M.C. and Á.Á.

Abbreviations

CBCF - consumption-based carbon footprints

CCA - canonical correlation analysis

GHG - greenhouse gas emissions

GIS - geographical information system

GPS - global positioning system

PPGIS - public participation GIS

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1. Introduction

Anthropogenic activity has driven our planet closer and closer to a breaking point (Steffen et al., 2018; Richardson et al., 2023; Crippa et al., 2021). According to a recent study, we have already exceeded the limits of six out of nine planetary boundaries[1], including climate change, with several more at risk of being crossed (Richardson et al., 2023). Despite multiple international agreements and rising awareness about the impacts of climate change, it is estimated that current policies are not enough to put us on a trajectory for keeping global warming below 1.5 degrees Celsius (IPCC, 2023). As our climate continues to change and urban populations continue to grow (Crippa et al., 2021; Bai et al., 2018), cities are causing a big part of global emissions (IPCC, 2014; Short & Farmer, 2021; Moran et al., 2018; Crippa et al., 2021). A stronger emphasis on cities as hubs of climate change mitigation is needed (IPCC, 2023; Bai et al., 2018; Crippa et al., 2021).

Cities are centres of consumption and mobility, characterised by hectic lifestyles (Hoornweg et al., 2011, 2016; Glaeser, 2011; Cardoso et al., 2021). Lifestyles in the cities of affluent countries tend to exceed the limits of sustainable living (Satterthwaite, 2008; Hoornweg et al., 2016). Scientists have warned about the long-term consequences of affluence on climate change and its mitigation efforts (Wiedmann et al., 2020). Indeed, consumption-based carbon footprints (CBCF) reflect the excess consumption of affluent countries (Ivanova et al., 2016; Akenji et al., 2021; Wiedmann et al., 2020), cities (Moran et al., 2018) and individuals (Moran et al., 2018; Chancel & Piketty, 2015). CBCF captures the environmental impacts of consumption from the origin of the product to its final user, accounting for final emissions at the user-end (Wiedmann, 2016). It has been estimated that CBCFs need to reduce by 74 % by 2030 and 93% by 2050 to stay within the 1.5-degree Celsius threshold (Akenji et al., 2021; Ivanova et al., 2016). The change primarily needs to take place in affluent countries (Ala-Mantila et al., 2023).

Mobility-related footprints constitute about 15% of global household CBCFs, but are higher, up to around 30%, in affluent countries like the Nordics or U.S. (Ivanova et al., 2016). Predictions for mobility in the near future show a growth trend based on current policies (World Tourism Organization & International Transport Forum, 2019; UNWTO, 2019) which complicates finding ways to radically reduce the emissions caused by the sector. Mobility makes up a good part of the climate impact of cities through both infrastructure and fuel consumption, exacerbated by mobile lifestyles (IPCC, 2023; Minx et al., 2013; Mi et al., 2019; Sims et al., 2014).

Mobility-related footprints can be broadly split into two – local travel and long-distance travel footprints. Local travel encompasses the day-to-day travel habits within the administrative area where one resides, typically including trips to work or school, errands, social activities, and so on. Long-distance travel refers to trips outside of the local administrative area, both within domestic and international bounds, and are done less regularly than local travel. Particularly in

[1] Planetary boundaries concept, coined by Rockström et al. (2009), estimates the limits of interconnected Earth's systems. Due to their interconnected nature, crossing the limits of even one of the boundaries can trigger a snowball effect across other boundaries. The boundaries annotate a safe operating space for anthropogenic activity, going beyond one-sector approaches and treating Earth as a system (Rockström et al., 2009; Steffen et al., 2015).

affluent locations, a large portion of personal mobility footprints comes from long-distance travel wherein travel by plane is a significant contributor (e.g. Akenji et al., 2021; Ivanova et al., 2016; Wadud et al., 2024).

Urban development has aimed to tackle the issue of local travel emissions through various strategies, for example reducing urban sprawl, densification, and 15-minute cities. Single-use zoning, for example by splitting the urban area into residential, commercial and industrial zones, has led to urban sprawl. Urban sprawl, in turn, contributes to longer travel distances due to the split nature of the urban fabric, driving automobile use to reach various faraway destinations at a local level (Hall, 2014). To tackle urban sprawl, densification has been a popular planning strategy. Densification refers to the increasing density of the built environment and/or urban population over time. As a strategy, it aims to reduce travel distances between residential and commercial areas, to reduce the need for personal vehicles such as cars, and also to reduce the need for infrastructure (Ewing & Cervero, 2010; Glaeser & Kahn, 2010; Sims et al., 2014; UN-Habitat, 2022).

However, studies have noted some adverse effects of densification policies, such as rebound effects and more consumerist lifestyles (e.g., Heinonen et al., 2013; Muñiz et al., 2013; Næss, 2012, 2016; Strandell & Hall, 2015). Furthermore, it has been suggested that densification policies can lead to dissatisfaction with the urban environment (e.g. lack of green areas, social destinations, etc.) and thus lead to increased leisure travel away from the urban area (e.g., Reichert et al., 2016; Ottelin et al., 2014; Czepkiewicz et al., 2019; Holden & Linnerud, 2011; Holden & Norland, 2005). Urbanites are more likely to have a cosmopolitan attitude, wanting to experience different cultures and new things, and often engage in more long-distance leisure travel (e.g., Czepkiewicz et al., 2020a; Czepkiewicz et al., 2018a). In addition to densification is the 15-or-20-minute city concept, which states that residents should be able to fulfil their day-to-day needs within a 15-to-20-minute walking or cycling distance from their home (e.g. Thornton et al., 2022; Duany & Steuteville, 2021). The strategy focuses on multi-zonal development and multi-functional buildings, accessibility and walkability, and is often interlaced with increased green spaces and mid-rise development (Thornton et al., 2022; Duany & Steuteville, 2021; Funk & Glickman, 2023).

Studies have shown that cities have an impact on wellbeing (Badland et al., 2017; Olsen et al., 2019; Giles-Corti et al., 2016), stemming from, for example, urban form (Perchoux et al., 2014; leBrasseur, 2022; Roe et al., 2013; Brown et al., 2016; Hrehorowicz-Gaber, 2013), accessibility (Giles-Corti et al., 2016), and exposure to the environment (Çelik & Jaiyeoba, 2023; Douglas et al., 2019; Bakolis et al., 2018; Bonaiuto & Chiozza, 2024; leBrasseur, 2022; White et al., 2013; Zhang et al., 2017; Neale et al., 2022), including exposure to urban greenness (i.e. Marselle et al., 2020; leBrasseur, 2022; White et al., 2013). Wellbeing should be an important consideration in the context of sustainable urban development and in urban climate mitigation consideration, as it is connected to mobility (e.g. Perchoux et al., 2014; Neale et al., 2022; leBrasseur, 2022; Roe et al., 2013).

Considering the environmental impact of mobility, its concentration in cities and the potential impact of urban development on human wellbeing, it can be said that urban development has a responsibility to meet the needs of people within the boundaries of the planet. Although there is a considerable body of literature discussing the various aspects of mobility and its relationship with urban environments, further research on climate impacts and wellbeing impacts is still needed. Therefore, the aim of this thesis is to better understand the climate impacts of mobility-related footprints, the potential reasons behind them that stem from the urban environment, and

how mobility within the urban environment is associated with perceived wellbeing. The thesis takes a mixed-methods approach, using quantitative and qualitative methods, as well as spatial analysis, to study the topic (Figure 1).

The focus of the thesis is on the Nordic countries. Nordic countries are affluent and have a similar cultural background (Olafsson, 2013; Tiemer, 2018). Moreover, we know that despite being praised for advanced environmental policies (Greaker et al., 2019), CBCFs of Nordic residents exceed recommended levels, partially owing to their travel-related behaviour (Akenji et al., 2021; Ivanova et al., 2016; Greaker et al., 2019; Salvucci et al., 2019). Further, the thesis examines Reykjavík, Iceland as a case study due to its unique geographic location, high affluence, and high travel footprints.

The thesis aims to study the following overarching question: How does the urban environment connect to mobility patterns, travel footprints and wellbeing? Thus, the thesis set out to answer the following questions:

RQ1: What is the climate impact of personal travel in the Nordics?

RQ2: How do people's interactions with the urban environment affect leisure travel?

RQ3: How do people's interactions with the urban environment affect perceived wellbeing?

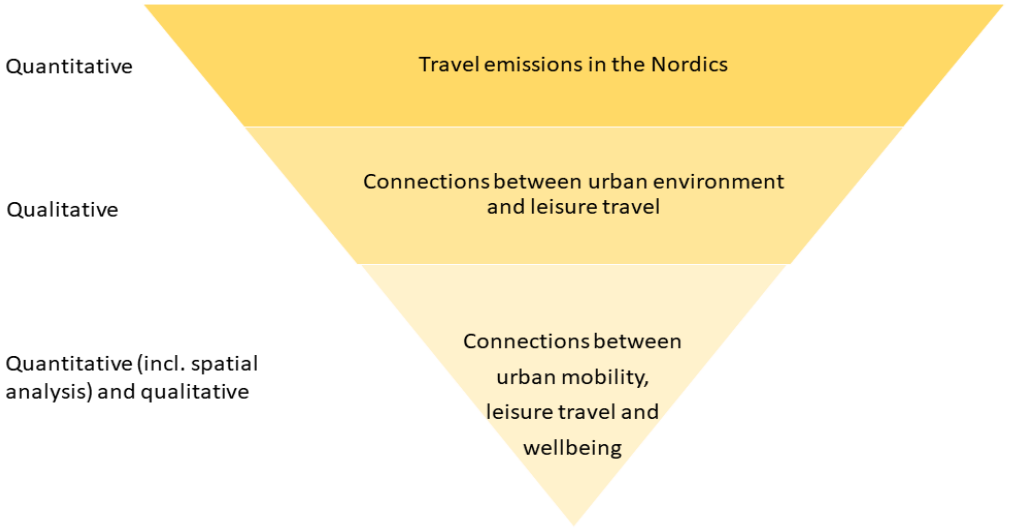

Figure 1. Overview of the thesis entity. The research questions aim to funnel the topic from a broader perspective to a narrower one.

RQ1 sets the background by investigating the climate impact of personal travel in the Nordics. The climate impact is assessed using a CBCF accounting method among residents of five Nordic countries and is then compared to recommended emissions threshold levels compatible with 1.5°C warming. Within its scope, personal travel includes local travel (all daily, regular trips such as for work, shopping, errands, hobbies) and long-distance leisure travel (both domestic and international, but excluding work-related trips). RQ2 examines how urban environments and people's interactions with them affect leisure travel behaviour. Within this question, people's motivation for leaving the city for leisure travel is investigated. The question also looks at people's local mobility and how that relates to leisure travel with the help of activity spaces. Lastly, RQ3 focuses on how interactions with the urban environment relate to

people's perceived wellbeing. Within the scope of this question is people's exposure to the urban environment on both neighbourhood and broader scales during their day-to-day mobility, which is examined using activity spaces, and how that relates to their perceived wellbeing.

The thesis is composed of four peer-reviewed articles (A) and this thesis compilation. First, the thesis examines travel-related footprints in the Nordic countries within the 1.5-degree warming limits (A1). Then, the thesis zooms in on a case study of one of the Nordic countries – Iceland – as travel behaviour is known to be context dependent, and Iceland has a unique context in many ways. Thus, the thesis proceeds to examine the reasons behind travelling (A2), how the urban environment connects to leisure travel behaviour (A2, A3, A4), and how urban mobility connects to long-distance leisure travel (A3, A4) and people's perceived wellbeing (A4).

The following section describes the theoretical background based on existing academic knowledge. Section 3 gives a brief overview about the geographic context of the study: the Nordic countries and the Reykjavík Capital Area in Iceland. Section 4 explains the methodology selection, covering the methods and data sets used. Then, the key results from the four articles are presented. This is followed by a discussion in section 6 which positions the thesis among previous literature and discusses its contribution, implications for methodology and policy, validity of the research, and future research outlooks.

2. Background

2.1. Travel and the urban environment

Reasons behind travel are complex, often having an overlap of several underlying reasons that people might not necessarily even recognize when describing their travel behaviour (e.g. van Wee & Mokhtarian, 2023; De Vos et al., 2021). Over the years, travel behaviour, attitudes and their connection to the built environment have been studied extensively. Several theories have been suggested which would describe the connections between built environment and travel behaviour and attitudes, but mainly have concluded that the examined issue is complex. Indeed, De Vos, Cheng and Witlox (2021) suggest that there are interconnected relationships between the built environment, travel behaviour and travel attitudes, which can explain, for example, changes in one's attitudes driven by the built environment, or connection between residential location and travel behaviour. This section aims to summarize some associations between residential location and both local and long-distance leisure travel. The residential location here refers to the location of the home within the city and its surrounding neighbourhood. Some known theories connecting the urban environment and travel will be briefly covered where relevant.

2.1.1. Local travel

Travel can be considered a necessity, especially at a local day-to-day level. Although definitions of needs vary, Mattioli (2016) has concluded that because one of our *basic needs*, as defined by Max-Neef (1992), is related to subsistence in the form of economic security (Doyal & Gough, 1984), which in turn is dependent on employment, travel is as a need satisfier (or in other words, a necessity) because it supports participation in the employment market (Mattioli, 2016). In addition, travel can help us reach other destinations which are important to meet needs related to access to food or health care (Mattioli, 2016; Max-Neef, 1992; Doyal & Gough, 1984). Although existing research highlights "soft" factors behind travel behaviour such as attitudes and norms (e.g., Mouratidis, 2019; Heinonen et al., 2021; Thøgersen et al., 2021; Mattioli, 2017), local travel connected to day-to-day activities is largely driven by utility theory: main factors influencing local activity location choices are functionality (how well can one complete the desired action in the chosen location) and travel time (what is the shortest time to the location where all the needs can be fulfilled) (Næss et al., 2018; van Wee & Mokhtarian, 2023).

Living closer to the city centre and in a higher neighbourhood density area leads to shorter daily travel to work or school and thus a higher satisfaction with local travel. In addition, using active travel modes leads to higher satisfaction with local travel (Mouratidis et al., 2019). Living close to the central area of a city is connected to better service accessibility than living in the suburbs, thus reducing travel distances and time (Næss et al., 2018). Plentiful job availability near the home (within 4 miles) was found to be more significant in reducing vehicle use (both miles and hours travelled) for work-related travel than retail and service availability. However, the finding does not negate the importance of land use balance in a residential area to reduce travel miles and hours in general (Cervero & Duncan, 2006).

A study on recently relocated residents suggests that the effects of the built environment on travel behaviour are gradual, and people slowly adapt to the conditions in their residential

environment (De Vos et al., 2021). The attitudes and urban environment can only be said to influence travel behaviour when choices have to be made or when travel behaviour is already habitual (based on where one lives). For example, one's attitude towards public transit or cycling may influence residential selection when one has decided to move. Conversely, when one is not planning to change their residential location, they are more likely to adapt to the transport conditions available in their local environment (De Vos et al., 2021). This is somewhat supported by Næss et al (2018) in a study in Norway, where travel-related attitudes are likely not as important when choosing a new residential location, and therefore people would be more likely to adapt to their surroundings afterwards.

The above-mentioned findings can be related to residential self-selection (Mouratidis et al., 2019; Cervero & Duncan, 2006; De Vos et al., 2021). Residential self-selection theory discusses how people's attitudes and preferences may guide their choice in choosing their residential location (e.g., Czepkiewicz et al., 2018b; Maat & de Vries, 2006; Næss, 2006; Große et al., 2019). Other studies have also discussed reverse causality in relation to residential self-selection (e.g., van Wee et al., 2019; Ramezani et al., 2021; De Vos et al., 2021; Næss et al., 2018). The reverse causality principle implies that attitudes and travel behaviour can change through the direct or indirect impacts of the urban environment. The change in attitude can stem from new experiences or a prior mismatch between attitude and behaviour (van Wee et al., 2019). Several studies argue that reverse causality is actually more prominent than residential self-selection (e.g., Coevering et al., 2016, 2021; van Wee et al., 2019; Næss et al., 2018). Although people may choose their residential location based on travel distance and accessibility, they are also very likely to adapt their attitudes to the conditions available in their residential location (Næss et al., 2018). While the reasons behind choosing one's residential location are manifold and people put different emphasis on different reasons (De Vos et al., 2021; Mouratidis et al., 2019; Cervero & Duncan, 2006), it can be concluded that the home location and the surrounding built environment influences local travel for non-leisure purposes.

Although residential self-selection stems from studies related to day-to-day travel, it also has relevance in leisure travel, both locally and in long-distance. For example, a person who has a preference for outdoor leisure activities may choose to live in an area that is in proximity to green spaces. Additionally, van Wee and Mokhtarian (2023) suggest that leisure travel often cannot be put into simple utilitarian terms of finding the best solution to the problem. They describe underlying drivers that are more personal, often emotional, that tend to lead to escape behaviour (van Wee & Mokhtarian, 2023). Escape behaviour has been suggested as the underlying reason for many forms of leisure travel (Larsen, 2008). Escaping is influenced by personal characteristics, attitudes and experiences, social environment, living environment, and time since previous escape, having various utilities (van Wee & Mokhtarian, 2023). Escape travel may have positive utility despite the negative driver, and it occurs on both short and long-distance levels. Having a lack of variety and availability of activity locations in the residential environment may drive one to travel elsewhere in the area and seek it there (Næss et al., 2018). Living in an area that has a low number of services and activity destinations available may cause everyday leisure trips to be joined with non-leisure travel, i.e. going to the cinema on your way home from work (Strömblad et al., 2022; Cervero & Duncan, 2006). This pattern can be explained with the compensation hypothesis, where one is compensating for something that is lacking in their home environment (Næss et al., 2018). Alternatively, van Wee & Mokhtarian (2023) describe it as travel-to-escape, which follows a similar principle of feeling the need to leave the home environment, which is lacking in one or many aspects, and to seek out activities in a new or different environment.

A summary of the above connections overview is given in Table 1.

Table 1. Synthesis of associations between residential location and travel theory for local travel.

Association	Theory	Examples of connected literature
Distance to city centre: living closer to the city centre reduces commuting time owing to a more compact urban form. People are more likely to adapt their mobility to their surroundings. However, one may choose to live downtown to reduce their daily travel.	Reverse causality; but can also be residential self-selection	De Vos et al., 2021; Næss et al., 2018; van Wee et al., 2019; Coevering et al., 2021; Czepkiewicz et al., 2018b; Maat & de Vries, 2006; Næss, 2006; Große et al., 2019
Population density is typically higher in densely built central urban areas, which may be appealing to some. High population density can also be stressful and lead people to escape from their environment.	Residential self-selection; compensation hypothesis or travel-to-escape	Næss et al., 2018; Holden & Norland, 2005; Næss, 2006; Maat & de Vries, 2006; Holz-Rau et al., 2014; Strandell & Hall, 2015; Czepkiewicz et al., 2018a
Land use: Mixed land use provides a multitude of activity locations, including proximity to jobs and schools. People may choose to live in a mixed land use area to benefit from reduced travel distances. What is more, proximity to potential leisure activities may reduce the need to escape and enable social interactions. Conversely, less diverse land use in an urban setting would increase travel distances and time, even if some trips are joint trips.	Reverse causality but can also be residential self-selection; compensation hypothesis; travel to escape	Coevering et al., 2016; van Wee & Mokhtarian, 2023; Næss et al., 2018; Cervero & Duncan, 2006; Strömblad et al., 2022
Good public transit infrastructure does not necessarily reduce travel distance or times, but rather improves accessibility to activity locations. One may choose to live in a well-connected area to increase the availability of locations to them, or to reduce their travel time, or to choose a more convenient travel mode. Alternatively, the residential location one resides in can guide their choices in transport mode.	Residential self-selection; reverse causality	Mouratidis et al., 2019; van Wee et al., 2019; Ramezani et al., 2021; De Vos et al., 2021; Næss et al., 2018

2.1.2. Long-distance leisure travel

Long-distance leisure travel is defined as leisure travel away from one's local region of residence (town, city, municipality). Several studies have noted that centrally living urban dwellers travel more frequently and for longer distances (e.g. Große et al., 2019; Reichert et al., 2016; Czepkiewicz et al., 2018a; Brand & Preston, 2010), many of these trips being done by airplane (e.g. Árnadóttir et al., 2019). For domestic travel, summer cottages serve as a compensation or escape destination for city dwellers (Große et al., 2019; Næss, 2006). People may value the option of escape whenever they wish (strongly connected to freedom of choice), and also being difficult to access when travelling to this place (van Wee & Mokhtarian, 2023; Holz-Rau et al., 2014). This observation relates to the compensation hypothesis and prior studies on the importance of cabin or summer cottage access for urban dwellers (Große et al., 2019; Næss, 2006; Strandell & Hall, 2015). Although the theoretical concepts overview provided here is not extensive, a good in-depth description is provided in Czepkiewicz et al. (2018a).

The compensation hypothesis is based on the notion that living in densely built and populated urban areas experience deficiencies of the urban environment which can lead to taking more long-distance leisure travel trips in order to escape from or compensate for these deficiencies (e.g., Holden & Norland, 2005; Næss, 2006; Maat & de Vries, 2006; Holz-Rau et al., 2014; Strandell & Hall, 2015; Czepkiewicz et al., 2018a). There may be several underlying reasons for which people are compensating or escaping from (van Wee & Mokhtarian, 2023), ranging from dissatisfaction with the residential environment or the home itself (Maat & de Vries, 2006; Næss, 2006; Holden & Norland, 2005; Strandell & Hall, 2015) to emotional or personal reasons such as feeling the need to escape the home for another continent for a change of pace and environment (van Wee & Mokhtarian, 2023). The theory typically is concerned with deficiencies such as dense urban form and high population density (e.g., Holz-Rau e al., 2014; Strandell & Hall, 2015; Czepkiewicz et al., 2020b; Große et al., 2019), and lack of greenness and nature, including limited access to a private yard, access to good quality green or open spaces, and more noise and pollution around the home, (e.g., Næss, 2006; Maat & de Vries, 2006; Czepkiewicz et al., 2020b; Holden & Norland, 2005; Holden & Linnerud, 2011).

Also, travel time is viewed differently based on the underlying motivation. When travel is done to get from one place to another, time is valued, but when travel is the escape then travel time is seen positively since it contributes to the escaping. When truly desiring to go 'off-the-grid' and not being reachable by others, the travel time and distance are both valued positively (van Wee & Mokhtarian, 2023). Some studies have noted that people may choose to live in a denser central, compact urban area to cut down on short-distance travel times on a daily basis (time-based rebound, e.g. Mokhtarian & Chen, 2004) and to reduce spending on car ownership and transit (monetary rebound, e.g. Heinonen et al., 2013; Muñiz et al., 2013) to enable themselves to take more long-distance trips. This also connected to residential self-selection.

Another theoretical explanation connecting long-distance travel to residential locations is cosmopolitan attitudes. The cosmopolitan attitudes theory ascertains that people living in dense central urban areas have desire to experience and explore different cultures, typically manifested in visiting other urban destinations for leisure, but also through trying new cuisines and experiencing new things in their home city (e.g., Czepkiewicz et al., 2018b, 2019, 2020a, 2020b; Holden & Norland, 2005; Næss, 2006, 2016; Muñiz et al., 2013). Cosmopolitan attitudes tend to be concentrated in the dense urban centres, wherein people seek to go to an environment that is different to or offers more variety than their current residential area (Næss et al., 2018; Chowdhury et al., 2020).

As mentioned in the previous section, leisure travel may also be connected to residential self-selection or the reverse causality. As an example, if a person has a preference for hiking and being in nature, they may choose to live in an area where they have easier access to hiking trails or green spaces. Alternatively, if a person is already living in a greener urban area, they may develop a preference for spending time in nature.

A summary of the above literature is presented in Table 2.

In summary, the urban environment related factors connected to local and long-distance travel differ slightly, but stem from similar urban and residential environment characteristics such as distance to city centre, density, and land use mix (Tables 2-3). In addition to these, there is an interplay between people's attitudes, the urban environment and travel behaviour. People's reasons for travelling are complex and often cannot be pinpointed to just one underlying driver (De Vos et al., 2021; van Wee & Mokhtarian, 2023). This is also reflected in the synthesis

tables, where several theories could, in parallel, be possible explanations to the same phenomenon. Furthermore, it can be difficult to study the causalities for leisure travel as such studies often depend on the perception of the respondent, as shown by van Wee and Mokhtarian (2023) with their empirical exploration. For example, people often do not know what it means to 'escape' or do not want to admit that they do something to 'escape' the day-to-day life, which was reflected in the quotes where people were unsure whether what they were doing was escaping (van Wee & Mokhtarian, 2023).

Table 2. Synthesis of associations between residential location and travel theory for long-distance travel.

Association	Theory	Examples of connected literature
Lack of opportunities for leisure near one's home, based on the spatial distribution of various destinations.	Compensation hypothesis	Næss et al., 2018
People seeking variety to their residential location, wanting to experience different cultures and gain new experiences, often by taking leisure trips to other cities. These cosmopolitan attitudes tend to be concentrated in central urban areas.	Cosmopolitan attitudes	Chowdhury et al., 2020; Næss, 2006, Czepkiewicz et al., 2018b, 2019, 2020a, 2020b; Holden & Norland, 2005; Næss, 2016; Muñiz et al., 2013
Choosing to live in a location that either matches one's lifestyle or that enables one to travel more by way of monetary savings or proximity to airport/central transport stations/destinations. Association can also be vice versa with the residential location one lives in guiding influencing their attitudes and thus the resulting travel behaviour.	Residential self-selection; reverse causality; rebound effect	Große et al., 2019; Reichert et al., 2016; Holden and Norland, 2005, Næss, 2016, Næss, 2006; van Wee & Mokhtarian, 2023; Große et al., 2019; van Wee et al., 2019
Distance to the city centre: living in the central area of a city connected to lower local but higher long-distance leisure travel emissions. Less local travel leads to monetary and time savings, which are then allocated for more leisure travel.	Compensation hypothesis; cosmopolitan attitudes; rebound effect	Holden and Norland, 2005, Næss, 2016, Næss, 2006; Heinonen et al., 2013; Muñiz et al., 2013; Mokhtarian & Chen, 2004
Residential location density, lack of greenness, environmental pollution could lead to more leisure travel stemming from a desire to compensate for these deficiencies in the residential location.	Compensation hypothesis	Holden and Norland, 2005, Næss, 2016, Næss, 2006; Große et al., 2019; Reichert et al., 2016; Maat & de Vries, 2006; Czepkiewicz et al., 2020b; Holden & Norland, 2005; Holden & Linnerud, 2011

2.2. Travel and wellbeing

Another important consideration within the wellbeing domain is how wellbeing links to travel. First, however, the concept of wellbeing will be discussed in brief, followed by a brief overview of some common methods of measuring wellbeing. This will then lead to the discussion of the links between travel and wellbeing.

Well-being in its simplest, most inclusive form means "to be well" (Kitayama & Markus, 2000). The WHO describes well-being as encompassing "quality of life and the ability of people and societies to contribute to the world with a sense of meaning and purpose" and includes "social, economic and environmental conditions" (WHO, n.d.). Although considered a fundamental

driver of policy and action, resilience, and sustainability (WHO, n.d.), well-being definitions still vary between cultures, disciplines, and even studies within the same discipline (Oishi, 2010; Huta & Waterman, 2014; McGillivray & Clarke, 2006), often providing a one-dimensional approach to assessing personal well-being (Oishi, 2010). Wellbeing can be split into subjective vs objective, eudaimonic vs hedonic.

Objective wellbeing aims at measuring well-being without personal bias, capturing various life domains that can be externally observed by various measures. Although there are many ways to approach objective wellbeing, Voukelatou et al (2021) have summarized some objective and externally observable needs-based aspects to objective wellbeing, such as health, socio-economic development, politics, job opportunities, safety and environment. Subjective well-being, on the other hand, refers to one's own perception of their quality of life or happiness across various dimensions (Veenhoven, 1984, as cited in Voukelatou et al., 2021). It is split into eudaimonic and hedonic well-being (Veenhoven, 2009). Voukelatou et al. (2021) summarise that subjective well-being is dependent on our genetics, universal needs, and our social, economic and political environments. Life satisfaction is a component of subjective well-being (Lucas et al., 1996) and is a way to assess eudaimonic well-being since it depends on our perception of life and our expectations for it (Veenhoven, 2009; Huta & Waterman, 2014; Ryan & Deci, 2001).

Hedonic well-being is related to enjoyment of life, emotional state, happiness and comfort. Eudaimonic well-being, on the other hand, is related to the meaning and value we place on certain aspects of our lives and personal growth and excellence, and our contentment with our lives based on our expectations (Ryan & Deci, 2001; Veenhoven, 2009). Huta and Waterman (2014) further distinguish well-being definitions in literature by four categories: orientations, behaviours, experiences and functioning. Orientations and behaviours describe what a person chooses to do in life and why and how. Experiences and functioning are seen as wellbeing outcomes, or how a person values and responds to their experienced life (Huta & Waterman, 2014).

In studies, various methods have been used to measure well-being (Huta & Waterman, 2014; Oishi, 2010). Objective well-being can be measured using personal data gathered by various methods, including call-detail records, GPS, social media, health and fitness data, or assessed by various numerical indicators (Voukelatou et al., 2021). Subjective well-being data is typically collected via surveys and interviews (Oishi, 2010) but can also be analysed using secondary sources like social media or news data for discourse analysis or content and search analysis (Voukelatou et al., 2021).

Huta & Waterman (2014) note the use of trait level and state level in measuring well-being. Trait level refers to an average or typical level of eudaimonic or hedonic well-being that does not change much over time, whereas state level refers to well-being in its current state, during a fixed period, or during some specific activity. The study argues that there are differing understandings in eudaimonic well-being and whether it is best measured by trait or state level items, and the use of both methodological approaches in empirical literature has been interchangeable or unclear (Huta & Waterman, 2014). Similarly, to Oishi (2010), Huta and Waterman (2014) highlight that life satisfaction scales can provide insight into hedonic, eudaimonic or both hedonic and eudaimonic well-being, depending on the way the questions are worded. Furthermore, the distinction between eudaimonic and hedonic well-being can depend on how they are measured (Huta, 2020).

As can be seen from the preceding overview, well-being can be described and measured in a wide variety of ways (e.g. Oishi, 2010; Huta & Waterman, 2014; McGillivray & Clarke, 2006). Three tools for measuring subjective wellbeing will be described below - the general life satisfaction item, Cantril's Ladder and the happiness item. The three selected tools have been selected for comparison as they seem to be common in well-being studies, and because this thesis focuses on subjective wellbeing.

Satisfaction With Life Scale (SWLS) is a measuring tool developed by Diener et al (1985) to measure global life satisfaction that assesses various subjective well-being components. The tool has high internal consistency and is reliable in temporal assessments as well, resulting in 5 positively worded items with moderate or high correlations with subjective well-being components. The items are rated on a 7-point Likert scale ranging from 1=strongly disagree to 7=strongly agree, with the total number of points available being 35. The overall life satisfaction is then assessed based on the total score of the respondent, where 5-9 points is 'extremely dissatisfied' and 31-35 points is 'extremely satisfied' (Diener et al., 1985). Although the tool tries to be balanced with the statements, including some general questions about happiness, the scale in general leans towards eudaimonic well-being.

Cantril describes a self-anchoring striving scale or Cantril's ladder, where a person defines their own perceptions or basic expectations on the very negative and the very positive end of the scale, and the respondent answers questions based on this self-defined scale from 0 to 10 and about their past, present and future (Cantril, 1965, as cited in Glatzer & Gulyas, 2014). The Ladder is likely eudaimonic in essence, since the respondents are asked to define the scale based on personal perception and attitudes and then they are asked to evaluate how well they essentially meet their own expectations for themselves.

Lyubomirsky and Lepper (1999) designed a 4-item Subjective Happiness Scale where each item is set up as an incomplete sentence and the respondent has a selection of 7-point-scale options to finish the sentence. The measure assesses only hedonic well-being using the concept of happiness, even though the concept of happiness is understood differently between cultures (Oishi, 2010). However, in the original analysis, Lyubomirsky and Lepper include samples from USA and Russia (Lyubomirsky & Lepper, 1999), where people could have differing perceptions of happiness.

Ruggeri et al (2020) critique the one-dimensional approaches, saying that fundamentally 'well-being is more than happiness and life satisfaction'. Instead, they develop a measurement of well-being that encompasses both hedonic and eudaimonic well-being based on the fundamental pillars of well-being: competence, emotional stability, engagement, meaning, optimism, positive emotions, positive relationships, resilience, self-esteem, vitality (Ruggeri et al., 2020). Charlemagne-Badal et al (2015) did an extensive review of well-being and life satisfaction instruments and settled on 15 domains inherent to measuring well-being and life satisfaction: "cognitive health, economic health, emotional health, environmental health, intellectual pursuits, health behavior, health care, leisure, life satisfaction, non-leisure activities, physical health, sleep, social health, spirituality and meaning, vitality" (Charlemagne-Badal et al., 2015 p. 317). Of these 15, emotional health, physical health, social health, and non-leisure activities appeared the most in the analysed instruments, but no instrument included all 15 and at most included 12 (Charlemagne-Badal et al., 2015).

The three examined measures have been commonly used in surveys to try to assess well-being (Oishi, 2010), but they cover only subjective well-being. Furthermore, out of the three, only the

SWLS tries to include both hedonic and eudaimonic dimensions of well-being, whereas the happiness item focuses only on hedonic, and Cantril's Ladder focuses on eudaimonic. Also, such measures have been shown to be influenced by personality and mood at the time of responding to the survey (Pavot & Diener, 2008). Although all above-mentioned measures have shown good results in terms of reliability (including temporal reliability), they offer a limited view of well-being (Oishi, 2010). Single-item measures capture just one generalised aspect of well-being, whereas multi-item measures increase reliability in wellbeing studies by capturing several aspects of the multi-dimensional essence of well-being (Oishi, 2010; Ruggeri et al., 2020; Charlemagne-Badal et al., 2015). The thesis uses satisfaction of life to measure perceived wellbeing as it can capture multiple aspects of one's life, and thus is deemed the best fit for the purpose. The utilised scale and its components are discussed in more detail in the methods section (section 4.4.3).

2.2.1. Local travel

According to previous literature, wellbeing and travel are interconnected through several mechanisms. Below some of these mechanisms will be discussed from the perspectives of local travel and long-distance leisure travel.

Travel time, reliability, travel distances, and activity participation contribute to travel-related stress, which in turns contributes to subjective wellbeing. In addition, perception and feelings towards safety, cleanness, shelter provision, comfort and other aspects of one's chosen way of travel influences wellbeing. And more objective factors such as travel time, frequency and cost do so as well. These aspects contribute to both hedonic and eudaimonic well-being (Ettema et al., 2010; Friman et al., 2017; De Vos et al., 2013; Zhu & Fan, 2018; Chatterjee et al., 2020). Trips and activity choice in local travel are often not made based on maximising one's wellbeing, but rather a utilitarian view is taken where people choose acceptable options that support that their wellbeing does not drop below some personally perceived low level (De Vos et al., 2013).

De Vos et al (2013) emphasise the need to examine residential location and its various parameters (i.e., density) as it is directly tied to mode choice and hence to travel satisfaction. Travel satisfaction in this context refers to how satisfied one is with their travel behaviour and its components (distance, mode, frequency, quality). Also, they note residential self-selection as a precursor to mode choice, where people would move to areas that enable them to use their preferred mode of choice (De Vos et al., 2013).

The urban form and land use can have an effect on people's wellbeing (Schwanen & Wang, 2014; Badland et al., 2017; Olsen et al., 2019; Mouratidis, 2019; Kyttä et al., 2016). Mouratidis (2019) suggests that compact urban environments can negatively impact leisure trip satisfaction due to lack of green spaces, but also positively impact leisure trip satisfaction thanks to a diverse land use mix with a higher concentration of services, shorter commutes, and enabling social interactions. Having more open and green spaces in the residential location can have a positive impact on physical and mental health (leBrasseur, 2022; Roe et al., 2013; Neale et al., 2022) and life satisfaction (Çelik & Jaiyeoba, 2023; Douglas et al., 2019; Bakolis et al., 2018; Bonaiuto & Chiozza, 2024; leBrasseur, 2022; White et al., 2013; Zhang et al., 2017). Alternatively, green space fragmentation and loss in urban areas may have a negative impact on wellbeing (Brown et al., 2016; Hrehorowicz-Gaber, 2013).

Friman et al (2017) found that satisfaction with daily travel is dependent on travel mode, with active travel and driving leading to higher satisfaction when compared to public transport. Then, they concluded that emotional well-being is directly influenced by daily travel satisfaction, and life satisfaction is influenced by travel satisfaction by way of emotional wellbeing (Friman et al., 2017). Similarly, active travel modes have been associated with increased wellbeing (Ramanathan et al., 2014; Mouratidis, 2019). Zhu & Fan (2018) take a happiness perspective and find that biking brings the most joy, while public transport the least. Long commutes are connected to higher stress. Trip purpose seems to also determine the happiness one feels. Trips for leisure and social activities increase happiness compared to work-related trips. Trips for eating and drinking purposes revealed the highest happiness score. Also, daily travelling with family or friends led to happier and more meaningful feelings (Zhu & Fan, 2018). Bergstad et al (2010) find that car use plays a mixed role in determining travel satisfaction and subjective well-being.

Travelling to work, or commutes, can be a bother, whereas travelling for work is seen to have certain perks that somewhat counteract the nuisance of the trip, such as experiencing new cultures (Wheatley & Bickerton, 2016). With the onset of the COVID-19 pandemic, the necessity of travel-for-work practices was questioned, as a lot of the same work was easily doable online, and people found working from home to be a nice change and break from the long-distance work-related trips (Guillen-Royo, 2022).

2.2.2. Long-distance leisure travel

Vacations can have a positive effect on life satisfaction, subjective well-being, and reduce burnout (Chen & Petrick, 2013; Blank et al., 2018). Even anticipating a trip and preparing for it can boost one's mental state (Kumar et al., 2014). Most tourism studies focus on subjective well-being (including life satisfaction) (Uysal et al., 2016). Bottom-up spillover theory sets a basic premise that life satisfaction is connected to satisfaction with all of life's domains and that life satisfaction sits at the top of a hierarchical set of life domains. In terms of tourism, various events that happen during a leisure trip relating to our usual life domains (e.g. social life, work life, health, etc) affect our satisfaction with the trip and in turn our overall subjective well-being. Additionally, the satisfaction related to one domain will vertically spill over domains above, that is to say accumulating into overall life satisfaction (Sirgy et al., 2011).

Su et al (2020) studied how eudaimonic and hedonic well-being change from a tourism trip by gathering data at 6 different time points in relation to the trip (baseline, pre-trip, during trip and three different time points post-trip). They found that eudaimonic well-being increases slightly during the trip, but hedonic well-being increases more. After the trip, both return to similar levels as pre-trip, but while eudaimonic well-being remains more or less stable, hedonic well-being continues to decrease and could drop even lower than it was pre-trip. Also, they found that relaxing trips greatly increase hedonic well-being, whereas challenging trips (such as something to do with extreme sports) were found to greatly increase eudaimonic well-being during the trip itself. Generally, eudaimonic well-being increases have lower intensity than hedonic well-being increases from leisure travel (Su et al., 2020).

Sirgy et al (2011) found that positive events during the tourism trips can have a positive impact on satisfaction with social life, leisure and recreation, love life, arts and culture, work life, spiritual life, intellectual life, culinary life and travel life. On the other hand, the study found that negative effects during trips can have a negative effect on social life, family life, love life,

arts & culture, work life, health and safety, financial life, spiritual life, culinary life. Overall satisfaction with oneself was not found to be connected to what happens on a trip (Sirgy et al., 2011).

Travel can contribute to higher hedonic well-being compared to just free evenings after work (de Bloom et al., 2016). Travelling away from the everyday environment can increase the mental distance from daily and work-related worries and help one recharge more completely (de Bloom et al., 2016; Chen et al., 2016). Chen et al (2016) found that weekend trips away from the home reduce work-related stress, whereas de Bloom et al (2016) found that the benefits between weekends at home ('staycation') and travelling domestically do not vary much. In addition, it has been found that less exposure to green spaces in the residential location could lead to taking more leisure trips (Sijtsma et al., 2012). Tourism also influences the well-being of both those who travel and those who reside in the destination (Uysal et al., 2016; Godovykh et al., 2023; Dwyer, 2022). Tourism can be a nuisance in the short-term, causing potential disruptions to daily life, but can have a positive impact on well-being in the long-term by bringing in money and supporting the development of local areas, which locals then benefit from (Godovykh et al., 2023).

In Table 3, some research into the relationships between wellbeing and travel are summarised to highlight key points, demonstrating the interconnectedness of the topics of wellbeing and travel. Broadly, more studies focus on hedonic well-being associated with local travel behaviour than eudaimonic well-being. In local or daily travel, travel satisfaction is mostly linked to travel mode and travel distances, which in turn is linked to one's emotional well-being and, through it, their overall life satisfaction. The direction of effect on well-being from local travel depends on a multitude of factors but is related to travel-mode-related attitudes, one's personality in addition to trip-related satisfaction. Leisure travel, on the other hand, can mainly have a positive effect on well-being as leisure trips offer a break from daily life and worries. It can have a short-term negative effect on the well-being of residents at tourism destinations due to disruptions to their daily lives caused by an influx of tourists.

Table 3. Summary of associations between well-being and travel based on literature.

	Local/daily travel	**Long-distance leisure travel/tourism**
Main focus of research	Subjective well-being. Hedonic well-being researched more (happiness, satisfaction)	Subjective well-being. Hedonic well-being researched more (satisfaction, quality of life), but eudaimonic perspectives are gaining momentum (e.g., Vada et al., 2020)
Influence on well-being	Influences both hedonic & eudaimonic well-being. Effects noticed in both directions between studies, depending on various reasons (see below)	Influences mainly hedonic well-being, but eudaimonic in certain conditions. Effects of leisure travel on well-being mainly positive
What influences wellbeing/ satisfaction?	Hedonic: • travel mode (De Vos et al., 2013; Friman et al., 2017; Ramanathan et al., 2014; Zhu & Fan, 2018; Bergstad et al., 2010; Mouratidis, 2019) • time (De Vos et al., 2013; Zhu & Fan, 2018; Chatterjee et al., 2020) • distance (De Vos et al., 2013; Zhu & Fan, 2018; Chatterjee et al., 2020; Mouratidis, 2019) • quality (Friman et al., 2017; Ettema et al., 2010; Chatterjee et al., 2020) • companionship (Friman et al., 2017; Ramanathan et al., 2014) • trip purpose (Wheatley & Bickerton, 2016; Guillen-Royo, 2022; Zhu & Fan, 2018) Eudaimonic: • ability to reach activity locations that fulfil personal goals (Ettema et al., 2010; Zhu & Fan, 2018)	• Trip duration - even short weekend getaways have shown positive results on well-being and stress reduction (de Bloom et al., 2016; Chen et al., 2014) • Events that occur on the trip - related to many life satisfaction domains and therefore trickle upwards into overall life satisfaction (Sirgy et al., 2011) • Trip type - trips with the purpose of relaxation increase hedonic well-being more, whereas trips with activity purpose stimulate eudaimonic well-being through the sense of achievements (e.g. doing extreme sports) (Su et al., 2020) • Anticipation – planning for trips and looking forward to them associated with increased well-being of an individual (Kumar et al., 2014; Su et al., 2020)
Relationship to home	• Residential location is an important determinant of how we travel, some may choose residential location to match travel preferences (De Vos et al., 2013; Schwanen & Wang, 2014) • Residential area can also influence the aforementioned - for example land use mix and density (De Vos et al., 2013; Schwanen & Wang, 2014; Mouratidis, 2019)	• Staying home vs leaving home - No significant differences between well-being benefits from staycations at home and domestic travel but being away from home helps to better unwind from work-related stress. (de Bloom et al., 2016; Chen et al., 2014; Chen & Petrick, 2013; Blank et al., 2018) • Influence on locals - Tourism can influence also residents of tourism destinations, causing short-term disruptions to daily life, but also increasing long-term well-being with monetary value added to the local society, which often gets translated into infrastructure development, benefitting local residents (Uysal et al., 2016; Godovykh et al., 2023; Dwyer, 2022)

2.3. Activity spaces as a method to connect the urban environment, travel and wellbeing

To study the connection between travel patterns, exposure to the environment, and wellbeing, it is necessary to summarise and represent these patterns in some meaningful way. Activity spaces can be a useful method in this regard. Activity spaces are defined as a set of regularly visited locations or areas during one's day-to-day activities, wherein one's work and home locations are often dominant (Horton & Reynolds, 1971; Golledge & Stimson, 1997; Schönfelder & Axhausen, 2004). Spatially, activity spaces are defined by a surface area that encompasses one's home and regularly visited locations outside of the home and can be used to understand the extent of one's mobility (Horton & Reynolds, 1971; Schönfelder & Axhausen, 2016). Activity spaces have applications in a variety of domains, as they can be helpful in understanding both an individual's travel habits and the environments with which they interact regularly (Järv et al., 2014).

The choice of method in activity space modelling should ultimately be based on what is the aim of the analysis and in what context and spatial scope. Depending on the model, different connections between the built environment and individuals can be studied (Laatikainen et al., 2018). Many modelling techniques involve simple buffers or spatial units, which can be over-simplistic in nature (Hasanzadeh, 2019; Kwan, 2012; Smith et al., 2021). Perchoux et al (2016) examined the residential buffer, perceived neighbourhood and individual activity space in relation to environmental exposure. Based on their findings, activity spaces can help understand exposure at destinations better than other examined methods. They also note that exposure captured differs spatially between methods (Perchoux et al., 2016), which may be mediated by activity spaces which capture exposure both in the residential area and the broader urban area with which the person experiences during travel. Some activity space models can help to ameliorate the inclusion of areas where people do not travel to, compared to street-network residential buffers (Perchoux et al., 2016).

Studies have suggested that when just looking at the residential area or examining some buffer around the home we get a limited view of the areas with which the individual comes into contact with (e.g. Cherrie et al., 2019; Wei et al., 2023). People may spend around 40% of their day-to-day life outside of their homes (Wei et al., 2023). Our exposure during travel is influenced by not just transport infrastructure, but also the people we come in contact with and travel with and their socio-economic background, as well as the physical environment including its natural elements (e.g. air quality, noise, green spaces, blue spaces, etc.) and built elements (e.g. parking lots, buildings, services, etc) (Poom et al., 2021).

Looking at exposure to various environments can help to understand how certain residential or urban environment characteristics impact our physical and mental well-being (Cagney et al., 2020). One's residential environment might be different (i.e. more disadvantaged) than the environment their activity locations are in (i.e. more opportunities in activity locations), which can in turn impact one's well-being and self-reported health (Sharp et al., 2015). Several health-related studies have linked exposure to greenery have positive effects or air and noise pollution to have negative effects on physical and mental health (e.g., Chaix et al., 2012; Perchoux et al., 2013; Zhang et al., 2018; Wei et al., 2023).

Travel modes and exposure are connected. Including travel modes to exposure modelling can reduce the activity space size, making it more compact to match the travel mode (Wei et al.,

2023). Exposure to green spaces has also been shown to influence satisfaction with active travel, particularly impacting satisfaction with walking and non-work trips. However, satisfaction with trips may depend on whether this person is usually exposed to green spaces (during regular trips) or whether they come into contact with green spaces only on some trips, with the latter option having a bigger positive impact on one's travel satisfaction (Ta et al., 2021).

This supports the use of individual-based activity space models, particularly related to exposure to different environments (Hasanzadeh, 2019; Kwan, 2012; Smith et al., 2021). Individual activity spaces can improve the understanding of human mobility in a geographical context compared to static spatial boundaries (e.g. local administrative boundaries, postal code areas, residential zones, static circular buffers, etc.) (Xiong et al., 2022). Individual-based activity space models are more spatially tailored to the individual. Depending on one's travel behaviour, an individual's experience in and with the urban environment will be different to another individual (Hasanzadeh, 2019; Kwan, 2012; Smith et al., 2021).

Individual activity spaces, although dependent on travel patterns, can cover more of the individual's visited areas than a simple spatial unit (e.g., postal code area or a simple circular buffer around the home) (Laatikainen et al., 2018). Individual activity spaces can help to capture connections between individual mobility patterns and health, and individual mobility and exposure to different environments, thus increasing the analytical possibilities and understanding of the context in which individuals operate (Hasanzadeh, 2019). Ramezani et al (2021) find that individual-based activity space models provide more significant and intuitive results regarding how travel behaviour is affected by the built environment. Individual-based activity space models can provide better insights compared to static buffers (such as 500m home buffers), in their study pertaining to mode choice stemming from exposure to the environment and activity space characteristics (e.g. shape, centricity). However, the authors emphasise that the results of the study cannot be generalised as it is the first of its kind to compare the different methods and do so within an older age group only (Ramezani et al., 2021).

One caveat of activity spaces overall is that the modelling accuracy of activity spaces depends on the availability of datasets (Hasanzadeh et al., 2018). For robust individual-based modelling we need rich data sets about individuals' mobility, including but not limited to trip destinations, trip frequency, trip routes, trip times, travel modes. However, such data can be difficult to obtain. GPS or mobile positioning data are more granular than survey or PPGIS data but are difficult to access (Ramezani et al., 2021, Järv et al., 2018; Xiong et al., 2022). Survey or PPGIS data can lack a long-term temporal component, which means activity spaces modelled with PPGIS data will offer only a static snapshot of one's mobility (Xiong et al., 2022; Järv et al., 2014). In addition, when using data gathered from individuals, there is a self-reporting bias (Brown, 2017; Hasanzadeh, 2022). Lastly, advanced models like the individualised residential exposure model can be complex to use, depending on the researcher's technical expertise (Hasanzadeh et al., 2018).

3. Nordic context

Nordic countries (Sweden, Denmark, Norway, Finland, Iceland) are known for high living standards, high incomes, developed social welfare (Martela et al., 2020; Norlén et al., 2024). In the region, GDP/cap was about 1.4 times higher than in the EU on average in 2022 (Norlén et al., 2024), and about 6.2 times the global average (International Monetary Fund, 2024; Norlén et al., 2024). Much of the population and economic activity in the Nordic countries is concentrated in bigger urban areas and around capital cities (Norlén et al., 2024). They are often listed among the happiest countries in the world (Greve et al., 2021; Helliwell et al., 2024). In terms of environmental policy and climate mitigation goals, they are often considered as a positive example, with ambitious goals set for upcoming years (Norlén et al., 2024; Greaker et al., 2019).

Although the Nordics consider their climate policies successful in moving towards climate neutrality (Norlén et al., 2024), the climate policies of the Nordics have been criticised for insignificant decoupling, ignoring the significance of demand-side reductions, and being too country-centric (Bhowmik, 2019; Greaker et al., 2019; Tilsted et al., 2021; Salvucci et al., 2019). There is further evidence in CBCFs in the Nordics, which are among the highest in the world, exceeding climate mitigation threshold levels even among people with the lowest incomes in these countries (Abdallah et al., 2024; Heinonen et al., 2022b).

Nordic countries are some of the most motorized in the world (Our World in Data, 2024). In the travel sector, some of the biggest challenges in the Nordics pertain to decarbonizing the transport fleet (Sovacool et al., 2021; Dillman et al., 2021a), long travel distances and population sparsity (Norlén et al., 2024; Sovacool et al., 2021) and insufficient public transport infrastructure (Heinonen et al., 2021; Sovacool et al., 2021). Moreover, a big part of the carbon footprint of Nordic urbanites stems from air travel and car usage (driving long distances) (Norlén et al., 2024). In addition, there is a higher concentration of pro-climate behavioural intentions among people living in urban areas, yet also higher consumption in the leisure domain (Anttonen et al., 2023). Higher awareness of and concern about climate change do not necessarily translate into reducing emissions from leisure travel (e.g., Aasen et al., 2022; Czepkiewicz et al., 2019; Jacobson et al., 2020), though they might yield results in personal car use (e.g., Mouratidis & Næss, 2024).

Within the Nordic context, the thesis examines the Reykjavík Capital Area as a case study (referred to also as Reykjavík). Reykjavík Capital Area (Höfuðborgarsvæðið in Icelandic) is the biggest urban area in size and population, with about 2/3 of the population living there (Statistics Iceland, 2023). It is also the commercial, industrial and cultural hub of Iceland (Britannica, 2024). The central area of the city sits on a peninsula, accessible only on one side by land. The city is influenced by its sub-polar oceanic climate with mild but quickly changing weather (Ingólfsson, 2008). Reykjavík is characterised by low building and population density. The city has many open spaces and green spaces along with an extensive waterfront that wraps around the city. The public transportation consists only of buses, and in recent years electric scooters have been introduced into the mix. Levels of car ownership are very high, with downtown residents having high-rates of car-free living (Heinonen et al., 2021; Næss et al., 2021). Furthermore, prior studies have shown that Reykjavík urbanites have high emissions in both local travel from car use (e.g., Heinonen et al., 2021) and long-distance leisure travel from flying (e.g., Czepkiewicz et al., 2019, 2020b) The latter has been shown not to be connected to income or climate concern (e.g., Czepkiewicz et al., 2019). Plans for connecting the outskirts

of Reykjavík to the central area by bridges and tunnels is underway, as well as plans for densification and establishing a rapid bus transit system (*Borgarlínan*, n.d.), although the plan has been criticised for its slow implementation speed.

4. Methodology

This chapter covers the methodological approaches used in this thesis and the two data sets used in the articles. The thesis utilises a case study approach as an overarching research strategy, in combination with a mixed methods approach in which the quantitative and the qualitative components both feed into the other component (Figure 2). The following sections describe each of these components one by one. The thesis will return to the evaluation of these methods in the discussion section.

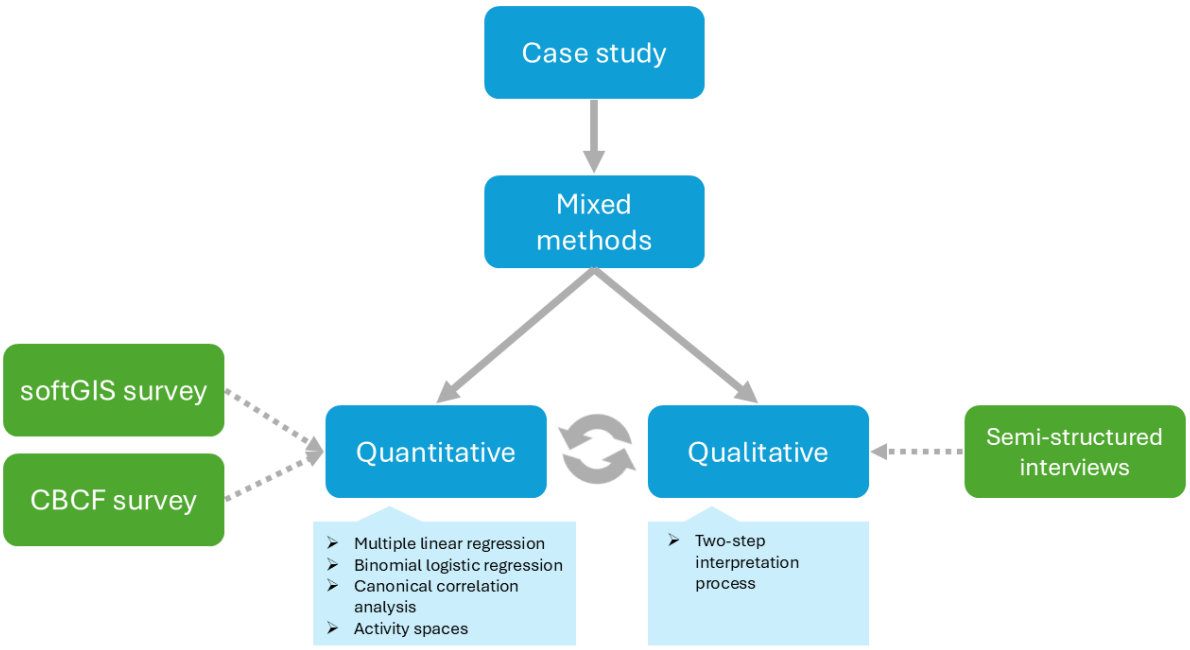

Figure 2. Overview of the methodological approach of the thesis.

4.1. Case study

Three complex interconnected topics form the core of the thesis – urban environments, travel emissions and wellbeing. The core topics of the thesis are highly context dependent and complex (e.g. Schwanen & Wang, 2014; Kyttä et al., 2016; Zhang & Zhang, 2020; Næss, 2012), which supports the notion of using a case study approach (Flyvbjerg, 2006; Yin, 1981). A case study approach supports a more in-depth analysis of a topic within a set context (Yin, 1981). Case studies are valuable particularly in studying extreme cases and complex topics within their context, instead of observing them as stand-alone phenomena (Yin, 1981; Flyvbjerg, 2006). Although the results of case studies are not generalizable to the whole population, they can be a useful tool in identifying "anomalies" that might apply within other populations and contexts as well (Flyvbjerg, 2006). Discovered patterns can be later tested in other settings, and if similar findings emerge throughout multiple case studies, they can be used to inform theories (Eisenhardt & Graebner, 2007). Yin (1981) emphasises that a case study is not a method, but rather a research strategy. Case studies are not limited in methodological selection, as both quantitative and qualitative methods can be applied as needed and depending on the context and topics being examined (Yin, 1981).

4.2. Mixed methods approach

Within the case study umbrella, the thesis takes a mixed methods approach by applying both qualitative and quantitative research methods within the same context of the case study, offering a multi-dimensional view of the research problem at hand (Migiro & Magangi, 2011). Mixed methods research can be defined as "*the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study*" (Johnson & Onwuegbuzie, 2004, p.17). Johnson and Onwuegbuzie (2004) call mixed methods research pragmatic in its nature, as it taps into the researcher's creativity in understanding a problem by using induction, deduction and abduction techniques. Although more time-consuming for the researcher, mixed methods enable the convergence of findings by looking at multiple layers of the same issue, offering valuable insights for both theory and practice that might otherwise be missed (Migiro & Magangi, 2011; Almalki, 2016). In addition, studies in the field of travel emissions and behaviour, which is still largely dominated by quantitative research, have called for using mixed methods (e.g. Næss, 2016; Czepkiewicz et al., 2018a; Næss et al., 2019; Smith et al., 2019).

Mixed methods can help understand causality (e.g., Næss, 2016; Maxwell & Loomis, 2003; Smith et al., 2019), wherein quantitative methods support the establishment of relationships between variables and qualitative methods can give meaning and context to those relationships (Maxwell & Loomis, 2003; Næss et al., 2018). Quantitative methods can help draw overarching and general conclusions based on numerical data, while qualitative methods are helpful in understanding people's perceptions and perspectives within their context (Berg & Lune, 2017). Qualitative methods can support, explain, complement or show exceptions to the general results of a quantitative study (Berg & Lune, 2017). Furthermore, applying mixed methods within a case study can increase the generalisability of the results (Migiro & Magangi, 2011).

Considering the benefits of using mixed methods, the thesis follows the interactive design model as suggested by Maxwell & Loomis (2003). Within its interactive design, quantitative methods inform qualitative and vice versa. The research questions of the thesis integrate results from both quantitative and qualitative components. Such an interactive approach is more dynamic, informing the researcher of the complex relationships between variables (Maxwell & Loomis, 2003; Migiro & Magangi, 2011; Almalki, 2016). In this thesis, quantitative methods informed qualitative research, and qualitative methods fed back into quantitative research, described in some more detail at the end of this chapter (see also Figure 2).

Sale et al (2002) argue somewhat against the interactive design principles proposed by Maxwell & Loomis (2003), stating that because quantitative and qualitative methods study different paradigms (objective vs perceptive) of the same phenomena, they cannot be used in combination for cross-validation, but rather should remain as separate complementary components within a case study. However, considering the nature of the three core topics of the thesis (travel behaviour, urban environments and wellbeing), mixed methods were considered invaluable in the research process.

Furthermore, within these complex core topics, reverse causality is known to occur (e.g., van Wee et al., 2019; Coevering et al., 2016, 2021) which quantitative methods might not be able to capture. Therefore, in-depth qualitative data collections, such as interviews or focus groups, can offer valuable insights about the causal relationships between examined variables (van Wee et al., 2019; Næss et al., 2018; Smith et al., 2019).

In this thesis, the interactive approach was applied, as mentioned above, wherein quantitative methods informed qualitative and vice versa (see also Figure 2). First, quantitative studies were used to inform the qualitative offering insight into which kind of questions to ask and what themes need to be studied more in depth. Then, qualitative methods raised interesting new points for future investigation, which were then studied in a quantitative manner. Without the interactive approach, it would not have been possible to show and study new links between the urban environment, travel and wellbeing.

4.3. Data collection

Three sets of data were applied in this thesis. A brief description of the data sets and their collection process is provided below, followed by an overview of analysis methods applied to these data sets. More detailed descriptions are provided in the articles forming the thesis as mentioned in the below sections.

4.3.1. 1.5-degree compatible lifestyles survey

Data of about 8000 respondents aged 18 and above from across five Nordic countries (Iceland, Norway, Denmark, Sweden, Finland) was collected in 2021-2022 using an online carbon footprint calculator survey, described in detail in Heinonen, et al. (2022b). The aim of the survey was to identify lifestyles that are compatible with the recommended 1.5-degree Celsius global warming levels. The survey involved a variety of themes relating to people's consumption habits across various categories. Full personal CBCFs were calculated for the respondents, including various domains like mobility, which had an important role in the survey. Within the scope of the thesis, the focus is on local and long-distance leisure travel emissions (A1). The thesis utilises background variables of the respondents, travel-related data for emissions calculations, and attitudinal questions about climate concern.

4.3.2. Sustainable Reykjavík Capital Region survey

In 2017, an online map-based survey was conducted (softGIS survey, a type of PPGIS) within the project "The quest for a Sustainable Reykjavík Capital Region: lifestyles, attitudes, transport habits, well-being and climate impact of young adults (SuReCaRe)". The softGIS survey asked questions about respondents' travel habits and their frequently visited locations, with the added feature of mapping the locations using the online survey interface (e.g., Czepkiewicz et al., 2018b; Brown & Kyttä, 2014). Respondents were asked questions about their residential location, urban mobility, leisure travel, attitudes, and socio-demographic background. The survey targeted 25-to-40-year-old people living in the Reykjavík Capital Area. In total, the survey gathered 706 responses, out of which 667 were usable for further analysis, used later in A3 and A4. At the end of the survey, respondents were able to opt in for further questioning about the topic. The thesis utilises background variables of the respondents, travel-related input for emissions calculations (discussed further in section 4.4.1), an array of life satisfaction questions as a measure of wellbeing (discussed further in section 4.4.3), and self-reported location data from the mapping portion of the survey for GIS analyses. The analyses of A3 and A4 also include attitudinal variables as control variables, which were calculated based on factor analysis in prior studies with the same data set, and which have been shown to influence travel behaviour (Czepkiewicz et al., 2019). These variables include pro-

environmental attitude, climate awareness, cosmopolitan attitude, preference for urban leisure travel compared to nature, preference for living in the suburbs, pro-car attitude, preference for shared housing and transport, and preference for nature and privacy. As the attitudes are only used as control variables in the thesis, their calculation is not covered here in the methods section. The variables are described in more detail in Czepkiewicz et al (2019).

4.3.3. Interviews

Respondents of the above-mentioned softGIS survey, who opted in for further research and who were still living in the Reykjavík Capital Area at the time, were invited to participate in semi-structured interviews about one's home and neighbourhood, day-to-day travel, leisure travel, and attitudes related to travel. The interviews took place at the interviewees' chosen location and lasted between 45 to 90 minutes. The interviewees were aware of the main topics beforehand but not the specific questions. Interviews were conducted in English, Icelandic and Polish based on the native language or language preference of the interviewee. The interviews were transcribed and translations into English were done by the researchers (see A2 for more information about the process). In total, 21 semi-structured interviews were collected.

4.4. Data analysis

4.4.1. Travel emissions

The thesis examines long-distance leisure travel and local travel CBCFs (A1, A3, A4). Long-distance leisure travel is defined as leisure travel away from one's local region of residence (town, city, municipality). Work-related emissions in this context are assigned to the employer and are therefore excluded from the emissions accounting. Local travel is defined as daily travel within one's local region of residence, which includes commuting for work, errands, social activities, etc. It is also referred to as urban mobility within the context of the thesis, as the focus within the case study approach is on an urban area (Reykjavík Capital Area) (A2, A3, A4). The emissions calculation procedure is described in more detail in the relevant articles within this thesis compilation (A1, A3, A4), but a brief description of the emissions estimation process is described below.

The thesis focuses on a consumption-based approach to travel emissions accounting (e.g., Baynes & Wiedmann, 2012). Emissions were calculated based on respondents' input in a survey and based on the country-context of the respondent and allocated to the consumer regardless of where the consumption of goods and services takes place (Heinonen et al., 2022a). This method for calculating personal travel emissions was applied to both data sets used in the thesis. Included within this scope are all motorised long-distance travel trips for leisure (that is, unrelated to work), and motorised local travel for all purposes, similarly to other major works in this field (e.g., Akenji et al., 2021). Based on the responses to either survey (see sections 4.3.1 and 4.3.2), respondents' consumption-based GHG emissions for local travel and long-distance leisure travel were calculated using Well-to-Wheel life cycle assessment, thus including only the emissions from vehicle use (incl. direct and indirect emissions for fuel and electricity) but excluding vehicle manufacturing. The data from the surveys included vehicle types and fuels, fuel efficiency, distances covered, allowing to account for, for example, electric vehicles, high fuel efficiency and alternative fuels within the footprint estimates.

For local travel, emissions calculations accounted for the use of the primary vehicle of the household (incl. size and type), fuel consumption, and weekly driven kilometres. Emissions from public transport use were added based on weekly kilometres taken with public transport. Active travel modes were assumed not to contribute to emissions. For long-distance leisure travel emissions calculations, vehicle type (car, bus, train, ferry, plane), trip frequency and roundtrip distances to destinations were accounted for based on survey data. For car use, the average car type and fuel consumption was calculated in each country and that data was used to calculated long-distance leisure travel emissions made by driving a car. This was done with the aim of accounting for rental car use when travelling, which was not covered within the survey. In addition to direct information from respondents, emissions factors were compiled based on previous literature and used in the calculations.

4.4.2. Activity spaces

Activity spaces were used as a tool to better understand human-environment interactions (A3, A4). This thesis uses activity spaces as a method in examining the relationships between the broader urban environment, leisure travel and life satisfaction. This is done in two ways. First, geometric activity space parameters, as described later in this chapter, are used to describe the travel patterns and spatial extent within the Reykjavík Capital Area (A3). Secondly, activity spaces are used as a container to estimate exposure to the green and grey spaces in the urban environment (A4). Although activity spaces have been in use for decades, the method has seen minimal applications in association to travel-related GHG emissions. The activity spaces were modelled, and three parameters were calculated using the individualised home range model (Hasanzadeh et al., 2017) and toolbox (Hasanzadeh, 2018) and are briefly defined below.

An individual-based model was chosen over simple buffers, ellipses and a traditional minimum convex polygon due to their numerous advantages. Individual-based activity space models are more spatially tailored to the individual. Depending on one's travel behaviour, an individual's experience in and with the urban environment will be different to another individual. Many modelling techniques involve simple buffers or spatial units, which can be over-simplistic in nature and underestimate the area with which an individual interacts (e.g., Holliday et al., 2017; Laatikainen et al., 2018). This supports the use of individual-based activity space models, particularly when studying exposure to different environments (Hasanzadeh, 2019; Kwan, 2012; Smith et al., 2021; Ramezani et al., 2021). The method increases analytical possibilities and understanding of the context in which individuals operate (Hasanzadeh, 2019; Ramezani et al., 2021), helping to unpack connections between individual mobility patterns, environmental exposure and health and wellbeing (e.g., Perchoux et al., 2014, 2019; Cherrie et al., 2019; Sharp et al., 2015; Hasanzadeh, 2019; Laatikainen et al., 2018; Zhang et al., 2016).

Activity spaces were modelled based on the softGIS survey (SuReCaRe, section 4.3.2) data where people marked their usually visited locations on a map, along with trip frequency, travel mode and trip purpose. Although not as detailed as, for example, GPS or mobile positioning data, the data collection method is more accessible for researchers (Czpekiewicz et al., 2018b). The softGIS survey enables to collect data about patterns of spatial behaviour, and can be used to model mobility patterns, routes and trip purposes (Czepkiewicz et al., 2018b), all of which are relevant to this thesis. Although the survey asks to reflect on one's usual and frequently visited locations, the data does not offer a longitudinal perspective nor does it account for seasonal or weekly differences in mobility, but rather offers a snapshot of one's mobility (Ziong et al., 2022; Järv et al., 2014). There are a variety of parameters described in literature that are

used to geometrically describe activity spaces. In this thesis, size and centricity play a more central role (A3, A4). In addition, elongation was covered in one study (A3).

Activity space size is one of the most used parameters in activity space research (Smith et al., 2019), and in this thesis it was used to measure the extent and breadth of an individual's activity space. Activity space size was used as one way to describe how big of an urban area a person interacts with on a regular basis, and the measure was partially treated as an indication of one's mobility. For example, if one has a small, local activity space, their mobility is limited to a small area. Activity space size was calculated based on the surface area of the activity space polygon and measured in km^2. The model used for calculating the activity space polygon could be overestimating the activity space as it does not account for the underlying road network, and it is therefore to be treated as an estimate with the acknowledgement that it might differ when using other models (Hasanzadeh et al., 2017).

Then, activity space centricity was applied (A3, A4). Centricity is a newer concept which identifies clusters of regularly visited activity locations within and outside of the home area (Perchoux et al., 2014; Hasanzadeh et al., 2019, 2021). In this thesis, centricity was used with the aim of understand whether people do their regular activities within a 15-20-minute walking range (1.6 km) from their home.

In addition to size and centricity, in A3 activity space elongation was used do delineate the spatial extension of the activity space and was used in relation to bicentric activity spaces and also to identify strong one-directional mobility patterns. Elongation is calculated as the major to minor axis ratio of an activity space (e.g., Hasanzadeh et al., 2019).

4.4.3. Wellbeing measures

As part of the thesis aims to understand people's perception of the urban environment, which is subjective, the focus of the wellbeing analysis is also on subjective wellbeing across various categories (A4). A self-reported life satisfaction scale is used in the thesis as a measure for perceived wellbeing based on data collected in the SuReCaRe survey (section 4.3.2). It featured one-item scale for overall life satisfaction, and a multi-item scale of life satisfaction with different life domains, totalling 10 questions covering both hedonic and eudaimonic wellbeing aspects (Table 4), phrased as questions "How satisfied are you with…?". The list of questions included in the survey were based on Domain Evaluation module of the OECD Guidelines on Measuring Subjective Wellbeing (OECD, 2013), with modifications made to fit the purpose of the survey and its target group. Respondents could answer on a scale of 0 (not at all satisfied) to 10 (completely satisfied). Although the scale items encompass both hedonic and eudaimonic aspects of wellbeing, they were examined separately to see whether there were differing influences of the urban environment on the sub-categories of life satisfaction.

Life satisfaction scales were chosen for this thesis as they can provide insight into hedonic, eudaimonic, or both hedonic and eudaimonic well-being, depending on the way the questions are worded (Oishi, 2010; Huta & Waterman, 2014). Life satisfaction scales have been widely used (e.g., Charlemagne-Badal et al., 2015; Oishi, 2010). Respondents may be influenced by cultural context, wording of the questions and question order, or mood at the time of answering the survey (Diener et al., 2013). In the analysis of the life satisfaction items in this thesis (A4), the context of the thesis case study, the Nordic countries, is considered. In the Nordic countries, life satisfaction is on average 7.5 on a 10-point scale, which is higher than the global average (Ziogas & Ballas, 2024).

Table 4. Life satisfaction scale items from the SuReCaRe survey used in A4.

How satisfied are you with… ?	Wellbeing type
your life as a whole these days	(one-item scale)
your material standard of living	hedonic
your current state of health	hedonic
your personal relationships	hedonic
feeling part of your community	eudaimonic
the quality of your local environment	eudaimonic
your main occupation such as job or studies	eudaimonic
things you are achieving in life	eudaimonic
the amount of time you have to do things you like doing	eudaimonic
how safe you feel	eudaimonic

4.4.4. Semi-structured interviews and analysis

In A2, semi-structured interviews were used to explore the connections between the urban environment and leisure travel behaviour. As most studies on the interactions between urban environments and people's travel behaviour are quantitative, adding a qualitative perspective via semi-structured interviews can provide a deeper understanding of the topic, complementing the quantitative analyses (Leech, 2002; Ngumbi & Edward, 2015; Berg, 2009; Berg & Lune, 2017). Semi-structured interviews combine fixed themes with open-ended questions, enabling the interviewee to express their thoughts more freely and the interviewer to ask additional questions when needed (Leech, 2002; Berg, 2009; Berg & Lune, 2017; Waller et al., 2016; Ngumbi & Edward, 2015). Face-to-face interviews can also help interviewers spot underlying attitudes by way of people's reactions to the questions (Leech, 2002).

Although they offer a valuable in-depth perspective, semi-structured interviews are not without their limitations. Firstly, topics of interest and the resulting questions, although open-ended, are pre-determined and may limit the breadth of the responses given, despite the opportunity to ask additional questions during the interview process (Leech, 2002; Ngumbi & Edward, 2015). Moreover, questions might be understood differently due to personal, cultural or other background factors of both researcher and interviewee, or due to the wording of the question (Ngumbi & Edward, 2015; Berg & Lune, 2017). Secondly, there is a risk of misinterpretation by the researcher analysing the interviews, although extra notes can be taken during the interview to minimise this risk (Leech, 2002). A two-step interpretation process which involves multiple researchers could minimise misinterpretation risk by way of peer validations (Næss, 2018). In A2, such a two-step interpretation method was applied, following the examples from Næss (2018) and Czepkiewicz et al (2020b). In its first step, the individual answers of interviewees were interpreted in relation to 35 predetermined themes and guiding questions. In the second step, the interpretations of individual answers were interpreted again to form an overall interpretation of central themes. One researcher performed both steps of the interpretation and a second researcher cross-checked and validated the interpretations. In

addition to peer-validation, the chosen analysis method allows new perspectives and themes to arise during the analysis. It is important to recognize that the themes which emerge during interviews are a reflection of only a part of the population's thoughts and perspectives and therefore cannot be generalised to the whole population (Galvin, 2015).

4.4.5. Statistical methods

Various statistical analysis methods were deployed throughout the articles in this thesis. Statistical analyses were conducted using IBM SPSS Statistics 29. Simple descriptive statistical and bivariate analyses were conducted for an initial overview of the samples (A1-A4). Attitudinal variables were constructed using factor analysis (A1, A3).

Multiple linear regression was used to study the relationship of various independent variables to travel emissions (A1, A3) and activity space size (A3) as dependent variables. Multiple linear regression examines the linear relationship between one dependent and multiple independent variables. The method was used to study effect sizes and directions.

Binomial logistic regression was used to study the participation or engagement in travel (A1, A3), as well as having a polycentric activity space (A3). Binomial logistic regression can be used to study the likelihood of belonging to a predetermined dependent variable group, where the outcome/dependent variable is binary.

The thesis also applied Canonical Correlation Analysis (CCA) for the analysis of relationships between exposure within an activity space, various perceived wellbeing parameters, and travel emissions (A4). CCA enables the study of the relationships between two sets of variables and can be used to capture complex and multidimensional data. CCA examined the relationship between the independent group and dependent group of variables, forming statistically significant variates, somewhat similarly to factor analysis (Hotelling, 1936; Thompson, 1984). The CCA coefficient shows how much of the relationship between the independent and dependent variables is explained by the variables included in the variates. The direction of the effects between relevant variables are examined using standardised canonical correlation coefficients.

5. Results

Nordic travel footprints are on a pathway to exceed climate mitigation threshold levels for 2030, particularly owing to high leisure travel emissions (A1). The results indicate that people who currently meet the threshold levels in travel might also be those who belong to more disadvantaged socio-economic groups (i.e., lower education level, lower income level, living alone) (A1). There is an additional important link between higher travel emissions and low climate concern (A1).

The results of the thesis indicate that people's decisions to travel outside of their local area for leisure could be influenced by the broader urban environment than just their home or neighbourhood, such as contact with the urban environment during daily commutes (A2, A3). High levels of urban mobility (a busy and mobile lifestyle) could lead to more travel away from the urban environment for leisure (A3). As such, the results of the thesis extend the perspective of the compensation or 'escape' hypothesis, going beyond its traditional residential neighbourhood view (A2, A3).

Exposure to green and grey spaces during daily mobility has some impact on how much people travel for leisure, but it is outweighed by their travel-related attitudes (A4). The results also highlight the importance of perceived wellbeing in both urban and transportation planning, as improving one's wellbeing can be a reason behind long-distance leisure travel (A2, A4). However, although exposure to both grey and green spaces during daily mobility is an important variable in perceived wellbeing, it is outweighed by people's socio-economic background (A4).

The thesis still ascertains that people's wellbeing should be considered alongside environmental and economic performance in urban areas. Modern day busy urban living in an affluent context seems to result in increased leisure travel for the benefit of one's wellbeing. The escape or compensation motivation behind leisure travel was more dominant among other explanations (e.g., experiencing other cultures, resting from work) (A2). Meanwhile, travel emissions in the Nordic countries are well beyond recommended thresholds and do not seem to be reducing (A1), as people could be prioritising wellbeing over environmental concern. The results of the thesis allow to argue that a re-evaluation of urban development strategies is needed, alongside broader lifestyle changes, to better meet the needs of urban residents and climate mitigation targets. Although global climate targets require a unified approach to mitigation, there is no one-size-fits-all solution for travel and transport emissions mitigation, as they are highly dependent on local context (A1). The thesis shows the value of using a mixed-methods approach in studying complex relationships like those between urban environments, travel behaviour and wellbeing (A1-A4).

The main thesis components (A1-A4) and how they contribute to the thesis entity are described in Table 5. The key results of the thesis are described in more detail in the following subsections in relation to the research questions. After this, three subsections delve into the results related to each research question.

Table 5. Overview of thesis components.

Research problem and research questions	Considering continuously rising urban populations and travel-related footprints, there is a need to study the relationships between people and the urban environment that goes beyond one's residential area. RQ1: What is the climate impact of personal travel in the Nordics? RQ2: How do people's interactions with the urban environment affect leisure travel? RQ3: How do people's interactions with the urban environment affect perceived wellbeing?			
	Article I	**Article II**	**Article III**	**Article IV**
Title	Travel footprints in the Nordics	Long-Distance Travel and the Urban Environment: Results from a Qualitative Study in Reykjavík	Activity spaces and leisure travel emissions: a case study in Reykjavík, Iceland	Does higher exposure to green spaces lead to higher life satisfaction and less leisure travel?
Perspectives	Overview of travel footprints in the Nordics	Exploration of why people travel for leisure	Novel method (activity spaces) for connecting urban mobility with travel emissions	Studying exposure to green and grey spaces during daily mobility and how that is associated with perceived wellbeing and leisure travel emissions
Study design	Quantitative analysis CBCF of travel in five Nordic countries	Case study in Reykjavík, Iceland; Qualitative analysis of 21 interviews	Case study in Reykjavík, Iceland; quantitative analysis of activity spaces and travel emissions	Case study in Reykjavík, Iceland; quantitative analysis of exposure within activity spaces and the links to perceived wellbeing and travel
Main contribution	Travel-related footprints in the Nordic countries exceed recommended threshold levels for climate change mitigation manifold, stemming mainly from long-distance travel. People who meet the threshold might belong to lower socio-economic groups. Low climate concern connected to both higher local and long-distance travel emissions. Study highlights the importance of local context in transport/travel policy.	People travel away from the city for their wellbeing and to escape the tumult of urban life. The study also indicates the impact of the broader urban environment on wellbeing and travel-related decision-making.	Combined with generally large average activity space size, a pro-car attitude and dominating polycentricity among the sample, it is an indication of a lack of functioning 15-minute neighbourhoods and public transportation in the Reykjavík capital area. The study indicates the presence of a highly mobile lifestyle among Reykjavík urbanites, which is reflected in the connection between activity spaces and domestic leisure travel engagement.	The results revealed that although exposure to green and grey spaces is important to overall life satisfaction, underlying socio-economic background is more relevant. There are indications of high levels of urban mobility being connected to more leisure travel away from the city.
Argument	A mixed-methods approach offers valuable multi-faceted perspectives in studying complex relationships like those between urban environments, travel behaviour and wellbeing. In the studied Nordic country context, it was shown in this thesis that travel emissions exceed 1.5-degree compatible threshold levels, owing largely to long-distance leisure travel. Moreover, people's wellbeing and how much they travel for leisure can be influenced by their regular interactions with the broader urban environment.			

5.1. The climate impact of personal travel in the Nordics

Considering climate mitigation targets in transport, many of which are already aimed at 2030, it is essential to understand the state of travel footprints. In A1, such a baseline for examination was established. According to the study, travel footprints in the five Nordic countries ranged from 2.5-3.4 tCO2eq/cap/year on average (Figure 3-a), exceeding recommended thresholds for 2030 (calculated as 0.962 tCOqeq/cap/year based on Akenji et al., 2021) about 3 times on average, particularly stemming from leisure travel (56-63%). Being a young male living alone with low climate concern was indicative of having a higher footprint in local travel. Significant predictors of higher leisure travel engagement and directions of impact on emissions varied between the countries, indicating context dependence. For example, even after controlling for income, low education level was linked to lower engagement in leisure travel in Finland, Norway and Denmark, while high education was indicative of the opposite pattern in Denmark and Sweden. However, having low climate concern was associated with higher emissions in leisure travel (Figure 3-d) when controlling for other effects. People living in urban areas had lower local travel footprints than their rural counterparts in Iceland, Denmark and Sweden. On the other hand, urban and semi-urban residents had higher footprints than rural residents in leisure travel in all countries except Norway (Figure 3-c).

It was also examined whether there were any people among our sample who were meeting the 2030 threshold levels already today. Notably, there were indications that those who meet the recommended thresholds today might belong to lower socio-economic groups. When factoring in climate concern, it could be seen that high climate concern only reduced one's overshoot in Iceland and Sweden, which indicates other possible underlying reasons for travelling less, such as accessibility, transport poverty and socio-economic status, raising the point of examining the social floor of the transport and travel sector (e.g., Dillman et al., 2021b).

The study (A1) further highlighted the context dependence of travel footprints and behaviour. Nordic countries can be grouped together, as is often done, based on many varied characteristics. Relatively high wealth of the population, developed social provisions, and cultural similarities unite these countries (e.g., Olafsson, 2013; Tiemer, 2018). However, despite all of the similarities, travel behaviour is highly individual and local context dependent, as evidenced by the differing composition of travel footprints across the five countries, despite the footprint levels being high across overall (A1). For example, in Iceland, car use is predominant in local travel, with about 92% of the average local travel emissions stemming from car use, and flying is predominant in leisure travel, while public transport modes are minimally used for both (A1). Geographical peculiarities play a key role in setting the context.

Thus, the thesis zooms in on a case study of Iceland (A2-A4), where the majority of the population is concentrated in the capital urban area, to better understand the rationales behind why people travel and what might be drivers in urban areas for leisure travel (A2).

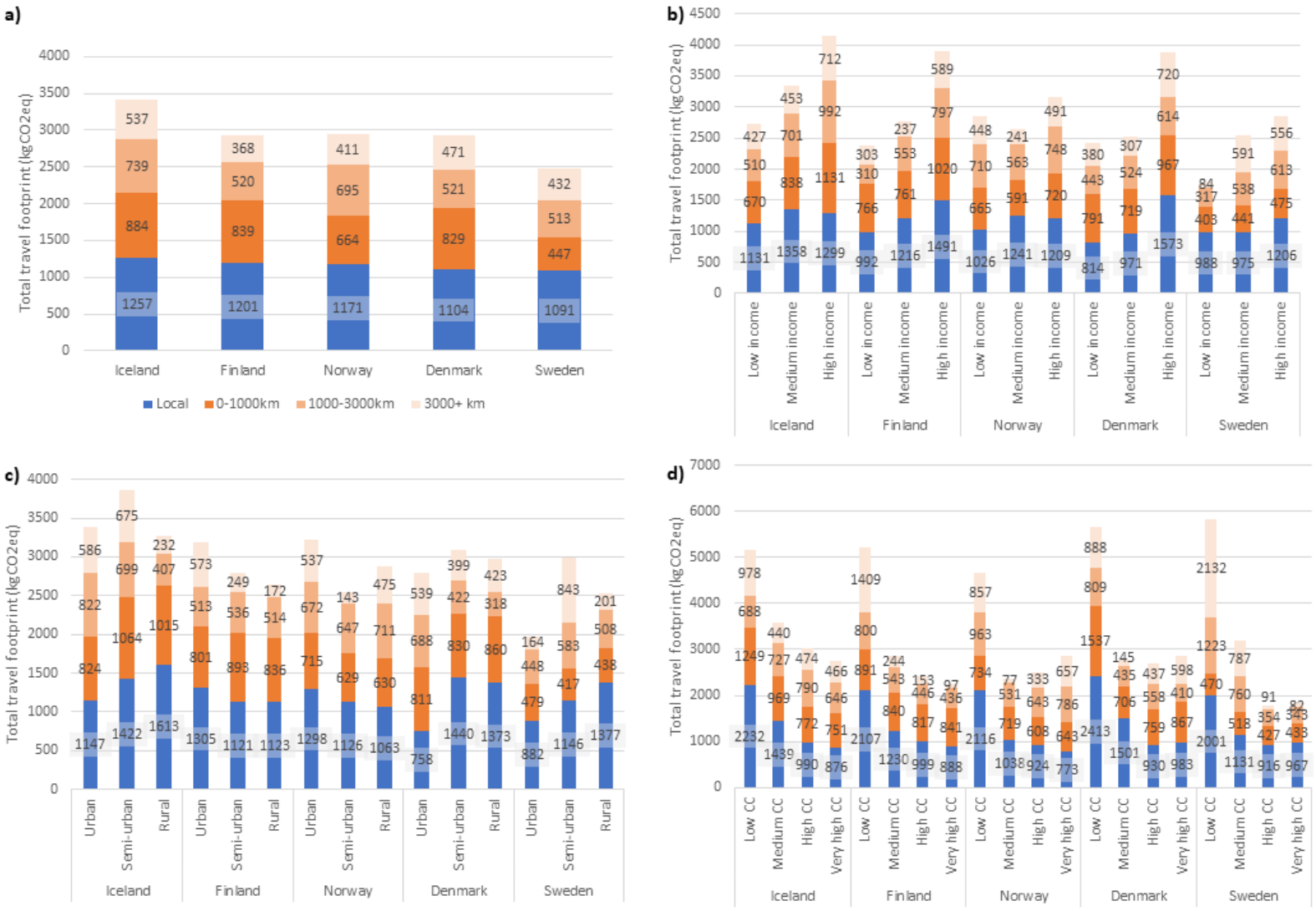

Figure 3. Average travel footprints across Nordic countries split into (a) local and long-distance travel (by round-trip distance bands), (b) income level, (c) degree of urbanisation, and (d) level of climate concern (CC) (Source: A1 p. 9).

5.2. Interactions with the urban environment and leisure travel

Focus was on a qualitative case study of the capital region of one of the Nordics with a unique geographical context. Interviews with people in Reykjavík revealed that people feel the need to escape the hectic urban life or compensate for things that are lacking in their urban environment. The study also shows that people are influenced by their broader urban environments, for example the ones they commute through daily, not just their immediate neighbourhoods (A2).

Interviewees brought out three main themes that act as drivers behind their leisure travel choices. Firstly, density of the urban fabric and car use. Due to the compact nature of central Reykjavík, residents can choose to live a car-free lifestyle and reap the benefits of compactness of the urban form. On the other hand, going car free could limit domestic travel options as the public transport infrastructure into rural areas is quite poor, and thus people might choose to take leisure trips abroad instead.

Secondly, urban greenness around the home, which was described as 'green enough' but lacking perhaps in its quality and usability, could be a reason for taking leisure trips into nature. Furthermore, having access to and usage of a private garden could play a part in taking fewer domestic trips, but did not seem to have broader implications for international travel as the latter mainly seemed to be connected to people's overall desire to travel abroad and experience new things.

Thirdly, throughout the interviews, several interviewees connected urban living to adjectives like claustrophobic, hectic, tumultuous, stressful, overwhelming. Some interviewees implied the influence of long commutes by car, driving culture and traffic jams as influencing factors, while others mention the general pace of life as a being hectic. In addition, they describe leisure trips outside of the city as a measure of escaping the above-mentioned characteristics of urban life. Therefore, it can be deduced that more so than urban density and lack of greenness, which the compensation hypothesis (e.g. Czepkiewicz et al., 2018a; Holden & Norland, 2005; Næss, 2006; Strandell & Hall, 2015) cites as reasons for people to leave the city, it is hectic urban living and seeking to improve one's wellbeing that drives some of the leisure travel among Reykjavík residents (wellbeing-related associations are discussed further in section 4.3).

This tendency is illustrated here by quotes from interviewees in A2, where the keywords mentioned above are underlined for clarity. For example, one respondent (female, 37) who previously lived in the city centre but had since moved to a more suburban location, described how the change in her environment might have reduced the need to travel:

> *"... there is a lot less stimuli exactly here because I'm just looking at a tree if I look outside [...] if I was in downtown then there would always be stimuli but here, somehow. Yes, it's just... it maybe has minimised the desire [to travel]" (F37)*

Another respondent (female, 29) who had decided to move to the city centre area and give up their car reflected that the change of location makes them feel "claustrophobia" and they would like to escape into nature. However, since giving up their car, it is much more difficult to do so:

> *"It's just about cities, there's something like claustrophobia and an overwhelming feeling that I can't stand. [...] [We travel domestically] a lot less since we sold the car. We used to do it a lot. ... It's expensive to take the bus there. [...] And that's what I miss - just getting outside a little bit, getting some nature, without having to borrow anything or anything like that." (F29)*

A respondent (female, 37) further elaborated on the reasons behind leaving the city for leisure travel as follows:

> *"Umm, most often it's that I want to get away from the... like a tornado, it can be a bit. It's the culture that you always have to be doing something and go somewhere ..." (F37)*

Similarly, another respondent (male, 40) mentioned that the fast-paced lifestyle of urban living is behind why they and other Icelanders like escaping to nature:

> *"I suppose it's just to escape for a bit from the tumult of the city ..., I feel like most Icelanders like getting out into nature a bit..." (M40)*

One respondent (female, 42) connected the hectic living and stressful feeling to commuting related things like bad driving. They felt like getting out of the city offers a much quieter pace of life:

> *"... Reykjavík - it's not a very big city, but people are really stressed. They drive badly and you know, it's like you... you feel it in the air somehow. So as soon as you get out, it's a completely different pace even though you're not exactly having a cottage in the mountain, but just staying in a little village... it's a lot quieter and more calm." (F42)*

A2 showed a multitude of behaviours and attitudes among interviewees that fit in a multitude of travel behaviour theories (such as compensation hypothesis and cosmopolitan attitudes), and did not necessarily challenge them, but rather complement them. A main takeaway, as highlighted at the beginning of this chapter, is that people are influenced by their broader urban environments, not just their immediate ones. This relationship to theories will be discussed in more detail in the discussion section.

Hence, A3 took a novel approach within the Icelandic context by studying people's activity spaces to understand urban mobility habits and patterns. It then connected activity spaces with emissions from and participation in leisure travel to see whether there was a connection between busy urban mobility and leisure travel (A3). Similarly to A1, in A3 there were indications that people who were less mobile in the city, represented by smaller and/or monocentric activity spaces, were more likely to belong to lower socio-economic groups. The study showed that people who travel more locally were also more likely to engage in domestic leisure travel, finding some support for the escape hypothesis (A3). The finding corroborated what the interviews in A2 suggested – hectic, busy urban life can be a push factor for leisure travel. There were clear indications of highly mobile lifestyles, both locally and in long-distance leisure travel, among Reykjavík urbanites (A2, A3).

As for travelling away from the city for leisure, the results showed that higher levels of exposure to green and grey spaces during day-to-day activities is significant in predicting higher long-

distance leisure travel emissions when socio-economic background was included. However, exposure lost its importance when people's underlying attitudes were accounted for (A4). As a continuation of A3, in A4 it could also be seen that high levels of urban mobility can lead to more leisure travel away from the city, reflected in the positive relationship between exposure and leisure travel emissions. Exposure (A4) was calculated based on activity spaces (as done in A3), which reflected local travel, and therefore such an association could be made.

A car-oriented urban form could be what drives the busyness of living in Reykjavík. Namely, by examining people's activity spaces, it could be seen that people living in supposedly well-connected public transport zones or centrally located areas still predominantly use a car and have dispersed activity locations. The study, therefore, pointed to a lack of functioning public transportation and active transport systems in the Reykjavík Capital Area (A3). The city in its form at the time of the study was potentially not meeting the day-to-day transport needs of its residents and not providing efficient alternatives to a car, which in turn could lead to frustration and stress from having to use a car, and as a result could lead to increased leisure travel away from the city (A2, A3). In addition, some interviewees mentioned the social conventions, the expectation to "go somewhere and do something" (A2), which could be another contributor to busyness and the stress that stems from it, but which are unrelated to the urban environment specifically.

5.3. Interactions with the urban environment and wellbeing

In addition to hectic urban living, residents of Reykjavík noted that leisure travel, particularly travel to nature and warmer climates, yields wellbeing benefits for them (A2). Interviewees noted that the greenness of Reykjavík was 'good enough' but emphasised that public green spaces are lacking quality and usability. In A2 it was further argued that if people do not come into contact with the green spaces in their neighbourhood, they do not reap the wellbeing benefits of them to the same extent as people who, for example, use their back yards regularly.

A4 explored exposure to grey and green areas during daily mobility, on the basis of activity spaces calculated in A3, to see how regular contact with the broader urban environment might influence leisure travel emissions and perceived wellbeing. In this study, life satisfaction scales were used as a measure of perceived wellbeing. A positive correlation could be seen between exposure to green spaces and satisfaction with job/studies, sense of achievement and local environment, while a negative correlation was noted with exposure to green spaces and satisfaction with how much free time one has to do what they like (A4). Opposite effect directions could be seen with exposure to grey spaces (A4). For overall life satisfaction, although exposure to green and grey spaces during daily mobility was important, socio-economic background outweighed that effect. The results could therefore be partially explained by background factors like income. The satisfaction categories that exposure was more connected to are also known to be linked to income (job/studies; sense of achievement). It could be that people with higher incomes are already living in a greener residential location and therefore their exposure to green spaces within their activity space is higher in general. Furthermore, income is also linked with working time. Working more can lead to less free time, but more income. People living in wealthier and also greener communities could therefore be less satisfied with the time they have for leisure.

In addition to socio-economic background, low vegetation levels or time of exposure to them being brief during a commute could also have influenced the results (A4). Indeed, during commuting by car, especially as a driver, our attention is elsewhere than on enjoying the scenery (e.g., Stefansdottir et al., 2024; Mouratidis, 2019; Bijker & Sijtsma, 2017). It can be deduced that the wellbeing benefits of exposure to green spaces during daily mobility in the Reykjavík context are limited compared to other socio-economic factors (A4), which draws the attention back to the usability issue related to green spaces which was mentioned in the interviews (A2). For example, when taking the time to use one's garden during leisure time, by truly experiencing it, the benefits could be such that it is relaxing enough for one not to wish to travel outside of the city (A2). One respondent (female, 30) expressed the link between having access to a private garden and travelling for leisure thusly:

> *"Yes, I think it matters less to go someplace else when you've got a nice setup to just be here on the sun deck, or out in the sun." (I11, F30)*

However, in a fast-paced society, such breaks are difficult to take at home as other obligations tend to overshadow them. As indicated in A4, not being satisfied with the amount of free time one has to do things they like could mean that people do not have enough leisure time to spend in green spaces, which results in them having less exposure to green spaces. Furthermore, wellbeing is not only mediated by green exposure, but is also influenced by personality, attitudes, resources and more.

6. Discussion

The thesis has shown the value of using a mixed-methods approach in understanding complex topics such as the relationships between urban environments, travel behaviour and wellbeing. The thesis examined the Nordic country context and showed that travel emissions among Nordic residents exceed recommended levels for meeting the 1.5-degree Celsius global warming limit. A big part of the emissions came from long-distance leisure travel. It was also shown that low climate concern was conducive of higher travel footprints. In a case study setting in Reykjavík, Iceland, it was shown that people's leisure travel behaviour and wellbeing could be influenced by their day-to-day exposure to the broader urban environment. In the following sections, results related to the research questions of the thesis will be discussed (section 6.1). Then, a discussion of broader contributions (section 6.2) and policy implications (section 6.3) of the thesis will be presented. This is followed by an evaluation of the conducted research (section 6.4) and a discussion of future research perspectives (section 6.5).

6.1. Discussion of main results

RQ1: What is the climate impact of personal travel in the Nordics?

With climate change mitigation targets in mind, the thesis raises overall concern about the state of travel emissions in the Nordic countries (A1), which have been hailed as leaders in climate mitigation efforts (Norlén et al., 2024; Greaker et al., 2019). It is established that personal travel-related footprints exceed the threshold levels manifold (A1) and are very high in the global context (e.g., Ivanova et al., 2016; Akenji et al., 2021; IEA, 2018). A large part of the emissions comes from long-distance leisure travel. In Nordic countries, engagement in leisure travel is higher than the European average, as also reported previously (Eurostat, 2023).

Low income was significantly associated to lower emissions in local travel only in Finland when other background factors were controlled for, while high income was significantly positively associated with leisure travel emissions in Iceland, Finland and Denmark. Similar patterns have been noted in prior studies within the same contexts (e.g., Árnadóttir et al., 2019; Czepkiewicz et al., 2019), while other studies note that Nordic residents travel a lot for leisure regardless of income (e.g., Sovacool et al., 2018). At the same time, low income was associated with a lower likelihood of participating in long-distance leisure travel, similarly to other findings (Brand & Preston, 2010). As the study was conducted in the offset of the COVID-19 pandemic and covered people's travel period in the past 12 months to taking the survey, it can be assumed that the overall global situation had an impact on people's travel habits, especially as low and medium-income people are estimated to have been impacted more (Sigurjónsdóttir et al., 2021, Greve et al., 2021, Geranios et al., 2022). There were indications that people who are meeting the threshold levels belong to lower socio-economic groups (A1). Still, it could be seen that people participated in long-distance leisure travel even under the circumstances and that the emissions from it exceeded those from local travel (A1). Even with the travel restrictions in place, the measured footprints greatly exceed recommended threshold levels (A1), which emphasises the need for rapid emissions reduction policies in the travel domain (Bhowmik, 2019).

Although spatial patterns somewhat varied between the Nordic countries, leisure travel emissions are particularly high among residents of urban and semi-urban areas (A1), as has also

been shown in prior studies (e.g., Czepkiewicz et al., 2018a). Local travel emissions were lower in urban areas in Iceland, Denmark and Sweden (A1). Previous studies have also shown the same correlation in both Nordic and Western European contexts (Ottelin et al., 2014; Reichert et al., 2016; Brand & Preston, 2010; Große et al., 2018). At the same time, previous literature has connected higher long-distance leisure travel emissions to urban living (Reichert et al., 2016; Czepkiewicz et al., 2018, 2019, 2020a; Ottelin et al., 2019; Árnadóttir et al., 2019), a connection which could also be seen in Iceland, Denmark and Sweden (A1).

Furthermore, one of the main indicators for high travel footprints in both local and leisure travel is low climate concern (A1), similarly to findings from other studies in similar contexts (Alcock et al., 2017; Árnadóttir et al., 2019, 2021; Aasen et al., 2022; Mouratidis & Næss, 2024). In slight contrast, in one prior study in Iceland it was found that people travel a lot for leisure regardless of climate concern (Czepkiewicz et al., 2019). The negative connection, as found in A1 has also been noted in qualitative studies, which show that internalised knowledge about climate change is a motivator for reducing flying (Jacobson et al., 2020; Wormbs & Wolrath Söderberg, 2021). At the same time, there are people who underestimate the climate impact of flying or justify their flights in other ways which outweigh their climate concern (Higham et al., 2014; Cocolas et al., 2021; Schmidt et al., 2023; Árnadóttir et al., 2021).

RQ2: How do people's interactions with the urban environment affect leisure travel?

A possible link is established between urban environments and leisure travel behaviour that extends beyond the immediate residential environment, thus going beyond the traditional theoretical explanations (A2, A3). As proposed by the compensation hypothesis in prior literature, built environment density, population density along with other deficiencies of the urban environment, like lack of greenness, could be reasons for engaging in more leisure travel away from the urban area (e.g. Czepkiewicz et al., 2018a; Holden & Norland, 2005; Næss, 2006; Strandell & Hall, 2015). The hypothesis particularly pertains to deficiencies of the residential area and neighbourhood, and the resulting escaping behaviour into domestic leisure travel. Qualitative inquiries have indicated that inner-city residents seem to seek nature and calmness (e.g., Czepkiewicz et al., 2020b; Næss, 2006), which was also evident in the interviews in A2. However, quantitative studies on the matter have shown mixed results (Czepkiewicz et al., 2020b; Maat & de Vries, 2006). Higher residential area density and having access to a private yard have been linked to travelling less for leisure (long-distance), but studies have been cautious to attribute the finding to the compensation hypothesis (Czepkiewicz et al., 2020b; Holden & Norland, 2005). Große et al (2019) do not find a substantial connection between satisfaction with one's home or residential location and long-distance leisure travel and suggest that most evidence of the compensation hypothesis relates to domestic trips.

The qualitative results of the thesis suggest similar connections. Namely, having access to a private yard may reduce the desire to travel elsewhere for relaxation, and that if people do want to be in nature for leisure, they will do so within the country (A2). However, respondents related seeking nature and calmness to the hectic and stressful lifestyles in the city beyond their residential location (A2). The finding suggests that an extension to the definition of the compensation hypothesis should be considered. At the same time, density in the Reykjavík Capital Area is relatively low compared to most major cities in the world, which could also have limited the emergence of a density-compensation connection emerging.

With activity spaces, it was possible to map people's daily mobility within the Reykjavík capital area and the areas people are exposed to regularly. Residents of Reykjavík were shown to lead

quite mobile lives in their day-to-day, as reflected in their large polycentric activity spaces (A3). Their mobile urban living was linked to higher likelihoods of engaging in long-distance leisure travel away from the city (A3, A4), as also indicated in the qualitative analysis of interviews (A2). Although exposure to grey and green spaces in local mobility (that is, within one's activity space) was important in predicting higher long-distance leisure travel emissions, it was outweighed by people's attitudes and preferences when it comes to (A4). Reykjavík could also be less green than some other cities, owing to its climatic conditions, which could partially explain the limited influence. In addition, due to its geographical location, winters in Reykjavík are long and dark, which could further reduce the positive impact of the city's greenness.

Interestingly, in studies on the relationships between urban environments and health (a sub-component of wellbeing), such a broader perspective has been suggested before, wherein daily mobility plays a key part in health-related outcomes and thus the interactions between a person and the broader urban environment are relevant (Perchoux et al., 2014; Perchoux et al., 2016). People spend a good amount of time outside of their homes (daily commutes, going to work, running errands), so it can be deduced that, as a result, their attitudes and behaviours are shaped by a broader urban environment than just their residential location. Stressors such as long commutes, traffic jams, inefficient public transport could all influence our travel behaviour both locally (van Wee et al., 2019) and for long-distance leisure travel (A2, A3). Considering that people's attitudes have a significant impact on travel behaviour (van Wee et al., 2019; Árnadóttir et al., 2019), and vice versa (van Wee et al., 2019; Coevering et al., 2016, 2021), urban development can play an important role in guiding travel behaviour. What is more, it is important to recognize that attitudes are not stagnant and can change over time (van Wee et al., 2019), which adds further emphasis on the role of cities and urban development.

RQ3: How do people's interactions with the urban environment affect perceived wellbeing?

Similarly to the results of RQ2, a parallel can be drawn between the broader urban environment and perceived wellbeing via leisure travel, as a person's wellbeing is an important reason behind taking more leisure trips (A2). People indicated that commuting, hectic urban life and not using green spaces are some of the reasons they want to leave the city to unwind (A2). It is worth noting that even in a sparsely built and small city like Reykjavík, strong adjectives like stressful, hectic and claustrophobic are used to describe the urban environment (A2). After examining people's exposure to green and grey spaces during daily mobility, it could be seen that both green and grey space exposure was an important factor in overall life satisfaction, but they had a weaker influence when socio-economic background was accounted for. The results and effect directions found in A4 were similar to those in prior literature. For example, a positive relationship was found between exposure to green spaces and overall life satisfaction (A4; Bakolis et al., 2018; Bonaiuto & Chiozza, 2024; leBrasseur, 2022; White et al., 2013; Zhang et al., 2017).

In addition, prior studies have also noted that the usability of urban green spaces, from public parks to private gardens, is an important factor in them yielding wellbeing benefits (e.g., Zhang et al., 2017; Roe et al., 2013; Neale et al., 2022), as was also indicated within the thesis results (A2, A4). Beyond the direct associations between the urban environment and wellbeing, there were also broader indications of people with lower socio-economic status being less mobile (A3), which can be linked to a lack of opportunities or lack of choice that could in turn affect wellbeing (Sharp et al., 2015; Chen & Akar, 2016; Perchoux et al., 2014). Prior research suggests that investigating urban green spaces can guide researchers in studying happiness

beyond GDP or economic growth (Kwon et al., 2021), indicating that in wealthy countries happiness would be guided more by factors other than wealth. In this thesis the case study was set in Iceland, which has a relatively high GDP, and it was still evident that socio-economic factors have a more important role in wellbeing in the form of life satisfaction than exposure to green spaces.

The thesis highlights the importance of wellbeing in both urban and transportation planning, as wellbeing is an important driver for leisure travel (A2, A4). In addition to satisfaction with life, well-managed transport and urban areas can benefit lower socio-economic groups (A1, A3; IPCC, 2023) who might be at a disadvantage (Sharp et al., 2015; Chen & Akar, 2016; Perchoux et al., 2014). Focusing on low-income and marginalised communities, those most vulnerable to the impacts of climate change, has great potential in increasing wellbeing in urban areas while meeting climate goals (IPCC, 2023).

6.2. Contribution of the thesis

The contributions of the thesis are manifold, from theoretical contributions to practical contributions that can be useful for policymaking and planning.

Two main associations can be deduced from the results of the thesis (Figure 4). First, the negative impacts of the broader environment that negatively impact one's perceived wellbeing, combined with affluence and low climate concern, lead to increased leisure travel, and through it to improved wellbeing. However, in this scenario, improved wellbeing comes at the cost of high emissions (Figure 4-a). On the other hand, we can see that low socio-economic status (or more disadvantaged socio-economic groups) can result in less opportunities and less mobility, which together can have a reverse causal effect and can result in less contact with the broader urban environment, which limits its impact on the individual. As a result, these people are more likely to have lower travel emissions, but possibly also lower perceived wellbeing. In this instance, lower emissions come at the cost of lower wellbeing (Figure 4-b).

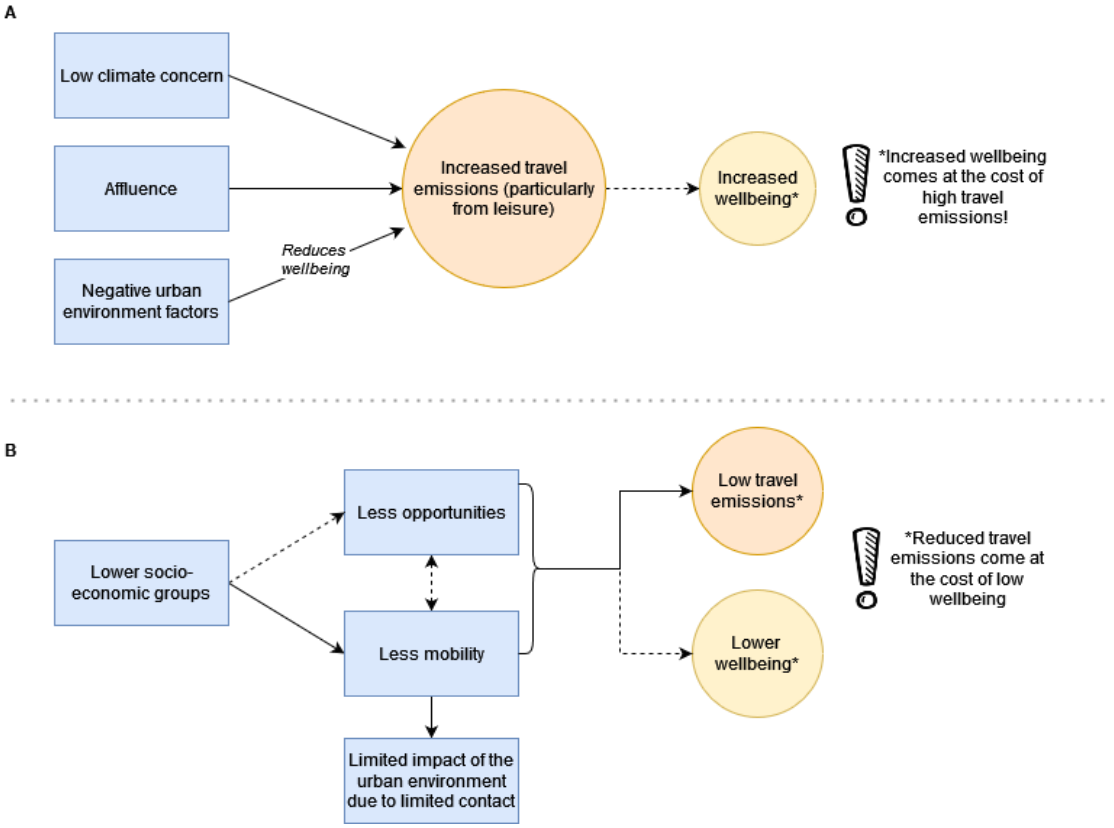

Figure 4. Synthesis of key contributions of the thesis based on results (smooth lines) and theoretical connections (dotted lines).

Secondly, the thesis demonstrates the significance of climate concern in travel emissions. Namely, low climate concern was associated with higher emissions in both local and leisure travel even when background variables like income were controlled for (A1). Several prior studies have discussed the potential of climate concern in relation to reducing flights (e.g., Jacobson et al., 2020; Wormbs & Wolrath Söderberg, 2021) and reducing car use (e.g., Alcock et al., 2017; Mouratidis & Næss, 2024), both of which contribute the most to personal travel emissions (e.g., Ivanova et al., 2016; Akenji et al., 2021; IEA, 2018). The connection discussed in this thesis related to climate concern (A1) seems to point to an emerging key theme in travel emissions studies.

Another contribution of the thesis is the connection to the compensation hypothesis (e.g. Czepkiewicz et al., 2018a; Holden & Norland, 2005; Næss, 2006; Strandell & Hall, 2015). In examining the case of Reykjavík, there were indications that people are influenced by more than their residential neighbourhood (A2, A3). This notion does not challenge the compensation hypothesis, but rather suggests an extension to its definition, which usually does not extend beyond one's residential location (A2). This connection was revealed thanks to the mixed-methods approach applied in the thesis. The use of mixed methods in studies has been called for in several research papers in the field (e.g., Czepkiewicz et al., 2018a; Næss et al., 2019). It should be noted that although thesis focuses on the urban environment related reasons for travel, there are other potential explanations, particularly for international travel, like social networks (e.g., Schmidt et al., 2023; Oswald & Ernst, 2021) or cosmopolitan attitudes (e.g., Czepkiewicz et al., 2020b; Oswald & Ernst, 2021).

Within the mixed methods settings, the thesis also demonstrated the value of studying activity spaces in relation to travel emissions. Keeping in mind the complex nature of the core thesis topic, examining the problem using a 'new' tool or method can provide valuable insights which may have previously not been captured in other ways (Flyvbjerg, 2006), as could be seen within the thesis (A2-A4). The activity spaces method was used to study how the day-to-day mobility and interactions between people and their urban environment might relate to leisure travel participation and emissions, and to perceived wellbeing (A3, A4). Although activity spaces are a well-established method in studying daily mobility (Golledge & Stimson, 1997), they had not been used to study the connection between urban mobility and long-distance leisure travel prior to this thesis (A3). Furthermore, by using activity spaces it was possible to see that while distance to the city centre from the residential location, which is often at the centre of urban environment – travel studies, is only one factor of urban mobility that can affect how people relate to the urban environment. Activity spaces showed that polycentricity of one's urban mobility could be another key factor in understanding the connection between urban mobility and long-distance leisure travel (A3).

6.3. Policy implications

Overall, rapid reductions in travel footprints are needed in the Nordic countries, and policymakers can play a key role in achieving them (Bhowmik, 2019). Although global and regional agreements are necessary in the fight against climate change, local and national contexts are unique, as even among countries with similar backgrounds like the Nordics conditions differ. With the local context in mind, policymakers and urban planners need to consider the source of emissions, travel behaviours and patterns, and attitudes towards travel and climate change. Concentration of pollutants from urban centres offers opportunities for spatially focused mitigation efforts (Crippa et al., 2021). However, planning is only powerful up to a point, as other influencing factors like prices, affluence, social norms, etc have a role to play as well.

Long-distance leisure travel in general should be given more attention, especially in affluent locations where it contributes significantly more to emissions than local travel. In wealthy countries like the Nordics, we are seeing that people living in urban areas might have lower local travel emissions. However, they also have higher leisure travel emissions compared to their rural counterparts. Long-distance leisure travel has a bigger environmental impact than local travel, particularly if done by plane. One of the main motivations behind this travel is wellbeing. But what if urban areas could meet the wellbeing needs of residents? Herein lie many opportunities for improved urban development, starting with good quality, usable urban green spaces. In addition, having free or low-cost opportunities for leisure and social activities around the urban area could invite people to use them, regardless of financial constraints. Walkable and mixed-use neighbourhoods facilitate social interaction, thus growing community interaction and engagement (Leyden, 2003). On top of local level changes such as in urban development, countries could move towards working time reduction and work-from-home policies. Working time reduction has been shown to improve both productivity at work and wellbeing (e.g. Ganster et al., 2018; Neubert et al., 2022), as well as potentially yielding environmental benefits (e.g. Neubert et al., 2022; Nässén & Larsson, 2015). At the same time, there could occur a rebound effect where extra leisure time is spent on taking more leisure trips with higher emissions, although Stopher et al (2017) argue that time does not accumulate over

the working week so that on the weekend people have more leisure time to spend (for example by working a few hours less every day).

It could also be seen from the results of the thesis that low climate concern was one of the key indicators of having higher travel footprints, both locally and for leisure. Hence, policies aimed at increasing awareness among the general population could help reduce travel emissions. The findings in A1, especially within the context of prior literature (Higham et al., 2014; Cocolas et al., 2021; Schmidt et al., 2023; Árnadóttir et al., 2021), emphasise the importance of climate change awareness and education in tackling high travel footprints. This needs to be supported by urban development, with making local travel efficient and accessible to all socio-economic groups. However, if people engage in leisure travel for the sake of their wellbeing, they might conclude that long-distance leisure travel is important for them and they are not willing to sacrifice it for the sake of the planet (Árnadóttir et al., 2021). Furthermore, there should be a consideration for dismantling social norms related to frequent travel, and wellbeing-boosting alternatives to long-distance travel should be supported (Árnadóttir et al., 2021; Schmidt et al., 2023). Walkable and mixed-use neighbourhoods facilitate social interaction, thus growing community interaction and engagement (Leyden, 2003). Furthermore, accessible and efficient public transport in the rural areas could provide opportunities for domestic leisure travel with less emissions. Currently, for example, Icelandic public transport outside of the capital area is lacking in connectivity, speed, convenience and affordability, which is why most people opt for a private car instead.

Our impact on the planet should remain within the sustainable consumption corridor, somewhere between its social floor and environmental ceiling (Dillman et al., 2021b; O'Neill et al., 2018), but unfortunately, it has been estimated that no country has achieved this equilibrium (Infante-Amate et al., 2024). In the Nordics, the situation even goes beyond a 'safe and just' space, as even the lowest income groups exceed climate mitigation threshold levels considerably (Olson et al., 2024; Hansen et al., 2024). The thesis suggests that people in lower socio-economic groups could be limited in their mobility locally and also more likely to meet the climate thresholds for travel emissions, owing largely to less leisure travel, but beyond them the travel footprints are high across the Nordic countries (A1, A3). However, in a recent study by Dillman et al (2023) it has been suggested that Iceland has been close to achieving the 'just' parameter related mobility in the past, although great strides are needed to meet the 'safe' space for sustainable mobility. A big part of the change has to be in the behaviour and attitudes of residents, as a shift to electric mobility has been shown to be not enough for an overall reduction in emissions (Dillman et al., 2021a).

6.4. Evaluation of the research

In this section, the validity and reliability of the thesis will be discussed. Validity is related to the applicability and accuracy of research methods to capture what was intended, while reliability is related to the relation of the results to prior studies and the generalisability of the results (Heale & Twycross, 2015). The author believes that the chosen methods fit the topic of research well, offering new multi-dimensional insights to the core topics, and therefore high validity was reached. The applicability and accuracy of the methods are discussed throughout the section.

A case study approach was deemed appropriate because of the complexity of the core topics featured in the thesis, which are known to be context dependent (Flyvbjerg, 2006; Yin, 1981). Within the broader case setting of the Nordic countries, it is shown even among countries with similar affluence and societal wellbeing, the explanatory factors behind travel footprints do not follow the same patterns throughout (A1). Case studies are also useful tools to examine extreme cases (Flyvbjerg, 2006). In the Nordic context, travel footprints in Iceland were the highest among the five, owing largely to long-distance leisure travel (A1). The findings in A1 were similar to those found in prior studies of the Icelandic context (e.g. Alcock et al., 2017; Árnadóttir et al., 2019; Mouratidis & Næss, 2024), which shows the reliability of the finding and supports a deeper investigation into travel among Icelandic people.

Case studies offer a unique glimpse into a research topic within a set context, helping to analyse the topic from multiple angles and studying complex relationships (Flyvbjerg, 2006; Yin, 1981), which was the purpose of this thesis as well. Indeed, the thesis demonstrates the value of single case studies, as the thesis revealed new links between urban environments and travel behaviour. Ultimately, the aim of a single case study is not necessarily to prove a hypothesis, but rather to challenge existing theories and provide new perspectives (Flyvbjerg, 2006), which was evident in this thesis. The utilised methodology was successful in providing a deeper understanding of the interplay between urban environments, travel behaviour and wellbeing. Future case studies in other countries, which differ in affluence, climate conditions, geography, can increase the generalisability of the results shown here (Eisenhardt & Graebner, 2007).

Mixed methods were applied within the case study. While each of the methods used in the thesis have their own caveats, combining multiple methods within the same case study can minimise the internal impacts of the methods and increase reliability of the results (Migiro & Magangi, 2011; Flyvbjerg, 2006; Almalki, 2016). The thesis used an interactive design and combined quantitative and qualitative research methods, which informed one another throughout and complemented one another (Maxwell & Loomis, 2003; Sale et al., 2002). However, the interactive design within a single case study setting cannot be used for cross-validation of the results (Sale et al., 2002). Instead, the thesis used mixed methods to dive deeper and understand causalities (Næss, 2016, 2018; Maxwell & Loomis, 2003; Smith et al., 2019). For that purpose, the interactive design's dynamic and informative nature helps to analyse complex relationships (Migiro & Magangi, 2011; Maxwell & Loomis, 2003; Almalki, 2016). Prior studies in the field have demonstrated the usability and value of using mixed methods (e.g., Næss, 2016, 2018; Czepkiewicz et al., 2020b). The disadvantages of the individual methods used in the thesis are addressed in the relevant articles and are covered here briefly.

Quantitative research methods within this thesis are used both for measurement and establishing relationships between variables (Maxwell & Loomis, 2003). Validity of quantitative methods lies in external comparability of the results (Maxwell & Loomis, 2003). Multiple linear regression was used in A1 and A3. Multiple linear regression is a useful tool to examine the linear relationship between one dependent and multiple independent variables. However, multiple linear regression requires several assumptions to be met: linearity, homoscedasticity, independence of errors, normality, and independence of independent variables. Firstly, the relationships between two independent variables in emissions studies are not necessarily linear (e.g., the non-linear relationship between CBCF and income, as demonstrated in Heinonen et al., 2022b). Secondly, to meet the assumption of homoscedasticity, variance of the variables was checked, with special emphasis on key variables like emissions and income, and significant outliers were removed. Within that process, the independence of errors and normality assumptions were also checked. However, if a sample is sufficiently large enough, normality

assumption can be omitted according to the Central Limit Theorem (Ross, 2017), as was the case with the samples used in the thesis. Lastly, the independence of independent variables (multicollinearity) was checked using Variance Inflation Factors, where values over 4 were investigated further and/or left out of the regression models (Sheather, 2009). Because of these caveats stemming from the nature of CBCF relationships to other variables, the results (beta values) were interpreted as indications of effect direction, rather than as absolute values.

In terms of results, the calculated travel footprints (A1, A3) were similar to prior estimates within the same context (e.g., Czepkiewicz et al., 2020b; Akenji et al., 2021; Clarke et al., 2017). In addition, the thesis utilised data sets from two different timepoints and saw similar footprints in both with similar distribution patterns (A1, A3), showing cross-validity between the two data sets and calculation methods, showing further validity of the thesis results. Although the reference values used in A1 are retrieved from older estimates (e.g., Chester & Horvath, 2009), emissions factors have not changed much in more recent years (e.g., Bieker, 2021). As with any estimations of climate impact, the accuracy of CBCFs is dependent on granularity of base data (in this case, input from surveys), calculation methods, and reference data/databases. Even with the same survey data and calculation method, different results could be reached by using different reference values for emissions. The results should be taken as an estimation of travel emissions in the Nordics, but not as absolute values (A1). The footprints do not consider work-related travel, nor the climate impact of consumption at travel destinations, which form a big part of the climate impact of travel (e.g., Sharp et al., 2016; Ottelin et al., 2019).

The activity spaces used in A3 were calculated based on self-reported input from the softGIS survey (section 4.3.2), which only offers a snapshot of people's travel habits within the survey collection period. What is more, the data is subject to errors as people might not have mapped their locations with care or accuracy, they might have had difficulty using the survey interface, they might not have remembered all of their trips and frequency of them. Lastly, the individualised home range model (Hasanzadeh et al., 2017) and toolbox (Hasanzadeh, 2018) used calculate the activity spaces likely overestimates the range of one's activity space because it does not consider the underlying route network, does not know the exact paths taken by the respondent and its minimal convex polygon basis will include areas that the respondent might not directly come into contact with. However, the model incorporates frequently visited points (destinations) and mobility patterns like centricity allowing to account for individual-specific variations in spatial behaviour more accurately and flexibly compared to an ellipsoid or minimum convex polygon (Hasanzadeh et al., 2017). Moreover, in A4 these issues are somewhat mitigated by using the individualised residential exposure model which is raster-based and considers the route network, and weighs exposure by mode of transport and trip frequency (Hasanzadeh et al., 2019). Also, although it is more difficult for researchers to obtain, using more aggregated data like GPS or mobile positioning data could offer a more detailed view of mobility, frequently taken routes, and offer longitudinal perspectives (e.g., Ramezani et al., 2021, Järv et al., 2018; Xiong et al., 2022).

Qualitative methods help give meaning and context to quantitative results, but also can help discover unexpected conditions or influences that quantitative methods might not detect (Maxwell & Loomis, 2003; Næss, 2018; Ngumbi & Edward, 2015; Berg & Lune, 2017). The method was relevant for the thesis to provide a deeper understanding of the relationships between travel and urban environments (Leech, 2002; Ngumbi & Edward, 2015), and to better understand the causal relationships which are difficult to capture with purely quantitative studies (e.g., Næss, 2018; Næss et al., 2019; van Wee et al., 2019). Semi-structured face-to-face

interviews were chosen as a method to support the emergence of themes (A2) (Leech, 2002; Berg, 2009; Berg & Lune, 2017; Waller et al., 2016; Ngumbi & Edward, 2015), which were then used to inform further quantitative investigations (A3, A4) (Maxwell & Loomis, 2003).

The validity of qualitative methods lies in the transferability of results to other contexts, and the possibility of generalising the theoretical implications of the results (Maxwell & Loomis, 2003). The qualitative results within this thesis showed some theoretical implications, namely in the form of expanding the definition of the compensation or escape hypothesis (A2). Although the interviews can tell us about the perspective of only a few individuals compared to the whole population (Galvin, 2015), they revealed the notion that the influence of the urban environment on travel goes beyond one's residential neighbourhood (A2, A3). The result does not necessarily challenge the compensation hypothesis but implies that a possible extension of its definition should be considered (A2). To minimise the risk of misinterpretation (Leech, 2002) and increase reliability of the results, a two-step interpretation process involving multiple researchers was used, following the example of Næss (2018). The thesis demonstrates the value of using in-depth interviews. Although the results presented in this thesis are based on a single case study, repeating similar studies in different contexts could improve the generalizability of the implications mentioned here (Eisenhardt & Graebner, 2007).

Last but not least, consideration needs to be given to the data. The thesis two data sets with their own unique caveats related to data collection methods, data quality and time period. The Sustainable Reykjavík Capital Region survey (section 4.3.2) was collected in 2017-2018, plus interviews within the same sample (section 4.3.3) followed in 2019-2020. The estimates of emissions from that time are slightly outdated. What is more, the data collection involved young adults aged 25-40, which offers only a snippet of the population. However, in A1, which was done using a newer data set, it could be seen that although older people engage in leisure travel more, young people have higher footprints in the leisure travel domain compared to people aged 65+. Young people also had higher footprints in local travel. This supports the in-depth analysis of younger adults in Reykjavík within the single case study, as they are somewhat more mobile in terms of emissions than older adults, although older adults might take trips more frequently but for shorter distances. Similarly, the dataset offers a glimpse of mobility patterns and activity locations in the 2017-2018 urban environment. However, in recent years, urban development has rapidly increased in the Reykjavík Capital area. That said, the majority of local travel is still done by car and public transport is still lacking (A1).

The interviewees for the semi-structures interview data set were gathered using an opt-in method from the prior survey. Although in selecting who to invite specifically for an interview, consideration was given to representativeness across varying residential locations and transport zones in the city of Reykjavík, it is likely that those who opted in for further research are also those who want to air their concerns, rather than those who are just satisfied with their environments.

The 1.5-degree compatible lifestyles survey was more recent, conducted in 2021-2022. However, in the survey, people were asked about their travel behaviour over the prior 12 months to filling out the survey. This means there is considerable overlap with the collection period and the offset of the COVID-19 pandemic and its restrictions on travel. On the other hand, A1 shows that despite these travel restrictions being in place, people's travel footprints still exceed recommended threshold levels, which still supports the call to action on reducing travel emissions. Furthermore, the survey did not aim to be representative for all the Nordic countries

and age groups, but rather to gather a large enough number of quality responses across the five countries and increase the likelihood of capturing extreme footprints on both ends of the scale.

6.5. Future research perspectives

There are several avenues for future research. While the below is not a comprehensive listing, it aims to highlight some of those avenues that could be explored in future studies based on the takeaways from this thesis. Similar in-depth qualitative studies could be conducted, with a special focus on collecting information about specific long-distance trips, their purpose, etc. Travel diaries could be used for more detailed data collection on trips.

Using softGIS or PPGIS datasets has its merits, such as accessibility to researchers, the ability to gather background information about the person, and to ask questions pertaining to their habits. Yet more aggregated data sets, like GPS or mobile positioning data, could provide a more detailed picture of urban mobility. Data like that would also help understand temporal changes, such as weekly or seasonal differences in mobility (Järv et al., 2014). Furthermore, longitudinal studies could be valuable, as attitudes and behaviours change over time (van Wee et al., 2019). It would also be valuable to collect a new data set using softGIS methods to see how travel patterns have now settled after the COVID-19 pandemic.

Studies into the barriers for change in travel behaviour could provide valuable insights. Both qualitative (e.g. focus group interviews) and quantitative perspectives could be useful. Inquiries should be made into internal and external barriers in changing travel behaviour, drivers behind current travel choices, willingness to change, etc. Furthermore, it could be useful to understand political orientation and how that relates to travel emissions, as people's voting decisions and orientation on a political scale can have a big impact on the future climate policies.

In the thesis, indications emerged that lower socio-economic groups could be limited in their mobility and at the same time are more likely to meet climate targets. It would be interesting to map how people for example with low income are making their financial limitations work for them, is their mobility meeting their needs, what choices they are making and why. In addition, studies could specifically examine people who have decided not to fly and why they have chosen to do so. Future studies could also include scenario modelling within the 1.5-degree Celsius global warming limits and include combinations of behavioural changes and technological improvements.

7. References

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Appendix

This appendix features four articles that form the basis of the dissertation, listed in the order shown below.

Article 1 (A1)

Raudsepp, J., Czepkiewicz, M., Heinonen, J., & Árnadóttir, Á. (2024). Travel footprints in the nordics. Environmental Research Communications, 6(9), 095002. https://doi.org/10.1088/2515-7620/ad718d

Article 2 (A2)

Raudsepp, J., Árnadóttir, Á., Czepkiewicz, M., & Heinonen, J. (2021). Long-Distance Travel and the Urban Environment: Results from a Qualitative Study in Reykjavík. Urban Planning, 6(2), Article 2. https://doi.org/10.17645/up.v6i2.3989

Article 3 (A3)

Raudsepp, J., Thorbjörnsson, K. M., Hasanzadeh, K., Czepkiewicz, M., Árnadóttir, Á., & Heinonen, J. (2025). Activity spaces and leisure travel emissions: A case study in Reykjavík, Iceland. Travel Behaviour and Society, 38, 100896. https://doi.org/10.1016/j.tbs.2024.100896

Article 4 (A4)

Raudsepp, J., Hasanzadeh, K., Árnadóttir, Á., Heinonen, J., & Czepkiewicz, M. (2024). Does Higher Exposure to Green Spaces Lead to Higher Life Satisfaction and Less Leisure Travel? A Case Study of Reykjavík, Iceland. Urban Science, 8(4), Article 4. https://doi.org/10.3390/urbansci8040236