Department of Built Environment

Urban sustainability? The spatial disparities of greenhouse gas emissions and subjective wellbeing

Sanna Ala-Mantila

Aalto University
UNIVERSITY OF ICELAND
DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 85/2017

Urban sustainability? The spatial disparities of greenhouse gas emissions and subjective wellbeing

Sanna Ala-Mantila

A doctoral dissertation completed for the degree of Doctor of Science (Technology) to be defended, with the permission of the Aalto University School of Engineering, at a public examination held at the lecture hall A2 of the school on 19 May 2017 at 12.

This doctoral dissertation is conducted under a convention for the joint supervision of dissertation at Aalto University, Department of Built Environment and University of Iceland, Faculty of Civil and Environmental Engineering.

University of Iceland
School of Engineering and Natural Sciences
Faculty of Civil and Environmental Engineering

Aalto University
School of Engineering
Department of Built Environment
Real Estate Business

Supervising professors
Professor Seppo Junnila, Aalto University, Finland
Professor Jukka Heinonen, University of Iceland, Iceland

PhD committee (University of Iceland)
Professor Jukka Heinonen (chair)
Guðmundur Freyr Úlfarsson
Professor Seppo Junnila (Aalto)

Preliminary examiners
Associate Professor Thomas Wiedmann, UNSW, Australia
Assistant Professor David Wachsmut, McGill, Canada

Opponent
Dr. Sylvia Lorek, SERI Deutschland e.V., Germany

Aalto University publication series
DOCTORAL DISSERTATIONS 85/2017

ISBN 978-952-60-7416-0 (printed)
ISBN 978-952-60-7415-3 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-60-7415-3

Unigrafia Oy
Helsinki 2017

Finland

441 697
Printed matter

Author
Sanna Ala-Mantila

Name of the doctoral dissertation
Urban sustainability? The spatial disparities of greenhouse gas emissions and subjective wellbeing

Publisher School of Engineering

Unit Department of Built Environment

Series Aalto University publication series DOCTORAL DISSERTATIONS 85/2017

Field of research Real Estate Business

Manuscript submitted 24 April 2017 **Date of the defence** 19 May 2017

Permission to publish granted (date) 12 April 2017 **Language** English

☐ **Monograph** ☒ **Article dissertation** ☐ **Essay dissertation**

Abstract

Cities are engines of growth and productivity. In addition, great expectations are set upon these agglomerations to contribute to development that meets the needs of the present without compromising the ability of future generations to meet their own. Indeed, mainstreaming of sustainability in planning and policy making is inevitable when reflected the current and projected pace of urbanization. However, the widely held association between sustainability and density of urban structure is not well-grounded in the existing empirical evidence.

This dissertation studies the relationship between urbanization and sustainability from the aspects of environmental and social sustainability. The knowledge about the environmental sustainability is contributed by studying the relationship between urbanity and direct and indirect consumption-based carbon footprints, both together and separately. And the relationships between urbanity and social sustainability are studied using two measures of subjective well-being, namely, happiness and quality of life. The main contribution is to show that just a limited set of measures is sufficient to reveal discrepancies within and between the studied sustainability measures. In addition, a framework of urban sustainability and multiple related factors is constructed to visualize the complexity of the concept. Finally, it is argued that urban sustainability should be understood as a contested concept, inevitably characterized by trade-offs and discrepancies. In other words, there seems to be no unambiguous urbanization gradient in sustainability.

The contribution of the dissertation is two-fold. First, it provides empirical evidence about the relationships between urbanity and the specific measures studied, using a high-quality data at disaggregated individual or household level. Second, it criticizes the shallow grounds of many urban sustainability statements by showing the limited power of the degree of urbanity, and even more so, the limited leverage of urban policies in determining sustainability outcomes. Even though transportation and housing choices of the residents can be influenced to some extent, urbanization is a multidimensional and multi-locational process related to deep reaching socioeconomic changes that are harder to influence. The conclusions of the dissertation call for keeping in mind the wide scope of urbanization, setting the power of planning to its proportion, and moving towards more human-centric approach to urban planning. The aim is not to dispute the importance of sustainable urbanization, but to underscore its complex nature and call for more ambitious urban sustainability policies that are more than rhetoric based on overoptimistic assumptions.

Keywords urbanization, environmental sustainability, social sustainability, GHG emissions, subjective wellbeing

ISBN (printed) 978-952-60-7416-0 **ISBN (pdf)** 978-952-60-7415-3

ISSN-L 1799-4934 **ISSN (printed)** 1799-4934 **ISSN (pdf)** 1799-4942

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2017

Pages 154 **urn** http://urn.fi/URN:ISBN:978-952-60-7415-3

Tekijä
Sanna Ala-Mantila

Väitöskirjan nimi
Kestävät kaupungit? Alueelliset erot kasvihuonekaasupäästöissä ja koetussa hyvinvoinnissa

Julkaisija Insinööritieteiden korkeakoulu

Yksikkö Rakennetun ympäristön laitos

Sarja Aalto University publication series DOCTORAL DISSERTATIONS 85/2017

Tutkimusala Kiinteistöliiketoiminta

Käsikirjoituksen pvm 24.04.2017 **Väitöspäivä** 19.05.2017

Julkaisuluvan myöntämispäivä 12.04.2017 **Kieli** Englanti

☐ **Monografia** ☒ **Artikkeliväitöskirja** ☐ **Esseeväitöskirja**

Tiivistelmä

Kaupungit ovat taloudellisen kasvun ja toimeliaisuuden moottoreita. Tämän roolin lisäksi kaupunkeihin kohdistuu suuria odotuksia myös kestävän kehityksen ajureina. Kestävyyskeskustelun yleistyminen kaupunkisuunnittelussa ja -politiikassa onkin välttämätöntä, kun huomioidaan nykyinen ja tuleva urbaanien alueiden väestönkasvu. Kaupunkisuunnittelussa kestävyyden tavoittelu on kuitenkin kilpistynyt yksinkertaistettuun yhteyteen kestävyyden ja tiiveyden välillä, vaikka ristiriidatonta empiiristä näyttöä tällaisen yhteyden olemassaolosta ei ole.

Väitöskirja pureutuu suhteeseen kaupunkimaisuuden ja kestävyyden välillä niin ekologisen kuin sosiaalisenkin kestävyyden näkökulmasta. Ekologista näkökulmaa lähestytään tutkimalla suhdetta kaupunkimaisuuden ja hiilijalanjälkien välillä, ja sosiaalista kestävyyttä lähestytään subjektiivisen hyvinvoinnin näkökulmasta. Hiilijalanjälkiä tutkitaan kulutusperustaisesti eli myös kulutukseen sitoutuneet epäsuorat päästöt huomioiden. Hyvinvointia taas mitataan kokemusperäisillä arvioilla onnellisuudesta ja elämänlaadusta. Väitöskirjan pääansiona on tuoda esiin, että jo verrattain suppealla tarkastelulla saadaan esiin ristiriitoja niin kestävyyden mittareiden sisällä kuin niiden välillä. Tämän lisäksi työssä esitetään kaupunkikestävyyden kompleksisuutta kuvaava viitekehys. Väitöskirjassa todetaan, että kestävä kaupungistuminen tulisi ymmärtää kiisteltynä käsitteenä, joka on lähtökohtaisesti ristiriitainen ja kompromissien värittämä.

Väitöskirjan ansiot voidaan jakaa kahteen luokkaan. Ensinnäkin, artikkeleissa tutkitaan valittujen kestävyyden mittareiden ja kaupunkimaisuuden empiiristä suhdetta aiempaa tarkemmalla tavalla ja laadukasta aineistoa hyödyntäen. Toiseksi, tiivistelmäosio tuo esiin, että kaupunkimaisuus on riittämätön perusta kestävyyskannanotoille jo senkin takia, että kaupunkitason toimenpiteiden vipuvaikutus on usein hyvin rajallinen ja rajoittuu lähinnä liikkumis- ja asumisvalintoihin. Vaikka kaupungistumisen monimutkaisuus on melko laajalti hyväksytty, vaikuttaa ymmärrys kestävän kaupungistumisten kompleksisuudesta olevan vähemmän laajalle levinnyt. Kaupunkirakenteellisten tekijöiden vaikutusmahdollisuuksiin tulisikin suhtautua realistisesti, ja esimerkiksi kotitalous- ja yksilötason tekijöihin tulisi kiinnittää suunnittelussa suurempaa huomioita. Väitöskirjan tavoitteena ei ole kiistää kestävän kaupungistumisen tarvetta vaan varmistaa, että ponnistelut sen saavuttamiseksi eivät perustu pelkkään toiveajatteluun.

Avainsanat kaupungistuminen, ekologinen kestävyys, sosiaalinen kestävyys, kasvihuonekaasupäästöt, koettu hyvinvointi

ISBN (painettu) 978-952-60-7416-0 **ISBN (pdf)** 978-952-60-7415-3

ISSN-L 1799-4934 **ISSN (painettu)** 1799-4934 **ISSN (pdf)** 1799-4942

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2017

Sivumäärä 154 **urn** http://urn.fi/URN:ISBN:978-952-60-7415-3

Aalto University

Útdráttur

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Höfundur
Sanna Ala-Mantila

Heiti doktorsritgerðar
Sjálfbær byggð? Staðbundið misræmi á losun gróðurhúsalofttegunda og huglægrar vellíðunar.

Útgefandi Verkfræðisvið

Svið Fasteigna-, skipulags- og landupplýsingadeild

Ritröð Útgáfurit Aalto-háskólans – DOKTORSRITGERÐIR /2017

Rannsóknasvið Fasteignaviðskipti

Handrit lagt fram þann 24.04.2017 **Dagsetning doktorsvarnar** 19.5.2017

Heimild til birtingar (dagsetning) 12.4.2017 **Tungumál** Enska

☐ **Sérrit** ☒ **Doktorsritgerð úr fræðigreinum (samantekt + upprunalegar fræðigreinar)**

Útdráttur

Borgir eru afl vaxtar og framleiðni. Miklar væntingar eru gerðar til byggðaakjarna um að stuðla að framþróun sem uppfyllir þarfir nútímans án þess að fórna möguleikum framtíðar. Það er því óumflýjanlegt að sjálfbærnimarkmið í skipulagsáætlunum séu almenns eðlis og taki mið af núverandi og áætluðum vaxtarhraða byggðar í framtíðinni. Hins vegar eru víðteknar hugmyndir um tengsl sjálfbærni og þéttingar byggðar ekki byggðar á nægilega vel ígrunduðum rökum í niðurstöðum rannsókna fram að þessu.

Þessi doktorsritgerð kannar sambandið á milli byggðaþróunar og sjálfbærni með tilliti til umhverfis- og félagslegra þátta. Umhverfisleg sjálfbærni er könnuð með því að rannsaka tengsl þéttbýliseinkenna við bein og óbein kolefnisspor neyslumynstra, bæði saman og í sitt hvoru lagi. Tengsl þéttbýliseinkenna við félagslega sjálfbærni eru rannsökuð með tveimur mælikvörðum huglægrar vellíðunar, þ.e. hamingju og lífsgæðum. Helsta framlag ritgerðarinnar er að sýna að aðeins þarf fáa mælikvarða til að sýna misræmi innan og milli þegar rannsakaðra mælikvarða um sjálfbærni. Einnig er sett fram myndræn lýsing á venslum sjálfbærni og tengdra þátta til að lýsa því hve hugtakið um sjálfbæra byggð er flókið. Að lokum eru færð rök fyrir því að skilja þarf sjálfbæra byggð sem umdeilt hugtak þar sem sífellt togast á kostir og gallar og ekkert einhlítt svar er til.

Framlag ritgerðarinnar skiptist í grunninn í tvennt. Í fyrsta lagi veitir ritgerðin rannsóknarniðurstöður um samband byggðar og sjálfbærnimælikvarðana sem kannaðir eru með ítarlegum og góðum gögnum um einstaklinga og heimili. Í öðru lagi gagnrýnir ritgerðin grunnhyggnar fullyrðingar um sjálfbæra byggð með því að sýna lítil áhrif þátt staðsetningar og sérstaklega lítil áhrif þéttleika byggðar á breytingar í átt að sjálfbærni. Þrátt fyrir að samgöngur og húsnæðisval íbúa verði fyrir einhverjum áhrifum af slíkum stefnum, þá er byggðaþróun margvítt og landfræðilega dreift ferli sem tengist félagshagrænum breytingum sem erfiðara er að hafa áhrif á. Ritgerðin kallar eftir því að tekið sé tillit til hins víða áhrifasviðs byggðaþróunar, að byggðaskipulagi sé beytt í hlutfallselegu samræmi við áhrif þess og að það taki aukið tillit til mannlegra þátta. Ritgerðin dregur ekki úr mikilvægi sjálfbærnihugsunar við byggðarskipulag heldur bendir á hve flókið viðfangsefnið er. Það er þörf á mun metnaðarfyllri sjálfbærniaðgerðum og stefnumörkun sem er ekki bara orðræða byggð á of bjartsýnum forsendum.

Lykilorð byggðaþróun, sjálfbært umhverfi, félagsleg sjálfbærni, losun gróðurhúsalofttegunda, huglæg vellíðan

ISBN (prentað eintak) 978-952-60-7416-0 **ISBN (pdf)** 978-952-60-7415-3

ISSN-L 1799-4934 **ISSN (printed)** 1799-4934 **ISSN (pdf)** 1799-4942

Útgáfustaður Helsinki **Prentstaður** Helsinki **Ár** 2017

Blaðsíðufjöldi 154 **urn** http://urn.fi/URN:ISBN:978-952-60-7415-3

Acknowledgements

I have always been the one to immerse myself into things I'm currently into. Thus, being in academia has been an enjoyable ride, and my gratitude goes to everyone involved.

Firstly, I want to thank my supervisors, professor Seppo Junnila and professor Jukka Heinonen. Seppo, you have been an encouraging supervisor. Even though, and perhaps just because, we do not always agree on everything, you sure have pushed me to express myself clearer and more confident. I also respect how you have contributed to creating the genial atmosphere in our research group. Jukka, I find your drive in following the literature and determination in the academic career in general, inspiring. I'm thankful for not only on your relevant and useful comments on my work, but also for all the fun times and conversations we have had.

I want to thank my pre-examiners, Associate Professors Thomas Wiedmann, and Assistant Professor David Wachsmuth for their insightful comments, which greatly improved the dissertation. I also wish to thank Dr. Sylvia Lorek for agreeing to act as my opponent.

I also cherish the research group and colleagues with whom I have spent a large share of my time with during the past years. When I first came around, I had my desk next to Eeva and she still, luckily, entertains me on a weekly basis. Special mention goes also to Riikka, who proofread and commented my dissertation. I also want to thank Juudit, who has been my co-author and an important coversation partner. I have had a pleasure of working and co-authoring with Perttu Saarsalmi, Michał Czepkiewicz, professor Marketta Kyttä, Kamyar Hasanzadeh, Dr. Jouni Juntunen and professor of practice Mikko Jalas. In addition, warm thanks to professor Guðmundur Freyr Úlfarsson for the unique possibility to complete a double degree. Finally, well reserved thanks goes to the administration of our department, your support has been essential especially for an absent-minded (non-professor) like me.

Besides the good people I have met in and around academia, I'm also thankful for all other extraordinary people in my life. Mia has been the longest around, and I'm happy that our two-woman production team for both surreal and real-life drama has never lost its stamina. In addition, the gangs from uni and well as from yke deserve a special mention. I also want thank my friend Heidi, in particular for all the academic related pondering we have had. And thanks goes also to Anna, my partner in crime in all kinds of clubs and teams one can come up with.

Finally, the most thankful I'm for my family. To my sweetheart Joona, who is the newest addition to the people I'm blessed to consider as a part of my family. Thank you for being so persistent with me. And thanks for all the hustling to Minna, who I know to always have my back. And above all, to mom and dad, for teaching me everything that matters the most, and for your continuous support and love. I love you.

Tikkurila, 25 April 2017
Sanna

“Gathering is peculiar, because you see nothing but what you're looking for. If you're picking raspberries, you see only what's red, and if you're looking for bones you see only the white. “

— Tove Jansson, The Summer Book

Contents

List of Publications

This doctoral dissertation consists of a summary and of the following publications which are referred to in the text by their roman numerals

I. Ala-Mantila, Sanna; Heinonen, Jukka and Junnila, Seppo. 2014. Relationship between urbanization, direct and indirect greenhouse gas emissions, and expenditures: A multivariate analysis. *Ecological Economics*, 104, 129–139.

II. Ala-Mantila, Sanna; Heinonen, Jukka and Junnila, Seppo. 2013. Greenhouse gas implications of urban sprawl in the Helsinki metropolitan area. *Sustainability*, 5(10), 4461–4478.

III. Ala-Mantila, Sanna; Ottelin, Juudit; Heinonen, Jukka and Junnila, Seppo. 2016. To each their own? The greenhouse gas impacts of intra-household sharing in different urban zones. *Journal of Cleaner Production*, 135, 356–367.

IV. Ala-Mantila, Sanna; Heinonen, Jukka; Junnila, Seppo and Saarsalmi, Perttu. 2017. Spatial nature of urban well-being. Submitted for consideration for publication to *Regional Studies*, published by Taylor & Francis, on 24 August 2016.

Author's Contribution

Publication 1: Relationship between urbanization, direct and indirect greenhouse gas emissions, and expenditures: A multivariate analysis

The author is responsible for initiating, executing and writing the paper. The co-authors provided advice, comments and suggestions.

Publication 2: Greenhouse gas implications of urban sprawl in the Helsinki metropolitan area

The author is responsible for initiating, executing and writing the paper. The co-authors provided advice, comments and suggestions.

Publication 3: To each their own? The greenhouse gas impacts of intra-household sharing in different urban zones

The author is responsible for initiating, executing and writing the paper. The second co-author, Mrs. Ottelin, was responsible for the construction of the carbon footprint model used in the study and wrote the parts of the paper that describe the model. In addition, all co-authors provided advice, comments and suggestions.

Publication 4: Spatial nature of urban wellbeing

The author is responsible for initiating, executing and writing the paper. The co-authors provided advice, comments and suggestions.

1. Introduction

We are living in the Century of the City (Seto et al., 2010). Cities are agglomerations of firms, people, ideas, and wealth, and economic growth, productivity, investments and innovation flourish in these gatherings (Fujita & Thisse, 1996; Duranton & Puga, 2004; Bettencourt et al., 2007; Puga, 2010). The greatness of cities is often attributed to the localization economies, i.e. positive externalities following from the greater variety and degree of economic activity nearby (Rosenthal & Strange, 2001; Glaeser & Gottlieb, 2009). City size per se has also been connected with higher productivity, sometimes referred to as the urbanization economies (Ciccone & Hall, 1996). The degree of urbanization seems to be highly correlated with a nation's income level also on a macro level (Bloom, Canning & Fink, 2008). Physical proximity in dense urban areas facilitates the production of knowledge by increasing the amount of interaction and face-to-face contacts (Storper & Venables, 2004). Indeed, a stream of literature highlights the role of skills, and it is argued that greatness of cities stems from the concentration of highly educated individuals and creative occupations (Florida, Mellander & Stolarick, 2008). However, urbanization also has negative externalities, such as habitat loss and alteration (McDonald et al., 2008), local air pollution, traffic, noise, congestion, and crime (Glaeser, Kolko & Saiz, 2001). Moreover, social problems, such as the rise of inequality (Baum-Snow and Pavan, 2013; Baum-Snow, Freedman & Pavan, 2014) has been named as a challenge of urbanization.

In addition to serving as the engines of growth, cities have a role in the search for sustainability: in other words, development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). The search has been going on for almost three decades, with the political momentum starting in the Rio summit in 1992, where the sustainable development action plan called Agenda 21 was launched (UN, 1992). Cities have had a role from the beginning, and at the same time, the concept of sustainable consumption have gained attention both at the policy level as well as in academia (Schrader & Thøgersen, 2011). In Agenda 21, the responsibility of the affluent consumers and the role of cities were seen as being intertwined, and it was argued that "in industrialized countries, the consumption patterns of cities are severely stressing the global ecosystem", and comprehensive approaches to planning were called for (UN, 1992). One of the most recent and ambitious examples of the global sustainability endeavors are the UN's Sustainable Development Goals (SDGs) (UN, 2015), which stress the possibilities rather than the challenges of the cities-sustainability nexus. SDG 11 calls for making cities and human settlements inclusive, safe, resilient and sustainable, and its subgoal stresses enhancing inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management (UN, 2015).

Mainstreaming of sustainability in planning and policy making (Connelly, 2007) is necessary considering the 3 billion additional urban dwellers the world is expected to have by 2050 (UN, 2015). The scale ensures that sustainability cannot be achieved without consideration of urban areas and urban dwellers. Indeed, cities and metropolises have been argued to be the primary agents of change in a resource- and carbon-constraint world (Rauland & Newman 2015), or as Hoornweeg et al. (2011) put it, the athletes that are even more important than national governments. This is also apparent in the vigorous discussions about the role of cities taking place under many names, such as urban metabolism, smart cities, sustainable cities, and urban self-sufficiency (Weisz & Steinberger, 2010). The confidence in local scales and decentralized actions as the most appropriate to reflect population-environment relationships (e.g. Curran & de Sherbinin, 2004) is materialized into hundreds of local and regional sustainability strategies. For example, the Covenant of Mayors, a voluntary policy initiative that canopies 160 million residents under its roof, pursues offering residents a "high quality of life in sustainable, climate-resilient and vibrant cities (CoM, 2016)".

However, the world is increasingly interconnected, and similarly, the grand challenges are shared, even if the emphasis might be different in different places. The fact that sustainability issues are at the same time global and local, as well as complex, interlinked, and transboundary makes others more critical about the actual impacts of a plethora of local -level strategies. Cities are not independent entities, yet to grow, or simply to maintain their status quo, they necessarily appropriate large quantities of useful energy and material from the ecosphere, i.e. are dependent on other areas of the same country, or from other countries (Rees & Wackernagel, 2008). Furthermore, the influence of cities is more or less limited to within their physical boundaries, and within these boundaries, urban planning is the main way of influencing how residents live, move, and locate. In recent decades, sustainability has become an overarching goal in planning, combined with the widely-held association between sustainability and the density of urban development (Bramley & Power, 2009). In this combination, the concentration of urban dwellers is often regarded as the key determinant of cities' sustainability (Jenks et al., 1997; Williams et al., 2000). The narrowing down of the current compact city -planning paradigm to mean high-density, potential sustainability trade-offs, with gains in one sustainability dimension accompanied by a loss in another (Westerink et al., 2013) tend to be forgotten or neglected. Furthermore, urbanization is a complex socionatural process, whereas the city is a site, which is one outcome, though not the only one, of that process (Angelo & Wachsmuth, 2015).

This dissertation aims to fill the gaps in knowledge about the relationship between urbanity and sustainability by studying whether more urban living is more sustainable than living in less urbanized built environments. The existing empirical evidence on the connection between sustainable development and compact cities is inconclusive, and the methodologies used to assess the possible relationship are varied and sometimes problematic (Neuman, 2005). This dissertation questions the grounds of the simplest urban sustainability associations by demonstrating how the complexity of urban sustainability can be demonstrated even by using only two measures of sustainability. The two measures used are carbon footprint, i.e. consumption-based GHG emissions for environmental sustainability, and subjective wellbeing (SWB) for social sustainability. First, the research contributes to knowledge about environmental sustainability by studying the relationship between urbanity and direct and indirect carbon footprints, both together and separately. Secondly, the dissertation approaches social sustainabil-

ity by studying the relationship between various spatial variables and subjective wellbeing, using measures of happiness and quality of life. However, it is important to notice that the selected measures are not the only suitable, or in themselves sufficient, measures for assessing the phenomena. Overall, the presented results from both the realms of environmental and social sustainability demonstrate the discrepancies both within and between the selected sustainability measures, and bring out the complex nature of urban sustainability by using empirical results.

1.1 Research question and research objectives

The overarching theme of this dissertation is to study urban sustainability from the aspects of environmental and social sustainability. More specifically, the dissertation provides empirical evidence on the current situation. The research question (RQ) of the dissertation is as follows:

> Is there an urbanization gradient in sustainability when measured by means of carbon footprints and subjective wellbeing?

The urbanization gradient refers to a difference between more and less urbanized environment, e.g., comparing rural to urban, or sub-urban to central urban. The research approach is quantitative, although the results are also analyzed qualitatively. The scope is limited to environmental and social sustainability, as those two are less studied than the economic aspect of sustainability, and there is no shared understanding of the relationship between the urban structure and the two. The measures of environmental and social sustainability – consumption-based emissions and subjective wellbeing – were chosen since they are emerging sustainability perspectives that both have a very comprehensive and holistic viewpoint. The set of measures is limited though sufficient for the purpose of demonstrating the complexity of the relationships between urban structures and sustainability measures. The selected measures of environmental and social sustainability are not argued to be commensurable, is as that is more normative question left for the reader, or to the policy maker. Likewise, no an all-encompassing index of "urban sustainability" is constructed. In other words, a bottom-up approach is used – the emergence of the theoretical idea about the complexity urban sustainability is legitimized using these empirical measures. In addition to urban structures, other variables and phenomena, such as affluence and household size, which are as important, or are even more important to sustainability outcomes, are identified.

The dissertation answers the research question by means of the following steps:

> i. Statistical analysis of the empirical relationship between consumption-based emissions, urbanity and other relevant variables.
> ii. Statistical analysis of the empirical relationship between subjective wellbeing, urban zone and other relevant variables.
> iii. Compiling a framework for visualizing the complexity of urban sustainability

The dissertation addresses certain sustainability statements somewhat critically, but the purpose is not to dispute the sustainability concept itself. Vica versa, sustainability is seen as such an important and urgent aim that it deserves even critical examination, especially when reflecting its frequent use in policy making. The results from the first two research steps are used

as a window for step three, which addresses the complexity of the concept of urban sustainability. The justification for selecting the measures, i.e. consumption-based GHG emissions and subjective wellbeing, to represent sustainability is organized into the following subsections. Furthermore, the subsections point out gaps in the existing literature regarding the relationship between these and the built environment.

1.1.1 Climate change and urbanity

Climate change has been argued to be the main driver of the sustainability discussion in the built environment (Brandon & Lombardi, 2010). Indeed, it is currently the most pressing problem of environmental sustainability (Allen et al., 2014). It is profoundly global since it affects all nations, as well as natural systems and other units not following the borders of cities or nation states. Drastic actions are called for, as we have already exceeded, or are about to exceed, our planetary boundaries and safety limits of operation (Rockström et al., 2009; Steffen et al., 2015).

Concentrating on climate change impacts is also relevant because cities have been active in climate change mitigation and adaptation, inspiring Lutsey and Sperling (2008) to even argue that in the USA, local- and state-level incentives have overcome the commons problem of climate change. Recent examples of ambitious climate policies include a city-level carbon tax and cap-and trade (Fercovic & Gulati 2016) and the Covenant of Mayors movement (CoM, 2016). However, it has been argued that such spatially limited systems are problematic and might just reallocate the emissions elsewhere, especially when there are also other policies in force (Braathen, 2011).

The interplay between the local and global is materialized in cities, which are nodes of economic activity and consumption. Indeed, throughout the course of history, cities have emerged and formed around their role as market-places and nodes in systems of long-distance trade (Wheatley, 1971; Ward-Perkins, 2005). In the globalized world, similar to how a country's emissions are produced in the complex and global chains of production and consumption and extend beyond its geographical borders, a resident's consumption causes a significant amount of emissions also outside the city (Ramaswami et al. 2008; Peters & Hertwich, 2008; Peters et al., 2011). This legitimatizes why using the consumption-based accounting provides important additional aspects to more widely adopted production-based accounting, and both methods should be utilized, as they allow for designing different types of mitigation strategies. The consumption-based approach takes into account those emissions embedded into the consumption of products and services, and thus arguably better reflects the emission implications of lifestyles (Dodman, 2009). In this dissertation, direct emissions refer to private vehicle driving and direct housing energy (i.e., electricity, gas, liquid and solid fuels, and heat energy used at home), and indirect emissions refer to embedded emissions, i.e. to all remaining consumption of products and services (a similar distinction is used by e.g. Bin & Dowlatabad, 2005; Druckman & Jackson, 2009).

Perhaps the most established evidence about the role of urbanity in explaining emissions comes from the domains of private vehicle driving and energy. Regarding the direct emissions, a large body of literature concentrating on the relationship between private transportation and urbanization concludes that higher density is related to lower private vehicle driving (Cao et al. 2009; Ewing & Cervero 2010; Naess 2012). Likewise, rather long-ranging evidence suggests that direct energy consumption per capita is lower in urban environments (Herendeen & Tanaka, 1976; Vringer & Blok, 1995; Pachauri, 2004; Lenzen et al., 2006). All in all, a large

share of the literature on consumer behavior as well as the attempts to identify rooms for improvement in such behavior has focused on direct emissions (Deetman et al., 2013; Girod et al., 2014).

However, while not disputing the importance of density in explaining direct emissions, the role of lifestyles, consumption habits, and related indirect emissions in explaining GHG emissions requires further attention (Ferrer-i-Carbonell & van den Bergh, 2004; Baiocchi et al., 2010). As increased service provision is one the characteristics of urbanization (Taylor, 2004), ignoring the related emissions seems irrational. Furthermore, it is known that the share of indirect emissions is comparable to the share of direct emissions (Jones & Kammen, 2011). When also indirect emissions are taken into account, the role of urbanity or density is less straightforward (Baiocchi et al., 2010), especially due to the role of smaller urban household size (Buchs & Schnepf, 2013) and emissions from recreation and leisure (Druckman & Jackson 2009, 2010; Benders et al., 2012). Also, earlier evidence from the Finnish context suggests that the urban structure has a direct impact only on the emissions related to private vehicle driving (Heinonen & Junnila, 2011a; 2011b; 2011c). This dissertation adds a relative perspective to the earlier Finnish studies.

The dissertation adds to the existing literature through explaining the indirect emissions at a disaggregated level. Paper I demonstrates how the disaggregation reveals contradictions in the effects of urbanity and Paper II takes an intra-urban perspective, connecting with the literature highlighting the importance of household context (Bento et al., 2005; Sovacool & Brown 2010; Newton & Meyer, 2012). The results also support the widely accepted importance of income in driving emissions (Weber & Matthews 2008; Buchs & Schnepf 2013; Baiocchi et al. 2010; Gough et al. 2011; Kerkhof et al. 2009; Minx et al. 2013; Chitnis et al. 2014, Druckman & Jackson, 2016), meaning that the responsibility of larger emissions can be traced to affluent individuals and household, regardless of their location. Furthermore, the dissertation suggests that there is a relation between intra-household sharing and urban zone, varying between emission categories, further highlighting the importance of inspecting the dynamics of emissions at a detailed level.

1.1.2 Subjective wellbeing and urbanity

Social sustainability is a wide-ranging multi-dimensional concept (Dempsey et al., 2011), and selecting the most accurate or urgent interpretation is not straightforward. Overall, compared to the situation in the climate change literature, the literature on the social implications of dense urban environments seems to be even more complex and contradictory (Burton, 2003; Dempsey et al., 2009; Yang, 2008).

In the earlier literature, self-reported wellbeing has not often been coupled with social sustainability, at least not explicitly. However, Jackson (2005) bundles the concept with sustainable consumption by using the metaphor of "double dividend": the ability to live better by consuming less and, simultaneously reduce the impact on the environment. Also, for example, Dietz et al. (2009) as well as Knight and Rosa (2011) have defined sustainability in terms of minimizing environmental impacts and maximizing human wellbeing. Thus, this dissertation proposes subjective wellbeing, more commonly used in happiness economics and psychology literature, to be a suitable measure for studying social sustainability, since it grasps many relevant aspects of ultimate utility derived from different actions (e.g., Frey & Stutzer 2002). Fur-

thermore, it seems that improvements in both objective (as measured by e.g. GDP) and subjective wellbeing might be feasible without linearly increasing consumption of environmental resources (e.g. Easterlin, 1974, 1995; Knight & Rosa, 2011).

Wellbeing's relationship to urbanity is especially intriguing, as there are strong, and in many cases, debated views on the topic. A stream of literature from the realm of environmental psychology has perhaps the gloomiest view – it has been argued that there is an inherent tension or paradox between the compact city and people's desire for a spacious, green, and quiet environment (Wiersinga, 1997) and that natural environments have stress-reducing effects (Ulrich, 1983; 1986). It is claimed that such a desire for contact with green goes beyond rural romanticism and is based on our evolutionary heritage (Orians & Heerwagen, 1992; Kaplan & Kaplan, 1989) or ancestral environment (Li & Kanazawa 2016).

However, even if, for the sake of argument, approving of these somewhat controversial (Joye & Van den Berg, 2011) evolutionary views on the restorative nature, it is still evident that in the current world with a population of 7.4 billion dwellers, planning for the typically sized hunter-gatherer society is impossible. Thus, for example, the question of how to combine nature with urban built environments is more relevant (Joye, 2007). In particular, more knowledge on the wellbeing implications of tools that are already available for planners and policy makers, such as transport planning, is needed.

It is recognized that moving toward social as well as environmental sustainability will require a focus on wellbeing (e.g. Moser, 2009; Rogers et al., 2012). Still, there does not seem to be any shared understanding in the literature of how social sustainability is best operationalized. Wellbeing was adopted in the current work, as there is a widespread agreement that wellbeing is a multi-dimensional concept embracing all aspects of human life (Clark & McGillivray, 2007). Furthermore, many of the most important correlates of subjective wellbeing, such as health or marriage (e.g. Dolan et al., 2008), do not intrinsically contradict environmental sustainability. It has been argued that self-reported survey measures of subjective wellbeing are good proxies of individual utility (e.g. Frey & Stutzer 2002b; Blanchflower & Oswald, 2004; Luttmer, 2005), and using such subjective measures is validated by a large number of experimental and neurobiological studies (e.g. Pavot et al., 1991; Di Tella, MacCulloch & Oswald 2003).

The happiness economics studies are not unanimous regarding the relationship between urbanity and wellbeing. Some studies from highly developed countries suggest those living in rural areas tend to report higher levels of wellbeing than those living in more urban areas (Easterlin, Angelescu, & Zweig, 2011; Berry & Okulicz-Kozaryn, 2011). However, there are also more unambiguous results, and Peterson, Park, and Seligman (2005) find no significant home-town size effect, whereas Rehdanz and Maddison (2005) report that country-level population density does not significantly influence self-reported happiness.

Furthermore, when moving from the rural-dichotomies to more detailed levels, existing research on the effect of population density is unanimous in its conclusions (e.g. review by Dolan et al., 2008). One gap, which Paper IV addresses, is that especially intra-urban studies about the possible connection between the built environment and SWB are few. For example, in a study from a context of a city in Indonesia, Afirwidodo (2012) assessed the effect of urban densifications and found that gross district density had no statistically significant relationship with life satisfaction. However, Li and Kanazawa (2016) found population density at the level of the census block group to decrease self-reported life satisfaction, and a similar finding was made by Cramer et al. (2004). Finally, for example, MacKerron and Mourato (2009) as well as Wang

and Wang (2016) conclude that wellbeing is increased closer to city centers than it is in the suburbs. Thus, based on a review of the literature, it can be concluded that the question about the relationship between wellbeing and urban environments is still open. Furthermore, many studies controlling for urbanity or density leave the existence, or nonexistence, of the wellbeing gradient largely unexplained and simply note the estimate and its significance level.

1.2 Structure of the dissertation and description of the Papers

The argumentation of the dissertation is built-up on four peer-reviewed journal papers and is elaborated in this compiling part. All four papers provide extensive literature reviews along with the details of the applied methodologies and datasets, as well as in -depth discussions about the results and their limitations. Papers I–III study the relationship between urbanity and GHG emissions, and Paper IV addresses a similar question, but from the perspective of subjective wellbeing. In brief, all papers study the relationship between the selected sustainability variable and selected urban structure variable. The system boundary of urbanization, i.e. the scope of the urban structure variable that is utilized, varies from a rural–urban continuum (in Paper I) to more detailed comparisons within a metropolitan area (Paper II), urban zones (Paper III), and finally, to the most nuanced classification of travel-related urban zones (Paper IV).

The dissertation carries out its examination in Finland. The country became urbanized relatively late, in the 1960s, and it is still relatively sparsely populated yet rather rapidly urbanizing. The average density is 18.06 inhabitants per sq km, and currently, 70% of the population is urban (OSF, 2017). The capital region, that is the Helsinki metropolitan area, is the largest agglomeration in the country, producing almost one-fourth of the national GDP. Finland is a relevant context for studying urban sustainability, as, currently, it is a wealthy country with an unsustainable ecological footprint (Global Footprint Network, 2017), even though it ranks high in many quality -of -life comparisons (Eurostat, 2017). Overall, in a recent assessment based on strong sustainability, Finland came 28th out of 147 countries (Sachs et al., 2016).

The research structure is presented in Table 1. The table illustrates the scope of each Paper, demonstrates how the Papers are linked to the research question, and presents their main conclusions. The themes brought out in the Table are further discussed and supported in the following sections of the compiling part. The four papers together answer the research question, as the results from individual papers are assembled in this compiling part.

Table 1. Summary of the papers in the dissertation.

RQ	**Is there an urbanization gradient in sustainability, when measured by means of carbon footprints and subjective wellbeing?**			
	Paper I	**Paper II**	**Paper III**	**Paper IV**
	Relationship between urbanization, direct and indirect greenhouse gas emissions, and expenditures: a multivariate analysis	Greenhouse gas implications of urban sprawl in Helsinki Metropolitan Area	To each their own? The greenhouse gas impacts of intra-household sharing in different urban zones	Spatial nature of urban well-being
SAMPLE	Finland	Helsinki metropolitan area	Urban agglomerations in Finland	Urban areas in Finland
URBANITY CLASSIFICATION	Helsinki metropolitan area, urban, semi-urban, and rural municipalities	Low- and high-rise residents	Helsinki and inner, outer and peri-urban zones	Travel related urban-zones, ranging from pedestrian to car-oriented zone
SUSTAINABILITY MEASURES	Consumption-based GHG emissions - Direct: personal transport, housing energy - Indirect: food and non-alcoholic beverages, housing, all other tangible goods, intangible goods	Consumption-based GHG emissions - Direct: personal transport, housing energy - Indirect: food and non-alcoholic beverages, housing, all other tangible goods, intangible goods	Consumption-based GHG emissions - Personal goods, personal services, home, energy, leisure, and private transport	Subjective wellbeing (SWB) - Self-reported happiness - Self-reported quality of life
CONCLUSIONS	Affluence is the most important factor driving GHG emissions. However, other things constant, urban living is related to lower total emissions than rural. For disaggregated emission categories the relationships are less clear, and emissions from services grow with urbanity.	There are no major differences in GHG emissions between low- and high-rise dwellers, despite the larger differences in background variables. Household size instead of dwelling type largely explains the direct emissions.	GHG emissions and household size are linked, and intra-household sharing and bigger household sizes alleviate the negative effects of urban sprawl. Increasing inter-household sharing holds promises for compensating the negative GHG impacts of smaller household sizes in inner urban areas.	There are no clear spatial wellbeing gradients, and the partially contradicting relationships are revealed when using two different SWB measures. Subjective spatial characteristics are more important than objective ones.

The structure of the compiling part is as follows: section 1 introduces the research topic and presents the research question and the structure of the dissertation. Section 2 describes the materials and methods. Section 3 presents the argument of the dissertation, derived from Papers I-IV. Finally, section 4 summarizes the argument of the dissertation by presenting the conclusions. Section 4 provides an assessment of the research and suggests future research directions.

2. Methodology

The methodologies used is Papers I-IV are quantitative. Bryman and Bell (2015) mention that the general benefits of quantitative research are related to measurement, generalizability, and replicability. However, some qualitative parts were included, for example, in the form of descriptive statistics and as well when interpreting the results, especially at the end of compiling part where a framework visualizing the complexity of urban sustainability is constructed.

The utilized data sets were cross-sectional and collected by external governmental organizations (in the case of Papers I-III by Statistics Finland, and in the case of Paper IV, by National Institute for Health and Welfare). Papers I & II used the Household Budget Survey Data from 2006, and Paper III used the year 2012. Paper IV used regional Health and Wellbeing surveys from the period 2013-2015, thus the data was a pooled cross-section. Furthermore, additional data were gathered from open databases.

The pros of using external governmental data are that they are high quality and the sample sizes are large enough to achieve statistical power. Furthermore, thanks to careful sampling, the data should be representative of the population of interest, which is further ensured by using weights provided with the data sets. The datasets were both collected using a complex survey sampling setting, with non-response bias as well as clustering among of the common problems related to survey sampling. These are taken into account and minimized by performing all analyses with Stata's (version 13.1) survey commands, which take into account the complex sample design and weights (and FPC-correction).

Finally, all data are at the household or individual level, which has certain benefits compared to having data aggregated at the city, county, or metropolitan level, which is the case in many of the classics in the field of urban sustainability (e.g. Newman & Kenworthy, 2006). Relative and per-capita -based assessments reveal the dynamics of different factors separately and allow for using more advanced statistical techniques that help in understanding the relevance of each factor. Furthermore, by using disaggregated data and simultaneously controlling for many socioeconomic variables, the problem of self-selection is likely alleviated (see e.g. Brownstone & Golob, 2009) compared to using only aggregated data.

2.1 Environmental sustainability: measuring GHG emissions

GHG accounting (WRI, 2014), and city-level consumption-based GHG accounting in particular (Ramaswami et al. 2012, Wiedmann et al. 2015), have become one of the tools utilized in the quest for sustainable consumption (Hertwich, 2005a). The GHG emissions analyzed in Papers I-III were calculated using a consumption-based version of ENVIMAT, an environmentally extended input–output life-cycle (EE I-O) assessment (LCA) model. The model developed

by Seppälä et al. (2011) measures the direct and indirect life-cycle environmental impacts caused by the Finnish economy. No separate city-level I-O tables were available.

Consumption-based accounting of emissions means that the domestic consumer's total emissions are allocated to domestic consumers , as the final consumer is the cause of demand and the primary beneficiary of the final product, regardless of where the product is produced (e.g. Peters & Hertwich, 2008; Peters et al., 2011). In brief, EE I-O is a top-down method, which results in the total life-cycle wide environmental impact of a monetary transaction on a certain sector of the economy (Wiedmann, 2009). The GHG emissions were also referred to as the carbon footprint, leaning on a definition by Wiedmann & Minx (2008) and Minx et al. (2009).

More specifically, the LCA employed throughout the dissertation is attributional LCA, which is based on the principle of dividing the existing emissions by the total number of products produced over a period. The other option would be marginal or consequential LCA, which measures what happens in response to a change in the output of the functional unit (Hertwich, 2005a).

The often -mentioned benefits of the input–output method are its capability to give an overview of the life-cycle effects of production and consumption, the lack of problems related to system boundaries and truncation errors, and the ease and repeatability of calculations once the model is developed (Suh et al., 2004; Tukker and Jansen, 2006). On the other hand, the most -cited problems relate to the assumptions of price homogeneity and linearity, and a high level of sector aggregation (e.g., Suh et al., 2004; Su et al., 2010).

A comprehensive introduction to applying the input–output technique to environmental problems can be found in Leontief (1970) or Miller and Blair (2009). Some modifications to the straightforward input–output technique were made and also the model itself was developed between the papers of this dissertation. To sum up the main changes, in Papers I and II, input data on housing energy and rent were modified. In Paper III, the method was a consumption-based hybrid life-cycle assessment, since the more traditional process LCA methods (Suh et al., 2004) were applied when calculating the emissions from private cars and housing energy. The details of the model and modifications made can be found from the Appended Papers. However, it should be noted that the variation in the methods between the papers causes some uncertainties in the results.

2.2 Social sustainability: measuring subjective wellbeing

Subjective wellbeing as analyzed in Paper IV was measured based on self-evaluative questions about the respondent's happiness and quality of life. Subjective wellbeing is an umbrella term that can refer to various matters, from emotional responses to global judgments (Diener & Seligman, 2004), but using such subjective measures is validated by experimental and neurobiological studies (e.g. Pavot et al., 1991; Di Tella, MacCulloch & Oswald, 2003). Two measures were analyzed separately, rather than combining multiple questions into one, to understand if they reflect a similar underlying concept. Self-reported happiness and life satisfaction seem to be the most dominantly used indicators of SWB, and the quality of life measure is less commonly utilized, at least in the recent happiness economics literature. Sometimes the subjective quality of life is seen as a separate measure from SWB, and sometimes the two are seen almost as synonyms (see discussion about definitions from Camfield & Skevington, 2008).

Two single-item measures, happiness and quality of life, were selected to represent subjective wellbeing, and thus social sustainability. In the data, happiness was measured based on asking

how much of the time the respondent felt happy over the past four weeks, and measure of quality of life was based on question about how the respondent would rate her or his quality of life if thinking about the life in the past two weeks. The consistency of different measurements of wellbeing is an ongoing debate, and evidence suggests that the influence of different factors vary depending on the indicator used (e.g. Peiro, 2006; Lucas, Scollon, & Diener, 2009; Kahneman & Deaton, 2010). However, some studies, such as Caporale et al. (2009), argue that the results are usually very similar, and not depending on the SWB indicator used. Thus, Paper IV adds important evidence to the debate by demonstrating that at least happiness and quality of life are in many regards different concepts, and the effect of, for example, neighborhood inequality are contradictory depending on the measure used.

2.3 Statistical methods

The applied statistical methods to analyze the underlying relationships in the selected sustainability measures that were discussed in the previous subsections were linear and non-linear regression analyses. Regression analysis allows for controlling for selected independent variables that affect the variable of interest (i.e. that affect the dependent variable), meaning that the effects of variables can be isolated from each other. Thus relationships that would be otherwise hidden can be revealed, which makes the method superior to e.g. comparing only averages. However, the results are still descriptive in nature, as the statistical methods utilized here do not allow for studying the potential causations but are merely a description of existing empirical relationships.

The regression models in papers I-III are linear, an exception being the exponential model used to test for the EKC-hypothesis in Paper I, whereas in Paper IV the models are non-linear, since ordered logistic models are used. The difference between the two is the dependent variable, which is in papers I-III continuous, and non-continuous in paper IV. In non-linear models, the interpretation of the coefficients is not as straightforward as with linear models, as the independent variables have proportional effects on the dependent variable. The non-linear model applied was an ordinal logit model, even though partial proportional odds models were also run to check for robustness.

One of the common pitfalls of regression methods is endogeneity, i.e., correlation between the independent variable and error term that can be caused by various reasons (Stock & Watson, 2003). In the appended Papers, the endogeneity issues are discussed in depth. The reasons for including each control was rationalized, with conceptual explanations for each inclusion provided.

However, in using the described methods – that is linear and non-linear regression analyses – there is always a possibility that some spurious correlations or endogenous variables that are not taken into account might exist. Thus, the derived conclusions and generalization of the results were done in a realistic way, which takes into account these uncertainties.

On a theoretical level, limiting the analysis to urban areas in Papers II-IV should reduce the unobserved heterogeneity between respondents in the sample, making the results more reliable.

3. Results

The main argument of the dissertation is that there is no unambiguous urbanization gradient in sustainability. In other words, living in more urban environments is not clearly or uniformly more sustainable than living in less urban environments. This was demonstrated using a limited set of indicators; disaggregated consumption-based GHG emissions and two subjective wellbeing measures. However, using only a limited set is proven to be sufficient to reveal that there are, firstly, discrepancies within the studied environmental and social sustainability aspects, and secondly, discrepancies between the two aspects.

The results of this dissertation demonstrate how complex the concept of urban sustainability is. Even if the complexity of urbanization is well understood, it still appears that the equally or even more complex link between sustainability and urbanization has been reduced to a rule of thumb about a connection between density and sustainability. This section first summarizes the main results of the Papers and then discusses the conclusions that can be drawn from their results. Then, the discussion is broadened to other related phenomena that interplay with urban sustainability. The second step uses a stylized visualization of urban sustainability that also revises how it was approached in this dissertation.

3.1 Summing up the findings of the Papers

The studies that form the basis of this dissertation addressed the research question from two different sustainability aspects: environmental (papers I, II and III), and social (Paper IV). The scope of the papers is funnel-shaped, as the starting point of the analyses is the whole scope of areas from the metropolitan to the rural (Paper I), and then the analysis focuses on only the urban areas, though using more detailed within-area classifications in each paper.

In **Paper I**, GHG emissions in four different types of areas were compared, and above all, direct and indirect emissions were analyzed separately. Analyses that are both sectorally and spatially disaggregated are relatively rare in the existing literature, even though it has been acknowledged that disaggregation helps to structure consumer practices and allows estimating the emission -saving potential of different mitigation measures (Schanes et al., 2016). The starting point was to look at the pure averages of GHG emissions, as in, for example, Heinonen and Junnila (2011a; 2011b; 2011c). The averages alone clearly demonstrate the main issues behind the reasoning of using a disaggregated analysis, instead of settling for the total carbon footprints alone. Firstly, using the classification into metropolitan, urban, semi-urban municipalities, it can be seen that the averages of total GHGs are rather similar, but the disaggregated distribution within the total GHG emissions reveal some deviations. The spatial pattern is most

visible in private driving, for which emissions grow toward the rural areas. Secondly, the importance of indirect emissions of household consumption is clear from the absolute amounts, in line with the results of e.g. Wiedmann et al. (2015) from Australia. It seems that the sum of direct emissions related to energy and private driving is smaller in absolute size than the sum of indirect emissions at all studied levels of urbanity.

However, the analysis was deepened with multivariable regression modeling, which confirmed the role of consumption as the main driver of GHG emissions. Emissions of households grow monotonically with expenditure and income levels, and no proof of delinking of environmental pressure and wealth, i.e. the environmental Kuznets curve, was found. Thus the conclusions echo the findings of earlier EKC-studies (e.g. Cole et al., 1997; Stern, 2004). In a similar way as in the macro-scale, the fossil-fuel-rich countries struggle to reduce carbon emissions (Friedrichs & Inderwildi, 2013), while in the micro-scale the households that have the greatest resources are likely to be responsible for more GHG emissions than less affluent households, regardless of their place of residence.

The less self-evident and more interesting results were revealed when other explanatory variables were added, and they were found to enhance the explanatory power of the models. First, controlling for expenditure the metropolitan dwellers have smaller footprints than dwellers in other urban, or semi-urban, or rural areas. However, the relationship between urbanity and emissions was less clear when direct and indirect footprints were explained separately. While a negative relationship was found when looking at the direct GHG emissions from private transportation and home energy demand, the relationships between indirect emissions categories embedded into product and service demand were not as obvious. In fact, it was found that emissions from service use, keeping other factors constant, grow with the degree of urbanity. The GHG consequences of personal services have also been highlighted by, for example, Gough et al. (2011).

The results imply that the emission-reducing effect of urbanity is above all related to direct emissions, especially to private driving, but highlight the need to investigate the less-clear relationship between urbanity, affluence, and indirect emissions further. Similarly, Wiedenhofer et al. (2017) find that the urban rich and middle class are driving the emissions from categories of mobility, goods, and services. As urbanization is rather widely understood as a deep reaching process, related to e.g. structural changes in lifestyles and choices (Seto et al., 2010; 2013), it is paradoxical to restrict the emission analyses only to the direct emissions, or even more so to only emissions from private driving. However, based on the findings, it is impossible to conclude what the real drivers of emission differences are between the dwellers in different types of areas.

Paper II shifts the focus to the Helsinki metropolitan area, HMA, with the purpose of investigating whether there are similar patterns as found in Paper I, but now in an intra-urban context. The aim was to explore how urban sprawl is reflected in the GHG emissions of the residents by dividing the area based on housing type: into low-rise and high-rise dwellers. When comparing averages, it was found that low-rise lifestyles cause approximately 14% more emissions than high-rise lifestyles. However, the difference is surprisingly small, and in most cases statistically non-significant, when controlling for expenditure. Thus the results indicate that low-rise living is not as unambiguously related to higher GHG emissions compared to high-rise living. However, in the bottom line, dwelling type was of minor importance when compared to household size. The benefits of larger household size were most evident when looking at the direct emissions. However, the main conclusion was similar to that of Paper I: lifestyles,

and especially their GHG consequences, within the metropolitan area do not vary as much as the more pronounced differences in background variables would suggest.

The Paper concluded that the even though the outcomes are surprisingly similar in terms of GHGs, the underlying reasons and possible solutions might still be different for different groups of residents. It was speculated that those living in city centers over-utilize the reachability of the consumption possibilities, which is positive from the lens of economic sustainability but not always from the lens of environmental sustainability, and under-utilize the available low-carbon alternatives, such as public transportation. Meanwhile, and in line with previous research (Glaeser & Kahn, 2010), those living in sprawled areas are responsible for higher GHG emissions arising from housing energy and private driving. However, this group benefits from the larger household sizes and subsequent higher resource-efficiency more, at least in per capita terms, even though not likely in terms of absolute emissions. All in all, Paper II brought out the importance of household size, meaning that the related scale economies seemed to have a stronger link with the carbon footprints than housing type itself.

Paper III studies the relationship between urban zone and consumption-based emissions, paying special attention to the household size dynamics. Differences were found in how households in different urban structures share. The findings suggest that sharing, and its GHG benefits, alleviate the GHG implications of urban sprawl, especially in the peri-urban zone. The main reason is that larger household sizes lead to lower per-capita GHG emissions from energy use, which is in line with, for example, the results of Buchs and Schnepf (2013) in highlighting that household economies of scale are less important for transport and indirect emissions. However, the relationships between GHG emissions from other categories, such as the home, were weaker. Moreover, sharing economies were not at all present in the case of embedded emissions from leisure, which grow with an additional adult in all zones. Overall, the results highlight the importance of lifestyle and life -stage differences and their carbon implications.

The Paper raises an intriguing suggestion about the link between urban zone and household size, and related emissions. For example, more adults were likely to cause more emissions per capita with their service use than solo households in the outer-urban zone, compared to the other urban zones. In the Paper, this was linked to the reachability of consumption possibilities. Following the thoughts of Taniguchi and Ikeda (2005), who argue that in large urban areas the vast supply of operations in multiple centers decreases energy consumption, whereas in small urban areas (i.e. outer urban areas) the effect is the opposite, as functions are used regardless of the distance. So, it was speculated that in outer-urban areas the consumption possibilities of inner-urban zones are still within reach and lifestyles are more mobile than in the most peri-urban zones, for example. This argument was further supported by a finding about emissions from transportation: emissions grow the most with an additional adult in the outer urban-zone.

The Paper linked intra-household sharing with inter-household sharing by suggesting that, smaller households in the most urban locations would benefit from the contemporary rise of the sharing economy. The benefits would be greatest if geared toward living and moving, i.e., GHG-intensive consumption categories such as heating and fuels. However, sharing may also lead to higher environmental load, particularly in cases where sharing does not lead to further behavioral changes, but a rise in consumption enabled by the monetary savings from sharing.

In addition, the Paper makes two important remarks: the current situation, where the solo households inhabit the inner zones, is not static and might change in the future, as well as it was highlighted that there are multiple, sometimes opposing, driving forces behind it. It is

likely that the inadequate supply of reasonable-priced family housing in inner-urban areas continues to push bigger families to move to more spacious and affordable outer-urban apartments, but at the same time it have been suggested that the preferences change, or have already changed (see e.g. Lilius 2014), and the inner urban amenities and transportation possibilities are gradually becoming pull factors for also larger households to live in inner centers. Similarly, outer urban zones have a limited supply of smaller apartments. Thus, the barriers related to intra-household sharing in the inner urban zone might not be behavioral or cultural, but structural barriers set by the infrastructure. An additional challenge is the aging population, likely to increase the number of solo households in the future. Therefore new solutions specifically aimed at older people are needed.

During the research process, it became apparent that concentrating only on the relationships between urban structures and greenhouse gas emissions was insufficient, and grasping the very core of urban sustainability required an additional perspective. In addition, Papers I-III use rather crude classifications based on, for example, municipal borders. Consequently a need to utilize more detailed data about the level of urbanity and the actual living environment emerged from the process.

Thus, **Paper IV**, introduced a new measure of sustainability, shifting the focus from GHG emissions to social sustainability. Social sustainability was measured based on self-evaluative questions about subjective happiness and quality of life, borrowing from an established tradition in happiness economics (e.g. Luttmer, 2005). Indeed, the implicit contribution of the paper is to suggest that subjective wellbeing (SBW) should be more widely utilized in measuring urban social sustainability. SBW is known to correlate with many aspects of social sustainability relevant in the spatial scale, such as social equity, accessibility, and safety (Dempsey et al., 2011). Thus, the Paper argues that utilizing SWB offers a possibility to set the importance of each aspect into proportion, and reflect those against a comprehensive and solid measure of wellbeing. Furthermore, urban studies focusing on, for example, residential satisfaction may be problematic, as the dissatisfaction of the negative aspects of density can intuitively dominate the positive and indirect side-effects of density, such as better service access.

While the Paper found no straightforward evidence about the spatial nature of subjective wellbeing, certain indications on spatial effects were found. For example, central pedestrian zones were related to higher quality of life, but to lower happiness. Happiness was the highest in the car-oriented zone, which is the least urbanized, or in other words, the most suburban of the studied zones. When using density instead of a more detailed travel-related urban zone classification, the conclusions were somewhat similar: people reported higher levels of happiness in the less dense areas. However, no evidence on a relationship between density and quality of life was found. Thus, the results perhaps raise more questions than answers. Additionally, the results highlight an interesting issue about the importance of using different area classifications. The crude density, which is perhaps the most used spatial variable in the literature, can be inferior to more detailed measures that take into account additional variables that essentially form and distinguish the type of living environment. These include employment density, service supply and transportation possibilities, to name but a few.

While it can be concluded that SWB has some spatial nature, no direction of such nature can be determined. Paper IV indeed revealed that the relationships between spatial variables and SWB variables are, even to a surprising extent, highly sensitive to the indicator of SWB used. The findings call for more attention concerning the effect of socio-spatial factors, namely, neighborhood inequality and relative spatial position. Dwellers of less unequal neighborhoods

reported to be happier, but have a lower quality of life. Likewise, having a higher relative position than one's neighbors was related to a negative effect on happiness, but a positive effect on quality of life. It was also suggested that the sometimes reported finding regarding higher rural happiness (e.g. Berry & Okulicz-Kozaryn, 2011) could be explained by higher inequality in denser areas, not by the spatial structures per se.

Overall, subjective spatial characteristics, such as perceived safety, were found to be more important for wellbeing than objective ones, such as those measuring density. Thus, this can be interpreted as a promise about the possibility to develop all kinds of areas into wellbeing promoting ones. For example, especially safety and lack of noise seem to be universally important for subjective wellbeing. Based on Paper IV, it can also be concluded that health and adequacy of income, as well as social capital, play an important role in wellbeing. This finding makes concentrating on the effects of spatial variables a less fruitful way to a more socially sustainable future. Especially the rather unambiguous results of the wellbeing-enhancing effects of social capital, such as contacts with friends or taking part in third sector activities, could be a direction worth investigating. This direction could yield benefits both from the perspective of environmental and social sustainability.

3.2 The complexity of urban sustainability

The dissertation establishes the complexity of urban sustainability by showing that it is a phenomenon characterized by discrepancies and trade-offs, visible even when only two potential aspects of environmental and social sustainability are analyzed. The results reveal that there are, firstly, discrepancies within the selected environmental and social sustainability aspects, and secondly, discrepancies between the two aspects. An example from the first category is the different relationship between urbanity and direct and indirect emissions, or the diverging estimates of the urban zone when explaining SWB measures. The latter discrepancy, between the two sustainability aspects, is revealed in the juxtaposition of the positive relationship between wealth and subjective wellbeing in Paper IV, for example, with Paper I's results, which reported no signs of de-linking of wealth and greenhouse gas emissions. Finally, if the range of sustainability measures were further expanded, the disparities and trade-offs in sustainability would probably be even more pronounced.

The main argument about no unambiguous urbanization gradient in sustainability is also backed up by the recurring finding of all the papers: the spatial disparities in terms of either GHG or SWB are small. This key finding indicates that urbanity per se is less relevant than is sometimes perceived in explaining and, even more importantly, influencing sustainability. In other words, even if there was an urbanity sustainability gradient, its leverage would be very small, and thus urbanization or densification are insufficient measures when reflecting the majority of the challenges of sustainable development. Thus, ignoring the multifaceted relationships between sustainability and urbanity, and concentrating solely on density will not lead to substantial improvements. Subsequently, policies based on over-optimistic and over-simplified assumptions should be re-tailored to take a more holistic approach to urban sustainability, and certainly to look beyond emissions from private driving. Evidence-based discussion on different sustainability measures and their implications is called for.

Complexity means that phenomena at different scales interact in a non-linear manner with other phenomena at any other scale, and that an understanding of the system is not possible through a simple reduction to its component elements (Martin & Sunley, 2007).The following

stylized Figure 1 visualizes some of the key findings of the Papers and conceptualizes their argumentation about the complexity of urban sustainability. The purpose of the Figure is not to present all the factors that affect, or are in interplay, with the phenomena, but to show how the dissertation approaches its topic and what kind of conclusions it presents. It also shows the main links between the themes. The lines and arrows do not represent causalities, but indicate the empirical relationships found in the Papers, and in some cases, confirmed in the previous literature. The orange lines with a triangle in the middle represent scales to indicate possible trade-offs between and within the studied measures of urban sustainability.

The Y-axis on the left-hand side revises how the concept of urban sustainability was approached in the dissertation, and what the analyzed empirical measures of social and environmental sustainability were (based on e.g. the framework of Bacharach, 1989). Here, it must be yet again highlighted, and as the Figure aims to communicate, that the selected measures represent only a fraction of issues that can be grouped under the theme of sustainable urbanization. To give an example, other environmental effects include e.g. ocean acidification and effects on land-use impairing ecosystem services and biodiversity (e.g. Nuissl et al., 2009; Rockström et al., 2009; Steffen et al., 2015). Furthermore, the pillar of economic sustainability is completely missing from the Figure, even though it is an equally important criterion in the sustainability frameworks (Brundtland, 1987; Valentin & Spangenberg, 2000).

The key variable of interest, or the tip of the iceberg, is urbanization, which is located above the horizontal wavy line, or the surface. The phenomena below the surface are themes brought out in the dissertation, linked to urbanization and related with each other as well as with the studied sustainability measures. The deeper below the surface that the phenomena are, the more derivable they are from individual and household-level decisions. These micro-level factors are harder to influence, at least with the tools available to urban planners. Thus the level of urban policy leverage (term by Seto et al., 2014) is low.

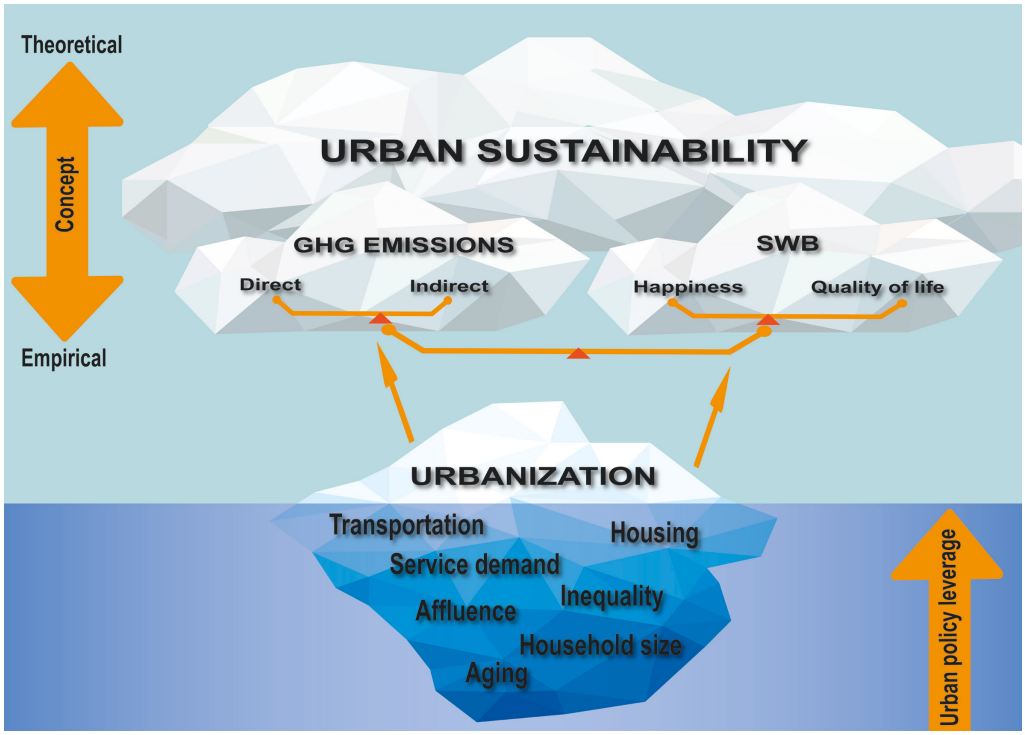

Figure 1. The complexity of urban sustainability.

As visualized in Figure 1, the main take-home message is that urban sustainability is complex, even when measured with only two indicators. This, however, is not surprising, as urbanization is a process involving simultaneous transitions and transformations across multiple dimensions, including demographic, economic, and physical changes in the landscape (Seto et al., 2014). The evidence on possible contradictions and trade-offs is even more interesting. Trade-offs exist both when comparing the different aspects of environmental sustainability, in other words, direct and indirect portions of consumption-based greenhouse gas emissions, or different measures of social sustainability, that is two different subjective wellbeing measures. For example, it was shown that even if the relationship between urbanity and direct emissions is negative, as supported by earlier literature (e.g. Ewing & Rong, 2008; Glaeser & Kahn, 2010; Holden & Norland, 2005; Hoornweg et al., 2011), a category of indirect emissions, emissions from leisure and service, has a positive relationship with the degree of urbanity. From the social sustainability perspective, happiness and quality of life had in some cases divergent relationships with, for example, neighborhood inequality and relative spatial position. Finally, the scale between environmental and social sustainability refers to the possible problematic role of income.

In the Figure, **housing and transportation** choices are the nearest to the surface of urbanization, as they are, at least at first glance, rather straightforwardly influenced by urban planning and urban policy making. Transportation choices have the strongest link with the studied urban sustainability measures, namely, with direct GHG emissions, in line with the earlier literature (Naess, 2012; 2016). However, the relatively small share of emissions from transportation means that concentrating on them alone would be inadequate. Housing choices, on the other hand, seem to have a rather tenuous link with emissions, since in Paper

III there were no statistically significant differences between the inner and outer urban zones in GHG's from housing energy. This result is somewhat surprising, as according to among others Myors et al. (2005) and Perkins et al. (2009), single-story freestanding housing units are more GHG-intensive than multifamily, semi-detached buildings.

In the context of housing, apartment sizes require further attention. For example, Paper I found the difference in average square meters per capita between the most urban and the most rural dwellers to be only five square meters. When looking only at the metropolitan region in Paper II, the difference between the low and high rise was eight square meters, and 11 square meters between the capital and peri-urban zones in Paper III. These can be considered to be relatively minor differences, when reflecting perceptions of the benefits of compactness in urban living (e.g. Fuller & Crawford, 2011, Anderson et al., 2015) and highlight the need to think beyond population density, and also concentrate on increasing dwelling unit density where possible. In the current situation, the material arrangements and the resources for performing household tasks, such as food preparation or laundry, are approximately similar in smaller and larger households (Yates, 2016).

On second thought, timing sets up certain challenges to influencing housing and transportation. The timing perspective is one of the topics that was not taken into account in the dissertation, even though it is of prime importance when talking about urbanization and its effects. Due to the slow pace of change in the urban structure, planning for a more compact urban structure has been estimated to decrease GHG emissions by less than 1% by 2020, when reflected to Finland's average GHG emissions for the period 2008–2012 (Nissinen et al., 2015). This is because investments in urban infrastructure are not only time-consuming decisions that take a long time to execute, but also very long-ranging, as they put in place "boundary conditions" that shape the city for up to a century (e.g. Creutzig et al. 2016). Unfortunately, at least in the highly developed nations, we cannot start anew with new zero energy buildings for everyone, and for example, the GHG impacts of replacing existing buildings with new more energy -efficient stock present an additional challenge (Säynäjoki et al., 2012). Thus, the hands of urban planners are relatively tied to the existing infrastructure and emissions associated with infrastructure systems are prone to lock-in (Unruh & Carrillo-Hermosilla, 2006; Davis et al., 2010). Moreover, more "soft" lock-ins can also exist; a study by Kitamura et al. (2001) suggest that in cities where motorization is deeply rooted, improving accessibility no longer influences automobile-dependent lifestyles and travel behaviors.

Based on the results, the climate change mitigating effect of higher **service demand** in urban areas is not self-evident, as the emissions intensities of services are at the middle range of all intensities. It was suggested that increasing service demand is not to the necessary extent complemented with less product demand, nor reflected in less space use at homes. Even if services are in general less GHG-intensive than, for example, white goods, it seems that services as a form of intra-household sharing require further facilitating, especially when it comes to their GHG implications, as was highlighted in Papers I-III. Service consumption and other private consumption that drives indirect emissions has been traditionally seen as an area of consumer or citizen sovereignty (Weber & Perrels 2000). Influencing this consumption has therefore been seen as an almost impossible task. In practice, however, consumption choices are constantly influenced through marketing and taxation, for example (Ferrer-I-Carbonell & Van Den Bergh, 2004). Consequently, the goods and services available in households, and the things considered normal to produce and consume in them, are interdependent with what is provided by the state, the market, and the community (Warde, 1992; Glucksmann, 2014).

However, even if accepting that indirect consumption could and should be influenced, the question of who is the right actor to carry out such influencing remains open. The consumption-based GHG accounting has been criticized for placing too much blame on the consumers (Liu, 2015), and indeed, when reflecting on the tools available to urban planners, the possibility to affect, for example, service emissions seems limited. However, for example Wiedenhofer et al. (2017) highlight spatial planning as an important long-term mean for facilitating low-carbon lifestyles, and Säynäjoki (2015) has argued, for example, that urban planners could take a more holistic approach to emissions and set the ambition level higher than just on private driving. Plepys et al. (2015) have argued that urban planning can arrange nudges, i.e. rearrangements of the market infrastructure and default options, toward more sustainable business models, as they are close to the context where the actual service delivery happens. However, they only provide a concrete example from the realm of mobility, even though they conclude that some observations are probably relevant for the area of consumer goods (Plepys et al., 2015).

Of the factors related to urbanity, the role of **affluence** is perhaps the most complicated. According to the results, it has a positive relation to both GHG emissions and subjective well-being, regardless of the location. However, the results on subjective wellbeing were not linked to the actual level of expenditure or wealth, but to perceived level of adequacy, and thus it can be hopefully speculated that a higher level of subjective adequacy is not necessarily equal to higher actual income. For example, Sekulova & van den Bergh (2013) argue that climate policy that affects income and consumption may not reduce overall happiness, based on their finding that the effect of income reductions on SWB was only temporary. Furthermore, Mogilner and Norton (2016) argue that spending money to acquire experiences rather than possessions increases happiness. However, the environmental implications of such experiences are not straightforward, as was discussed earlier. Despite optimistic results from the micro-scale, the results from the macro-scale seem to imply that rather than becoming more sustainable, economic growth seems to continue to increase the carbon intensity of wellbeing (Jorgenson, 2014).

Based on the findings, neighborhood **inequality** seems to be related to controversial well-being outcomes. The theme of inequality is important though complicated, since it is also essentially related to the results of Papers I-III, which highlight the role of high incomes in driving high GHG emissions. Inequality and environmental deterioration are linked (Berthe & Elie, 2015): theoretically, the two have been claimed to either grow simultaneously (Boyce, 1994; Magnani, 2000; Wilkinson & Pickett; 2010) or to have a converse relationship, meaning the affluent generate less environmental pressure (Scruggs, 1998; Heerink et al., 2001). Paper I found that expenditure elasticities were higher than income elasticities, implying that there is a decreasing relationship between income and consumption levels, and thus, between the consumption level and the related environmental pressures (see Berthe & Elie, 2015). If an additional unit consumed by the affluent causes less environmental pressure than an additional unit consumed by the less wealthy person, policies must be tailored to take into account that fact so as to avoid, for example, consumption taxes on environmentally harmful goods are relatively harder for low-income households. Furthermore, this might drive inequality and deteriorate social trust as, in particular, residential inequality has been linked to lower social trust (Gould & Hijzen, 2016), which is probably related to the house as a positional good associated with status and social standing (Jackson, 2005).

The continuously declining average **household size** has been seen as a major environmental problem (Williams, 2007; Bradbury et al., 2014), and it is likely to have effects also on social sustainability, as social relationships were influential in explaining both the measures of subjective wellbeing here analyzed. Moreover, our results support the negative GHG consequences of single living, as the household scale economies in energy and housing were found to be substantial, especially for households with more than two persons. Yates (2016) argues that the literature presumes daily life in small households to be qualitatively similar though quantitatively different compared to life in larger households. This assumption indeed seems flawed, as our results suggest that, for example, the second child has a more profound effect on lifestyles, consumption habits, and subsequent GHG consequences, than the first child. The personal service emissions per capita are clearly lower for two- than one-child households, which suggests that the allocation of resources, be they time or money, within the family also confronts qualitative changes. However, a larger household size can also have negative dynamics with regards to GHG emissions, and it was suggested in Paper III that a larger household size leads to having more vehicles and/or driving more (the influence was not decomposed). This is again probably related to qualitatively different lifestyles of larger households, and reflect their larger spatial scope of life, at least when looking at the trips achievable with private ground transport. Finally, it must be highlighted that the macro-level population growth, be it geared towards any kinds of households, is detrimental to the environment (Lorek & Spangenberg, 2014).

The more urbanized the household, the smaller it is likely to be. For example, in Paper III, it can be seen that that "the nuclear family", i.e. a household with two adults and two children, is the most common household type only in the outer and peri-urban areas; and their share is still smaller than the share of single households in the capital and inner urban zones. However, on a related note, it must be kept in mind that when problematizing the small household sizes in the urban areas, the intention is not to argue that everyone should be part of a nuclear family, but to refer to new forms of shared living, such as house-shares, communes, and cooperatives (Jarvis, 2015).

Aging is another phenomenon that is partly behind the findings of the dissertation and continues to be connected with sustainability outcomes to an increasing extent. At first glance, it seems older people are likely to live in a more home-centered manner, and thus create fewer emissions from traveling. However, currently retired persons are often wealthy and healthy, which challenges the assumption and underscores the importance of seeing the results as static, and not necessarily constant in the long run. For example, the consumption of services and leisure are likely to continue to have a larger and larger role also in older age, being combined, and not complemented, with well-equipped homes.

Paper IV found age to have an effect on subjective wellbeing, even thought it was mediated by the lower affluence among older persons. From the perspective of GHG emissions, aging is self-evidently linked with declining household size, the problems of which are discussed below. Older persons tend to consume relatively more housing energy, partly stemming from the fact that their dwelling size per capita was the highest of all household types compared. However, GHG emissions from private travel decreased with age, in line with the results of Liddle (2011) and Büchs and Schnepf (2013). However, the overall macro-level effects of population aging are not straightforward, as O'Neill et al. (2010) have for example argued that population aging alone can reduce absolute emissions in the long term, due to reduced labor supply. It has also been argued that longevity is likely to boost carbon emissions, at least in the medium-term

(Menz & Welsch, 2012). Finally, aging can also affect sustainability-relevant attitudes and lifestyles, which are partly dependable on the period in which a person was born and raised (Menz & Welsch, 2012).

The dissertation has identified key factors influencing the selected sustainability measures. However, even if a particular phenomenon is a quantitatively significant driver of emissions, it does not mean that it is also an important policy lever (O'Neill et al., 2010). This partly explains the policy focus on controlling for densities, which are easy to define and relatively straightforward to control. Indeed, in Figure 1 most of the phenomena floating under the top of the iceberg of urbanization can be traced to **lifestyles**, or, according to the dictionary definition, to the typical ways of life of an individual, group, or culture (Merriam-Webster). Lifestyles are complicated to precisely define, and probably even more complicated to influence, at least with direct governmental decisions. However, that is not to say that both culture and urban form could not support sustainability, which are likely behind the proliferation of recycling and waste sorting. On another note, excessive consumption could be alleviated by creating public and private spaces, the functions of which encourage spending time there and in socializing, not consuming. Another possibility for influence might lie in "invisible" regular payments, such as energy bills, which are not associated with status or social standing, and thus people are likely less motivated to diminish them (Jackson, 2005). For this type of consumption, local policies could take the lead. Alcott (2011) has provided evidence that energy reports that compare energy use with neighbors and provide energy conservation tips can substantially and cost-effectively change consumer behavior. This kind of a behavioral approach is particularly suitable for urban dwellers, as it has been found that currently, apartment dwellers' influence on energy consumption is limited, at least in the Finnish context (Kyrö et al., 2011).

Lifestyles and cultural changes can in some cases be swift, but understanding the consequences of behavioral changes is never simple. The complexity can be exemplified with the rapid rise of the sharing economy, also discussed in Paper III. Contemporary sharing is an example of a relatively new urban phenomenon that holds potential for affecting both the environmental and social practices of people. Still, if sharing is only reflected in, and motivated by, monetary savings and not in a more thorough transformation of consumption habits, the money saved may cause rebound effects (e.g. Hertwich, 2005b; Druckman et al., 2011): When money saved is spent on holidays or other emission-intensive activities, the actual consequences of a seemingly environmentally-friendly change are smaller than anticipated (Ottelin et al., 2017). Rebound effects are not often connected with the rise of the sharing economy, but similarly to all other possible emissions reductions, it makes emission reductions more of an uphill task than often acknowledged (Druckman & Jackson, 2016). Another avenue through which sharing can lead to higher environmental impacts is when it is related to less careful user behavior, since the consumer no longer owns the product (Tukker, 2015).

Overall, the dissertation finds surprisingly small spatial disparities in either terms of GHG or SWB, indicating spatial position per se is insufficient in making sustainability statements. Another deduction from the results is that urban lifestyles seem to converge, as they produce relatively similar final outcomes regarding the studied sustainability measures. The convergence is intriguing, since comparing background variables, such as household types and levels of wealth, leads to expectations of much larger differences. This is also analogous to the idea suggesting that the daily amount of time spent commuting is relatively stable for everyone (Marchetti, 1994; Zahavi, 1976). Thus, even if living in a dense area is likely to reduce the emissions from driving, it is probably counter-balanced by more frequent travels abroad (see e.g. Ottelin

et al., 2014) or in more frequent second home ownership (Strandell & Hall, 2015). However, even if carrying negative GHG consequences, holiday travels are likely to boost one's wellbeing, at least temporarily (Chen & Petrick, 2013), which is a perfect everyday example of the trade-offs typical of sustainability.

4. Discussion

In this dissertation I set out to answer the following research question: Is there an urbanization gradient in sustainability, when measured with carbon footprints and subjective wellbeing?

The answer is rather simple: the power of spatial position in determining sustainability is limited at best, nonexistent at worst. Moreover, no generalizations can be made about one type of urban structure being more sustainable than another. In the dissertation, this was demonstrated using a small, though an adequate set of sustainability measures from the realms of both environmental and social sustainability. Private driving was an exception to the studied measures, since its emissions seem to be reduced in more urban structures. However, the connection between GHG emissions from private driving and urban structure is not equal to the connection between sustainability and urban structure, even though the two seem to be intuitively bundled in certain urban policy statements. Urban sustainability is by nature characterized by trade-offs, and in some cases, juxtaposing sustainability measures leads to contradictory conclusions. Especially decoupling affluence from both higher emissions and higher subjective wellbeing is likely to remain a challenge, and acknowledging the existence of the connection is the first necessary step towards designing and implementing meaningful cross-sectional urban sustainability policies. The dissertation does not wish to declare the quest for urban sustainability meaningless - however, in order to claim the great expectations related to urbanization as a driver for sustainability, we need to be aware of its complexity and address the related challenges head-on.

The presumption guiding the dissertation process focused on the relationships between the selected sustainability measures and urban structure measures, with the models indeed gaining some additional statistical power when the spatial variables were added. However, the conclusions were rather unanimous, even disappointing for any eager urbanist – urbanization alone has a relatively weak, and even controversial, relationship with sustainability. It seems that the level of urbanization or the type of urban structure is sometimes treated as a panacea in the sustainability discussions. More empirical evidence on urban sustainability is needed, as the analyses of cities' sustainability efforts often remain at the level of analyzing the extent that policy measures are addressed, instead of studying the actual outcomes achieved (Portney, 2003).

Another merit of the dissertation lies in bringing together two aspects of sustainability in the context of urbanization. For example, it is widely acknowledged that understanding consumer behavior is crucial to identifying and changing the impact that society has on the environment (Marcotullio et al., 2014). Even though understanding the motivations behind sustainable behaviors is a complex task and a plethora of theories have been proposed (e.g. see review by Jackson, 2005), self-reported wellbeing is one of the most widely used measures representing the utility that an individual derives from different actions (Blanchflower & Oswald, 2004;

Luttmer, 2005). The key question thus reads: can we reduce our GHG emissions without sacrificing our wellbeing? Actually, the most optimistic results even propose that subjective and ecological wellbeing are positively related, meaning that happy people live in a more environmentally responsible manner (Brown & Kasser, 2005). Due to the separate datasets utilized to analyze environmental and social sustainability, this dissertation does not provide any direct evidence regarding this key question. However, the parallel analyses suggest that higher standard of living are indeed related to both higher GHG emissions and higher subjective wellbeing. Uncoupling these connections should be the main goal when striving for environmentally and socially sustainable urban areas.

The wide scope of urbanization

The contradictory and complex results of the dissertation are not unexpected, in particular when reflecting on the vastness of the key phenomena of interest, urbanization and sustainability. Even if the definitions of urbanization somewhat vary across disciplines (Marcotullio et al., 2014), they all refer not only to more people living in more dense aggregations, but to a far-reaching process that change consumption habits and lifestyles. In other words, urbanization is a complex and global socionatural process, whereas the city is a site, which is one, but not the only, outcome of that process (Angelo & Wachsmuth, 2015). Thus, the results of this dissertation highlight the relatively limited potential of cities, and planning reduced to densification in particular, to contribute to something as complex as urban sustainability, especially if its inherent complexity is ignored. Finally, it must be stated that the results of the dissertation could be probably just as plausibly be mobilized to challenge the whole epistemology of urban sustainability as to underscore its complexity. However, exploring this possibility further would require another dissertation, so it is left for future research.

Furthermore, even if urbanization is inarguably a megatrend, i.e. a significant and long-term social, economic, political and/or technological movement that shapes our lives (Naisbitt, 1982), it is not the only one. For example, aging populations (O'Neill et al., 2010) and shrinking household size (Underwood & Zahran, 2015) have been similarly called megatrends taking place all over the Western world. Indeed, it is worth highlighting that these changes are happening in interrelation with urbanization, meaning that the independent effects are difficult to distinguish.

The results of the dissertation are based on static assumptions. The urbanization we have faced, and are facing today might be different to urbanization in the coming years. Even though cities often portray features of “path dependency”, meaning that earlier decisions affect and restrict current and future choices (Arthur, 1989), urbanization, as with all socioeconomic transitions, is difficult to project (Berkhout et al., 2002; Jiang & O’Neill, 2015). Globally, variations in the quantity and quality of urbanization have been related to, for example, migration (Harris & Todaro, 1970; Keyfitz, 1980) technological development (Tarr, 1984), culture (Inglehart, 1997), governance institutions (Montgomery et al., 2003), as well as environmental factors such as the availability of energy (Jones, 2004). Also, technological development in energy production plays a key role, as they either directly or indirectly affect all the GHG emissions produced due to our consumption, as well as the pace of urbanization likely affecting the way the energy industries develop.

Why has planning not delivered sustainability?

Even though the complexity of urbanization seems to be rather well understood, it is somehow disregarded in the widely held density–sustainability connection, especially in its manifestation in policy statements. Regardless of this paradigm often held by the planning profession, cities are not currently sustainable, questioning the density-sustainability paradigm, or its practical deployment. Simmie (2003) even argues that despite the potential power of urban planning to direct the scale, rate, and form of urbanization, it has been incapable of controlling and orienting urban growth. Furthermore, if controlling for growth had failed, it would be highly surprising if controlling for something as complex as sustainability has succeeded. Indeed, it has been suggested that in practice, urban sustainability projects tend to take place in new residential areas with affluent residents. This means that endeavors classified under and communicated as urban sustainability projects are typically reduced to addressing a single ecological issue in the selected area, for example, the neighborhood (Wachsmuth et al., 2016) or in an isolated ecoregion or bioregion (McGranahan & Satterthwaite, 2003).

Nonetheless, there is no miracle cure for the complexity of sustainable urbanization, i.e., the aim is not to argue, given the multiple drivers of urbanization, that it is an issue just waiting for a better paradigm to occur. Still, it can be that planning was all along the wrong way to strive for something as complex as sustainability, or that the potential of planning, and densification in particular, to contribute to sustainability has not yet been proclaimed. The second option suggests that instead of implementing the great long-term visions, often found in plans and policy documents, in reality, the planners have settled for more pragmatically offering what is demanded of them. In the USA, urban planning is increasingly decentralized and privatized (McCann, 2001) and similar trends have been suggested as taking place also in Finland (Mäntysalo & Saglie, 2010; Mäntysalo et al., 2014), where the planning system is currently under a reform aiming to further relax the bureaucratic control of planning processes (Puustinen et al., 2017). Thus, combined with the fact that urban policies typically have multiple goals, of which economic growth and competitiveness are certainly not the least important (see e.g. Jonas & Wilson, 1999; Puustinen et al. 2013), suggest that multiple interests interact. Indeed, the logic of land-use intensification has been argued to lie in growth and economic development (Wachsmut, 2016). Furthermore, the risk of sustainability remaining rhetoric or artificial add-on is probably heightened by the fact that local policy makers are likely the most interested in local, not global, effects. Especially climate change is a profoundly global issue and acting on it does not straightforwardly lead to tangible and local benefits that are clearly communicable to potential voters. Thus, the final verdict on the true potential of urban planning, and cities as actors, to contribute to sustainability cannot be given. However, it can still be concluded that increasing the awareness of the complexity can hopefully contribute to creating favorable conditions for more sustainable, even though not probably ultimately sustainable, planning.

Focus on influencing individuals and households

Even though many functions, such as commuting, are spatially bound to cities, it remains unknown whether the physical form or other spatial elements of the city per se are driving them. Instead, the drivers could be the people or processes taking place within cities. Subsequently, the results of the dissertation are not necessarily causal, mostly due to the residential self-selection problem. The existence of self-selection, that is, that people with similar lifestyles tend

to cluster, is a longstanding theoretical and empirical finding in the sociological literature, as an example (Schelling 1969; Pancs & Vriend 2007; Vickers & Rees 2007). The unobserved characteristics that are similar among people who have chosen to live in a certain residential location is problematic for research as it leads to the correlation of error terms and hinders the ability to detect true causalities. As stated, this notion naturally also applies to the results of this dissertation.

The most widely held causalities are also challenged when self-selection is taken into account. In their review of the literature, Cao et al. (2009) found that controlling for self-selection results in a less pronounced relationship between the built environment and travel outcomes. Due to self-selection, Browstone and Golob (2009) even end up concluding that the impacts of increased residential density are too small to make increasing density a relevant policy for reducing either the amount of vehicle driving or greenhouse gas emissions caused. However, their context was California and thus, the lower density of Finland is likely to offer greater room for maneuver when aiming to control residential driving emissions with land use planning. Furthermore, some results disputing the effect of self-selection have also been reported (e.g. Ewing & Cervero, 2010).

The relevance of focusing on influencing places rather than people is questioned by the results of this dissertation, since factors other than the level of urbanization were identified to be more important for the selected sustainability outcomes. The results are in line with those of Bento et al. (2005) and Lo (2016), who found individual and household level predictors to be more important than structural predictors. Also, Satterthwaite (2008) and Dodman (2009) argue that the efforts should focus on people with different income levels and different habits, instead of urban structures. Similarly, on a political level, it is argued that the mitigation efforts in cities are caused by the environmental preferences of voters, namely, individual characteristics, and so the realization of mitigation efforts is, in reality, indifferent to whether cities have implemented climate plans (Millard-Ball, 2012; 2013). Moreover, the literature on so -called neighborhood effects, in other words the possible effects that neighborhood environments have on people's lives, is inconclusive in its conclusions (Gibbons et al., 2013). The possible existence of such effects is a crucial issue for policy design - if the neighborhood effects do not exist, it suggests that the suitable antidotes for sustainability issues, such as segregation, are not to be targeted at areas but at households and individuals living in them.

Understand urban sustainability as a contested concept

Urban sustainability should be understood as a contested concept. Consequently, caution in its use, especially in the context of urban policy making, is needed. Treating it as essentially contested highlights the importance of the analysis of different "conceptions of the concept" and, especially, how those are put into practice via policy-making (Connelly, 2007). The ambiguity in definitions and lack of knowledge about tensions and conflicts in selected goals is not only a rhetorical issue, but it weakens sustainability as a policy goal (Connelly, 2007).

However, the point is not to argue that cities should not focus on things they can affect. Rather, the argument is that focusing on cities and urban planning is not sufficient to make sustainability statements. The widely used over-simplified rhetoric ignoring the inherent complexity and trade-offs in sustainability in general, and in urban sustainability in particular, decreases the legitimacy of urban sustainability policies, and avoids the true value-based selec-

tion of the policy goals. For example, taking a non-comprehensive perspective on urban sustainability, such as focusing only on improving density to decrease private driving, makes the possibility of win-win-win policies seem real (Connelly, 2007). Furthermore, if settling for only an aspect of sustainability, but associating it with wider sustainability, might give a false impression of the ability of urban planning to control for something as complex as sustainability. Then, incentives to develop complementary as well as substituting measures and policies might decrease. Urbanization unfolds on multiple scales and, therefore, needs to be addressed at these scales (Solecki et al., 2013).

The results of the dissertation are not meant to be used as straightforward inputs into policy making, as no simple sets of policy implications of sustainable urbanization are presented, nor even pursued. The aim is to highlight the need for a broader understanding of sustainability's different aspects and the impacts of the selected operationalizations. For example, using the consumption-based accounting is wished to stimulate the creation of innovative strategies across spatial scale to promote GHG mitigation (see also Ramaswami et al., 2012). Discussion within and between policy makers and citizens would be beneficial and improve the legitimacy of urban sustainability policies, and create a shared understanding about different sustainability measures, their operationalization, and implications. In other words, the decision on how urban sustainability is measured is a political, not a technical issue. Furthermore, public participation has been argued to facilitate and provide incentives for behavior change in practice (Caeiro et al., 2012).

Finally, and due to the contested nature of sustainability, no absolute position on what is sustainable is taken in this dissertation, as it is an entirely different challenge. In reality, all sustainability measures are just pure predictions of the characteristics of the system that might ultimately be sustainable (Costanza & Patten, 1995; Garnåsjordet et al., 2012).

4.1 Relevance

In this section, relevance is mostly referring to the relevance of the presented dissertation to research, even though some more practical and policy-related suggestion are also brought out. Spatial aspects have gained a permanent foothold in sustainability discussions, and perhaps the most common approach is to describe urban-rural differences in selected sustainability measures. In the realm of environmental sustainability, traditionally, urban living has been argued to be more energy-efficient than rural living (e.g. Herendeen & Tanaka, 1976; Vringer & Blok, 1995; Lenzen et al., 2006) and that urban per capita energy use in advanced, service-oriented economies is lower than national averages (Poumanyvong & Kaneko, 2010; Marcotullio et al., 2013). These, and other similar results have probably lead to the sustainability–density connection in urban policy making. The results of the dissertation question the wisdom of clinging to the assumption, as it was shown that when looking at the disaggregated or multiple sustainability measures, the role of urbanity in explaining sustainability outcomes is either relatively low, or in some cases, contradictory.

However, considering direct emissions, or any other distinct measure for that matter, is only one possible approach to sustainability, as has constantly been highlighted in this dissertation. Thus, the main relevance of this research lies in showing that utilizing even a limited set of sustainability indicators as opposed to a single indicator seems to indicate no clear urbanity – sustainability gradient. Secondly, it is argued that dichotomies such as “urban” and “rural” are

irrelevant to the type and scale of urbanization we are currently experiencing, and more detailed classifications that describe the structures within urban areas are more valuable for portraying and understanding the consequences of the current growth of urban populations. As was suggested in Paper II, even if the background variables of different urban groups can vary a lot, the outcomes can be surprisingly similar. Finally, the presented research can bridge the gap between discussions within different types of sustainability standpoints, which at the moment are sporadic at best. The systematic argumentation of the differences between scientific traditions or schools of thought and the reasons for them – for example, when it comes to principles of GHG calculations and derivable responsibilities – can hasten the emergence of a common understanding. At the very least, the results can act as a starting point for discussions between different schools of thought.

In addition to the collaborative contribution of this dissertation, each paper also presented novel contributions to the existing literature. Papers I-II adopted a disaggregated division into direct and indirect GHG emissions that has been used by other authors as well (e.g. Bin & Dowlatabadi, 2005; Druckman & Jackson, 2009). However, separate statistical analyses for disaggregated categories that allow for controlling the effects of background variables and that also reveal the sometimes contradictory relationships are much less common. Thus, this kind of approach that distinguishes between direct and indirect emissions allows for a more in-depth understanding of the drivers of different types of GHG emissions. The approach also allows for estimating the magnitudes of different types of mitigation efforts. Nevertheless, identifying suitable policy instruments for curbing the rather high shares of indirect emissions following private consumption, as an example, remains mostly out of the scope of this dissertation. However, in line with Heiskanen (2002), the merits of LCA are seen in its distinctive way to construct problems, and in raising awareness and motivating the responsibilities and capabilities of people.

Paper III innovatively bundled the relatively novel concept of the sharing economy or collaborative consumption, and consumption-based greenhouse gas impacts. The merit of the Paper lies in the notion of that especially dwellers in most urban areas could and should benefit from the rise of novel forms of sharing, as the typically smaller household leads to less within - household sharing of especially the most GHG-intensive goods, such as energy and housing. Furthermore, taking part in the sharing economy has been characterized as a communal act that links people (Belk 2010). Social contacts, in turn, are among the central dimensions of subjective wellbeing, as was also found in Paper IV, and therefore increasing intra-household sharing has the potential to alleviate both environmental and social sustainability problems in urban areas.

Paper IV looked into social sustainability and found that different measures of subjective wellbeing can produce contradictory results, especially in relation to spatial variables. To the best of my knowledge, this is among the first attempts to compare two subjective wellbeing measures in the Finnish context. Policy-wise, the main take-home message from this section is that there are drastic differences between the SWB measures, and using a single wellbeing item as a basis for policy development ignores the multifaceted nature of wellbeing. Results from wellbeing research can lead to the adoption of too simplistic an understanding of public policy, while the wellbeing measures should be used rather as inputs to the political and citizen discussions, and not as simple inputs to wellbeing functions that can be maximized by individual politicians and public officials (Frey & Stutzer, 2012). As the data used in Paper IV has a

stated objective to "inform policy-making by helping municipalities and regions to predict, follow, and prioritize actions to support resident's welfare and municipal vitality" (THL, 2016), the notion is especially relevant and timely.

Finally, the research has implications for researchers and policy makers in that it enables an identification of where further studies and actions are needed. Especially a re-orientation of sustainability policies to acknowledge the relevance of individual and household level over and above spatial position is called for. Another key message is that sustainability, and urban sustainability in particular, should not be reduced to a single measure but seen as a contested concept (Connelly 2007), where positions must always be located in relation to one another, and to the triple bottom line. Acknowledging this ambiguity in goals and their content is also essential in policy making.

4.2 Evaluation

This section evaluates the research's reliability, that is, the repeatability of the study, as well as its validity, that is, the extent to which the findings can be generalized. The focus is on the dissertation as a whole, as detailed evaluations of the individual studies can be found from each of the appended Papers. Three out of four Papers have been accepted for publication in peer-reviewed journals, which increases the confidence in the findings in the Papers and provides a solid base for building the argumentation in the current part of the dissertation.

The general **reliability** is evaluated first, followed by the internal and external validity evaluations. Internal validity refers to the validness for the population and settings studied, while external validity refers to the generalizability of the findings to other populations and settings (Stock & Watson, 2003). The chosen research strategy was quantitative in all of the papers, although some qualitative parts were also included, especially when interpreting the results and drawing the conclusions.

Quantitative measurement also carries some limitations and the usual problems with reliability relate to the ability of measures to produce the same results consistently (Ruane, 2004). Reliability is ensured by having a large enough sample size and utilizing sound methods. In this dissertation, sample sizes were adequate and varied from good (n=559 in Paper II) to excellent (almost 60 000 in Paper IV), being always adequate relative to the models used. In all the Papers, weights were applied, which should further ensure the representativeness. However, applying the weights to subsamples brings about some uncertainties, since the weights were originally constructed to be representative of the whole sample. Also, the methodological base of the individual papers and the sustainability measures utilized in each is sound and based on established traditions in the field. Still, they include some built-in uncertainties, which are discussed in depth in the appended Papers. For example, in E-E I-O model, homogeneity and linearity assumptions are the most problematic. Finally, it is acknowledged that analyzing the empirical relationships between variables brings about a static view of the social world, no matter how many quantitative researchers have reached certain conclusions using similar methods. Thus, the results are tied to the time at which the data were collected, and so future developments in lifestyles and technologies, for example, may impact future the results.

The **internal validity** of multiple regression studies can be threatened because of issues related to omitted variables, functional form misspecification, errors-in-variables, sample selection, and simultaneous causality (Stock & Watson, 2003). Of these, omitted variable bias was alleviated by theoretical work, and based on earlier literature, identifying the key variables

of interest, as well with reporting the effects of including and excluding variables in a transparent manner. Functional form misspecification and errors-in-variables are not likely problematic, as the form of the models and variables were based on earlier literature and established traditions in the field. Also, the sample selection is not a threat to internal validity, as external data sampled with carefully-designed procedures combined with utilizing weights in all papers should ensure the randomness of the samples. Probably the most likely threat is simultaneous causality, which means that there is a simultaneous causal link between the dependent and independent variables. However, the potential weak internal validity, traced to an inherent weakness of the calculation procedures of dependent variables that was discussed in detail in the Papers, deters us from making causal claims. Thus in this dissertation as a whole, as well as in the individual papers, the results are presented as descriptions of the existing empirical relationships, without aiming to make claims on causality. The broader level conclusions drawn in this compilation part are likewise rather stylized, and no causal claims are made.

External validity can be threatened by either differences in populations or differences in settings (Stock & Watson, 2003). However, the differences in populations is not likely a problem, as external datasets with a carefully-designed sampling procedure were utilized, and the weights provided with each dataset were used, making the results representative of the Finnish population. However, the generalizability of the specific results of the papers, or the general theoretical idea of the dissertation, to different settings is more or less limited; it is not known to what extent Finland is an adequate context for exploring the entire range of the urban-rural continuum as it exists in other global contexts. To give an extreme example, the population density at Manhattan is approximately 28,000 inhabitants per square kilometer, whereas the average density in Helsinki is one tenth of that – however, there are also a handful of neighborhoods where the density is higher than 20 000 inhabitants per sqkm. Another angle to the perhaps limited generalizability of the results comes from the different policy contexts and capacities both between countries and areas within them. When reflecting the rural urban differences, different national political and institutional contexts (for example centralism versus federalism) mean that municipal and regional governance institutions, and planning institutions in particular, in some cases have relatively similar policy capacities across the urbanization gradient, and in other cases there are significant differences. For example, Puustinen et al. (2017) argue that in Finland, small size of local governments and narrow industrial base are risk factors that may lead to major private sector pressures.

It has been suggested that that the transferability of place-based research can be estimated by identifying similar patterns of land use, and environmental and socioeconomic conditions (Václavík et al., 2016). Taking into account the nature of this research, sociocultural conditions would probably be a relevant addition to the list. Thus, the main argumentation, or the theoretical idea, of the dissertation, namely, that many urban sustainability statements are overused but under-analyzed, and that, urban sustainability should be understood and treated as a contested concept, is likely to be generalizable at least to similar institutional contexts, such as to other Nordic countries. However, there are also somewhat similar results from the USA, which, however, also suggest that the inverted-U relationship between GHGs and density may not hold at moderately increased population densities, but only at extremely population-dense metropolitan areas, or megacities (Jones & Kammen, 2014).

The key phenomenon in the dissertation, urbanization, is here described with varying terms. In addition to being a strength, expanding the scope of the studies, this can also be considered to cause some uncertainties in the results and their cross-comparisons. Furthermore, the scope

of each urbanity classification is based on either administrative borders, or on a slightly more detailed classification, while multiple other possible factors that can differentiate areas are not taken into account. For example, the amount of mixed-use structure was not taken into account. Also more detailed description of connectivity could be relevant to the phenomena studied, as it can affect both GHG emissions (Gehl, 2013) and social wellbeing due to increased interaction in the neighborhood (Putnam, 2000). Also factors such as shape, irregularity and ruggedness of urban settlement patches, and mono-centrism have been considered in earlier literature (e.g. Makido et al., 2012).

4.3 Future research recommendations

Papers I-IV all include suggestions for future research, and here the most important of those, as well as some recent ideas, are brought forward.

Firstly, the use of methods from the field of future studies to explore the phenomena explored in this dissertation would be beneficial. The epistemology of future studies is quite compatible with the consumer-centric approach of this dissertation, as it shares the implicit faith in our ability to control our own lives and to strive toward a better world both individually and collectively (Flechtheim, 1971; Helmer, 1983; Bell, 2003). As Hertwich (2005a) likewise highlights, research based on the current situation, for example, combining expenditure surveys and LCAs as in Papers I-III, is mostly descriptive; scenario analysis and back-casting and other strategic and long-range methods would support the use of results in decision-making.

Secondly, an interesting avenue for related research would be combining the environmental, social, and economic measures, and even develop new sustainability measures. Some potential ideas and novel conceptualization that are worth looking into have already been suggested, and these include, for example, the Efficient Wellbeing (EWEB) approach by Dietz et al. (2009) and the Sustainable Wellbeing Index (SWI) by Costanza et al. (2016). Both approaches take into account the interdependencies between different economic, social, and environmental elements, and highlight structural changes that can be made that will improve human wellbeing without increasing the impact on the environment and help in the search for balanced prosperity, equality and sustainability.

Finally, and perhaps most importantly, theoretical research and theory building on (urban) sustainability is called for. Studies based only on empirical observations and analyses of empirical relationships, no matter their rigorousness, are an insufficient basis for drawing confident conclusions, and further development of the theory of urban sustainability, or unsustainability for that matter, is needed.

References

Arifwidodo, S. D. (2012). Exploring the effect of compact development policy to urban quality of life in Bandung, Indonesia. *City, Culture and Society*, 3(4), 303-311.

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, 95(9), 1082-1095.

Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A., ... & Edenhofer, O. (2014). *IPCC Fifth Assessment Synthesis Report-Climate Change 2014 Synthesis Report*.

Anderson, J. E., Wulfhorst, G., & Lang, W. (2015). Energy analysis of the built environment—A review and outlook. *Renewable and Sustainable Energy Reviews*, 44, 149-158.

Angelo, H., & Wachsmuth, D. (2015). Urbanizing urban political ecology: A critique of methodological cityism. *International Journal of Urban and Regional Research*, 39(1), 16-27.

Arthur, W. B. (1989), Competing technologies, increasing returns and lock-in by historical events. *The Economic Journal*, 99(394), 116–131.

Bacharach, S. B. (1989). Organizational theories: Some criteria for evaluation. *Academy of management review*, 14(4), 496-515.

Baiocchi, G., Minx, J., & Hubacek, K. (2010). The impact of social factors and consumer behavior on carbon dioxide emissions in the United Kingdom. *Journal of Industrial Ecology*, 14(1), 50-72.

Baum-Snow, N., and Pavan, R. (2013). Inequality and city size. *Review of Economics and Statistics*, 95(5), 1535-1548.

Baum-Snow, N., Freedman, M., & Pavan, R. (2014). Why has urban inequality increased. *Processed, Providence, Brown University*.

Belk, R. (2010). Sharing. *Journal of consumer research*, 36(5), 715-734.

Bell, W. (2003). Foundations of Futures Studies: History, Purposes, and Knowledge, Volume 1: Human Science for a New Era.

Benders, R. M., Moll, H. C., & Nijdam, D. S. (2012). From energy to environmental analysis. *Journal of industrial ecology*, 16(2), 163-175.

Bento, A. M., Cropper, M. L., Mobarak, A. M., & Vinha, K. (2005). The effects of urban spatial structure on travel demand in the United States. *Review of Economics and Statistics*, 87(3), 466-478.

Berkhout, F., Hertin, J., & Jordan, A. (2002). Socio-economic futures in climate change impact assessment: using scenarios as 'learning machines'. *Global Environmental Change*, 12(2), 83-95.

Berry, B. J., and Okulicz-Kozaryn, A. (2011). An urban-rural happiness gradient. *Urban geography*, 32(6), 871-883.

Berthe, A., & Elie, L. (2015). Mechanisms explaining the impact of economic inequality on environmental deterioration. *Ecological Economics*, 116, 191-200.

Bettencourt L. M. A., J. Lobo, D. Helbing, C. Kühnert, and G. B. West (2007). Growth, innovation, scaling, and the pace of life in cities. *Proceedings of the National Academy of Sciences*, 104, 7301–7306.

Bin, S., & Dowlatabadi, H. (2005). Consumer lifestyle approach to US energy use and the related CO 2 emissions. *Energy Policy*, 33(2), 197-208.

Blanchflower, D. G., and Oswald, A. J. (2004). Money, sex and happiness: An empirical study. *The Scandinavian Journal of Economics*, 106(3), 393-415.

Bloom, D. E., Canning, D., & Fink, G. (2008). Urbanization and the wealth of nations. *Science*, 319(5864), 772-775.

Boyce, J. K. (1994). Inequality as a cause of environmental degradation. *Ecological Economics*, 11(3), 169-178

Braathen, N. A. (2011). Interactions between emission trading systems and other overlapping policy instruments.

Bradbury, M., Peterson, M. N., & Liu, J. (2014). Long-term dynamics of household size and their environmental implications. *Population and Environment*, 36(1), 73-84.

Bramley, G., & Power, S. (2009). Urban form and social sustainability: the role of density and housing type. *Environment and Planning B: Planning and Design*, 36(1), 30-48.

Bramley, G., Dempsey, N., Power, S., Brown, C., & Watkins, D. (2009). Social sustainability and urban form: evidence from five British cities. *Environment and Planning A*, 41(9), 2125-2142.

Brandon, P. S., & Lombardi, P. (2010). Evaluating sustainable development in the built environment. John Wiley & Sons.

Brown, K. W., & Kasser, T. (2005). Are psychological and ecological well-being compatible? The role of values, mindfulness, and lifestyle. *Social Indicators Research*, 74(2), 349-368.

Brownstone, D., & Golob, T. F. (2009). The impact of residential density on vehicle usage and energy consumption. *Journal of Urban Economics*, 65(1), 91-98.

Brundtland, G., Khalid, M., Agnelli, S., Al-Athel, S., Chidzero, B., Fadika, L., ... & Singh, M. (1987). Our common future (\'brundtland report\').

Bryman, A., & Bell, E. (2015). Business research methods. Oxford University Press, USA.

Burton, E. (2003). Housing for an urban renaissance: implications for social equity. *Housing Studies*, 18(4), 537-562.

Büchs, M., & Schnepf, S. V. (2013). Who emits most? Associations between socio-economic factors and UK households' home energy, transport, indirect and total CO2 emissions. *Ecological Economics*, 90, 114-123.

Caeiro, S., Ramos, T. B., & Huisingh, D. (2012). Procedures and criteria to develop and evaluate household sustainable consumption indicators. *Journal of Cleaner Production*, 27, 72-91.

Camfield, L., and Skevington, S. M. (2008). On subjective well-being and quality of life. *Journal of Health Psychology*, 13(6), 764-775.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2009). Examining the impacts of residential self-selection on travel behaviour: A focus on empirical findings. *Transport Reviews*, 29(3), 359–395.

Caporale, G. M., Georgellis, Y., Tsitsianis, N., and Yin, Y. P. (2009). Income and happiness across Europe: Do reference values matter?. *Journal of Economic Psychology*, 30(1), 42-51.

Chen, C. C., & Petrick, J. F. (2013). Health and wellness benefits of travel experiences a literature review. *Journal of Travel Research*, 52(6), 709-719.

Chitnis, M., Sorrell, S., Druckman, A., Firth, S. K., & Jackson, T. (2014). Who rebounds most? Estimating direct and indirect rebound effects for different UK socioeconomic groups. *Ecological Economics*, 106, 12-32.

Ciccone, A., & Hall, R.E. (1996). Productivity and the density of economic activity. *American Economic Review*, 86 (1), 54–70.

Clark, D., & McGillivray, M. (2007). Measuring human well-being: key findings and policy lessons. UNU-WIDER.

Connelly, S. (2007). Mapping sustainable development as a contested concept. *Local Environment*, 12(3), 259-278.

Costanza, R., & Patten, B. C. (1995). Defining and predicting sustainability. *Ecological Economics*, 15(3), 193-196.

Costanza, R., Daly, L., Fioramonti, L., Giovannini, E., Kubiszewski, I., Mortensen, L. F., ... & Wilkinson, R. (2016). Modelling and measuring sustainable wellbeing in connection with the UN Sustainable Development Goals. *Ecological Economics*, 130, 350-355.

Covenant of Mayors. 2016. The Covenant of Mayors for Climate & Energy [online]. Available from: http://mayors-adapt.eu/wp-content/uploads/2016/05/Covenant-leaflet-1page-version.pdf

Cramer, V., Torgersen, S., & Kringlen, E. (2004). Quality of life in a city: The effect of population density. *Social Indicators Research*, 69(1), 103-116.

Creutzig, F., Agoston, P., Minx, J. C., Canadell, J. G., Andrew, R. M., Le Quéré, C., ... & Dhakal, S. (2016). Urban infrastructure choices structure climate solutions. *Nature Climate Change*, 6(12), 1054-1056.

Curran, S. R., & de Sherbinin, A. (2004). Completing the picture: the challenges of bringing "consumption" into the population–environment equation. *Population and Environment*, 26(2), 107-131.

Davis, S. J., K. Caldeira, and H. D. Matthews (2010), Future CO2 emissions and climate change from existing energy infrastructure. *Science*, 329(5997), 1330.

Deetman, S., Hof, A. F., Pfluger, B., van Vuuren, D. P., Girod, B., & van Ruijven, B. J. (2013). Deep greenhouse gas emission reductions in Europe: Exploring different options. *Energy Policy*, 55, 152-164.

Dempsey, N., Bramley, G., Power, S., & Brown, C. (2011). The social dimension of sustainable development: Defining urban social sustainability. *Sustainable development*, 19(5), 289-300.

Di Tella, R., MacCulloch, R. J., & Oswald, A. J. (2003). The macroeconomics of happiness. *Review of Economics and Statistics*, 85(4), 809-827.

Diener, E., and Seligman, M. E. (2004). Beyond money toward an economy of well-being. *Psychological science in the public interest*, 5(1), 1-31.

Diener, E., Scollon, C. N., & Lucas, R. E. (2009). The evolving concept of subjective well-being: The multifaceted nature of happiness. In *Assessing well-being* (pp. 67-100). Springer Netherlands.

Dietz, T., Rosa, E. A., & York, R. (2009). Environmentally efficient well-being: Rethinking sustainability as the relationship between human well-being and environmental impacts. *Human Ecology Review*, 16(1), 114-123.

Dodman, D. (2009). Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories. *Environment and Urbanization*, 21(1), 185-201.

Dolan, P., Peasgood, T., & White, M. (2008). Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective well-being. *Journal of economic psychology*, 29(1), 94-122.

Druckman, A., & Jackson, T. (2009). The carbon footprint of UK households 1990–2004: a socio-economically disaggregated, quasi-multi-regional input–output model. *Ecological Economics*, 68(7), 2066-2077.

Druckman, A., & Jackson, T. (2010). The bare necessities: How much household carbon do we really need?. *Ecological Economics*, 69(9), 1794-1804.

Druckman, A., & Jackson, T. (2016). Understanding Households as Drivers of Carbon Emissions. In *Taking Stock of Industrial Ecology* (pp. 181-203). Springer International Publishing.

Druckman, A., Chitnis, M., Sorrell, S., & Jackson, T. (2011). Missing carbon reductions? Exploring rebound and backfire effects in UK households. *Energy Policy*, 39(6), 3572-3581.

Duranton G., and D. Puga (2004). Micro-foundations of urban agglomeration economies. In: Handbook of Regional and Urban Economics. J.V. Henderson, J.-F. Thisse, (eds.), Elsevier, pp. 2063–2117. ISBN: 9780444509673.

Easterlin, R. A. (1974). Does economic growth improve the human lot? Some empirical evidence. *Nations and households in economic growth*, 89, 89-125.

Easterlin, R. A. (1995). Will raising the incomes of all increase the happiness of all?. *Journal of Economic Behavior & Organization*, 27(1), 35-47.

Easterlin, R. A., Angelescu, L., and Zweig, J. S. (2011). The impact of modern economic growth on urban–rural differences in subjective well-being. *World development*, 39(12), 2187-2198.

Eurostat, 2017. Quality of life in Europe - facts and views - overall life satisfaction. [referred: 15.1.2017]. Access method: http://ec.europa.eu/eurostat/statistics-explained/index.php/Quality_of_life_in_Europe_-_facts_and_views_-_overall_life_satisfaction

Ewing, R., & Cervero, R. (2010). Travel and the built environment: a meta-analysis. *Journal of the American planning association*, 76(3), 265-294.

Ewing, R., & Rong, F. (2008). The impact of urban form on US residential energy use. *Housing policy debate*, 19(1), 1-30.

Fercovic, J., & Gulati, S. (2016). Comparing household greenhouse gas emissions across Canadian cities. *Regional Science and Urban Economics*, 60, 96-111.

Ferrer-i-Carbonell, A., & van den Bergh, J. C. (2004). A micro-econometric analysis of determinants of unsustainable consumption in the Netherlands. *Environmental and Resource Economics*, 27(4), 367-389.

Flechtheim, O. K. (1971). Futurologie: der Kampf um die Zukunft. Verlag Wissenschaft und Politik.

Florida, R., Mellander, C., & Stolarick, K. (2008). Inside the black box of regional development—human capital, the creative class and tolerance. *Journal of economic geography*, 8(5), 615-649.

Frey, B. S., & Stutzer, A. (2002). What can economists learn from happiness research?. *Journal of Economic literature*, 40(2), 402-435.

Frey, B. S., & Stutzer, A. (2012). The use of happiness research for public policy. *Social Choice and Welfare*, 38(4), 659-674.

Friedrichs, J., & Inderwildi, O. R. (2013). The carbon curse: Are fuel rich countries doomed to high CO2 intensities?. *Energy Policy*, 62, 1356-1365.

Fujita M., and J.-F. Thisse (1996). Economics of agglomeration. *Journal of the Japanese and International Economies,* 10, 339–378.

Fuller, R. J., & Crawford, R. H. (2011). Impact of past and future residential housing development patterns on energy demand and related emissions. *Journal of housing and the built environment*, 26(2), 165-183.

Garnåsjordet, P. A., Aslaksen, I., Giampietro, M., Funtowicz, S., & Ericson, T. (2012). Sustainable development indicators: from statistics to policy. *Environmental Policy and Governance*, 22(5), 322-336.

Gehl, J. (2013). Cities for people. Island press.

Gibbons, S., Silva, O., & Weinhardt, F. (2013). Everybody needs good neighbours? Evidence from students' outcomes in England. *The Economic Journal*, 123(571), 831-874.

Girod, B., van Vuuren, D. P., & Hertwich, E. G. (2014). Climate policy through changing consumption choices: Options and obstacles for reducing greenhouse gas emissions. *Global Environmental Change*, 25, 5-15.

Glaeser, E. L., & Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of Economic Literature*, 47(4), 983-1028.

Glaeser, E. L., & Kahn, M. E. (2010). The greenness of cities: carbon dioxide emissions and urban development. *Journal of Urban Economics*, 67(3), 404-418.

Glaeser, E. L., Kolko, J., & Saiz, A. (2001). Consumer city. *Journal of economic geography*, 1(1), 27-50.

Global Footprint Network, 2017. Finland. [referred: 15.1.2017]. Access method: http://www.footprintnetwork.org/en/index.php/GFN/page/trends/finland/

Glucksmann, M. A. (2014). Bake or buy? Comparative and theoretical perspectives on divisions of labour in food preparation work. *Anthropology of food*, (S10).

Gough, I., Abdallah, S., Johnson, V., Ryan-Collins, J., & Smith, C. (2011). The distribution of total greenhouse gas emissions by households in the UK, and some implications for social policy. *LSE STICERD Research Paper No. CASE152*.

Gould, E. D., & Hijzen, A. (2016). Growing Apart, Losing Trust? The Impact of Inequality on Social Capital.

Harris, J. R., & Todaro, M. P. (1970). Migration, unemployment and development: a two-sector analysis. *The American economic review*, 126-142.

Heerink, N., Mulatu, A., & Bulte, E. (2001). Income inequality and the environment: aggregation bias in environmental Kuznets curves. *Ecological Economics*, 38(3), 359-367.

Heinonen, J., & Junnila, S. (2011). A carbon consumption comparison of rural and urban lifestyles. *Sustainability*, 3(8), 1234-1249.

Heinonen, J., & Junnila, S. (2011). Case study on the carbon consumption of two metropolitan cities. *The International Journal of Life Cycle Assessment*, 16(6), 569-579.

Heinonen, J., & Junnila, S. (2011). Implications of urban structure on carbon consumption in metropolitan areas. *Environmental Research Letters*, 6(1), 014018.

Heiskanen, E. (2002). The institutional logic of life cycle thinking. *Journal of Cleaner Production*, 10(5), 427-437.

Helmer, O., & Helmer-Hirschberg, O. (1983). Looking forward: a guide to futures research. Sage Publications, Inc.

Herendeen, R., & Tanaka, J. (1976). Energy cost of living. *Energy*, 1(2), 165-178.

Hertwich, E. G. (2005a). Life cycle approaches to sustainable consumption: a critical review. *Environmental science & technology*, 39(13), 4673-4684.

Hertwich, E. G. (2005b). Consumption and the rebound effect: An industrial ecology perspective. *Journal of industrial ecology*, 9(1-2), 85-98.

Holden, E., & Norland, I. T. (2005). Three challenges for the compact city as a sustainable urban form: household consumption of energy and transport in eight residential areas in the greater Oslo region. *Urban studies*, 42(12), 2145-2166.

Hoornweg, D. (Ed.). (2011). Cities and climate change: responding to an urgent agenda. *World Bank Publications*.

Inglehart, R. (1997). Modernization and postmodernization: Cultural, economic, and political change in 43 societies (Vol. 19). Princeton, NJ: Princeton University Press

Jackson, T. (2005). Live better by consuming less?: is there a "double dividend" in sustainable consumption?. Journal of Industrial Ecology, 9(1-2), 19-36.

Jarvis, H. (2015). Towards a deeper understanding of the social architecture of co-housing: evidence from the UK, USA and Australia. *Urban Research & Practice*, 8(1), 93-105.

Jenks, M., Burton, E., Williams, K., & Symes, M. (1997). The Compact City: A Sustainable Urban Form?. *Land Use Policy*, 14(3), 215.

Jiang, L., & O'Neill, B. C. (2015). Global urbanization projections for the Shared Socioeconomic Pathways. *Global Environmental Change*.

Jonas, A. E., & Wilson, D. (1999). The urban growth machine: Critical perspectives, two decades later. *Suny press*.

Jones, C. M., & Kammen, D. M. (2011). Quantifying carbon footprint reduction opportunities for US households and communities. *Environmental science & technology*, 45(9), 4088-4095.

Jones, C., & Kammen, D. M. (2014). Spatial distribution of US household carbon footprints reveals suburbanization undermines greenhouse gas benefits of urban population density. *Environmental science & technology*, 48(2), 895-902.

Jones, D. W. (2004). Urbanization and energy. *Encyclopedia of energy*, 6(1-6), 329-35.

Jorgenson, A. K. (2014). Economic development and the carbon intensity of human well-being. *Nature Climate Change*, 4(3), 186-189.

Joye, Y. (2007). Architectural lessons from environmental psychology: The case of biophilic architecture. *Review of General Psychology*, 11(4), 305.

Joye, Y., & Van den Berg, A. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry & Urban Greening*, 10(4), 261-268.

Kahneman, D., & Deaton, A. (2010). High income improves evaluation of life but not emotional well-being. *Proceedings of the national academy of sciences*, 107(38), 16489-16493.

Kaplan, R., & Kaplan, S. (1989). The experience of nature: A psychological perspective. CUP Archive.

Kerkhof, A. C., Benders, R. M., & Moll, H. C. (2009). Determinants of variation in household CO 2 emissions between and within countries. *Energy Policy*, 37(4), 1509-1517

Keyfitz, N. (1980). Do cities grow by natural increase or by migration?. *Geographical Analysis*, 12(2), 142-156.

Kitamura, R., Akiyama, T., Yamamoto, T., & Golob, T. (2001). Accessibility in a metropolis: Toward a better understanding of land use and travel. *Transportation Research Record: Journal of the Transportation Research Board*, (1780), 64-75.

Knight, K. W., & Rosa, E. A. (2011). The environmental efficiency of well-being: A cross-national analysis. *Social Science Research*, 40(3), 931-949.

Kyrö, R., Heinonen, J., Säynäjoki, A., & Junnila, S. (2011). Occupants have little influence on the overall energy consumption in district heated apartment buildings. *Energy and Buildings*, 43(12), 3484-3490.

Lenzen, M., Wier, M., Cohen, C., Hayami, H., Pachauri, S., & Schaeffer, R. (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. *Energy*, 31(2), 181-207.

Leontief, W. (1970). Environmental repercussions and the economic structure: an input-output approach. *The review of economics and statistics*, 262-271.

Li, N. P., and Kanazawa, S. (2016). Country roads, take me home… to my friends: How intelligence, population density, and friendship affect modern happiness. *British Journal of Psychology*.

Liddle, B. (2011), Consumption-driven environmental impact and age-structure change in OECD countries: A cointegration-STIRPAT analysis.

Lilius, J. (2014). Is there room for families in the inner city? Life-stage blenders challenging planning. *Housing Studies*, 29(6), 843-861.

Liu, L. (2015). A critical examination of the consumption-based accounting approach: has the blaming of consumers gone too far?. *Wiley Interdisciplinary Reviews: Climate Change*, 6(1), 1-8.

Lorek, S., & Spangenberg, J. H. (2014). Sustainable consumption within a sustainable economy–beyond green growth and green economies. *Journal of Cleaner Production*, 63, 33-44.

Lutsey, N., & Sperling, D. (2008). America's bottom-up climate change mitigation policy. *Energy Policy*, 36(2), 673-685.

Luttmer, E.F.P. (2005). Neighbors as negatives: Relative earnings and well-being. *Quarterly Journal of Economics*, 120(3), 963-1002.

MacKerron, G., & Mourato, S. (2009). Life satisfaction and air quality in London. *Ecological Economics*, 68(5), 1441-1453.

Magnani, E. (2000). The Environmental Kuznets Curve, environmental protection policy and income distribution. *Ecological Economics*, 32(3), 431-443.

Makido, Y., Dhakal, S., & Yamagata, Y. (2012). Relationship between urban form and CO 2 emissions: evidence from fifty Japanese cities. *Urban Climate*, 2, 55-67.

Marchetti, C. (1994). Anthropological invariants in travel behavior. *Technological forecasting and social change*, 47(1), 75-88.

Marcotullio, P. J., Hughes, S., Sarzynski, A., Pincetl, S., Sanchez Peña, L., Romero-Lankao, P., ... & Seto, K. C. (2014). Urbanization and the carbon cycle: Contributions from social science. *Earth's Future*, 2(10), 496-514.

Marcotullio, P. J., Sarzynski, A., Albrecht, J., Schulz, N., & Garcia, J. (2013). The geography of global urban greenhouse gas emissions: An exploratory analysis. *Climatic change*, 121(4), 621-634.

Martin, R., & Sunley, P. (2007). Complexity thinking and evolutionary economic geography. *Journal of Economic Geography*.

McCann, E. J. (2001). Collaborative Visioning or Urban Planning as Therapy? The Politics of Public-Private Policy Making. *The Professional Geographer*, 53(2), 207-218.

McDonald, R. I., Kareiva, P., & Forman, R. T. (2008). The implications of current and future urbanization for global protected areas and biodiversity conservation. *Biological conservation*, 141(6), 1695-1703.

McGranahan, G., & Satterthwaite, D. (2003). Urban centers: an assessment of sustainability. *Annual Review of Environment and Resources*, 28(1), 243-274.

Menz, T., & Welsch, H. (2012). Population aging and carbon emissions in OECD countries: Accounting for life-cycle and cohort effects. *Energy Economics*, 34(3), 842-849.

Millard-Ball, A. (2013). The limits to planning causal impacts of city climate action plans. *Journal of Planning Education and Research*, 33(1), 5-19.

Millard-Ball, A., (2012), Do city climate plans reduce emissions?, *Journal of Urban Economics*, 71 (3), 289–311.

Miller, R. E., & Blair, P. D. (2009). Input-output analysis: foundations and extensions. *Cambridge University Press*.

Minx, J., Baiocchi, G., Wiedmann, T., Barrett, J., Creutzig, F., Feng, K., ... & Hubacek, K. (2013). Carbon footprints of cities and other human settlements in the UK. *Environmental Research Letters*, 8(3), 035039.

Minx, J., Wiedmann, T., Wood, R., Peters, G., Lenzen, M., Owen, A., Scott, K., Barrett, J., Hubacek, K., Baiocchi, G., Paul, A., Dawkins, E., Briggs, J., Guan, D., Suh, S., Ackerman, F. (2009) Input-output analysis and carbon footprinting: an overview of applications, *Economic Systems Research*, Vol. 21(3), pp. 187–216.

Mogilner, C., & Norton, M. I. (2016). Time, money, and happiness. *Current Opinion in Psychology*, 10, 12-16.

Montgomery, M. R., Stren, R., Cohen, B., & Reed, H. E. (Eds.). (2003). Cities transformed: demographic change and its implications in the developing world. *National Academies Press*.

Moser, G. (2009). Quality of life and sustainability: Toward person–environment congruity. *Journal of Environmental Psychology*, 29(3), 351-357.

Myors, P., O'Leary, R., & Helstroom, R. (2005). Multi Unit Residential Buildings Energy & Peak Demand Study. *Energy News*, 23(4), 113-116.

Mäntysalo, R., & Saglie, I. L. (2010). Private influence preceding public involvement: Strategies for legitimizing preliminary partnership arrangements in urban housing planning in Norway and Finland. *Planning Theory & Practice*, 11(3), 317-338.

Mäntysalo, R., Jarenko, K., Nilsson, K. L., & Saglie, I. L. (2015). Legitimacy of Informal Strategic Urban Planning—Observations from Finland, Sweden and Norway. *European Planning Studies*, 23(2), 349-366.

Naess, P. (2012). Urban form and travel behavior: Experience from a Nordic context. *Journal of Transport and Land Use*, 5(2), 21-45.

Næss, P. (2016). Built environment, causality and urban planning. *Planning Theory & Practice*, 17(1), 52-71.

Naisbitt, John (1982), Megatrends: Ten New Directions Transforming Our Lives. New York, NY: Warner Books

Neuman, M. (2005). The compact city fallacy. *Journal of planning education and research*, 25(1), 11-26.

Newman, P., & Kenworthy, J. (2006). Urban design to reduce automobile dependence. *Opolis*, 2(1).

Newton, P., & Meyer, D. (2012). The determinants of urban resource consumption. *Environment and behavior*, 44(1), 107-135.

Nissinen, A., Heiskanen, E., Perrels, A., Berghäll, E., Liesimaa, V., & Mattinen, M. K. (2015). Combinations of policy instruments to decrease the climate impacts of housing, passenger transport and food in Finland. *Journal of Cleaner Production*, 107, 455-466.

Nuissl, H., Haase, D., Lanzendorf, M., & Wittmer, H. (2009). Environmental impact assessment of urban land use transitions—A context-sensitive approach. *Land use policy*, 26(2), 414-424.

O'Neill, B. C., Dalton, M., Fuchs, R., Jiang, L., Pachauri, S., & Zigova, K. (2010). Global demographic trends and future carbon emissions. *Proceedings of the National Academy of Sciences*, 107(41), 17521-17526.

Orians, G. H., & Heerwagen, J. H. (1992). Evolved responses to landscapes.

OSF, Official Statistics of Finland (2017). Population structure [e-publication]. Helsinki. [referred: 15.1.2017]. Access method: http://www.stat.fi/til/vaerak/index_en.html

Ottelin, J., Heinonen, J. & Junnila, S. 2017, 'Rebound effect for reduced car ownership and driving', in: Nordic Experiences of Sustainable Planning: Policy and Practice, ed: Sigríður Kristjánsdóttir, Routledge's book series on Urban planning and environment. In press.

Ottelin, J., Heinonen, J., & Junnila, S. (2014). Greenhouse gas emissions from flying can offset the gain from reduced driving in dense urban areas. *Journal of Transport Geography*, 41, 1-9.

Pachauri, S. (2004). An analysis of cross-sectional variations in total household energy requirements in India using micro survey data. *Energy Policy*, 32(15), 1723-1735.

Pancs, R., & Vriend, N. J. (2007). Schelling's spatial proximity model of segregation revisited. *Journal of Public Economics*, 91(1), 1-24.

Pavot, W., Diener, E. D., Colvin, C. R., & Sandvik, E. (1991). Further validation of the satisfaction with life scale: Evidence for the cross-method convergence of well-being measures. *Journal of personality assessment*, 57(1), 149-161.

Peiro, A. (2006). Happiness, satisfaction and socio-economic conditions: Some international evidence. *The Journal of Socio-Economics*, 35(2), 348-365.

Perkins, A., Hamnett, S., Pullen, S., Zito, R., & Trebilcock, D. (2009). Transport, housing and urban form: the life cycle energy consumption and emissions of city centre apartments compared with suburban dwellings. *Urban Policy and Research*, 27(4), 377-396.

Peters, G. P., & Hertwich, E. G. (2008). CO2 embodied in international trade with implications for global climate policy. *Environmental science & technology*, 42(5), 1401-1407.

Peters, G. P., Minx, J. C., Weber, C. L., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences*, 108(21), 8903-8908.

Peterson, C., Park, N., and Seligman, M. E. (2005). Orientations to happiness and life satisfaction: The full life versus the empty life. *Journal of happiness studies*, 6(1), 25-41.

Plepys, A., Heiskanen, E., & Mont, O. (2015). European policy approaches to promote servicizing. *Journal of Cleaner Production*, 97, 117-123.

Portney, K. E. (2013). Taking sustainable cities seriously: Economic development, the environment, and quality of life in American cities. MIT Press.

Poumanyvong, P., & Kaneko, S. (2010). Does urbanization lead to less energy use and lower CO 2 emissions? A cross-country analysis. *Ecological Economics*, 70(2), 434-444.

Puga D. (2010). The magnitude and causes of agglomeration economies. *Journal of Regional Science*, 50, 203–219.

Putnam, R. D. (2000). Bowling alone: America's declining social capital. In *Culture and Politics* (pp. 223-234). Palgrave Macmillan US.

Puustinen, S., Hirvonen, J., Niemi, P., & Mäntysalo, R. (2013). Selvitys alueidenkäytön suunnittelun ja ohjauksen voimavaroista.

Puustinen, S., Mäntysalo, R., Hytönen, J., & Jarenko, K. (2016). The "deliberative bureaucrat": deliberative democracy and institutional trust in the jurisdiction of the Finnish planner. *Planning Theory & Practice*, 1-18.

Ramaswami, A., Hillman, T., Janson, B., Reiner, M., & Thomas, G. (2008). A demand-centered, hybrid life-cycle methodology for city-scale greenhouse gas inventories. *Environmental science & technology*, 42(17), 6455-6461.

Rauland, V., & Newman, P. (2015). Why Cities?. In *Decarbonising cities* (pp. 19-35). Springer International Publishing.

Rees, W., & Wackernagel, M. (2008). Urban ecological footprints: why cities cannot be sustainable—and why they are a key to sustainability. In *Urban Ecology* (pp. 537-555). Springer US.

Rehdanz, K., & Maddison, D. (2005). Climate and happiness. *Ecological Economics*, 52(1), 111-125.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., ... & Nykvist, B. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472-475.

Rogers, D. S., Duraiappah, A. K., Antons, D. C., Munoz, P., Bai, X., Fragkias, M., & Gutscher, H. (2012). A vision for human well-being: transition to social sustainability. *Current Opinion in Environmental Sustainability*, 4(1), 61-73.

Rosenthal, S. S., & Strange, W. C. (2001). The determinants of agglomeration. *Journal of Urban Economics*, 50(2), 191-229.

Ruane, J. M. (2004). Essentials of research methods: a guide to social research, Wiley-Blackwell.

Sachs, J. D., Schmidt-Traub, G., & Durand-Delacre, D. (2016). Preliminary Sustainable Development Goal (SDG) Index and Dashboard. *SDSN Working Paper*, 15 February.

Satterthwaite, D. (2008). Cities' contribution to global warming: notes on the allocation of greenhouse gas emissions. *Environment and urbanization*, 20(2), 539-549.

Schanes, K., Giljum, S., & Hertwich, E. (2016). Low carbon lifestyles: A framework to structure consumption strategies and options to reduce carbon footprints. *Journal of Cleaner Production*, 139, 1033-1043.

Schelling, T. C. (1969). Models of segregation. The American Economic Review, 59(2), 488-493.

Schrader, U., & Thøgersen, J. (2011). Putting sustainable consumption into practice. *Journal of consumer policy*, 34(1), 3-8.

Scruggs, L. A. (1998). Political and economic inequality and the environment. *Ecological Economics*, 26(3), 259-275.

Sekulova, F., & van den Bergh, J. C. (2013). Climate change, income and happiness: An empirical study for Barcelona. *Global environmental change*, 23(6), 1467-1475.

Seppälä, J., Mäenpää, I., Koskela, S., Mattila, T., Nissinen, A., Katajajuuri, J. M., ... & Virtanen, Y. (2011). An assessment of greenhouse gas emissions and material flows caused by the Finnish economy using the ENVIMAT model. *Journal of Cleaner Production*, 19(16), 1833-1841.

Solecki, W., Seto, K. C., & Marcotullio, P. J. (2013). It's time for an urbanization science. *Environment: Science and Policy for Sustainable Development*, 55(1), 12-17.

Seto, K. C., Sánchez-Rodríguez, R., & Fragkias, M. (2010). The new geography of contemporary urbanization and the environment. *Annual review of environment and resources*, 35, 167-194.

Seto K.C., S. Dhakal, A. Bigio, H. Blanco, G.C. Delgado, D. Dewar, L. Huang, A. Inaba, A. Kansal, S. Lwasa, J.E. McMahon, D.B. Müller, J. Murakami, H. Nagendra, and A. Ramaswami, 2014: Human Settlements, Infrastructure and Spatial Planning. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Simmie, J. (2003). Planning at the Crossroads. Routledge.

Sovacool, B. K., & Brown, M. A. (2010). Twelve metropolitan carbon footprints: A preliminary comparative global assessment. *Energy Policy*, 38(9), 4856-4869.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 1259855.

Stock, J. H., & Watson, M. W. (2003). Introduction to econometrics (Vol. 104). Boston: Addison Wesley.

Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of economic geography*, 4(4), 351-370.

Strandell, A., & Hall, C. M. (2015). Impact of the residential environment on second home use in Finland–Testing the compensation hypothesis. *Landscape and Urban Planning*, 133, 12-23.

Su, B., Huang, H. C., Ang, B. W., & Zhou, P. (2010). Input–output analysis of CO 2 emissions embodied in trade: the effects of sector aggregation. *Energy Economics*, 32(1), 166-175.

Suh, S., Lenzen, M., Treloar, G. J., Hondo, H., Horvath, A., Huppes, G., ... & Munksgaard, J. (2004). System boundary selection in life-cycle inventories using hybrid approaches. *Environmental Science & Technology*, 38(3), 657-664.

Säynäjoki, A., Heinonen, J., & Junnila, S. (2012). A scenario analysis of the life cycle greenhouse gas emissions of a new residential area. *Environmental Research Letters*, 7(3), 034037.

Säynäjoki, E. S. (2015). The Untapped Potential of Urban Planning: Achieving Greater Success in Environmental Sustainability.

Taniguchi, M., & Ikeda, T. (2005). The compact city as a means of reducing reliance on the car: A model-based analysis for sustainable urban layout. *Spatial Planning, Urban Form and Sustainable Transport*, Ashgate, Aldershot, pp139–150.

Tarr, J. A. (1984). The search for the ultimate sink: Urban air, land, and water pollution in historical perspective. Records of the Columbia Historical Society, Washington, DC, 51, 1-29.

Taylor, P. J. (2004). World city network: a global urban analysis. Psychology Press.

THL, https://www.thl.fi/fi/web/thlfi-en/research-and-expertwork/population-studies/ath-health-and-well-being-for-residents/context-and-objectives Accessed 29.9.2016.

Tukker, A. (2015). Product services for a resource-efficient and circular economy–a review. *Journal of Cleaner Production*, 97, 76-91.

Tukker, A., & Jansen, B. (2006). Environmental impacts of products: A detailed review of studies. *Journal of Industrial Ecology*, 10(3), 159-182.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In Behavior and the natural environment (pp. 85-125). Springer US.

Ulrich, R. S. (1986). Human responses to vegetation and landscapes. *Landscape and urban planning*, 13, 29-44.

Underwood, A., & Zahran, S. (2015). The carbon implications of declining household scale economies. *Ecological Economics*, 116, 182-190.

United Nations, 1992. Results of the World Conference on Environment and Development: Agenda 21. UNCED United Nations Conference on Environment and Development, Rio de Janeiro, United Nations, New York.

United Nations, 2015. Transforming our World: The 2030 Agenda for Sustainable Development. Outcome Document for the UN Summit to Adopt the Post-2015 Development Agenda: Draft for Adoption. New York. 2015.

Unruh, G. C., & Carrillo-Hermosilla, J. (2006). Globalizing carbon lock-in. *Energy Policy*, 34(10), 1185-1197.

Wachsmuth, D. (2016). Competitive multi-city regionalism: growth politics beyond the growth machine. *Regional Studies*, 51(4), 643-653.

Wachsmuth, D., Cohen, D. A., & Angelo, H. (2016). Expand the frontiers of urban sustainability. *Nature*, 536(7617), 391-393.

Václavík, T., Langerwisch, F., Cotter, M., Fick, J., Häuser, I., Hotes, S., ... & Seppelt, R. (2016). Investigating potential transferability of place-based research in land system science. *Environmental Research Letters*, 11(9), 095002.

Valentin, A., & Spangenberg, J. H. (2000). A guide to community sustainability indicators. *Environmental Impact Assessment Review*, 20(3), 381-392.

Wang, F., & Wang, D. (2016). Geography of urban life satisfaction: An empirical study of Beijing. *Travel Behaviour and Society*, 5, 14-22.

Warde, A. (1992). Notes on the relationship between production and consumption. In *Consumption and* class (pp. 15-31). Palgrave Macmillan UK.

Ward-Perkins, B. (2005) The fall of Rome and the end of civilisation. Oxford University Press, Oxford.

Weber, C. L., & Matthews, H. S. (2008). Quantifying the global and distributional aspects of American household carbon footprint. *Ecological Economics*, 66(2), 379-391.

Weber, C., & Perrels, A. (2000). Modelling lifestyle effects on energy demand and related emissions. *Energy Policy*, 28(8), 549-566.

Weisz, H., & Steinberger, J. K. (2010). Reducing energy and material flows in cities. *Current Opinion in Environmental Sustainability*, 2(3), 185-192.

Westerink, J., Haase, D., Bauer, A., Ravetz, J., Jarrige, F., & Aalbers, C. B. (2013). Dealing with sustainability trade-offs of the compact city in peri-urban planning across European city regions. *European Planning Studies*, 21(4), 473-497.

Wheatley, P. (1971) The pivot of the four quarters: a preliminary enquiry into the origins and character of the ancient Chinese city. Aldine, Chicago.

Vickers, D., & Rees, P. (2007). Creating the UK National Statistics 2001 output area classification. *Journal of the Royal Statistical Society: Series A* (Statistics in Society), 170(2), 379-403.

Wiedenhofer, D., Guan, D., Liu, Z., Meng, J., Zhang, N., & Wei, Y. M. (2016). Unequal household carbon footprints in China. *Nature Climate Change*.

Wiedmann, T. (2009). A review of recent multi-region input–output models used for consumption-based emission and resource accounting. *Ecological Economics*, 69(2), 211-222.

Wiedmann, T., Minx, J. (2008). A Definition of 'Carbon Footprint'. In *Ecological Economics Research Trends*. Chapter 1, pp. 1-11. Hauppauge, NY, USA: Nova Science Publishers.

Wiedmann, T. O., Chen, G., & Barrett, J. (2015). The concept of city carbon maps: A case study of Melbourne, Australia. *Journal of Industrial Ecology*.

Wiersinga, W. (1997). Compensation as a strategy for improving environmental quality in compact cities. Amsterdam: Bureau SME.

Wilkinson, R., & Pickett, K. (2010). The spirit level. Why equality is better for everyone. Penguin UK.

Williams, J. (2007). Innovative solutions for averting a potential resource crisis—the case of one-person households in England and Wales. *Environment, Development and Sustainability*, 9(3), 325-354.

Williams, K., Burton, E., & Jenks, M. (2000). Achieving sustainable urban form: an introduction. *Achieving sustainable urban form*, 1-5.

Vringer, K., & Blok, K. (1995). The direct and indirect energy requirements of households in the Netherlands. *Energy Policy*, 23(10), 893-910.

Yang, Y. (2008). A tale of two cities: Physical form and neighborhood satisfaction in metropolitan Portland and Charlotte. *Journal of the American Planning Association*, 74(3), 307-323.

Yates, L. (2016). Sharing, households and sustainable consumption. *Journal of Consumer Culture*, 1469540516668229.

Zahavi, Y. (1976). Travel characteristic cities of developing and developed countries. The World Bank.

The current period in humankind's existence is being called the century of the city. Cities have an extremely important role, both as engines of growth and also as key actors in a change trajectory toward a more sustainable future. Indeed, the fast pace of urbanization makes mainstreaming of sustainability in planning and urban policy making inevitable. Still, the widely-held association between sustainability and density of urban structure is not well-grounded on existing empirical evidence. The dissertation adds to this mixed evidence on the relationships between urbanity and sustainability by studying GHG emissions and subjective well-being. It is demonstrated that a finite set of measures is sufficient to reveal trade-offs and discrepancies within and between the sustainability measures, making urban sustainability essentially a contested concept. Furthermore, there seems to be no unambiguous urbanization gradient in sustainability. The aim is not to dispute the importance of sustainable urbanization, but to underscore its complex nature and call for more ambitious urban sustainability policies.

Aalto-DD 85/2017

ISBN 978-952-60-7416-0 (printed)
ISBN 978-952-60-7415-3 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

Aalto University
School of Engineering
Department of Built Environment
www.aalto.fi

BUSINESS + ECONOMY

ART + DESIGN + ARCHITECTURE

SCIENCE + TECHNOLOGY

CROSSOVER

DOCTORAL DISSERTATIONS