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Greening the compact city: Unarticulated tensions and incremental advances in municipal climate action plans

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ABSTRACT

Municipal climate policies tie in closely with sustainable urban development. Land use has far-ranging impacts on carbon emissions from mobility, housing, and consumption; as well as climate resilience, carbon sinks, and biodiversity. While compact city is well-established as the dominant strategy for climate-wise planning, a parallel approach focused on greening and its climate advantages is gaining prominence. However, there is little empirical evidence on how municipal climate policies address the relationship between these often conflicting strategies. This study examines how compacting and greening are motivated and how greening is negotiated in relation to compacting in the six largest cities in Finland. Based on a qualitative content analysis of municipal climate action plans (CAP), we show that the primacy of compacting as a strategy is not questioned, however, the importance of greening is increasingly underlined. We demonstrate that the relationship between compacting and greening policies is framed by three main discourses: 1) compacting while protecting the green, 2) greening the built-up structure for adaptation purposes, and 3) greening as a multifunctional strategy parallel with compacting. The study contributes to the topical debate on the integration of compacting and greening and to the need for cross-sectoral and systemic climate-wise policies in general.

1. Introduction

Cities account for over 70 % of global CO_2 emissions and therefore have a crucial part to play in limiting the rise in global temperatures in line with the Paris Agreement (e.g., Rosenzweig et al., 2010; UN, 2015). Through their climate actions, local authorities are expected to work to reduce and offset carbon emissions and to prepare for the impact of climate change (e.g., Amundsen et al., 2018; Bai et al., 2018; Bertoldi, 2018; Croci et al., 2021; Rosenzweig et al., 2010). Many of these municipal climate actions tie in closely with urban development. Land use decisions impact on carbon emissions from mobility and transport, housing, and consumption; carbon sinks and sequestration; biodiversity; and urban climate resilience (e.g., Bibri et al., 2020; European Commission, 2021; Heinonen et al., 2011; Raymond et al., 2023).

In recent decades, compact city development has become established as the dominant urban policy strategy for advancing climate goals and other sustainability objectives (Artmann et al., 2019; Balikçi et al., 2022; UN Habitat, 2022). It is recognized as an urban planning paradigm that can deliver multiple economic, environmental, and social advantages (e.g., Berghauser Pont et al., 2021; Jabareen, 2006). From a climate perspective, the compact city is seen as an alternative trajectory to urban sprawl and its adverse climate effects. Compact cities are associated with lower carbon emissions from mobility, cost and energy efficient service and infrastructure networks, and reduced land take (e.g. Bibri et al., 2020). That being said, it is widely acknowledged that despite its many advantages, compact city development entails contradictions between various sustainability and climate impacts across diverse contexts and levels (e.g., Berghauser Pont et al., 2021; Gren et al., 2019; Haarstad et al., 2023; Heinonen et al., 2011; McFarlane, 2023; Wachsmuth et al., 2016). One of these contradictions concerns the effects of compact city development on green infrastructure, the focus of this paper.

The climate crisis and biodiversity loss have led to the rise of green city development as a parallel planning strategy alongside compact city development (e.g., Artmann et al., 2019; Haaland & van Den Bosch, 2015). Green infrastructure (GI) is defined as a "*network of high quality natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services*" (European Commission, 2014, 7). GI is generally regarded as multifunctional,

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bringing a wide range of ecological, social, and economic benefits (European Commission, 2014; Wang & Banzhaf, 2018). From the perspective of climate change mitigation and adaptation, GI contributes to carbon sinks and storage, to preparing for extreme weather conditions, such as heat waves and urban flooding, as well as to biodiversity and human wellbeing (Haaland & van Den Bosch, 2015; Raymond et al., 2023; Sunding et al., 2024).

Although both compact city and green infrastructure strategies are advocated for climate reasons, they are often conflicting and contradictory (e.g., Berghauser Pont et al., 2021; Eichhorn et al., 2021; Madureira & Monteiro, 2021; Randrup et al., 2021). It has been shown that densification reduces green space in urban areas and increases its fragmentation, affecting the connectivity, accessibility, and quality of green spaces (e.g., Balikçi et al., 2022; Byomkesh et al., 2012; Giezen et al., 2018; Haaland & van Den Bosch, 2015; Tian et al., 2014). This impacts crucial ecosystem services for climate adaptation and mitigation, such as cooling, carbon sequestration and storage potential, water infiltration, biodiversity and recreational facilities (e.g., Haaland & van Den Bosch, 2015; Trlica et al., 2017; Vaughn et al., 2014; Vergnes et al., 2014). Furthermore, the scarcity of green spaces in urban areas affects residents' health and well-being (e.g., Li et al., 2020; Olsen et al., 2019). As GI is central to both climate and biodiversity actions, it is crucial to address the contradictions between compacting and greening and to seek ways to balance the two approaches. However, we still lack a clear vision on how to reconcile and integrate GI and compact city development (Artmann, 2016; Artmann et al., 2019; Haaland & van Den Bosch, 2015; Jensen et al., 2023; Larondelle & Lauf, 2016). Integrative concepts and methods are needed both for research purposes and, in particular, for urban planning practice (Artmann, 2016; Artmann et al., 2019; Jensen et al., 2023).

Cities and municipalities around the world increasingly outline their climate targets, climate actions, and implementation plans in climate action plans (CAPs) or similar documents (e.g., Grafakos et al., 2020; Guyadeen et al., 2019; Reckien et al., 2018). The need for an integrated approach is evident in these documents that are expected to set out holistic, cross-sectoral and systemic strategies for achieving the climate targets specified and to cover a whole range of climate-related issues ranging from climate change mitigation and adaptation to the impacts of climate change on biodiversity and human wellbeing (e.g., Guyadeen et al., 2019; Schiappa et al., 2023). So far, however, it has been found that incorporating the aspects of resilience and adaptation into CAPs is insufficient (e.g., Grafakos et al., 2020; Guyadeen et al., 2019; Parsaee et al., 2019; Stone et al., 2012). There is also limited evidence on whether and how municipalities address the constraint relationship between compacting and greening strategies in their CAPs and facilitate the much-needed integration.

This is the gap we address in this paper. Our aim is, first, to investigate the objectives and motivations behind compacting and greening. Second, we examine how greening is articulated and negotiated in relation to compacting in the climate action plans (CAPs) of the six most populated cities in Finland. The data for the study consists of the CAPs of these cities. The paper contributes to the topical debate on the integration of compact city and greening strategies and understanding climate-wise policies in general.

The paper is structured as follows. Section 2 reviews literature on motives for compact city development, its controversies on sustainability dimensions, the increasing role and significance of GI in planning climate-wise cities and finally challenges and opportunities in reconciling these two strategies. Section 3 outlines the study's data and methods, introduces the case cities, and provides a context for municipal CAPs in Finland. Section 4 demonstrates our findings that are further discussed in Section 5. We conclude with concluding remarks.

2. The compact and the green as climate-wise urban development strategies

Since the early 1990s the planning paradigm has shifted increasingly toward the development of compact cities, with greater emphasis placed on high density, mixed land uses, sustainable transportation, and the prevention of urban sprawl (e.g., Bibri et al., 2020; Jenks et al., 1996; Williams, 1999). The compact city discourse is framed by sustainability: it is often portrayed as a panacea for various environmental and social challenges, while simultaneously bringing various economic benefits (e.g. Haughton & Hunter, 1994; Jabareen, 2006; Williams, 1999; Bibri et al., 2020). A key compacting strategy is the densification of built-up areas. Forms of densification vary, ranging from large-scale redevelopment projects to incremental infill development on low-rise sites (Puustinen et al., 2022). Thus, as concepts, both compact city and densification are rather ambiguous and elusive (Bibri et al., 2020; Puustinen et al., 2022).

In the context of the escalating climate crisis, the compact city is often depicted as a sustainable, smart, and green model that can help steer urban growth and development (e.g., Artmann et al., 2019). The climate benefits of the compact city are particularly associated with reduced carbon emissions from private car use and mobility, enhanced opportunities for public transportation, and light traffic and an energy efficient urban structure (e.g., Berghauser Pont et al., 2021; Bibri et al., 2020). The reduced need for mobility relates closely to a key environmental narrative of compact city development, that is, mitigating the negative effects of urban expansion and sprawl (e.g. Williams, 1999). This is achieved by minimizing land take in natural, semi-natural, or agricultural areas. In addition to mobility issues, curtailing urban sprawl contributes to conserving biodiversity, preventing soil erosion and degradation, and mitigating the loss of carbon stored in the soil (European Commision, 2020).

Despite the dominant role of compact city development in urban planning, it is widely acknowledged that it involves various conflicts and contradictions with respect to its true motives and its impacts on different sustainability aspects and their interplay when examined across diverse scales and contexts (e.g., Berghauser Pont et al., 2021; Breheny, 1996; Haarstad et al., 2023; Heinonen et al., 2011; McFarlane, 2023; Wachsmuth et al., 2016; Westerink et al., 2013). The most intrinsic motivations for compact city development are usually economic (Bibri et al., 2020), while the negative social or environmental consequences are sometimes downplayed (McFarlane, 2023). Moreover, the environmental sustainability motives for compact city development and the existing scientific evidence do not always align (Berghauser Pont et al., 2021). In their extensive literature review and synthesis, Berghauser Pont et al. (2021) show that the micro-climate, biodiversity, and wellbeing effects of compact city development are often negative. Regarding GI, the negative effects of densification are described in more detail in the introduction. Gren et al. (2019), for their part, show that especially the environmental validation of compact city lacks scientific proof. These controversies, coupled with the overemphasis on certain subjects in the literature (most notably traffic emissions) and the absence of discussion on others, underscore the challenge faced by urban planners in evaluating the trade-offs between densification and adapting to current rates of urbanization (Berghauser Pont et al., 2021).

While the compact city has become established as the dominant planning principle, the climate crisis and biodiversity loss have reinforced another, competing paradigm which addresses greening and its climate benefits. The European Commission has launched green infrastructure (GI) as a strategic focus area in Europe, highlighting the importance of GI planning and the benefits of urban green spaces (2014). Similarly, the newly approved Nature Restoration Law (2023), following the EU Biodiversity Strategy for 2023 (2020), urges member states to ensure there is no net loss of urban green space and urban tree canopy cover. GI is generally regarded as multifunctional, bringing a wide range of ecological, social, and economic benefits (European Commission, 2014; Wang & Banzhaf, 2018). Multifunctionality is also defined as the capacity of GI to provide multiple ecosystem services (e.g. Hansen et al., 2019; Meerow, 2020) or nature-based solutions that yield environmental, social, and economic benefits and help build resilience (e.g. Raymond et al., 2017).

GI supports climate change adaptation by increasing the fraction of permeable surfaces and by so improving urban flood control and stormwater management (Grafakos et al., 2019; Reu Junqueira et al., 2022). It also improves microclimatic conditions and air quality and enhances indoor and outdoor thermal comfort by providing cooling benefits (Coutts et al., 2010; Demuzere et al., 2014). Furthermore, GI can help reduce urban heat island effects (Marando et al., 2022). While the main focus has been on adaptation benefits, considerable evidence has also been reported on the mitigation co-benefits of GI that are mainly related to carbon sequestration. Carbon sequestration and storage for vegetation and soils is one of the most efficient natural mechanisms for removing carbon from the atmosphere (Ariluoma et al., 2023; Griscom et al., 2017). In addition, there is a growing need to recognize biodiversity preservation and human wellbeing as integral parts of climate actions. Several studies call for research on the interlinkages between biodiversity, climate adaptation, and mitigation as well as on environmental justice outcomes (Pascual et al., 2022; Raymond et al., 2023; Seddon, 2022). Much research stresses the win-win nature of co-benefits (e.g. Malico et al., 2016; Strassburg et al., 2012), but scholars have also highlighted conflicts of interest between biodiversity conservation and climate targets (Mauerhofer & Essl, 2018; Phelps et al., 2012; Young et al., 2010).

2.1. Challenges in integrating the two strategies

As described above, the compact and the green are both regarded as prime prerequisites for sustainability and climate-wise urban development. Nevertheless, their coexistence is fraught with tension and friction: within the urban structure, densification inevitably puts green areas under increased pressure. Thus, there is a growing need for holistic, integrative approaches and strategies to foster dense and green cities (e.g., Artmann, 2016; Artmann et al., 2019; Hautamäki, 2019; Jensen et al., 2023; Lin & Yang, 2006; Westerink et al., 2013). However, developing such approaches is challenging.

The complexities of compact city development and its environmental implications are particularly pronounced in the realm of policy formulation and assessment. Traditionally, policy evaluations focus on single policy outcomes (Giezen et al., 2018), and this trend is also apparent in urban climate policies. While compact city development is often justified by reduced land use, GI within the built-up structure is often overlooked (European Commision, 2020). Current climate assessments of compact city development tend to concentrate on traffic emissions (Berghauser Pont et al., 2021) rather than provide a comprehensive evaluation of climate impacts on GI. Different forms of densification have different effects on water flow regulation, microclimate regulation, carbon storage, and air pollution control, for example (e.g., Grêt-Regamey et al., 2020), as well as on wellbeing and recreation opportunities (Haaland & van Den Bosch, 2015). Limited (cross-)evaluation of the various climate effects associated with compact city development and failure to address their corresponding trade-offs in policymaking may hinder efforts to establish a comprehensive and integrated approach. Acknowledging the tradeoffs is essential to formulating tailored, context-specific sustainability strategies in densification (e.g., Westerink et al., 2013).

In addition to the above-described obstacles to balancing the relationship between the compact and the green, the integration of GI in climate policies involves various other challenges and tensions, even though GI is recognized as an integral part of climate change adaptation and mitigation. The capacity of GI to respond to multiple climate-related targets is not only a strength but also a challenge. GI falls under several separate sectoral policies which complicates forming comprehensive and systemic strategies. Moreover, the multifunctionality of GI is not always recognized: Pulighe et al. (2016) found that most studies on urban ecosystem services address just one aspect at a time. Planners likewise tend to consider one GI function at a time instead of multiple functions or ecosystem services (Davies et al., 2015; Hansen & Pauleit, 2014). In addition, multifunctionality is difficult to operationalize, assess, and visualize (e.g. DiMarino et al., 2019).

Another difficulty in approaching climate policies holistically stems from the lack of linkages between adaptation and mitigation objectives and measures. Even though they should respond to both mitigation and adaptation, some cities prioritize only one or the other (Sharifi, 2021). This imbalance is due to multiple factors, such as difficulties in coordinating the activities of various departments with diverse and sometimes conflicting priorities, and the common notion that mitigation is more relevant on the national scale, while adaptation is mainly a local concern (He et al., 2019; Lwasa et al., 2018; Sharifi, 2021). Another topical gap in climate actions concerns the link between climate measures and biodiversity conservation. Although the climate change and biodiversity crises are fundamentally connected, they are primarily addressed independently (Pettorelli et al., 2021), in separate policies, which effectively hinders the development of an integrative approach (Essl & Mauerhofer, 2018). A stronger integration of the biodiversity and climate change agendas is essential for identifying win–win situations between climate change mitigation and adaptation actions and biodiversity conservation (Malico et al., 2016; Pettorelli et al., 2021; Raymond et al., 2023; Strassburg et al., 2012).

3. Materials and methods

The aim of the empirical part of this study is to provide a cross-section of how compact city and GI are motivated, negotiated and balanced in municipal CAPs. As strategic, cross-sectoral policy documents, CAPs can address a wide range of measures toward carbon-neutral and climate-responsive cities, including not only targets for emissions reductions but also compensation, adaptation, and biodiversity. Thus, CAPs provide an avenue through which municipalities can articulate and negotiate this relationship, notwithstanding any contradictory objectives and related tradeoffs and synergies. To reach our empirical aim, we analyze the CAPs of the six most populated cities in Finland. The case cities, data methods and the background for CAPs are detailed in this section.

3.1. Background for CAPs in Finland

The Finnish climate policy follows international decrees on climate mitigation, for example Paris Agreement (2015) and the European Climate Law (2021). The history of municipal CAPs traces back to the early 2010s. It was only until 2023, when CAPs were obliged by legislation. Under the newly adopted Climate Change Act (2022, 2023) municipalities are required to prepare or update their CAPs at least once within the four-year municipal council term. Approved by the city or municipal council, the CAP should specify targets for greenhouse gas

(GHG) reduction, the actions that will be taken to meet these targets, data on municipal GHG development, and the methods of monitoring and measuring progress. The plan can also, but does not have to, include measures for carbon sinks and climate change adaptation. The Ministry of the Environment recently came out with a guide for drafting CAPs (Ulvi et al., 2023) which defines the minimum document requirements. It is noteworthy that while emissions reductions are included among these minimum requirements, adaptation, carbon sinks, impacts on biodiversity, and sustainable public procurement are listed as recommendations only.

The political process around CAPs has been less than straightforward. The Finnish government 2019–2023 revised the Climate Change Act with a view to supporting carbon neutrality, but the newly installed government has proposed that CAPs be scrapped altogether as a cost-saving exercise (Government Programme, 2023). Similarly, climate actions have been the subject of contentious political debate, especially concerning carbon sinks.

3.2. Case cities and materials for the study

The case cities selected for this study are the six most populated cities in Finland: the capital city Helsinki, its neighboring cities Espoo and Vantaa, and Tampere, Turku, and Oulu (Fig. 1). These cities, often referred to as the "Six Cities", provide a useful framework for studying climate actions and the relationship between compacting and greening. In 2022, the six cities accounted for 33.4 % of the Finnish population. They are all growing urban regions, with annual population growth rates ranging from 0.8 % (Helsinki) to 2.7 % (Espoo) (Table 1). Population growth is putting pressure on housing production, highlighting the importance of climate-wise urban development.

The six cities have ambitious climate initiatives in place and have all recently published CAPs. Most of them have long been forerunners in climate work, and they are actively involved in international climate collaborations, partnerships, and programs. For example, all six cities are committed to the *Covenant of Mayors for Climate and Energy* whose signatories are committed to supporting the European Union's 40 % GHG emission reduction goal by 2030. In addition, Vantaa, Tampere, Oulu, and Turku are A-listed by CDP, a not-for-profit charity that runs a global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts. All six cities have set carbon emission reduction targets, compiled CAPs or similar documents before they were legally required to do so, and most cities have already updated or revised their CAPs, indicating a commitment to developing their climate policy formulation and implementation.

The data for this research consists of the case cities' current CAPs (see Appendix 1). As municipalities have discretion over the content and structure of their CAPs, the plans vary in terms of structure and comprehensiveness, themes, and level of detail concerning implementation, monitoring and evaluation. For example, Helsinki and Espoo have a separate document both for climate change mitigation and adaptation while the other cities have only one document on climate targets. Fig. 2 and Appendices 1 and 2 describe the main content and directions of these CAPs. In the studied CAPs, transport (37 %) and energy (26 %) are the most dominant in climate discourse, however, green-related aspects (16 %) are prominent, too. There are also differences between the cities: Espoo, Tampere and Helsinki highlight transport while Oulu and Turku stress energy. Vantaa represents the most green-oriented CAP. Despite these differences, the studied documents can all be interpreted as climate action plans, defined by the Climate Change Act (2023). In addition, they are well integrated in the municipal decision-making system: they are prepared cross-sectorally and approved by the city or municipal board or council.

It is important to note that local master plans and detailed plans steering urban development, as well as sectoral policy documents on biodiversity or stormwater management, for example, are beyond the scope of this study. While we acknowledge their importance to urban development, we have chosen to focus on CAPs in order to provide a comprehensive overview of the compacting-greening relationship from the climate perspective. We also note that the six cities touch upon their climate policy in many other strategic documents, and the mutual relationship, hierarchy and/or potential overlap of different documents

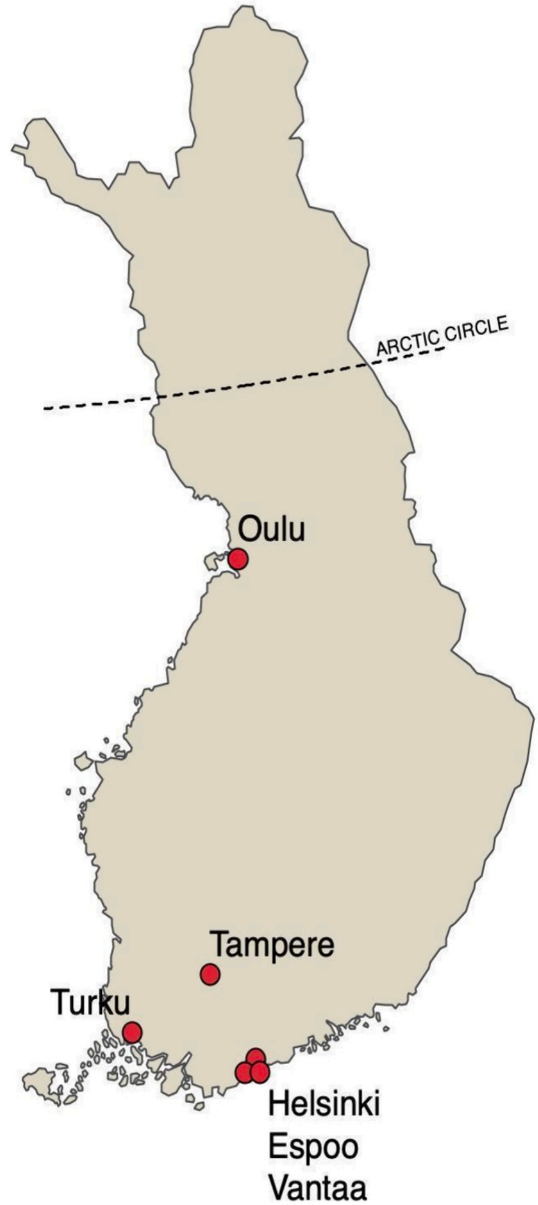
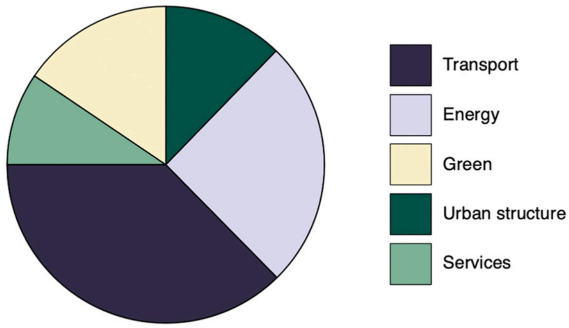


Fig. 1. The case cities' geographic locations in Finland.

Table 1
Information on the six most populated cities in Finland. Source: Population and growth in 2022: Statistics Finland [online] accessed on July 20th 2023. Land area, as on Jan 1st 2023: National Land Survey of Finland [online] accessed on July 20th 2023.

City	Population	Land area (km^2)	Population density (persons/km^2)	Population growth (%)
Helsinki	664,028	214,42	3065,60	0,8
Espoo	305,274	312,35	937,50	2,7
Tampere	249,009	524,89	459,10	2,0
Vantaa	242,819	238,38	995,20	1,5
Oulu	211,848	2972,44	69,80	1,1
Turku	197,900	245,63	791,30	1,4



Transport-oriented with energy:

	TRANSPORT	ENERGY
Espoo:	37%	28%
Tampere:	49%	15%

Energy-oriented with transport:

	ENERGY	TRANSPORT
Oulu:	46%	30%
Turku:	30%	29%

Transport-oriented with green:

	TRANSPORT	GREEN
Helsinki:	25%	25%

Green-oriented with transport:

	GREEN	TRANSPORT
Vantaa:	34%	25%

Fig. 2. On the left: Quantification of the key themes and directions of the case CAPs demonstrate that transport (37 %) and energy (26 %) are the most dominant in climate discourse, however, green-related aspects (16 %) are prominent, too. The keywords applied for the analysis are described in Appendix 2.
On the right: Main categories and their percentage of CAPs of case cities. CAPS can be categorized into four: transport-oriented with energy focus (Espoo, Tampere), transport-oriented with green focus (Helsinki), energy-oriented with transport focus (Oulu, Turku) and green-oriented with transport focus (Vantaa). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

are not necessarily self-evident or explained. We chose to use CAPs as our research data as they are the main – and legally required – documents describing climate targets and their implementation.

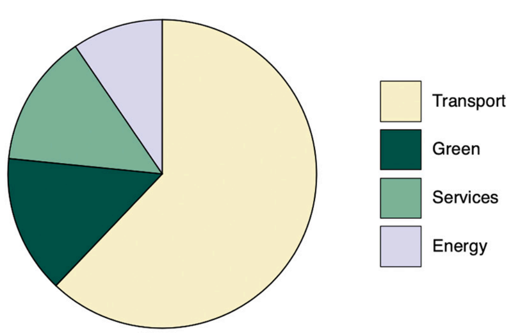
3.3. Method

The aim of this research is to investigate the objectives and motivations behind compacting and greening (Aim 1) and how greening is articulated and negotiated in relation to compacting (Aim 2). To achieve these aims, we conducted a qualitative content analysis with a two-step approach consisting of both surface (manifest) and latent analysis. This integrative analysis enables a systematic examination of explicit content while also uncovering underlying meanings (Graneheim et al., 2017). Moreover, the surface and latent analysis complement and validate each other and, thus, the analysis done allows developing a more comprehensive and nuanced understanding of the content of the CAPs.

The first step was the manifest content analysis emphasizing the "surface of the texts", with a focus on the key words and expressions (Potter & Levine-Donnerstein, 1999). We identified, categorized and quantified the objectives and motivations related to compacting and greening, and then investigated how they varied in the studied CAPs.

As compacting was often not explicitly addressed, we examined all expressions describing densification of urban structure and its motivations, such as "*resource-wise or dense urban structure*" and "*densifying areas supported by rail transport*" (see Appendix 3). The objectives for compacting were categorized and quantified into four groups: transport, energy, nature/green and services. These categories were identified as primary motivations for compacting in the CAPs and were also highlighted in our literature review. In the greening-related analysis, we identified four primary motivations in the CAPs: adaptation, biodiversity, mitigation, and well-being (see Appendix 4). These categories are similarly supported by literature. In both compacting and greening related analysis, it is important to note that the objectives are often interlinked, with several objectives present in the same CAPs. However, the results reveal differing emphases among cities, highlighting what aspects are prioritized.

While the first analysis focused on compacting and greening as separate actions, the second step aims to examine their relationship and to reveal how greening is articulated and negotiated in relation to compacting. As this complex and often implicit relationship can not be fully captured by quantification of keywords, we conducted a latent content analysis to uncover underlying meanings and relationships, focusing on what lies "under the text" (Potter & Levine-Donnerstein, 1999). By identifying generic discourses, we examined how greening was negotiated in relation to compacting across the CAPs and compared the differences and similarities between them. The findings from the first analysis step were also utilized in this latent analysis to enrich the interpretation. It is important to note that the discourses are not strategies per se but offer comprehensive interpretations (Graneheim et al., 2017) of how the relationship between greening and compacting is negotiated in the CAPs.



Transport-oriented with services:

	TRANSPORT	SERVICES
Oulu:	58%	26%
Tampere:	69%	14%
Turku:	50%	25%

Transport-oriented with green:

	TRANSPORT	GREEN
Espoo:	75%	14%
Helsinki:	75%	25%
Vantaa:	39%	33%

Fig. 3. On the left: Quantification of the key motivations for compacting in all six CAPs. Transport (62 %) is clearly the most prominent category, followed by services (14 %) and green-related (14 %) motivations. The keywords applied for the analysis are described in Appendix 3.
On the right: Main categories and their percentage of CAPs of case cities. The motivations for compacting in different CAPS can be categorized into two: transport-oriented with the focus on services (Oulu, Tampere, Turku) and transport-oriented with green focus (Espoo, Helsinki, Vantaa). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. Results

4.1. Compacting and greening and their main motivations in CAPs

The six CAPs differ in motivations attached to compacting and greening policies. While all CAPs emphasize climate-wisdom, the approaches to achieving it vary. Emission reduction is the dominant topic, often directly or indirectly linked to compacting. Regardless of how explicitly compacting is addressed, compact city development is closely tied to climate change mitigation efforts in all the CAPs studied.

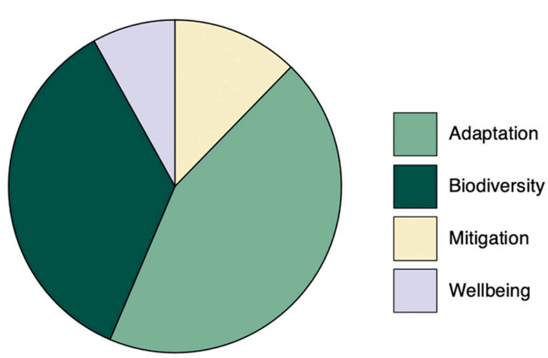
The significance of a coherent and dense urban structure is acknowledged in the CAPs of five case cities. The exact wordings used to describe a densified built-up structure includes, for example, "*dense or coherent or resource-efficient urban structure*" and "*densifying areas supported by rail transport*". Notably, there are only few references to urban structure or urban planning in general or more specifically to compacting (Fig. 2, Appendix 2). Helsinki has the least references to compacting - only three mentions - while Oulu has most references, 17 in total. Despite the scarcity of explicit mentions, compacting is the underlying strategy in all CAPs and is not questioned as the leading urban development strategy. Compacting is regarded as self-evident, almost as a naturally evolving strategy with expressions such as "*the city grows along public transport corridors*" (Espoo, page 9; Oulu, page 23; Vantaa, page 16; Turku, page 35) or "*the tram densifies the city*" (Tampere, page 139).

The primary motivation for compacting is to create a well-functioning and efficient public transportation system, contributing to reduced carbon emissions from traffic (Fig. 3). This is most often referred to as a sustainable transport system enabled by dense urban structure or reducing car-dependency and supporting public transport, bicycle and pedestrian traffic. Transport topics are in general the most prominent category in CAPs (Fig. 2) which echoes the guidelines of SEAP (European Union, 2010) and SECAP (Bertoldi, 2018) and their special emphasis on transport. In Oulu, Espoo, Tampere, Vantaa, and Turku, growth or new development is mainly targeted to public transportation zones or similar areas. Another important motivation for compacting is an efficient and accessible service structure which is often expressed as densification enables "*efficient service structure*" or "*accessibility of local services*". This is highlighted especially in Oulu, Turku and Tampere. The third main motivation is the preservation of natural values outside the dense urban structure which is emphasized especially in Vantaa, Helsinki and Espoo. This is expressed as compacting ensures "*the protection of larger green areas*" or "*sustainable use of natural resources*" and also "*accessibility of recreation services*". For example, Vantaa states that *"a dense urban structure enables better accessibility of services and preservation of larger green areas"* (page 18). Tampere points out that public services, including recreational facilities, should be accessible by sustainable mobility (page 36).

While the motivations for compacting are highlighted in all cities, our analysis shows that CAPs are also increasingly focusing on greening. The emphasis given to and objectives set for urban GI vary across different CAPs, though. For example, Helsinki has excluded GI from its latest climate mitigation plan and includes it only in its adaptation plan, while Tampere, Vantaa, and Turku recognize the multifunctional role of GI and actually give it more emphasis than in their previous action plans. There are also major differences in the emphasis given to greening in CAPs: Espoo, Helsinki, Oulu emphasize adaptation-related objectives while Tampere, Turku and Vantaa have more biodiversity-focused policies (Fig. 4).

Adaptation and stormwater management are the strongest and most established aspects of greening objectives and motivations in the CAPs (Fig. 4). This can be explained by the fact that urban flood management is covered under the Land Use and Building Act and has also been a national policy focus for 10 years. In addition to urban flooding and the capacity of GI to mitigate flooding with nature-based solutions, the CAPs also recognize other adaptation-related aspects. Urban heat island effect, extreme hot weather, and droughts are mentioned in all CAPs, indicating an increased level of attention. Other adaptation-related aspects link to the impacts on biodiversity (Tampere, Vantaa, Turku) and wellbeing (Tampere, Vantaa, Oulu).

The second dominant objective attached to greening actions is biodiversity. The interconnectedness of climate and biodiversity actions is widely recognized in the academic literature and also manifested in our case cities. Tampere, Turku and Vantaa have a specific focus on biodiversity highlighting nature conservation and protection of biodiversity. For example, Turku aims to be "*a world-class leading climate and nature city*" (page 6). Also Vantaa has established biodiversity as one of the six main topics of climate policy. The CAP refers to nature conservation actions in forests, waterways, and meadows and specifies indicators for each of them. Espoo, Helsinki and Oulu recognize the importance of biodiversity, however, attach it more to adaptation (Fig. 4). Most cities stress the importance of the ecological network and its link to GI network planning. It is interesting that all six cities mention the prevention of invasive species, an important biodiversity action but



Adaptation-oriented with biodiversity:

	ADAPTATION	BIODIVERSITY
Espoo:	76%	18%
Helsinki:	67%	29%
Oulu:	57%	33%

Biodiversity-oriented with mitigation:

	BIODIVERSITY	MITIGATION
Tampere:	38%	23%
Turku:	48%	26%
Vantaa:	67%	19%

Fig. 4. On the left: Quantification of the main motivations for greening in all six CAPs. Adaptation represents 44 %, biodiversity 36 %, mitigation 12 % and wellbeing 8 %. The keywords applied for the analysis in Appendix 4.
On the right: Main green categories and their percentage of CAPs of case cities. Two main approaches can be identified: adaption-oriented CAPs (Espoo, Helsinki, Oulu) and biodiversity-oriented CAPs (Tampere, Turku, Vantaa). In adaption-oriented CAPs biodiversity is the second biggest category while in biodiversity-oriented CAPs it is mitigation.

not directly linked to urban development.

All CAPs give central focus to mitigation, but it is linked to GI only in the CAPs of Tampere, Turku and Vantaa. Every CAP mentions carbon sinks as a means to compensate for emissions, but only three aforementioned cities specify how the compensation targets shall be reached. These cities all say that forests and sustainable forest management are primary ways of safeguarding carbon sinks. Carbon sinks are also improved by greening actions, such as tree planting and use of the green factor tool. Tampere also mentions reducing emissions in landscape construction and management. Tampere has the most specific targets and indicators for carbon sinks and for reducing emissions in green spaces. Helsinki, Espoo, and Oulu, on the other hand, have no measures for carbon sinks in their mitigation plans.

While wellbeing is generally a well-recognized benefit of GI, it is the weakest aspect of the CAPs (Fig. 4). Wellbeing is a cross-cutting concern for several administrative sectors but unlike stormwater management and biodiversity, wellbeing and health are not afforded their own policies. Wellbeing is mentioned in several sections of the CAPs, most commonly in reference to accessible recreational networks and the health benefits of pedestrian and bicycle networks. The link to connected ecological networks and biodiversity is recognized in Vantaa, Tampere, and Oulu, with the interconnectedness of human and non-human wellbeing at the core. Health aspects are also addressed: Tampere, Espoo, and Vantaa mention the improvement of air quality, for example, and Espoo also stresses the impact of urban heat waves on vulnerable groups. However, even though they receive multiple references in the CAPs, wellbeing and health are mostly addressed as an extra benefit of climate actions.

4.2. Three discourses on negotiating greening with compacting

The previous analysis on the objectives related to compacting and greening demonstrate that both strategies are present in climate actions although compacting is still dominating as underlying strategy. However, while the objectives for both compacting and greening are more or less explicitly expressed, the relationship between these two strategies is more obscure, including the potential conflicts between GI and compacting. The CAPs place their words very carefully when addressing the pressure on green areas and the tensions between land take and preservation. Although the case cities rely on compacting policies, which have implications for green areas as well, it is striking that in most cases this is not explicitly expressed but in fact consciously avoided. For example, although Espoo highlights the development of new, "climate-friendly" residential districts along public transportation networks, the city does not address any tensions or challenges concerning GI. In addition, for reasons unknown, references to tensions or pressures mentioned in the draft version have been removed from the recently updated CAP of Vantaa. In the CAPs studied, the negative effects of urban development are mostly connected to biodiversity and fragmented ecological networks or endangered biotopes or species (Turku, Vantaa, Espoo). Tampere is the only city that mentions the pressure to expand new development on green areas and that highlights the need for special consideration before allowing construction on green areas. Nevertheless, the careful wording or absence of tensions in general can be seen as a strategy of rephrasing the relationship between the green and the compact.

While the potential conflicts between greening and compacting are largely obscure in the CAPs, so is the integration of greening and compacting, despite the many references to diverse intended actions. In order to reveal these underlying intentions, we identified three main discourses describing how greening is articulated and negotiated in relation to compacting (Fig. 5). Two of these discourses advocate for compact city policies, while the third one leans toward greening policies. The first two discourses – *Compacting while protecting the green* and *Greening the dense urban structure for adaptation purposes* – do not explicitly address the tensions between the two strategies. Instead, those

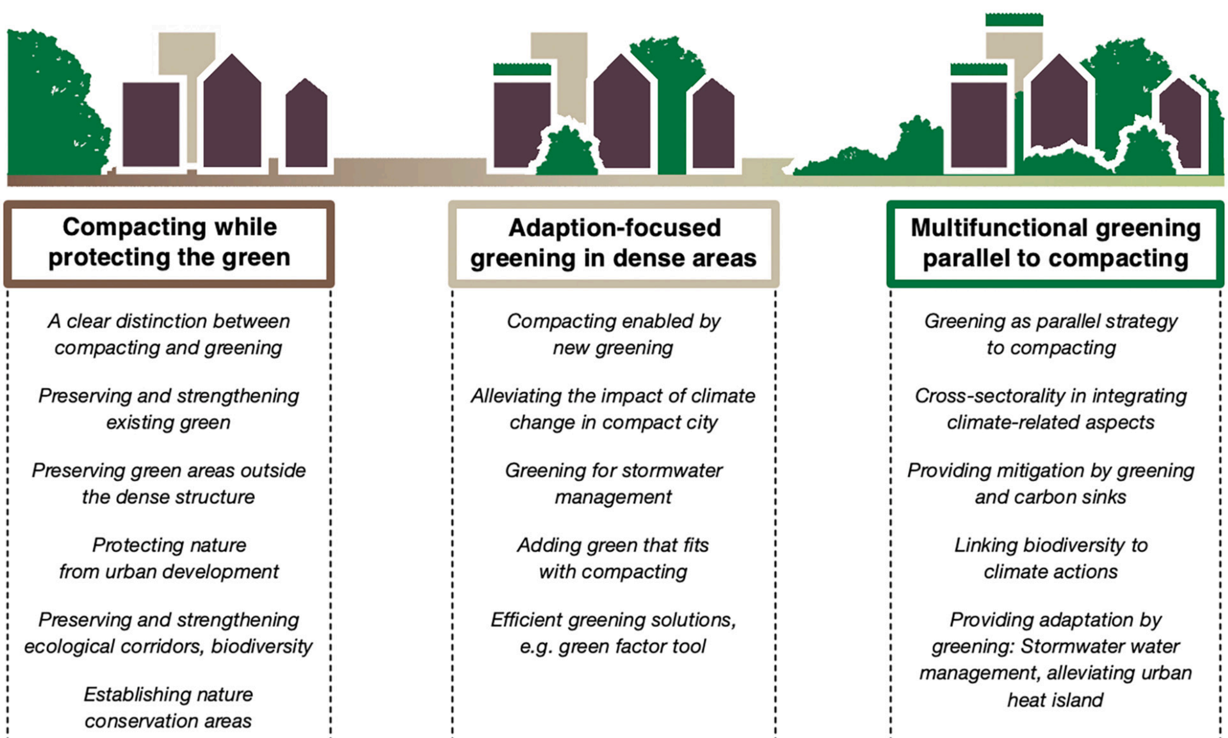


Fig. 5. Three main discourses describing how greening is articulated and negotiated in relation to compacting in climate action plans of case cities.

City	Compacting while protecting the green	Adaptation-focused greening in dense areas	Multifunctional greening parallel to compacting
Espoo	**	***	*
Helsinki	**	***	*
Oulu	**	***	*
Tampere	***	*	**
Turku	***	*	**
Vantaa	***	*	**

Fig. 6. Our findings indicate that there is a variation in the emphases of the three discourses in the case CAPs. Three stars demonstrate the most predominant discourse, two stars the second important and one star the least dominant discourse.

tensions are framed and worded in rather positive terms: in actions and opportunities for protecting the green and greening the built-up environment. The first discourse particularly highlights the protection of natural areas, biodiversity, ecological corridors, and GI in general terms, but without touching upon the topic of land take per se. The second discourse deals with the challenges of a dense urban structure from the perspective of climate risks and vulnerabilities, addressing the need for greening built-up areas to advance climate change adaptation. The third discourse concerns greening as a *multifunctional strategy parallel with compact city development*. As such, it represents a novel, integrative understanding of climate-wise urban development.

4.2.1. Compacting while protecting the green

The first discourse acknowledges the need for compacting but also recognizes the importance of protecting the green and especially its biodiversity values. All cities highlight biodiversity in their CAPs. Tampere, Turku and Vantaa can be regarded as biodiversity-oriented cities as nature conservation is their primary green-related category in CAPs (Fig. 6, Appendix 4). Also for Espoo, Helsinki and Oulu, biodiversity is the second most-referred category. Vantaa has the strongest emphasis on biodiversity and states that "*biodiversity will be systematically added, protected and strengthened*" (page 33). Vantaa also stresses the importance of nature conservation and plans to establish 800 ha of conservation areas.

Also Tampere and Turku highlight biodiversity. Tampere aims to "*ensure the continuity and sufficiency of green networks in urban planning*" (page 40) and support biodiversity and carbon sinks in urban forests. Accordingly, Turku highlights the link between biodiversity and carbon sinks and states that "*protecting biodiversity and ecosystems is vital for climate resilience: nature conservation and restoration require efficient actions*" (page 33). Both Turku and Tampere link preservation to compacting and note the importance of preserving and strengthening green structures along with densification as a land use strategy. Espoo and Oulu aim to preserve the most valuable areas and ecological corridors in urban planning while Helsinki avoids reference to urban planning.

The discourse "compacting while protecting the green" can be regarded as a protection-oriented discourse which indicates that the green is distinct from the compact city, a reservoir to be protected from urban development. Even though compact city development leans on the idea of preserving natural areas outside the dense urban structure, it is striking that only two cities (Vantaa, Tampere) explicitly state that growth or densification will be enabled in a way that preserves larger green areas from construction. The need to protect nature from the negative impacts of the compact city is expressed in three CAPs. Tampere and Espoo introduce ecological compensation as a new CAP measure to offset adverse effects on biodiversity and ecosystem services by providing new values in another area. Vantaa and Tampere also highlight the increased pressure on natural areas for recreational purposes. Vantaa stresses the need to protect nature against erosion and damage by directing visitors to use carefully mapped routes in natural sites.

4.2.2. Greening the dense urban structure for adaptation purposes

In addition to their commitment to protect the existing green, the CAPs address greening policies to expand and increase the green. In this discourse, greening mainly serves as an adaptation strategy, enabling a dense urban structure and alleviating the climate risks and vulnerabilities related to compacting. The risks mentioned include floods, heavy rains, and urban runoff, as well as heat, microclimate, urban heat islands, and drought. Especially Espoo, Helsinki and Oulu can be regarded as adaptation-oriented cities as adaptation and especially storm water management is their primary category in green-related objectives (Figs. 4 and 6). Espoo mentions as a specific challenge "*dense urban areas with a large amount of impermeable surfaces*" (2019, page 63) and proposes green roofs and woody green areas as a solution. Also Oulu suggests that "*increasing permeable surfaces in urban areas prevents flooding*" (page 47). Helsinki states that "*green structures in public and private areas are a natural way to support climate adaptation while simultaneously creating a comfortable and diverse milieu*" (2019, page 21).

The CAPs identify several greening strategies, tools, and measures for adapting to the consequences of extreme weather events. Adaptation-focused greening actions include increasing vegetation in the dense urban structure to support climate resilience and to reduce urban flooding and urban heat island effects. For example, Espoo mentions "*greenfixing the dense urban structure*" (2019, page 83), referring to improving stormwater management, enhancing GI, and ensuring the accessibility of green areas. Increasing greenery and the number of trees is mentioned in most cities (Tampere, Vantaa, Helsinki, and to some extent Turku).

Many CAPs touch upon the idea of the "efficient green" for the efficient land use. For example, Espoo advocates for green roofs and green walls to solve the challenge to increase vegetated surfaces in existing dense urban structures. Other cities (Helsinki, Tampere, Vantaa, and Turku) also mention green roofs as a potential strategy for preventing urban flooding, and some CAPs suggest that green roofs could provide an effective response to urban heat island effects (Espoo) and biodiversity loss (Turku). Green roofs are still relatively rare in Finland, and in this light it is interesting that they receive such focus in the CAPs. This focus underlines the discourse on efficient and space-saving green that fits in the dense urban structure. Turku also mentions the aim of increasing greenery and carbon sinks in response to densification (page 41). Rather than addressing the tensions between the opposite objectives of increasing GI and densification, then, most CAPs view the implementation of efficient greening as enabling compact city development.

Another example and application of the efficient green is the green factor, an established greening tool that is applied or mentioned in all six case cities. The green factor tool is a sustainability metrics framework used in local detailed plans which aims to ensure a sufficient level of GI on private plots. Developed on the basis of models in Malmö, Sweden (grönytefaktor) and Berlin, Germany (Biotopflächenfaktor), the green factor is calculated as the ratio of the scored green area to the lot area (Juhola, 2018). It is intended to respond to multiple challenges: its main focus is on stormwater management and increasing resilience against floods and heavy rains, but other concerns include mitigating urban heat island effects, enhancing carbon sequestration and urban biodiversity, and supporting wellbeing. The green factor tool is most specifically used in dense urban structures. Vantaa in fact uses the term "green efficiency target" to underline the efficient use of greenery. Vantaa is committed to enhance green efficiency in all its local detailed plans, using the percentage of local detailed plans that apply the green efficiency tool as one of its indicators (page 17).

4.2.3. Greening as a multifunctional strategy parallel with compact city development

While the two previous discourses emphasize the compact city and consider either the protection of the green or enabling densification by greening, the third discourse highlights greening as an integral and rather independent part of climate actions. A key element of this discourse is the multifunctionality of green spaces, allowing for a response to multiple societal challenges related to climate change. Multifunctionality is also linked with recognizing the interconnectedness of climate-related challenges and biodiversity loss and the need to tackle them with a cross-sectoral approach. The multifunctionality-approach is acknowledged especially in the CAPs of Vantaa, Tampere and Turku while Espoo, Helsinki and Oulu have more limited scope in this regard (Fig. 6). There is also an increasing tendency in integrative approach when comparing the earlier and the new version of CAPs in respective cities. Tampere, for example, has added adaptation in its latest CAP, while Vantaa has added carbon sinks and biodiversity and Turku biodiversity.

The interlinkages between climate, biodiversity and wellbeing targets are well-recognized in Vantaa, Tampere and Turku. For example, Tampere says in its CAP introduction that "*the climate crisis and biodiversity loss are part of the same crisis*" (page 7) and that biodiversity is a cross-cutting theme closely linked to greening actions and to safeguarding the carbon sinks. In addition, Tampere mentions supporting GI provides several benefits such as "*ensuring carbon sinks of urban greenery; strengthening biodiversity and providing positive impacts on comfort and microclimate by alleviating heat waves, windiness and urban flooding*" (page 40). The CAP of Vantaa recognizes also the interlinkages between biodiversity and human wellbeing and states that "*biodiversity is vital not only for the protection of species but also for human wellbeing*" (page 33). Turku names itself as a "*nature city*" and adds that "*nature contributes significantly to comfort, health and vitality*" (page 40).

The multifunctionality of greening is also highlighted through the use of integrative concepts such as ecosystem services. All cities emphasize that GI provides ecosystem services that are vital for humans, such as food, water and climate regulation, as well as cultural benefits such as reduced stress and anxiety. For example, Vantaa states that "*diverse urban nature provides vital ecosystem services such as pollination, regulation of climate, carbon storage, clean water, flood protection and recreational services*" (page 33). Tampere and Espoo use the mapping of ecosystem services as a tool to provide knowledge of the multiple values of green infrastructure.

5. Discussion

The cross-section of the CAPs of Finland's six largest cities provided in this paper offers an insight into the ongoing academic discourse surrounding the integration of compacting and greening strategies, as well as cross-sectoral and systemic climate-wise policies. These discussions are pertinent not only for Finnish municipalities but also internationally as cities worldwide face the urgent need to mitigate carbon emissions and prepare for the effects of climate change under the megatrend of urbanization. The integration of compacting and greening strategies plays a key role in developing sustainable and resilient urban environments (e.g., Aquilina & Sheate, 2022; Artmann et al., 2019).

With a two-step content analysis, we first identified the main motivations and objectives for compacting and greening and, second, uncovered the underlying discourses on how greening is negotiated in relation to compacting. In our first analysis, we found that compacting is not explicitly discussed but regarded almost as an inevitable and unquestioned principle, mainly motivated by the reduction of emissions, specifically from transport. Our findings show that in the CAPs, the current understanding of the resource and climate-smart city relies on the premise that a dense city is a climate-smart city in terms of mobility, efficient service structure and preservation of natural resources.

While compact city development remains a dominant approach, there is, however, a noticeable shift toward acknowledging the importance of GI and greening strategies in the CAPs. Despite the growing focus on greening in climate actions plans, our research indicates that, at the municipal level, the transition toward integrative approach is an ongoing and evolving process (see Hansen et al., 2023). Our analysis on the relationship between compacting and greening demonstrates that the conflicts between these two strategies are seldom touched, even though the negative effects of densification on green areas are much debated in academic literature (e.g. Giezen et al., 2018; Haaland & van Den Bosch, 2015). In general, the negative effects of densification were not discussed in terms of GI loss. Only one of our case cities articulated the complex relationship between compacting and greening by referring to pressures on land take in green areas. This is quite surprising given the EU's no net land take objective (e.g., European Commission, 2021). This lack of critical consideration reflects the political reluctance or inability to address any existing tensions and critique concerning land take. Similar dominance of urban development plans over urban greenspace policies has been observed in Amsterdam and Brussels, for instance. Across both cities, there has been a decline in greenspace at the macro-level associated with increased fragmentation amid compacting schemes (Balikçi et al., 2022). In our data, the careful wordings or the absence of such an uncomfortable topic can be seen as a strategy of rephrasing the relationship between the green and the compact.

While compacting and greening are recognized as separate policies, the complexities of their relationship remain obscure in the studied CAPs. In order to reveal these latent discourses, the second step in our analysis identified three main narratives that describe how greening is articulated and negotiated in relation to compacting in the CAPs: 1) compacting while protecting and preserving green areas, 2) adaptation-focused greening of dense or densifying areas, and 3) greening as a multifunctional strategy parallel with compact city development (Fig. 4). While the first two acknowledge the rationale for compacting, the third one introduces an alternative strategy.

The first discourse highlights the increasing attention given to biodiversity loss (Pettorelli et al., 2021) and protection-oriented approach which reflects a traditional - and conventional - urban conservation approach dating back to the early 20th century (Benedict & McMahon, 2006). The discourse aligns with the prevailing narrative of preserving natural or semi-natural environments beyond the confines of dense urban areas (e.g., Williams, 1999) which reflects the strategy of "land sparing" over "land sharing" in nature conservation and biodiversity preservation (Lin & Fuller, 2013; Soga et al., 2014).

In the second discourse, greening is defined narrowly in terms of "greenfixing" for climate adaptation purposes and harnessed to serve compact city policies. Similar trend of policies underscoring adaptive solutions leading to increased urban greening can be detected also in other cities, for example in New York's GI program focusing on water quality (Meerow, 2020) or in the tree planting program of Paris, motivated largely by the mitigation of urban heat waves (Ville de Paris, 2021). This discourse suggests that the role of greening in climate change adaptation – a topic that previously received only limited attention in climate action plans (e.g. Grafakos et al., 2020; Guyadeen et al., 2019; Parsaee et al., 2019; Stone et al., 2012) – is gaining increasing recognition.

The third discourse stresses greening as a parallel strategy to compacting, emphasizing green infrastructure's multifunctionality in addressing complex climate challenges, aligning with academic research (e.g., Hansen et al., 2019; Pascual et al., 2022; Raymond et al., 2023; Seddon, 2022) and international policy trends, such as EU policies on nature-based solutions and biodiversity strategies and the Nature Restoration Law (2023). Our analysis demonstrates that greening actions are mostly motivated by climate adaptation and stormwater management, followed by preservation of biodiversity. Moreover, there appears to be an emerging interest in urban carbon sinks, a topic which requires further attention (see Zhao et al., 2023). The weakest aspect is health and wellbeing, which are not yet well-integrated in CAPs. This reflects the findings by Sunding et al. (2024) that demonstrate an undeveloped link between GI and health and well-being in comprehensive plans in six Nordic cities.

5.1. Implications for further research and practice

The findings of our study highlight several policy and research needs for the future. As cities are faced with the imperative to respond to both climate and biodiversity targets, they are under increasing pressure to balance urban growth with GI. One topical example is the European Commission's Nature Restoration Law and its requirements for urban ecosystems (Council of the European Union, 2023). Article 8 of the latest version of the law refers to an increasing trend of urban green spaces and tree canopy cover after 2030 until the satisfactory level is reached. However, the exact criteria for a "satisfactory level" are not elaborated.

Combining climate and biodiversity targets and linking greening strategies and urban growth call for an integrative policy framework (e.g. Artmann et al., 2019). Climate action plans have the potential to serve as such an integrative tool to support climate-wise urban planning. The climate policies of our case cities have certainly taken steps toward a more holistic, integrated perspective in this regard, although there is some variation. Developing an integrated approach requires systems-level thinking; recognizing potentially contradictory policy objectives and related tradeoffs and synergies; and contemplating ways to overcome professional and departmental silos in formulating a cross-sectoral climate policy, as shown also by the study of Aquilina and Sheate (2022) on climate resilience development in the nexus of green infrastructure, sustainable transport and urban form in London. While the importance of cross-sectorality and knowledge integration between different administrative sectors and disciplines is well-recognized, its implementation still requires further attention. Our study makes it clear that horizontal integration and monitoring between different policies in particular needs further research. Another topical question concerns the priority of climate objectives and measures over sectoral policy objectives as well as the translatability of CAP targets and implementation plans into concrete objectives, measures, indicators, and monitoring processes in urban policy and planning (e.g., Hansen et al., 2019; Widmer, 2018).

6. Conclusions

Our study shows how municipal climate policies negotiate and balance between compacting and greening strategies in the six largest cities in Finland. The CAPs of the case cities do not question the dominance of the compact city development strategy in climate-wise urban planning, despite the contradictions identified in the literature. However, GI and its multifunctionality is gaining increasing weight and used to complement the dominant strategy, although there are major differences between cities in this regard. Moreover, alleviating the strategies of greening and compacting is not directly addressed, even though the tension is evident. We identified three discourses that describe the relationship between compacting and greening: compacting while protecting the green from urban development; enabling compacting through adaptation-oriented greening; and greening as a multipurpose strategy parallel with compacting. The findings suggest that a holistic and integrated understanding of climate-wise urban development is still evolving. Our study contributes to the international debate on how to integrate the compact and the green. It highlights the role of the CAP as a holistic tool that can be used to tackle climate-related challenges and address the crucial relationship between compact city development and greening actions.

CRediT authorship contribution statement

Ranja Hautamäki: Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Tuulia Puustinen:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tiina Merikoski:** Writing – review & editing, Visualization, Data curation, Conceptualization. **Aija Staffans:** Writing – review & editing, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

Data availability

Data will be made available on request.

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Appendix A

CAP title and length *Preceding CAPS*	**Main content and categories**	**Format of the report** **Level of detail**
Sustainable Energy and Climate Action Plan (SECAP) of Espoo (2019), 121 p.	• Aims for both mitigation and adaptation • Mitigation focused on transport and energy • Adaptation focused on mapping the risks and vulnerabilities.	• Comprehensive but generic report based on SECAP format • Includes GHG emission calculations and energy and transport related actions • Mitigation related risks are described in detail, actions in a general level
Espoo's Action Plan for climate change adaptation 2022-2025 (2022), 17 p.	• Aims for adaptation • Themes: 1) Land use, Infrastructure and housing; 2) GI and biodiversity; 3) Health and security; 4) Communications and regional collaboration	• Compact, tabular presentation • Includes thematic tasks with executing bodies, risks, costs, and schedules
Carbon neutral Helsinki Action Plan (2022), 36 p. *Carbon Neutral Helsinki 2035 (2018) SECAP (2021)*	• Mitigation program for key sources of GHG emissions: 1) Heating; 2) Transport; 3) Electricity • Focus on transport and energy	• Compact program focusing on the most effective actions to reduce emissions • Includes actions, metrics, reduction effects, cost effects, and executing bodies
Helsinki's climate change adaptation policies 2019-2025 (2018), 47 p.	• Adaptation program with four themes: 1) Preparedness (incl. risk assessment; 2) Integration; 3) Development and expertise; 4) Overall economy and business opportunities • Additional chapter for monitoring	• Includes thematic priorities, actions, schedule and executing bodies • Incl. also relationship to other policies, programs and plans is elaborated as well as related development needs
Sustainable Energy and Climate Action Plan (SECAP) of Oulu (2018), 48 p.	• Mitigation program focused on energy and transport • Incl. also aspects of adaptation: risk assessment and alleviation	• General level report based on SECAP format • Includes GHG emission calculations, and energy and transport related actions, schedules, executing bodies, and costs • Incl. also mitigation actions in a general level
Carbon neutral Tampere 2030 Road map (2022), 155 p. *Updated from 2020*	• A road map combining mitigation and adaptation • Themes: 1) Urban planning; 2) Transport system; 3) Construction; 4) Consumption; 5) Urban nature • Focus on transport and energy	• Detailed program formulated as a road map • Includes thematic aims, metrics and relations to other programs • Incl. also actions, schedules, executing bodies, and costs
Turku Climate Plan 2029 (2022), 94 p. *Updated from 2018*	• Mitigation program • Themes: 1) Carbon neutral energy system; 2) Low carbon mobility; 3) Urban structure and low carbon construction; 4) Investments, procurement and climate responsibility; 5) Biodiversity and carbon sinks • Focus on energy and transport • Incl. also notions on adaptation, focusing on risks	• General level report based on SECAP format • Includes GHG emission calculations and energy and transport related actions • Incl. also SECAP action cards with executing bodies
Vantaa's Road map to resource wisdom, update for council term 2021-2025 (2022), 53 p. *Updated from 2018*	• A road map combining mitigation and adaptation • Themes: 1) Urban structure and mobility; 2) Carbon neutral energy; 3) Life cycle of materials and circular economy; 4) Biodiversity; 5) Responsible Vantaa; 6) Carbon sinks and compensation • Focus on greening and transport	• Compact program formulated as a road map • Includes thematic aims and indicators

Appendix 1. The main content of the case city CAPs.

City	Transport	Energy	Green	Urban structure	Services
Espoo	301	226	126	96	68
Helsinki	73	66	72	57	19
Oulu	155	240	36	48	41
Tampere	558	168	147	125	133
Turku	148	154	94	65	54
Vantaa	44	30	60	29	13
Total	**1279**	**884**	**535**	**420**	**328**

Appendix 2. Quantification of key themes of the case CAPs, demonstrating with green the most frequent category and with yellow the second most common category. While transport and energy are the most established categories, there are differences in how green-related aspects are manifested. The keywords applied for the analysis:

Transport: traffic, mode of transport, public transport, vehicle, cycling (in Finnish: liikenne, liikkuminen, kulkumuoto, kulkutapa, ajoneuvo, joukkoliikenne, pyöräily).

Energy (in Finnish: energia).

Green: green area, green space, green structure, all green-related words, landscape construction, nature, urban nature, nature conservation, nature-based solutions, all nature-related words (in Finnish: viheralue, viherverkosto, viher-alkuiset sanat, luonto, luonnonsuojelu, luontopohjaiset ratkaisut, luonto/luonnon-alkuiset sanat).

Urban structure: urban planning, urban structure, city structure, construction, building (in Finnish: kaupunkisuunnittelu, kaupunkirakenne, yhdyskuntarakenne, rakentaminen).

Services (in Finnish: palvelut).

City	Transport	Energy	Green	Services
Espoo	47	5	9	2
Helsinki	3		1	
Oulu	11		3	5
Tampere	41	6	4	8
Turku	16	6	2	8
Vantaa	13	3	11	6
Total	**131**	**20**	**30**	**29**

Appendix 3. Quantification of key motivations for compacting, demonstrating with green colour the most frequent category and with yellow the second most common category. Transport is clearly the most established category, followed by services and green-related aspects. The key expressions applied for the analysis:

Transport: enabling sustainable transport, reducing the need for transport, densification along the transport corridors/tram line/public transport, enabling efficient public transport/pedestrian/cycling possibilities, (in Finnish: vähennetään liikkumistarvetta, kestävät liikenneratkaisut, tiivistäminen joukkoliikenteeseen/raideliikenteseen tukeutuen, kävelyn/pyöräilyn/joukkoliikenteen edistäminen).

Energy: reducing energy, enabling energy-efficient and dense urban development, (in Finnish: energiakulutuksen vähentäminen, energiatehokas tiivis kaupunkirakenne).

Services: improving accessibility of services, enabling efficient service structure and local services (in Finnish: palvelujen saavutettavuus, tiivistäminen mahdollistaa lähipalvelut/tehokkaan palvelurakenteen).

Green: enabling the preservation nature/larger green areas outside the dense urban structure, sustainable use of natural resources, improving accessibility of local green areas (in Finnish: mahdollistetaan tiiviillä kaupunkirakenteella luonnonarvojen/laajempien viheralueiden säästäminen, luonnonvaroja käytetään kestävästi, lähiviheralueiden saavutettavuuden parantaminen).

City	Adaptation	Biodiversity	Mitigation	Wellbeing
Espoo	170	41	2	12
Helsinki	100	44	5	7
Oulu	52	30	2	7
Tampere	35	61	36	27
Turku	45	95	53	13
Vantaa	4	54	15	8
Total	**407**	**325**	**113**	**74**

Appendix 4. Quantification of key motivations for greening, demonstrating with green the most frequent category and with yellow the second most common category. Adaptation and biodiversity are the most established categories, followed by mitigation. The keywords applied for the analysis:

Adaptation: storm water, rain, flooding, urban heat island, heat, thermal control (in Finnish: hulevedet, hulevesien hallinta, sadevedet, tulva, lämpösaareke, helle, lämpötilojen hallinta).

Biodiversity: biodiversity, nature/ecological conservation, nature values/types, ecosystem, ecological connectivity, ecological compensation, invasive alien species (in Finnish: luonnon monimuotoisuus, luonnonsuojelu/hoito, luontoarvo/alue/tyyppi, ekologinen yhteys/verkosto/kompensaatio vieraslajit).

Mitigation: carbon sink, carbon sequestration, carbon storage, carbon stock (in Finnish: hiilinielu, hiilen sidonta, hiilen varastointi, hiilivarasto).

Wellbeing: wellbeing, recreation, recreational area/service, accessibility, health, health benefits/risks (in Finnish: hyvinvointi, virkistys, virkistysalue/käyttö/arvo/spalvelu, saavutettavuus, terveys, terveyshyöty/riski).

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