

The Impact of Compact Cities on Carbon Emissions

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論 文 内 容 の 要 旨

Compact cities, characterized by high density and accessibility with fully developed inner-city public transport, are widely discussed and implemented around the world in response to the challenges of sustainable development and global warming. While compact city policies are widely believed to contribute to urban low-carbon objectives, empirical evidence has been lacking. This thesis focuses on the relationship between compact cities and carbon emissions and examines how key characteristics of compact urban environments impact urban carbon emissions, aiming to provide deeper insights both theoretically and empirically.

Chapter 1 introduces the research background of this thesis and, through a literature review, outlines the definition, development, characteristics, and potential environmental impacts of compact cities. It was found that key indicators related to compactness, including density and accessibility, significantly impacted urban carbon emissions. While public transportation is often strengthened in compact city policies, there is a lack of quantitative evidence on its overall effect on urban CO₂ emissions. Based on the identified research gaps, the research objectives of this study are formally presented, and the research scheme is preliminarily designed.

Chapter 2 addresses how cities with varying urban growth rates adopt different policy practices and whether these practices contribute to building sustainable, low-carbon cities. This chapter summarizes previous research on compact city dimensions and indicators related to urban form and policies. Representative case studies are conducted, comparing strategies from these cases and identifying two types of cities employing compact city strategies. The first type includes cities with low urban growth that use compact city strategies to counter an aging society and population loss. The second type includes megacities with rapidly increasing populations that employ these strategies to address issues arising from increased population density.

Chapter 3 aims to clarify the impact of different dimensions of compact urban development on CO₂ emissions, providing guidance for the formulation of compact city policies. This chapter focuses on pivotal elements of compact city development, investigating impacts on sectoral urban carbon emissions and uncovering spatial heterogeneity. The research outcomes affirm that density and accessibility indicators significantly reduce carbon intensity in the energy, industrial, household, and transportation sectors. However, public transport, despite its fundamental role in compact city theory, does not show the expected effectiveness in reducing urban carbon emissions. The study highlights the need for a balanced approach in applying

compact city development strategies to achieve urban sustainability under climate change adaptation.

Chapter 4 seeks to understand the nuanced, non-linear relationships between compact cities and carbon emissions. The research methodology builds on existing literature and incorporates machine learning and interpretive methodologies to elucidate the nature and trends of the relationships between compact city factors and emissions intensity. By clustering cities by type and growth dynamics, nuanced policymaking toward carbon emission reduction is developed. The findings reveal that these relationships are indeed nonlinear and that urban sustainability dynamics are complex. For example, higher population density and varied land use are beneficial up to a point but may impart diminishing returns or even negative impacts if overextended. Moreover, the presence of public transport alone does not necessarily reduce carbon emission intensity. To improve public transportation outcomes, progressing the energy transition and the integration of new energy vehicles (NEVs) must be prioritized.

Chapter 5 concludes the thesis by summarizing the important findings including the different emphases in compact city policies across various city types. Second, the significant impact of compact city characteristics on urban carbon emissions with spatial heterogeneity. Third, identifying density and accessibility as effective measures for curbing carbon emission growth within optimal ranges, and, finally, the importance of the integration of public transportation and the energy transition in compact city policies.