

Thesis Abstract

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Thesis Title: Towards the Regeneration of Compact Cities: Developing a Sustainable Transit-Oriented Development (TOD) Assessment Model			
Thesis Summary: In the late 20th century, urban shrinkage became a prevalent issue in many developed cities, characterized by population decline, aging societies, and underutilized spaces. To address these challenges, the compact city concept emerged as a sustainable urban development strategy, with Transit-Oriented Development (TOD) serving as a critical implementation approach. TOD promotes high-density, mixed-use urban environments near transit hubs, reducing car dependency and fostering public transport use. However, despite its widespread application, TOD assessment methods remain inadequate in evaluating long-term sustainability, particularly from an environmental perspective. This study aims to develop a comprehensive framework for measuring and evaluating the sustainability of TOD, addressing the current lack of effective assessment tools. The Node-Place model, a widely recognized framework for TOD assessment, focuses primarily on the relationship between transportation and land use but overlooks key environmental considerations, such as carbon emissions and natural resource utilization. Meanwhile, the Node-Place model struggles to track the long-term dynamic changes in TOD development. To bridge this gap, this study develops the Node-Place-Environment (NPE) model, integrating an "Environment" dimension into the traditional framework. The NPE model enables a multidimensional assessment of TOD stations, encompassing transportation efficiency (Node), land use characteristics (Place), and environmental sustainability (Environment). Furthermore, to overcome the limitations of static TOD evaluations, we introduce a "Timeline-Based" approach, allowing for dynamic assessment of TOD station evolution over time. This framework integrates a variety of quantitative tools. The final values of each TOD across three dimensions are calculated using min-max normalization, thereby determining the coordinates (x, y, z) of TODs within the three-dimensional space of the NPE model. The TOD performance is systematically evaluated, and the sustainable development trend of a station is relatively determined by a set of factors: (x, y, z, and the distance to SDL). This study focuses on the Tokyo Metropolitan Area and uses the NPE model in case studies to assess the sustainability of TOD in various urban areas. In the suburban city of Odawara, we found that the "environment" dimension plays a crucial role in balancing the negative impacts of overheating urban development. Additionally, along the Odakyu Line, which spans Tokyo and Kanagawa Prefecture, we observed an increasing concentration of resources at central city stations, leading to a growing			

monopolistic trend and an unbalanced development pattern compared to suburban stations. Finally, using the Den-en-toshi line, we identified that excessive development in any one of the three dimensions—node, place, and environment—could lead to the unsustainability of TOD. We also identified the key indicators that have the most significant impact on sustainability.

Chapter 1 introduces the emergence of the compact city concept as a response to urban shrinkage. TOD, as a key approach to compact cities, has received significant attention. The chapter clarifies the research objectives and significance.

Chapter 2 discusses the key issues in current TOD research and identifies the research gap in the classic Node-Place model as a quantitative framework for TOD. The chapter emphasizes that environmental issues arising from TOD development should not be overlooked and highlights the necessity of introducing the "Environment" dimension.

Chapter 3 builds on the Node-Place-"X" model by incorporating ecological considerations within the "Environment" dimension, expanding the traditional two-dimensional TOD evaluation framework into a three-dimensional model. This model is applied to 18 stations in Odawara, a suburban city in the Tokyo metropolitan area, to examine the impact of TOD on urban development. The results reveal discrepancies between the actual conditions of the stations and their official designations, as well as a negative correlation between the Node-Place value and the Ecology value. The chapter not only establishes a direct link between TOD and ecological factors, proposing a new quantitative evaluation method, but also provides new perspectives and tools for the sustainable development of metropolitan suburban areas rich in ecological resources.

Chapter 4 addresses the static nature of the traditional Node-Place model by proposing a "Timeline-based Assessment" method that incorporates a temporal dimension. The concept of a "Low-Carbon City" is integrated into the Node-Place-Environment framework to explore the sustainable development progress of 96 TOD stations in the Tokyo metropolitan area from 2011 to 2019. The results show an overall positive development trend, but stations in the metropolitan center exhibit increasing concentration in the Node, Place, and Environment dimensions. The chapter highlights the necessity of dynamic TOD models in urban planning and provides new perspectives for the sustainable development of transit hubs.

Chapter 5 constructs different policy scenarios and, using the Node-Place-Environment (NPE) model, analyzes the TOD sustainability changes of 27 stations along the Den-en-toshi Line in Tokyo and Kanagawa Prefecture under policy interventions. The study employs K-means clustering and Sustainable Development Line (SDL) testing to identify stations deviating from sustainable development, and uses scenario and sensitivity analysis to assess the impact of policies on their development. This chapter emphasizes that urban policy interventions in TOD should be timely and

cautious, as overly hasty actions could lead to unsustainable development of TOD.

Chapter 6 systematically discusses the key findings derived from the three case studies and further summarizes the contributions of this research to the field of TOD studies. The chapter also outlines the limitations of the study and emphasizes that these will be addressed in future work.

This research makes several key contributions:

1. **Methodological Innovation** – The introduction of the NPE model and timeline-based analysis provides a more comprehensive and dynamic approach to TOD sustainability assessment.
2. **Empirical Insights** – By applying the model to the Tokyo Metropolitan Area, the study offers real-world evidence on TOD performance, supporting policy optimization.
3. **Policy Recommendations** – The findings emphasize the need for balanced TOD development, advocating for policies that integrate transportation, land use, and environmental sustainability.

Overall, this study advances the theoretical and practical understanding of sustainable TOD development, offering a quantitative, adaptable framework applicable to cities worldwide. At the same time, the limitations of the study include insufficient integration with policies, challenges in bridging different urban contexts, and the need for more tailored analysis of urban and suburban TOD differences. Additionally, its applicability beyond the Tokyo Metropolitan Area remains uncertain, requiring further adjustment and validation in different global contexts.

Keyword: Compact city; Transit-oriented development; Node-place model; Node-place-ecology model; Tokyo metropolitan area; Sustainable development