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Neighbourhood planning approaches to net zero transport

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Abstract

Limited research exists on how various neighborhood types affect transport emissions, which restricts our understanding of the impacts of land use and transport integration. This study develops a neighborhood classification framework, categorizing 10,068 neighborhoods in the Greater Melbourne area into 14 types based on their level of integration. Using VISTA data, the study finds that mobility-oriented development (MOD), transit-oriented development (TOD), 20-Minute Neighborhoods, and Activity Centers are respectively 5, 3, 1.6, and 1.5 times more effective in reducing transport emissions compared to sprawl neighborhoods.

1 Introduction

Hundreds of neighbourhood planning approaches have been practiced over a century (Sharifi, 2016, Rohe, 2009), such as garden city, neighbourhood unit, superblock, transit-oriented development, transit-adjacent development, urban village, fused grid, activity centre, 15/20-minute neighbourhood, and sprawl. They are distinguished by their urban form standards (e.g., low- vs. high-density), which in turn shape travel demand and transport emissions. Although previous studies have estimated the individual effects of urban form indicators on transport emissions, the cumulative impact of these elements that make up the type a neighbourhood remains unknown. Typological approaches are commonly employed to identify different neighbourhood types and assess urban outcomes, yet their use in understanding transport emissions is still limited (Baiocchi et al., 2015).

Existing studies often rely on statistical or machine learning techniques (k-means, factor analysis, classification and regression trees) to derive neighbourhood typologies. However, these data driven techniques present several limitations: a) They lack a theoretical foundation, as the technique defines classes purely by partitioning data for best fit; b) The generated classes are often incomparable between studies; c) These classes do not align well with the neighbourhood concepts used in practice; and d) The classes are mutually exclusive, despite neighbourhoods can satisfy criteria for multiple types (e.g., TOD and 20-minute neighbourhoods), limiting our understanding of their combined effect. To address these limitations, this paper aims to develop a theoretically grounded and practically applicable neighbourhood classification framework. Specifically, it seeks to:

1. Establish a classification framework informed by theory for practical use;
2. Quantify the climate cost of transport emissions from personal travel; and
3. Investigate how these costs vary across neighborhood types.

2 Data and methods

The study utilises data from Greater Melbourne, Australia. Each of the 10,289 SA1 (Statistical Area Level 1) in Greater Melbourne area is considered as a neighbourhood–a commonly used spatial unit to define a neighbourhood in Australia (Zhang and Luo, 2024, Thackway et al., 2023). A classification framework was developed by identifying different urban form indicators that define the type of a neighbourhood including the 5Ds (e.g., density, diversity, design,

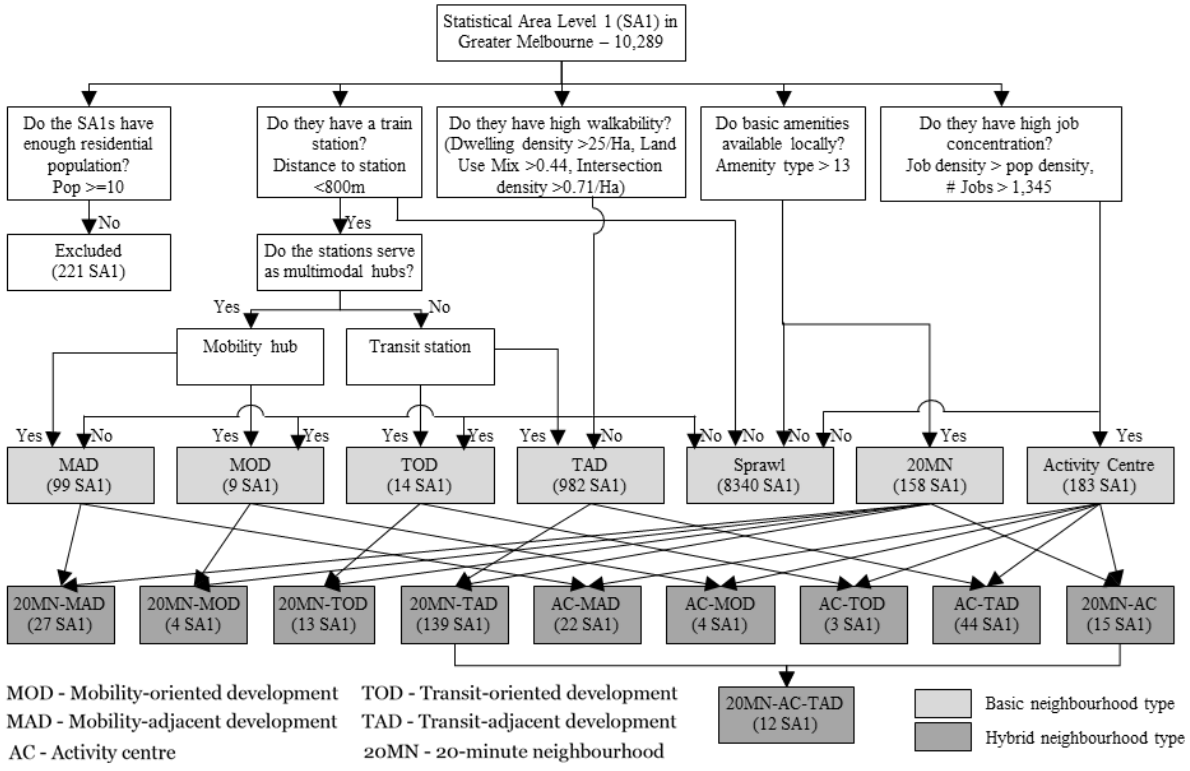
destination accessibility, and distance to transit), and concentration of jobs. Figure 1 outlines the standards applied to these indicators to distinguish the SA1s into seven basic types of neighbourhoods that currently in practice or promoted for future planning in Australia. The seven basic neighbourhood types were cross-examined to identify if any of the selected SA1s falling under a particular category also satisfy the criteria for other categories, which resulted in 10 hybrid neighbourhood types. The average climate change cost from transport emissions of people living in these neighbourhood types were estimated using Equation 1 based on the VISTA travel diary data.

$$CCC_i = \sum M_{mil} D_{mil} \quad (1)$$

where, CCC_i = Climate change cost of trip *i* (AU$), M_{mil} = Climate change cost per passenger kilometre (pkm) for mode *m* in leg *l* of trip *i (AU$/pkm),* D_{mil} = Travel distance in kilometre using mode *m* in leg *l* of trip *i (pkm).* Mode-specific climate change cost per passenger kilometre values were obtained from the Australian Transport Assessment and Planning Guidelines (2021).

Descriptive analyses were conducted to understand how the climate change costs from transport emissions vary across the neighbourhood types. In addition, the climate change costs were regressed on the various urban form indicators, as employed to classify the neighbourhoods, to verify their relevance to classify the neighbourhoods.

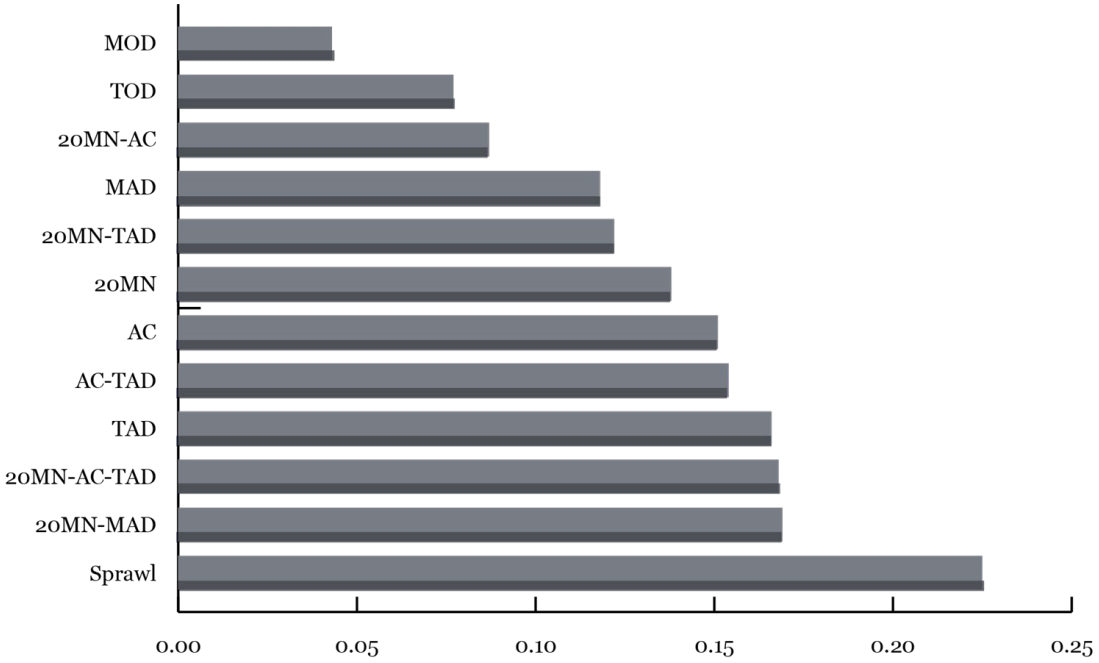
Figure 1: Proposed neighbourhood classification framework



3 Results

Figure 2 illustrates the levels of climate change costs incurred in different types of neighbourhoods analysed in this study. Consistent with common wisdom, sprawl neighbourhoods emerge as the largest contributor to climate change costs. In contrast, MOD neighbourhoods exhibit the greatest potential for reducing climate change costs from transport emissions, followed by TOD, 20MN-AC, 20MN-AC, MAD, 20MN-TAD, 20MN neighbourhoods.

Figure 2: Climate change cost from transport emissions across different neighbourhood types



Four out of the six urban form indicators used to classify the neighbourhoods were found to have a statistically significant association with the climate change costs from transport emissions, as shown in Table 1, thereby largely validating the suitability of the neighbourhood classification framework proposed in this study.

Table 1: Effects of urban form factors on the cost of climate change from transport emissions

Explanatory factors	Outcome variable: climate change cost ($) from transport emissions per person per weekday	
	B	Standardised B
Population density (person/ha)	-0.001**	-0.076
Types of amenities available	-0.002**	-0.063
Intersection density	-0.014**	-0.038
Access to train (1: Yes, 0: No)	-0.015**	-0.048
Distance to CBD (km)	0.004**	0.404
Median total personal income ($/week)	0.001**	0.184
Median rent ($/week)	-0.001**	-0.045
Average household size	0.015**	0.059
Constant	0.061**	
N		2,704
R^2		0.24
F		96.77**

** Coefficients are significant at the 0.05 level

4 Discussion and conclusions

This study introduces a novel neighbourhood classification framework that confirms known trends in transport emissions – particularly, that sprawling neighbourhoods contribute

significantly to these emissions. The framework also underscores the effectiveness of integrated transport and land use planning approaches, as seen in MOD and TOD neighbourhoods, in reducing climate change costs associated with transport emissions. These findings affirm the framework's applicability and provide valuable insights for low-carbon neighbourhood planning by exposing which urban form indicators and standards are critical for emissions reduction. For example, the stronger performance of TOD over TAD highlights the importance of neighbourhood design in promoting sustainable transport modes. Furthermore, the enhanced outcome of MOD over TOD, and MAD over TAD, demonstrate the added value of integrating multimodal transport options in achieving emissions reductions. Taking together, these results emphasise that a cohesive approach to land use and multimodal transport integration is critical for future neighbourhood planning if net zero transport is to be realised.

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