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Make TOD More Bicycling-Friendly: An Extended Node-Place Model Incorporating a Cycling Accessibility Index

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Abstract: Building cities more sustainably through transit-oriented development (TOD) has become a principal planning concept in recent decades. The node-place model serves as an important tool for determining the TOD typology, combining the consideration of the station with the transport network in which it is located. A number of studies have proposed the addition of new indicators to the original node-place model. However, the importance of bicycling as a mode of transport to access the transport mode, and within the vicinity of TODs, has been overlooked in the literature. In this paper, two bicycling-related indicators are added to the extended node-place model using Burwood Station in Sydney, Australia, as a case study. The results of the analysis show that the introduction of bicycle accessibility-related factors significantly impacts the TOD typology, and particularly the design index of the extended node-place model. This result implies that only considering pedestrian-related indicators may cause certain deviations in terms of the modelling result. The study highlights the significance of considering bicycling infrastructure in TOD planning to promote the use of active travel and sustainable transport behaviour.

Keywords: transit-oriented development; node-place model; extended node-place model; cycling; accessibility

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Citation: Zhang, M.; Lee, J. Make TOD More Bicycling-Friendly: An Extended Node-Place Model Incorporating a Cycling Accessibility Index. *Buildings* **2023**, *13*, 1240. https://doi.org/10.3390/buildings13051240

Academic Editor: Pierfrancesco De Paola

Received: 6 April 2023
Revised: 27 April 2023
Accepted: 5 May 2023
Published: 9 May 2023

1. Introduction

The rapid pace of urbanisation has brought immense growth potential to cities, but it has also resulted in significant socio-economic and environmental costs that cannot be ignored, as highlighted by [1]. The expansion of urban sprawl has resulted in a range of issues such as increased auto dependency, traffic congestion, longer commute times, inefficient land use, loss of farmland and green space, and increased greenhouse gas emissions. Additionally, urban sprawl can contribute to economic and social inequality by creating pockets of communities isolated from vital activity centres and services [2,3].

The idea of transit-oriented-development (TOD) is to build sustainable and livable communities by integrating transport and land use. The fundamental principle of TOD is to place high-density, mixed-use developments near or on a major transit station to promote the use of public transport and active transport modes, reduce auto dependency, and improve the utilization of land. Since its first introduction by [4], TOD has emerged as a widely accepted urban planning approach adopted by cities globally to address the issues of urban sprawl [5,6]. TODs reportedly deliver a variety of economic, health, and environmental benefits by increasing public transport usage [7–9], encouraging non-motorised travels [10–12], and reducing auto dependency [13,14].

One of the most significant benefits of TODs is that they promote sustainable transport modes such as walking or cycling. This shift towards more sustainable travel options can be particularly effective for shorter journeys [15], helping to reduce auto dependence and its associated negative impacts on the environment, public health, and traffic congestion. As such, the promotion of sustainable transport modes within TODs and amongst the residents represents an important strategy for creating more livable, resilient, and environmentally friendly communities. Implementing pedestrian- and bicyclist-friendly urban and street designs, which offer a greater variety of transport options and attract more urban consonants through positive self-selection effects, could prove to be an effective strategy for achieving the goals of TODs [16].

TODs are not solely dependent on their proximity to transit stations, and the quality of the surrounding urban design plays a crucial role to promote sustainable travel patterns [17]. TODs serve to strengthen the connections between people's daily activities, including work, leisure, and socialising, and their surrounding community. This emphasis on community-building and the integration of various activities into a cohesive urban environment is a critical aspect of the TOD concept. High-density, well-connected urban designs can provide people with a healthier living style [8]. Prioritising walking and cycling as means of transport can offer residents the opportunity to lead more socially connected lifestyles. This increased sense of community can create more opportunities for people to meet and interact with their neighbours. Overall, the integration of sustainable transport options into TODs can help promote a healthier, happier, and more connected urban environment [18].

TODs must balance the need for comfortable living conditions with the demand for public transport. To achieve this balance, high-density development is required within walking distance of transit stations. However, relying solely on walking as the mode of access may make it difficult to achieve both high transit ridership and comfortable living conditions without compromising one or the other [19]. Bicycles can be an effective means of reducing the inconvenience caused by high-density development in TODs while significantly expanding the catchment area. By enabling access to transit stations within a wider radius, bicycles can help achieve a balance between comfortable living conditions and high transit ridership [20].

Many studies in the literature have proposed models to evaluate and classify station areas, including TOD. These models often consider a range of factors, such as land use patterns and transport infrastructure, to assess the effectiveness of the station area in promoting sustainable, liveable, and attractive communities [21,22]. The node and place model, proposed by [23,24], is the most widely recognised model for balanced development of station areas, utilising a range of transit "node" and surrounding "place" indexes. This model is designed to ensure that both the transit node and the surrounding development are given equal importance in the planning and development process, promoting a balanced and sustainable approach to urban development around transit stations.

The original node and place model has been expanded to incorporate a "design" element that reflects the principles of the 3 Ds (Density, Diversity, and Design) in TOD planning [22]. This extension of the model emphasises the importance of designing the built environment around transit nodes to promote active travel. Whereas existing studies have explored pedestrian-friendly street design and connections [22,25–27], the role of cycling and its related infrastructure or street design has been relatively unexplored in the literature. This suggests a potential gap in the research about the incorporation of cycling into the node and place model for TOD planning.

This study introduces two new urban design indicators that can be utilised to evaluate the degree of cyclist-friendly urban design and infrastructure, with the aim of incorporating these indicators into an extended node-place model. Those indicators include the cycling accessibility index and the length of the cycling network. To the best knowledge of the authors, this study represents the first instance in which a cycling accessibility index has been applied to a node-place model. In addition, two indicators are proposed to evaluate pedestrian-friendly urban design. Those indicators include the pedestrian network length, and the pedestrian shed ratio. The present paper proposes an extension to the node-place model by incorporating these four indicators mentioned earlier, along with a range of other transport and land-use indicators. The impact of this extended model is demonstrated by comparing the evaluation results before and after incorporating the new indicators in a case study area.

The paper is structured as follows: Section 2 provides a detailed introduction to the node-place model, as well as the extended node-place model that incorporates the "design" dimension and its applications in various cities. In Section 3, the methodology and data sources used to examine the TOD typology of the case study area are presented, including a description of the indexes and data utilised in the study. Sections 4 and 5 present the main findings and discussions of the study, respectively, with a focus on the practical analysis of the study site. Finally, the article concludes with a summary of the key findings and their implications for TOD planning and design.

2. Literature Review

2.1. Node-Place Model

The node-place model was proposed for evaluating and classifying station areas, including TODs, based on their functions as both transport nodes and places for land use [23,24]. The model considers the balance between these two components and identifies areas that may require further development or improvement. Later, Bertolini (1999) [24] demonstrated how the node and place factors are interconnected and mutually beneficial, as exemplified by the case studies of the Amsterdam and Utrecht urban regions. In Figure 1, the *x*-axis shows the value of the place component, which generally reflects the level of activity or development intensity in the corresponding area. The *y*-axis represents the transport node value, which shows the quality of transport networks and systems, including the public transport systems.

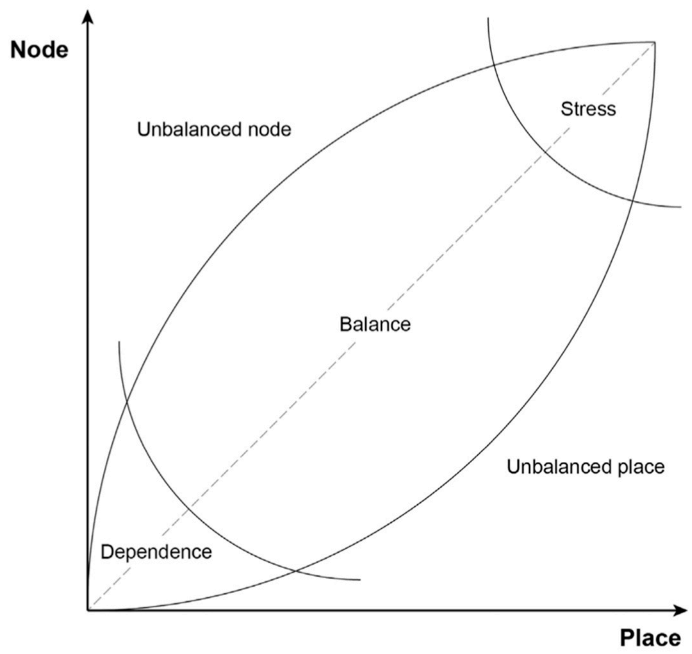

Figure 1. Node-place model [23].

The categorisation of station areas is firstly determined by a "balance" line, wherein TODs achieve a balance when the nodal value and the place value are relatively similar. In "stress" areas, where both nodal and place values are strong, mobility and urban activity are at their peak and land use is maximized. The area that belongs to the lower left corner of the diagram is defined as the "dependence" area. The public transport system and services in this area are too weak to attract many passengers, and the level of development in this area is still very low. The term "unbalanced place" refers to an area where the nodal value is excessively high, whereas the place value is insufficiently low, indicating an excess of transport supply and a lack of urban activities (located in the top left quadrant of the diagram). Another scenario is where the place value is excessively high, but the node value is insufficiently low (bottom right). In such areas, the provision of transport infrastructure is insufficient to meet the demand for urban activities.

Using the node-place model, it is possible to pinpoint the areas that require additional transit services to facilitate urban activities [28]. This model also can be used to identify areas where public transport systems can meet additional demand, so further development is possible [25]. As such, the node-place model is an effective urban planning framework to guide the balanced development of TODs [29,30]. However, there have been several studies that suggest potential improvements for the node-place model. The original node-place model has a limited scope as it only takes into account the rail system and disregards other transit modes, as well as potential impedances to access the public transport station due to, for example, poor walking or bicycling networks [26,31,32]. In addition, the original node-place model's five types of categories do not encompass all possible typologies of station areas and TODs [22,26,30]. More importantly, this model is unable to identify the functional connections, such as pedestrian or bicycling links, between transport nodes and place features. This can lead to confusion between TODs and Transit Adjacent Developments (TADs) that have similar characteristics to TODs but lack the necessary functional links [22].

2.2. Extended Node-Place Models

Recent studies have suggested enhancing the original node-place model by incorporating walkability measures of station areas, thereby introducing a third dimension of "design" to address its limitation [25,26,30]. Schlossberg and Brown (2004) [33] suggested that the good connectivity between transport nodes and surrounding land uses for pedestrians is one of the key factors for the success of TODs. The quality of the pedestrian environment can be influenced by various factors, including the layout of the street and the condition of the pavement, as noted by [17,33]. Furthermore, Wegener and Fuerst (2004) [34] propose that the relationship between land use and accessibility is influenced by multiple factors, such as the level of development density, street design, urban location, and scale.

By incorporating the design index into the existing model, it becomes possible to consider the connectivity between nodes and neighbouring land uses (or vice versa), which allows for an explanation of how easily transport nodes can be accessed from surrounding land uses [27,33]. Lyu et al. (2016) [25] identified six categories of station areas in the Beijing metro region using the node-place-design model. Vale et al. (2018) [26] further illustrated these development types through diagrams. Of the typologies, "Urban TOD" refers to station areas that have both strong node, place, and design values, wherein diverse urban activities and high-density development are generally included. "Balanced TAD" refers to stations with strong node and place values, but a low design index with a poor pedestrian environment. "Suburban TOD" has a high design value but a lower node and place value than "Urban TOD". The fourth type is the "Undersupplied Transit TOD", which has a node index lower than the design and place index, and wherein the provision of transport facilities does not match the high density of development in the area, nor provide good pedestrian accessibility. "Unbalanced TOD" has a low place index and average node and design value. Finally, "Future TOD" has a low place and design index that defines it as "isolated" in the city, despite having the basic transport infrastructure. "Urban TOD" and "Suburban TOD" both correspond to "balanced" places of the original node-place model, whereas, for the other three types, transport provision, urban activities, or pedestrian environments need to be enhanced according to the weaknesses in each type in order to achieve a "balanced" outcome [30]. Their extended node-place model further refines the classification of TODs by distinguishing TODs from TADs [25,26,26]. This allows decision-makers and urban planners to establish more targeted strategies to facilitate sustainable urban planning [25,29,34,35].

Numerous researchers have utilised the extended node-place model, which incorporates a design index, to examine Transit-Oriented Developments (TODs) in different urban areas. Vale et al. (2018) [26] demonstrated that the metro station areas of Lisbon, Portugal, fall into the "Unbalanced TOD" and "Undersupplied Transit TOD" typologies by utilizing a node-place-design model. Using a similar approach, Zhang et al. (2019) [27] evaluated London's metro station areas and showed that Inner London station areas have relatively high design and place indexes, so they are classified as "Urban TOD" and "Balanced TOD", whereas the outer London station areas tend to have lower design and place scores, as they further away from the inner city ring. Using a similar approach, Zhang et al. (2019) [27] analysed the metro station areas in London and found that the Inner London station areas have better design and place characteristics, leading to their classification as "Urban TOD" and "Balanced TOD". Conversely, the station areas located in the outer regions of London generally have lower design and place values than the transport node index, likely due to their greater distance from the city centre. Su et al. (2020) [22] studied the typology of TODs in five mega-cities in China. The finding indicated that most of the TODs in the study area fall to the "Undersupplied Transit TOD" and "Future TOD" typologies, with very poor design indexes.

Recent studies have revealed correlations between the three indexes of node, place, and design. Typically, there is a positive correlation between node and place, and between place and design; however, the association between node and design is weak [26,27]. The interpretation of the result highlights the significance of incorporating a design index, as it reveals that the presence of a well-established transport hub does not necessarily guarantee good connectivity with surrounding areas via pedestrian- and cycling-friendly links [26,27].

The literature review emphasised the significance of incorporating the design aspect when evaluating and categorising station areas. The current node-place-design models take into account various pedestrian-related measures to capture the level of connectivity between transport nodes and nearby locations through walking. For example, the pedestrian shed ratio has been used as a measure of the pedestrian environment to indicate the cover area within a five-minute walk from the transport node [26,30,33]. Despite the fact that cycling is a crucial component of the design index and a fundamental requirement for the success of TOD, the current literature has left relatively unexplored its incorporation into the existing models, to the best knowledge of the authors.

3. Study Area and Data

3.1. Study Area

For the purpose of testing the new node-place model and demonstrating its effectiveness, the Burwood station area in Sydney, Australia was selected as a case study in this research. The Burwood Station was built in the year of 1855 to serve the railway from Sydney to Parramatta [36]. At the time, Burwood Train Station was one of only four train stations in existence in Sydney, which highlights the strategic importance of the study area [36]. Burwood is situated to the west of Sydney's CBD, at a distance of approximately 11 km (Figure 2). Burwood Station has become a crucial transport hub, connecting Sydney's CBD and Parramatta (Sydney West) as well as serving as a gateway to the north.

The vicinity of Burwood station features a vibrant commercial and retail hub that can be conveniently accessed by walking or bicycling. There are a wide variety of shops, restaurants, and one of the largest shopping centres in Sydney. Another major point of interest could be Burwood Park, a large public park with playgrounds, gardens, and sports facilities, also located in the vicinity of the station. The park provides a green space for residents and visitors.

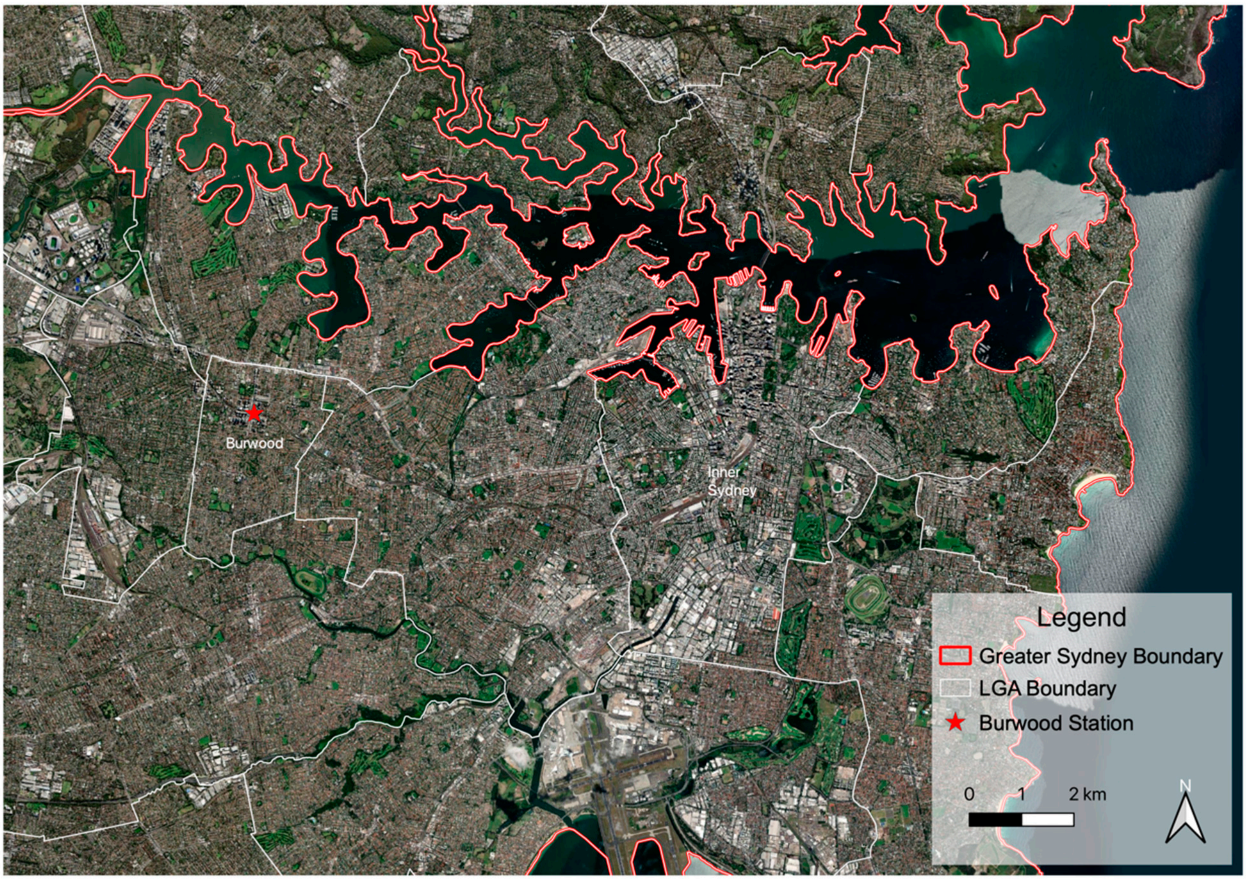

Figure 2. Location of Burwood Station.

3.2. Data

To conduct this study and develop the model for the Burwood station area, a diverse range of data related to transport, land use, and urban design was required. The majority of the data required for the transport node index formulation was obtained from the New South Wales government's open data hub and the GTFS (General Transit Feed Specification) dataset, which provide information regarding the train service routes, daily frequency of train services, and the bus route options available at Burwood Station. The car parking availability data is obtained from the Burwood Council [36].

The data required for the place index formulation was primarily obtained through the Australian Bureau of Statistics (ABS). As the census in Australia is conducted every five years, the latest 2021 census data was used to develop the model for this study. In addition to demographic data, point of interest information (POI) was essential for formulating the place index in this study. The NSW Government Special Services (DCS) dataset provides data on the location, number, and type of POIs.

To formulate the design index, pedestrian-related data were obtained from OpenStreetMap, while data related to bicycle infrastructure, specifically for the purpose of bicycle accessibility modelling, was obtained using the NSW Bicycling Network Map, which is accessible through the NSW Open Data Hub.

4. Modelling

In this study, a node-place-design model was formulated using a total of 17 measures including 5 node indexes, 8 place indexes, and 4 design indexes (Table 1). Two new measures related to bicycles were added. The first is the total length of bicycle lanes within a 2 km boundary from the train station, and the second measure is the number of points of interest (POIs) accessible via bicycle lanes within the same 2 km boundary. To measure these two dimensions, only bicycle lanes separated from car traffic or designated for bicycles were considered among the existing bicycle infrastructure in the area. In addition, the remaining 16 measures were based on measures commonly used in previous studies [22,25–27].

Table 1. Indicators of the extended node-place model in the research.

	Indicators	Description
Node index	Number of directions served by railway	n1 = number of directions served by train
	Daily frequency of train services	n2 = daily frequency of train services
	Number of directions served by other public transport	n4 = number of bus services offered at the station
	Number of station platforms	n5 = number of platforms of each station
	Car park availability	n6 = existence of public car parking at the station (yes/no)
Place index	Number of residents	p1 = number of residents within 500 m from the station
	Number of workers in the retail, hotel, and catering sectors	p2 = Number of workers in the retail, hotel, and catering sectors within 500 m from the station
	Number of workers in the education, health, culture sectors	p3 = number of workers in the education, health, and culture sectors within 500 m from the station
	Number of workers in the administration and services sectors	p4 = number of workers in the administration and services sectors within 500 m from the station
	Number of workers in the industry and distribution sectors	p5 = number of workers in the industry and distribution sectors within 500 m from the station
	Degree of functional mix	$p6 = 1 - \frac{\left(\left(\frac{a-b}{d}\right)-\left(\frac{a-c}{d}\right)\right)}{2}$ which $\begin{cases} a = \max\{p1,\ p2,\ p3,\ p4,\ p5\} \\ b = \min\{p1,\ p2,\ p3,\ p4,\ p5\} \\ c = \frac{(p1+p2+p3+p4+p5)}{5} \\ d = p1+p2+p3+p4+p5 \end{cases}$
	Number of points of interest	p7 = numbers of points of interest within 500 m from the station
	Variety of points of interest	p8 = variety of points of interest within 500 m from the station
Design index	Pedestrian shed ratio	d1 = covered area within a five-minute walk from the station
	Accessible pedestrian network length	d2 = length of the accessible pedestrian path within 500 m boundary from the station
	Accessible cycling network length	d3 = length of cycling lanes (only selected types) within 2000 m boundary from the station
	Cycling accessibility	d4 = numbers of points of interest accessible via cycling lanes (only selected types) within 2000 boundary from the station

4.1. Node Index

The Burwood Station is severed by four railway services, including the T1 route between "Sydney CBD" and "Emu Plains or Richmond", the T2 route between "Inner West" and "Leppington", the T3 route between "Sydney CBD" and "Liverpool or Lidcombe", and the T9 route between "North Shore" and "Hornsby". On a typical weekday, the train services to Burwood Station have a total frequency of 120 and are provided through the four train lines. Burwood Station is comprised of a total of six platforms that can service six tracks in order to facilitate four train lines. In addition, there are 24 bus routes connecting the Burwood station to its neighbouring suburbs as well as the Sydney CBD. Instead of quantifying the number of parking spots available, the car park measure was added to the model as a binary variable (0 or 1) to indicate the presence or absence of commuter parking for park-and-ride purposes [26].

4.2. Place Index

A place index consists of indicators mainly related to population, land use, and points of interest around transport hubs. These indicators are used to determine the demand for transport systems in the area surrounding public transit stations. According to the 2021 ABS census data, Burwood has a total population of 40,217 and a population density of 5651 people per square kilometre [37]. Burwood's population has grown by 1861 individuals since 2016. Moreover, Burwood boasts a diverse occupational composition, with the highest number of individuals employed in education, health, and culture, constituting a population of 1243 [37]. Of the remaining occupational shares, 943 are employed in the retail, hotel, and catering sectors, the number of workers in the administration and services sectors is 634, and there are 371 people working in the industry and distribution sectors [37].

The predominant land use categories in the area surrounding Burwood Station are R1 General Residential, R2 Low Density Residential, R3 Medium Density Residential, RE1 Public Recreation, and B4 Mixed Use, as illustrated in Figure 3. The B4 Mixed Use Zone encompasses most of the lots within a 500 m radius of the station, and the land uses in this area are marked by a diverse range of residential, commercial, and retail activities. The area boasts a unique streetscape, characterised by a variety of building sizes and forms.

Figure 3. Land use map [38].

The POIs within a 500 m catchment from Burwood Station are shown in Figure 4. The POIs that won't attract significant trips have been excluded from the analysis, such as the courthouse, fire station, monument, etc. The remaining 23 POIs have been grouped into four categories based on their function, including healthcare (12), recreational (5), commercial (4), and educational (2).

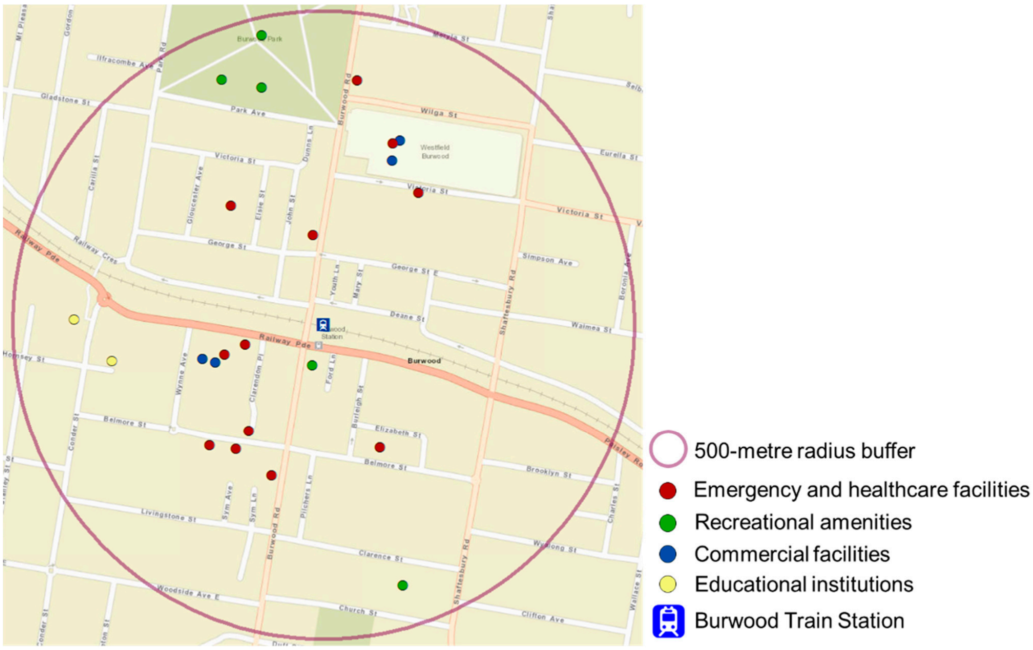

Figure 4. POIs analysis within 500 m of Burwood Station.

4.3. Design Index

Within 500 m of Burwood Station, the total length of footpaths, defined as pedestrian-only paths or streets, or pedestrian paths separated from traffic, is 2744 m. The area that can be covered by walking distance within the prescribed five-minute walking time is 0.32 km^2. Figure 5 shows a map of the pedestrian shed ratio and the pedestrian footpaths within the 500-m buffer catchment.

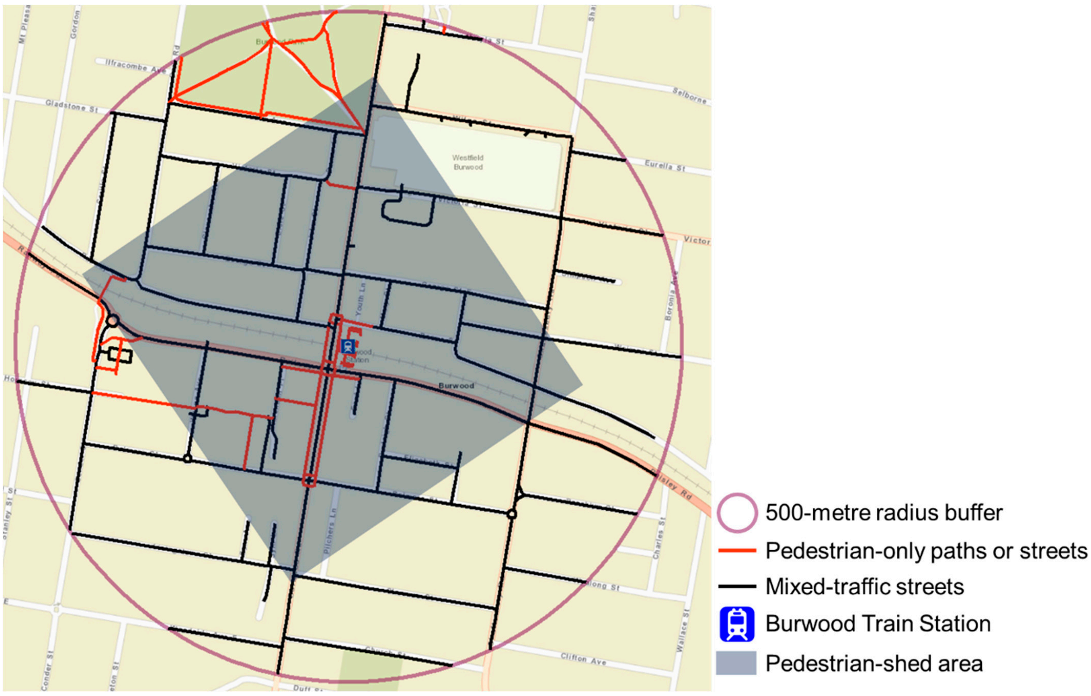

Figure 5. Walking footpaths and pedestrian shed area.

The type of bicycle infrastructure has a significant impact on the perceived safety of cyclists depending on whether the bicycling lanes are separated from traffic lanes or not.

Additionally, when bicycle lanes are not physically separated from traffic lanes, the type of roadway (i.e., local road or arterial) can greatly affect the use of cycling.

The Level of Traffic Stress (LTS) concept is used in this study to measure the level of safety perceived by cyclists, and it is divided into four classes. LTS4 indicates that the road is at the maximum level of cyclist stress, and it usually refers to a busy road with no separated cycle lanes; LTS3 is used to describe a narrow cycle lane in a busy road; LTS2 is a buffered cycling lane; LTS1 is a cycling lane that is physically separated. There are barely any high-level (LTS1 and LTS2) cycle lanes throughout the study area, and for LTS3, separated cycle lanes are only provided on some local streets (Figure 6). Most streets have mixed traffic lanes, with a mix of bicycle and motor vehicle traffic, which should hinder cycling to the station.

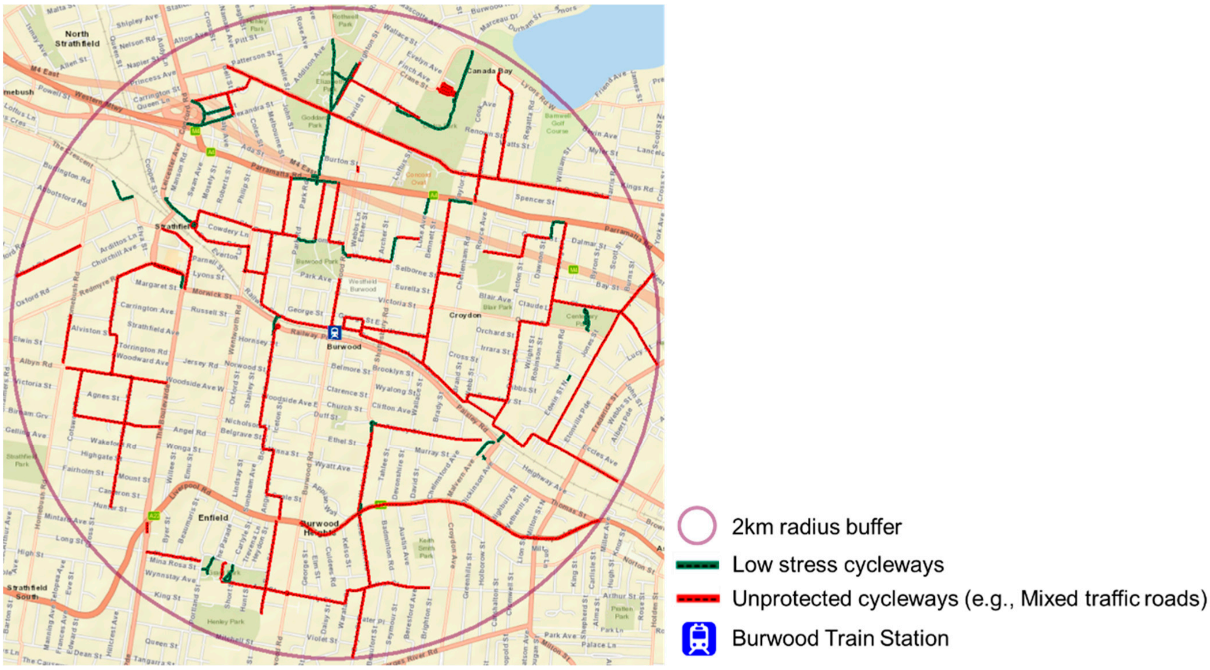

Figure 6. Bicycling lanes within a 2 km boundary from the station.

We calculated the total length of bicycle lanes within a 2 km boundary from Burwood Station by only taking into account LTS1 and LTS2 types of cycling paths (i.e., green-coloured links in Figure 6). This calculation was made with the assumption that cyclists could safely use these types of bicycle lanes to travel to the train station [39,40]. The calculated total length of bicycling lanes is 2703 m.

4.4. TOD Typology of the Burwood Station Area

The extended node-place model in the article considers three dimensions—node, place, and design. Table 2 shows the results of applying the model to Burwood Station, comparing before and after adding the new bicycling-related measures including a d1-accessible cycling network length and a d2-cycling accessibility index. The original node-place framework proposed by [29] was used for the calculation of the indexes. The results show that there is a significant decrease in the design index with the addition of bicycle-related indicators. It appears that the design index has significantly dropped due to the scarcity of bicycle facilities that provide a safe environment for cyclists to ride their bikes in the surrounding areas of Burwood. The changes in the two sets of data before and after the application of bicycle-related indicators presented in the evaluation illustrates the importance and necessity of including safe cycling infrastructure to support sustainable travel behaviour in TODs.

Table 2. The result of the node, place, and design indexes.

	Before Considering Cycling Factors	After Considering Cycling Factors
Node	0.258	0.258
Place	0.355	0.355
Design	0.781	0.547

5. Conclusions

The combination of TOD typology and site analysis can effectively help urban planners and policymakers to develop locally targeted policies, as demonstrated by the Burwood Station case study. In the vicinity of Burwood Station, the dominating land use in the area can be characterised by a wide variety of retail, commercial, and residential uses. Building volumes of different scales and different building forms make up a highly distinctive streetscape. In the future development plan of the study area, the mixed-used zone has been assigned to encourage high-density developments in the station area. It will take advantage of its proximity to the rail station and bus hub to promote high-density development, which provides a solid and reliable basis for the future economic development of Burwood as well as TOD development.

In terms of the street and urban design characteristics aspect, the pedestrian environment appears to be reasonably pleasant, which confirms the outcome of the extended node-place model. Even on the local streets, most of the streets have wide footpaths and greenery along the streets to ensure pedestrian amenities. Within 500 m of the station, there are shopping malls that are connected to the station by a large number of commercial premises. These commercial premises not only provide convenience for the local residents, but also act as a guide, invisibly leading people along their routes of movement. The pedestrian paths in the main commercial areas are sheltered from sunlight and rain.

The cycling network and its accessibility are significantly poorer compared to the walking environment. This is also the reason why the design index for the study area could have declined after the inclusion of the new cycling-related factors. The Level of Traffic Stress (LTS) was used in this article to measure the level of safety perceived by cyclists, and it is divided into four classes. It is also worth noticing that the on-street parking within the study area highly increased the potential danger for cyclists. The cyclist must be very careful with opening doors at any time while travelling. Exclusive bicycling lanes are mostly located within parks only. Figure 7 shows some photos of the streets where cyclists share the right-of-way with vehicle traffic.

(**a**) (**b**)

Figure 7. A multi-lane road (**a**) and a local street (**b**) where cyclists share the road with vehicles.

This paper presented the application of the node-place model to a train station area in Sydney, Australia, by extending the model to incorporate new cycling-related indicators. In particular, the study introduced a consideration of bicycle accessibility and bicycling lane length to incorporate into the design index. To account for the low cycling participation rate in Sydney, only certain types of bicycling lanes were taken into consideration. According to the results, after the introduction of bicycle-related considerations, the TOD types of the study area have significantly changed, which indicates that only considering walking accessibility may cause certain deviations in terms of the modelling result, and the introduction of relevant cycling indicators has a significant impact.

The research was carried out in the middle ring of Sydney, which is characterized by a higher population density than other LGAs within the same geographic area. Despite this, the node and place indexes did not exhibit the high values anticipated based on the analysis results. The design index value surpassed the node and place index values, indicating that there is potential for additional transport supply and land use development in the vicinity. These findings could also serve as a guide for policymaking in the future, as more transport and cycling infrastructure is required to improve the transport capacity and attractiveness of the area.

The study still has certain limitations that need to be acknowledged. The methodological design did not account for the varying importance of each node, place, and design indicator, which could potentially lead to an inaccurate depiction of reality and analysis results. Secondly, the study only focused on a single station, and, therefore, the generalisability of the findings may be limited. Furthermore, the selection of the study area was not based on specific criteria. These limitations could be addressed by conducting further research that is more comprehensive and in-depth. Additionally, missing and inaccurate data are inevitable in the analysis, and future research should focus on refining the data to obtain more valid results.

Author Contributions: Conceptualisation, J.L.; Methodology, M.Z.; Modelling and Analysis, M.Z.; writing—original draft preparation, M.Z.; writing—review and editing, J.L.; Supervision, J.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: No data can be shared.

Conflicts of Interest: The authors declare no conflict of interest.

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