

Article

Built-Form Intensity and Transit-Oriented Development Analysis of Louis Botha Corridor, Johannesburg

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Abstract

The Louis Botha Transit-Oriented Development (TOD) was introduced to address apartheid-era urban fragmentation. However, the extent to which the TOD initiative has translated into tangible built-form outcomes remains unclear. This study empirically evaluates TOD performance along the Louis Botha Corridor, covering eight precincts along the 13.16 km stretch. The precincts include Hillbrow, Berea, Orange Grove, Highlands North, Balfour, Bramley, Wynberg, and Marlboro. The measurable parameters are Building Footprint Density (BFD), Floor Area Ratio (FAR), land-use composition, and transit accessibility. The results show a corridor-wide average BFD of 0.2689 and average FAR of 0.5046, indicating moderate but uneven development intensity. Wynberg emerges as the highest-intensity node, (BFD 0.4049 and FAR 0.8196), while Hillbrow exhibits strong vertical intensification with a high FAR of 0.7098 despite a lower BFD (0.1925). In contrast, Marlboro, Berea, Balfour, Orange Grove, and Highlands North have a FARs below the corridor average of 0.5046. Land-use analysis reveals a corridor-level balance (53.14% residential, 44.40% non-residential); however, at the precinct level, monofunctional use prevails, with residential dominance in Orange Grove (87.96%), Highlands North (79.39%), and Berea (75.86%). Transit accessibility analysis indicates inconsistent station spacing (mean = 1.68 km; SD = 0.75 km), with about 87.51% of walking distances exceeding 400 m, which exceeds recommended TOD thresholds. The findings underscore the need for precinct-specific densification policies and stronger coordination between transit investment, development control, and urban governance to achieve more inclusive, transit-supportive urban growth.

Keywords: transit-oriented development (TOD); built-form intensity; building footprint density (BFD); floor area ratio (FAR); land-use mix; transit accessibility; corridor-based development; Louis Botha development corridor (LBDC)



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1. Introduction

Transit-Oriented Development (TOD) has emerged as a widely adopted planning strategy to address the global trend of urbanization and its associated challenges [1]. As urbanization continues to shape contemporary cities [2,3], a significant increase in the urban population is expected over the coming decades [4]. This is posited to be accompanied by rapid urban expansion, characterized by low-density growth, land fragmentation, and increasing dependence on private vehicles, particularly in developing nations [5,6]. The need for a concerted effort to address environmental sustainability, infrastructure deficiencies, and socio-spatial inequality calls for the adoption of more compact, integrated

urban development strategies, such as TOD. TOD is recognized as a critical urban planning strategy for addressing significant challenges such as traffic congestion, pollution, and inadequate infrastructure [7]. Previous research [8] described TOD as a land-use and transportation planning approach that makes walking, cycling, and transit convenient and desirable by maximizing the efficiency of public transit services, thereby focusing development on public transit stations. It also aims to promote higher-density, mixed-use, transit-accessible urban forms to mitigate the sprawling nature of towns and cities [9]. The strategy is rooted in the principles of concentrating development within walking distance of public transport nodes, thereby reducing car dependency, enhancing accessibility, and improving urban efficiency [10]. It is increasingly appreciated as an opportunity not only to improve urban mobility and sustainability but also to promote active travel modes such as walking and cycling, and to reduce pollution, thus making the strategy beneficial to health [11].

In theory, TOD facilitates land-use optimization by aligning transport infrastructure with urban form, thereby increasing development intensity and functional diversity along transit corridors [12,13]. Despite its conceptual appeal and widespread adoption, its implementation, particularly in sub-Saharan African cities, has produced mixed outcomes [11]. The promotion and practice of TOD require significant investment, resources, and government support and involvement, including the construction of public transportation facilities, real estate development, and rational land-use planning [14]. In many cities, translation of TOD principles into actual built form has been uneven, constrained by institutional limitations, market dynamics, infrastructure deficits, and socio-economic inequalities [15,16]. As a result, several studies have highlighted a persistent gap between TOD principles and observed spatial realities, raising critical questions about TOD's effectiveness as a tool for urban restructuring. However, ref. [14] suggested that relevant policymakers in developing nations must identify TOD strategies that align with their specific growth and development challenges.

In the South African context, urban spatial structure remains deeply influenced by apartheid-era planning, characterized by fragmentation, low-density sprawl, and spatial mismatch between residential areas and economic opportunities [17–19]. However, post-apartheid planning in South Africa has adopted the TOD approach to transform earlier apartheid-era planning policies by promoting spatial inclusion and transformation [20–22]. Within the TOD framework, the City of Johannesburg has implemented corridor-based development strategies to restructure urban form through densification and transit integration, prioritizing the Louis Botha Avenue, a major route linking Johannesburg and Pretoria, under the Corridors of Freedom initiative [22,23]. The corridor is expected to serve as a spine of urban intensification, attracting investment and promoting efficient land-use patterns. Conversely, emerging evidence suggests that the extent to which these expectations have materialized in actual built-form transformation remains uncertain [22,24,25].

A critical dimension of TOD performance lies in built-form intensity, which reflects the degree of land utilization through indicators such as Building Form Density (BFD), Floor Area Ratio (FAR), Mixed Land-Use (MLU), and accessibility [26,27]. These metrics provide a quantitative basis for TOD assessment. While previous studies have examined TOD impacts on mobility, land values, and accessibility, relatively limited attention has been given to the spatial quantification of built-form intensity, particularly in sub-Saharan African cities such as Johannesburg [28,29]. Furthermore, existing studies often emphasize policy frameworks and planning intentions without sufficiently interrogating the spatial manifestation of development on the ground. This creates a significant research gap, as this study moves beyond policy intentions, accessibility, and mobility outcomes to

quantitatively assess the actual spatial manifestation of TOD through BFD, FAR, MLU, and accessibility at the precinct level.

This study, therefore, seeks to find answers regarding the current state of built-form intensity along the corridor and the extent to which the observed built environment aligns with TOD principles. This study addresses this research gap by conducting a spatially explicit analysis of built-form intensity across the precincts of the Louis Botha TOD corridor, using building footprint and spatial analytical techniques to evaluate the extent to which TOD objectives have been realized. By adopting this method, this study contributes to an evidence-based understanding of the TOD performance of the Louis Botha Development Corridor initiative. It is also expected to inform policy responses towards ongoing debates on sustainable urban development in rapidly urbanizing contexts.

2. Literature Review

2.1. Overview of Transit-Oriented Development (TOD)

The concept of TOD has its roots in the historical urban forms of the early 1900s, in the wake of rapid industrialization, urbanization, and population growth in the late 19th century, which led to the evolution and popularization of the earliest forms of mass transit [30]. According to researchers [31,32], TOD is an urban development approach that integrates high levels of transit accessibility with mixed land-uses and increased development intensity to promote a compact, efficient, and sustainable urban form. It has been described [20,33,34] as a widely adopted approach to address urban issues, such as urban land-use fragmentation, sprawling development, traffic congestion, the high cost of urban infrastructure, environmental degradation, and spatial inequality.

The TOD model integrates land-use elements, transport planning, urban design, urban regeneration, real estate development, financing, land-value capture, and infrastructure implementation to achieve sustainable urban development [35]. The approach aims to concentrate housing and commercial development near existing transit infrastructure, thereby providing an alternative to automobile trips [36]. According to [14], TOD is based on the concept of ‘Pedestrian Pocket’. The concept proposed developing a 400 m buffer zone to signify a walking distance from a transit point, thereby reducing reliance on small vehicles. The model also promotes vertical development to accommodate a larger urban population within a smaller area, as well as commercial, industrial, recreational, and other uses within a 5 to 10 min walking distance [35,37], thereby mitigating urban sprawl. This was aimed at conserving space, reducing costs in the provision of basic infrastructure and amenities, and creating compact, self-service neighborhoods. It also aims to prevent private cars from inducing sprawl and pollution from burning fossil fuels [38].

The approach was designed to address contemporary urban challenges, especially in rapidly growing cities, by promoting sustainable, compact development [39–41]. As the urban population is increasing at an uncontrolled pace [42], a strategic approach, such as TOD, is needed to accommodate the growing population in a more sustainable manner, addressing space, transportation, and basic infrastructure. Therefore, the principles of leave, work, and play, and access to a more efficient, cost-effective transportation system within the same environment have defined TOD as a sustainability model. However, implementing such an approach is expected to entail its own challenges, especially in developing nations, due to economic constraints, political will, and technological development [35].

2.2. TOD Implementation: South Africa

The implementation of TOD in South Africa, according to previous commentators [43], is a socio-spatial intervention designed for inclusion to bridge the gap between apartheid and post-apartheid planning. It was, however, described as a contextually adaptive

planning paradigm aimed not only at redressing apartheid-era spatial fragmentation but also promoting the integration of transport, land-use, and socio-economic development [22,44,45]. Early efforts, such as the Klipfontein Corridor in Cape Town, demonstrate the ambition to leverage BRT and mixed-use densification to transform marginalized corridors. Although they were not fully realized, these initiatives laid the institutional and conceptual groundwork for TOD implementation in South Africa [46].

In Johannesburg, the TOD initiative, Corridors of Freedom, was launched in 2013 [24]. The initiative includes the Empire-Perth (Southwest), Turffontein (South), and Louis Botha Avenue (Northeast) Development Corridors. These initiatives form part of the City of Johannesburg's Growth and Development Strategy (GDS) [47]. The three corridors were to be served by the Rea Vaya BRT as the primary mode of transportation alongside high-density accommodation, leisure and recreation facilities, offices, and retail outlets [48]. This was reportedly [46] constrained by political shifts, funding limitations, and weak private-sector uptake, particularly given the preference for rail-based investments over bus systems.

Given the underlying constraints, it is necessary to properly evaluate the TOD initiative and its successes in South Africa, a sub-Saharan African country. Various issues have been studied, including transport efficiency and the economic viability of the initiative, among others [7,8,13,22,25], yet a gap remains in the spatial evaluation of TOD principles, separating expectations and reality. This study, therefore, seeks to fill this gap by examining TOD implementation in one of Johannesburg's Corridors of Freedom initiatives, namely, the Louis Botha Corridor, using BFD, FAR, land-use composition, and accessibility parameters.

2.3. Theoretical Framework

This study adopts a combined theoretical framework drawn from the TOD and Expectation-Reality Frameworks. The TOD framework promotes a compact, high-density, mixed-use development serviced by a public mass transportation system. The model promotes living, working, and playing in the same environment. It also discourages the use of private vehicles as a means of preventing car dependency; private cars induce sprawl and pollution from burning fossil fuels. It was designed to promote vertical development by enabling more people to occupy a small area, thereby conserving space and reducing costs in the provision of basic infrastructure and amenities. The model also promotes the development of transit stations within convenient walking distance, as well as compact, self-service neighborhoods.

The TOD theoretical framework is often explained through the "6Ds" (Density, Diversity, Design, Destination accessibility, Distance to transit, and Demand Management) as baseline principles [14,24,49]. The term density refers to the concentration of people, jobs, and housing within a given area. According to this element, higher density means that activities are closer together, reducing travel distances and encouraging walking, cycling, and public transport use [49]. Diversity, on the other hand, focuses on the coexistence of multiple land-uses, such as residential, workplace, shopping, and recreational spaces, within a neighborhood [24]. This includes both primary and secondary uses that draw people in and complement them, respectively. Design connotes the provision and arrangement of urban fabrics, such as safe walkways, cycling paths, lighting, and public amenities, thereby discouraging reliance on cars [24]. The remaining "Ds" further support accessibility and efficient mobility. While destination accessibility refers to the efficiency of movement within the city using the public mass transit system, distance to transit, on the other hand, connotes how far people need to travel between home, work, and services [24]. Shorter distances mean greater transportation sustainability and reduced pollution, and vice versa. Demand management, the last of the "Ds", involves

strategies to ensure compliance with the TOD principles. This study focuses on the variables density, diversity, and distance to transit. These principles were measured using building density ratio, floor area ratio, land-use proportion, and a 800 m buffer representing a 10 min convenient walking distance to transit stations to assess the extent to which the corridor's objective is realized.

The Expectation-Reality Framework is an analytical approach for comparing anticipated and actual outcomes. The framework focuses on identifying the gap between expectations from principles and their implementation. The framework is necessary for this study, as its adoption enables a critical evaluation of the gap between TOD expectations as designed in the model and the actual spatial transformation along the Louis Botha Development Corridor.

2.4. Conceptual Framework

The conceptual framework adopted in this study is derived from the TOD principles and serves as the basis for comparing expectations with empirical outcomes. This framework is explained in Figure 1. This outcome is expected to fill research gaps by answering questions about government commitment, such as financing, political will, and the ability to influence and drive transformation via the Corridors of Freedoms initiative on the Louis Botha TOD.

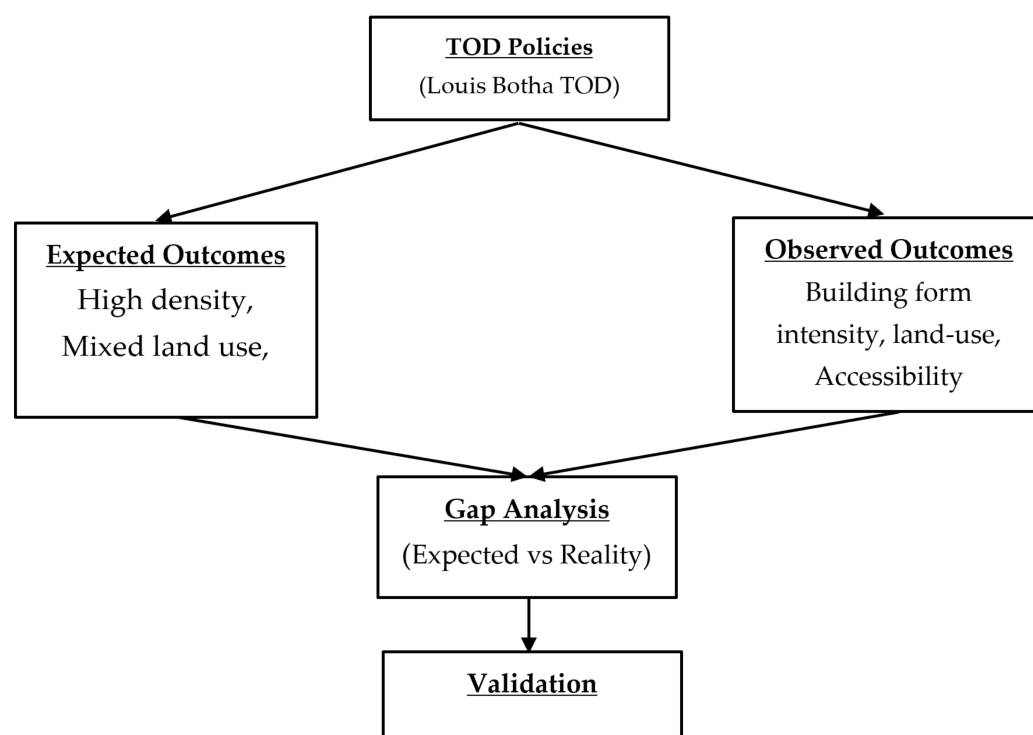


Figure 1. Conceptual framework for building-form intensity and TOD outcomes.

3. Materials and Methods

3.1. Research Design and Analytical Framework

This study uses a quantitative geospatial urban morphology method [27] to assess the extent to which TOD principles have translated into measurable built form along the Louis Botha Development Corridor (LBDC) in Johannesburg, South Africa. The analysis is based on TOD principles that encourage compact urban design, mixed land use, increased development density, and improved access to non-motorized transport near public transport hubs [1,9].

The research framework evaluates TOD performance across four key dimensions, namely: development density (horizontal intensification), vertical intensification, land-use diversity, and transit accessibility. These dimensions were chosen as they reflect physical characteristics commonly used to assess TOD effectiveness [49]. Geographic Information Systems (GIS) and spatial metrics were used to quantify the distribution of urban development across precincts and station catchment areas along the corridor.

The analytical process encompassed five sequential steps: data acquisition and pre-processing, extraction of building and land-use information, delineation of TOD catchment zones, computation of TOD indicators, and comparative spatial analysis of precinct-level performance. While the precinct serves as the primary analytical unit, station-based catchments offer a supplementary spatial framework for evaluating accessibility-related TOD outcomes.

3.2. Study Area

The Louis Botha Development Corridor (LBDC) is located in Johannesburg, one of the cities within the Gauteng Province of South Africa. It was identified as a priority Transit-Oriented Development (TOD) zone under the City's Corridors of Freedom initiative [22,28]. The corridor is approximately 13.16 km long, from Hillbrow in the city center to Wynberg, on the M11 highway connecting Johannesburg and Pretoria. It traverses eight precincts: Hillbrow, Berea, Orange Grove, Highlands North, Balfour, Bramley, Wynberg, and Marlboro. The TOD corridor has Rea Vaya Bus Rapid Transport (BRT) as its primary public transportation backbone, with interstations along the corridor. The corridor is geographically situated between longitudes 28°2'12" and 28°5'48" E and latitudes 26°11'20" and 26°5'50" S (See Figure 2). The Louis Botha corridor was historically part of the racially segregated neighborhoods under apartheid before its present transformation under the Corridors of Freedom transit-oriented initiative [28]. What makes the Louis Botha Transit-Oriented Development case distinct from other cases is that the initiative integrates the natives into the central business district, in contrast to the apartheid-era arrangements. The development program, according to the City of Johannesburg [29], is designed to create a work, live, and play environment free of private car ownership and to bring residents closer to their workplaces. The corridor was selected because it represents one of the earliest and most strategic TOD intervention areas within the City of Johannesburg's Corridors of Freedom program and therefore provides a suitable case for evaluating the spatial manifestation of the TOD initiative.

3.3. Data Sources and Spatial Data Preparation

Three secondary spatial datasets were utilized: building footprints from Google Open Buildings (2021 release; confidence score ≥ 0.65), road network data from OpenStreetMap (OSM), and precinct boundary shapefiles from the City of Johannesburg. Extensive pre-processing was conducted to enhance spatial accuracy and consistency. Initial inspections identified various issues, including positional shifts, duplicated geometries, overlapping features, disconnected road segments, and coordinate inconsistencies. Corrections were made through visual verification using high-resolution imagery from Google Earth Pro. Subsequently, all spatial datasets were projected to WGS 84/UTM Zone 35S, suitable for area, distance, and density calculations. The road network shapefile was refined to include pedestrian infrastructure, such as footpaths, pedestrian bridges, informal walkways, and pedestrian crossings, which were underrepresented in the original OSM dataset. This refinement facilitated the development of a realistic pedestrian network for accessibility analysis.

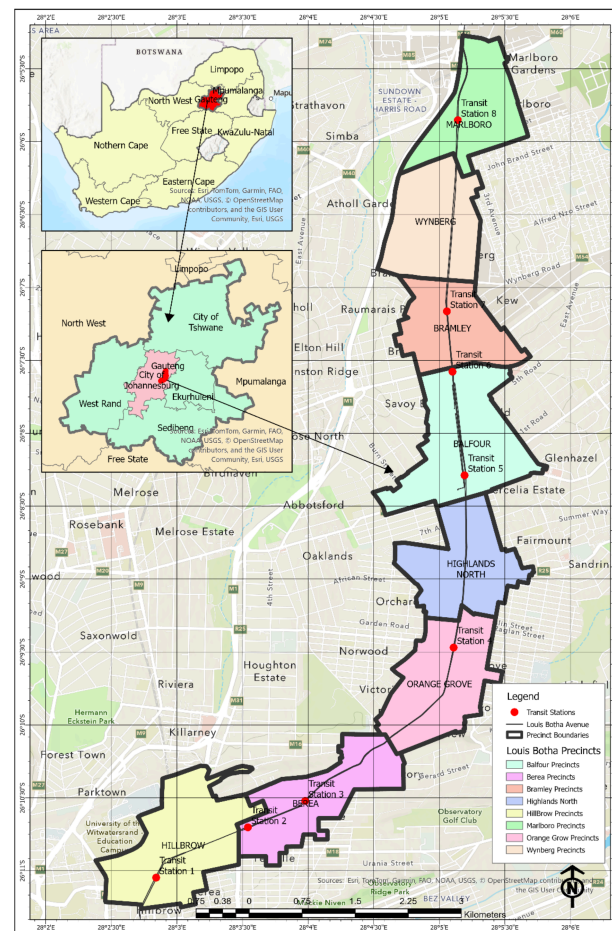


Figure 2. Louis Botha Transit-Oriented Development, City of Johannesburg.

3.4. Floor Number and Land-Use Classification

Floor numbers and land-use classifications were extracted from Google Earth Pro (Desktop), software, Version 7.3.x, access and utilized from February–April 2026 using a combination of Street View, oblique aerial imagery, and site visitation. The number of floors and classes for each building was recorded and subsequently used to determine the number of floors and the types of land-use. For simplification and consistency, all buildings were classified into three broad categories: residential, mixed use, and non-residential. The non-residential category encompasses commercial, industrial, institutional, public service, and other employment-generating land uses. This simplified classification aligns with the primary objective of assessing the degree of functional integration promoted by Transit-Oriented Development (TOD) principles.

3.5. Accessibility Analysis

Accessibility analysis was conducted using a pedestrian-network-based approach in the Origin–Destination (OD) cost matrix. The modified pedestrian network calculated actual walking distances between buildings and transit stations. Based on TOD principles, three catchment zones were defined: the core TOD zone (≤ 400 m walking distance), primary TOD zone (>400 m and ≤ 800 m walking distance), and extended catchment zone (>800 m walking distance). These catchments were used to evaluate public transport accessibility.

3.6. Computation of TOD Indicators

3.6.1. Building Footprint Density (BFD)

Building Footprint Density (BFD) measured horizontal development intensity as follows:

$$\text{BFD} = \text{Total Building Footprint Area} / \text{Total Land Area},$$

where Total Building Footprint Area represents the cumulative ground coverage of all buildings within a spatial unit, and Total Land Area encompasses the total area of the precinct or catchment. Higher BFD values indicate greater land consumption by built structures and a more compact urban form.

3.6.2. Floor Area Ratio (FAR)

Vertical development intensity was measured using Floor Area Ratio (FAR):

Using the formula,

$$\text{FAR} = \text{Total Gross Floor Area} / \text{Total Land Area}.$$

where the total gross floor area was estimated by multiplying each building footprint by its recorded number of floors. FAR provides a measure of vertical intensification and indicates the extent of land utilization through multi-story development.

3.6.3. Land-Use Diversity

Land-use diversity was assessed using both footprint-based and floor-area-based measurements. The proportional share of each land-use category was computed as:

$$\text{Land-Use Share (\%)} = (\text{Land-Use Area} / \text{Total Developed Area}) \times 100.$$

3.6.4. Accessibility Performance

Accessibility performance was evaluated by calculating the distance between the respective building footprints and transit stations. The distances obtained using the pedestrian-network-based approach in the Origin–Destination (OD) cost matrix were classified into the Core TOD zone (≤ 400 m walking distance), Primary TOD zone (>400 m and ≤ 800 m walking distance), and Extended catchment zone (>800 m walking distance). This distribution was compared with TOD planning expectations, prioritizing concentration within the core and primary TOD zones [25].

3.7. Comparative Spatial Analysis

The calculated indicators were aggregated at both precinct and corridor levels. Descriptive statistics, percentage distributions, and spatial visualization techniques identified spatial variations in TOD implementation. Indicator values were compared with corridor-wide averages to distinguish precincts exhibiting above-average, moderate, and below-average TOD performance, given the absence of a standard value for TOD performance.

3.8. Methodological Limitations

Methodological limitations include the acquisition of building heights and land use classifications from Google Earth Pro imagery and from ground validation, both of which involve some degree of observer subjectivity. However, repeated verification and cross-referencing of multiple imagery sources minimized classification errors and improved data reliability. Other limitations of the data include its inability to generate socio-economic and other auxiliary data for TOD measurements.

4. Results

4.1. Analysis of the Louis Botha Development Corridor

The study shows that the Louis Botha development corridor covers a total land area of about 13.21 Km², with Balfour recording the largest area, covering about 2.09 km². Other precincts, arranged in order of size, are Hillbrow (2.03 km²), Orange Grove (1.71 km²), and Wynberg (1.60 km²). Others are Highlands North (1.57 km²), Berea (1.53 km²), Marlboro (1.35 km²), and Bramley (1.33 km²). (See Figure 3 and Table 1).

Table 1. Area covered by the Precincts of Louis Botha Development Corridor.

Sr. No.	Precincts	Area (Km ²)	Area (Percentage)
1.	Balfour	2.09	15.84
2.	Berea	1.53	11.60
3.	Bramley	1.33	10.04
4.	Highlands North	1.57	11.88
5.	Hillbrow	2.03	15.38
6.	Marlboro	1.35	10.22
7.	Orange Grove	1.71	12.95
8.	Wynberg	1.60	12.10
		13.21	100.00

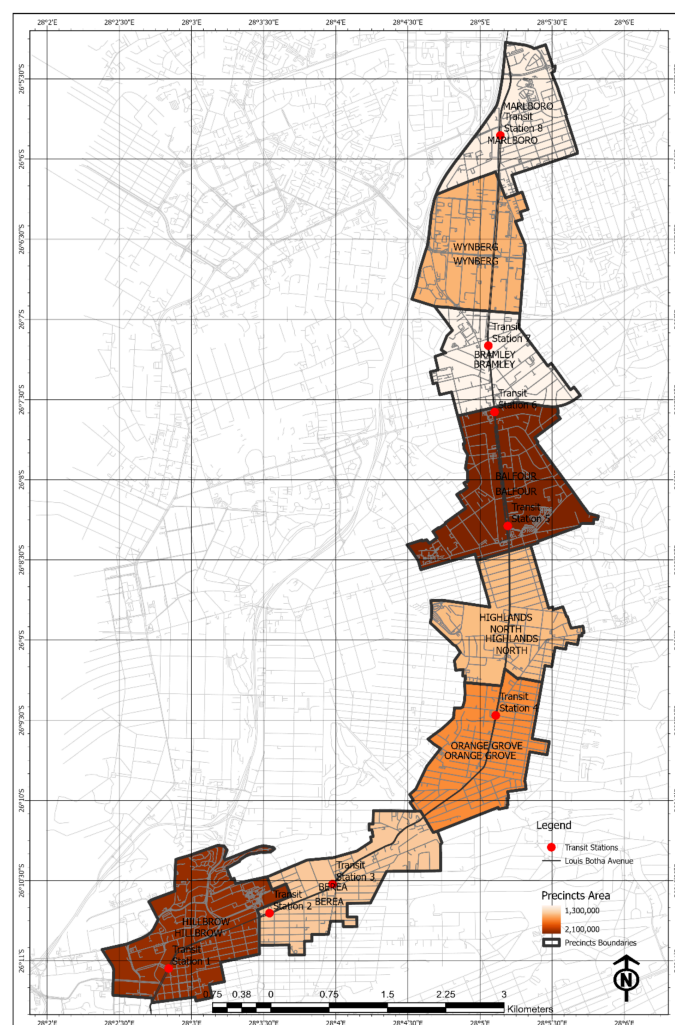


Figure 3. Cont.

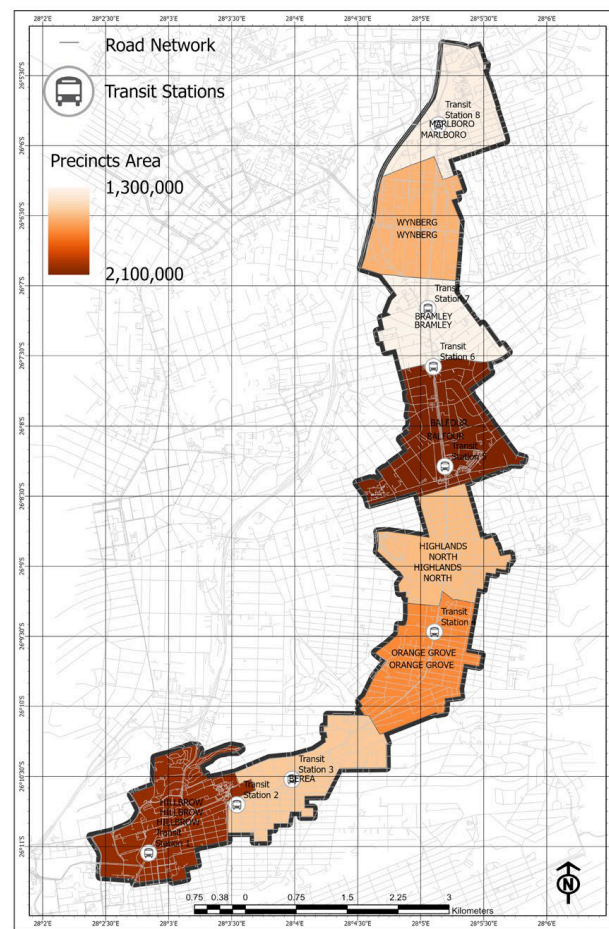


Figure 3. Louis Botha Corridor: Precincts, Transit Stations, and Area Coverage.

4.2. Analysis of the Louis Botha Building Footprint Density

Building footprint density is the ratio of the area covered by the building footprint to the total boundary of the precincts or the entire corridor. The analysis shows that the Louis Botha transit-oriented corridor has 25,261 buildings distributed within the eight (8) precincts. Orange Grove (5454), Highlands North (3619), Marlboro (3535), and Balfour (3392) ranked first through fourth in terms of the number of buildings. Hillbrow (2073), Bramley (2197), Wynberg (2333), and Berea (2658) ranked lowest. See Table 2.

Table 2. Number of Building Footprints in the Louis Botha Corridor.

S. No.	Precincts	Number of Building Footprints	Percentage
1.	Balfour	3392	13.43
2.	Berea	2658	10.52
3.	Bramley	2197	8.70
4.	Highlands North	3619	14.33
5.	Hillbrow	2073	8.21
6.	Marlboro	3535	13.99
7.	Orange Grove	5454	21.59
8.	Wynberg	2333	9.24
Total	Louis Botha Corridor	25,261	100.00

The buildings occupied an area of about 3.55 km². Of the 3.55 km², 0.65 km² were in Wynberg, 0.52 km² in Orange Grove, and 0.45 km² in Balfour, making these the precincts

with the highest development ratio. The precincts with the least area of building floor area were Bramley (0.38 km²) and Hillbrow (0.39 km²). See Table 3 and Figures 4 and 5.

Table 3. Average Building Footprint Distribution (BFP vs. area, intensity, and shares).

Precinct	BFP (km ²)	Precinct Area (km ²)	BFD	BFP Share	Area Share	Δ BFD vs. Corridor (0.2689)
Wynberg	0.65	1.60	0.4049	18.21%	12.10%	0.13697
Orange Grove	0.52	1.71	0.3031	14.59%	12.95%	0.03418
Marlboro	0.39	1.35	0.2914	11.08%	10.22%	0.02252
Bramley	0.38	1.33	0.2830	10.57%	10.04%	0.01403
Highlands North	0.40	1.57	0.2565	11.33%	11.88%	−0.01239
Berea	0.38	1.53	0.2459	10.60%	11.60%	−0.02299
Balfour	0.45	2.09	0.2141	12.61%	15.84%	−0.05486
Hillbrow	0.39	2.03	0.1925	11.01%	15.38%	−0.07646

Corridor totals: BFP = 3.55 km², Area = 13.21 km², and Average BFD = 0.2689.

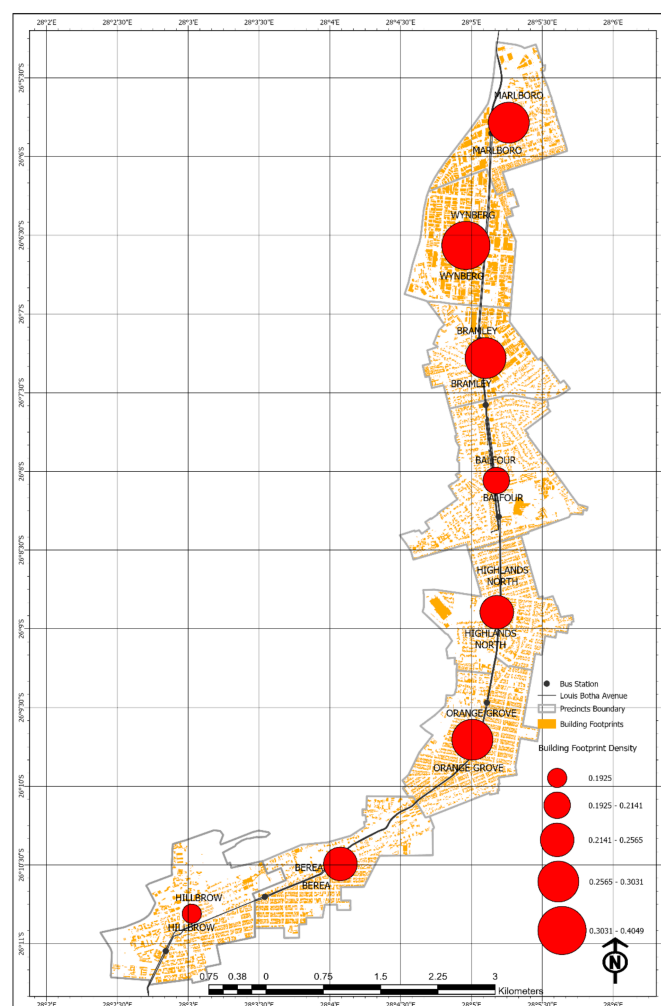


Figure 4. Cont.

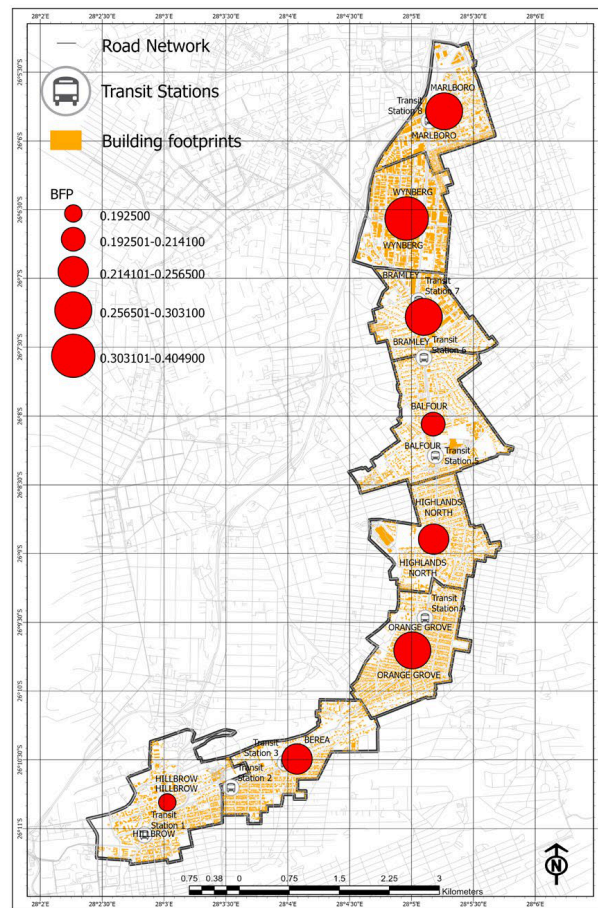


Figure 4. Choropleth showing building footprint density (BFD) across Louis Botha Development Corridor.

The spatial distribution of building footprint density (BFD) across the precincts reveals significant variation in development intensity along the corridor, with a corridor-wide average of 0.2689. Wynberg and Orange Grove Precincts recorded BFDs and deviations above the corridor's BFD (0.2689), with BFD values of 0.4049 and 0.3031, and deviations of 0.1370 and 0.0342, respectively, indicating a higher built-up area intensity. Based on the result, with a deviation of 0.1370 from the corridor mean of 0.2689, Wynberg was identified as the precinct with the highest density node, indicating compatibility with TOD characteristics.

In contrast, Highlands North, Berea, Balfour, and Hillbrow precincts recorded a BFD below the corridor average, with Hillbrow recording the lowest BFD (0.1925) and deviation (−0.07646). The results also showed that, despite the large areas of Hillbrow and Balfour, they recorded lower BFD, indicating the presence of open spaces mostly in Hillbrow and underutilized land in Bramley, which may have weakened TOD performance.

The comparison between BFP share and area share further reinforces this pattern; precincts like Wynberg and Orange Grove contribute a higher proportion of built-up area relative to their size, while Balfour occupies a larger land area but contributes proportionally less to the total building footprint.

The results indicate a spatial imbalance in development intensity, with a few precincts having compact development. This uneven development pattern implies the need to utilize the unutilized space within the corridor to promote a balanced, integrated corridor. However, the BFD alone is not sufficient for compatibility measurement without considering the floor area ratio. This is because vertical development could not be considered when calculating the BFD.

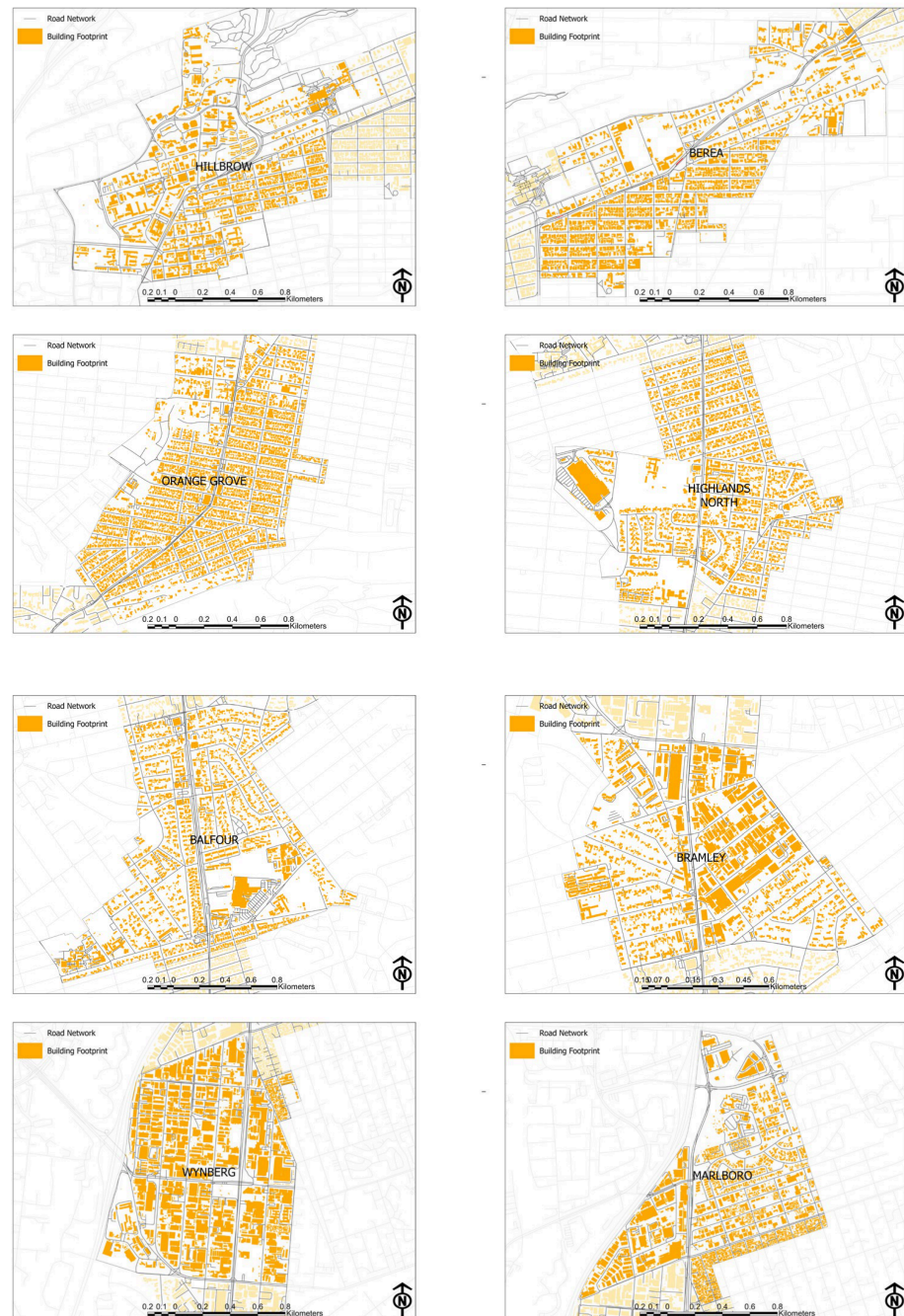


Figure 5. Choropleth showing building footprint density (BFD) per precinct.

4.3. Analysis of the Louis Botha Floor Area Ratio (FAR)

The Floor Area Ratio (FAR) is the number of floors in a building multiplied by the area of the building, divided by the total area covered by the precincts or the entire corridor. The FAR analysis shows the carrying capacity of precincts or corridors in terms of development intensity. The distribution of Floor Area Ratio (FAR) across the precincts showed a variation in vertical development intensity along the corridor, relative to the corridor FAR of 0.5046. Precincts such as Wynberg (0.8196) and Hillbrow (0.7098) had FARs significantly above the corridor-wide FAR, with +0.3149 and +0.2052, respectively, indicating a strong positive deviation. This signifies a high level of vertical development, indicating the high built-up intensity within these precincts.

These precincts reveal a disproportionately higher floor-area share relative to their land share, suggesting efficient land utilization through vertical development, a key feature of

high-performing TOD nodes. Similarly, Bramley (0.5902) also had an FAR above that of the entire corridor, though at a more moderate level, reflecting emerging densification potential. In contrast, Marlboro (0.4885), Berea (0.4597), Balfour (0.3528), Orange Grove (0.3381), and Highlands North (0.2980) recorded FARs below the corridor average, characterized by negative deviations indicating lower vertical development intensity. On the other hand, Balfour, Orange Grove, and Highlands North precincts contributed less to the total floor area, reflecting underutilization of development capacity and a predominance of low-rise structures. This imbalance suggests that, despite their spatial availability, these precincts are not fully utilizing their potential for compact development and transit-supportive growth. See Table 4 and Figures 6 and 7.

Table 4. Average Floor Area Ratio (FAR): Louis Botha Precincts.

Precinct	Total Area BFP FA (km ²)	Precinct Area (km ²)	FAR	Floor-Area Share	Land Share	Δ FAR vs. Corridor (0.5046)
Wynberg	1.31	1.60	0.8196	19.65%	12.10%	0.3149
Hillbrow	1.44	2.03	0.7098	21.63%	15.38%	0.2052
Bramley	0.78	1.33	0.5902	11.75%	10.04%	0.0856
Marlboro	0.66	1.35	0.4885	9.90%	10.22%	−0.0161
Berea	0.70	1.53	0.4597	10.56%	11.60%	−0.0449
Balfour	0.74	2.09	0.3528	11.07%	15.84%	−0.1519
Orange Grove	0.58	1.71	0.3381	8.67%	12.95%	−0.1666
Highlands North	0.47	1.57	0.2980	7.01%	11.88%	−0.2066

Corridor totals (from first row): total floor area = 6.67 km²; total land area = 13.21 km² and FAR = 0.5046.

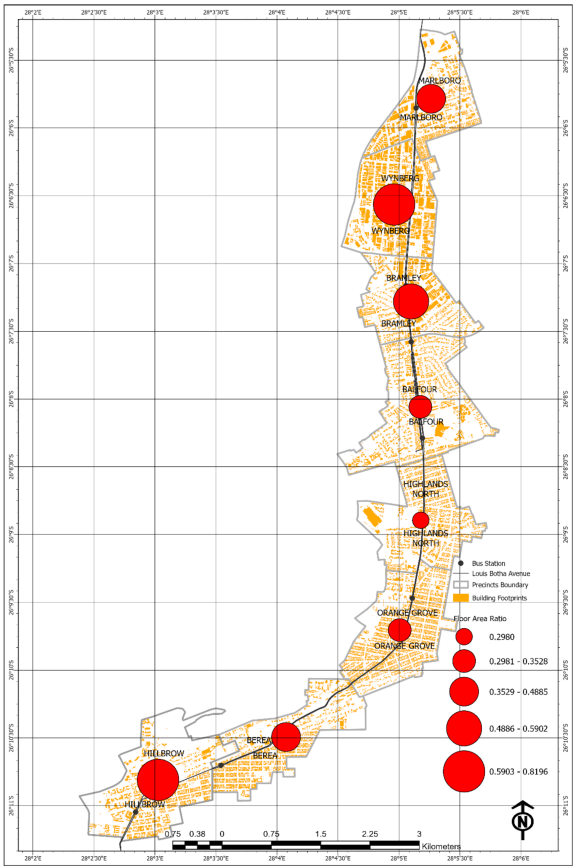


Figure 6. Cont.

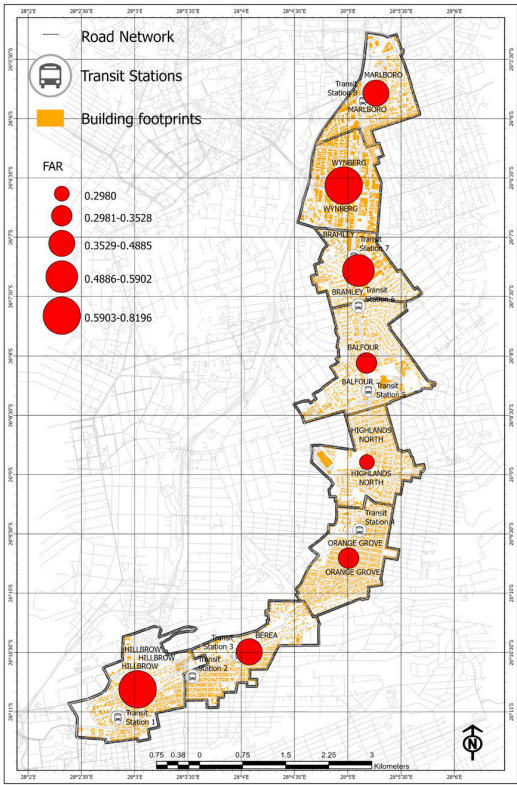


Figure 6. Choropleth showing floor area ratio (FAR) across the Louis Botha Development Corridor.

From a TOD perspective, the findings highlight a spatially uneven pattern of intensification, with only the Wynberg and Hillbrow precincts reflecting the high-density, vertical development characteristics of a TOD. This uneven FAR distribution within the corridor may lead to inefficient utilization of transit catchments and reduced ridership potential in low-density areas along the corridor. To enhance TOD performance, deliberate vertical densification is needed in underperforming precincts, aligning land-use policies with transit investments to achieve a more balanced, integrated corridor structure.



Figure 7. Cont.



Figure 7. Choropleth showing floor area ratio (FAR) per precinct.

4.4. Analysis of the Louis Botha Land Use

The land uses were classified as residential, mixed, and non-residential. Mixed uses combine residential uses with commercial retail shops and other services. Non-residential uses include large department stores, industrial buildings, and institutional uses such as schools and churches, among others, that do not function as residences. The land use for the LBDC and the precincts is shown in Figures 8 and 9, respectively.

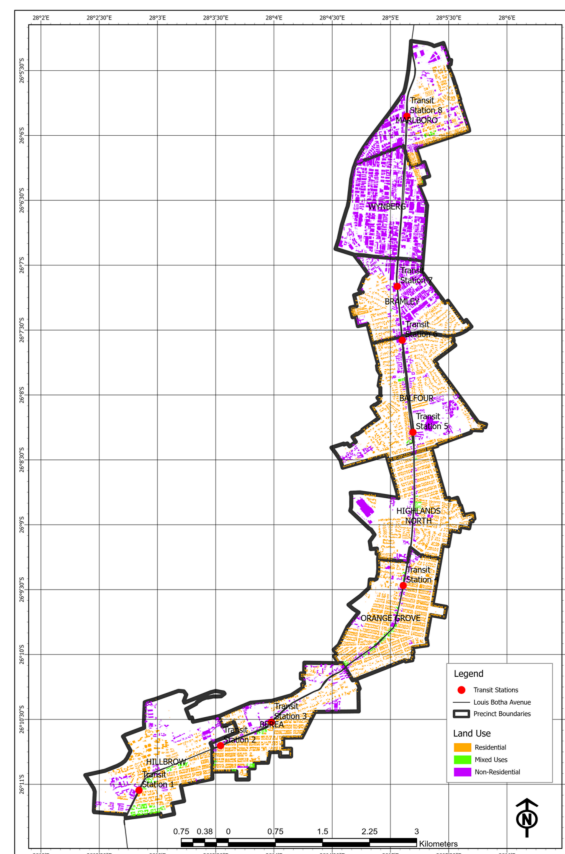


Figure 8. Land-use map of the Louis Botha Development corridor.

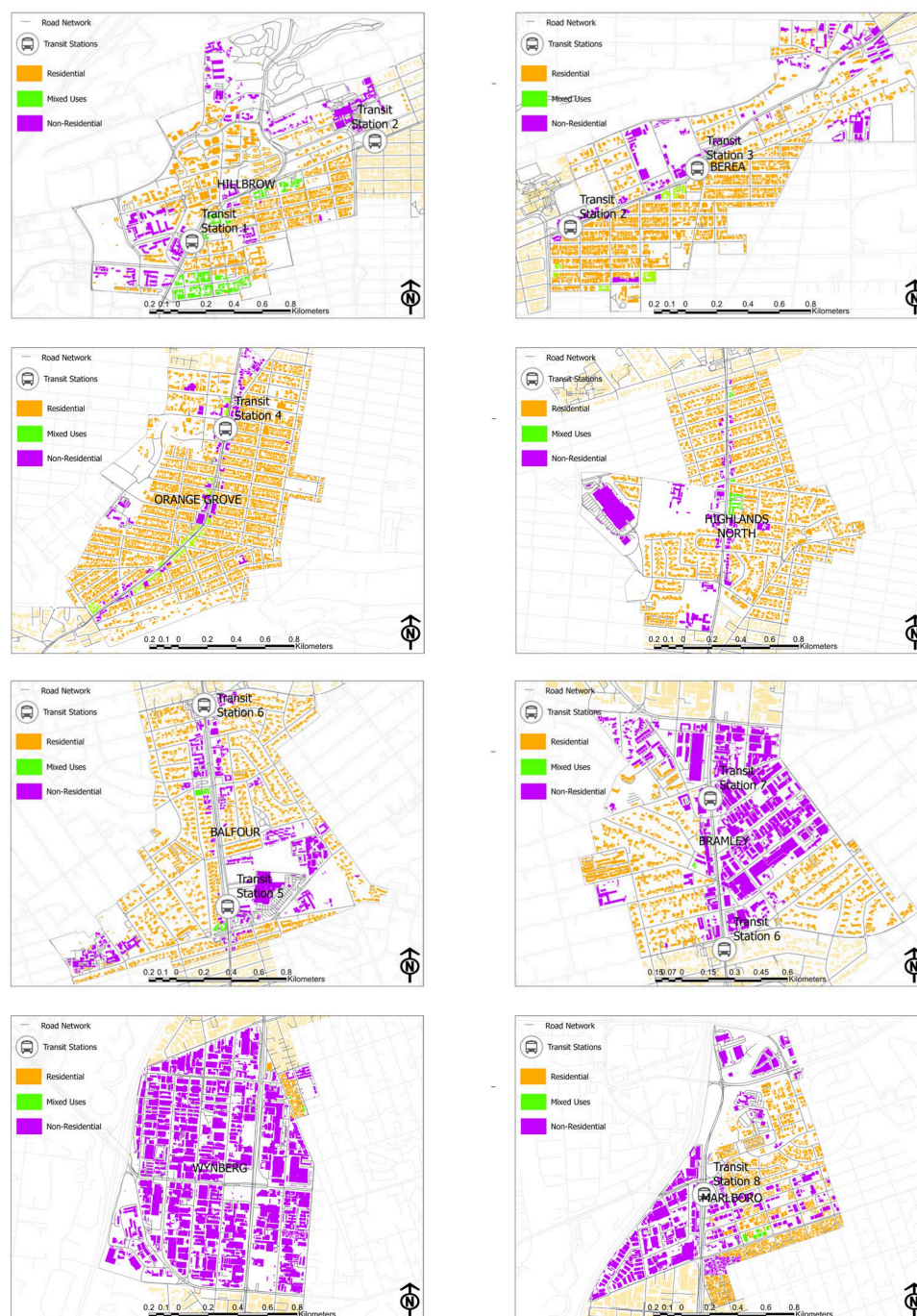


Figure 9. Land-use map per precinct.

The land-use analysis of the Louis Botha transit-oriented development corridor reveals that residential land use accounted for the highest proportion, at 53.16%, while non-residential and mixed-use accounted for 44.46% and 2.38%, respectively. Further analysis at the precinct level shows that Orange Grove (87.96%), Highlands North (79.39%), and Berea (75.86%) have the highest proportions of residential land use. In contrast, Wynberg and Marlboro recorded the lowest residential land-use percentages of 2.06% and 40.12%, respectively, below the overall residential land use proportion in the entire corridor. The results also showed that Wynberg recorded the highest percentage of non-residential uses, at about 97.85%. Other precincts with non-residential land-use above the corridor's percentage are Bramley (66.92%) and Marlboro (58.85%). See Table 5.

Table 5. Land-use Distribution of the Louis Botha Development corridor.

	Residential (km ²) (%)	Mixed Residential (km ²) (%)	Non-Residential (km ²) (%)	Total (km ²) (%)
Balfour	0.29 (64.60)	0.01 (1.18)	0.15 (34.22)	0.45 (100.00)
Berea	0.29 (75.86)	0.01 (2.95)	0.08 (21.09)	0.38 (100.00)
Bramley	0.12 (32.97)	0.00 * (0.11)	0.25 (66.92)	0.38 (100.00)
Highlands North	0.32 (79.39)	0.01 (1.63)	0.08 (18.98)	0.40 (100.00)
Hillbrow	0.24 (61.99)	0.04 (10.33)	0.11 (27.58)	0.39 (100.00)
Marlboro	0.16 (40.12)	0.00 ** (1.03)	0.23 (58.85)	0.39 (100.00)
Orange Grove	0.46 (87.96)	0.02 (3.13)	0.05 (8.86)	0.52 (100.00)
Wynberg	0.01 (2.06)	0.00 *** (0.09)	0.63 (97.85)	0.63 (100.00)
Louis Botha	1.89 (53.16)	0.08 (2.38)	1.58 (44.46)	3.55 (100.00)

* 11,118.84 m², ** 16,208.22 m², *** 561.93 m².

The land-use distribution across the precincts reveals strong spatial variation in functional structure along the corridor, with implications for TOD performance. Residential land use dominates in the Orange Grove (87.96%), Highlands North (79.39%), and Berea (75.86%) precincts, indicating a high residential character and limited functional diversity. This form of land-use characteristics supports a high population density, while the low proportion of non-residential land-use could limit access to jobs, services, and economic activities, potentially reducing trip internalization and increasing commuting needs. In contrast, Bramley (66.92% non-residential) and Marlboro (58.85% non-residential) precincts were discovered to be economically oriented, with a greater percentage of non-residential uses; however, they lack sufficient residential integration to support balanced TOD environments.

Wynberg recorded a very high proportion of non-residential land use (97.85%), identifying it as a non-residential node rather than a mixed-use TOD precinct. The only precinct that demonstrated a more balanced land-use structure was Hillbrow, with residential (61.99%), mixed use (10.33%), and non-residential (27.58%), representing a true mixed-use TOD environment within the corridor. Thus, mixed residential land-use, which is critical for integrating living and working functions, remains generally low across most precincts, except in Hillbrow and Orange Grove.

The results further show that the land-use distribution of the entire Louis Botha corridor appears relatively balanced, with residential (53.16%) and non-residential (44.46%) uses. However, at the precinct level, the case is the opposite, as mono-functional land use was established. The results further reveal that not all precincts demonstrate potential for TOD, as the corridor is functionally segregated, making the sustainability of each precinct nearly impossible and, in the long run, hindering the development of vibrant, accessible, and self-sustaining transit-oriented environments. This is because strengthening TOD outcomes will require greater land-use integration [31,33], increased mixed-use development [26,50], and better alignment between residential and other non-residential functions [27,39] across precincts. These results align with previous findings [44,46] that TOD initiatives in South Africa often intensify land use without achieving true mixed-use integration, resulting in transit-adjacent rather than TOD outcomes. These findings also align with other research [11] noting that residential dominance or non-residential clustering weakens TOD effectiveness.

4.5. Analysis of the Louis Botha Accessibility Performance

The development corridor includes eight transit stations along the Louis Botha Avenue. Berea and Balfour have two transit stations each, while Hillbrow, Orange Grove, Bramley, and Marlboro each have a single transit station. Highlands North and Wynberg have no transit stations. The maximum distance between transit stations on the Louis Botha corridor is about 2.84 km, while the minimum and average distances are 0.77 km and 1.68 km, respectively (Table 6). The range and standard deviation were calculated to be 2.84 km and 0.75 km, respectively. While the range confirms inconsistency in transit station spacing, the standard deviation indicates significant variation in that spacing. This reveals that while some transit stations are closer, others are farther apart, which may affect movement within the corridor.

Table 6. Distance between Transit Stations.

Sr. No.	Transit Stations	Distance (Km)
1.	Transit Station 1 to Transit Station 2	1.36
2.	Transit Station 2 to Transit Station 3	0.82
3.	Transit Station 3 to Transit Station 4	2.84
4.	Transit Station 4 to Transit Station 5	2.20
5.	Transit Station 5 to Transit Station 6	1.32
6.	Transit Station 6 to Transit Station 7	0.77
7.	Transit Station 7 to Transit Station 8	2.43

Further analysis of the results shows that the distances between Transit Station 3 and Transit Station 4 (2.84 km), Transit Station 7 and Transit Station 8 (2.43 km), and Transit Station 4 and Transit Station 5 (2.20 km) are greater than the average distance (1.68 km). This implies that some building footprints are beyond the comfortable walking distance of 400–800 m, the optimal station spacing as specified in the TOD benchmarks [31,51], indicating poor TOD performance, as larger gaps tend to weaken transit opportunities. This may increase reliance on other modes of transportation, such as minibusses, personal cars, and other feeder transit services.

The Origin-Destination Matrix (ODM) results are presented in Figure 10 for the LBDC, Figure 11 for the respective precincts, and Tables 7 and 8. Recall that LBDC had a total of 25,261 building footprints distributed across the eight precincts: Hillbrow (2073), Berea (2658), Orange Grove (5454), Highlands North (3619), Balfour (3392), Bramley (2197), Wynberg (2333), and Marlboro (3535). Table 7 shows that the minimum distance from the building footprints to a transit station was 0.13 m, while the maximum, average, and standard deviation were 2960.99 m, 798.87 m, and 366.80 m, respectively. At the precinct level, the shortest distance was in Berea (0.13 m), whereas the longest was recorded in Hillbrow (2960.99 m).

Table 7. Distance Statistics of Building Footprints to Transit Stations.

Precinct	Min Distance	Max Distance	Avg Distance	SD
Hillbrow	12.31	2960.99	703.42	490.82
Berea	0.13	1706.32	562.73	308.46
Orange Grove	0.37	2003.59	854.69	361.29
Highlands North	291.18	1891.82	1005.97	317.98
Balfour	0.61	1713.19	689.86	277.96
Bramley	1.16	1278.26	618.12	261.51
Wynberg	438.93	2518.43	1078.10	296.13
Marlboro	6.10	2367.62	771.64	300.36
Louis Botha	0.13	2960.99	798.87	366.80

Berea had the lowest average distance to a transit station (562.73 m), while Wynberg (1078.10 m) and Highlands North (1005.97 m) had averages above 1000 m. Bramley (618.12 m), Balfour (689.86 m), Hillbrow (703.42 m), and Orange Grove (854.69 m) all had average distances below the Louis Botha average distance. Standard deviation results indicate that Bramley (261.51), Balfour (277.96), and Wynberg (296.13) had the lowest variability, while Berea (308.46), Orange Grove (361.29), and Hillbrow (490.82) had the highest. Figure 8 further illustrates that Highlands North and Wynberg relied on transit stations located in neighboring precincts.

Table 8. Distance classification between transit stations.

Precinct	Less Than 400 m	400–800 m	Above 800 m	Total
Hillbrow	363 (17.51)	1261 (60.83)	449 (21.66)	2073 (100.00)
Berea	854 (32.13)	1355 (50.98)	449 (16.89)	2658 (100.00)
Orange Grove	527 (9.66)	2086 (38.25)	2841 (52.09)	5454 (100.00)
Highlands North	47 (1.30)	950 (26.25)	2622 (72.45)	3619 (100.00)
Balfour	567 (16.72)	1689 (49.79)	1136 (33.49)	3392 (100.00)
Bramley	502 (22.85)	1111 (50.57)	584 (26.58)	2197 (100.00)
Wynberg	0 (0.00)	374 (16.03)	1959 (83.97)	2333 (100.00)
Marlboro	296 (8.37)	1812 (51.26)	1427 (40.37)	3535 (100.00)
Louis Botha	3156 (12.49)	10,638 (42.11)	11,467 (45.39)	25,261 (100.00)

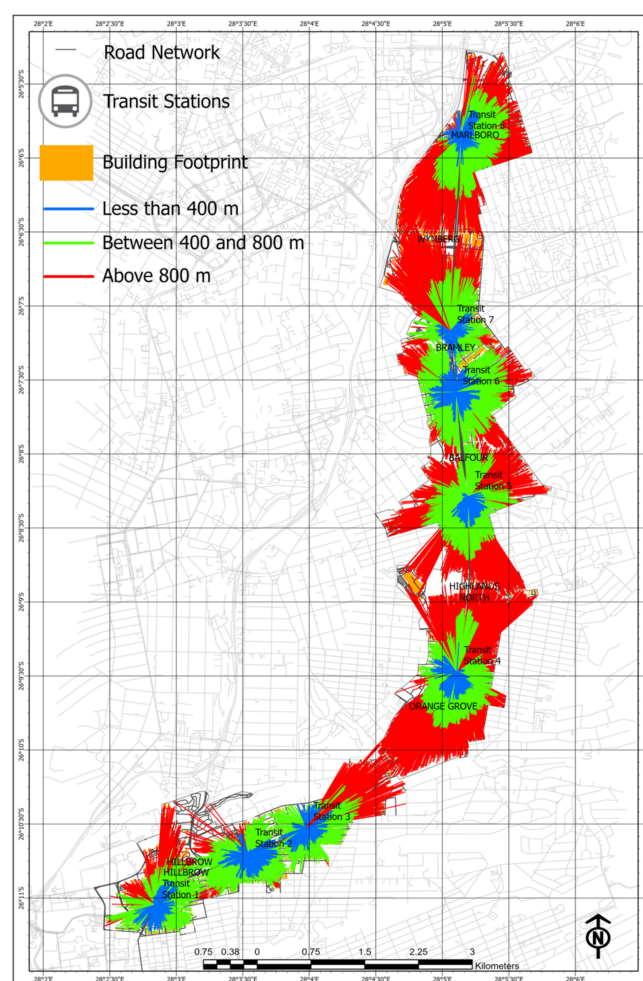


Figure 10. Accessibility performance of the Louis Botha Corridor.

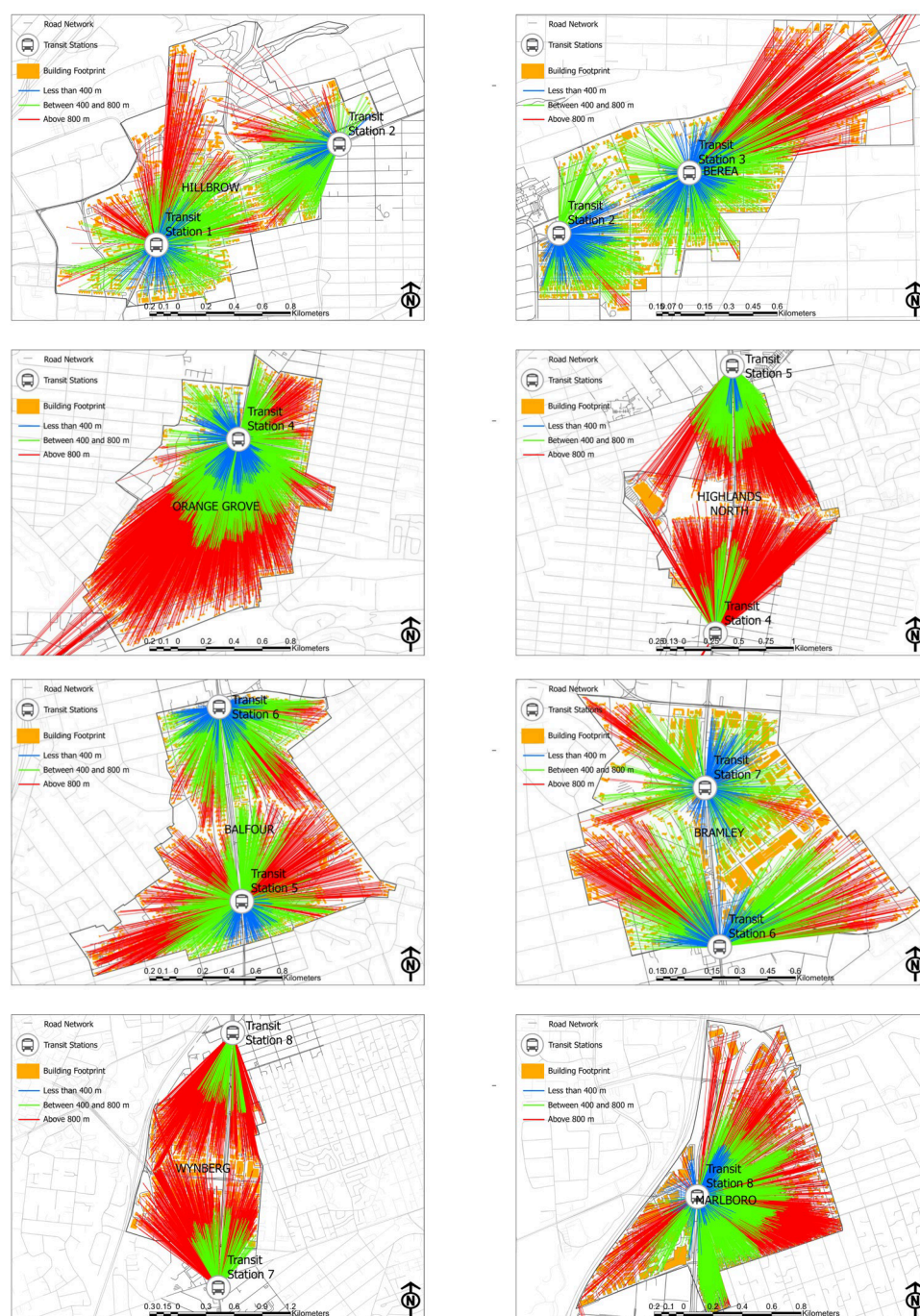


Figure 11. Accessibility performance at the precinct level.

The analysis of walking distances within the Louis Botha corridor, based on TOD catchment principles of core TOD (0 to 400 m), primary TOD (400 to 800 m), and extended TOD (above 800 m), is presented in Figures 10 and 11 and Table 8. This threshold was adopted due to the lack of a TOD distance threshold for Johannesburg. The results reveal that a larger proportion of the corridor (87.51%) falls within the primary and extended catchment, exceeding the recommended TOD threshold. In contrast, only 12.49% of the corridor lies within the core TOD, while 42.11% falls within the primary catchment. At the precinct level, Berea (32.13%) and Bramley (22.85%) recorded the highest proportions of Core TOD accessibility, suggesting relatively strong alignment with TOD principles. Conversely, Wynberg (0%) and Highlands North (1.30%) exhibited minimal core TOD coverage, reflecting poor integration with transit infrastructure. Within the primary catchment,

Hillbrow (60.83), Marlboro (51.26), Berea (50.98%), and Bramley (50.57%) demonstrated higher proportions, indicating moderate accessibility. However, Highlands North (72.45%) and Wynberg (83.97%) were dominated by extended catchment distances, underscoring significant accessibility challenges.

These findings highlight two critical issues. First, most building footprints in the corridor are located at walking distances that exceed TOD recommendations, undermining the intended benefits of TOD. Second, the results raise questions about the applicability of the 400 m walking distance threshold in Africa and other developing nations of the world. The dominance of extended catchment walking distance suggests that TOD implementation in such environments may require context-specific adaptations, including flexible distance thresholds and improved integration of transit stations within residential precincts.

5. Discussion

This discussion centers on findings from the TOD literature between 2020 and 2026. Analysis of BFD reveals a spatial variability along the LBDC, with Wynberg and Orange Grove precincts showing above-average (BFD) values. The precincts of Balfour, Berea, Highlands North, and Hillbrow recorded lower values, despite their proximity to transit stations. This pattern violates the principles of horizontal compactness as crucial for enhancing walkability, efficient land use, and the creation of viable transit catchments [22,23,27,39]. The low BFD levels further reflect limited TOD implementation. Similarly, the observed spatial imbalance in the FAR, with Wynberg and Hillbrow precincts exceeding the corridor average, indicated localized vertical intensification, whereas Balfour, Orange Grove, and Highlands North showed limited development potential. Although higher FAR generally correlates with increased population and employment density, transit ridership, and agglomeration benefits [12,14], its uneven distribution points to fragmented TOD implementation. Hillbrow's high FAR, combined with a relatively low BFD, indicates a vertical inner-city structure typical of historic urban centers. However, low FAR in other precincts aligns with evidence that bus-based TOD corridors struggle to attract vertical investment due to market uncertainties and ineffective land-value capture mechanisms, as noted in previous work [46,48].

The LBDC analysis of land use reveals a balanced, monofunctional characteristic at the precinct level. Residential-dominant precincts such as Orange Grove, Highlands North, and Berea could have limited employment and service activities, whereas Wynberg and Marlboro primarily serve as economic nodes. The observed monofunctionality of land use undermines the TOD principle, thereby imposing significant constraints on its performance in terms of trip internalization and minimization [11,22]. Compatibility and multifunctional land use were observed along Louis Botha Avenue, with limited spread into surrounding areas, resulting in fragmentation. However, like many other cities in developing nations, outcomes along the corridor show increased density without functional integration, largely due to rigid zoning regulations and planning strategies [44,52–54]. This could not be far from the apartheid-era spatial legacies and market-driven limitations, which continue to hinder the development of self-sustaining, transit-supportive neighborhoods [17,18]. Furthermore, inconsistent station spacing limits transit accessibility, with distances between stations exceeding the 800 m walking threshold specified in the TOD principles. This scenario reduces walkability, weakens transit catchment efficiency, and increases reliance on feeder transport systems such as minibus taxis. Consequently, areas with moderate density and mixed-use potential fall short of achieving strong transit-oriented outcomes.

The findings reveal that TOD implementation in the Louis Botha corridor is similar to that in other Sub-Saharan cities, which rely more on aspirational mechanisms than on regulatory mechanisms to ensure actual development [15,46]. The research showed the

relevance of physical attributes such as horizontal density (BFD), vertical intensification (FAR), land-use diversity, and accessibility, rather than other auxiliary factors considered by numerous scholars.

The study, as a measure to improve TOD performance, observed that fragmented development patterns along the corridor indicate that simply designating TOD corridors is insufficient to transform urban form without precinct-level regulatory tools. Therefore, policy responses should be geared towards establishing a standard development density, FAR thresholds, transit station intervals, standardized land-use integration, and vertical development for all precincts. This study therefore contributes to TOD scholarship by adopting physical parameters (BFD, FAR, land-use composition, and accessibility) to assess built-form outcomes in corridor-based TOD contexts. This is in contrast to most of the literature, which considers non-physical and subjective parameters that are limited in terms of locational empirical evidence at the precinct level.

6. Conclusions

This study assesses the extent to which TOD principles have translated into built-form outcomes along the Louis Botha Development Corridor (LBDC) using BFD, FAR, land-use composition, and transit accessibility. The findings show that development remains uneven, with higher-intensity development concentrated in Wynberg and Hillbrow, while several transit-accessible precincts remain underdeveloped. Furthermore, low-density, monofunctional land use, limited mixed-use development, and weak pedestrian connectivity further hinder TOD performance within the corridor. This pattern reflects not only the relatively recent implementation of TOD but also Johannesburg's historical spatial structure, market conditions, land values, and institutional constraints as outlined in the literature. This, therefore, necessitates further research in these areas, particularly in sub-Saharan African cities. The analysis highlights the need to introduce TOD in the African context by examining how market forces, and institutional mechanism affect land development dynamics.

However, these findings should not be interpreted as evidence of TOD failure, given the relatively short implementation period and the time required for substantial changes in the built environment to occur. Rather, they provide an important baseline for the current stage of TOD development within the corridor and the variation in TOD across precincts. In addition, the precinct-level findings, therefore, provide a basis for targeted interventions and future assessment as the LBDC continues to mature. This study demonstrates that transit investment alone is unlikely to produce compact and integrated urban form without complementary land-use planning, appropriate development controls, improved pedestrian connectivity, and supportive institutional arrangements.

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References

1. Fang, Q.; Inoue, T.; Li, D.; Liu, Q.; Ma, J. Transit-oriented development and sustainable cities: A visual analysis of the literature based on CiteSpace and VOSviewer. *Sustainability* **2023**, *15*, 8223. [\[CrossRef\]](#)
2. Seto, K.C.; Güneralp, B.; Hutyra, L.R. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 722–729. [\[CrossRef\]](#)
3. UN-Habitat. *World Cities Report 2022: Envisaging the Future of Cities*; UN-Habitat: Nairobi, Kenya, 2022.
4. Gu, D.; Andreev, K.; Dupre, M.E. Major trends in population growth around the world. *China CDC Wkly.* **2021**, *3*, 604. [\[CrossRef\]](#)
5. Alkhresheh, M. Urban sprawl in Riyadh: Assessing the impacts of horizontal expansion on sustainability and quality of life. In *Urban Innovation: To Boldly Go Where No Cities Have Gone Before—Medium-Sized Cities and Towns as a Major Arena of Global Urbanisation, Proceedings of REAL CORP 2025, 30th International Conference on Urban Development, Regional Planning and Information Society*; CORP—Competence Center of Urban and Regional Planning: Vienna, Austria, 2025; pp. 973–980.
6. Soltani, A.; Azizi, P.; Javadpoor, M.; Allan, A.; Bagheri, B. Determining and quantifying urban sprawl drivers: A Delphi–DANP approach. *Land* **2025**, *14*, 311. [\[CrossRef\]](#)
7. Kasuku, S. Evaluating the socio-economic benefits of transit-oriented development (TOD) along Thika Road Corridor, Nairobi. *Afr. Habitat Rev.* **2024**, *19*, 3002–3015. [\[CrossRef\]](#)
8. Cucuzzella, C.; Owen, J.; Goubran, S.; Walker, T. A TOD index integrating development potential, economic vibrancy, and socio-economic factors for encouraging polycentric cities. *Cities* **2022**, *131*, 103980. [\[CrossRef\]](#)
9. Mazzetto, S.; Furlan, R.; Awwaad, R. Sustainable urban renewal: Planning transit-oriented development (TOD) in Riyadh. *Sustainability* **2025**, *17*, 4310. [\[CrossRef\]](#)
10. Farahnak, N. Accessibility in Transit-Oriented Development (TOD) Areas: A Case Study of the Copenhagen Metropolitan Area. Doctoral Dissertation, Politecnico di Torino, Torino, Italy, 2025.
11. Cui, N.; Yang, H.; Mwetuhafifa, N.M. Evaluating TOD performance through node–place model: Evidence from bus stop areas in Windhoek, Namibia. *Front. Public Health* **2025**, *13*, 1697702. [\[CrossRef\]](#)
12. Chen, H.; Zhao, K.; Zhang, Z.; Zhang, H.; Lu, L. Methods for the performance evaluation and design optimization of metro transit-oriented development sites based on urban big data. *Land* **2024**, *13*, 1233. [\[CrossRef\]](#)
13. Sharma, S.N.; Dehalwar, K. A systematic literature review of transit-oriented development to assess its role in economic development of cities. *Transp. Dev. Econ.* **2025**, *11*, 23. [\[CrossRef\]](#)
14. Ogra, A.; Ndebele, R. The Role of 6Ds: Density, Diversity, Design, Destination, Distance, and Demand Management in Transit Oriented Development (TOD). In Proceedings of the Neo-International Conference Habitable Environment, Punjab, India, 31 October–2 November 2014.
15. Abdi, M.H.; Lamíquiz-Daudén, P.J. Transit-oriented development in developing countries: A qualitative meta-synthesis of policy and implementation challenges. *Int. J. Sustain. Transp.* **2022**, *16*, 195–221. [\[CrossRef\]](#)
16. Ollivier, G.; Ghaté, A.; Bankim, K.; Mehta, P. *Transit-Oriented Development Implementation Resources and Tools*, 2nd ed.; World Bank Group: Washington, DC, USA, 2021; Available online: <http://documents.worldbank.org/curated/en/261041545071842767> (accessed on 20 April 2026). (In English)
17. Mudiriza, G.; Edwards, L. The persistence of apartheid regional wage disparities in South Africa. *J. Econ. Geogr.* **2021**, *21*, 807–839. [\[CrossRef\]](#)
18. Monama, S.A.; Mokoele, N.J.; Mokgotho, K.D. South African spatial planning fragmentation: Repealing the apartheid planning imprint. *Int. J. Entrep.* **2022**, *26*, 1–11.
19. Mkhwanazi, S.B.; Jili, N.N. Spatial governance of the peripheries in South Africa: Past lessons and a look into the future. *Afr. Public Serv. Deliv. Perform. Rev.* **2024**, *12*, 9. [\[CrossRef\]](#)
20. South African Cities Network (SACN). *The Urban Land Paper Series*; South African Cities Network: Johannesburg, South Africa, 2017; Volume 2.
21. Naidoo, D.; Ogra, A.; Mbinza, Z. Spatial Transformation and Nodal Planning in the City of Pietermaritzburg: The Case of Transit-Oriented Development (TOD) along Edendale/Northdale Corridor. In *Future Is Urban: Livability, Resilience & Resource Conservation*; Routledge: Abingdon, UK, 2023; pp. 540–553.
22. Van der Walt, B.; Pretorius, O. Transit-oriented development, development corridors and economic access: The Louis Botha development corridor’s impact. *Town Reg. Plan. (Online)* **2023**, *83*, 1–17. [\[CrossRef\]](#)
23. Musonda, I.; Mwanaumo, E.; Onososen, A.; Kalaoane, R. (Eds.) *Development and Investment in Infrastructure in Developing Countries: A 10-Year Reflection, Proceedings of DII 2024*; CRC Press: Boca Raton, FL, USA, 2024.
24. Ndebele, R.; Ogra, A. A place-based approach to spatial transformation: A case study of transit-oriented development (TOD), Johannesburg. *Plan. Afr.* **2014**, *2014*, 452–475.
25. Ngidi, Z.S. Assessing the Role of Public Transport-Oriented Development in Promoting Investment: The Case of Johannesburg’s Rea Vaya and the Louis Botha Corridor of Freedom. Doctoral Dissertation, University of the Witwatersrand, Johannesburg, South Africa, 2019.

26. Maheshwari, R.; Grigolon, A.; Brussel, M. Evaluating TOD in the context of local area planning using mixed methods. *Case Stud. Transp. Policy* **2022**, *10*, 1015–1025. [CrossRef]
27. Xia, Z.; Feng, W.; Cao, H.; Zhang, Y. Understanding the influence of built environment indicators on transit-oriented development performance according to the literature from 2000 to 2023. *Sustainability* **2024**, *16*, 9165. [CrossRef]
28. Harrison, P.; Rubin, M.; Appelbaum, A.; Dittgen, R. Corridors of freedom: Analyzing Johannesburg's ambitious inclusionary transit-oriented development. *J. Plan. Educ. Res.* **2019**, *39*, 456–468. [CrossRef]
29. City of Johannesburg. *Corridors of Freedom Strategic Area Framework*; City of Johannesburg: Johannesburg, South Africa, 2012.
30. Baverman, M. Transit-Oriented Development and Commuting Patterns in a Gentrifying Bay Area: Exploring the Relationships Between Neighborhood Change, Displacement, and Implications for Transit Use [Technical Report]. 2025. Available online: <https://escholarship.org/uc/item/9bt7x4xx> (accessed on 23 March 2026).
31. Calthorpe, P. *The Next American Metropolis: Ecology, Community, and the American Dream*; Princeton Architectural Press: New York, NY, USA, 1993.
32. Zhang, P.; Yuan, Y.; Zhang, H. Measuring the TOD level of rail transit stations based on the node–place–activity dimension. In *Proceedings of the 11th International Conference on Traffic and Logistic Engineering (ICTLE)*; IEEE: New York, NY, USA, 2023; pp. 30–35.
33. Institute for Transportation and Development Policy. *TOD Standard 3.0*; ITDP: New York, NY, USA, 2017.
34. Organisation for Economic Co-operation and Development; OECD. *Rethinking Urban Sprawl*; OECD Publishing: Paris, France, 2018.
35. Ardila-Gomez, A.; Namkung, O.S.; Dominguez-Gonzalez, K.; He, H.; Bona, N. *Planning for Transit-Oriented Development in Emerging Cities*; World Bank: Washington, DC, USA, 2024.
36. Chan, N.W.; Nakamura, A.; Imura, H. Transit-oriented development (TOD). In *Sustainable Urban Development*; Water Watch Penang: Penang, Malaysia; Yokohama City University: Yokohama, Japan, 2016; pp. 177–183.
37. Bolleter, J.; Ramalho, C.E. Transit-oriented development (TOD) and its problems. In *Greenspace-Oriented Development: Reconciling Urban Density and Nature in Suburban Cities*; Bolleter, J., Ramalho, C.E., Eds.; Springer International Publishing: Berlin/Heidelberg, Germany, 2019; pp. 13–39. [CrossRef]
38. Renne, J.; Wolshon, B.; Pande, A.; Murray-Tuite, P.; Kim, K. *Creating Resilient Transportation Systems: Policy, Planning, and Implementation*; Elsevier: Amsterdam, The Netherlands, 2022.
39. Ibraeva, A.; de Almeida Correia, G.H.; Silva, C.; Antunes, A.P. Transit-oriented development: A review of research achievements and challenges. *Transp. Res. Part A Policy Pract.* **2020**, *132*, 110–130. [CrossRef]
40. Hardi, A.Z.; Maatouk, M.M.H. The criteria and indicators for applying transit-oriented development (TOD) in metropolitan cities based on lessons learned from international experiences. *Eur. J. Archit. Urban Plan.* **2023**, *2*, 1–14. [CrossRef]
41. Bhagwati, P.; Kumar, M. Transit-oriented development: Learnings from global examples. *LOGI-Sci. J. Transp. Logist.* **2024**, *15*, 1–12. [CrossRef]
42. Sinha, B.R.K. Introduction: A broad perspective on the concepts of urban dynamics, environment, and health. In *Urban Dynamics, Environment and Health: An International Perspective*; Springer Nature: Singapore, 2024; pp. 3–79.
43. Pieterse, E.; Owens, K. Johannesburg: Confronting Spatial Inequality. 2018. Available online: https://www.wri.org/research/johannesburg-confronting-spatial-inequality?utm_medium=website&utm_source=archdaily.com.br (accessed on 3 March 2026).
44. Bickford, G.; Behrens, R. What does transit-oriented development mean in a South African context? A multiple stakeholder perspective from Johannesburg. In *Proceedings of the Southern African Transport Conference*, Pretoria, South Africa, 6–9 July 2015.
45. Juries, J. Transit-Oriented Development in the Context of Cape Town: A Case Study of Bellville. Master's Thesis, University of Cape Town, Cape Town, South Africa, 2018. Available online: <http://hdl.handle.net/11427/28018> (accessed on 2 April 2026).
46. Wood, A. Problematising concepts of transit-oriented development in South African cities. *Urban Stud.* **2022**, *59*, 2451–2467. [CrossRef]
47. City of Johannesburg. *Integrated Development Plan 2012–2016 Review: Turning Challenges into Opportunities*; City of Johannesburg: Johannesburg, South Africa, 2015.
48. Kotze, N.; De Vries, L. Resuscitating the African giant: Urban renewal and inner-city redevelopment initiatives along the Corridors of Freedom in downtown Johannesburg. *Geogr. Pol.* **2019**, *92*, 57–70. [CrossRef]
49. Haque, A. Transit Oriented Development (TOD) in Dhaka: Measuring Spatial Potential from Node Place Perspective. *Transp. Res. Procedia* **2025**, *82*, 2172–2187. [CrossRef]
50. Wu, T.; Yuan, Z.; Gao, L.; Zhang, M.; Li, M. TOD typologies for metro stations based on the butterfly model. *Front. Environ. Sci.* **2024**, *12*, 1327535. [CrossRef]
51. Cervero, R.; Murakami, J. Rail and property development in Hong Kong. *Urban Stud.* **2009**, *46*, 2019–2043. [CrossRef]
52. Liu, Y.; Nath, N.; Murayama, A.; Manabe, R. Transit-oriented development with urban sprawl? Four phases of urban growth and policy intervention in Tokyo. *Land Use Policy* **2022**, *112*, 105854. [CrossRef]

53. Libunyu, E. Paratransit-Oriented Transit-Oriented Development (TOD) in the Global South: Minibus Taxi Urbanism in South Africa. Master's Thesis, Stellenbosch University, Stellenbosch, South Africa, 2024. Available online: <https://scholar.sun.ac.za/server/api/core/bitstreams/240308ba-7a99-402e-809b-2c09538c38d6/content> (accessed on 20 April 2026).
54. Bahaelu Horeh, S. Evaluating Transit-Oriented Development (TOD) Challenges and Prospects in Tehran: A Focus on Land Use Strategies Around Metro Stations. Rel. Luca Staricco. Politecnico di Torino, Master of Science Program in Territorial, Urban, Environmental and Landscape Planning. 2025. Available online: <https://webthesis.biblio.polito.it/id/eprint/36016> (accessed on 20 April 2026).

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