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Transport planning based on the transit-oriented development model in railway station areas: Lessons learned and applications in the context of Ho Chi Minh city

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Abstract:

This article reviews and synthesises international experience and related studies on transport planning under the transit-oriented development (TOD) model at high-speed rail (HSR) and metro stations and compares them with existing policies and development plans in Ho Chi Minh city. Based on this foundation and combined with quantitative assessments and microsimulations of transport organisation around Phuoc Long station, the study proposes a set of TOD-oriented strategies for HSR and metro stations in the city. These include high-density and mixed-use urban planning, optimisation of public transport connectivity, promotion of green mobility, investment in modern transport infrastructure, development of high-quality public spaces, and improvements in traffic management. Simulation results comparing two scenarios (existing conditions and TOD-oriented transport planning) demonstrate that the TOD scenario yields significantly better performance. Projected passenger volumes increase substantially, vehicle speeds improve, and both delay and total travel time are reduced. These findings underscore the crucial role of TOD-oriented transport planning in enhancing the operational efficiency of public transport systems and improving the quality of the urban environment surrounding railway stations.

Keywords: **high-speed rail station areas, Ho Chi Minh city, transit-oriented development, transport planning, urban rail station areas.**

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1. Introduction

Ho Chi Minh city, although serving as the nation's foremost economic hub, still grapples with substantial deficiencies in its urban transport infrastructure. The proportion of transport land to urban construction land is only about 12.2%, approximately 10% below national standards. This deficiency has contributed to chronic infrastructure overload and frequent traffic congestion. The total length of the city's road network is roughly 4,500 km, with a density of 2.26 km per square kilometre - only one-fifth of the recommended benchmark and notably lower than that of comparable metropolitan areas such as Bangkok or Taipei [1]. The public transport system lacks coordination and integration, resulting in weak connections among various modes, including private vehicles, bus services, and high-capacity transit. Moreover, bus stops, transfer facilities, and stations are often inadequately planned and poorly distributed, diminishing system efficiency and limiting accessibility. These shortcomings not only undermine the attractiveness of public transport but also reinforce the public's reliance on private motorised travel, thereby worsening congestion and contributing to increased air pollution.

Transit-Oriented Development (TOD) not only facilitates the provision of efficient public transport systems but also promotes the creation of sustainable living environments. In Ho Chi Minh city, TOD has been identified in urban development strategies as a key solution for addressing persistent urban transport challenges [2]. However, its practical implementation remains limited. Policy gaps, infrastructure constraints, financial challenges, and inadequate inter-agency coordination continue to hinder the effective adoption of TOD.

Effective transport organisation within TOD areas requires close integration between public transport modes and urban infrastructure. Under the TOD framework, transport operations are structured to optimise connectivity among metro and urban rail services, bus networks, public bicycle systems, and environmentally friendly modes of personal mobility [3]. The overarching objective is to provide residents with a seamless, accessible, and convenient mobility network while reducing dependency on private motorised vehicles.

Well-organised transport systems within TOD areas not only encourage public transport use but also stimulate local socio-economic development. Concentrating commercial services, office space, and housing around intermodal hubs creates vibrant urban settings and fosters social interaction. At the same time, such integration reduces the intensity of private vehicle use on road networks,

alleviates congestion, and improves air quality. These outcomes collectively support sustainable and environmentally responsible urban development.

2. Methodology and related work

2.1. Research framework and methodology

2.1.1. Objectives, scope, and limitations

This study aims to develop a TOD-based transport planning approach for railway station areas in Ho Chi Minh city. The objectives are: (i) to synthesise experience in TOD-oriented transport planning; (ii) to examine consistency with the policy and planning framework in Vietnam and Ho Chi Minh city; (iii) to propose a TOD-based transport organisation framework for urban rail and high-speed rail stations; and (iv) to quantitatively evaluate the operational impacts of TOD-oriented measures through a microsimulation case study at Phuoc Long station.

The study focuses on transport organisation within station areas, emphasising intermodal connectivity, pedestrian accessibility, and operational performance. The quantitative assessment is demonstrated through a scenario-based simulation for a representative case study. The main limitations include the use of hypothetical scenarios in microsimulation rather than post-implementation data, and the context-specific nature of the case study. Nevertheless, the proposed framework provides practical insights for TOD-oriented transport planning in rapidly urbanising cities.

2.1.2. Research methodology

The study adopts a mixed-methods, application-oriented approach that combines qualitative analysis and quantitative evaluation (Fig. 1). *First*, the literature on TOD and station-area transport planning was reviewed to identify key principles and performance indicators. *Second*, relevant policy and planning documents in Vietnam and Ho Chi Minh city were analysed using a five-point Likert scale to assess their alignment with international TOD practices.

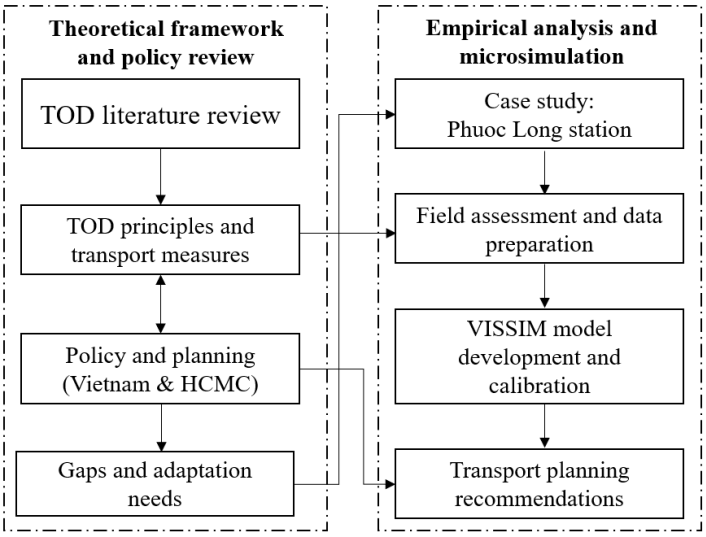

Fig. 1. Research methodology flowchart.

Third, a field assessment of Phuoc Long station was conducted to establish baseline conditions and develop a TOD-oriented scenario. *Finally*, microsimulation using PTV VISSIM was applied to compare existing conditions with a TOD-based scenario. Key outputs included passenger volumes, speed, delay, travel time, distance, and number of stops, which were used to evaluate the operational impacts of TOD transport organisation.

2.2. Related work

Domestic and international research demonstrates that TOD is an effective approach to mitigating environmental impacts, reducing emissions, and advancing sustainable urban development. Therefore, the study conducted a structured literature review and screened the retrieved studies for relevance, methodological clarity, and recency based on key success factors to identify gaps and implications for Ho Chi Minh city.

International studies regard TOD as an integrated model for restructuring cities toward sustainability under growing congestion and environmental pressures. Foundational reviews and specialised monographs consistently define TOD as the simultaneous combination of: (i) high-capacity public transport systems, (ii) high-density, mixed-use land development within a walkable catchment, and (iii) pedestrian- and bicycle-friendly urban design aimed at reducing automobile dependence [4]. Key points from these reviews are that TOD's effectiveness stems primarily from the integration of transport, land use, and urban design, rather than from any single component alone; without such integration, TOD is easily "labelled" as such but fails to increase public transport mode share [5, 6].

Methodologically, international studies employ a wide range of quantitative tools to verify TOD's effectiveness. H. Sung, et al. (2011) [7] used regression models and ridership data in Seoul to demonstrate a strong relationship between density, functional mix, and walkable accessibility around stations, and metro ridership output. The International Transport Forum (2018) [8] synthesised empirical studies in Europe through a system-level synthesis approach, showing that TOD cities integrating public transport and cycling achieve higher shares of non-motorised/public-transport travel and markedly lower car use. P. Newman, et al. (1999) [9] applied a historical-statistical comparative approach across multiple cities to show that high-density coupled with public transport is a fundamental factor in reducing automobile dependence. These quantitative findings reinforce the argument that TOD is effective, while also implicitly highlighting a prerequisite: Transport organisation and micro-level accessibility must be sufficiently well designed to translate urban structure into actual travel behaviour.

Recent TOD trends emphasise multidimensional assessment rather than focusing solely on "transport connectivity" and "density". The Node-Place-Ecology (NPE) model proposed by W. Yang, et al. (2024) [10], drawing on a meta-synthesis and case studies in Guangzhou/Shanghai, show that if TOD merely maximises the "node" dimension (connectivity capacity) without balancing it with "place" (urban space quality) and "ecology" (environmental impacts), it may produce intensive but unsustainable development. P. Newman, et al. (2016) [11] with "urban fabrics" theory add a multi-layered urban-structure perspective, stressing that TOD is successful when it enables cities to shift from an "automobile fabric" to a "transit/walking fabric". The World Bank developed the 3V framework (node-place-market) based on project appraisal and investment prioritisation by considering connectivity potential, urban environmental quality, and market absorption capacity; this is especially suitable for developing cities where public resources are constrained [12, 13]. The convergence of NPE, 3V, and urban fabrics indicates that contemporary TOD seeks to optimise transport, space, environment, and market simultaneously - meaning TOD must be governed as an urban system rather than treated as a purely infrastructure project.

At the station level, many empirical studies show that TOD can generate new growth poles, while also warning of sprawl risks if land control and micro-level transport organisation are inadequate. M.D. Mahardika, et al. (2022) [14], using demand analysis and corridor scenarios for Jakarta - Bandung, find that TOD around intermediate stations can turn them into "new development poles" through the integration of housing, services, and public space. F. Long (2018) [15] employs satellite data to quantify urban expansion along HSR in China, indicating that population and employment

are reallocated and concentrated around well-connected nodes; S. Shao, et al. (2017) [16] and J. Shen, et al. (2019) [17], based on economic and land-use data, show that HSR stations combined with TOD promote the agglomeration of high-value services and function as a mechanism for infrastructure financialisation via land-value capture.

By contrast, B. Wang, et al. (2023) [18] apply comparative plan-content analysis to 15 HSR station-area plans and find that many projects "claim TOD" but in practice extend suburban development, turning TOD into a driver of sprawl. Y. Liu, et al. (2022) [19], through a time-series analysis of Tokyo's development, likewise confirm that TOD can either stimulate or restrain sprawl depending on the degree of land-policy control. European cases indicate that HSR enhances regional accessibility and attracts new investment when accompanied by appropriate spatial and transport organisation: I. Mohíno, et al. (2014) [20] analyse London/Madrid/Paris, while X. Chen, et al. (2015) [21] use a node-place framework to explain the "hubtropolis" structure of Hongqiao. Studies on London - Berlin further underline the importance of car restraint and the prioritisation of public transport and walking within station areas [22].

An important critical point in international research is that TOD does not bring only benefits. A. Randhawa (2021) [23] synthesises key challenges - fragmented institutions, lack of long-term capital, planning conflicts, and limited community participation - which make TOD prone to failure in developing-country contexts. T. Kidokoro (2019) [24] stresses that TOD in Asia requires land-finance policies, public-private partnership mechanisms, and affordable housing provision to avoid gentrification and the exclusion of low-income groups. Studies in Seoul likewise indicate that TOD increases land values and local economic vitality (through land-price and consumption analyses), yet this very effect can generate upward pressure on housing prices if regulatory policies are absent [25, 26]. Overall, international research both confirms TOD's effectiveness and clearly identifies its conditions for success and associated risks (sprawl, gentrification, and institutional barriers).

In Vietnam, TOD is increasingly framed as a strategic mechanism for integrating public transport with urban planning, with the aims of alleviating congestion and improving land-use efficiency along metro and high-speed rail (HSR) corridors. V.A. Tuan, et al. (2022) [27] develop a TOD strategy for Ho Chi Minh city based on alternative development scenarios, identifying two key bottlenecks - capital constraints and low initial ridership. They therefore argue that TOD is only feasible when closely coupled with multimodal feeder services and supported by land-value capture and PPP financing arrangements. L.C. Truc (2023) [28], in an analysis of TOD spatial organisation in Hanoi, emphasises walkable catchment radii, functional mix, and high-quality public space as core

performance criteria; V.V. Anh (2018) [29] proposes a TOD framework aligned with the expansion of urban rail in Ho Chi Minh city and recommends institutional mechanisms to better integrate planning and investment processes.

Regarding micro-level transport organisation around stations, Vietnam - Japan cooperation projects provide the main empirical evidence. The Japan Bank for International Cooperation report and the SAPI project, based on existing-condition surveys and access design, propose reorganising service roads and transfer points, improving walking and cycling conditions, and integrating ticketing and smart technologies to enhance the convenience of metro-bus-taxi interchanges [30]. Metro Line 2 developed demand models and restructured feeder routes in line with TOD principles for key stations such as Ben Thanh and Tham Luong in 2018 [31]. However, compared with the international literature, domestic studies still tend to focus on macro-level strategies and descriptive solutions, and lack quantitative or micro-simulation work to verify the effectiveness of specific traffic organisation measures at individual stations. This gap is particularly notable given international evidence that TOD success depends directly on micro-level transport organisation and pedestrian accessibility around stations [8, 18, 19].

From the domestic and international literature review, two implications can be drawn for Ho Chi Minh city. *First*, emerging TOD frameworks (NPE, 3V, and urban fabrics), together with international quantitative evidence, indicate that TOD needs to pursue multi-objective optimisation and be validated through data and simulation, rather than relying only on general principles. *Second*, TOD in Ho Chi Minh city must confront institutional and financial barriers, as well as the risk of rising land and housing prices in the absence of regulatory instruments - consistent with warnings from other developing Asian contexts. Therefore, the present study needs to move beyond merely "reiterating high-density planning" and instead develop an analytical and micro-level transport organisation framework suited to Ho Chi Minh city, while quantitatively testing it through simulation at specific stations-this is precisely the gap that remains in the current body of research.

2.3. Synthesis of previous research and contributions of this article

The reviewed studies indicate that the effectiveness of traffic organisation under the TOD model depends on six main factors: (i) multimodal transport connectivity, (ii) high-density urban development and mixed land use, (iii) supportive policies and institutional frameworks, (iv) the quality of the urban environment and amenities, (v) accessibility to stations, and (vi) planning tools and analytical models. The study employs a five-point Likert scale (1-5) to quantify assessments such

as prevalence, importance, or increasing levels of agreement from very low to very high, thereby allowing the synthesis of results into comparable scores [32].

Table 1. Summary of previous studies by success factors.

Factor	Score	Comment
Optimised intermodal connectivity	5	Consistently highlighted across TOD and rail-station studies; emphasises integration of rail with feeder buses, walking/cycling networks, and well-organised interchange spaces around stations.
High-density development and mixed land use	4	A core spatial-structural condition for TOD; however, some studies caution that TOD may drift towards sprawl if land-use control is weak.
Supportive policies and institutional framework	5	A decisive factor in developing-country contexts; typically linked to cross-sector coordination, urban finance, and land-value capture mechanisms.
Urban environmental quality and amenities	4	More strongly emphasised in recent research (NPE/urban fabrics/3V), connecting TOD to environmental sustainability.
Accessibility to public transport/stations	5	A critical criterion in both quantitative studies and applied projects; relates to walkable catchments, safety in access spaces, and the placement of stops and interchange parking.
Planning tools and analytical models	4	Highly prevalent in recent work: TOD indices, NPE/3V frameworks, and micro-simulation for scenario validation.

The international and domestic studies synthesised in Table 1 indicate that TOD is a multi-pillar model, in which the three most prevalent factors (scoring 5/5) are multimodal connectivity, policy-institutional arrangements, and accessibility to stations/public transport. This reflects a broad consensus that TOD cannot succeed merely by increasing density or developing space around stations; rather, it must ensure an integrated and coherent alignment of transport organisation, accessibility, and governance. The remaining factors - density and mixed use, urban environmental quality, and modelling/analytical tools - also show high prevalence (4/5). Their prominence has increased markedly in more recent studies, as TOD has been expanded towards multi-objective

optimisation of "node-place-ecology-market" (NPE/3V) and relies more heavily on quantitative evaluation.

However, the review also identifies three important gaps that should be highlighted. *First*, many case studies of HSR/metro stations and rail corridors focus on spatial planning and regional strategies, while relatively few examine micro-level transport organisation at the individual station scale - where transfer behaviour and operational performance are determined most directly. *Second*, newer TOD trends have placed greater emphasis on environmental sustainability, market absorption, and social equity, while warning of risks such as sprawl, gentrification, and institutional/financial barriers in developing cities; therefore, TOD assessment should avoid overly optimistic approaches or benefit-only descriptions. *Third*, in Vietnam, existing studies and projects have addressed multimodal connectivity and station accessibility, but mainly at the level of network and infrastructure planning, with limited quantitative verification through microsimulation for specific stations.

3. Experiences in transport organisation under the TOD model at urban rail and high-speed rail stations

Developed countries such as China, Japan, Korea, and Singapore have successfully implemented TOD model, particularly in HSR station areas and metro systems. These practical experiences provide valuable lessons for rapidly developing cities such as Ho Chi Minh city.

3.1. Experience on perspectives and principles of transport organisation

TOD not only reduces dependence on private vehicles but also optimises the use of public transport, while fostering sustainable urban development. The model has demonstrated effectiveness in addressing urban transport challenges, particularly congestion and pollution, while at the same time creating vibrant and convenient urban districts.

Table 2. International experience on perspectives and principles of transport organisation.

Criterion	Description	Country/Example	Outcome
Integration of multiple transport modes	Seamless connections among public transport, bicycles, walking, and limited private vehicle use	Germany (Munich), Netherlands (Amsterdam), Japan (Tokyo), Singapore	Reduced dependence on private vehicles, improved accessibility to public transport

Criterion	Description	Country/Example	Outcome
Increased density and land use around transit stations	Planning for high-density residential, commercial, and service functions near stations	Netherlands, Germany, Japan, Seoul, Singapore	Higher public transport ridership and creation of vibrant communities
Development of urban centres around stations	Stations serve not only as transport nodes but also as integrated urban centres	Japan (Shibuya, Shinjuku), Singapore (MRT), Seoul	Creation of mixed living, working, and recreational spaces within walking distance
Optimised station access via public transport	Station design and surrounding infrastructure facilitate pedestrian and bicycle access	Japan, Netherlands, Singapore	More than 75% of residents within 500 meters use public transport daily
Reduction of private vehicle demand	Strengthened public transport services combined with parking and road use restrictions for private vehicles	Seoul, Singapore	Private vehicle density reduced by 10% annually, with significant declines in congestion and emissions
Urban space organised around public transport	Urban design prioritises public transport rather than private cars	Germany, Netherlands, Japan	Improved quality of life, greater energy efficiency, and lower emissions
Policy support for TOD planning and investment	Support from central and local governments through policy, planning, and infrastructure investment	Netherlands, Singapore, Korea	Ensured coordination between public transport development and urban growth

The evidence presented in Table 2 shows that countries and cities which have successfully implemented TOD consistently adhere to fundamental principles for effective transport organisation, particularly the integration of multiple transport modes. TOD emphasises not only the development of public transport but also the coordination with other modes of mobility. This approach creates a comprehensive, convenient, and accessible transport ecosystem for urban residents.

In Europe, the Netherlands and Germany provide exemplary cases of successful TOD implementation. In the Netherlands, the government has planned high-density development around public transport stations in major cities such as Amsterdam and Utrecht. Approximately 60 percent of residents in TOD areas live within one kilometre of a transit station, with public transport accounting for 40-50% of total trips [8]. The TOD oriented perspective on transport organisation in station areas is to establish a seamless network that integrates different transport modes, particularly between railway lines and other public transport services such as buses and trams, as well as individual modes like bicycles [10].

In Asia, many cities have also successfully implemented TOD, particularly in Japan and Singapore. In Japan, railway stations play a central role, functioning not only as transport nodes but also as hubs of urban activity. Transport organisation at these stations must ensure connectivity and efficiency in order to create urban spaces that support both mobility and daily living needs. This arrangement increases the use of public transport and reduces reliance on private vehicles. Areas surrounding major stations such as Shibuya and Shinjuku in Tokyo are planned with high residential and commercial density. According to the Ministry of Land, Infrastructure, Transport and Tourism of Japan, more than 80 percent of residents within 500 meters of major stations in Tokyo rely on public transport [33]. The TOD model in Singapore has contributed to reductions in congestion and pollution while improving quality of life through the development of vibrant, accessible urban districts supported by an efficient public transport system [34]. According to the Seoul Metropolitan Government (2023), public transport ridership in TOD areas reaches about 65 percent, while private vehicle traffic has declined by up to 10 percent annually over the past decade. The model encourages the development of compact urban districts where offices, commercial services, and housing are located in close proximity to public transport stations [26].

3.2. Experience with models and content of transport organisation

Several lessons regarding models and the content of transport organisation in TOD areas around urban rail and high-speed rail stations are summarised in Table 3.

Table 3. Synthesis of experience on models and content of transport organisation.

Criterion	Description	Country/Example	Outcome
High-density and mixed land use urban development	• Integration of residential, commercial, service, and office functions within walking distance of stations. • Optimised land use to reduce long-distance travel demand.	Zurich, Berlin, Lyon, Shibuya [11]	• Enhanced socio-economic vibrancy around stations. • Reduced dependence on private automobiles. • Emergence of new urban centres.
Integrated multimodal public transport connectivity	• Seamless integration of HSR, metro, bus, and taxi within a coordinated system. • Reduced transfer time and costs.	Hongqiao, Yongsan, Berlin [22]	• Improved convenience and journey efficiency. • Increased public transport share (e.g., 70% at Hongqiao). • Mitigation of congestion in central areas.
Pedestrian and bicycle friendly infrastructure	• Design of pedestrian pathways, bicycle lanes, and public spaces near stations. • Improved accessibility and safety for vulnerable users.	Shibuya, Zurich, Yongsan [5, 35]	• Higher station access via non-motorised modes. • Creation of attractive and liveable urban environments. • Reduction of emissions.
Concentrated transport organisation (“hub-and-spoke” model)	• Station functions as a primary interchange hub. • Efficient distribution of passenger flows to surrounding areas.	Zurich, Seoul [25, 26]	• Optimisation of public transport networks. • Shorter interregional travel times. • Reduced pressure on central corridors.

Criterion	Description	Country/Example	Outcome
Application of advanced technology and modern management	• Use of electronic ticketing, digital wayfinding, and AI-assisted passenger flow management. • Integrated systems for coordinating transport and urban planning.	Shibuya, Seoul, Hongqiao [21, 36]	• Faster operational performance. • Improved user experience. • Reduced long-term operating costs.

An effective transport organisation model requires high-density development around station areas, which enhances convenience for residents and visitors while reducing the demand for private automobile use. Zurich station exemplifies this approach by integrating high-speed rail, urban rail, trams, and buses into a unified public transport system. The seamless connections among these modes allow passengers to move easily within and beyond the city. The Zurich transport system operates on the "hub and spoke" principle, in which the station functions as the central hub for both national and regional railway lines. This system ensures high service frequency, short waiting times, and optimised mobility throughout the metropolitan area.

3.3. Experience on policies and solutions

Research on planning policies, urban management, public transport infrastructure development, and financial and legal mechanisms supporting transport organisation under the TOD model is summarised in Table 4.

Table 4. International experience on policies and solutions for TOD-based transport organisation.

Criterion	Description	Country/Example	Outcome
Land use planning concentrated around stations	• Development of high density urban areas surrounding stations. • Mixed use functions (residential, commercial, public).	Switzerland (Zurich), Netherlands (Amsterdam), Japan (Tokyo), France (Lyon)	• Optimised land use. • Creation of multifunctional living environments. • Prevention of suburban sprawl.

Criterion	Description	Country/Example	Outcome
	• Area of influence within 400-800 meters from stations.		• Increased population density within public transport catchment areas.
Policies to encourage public transport use and restrict private vehicles	• Higher parking fees in central areas. • Reduced parking supply or road space for cars. • Increased costs of private car use.	Netherlands, China, Korea, Switzerland	• Decline in private vehicle entries into city centres. • Higher share of public transport in short and medium distance trips.
Investment incentives and financial support for TOD projects	• Tax reductions for TOD real estate projects. • Provision of direct financial subsidies. • Priority access to land or infrastructure.	France, China, Korea, Switzerland	• Attraction of private investment. • Acceleration of TOD project implementation. • Increased housing and service supply around stations.
Investment in public transport infrastructure and intermodal integration	• Expansion of metro and urban rail networks. • Intermodal connections across public transport modes. • Establishment of efficient transfer hubs.	China (Shanghai), Korea (Seoul), Japan (Tokyo), Switzerland (Zurich)	• Formation of efficient and integrated public transport networks. • Reduced travel times. • Enhanced attractiveness of public transport.
Pedestrian friendly infrastructure and public spaces	• Development of pedestrian and cycling facilities near stations.	Switzerland, Japan, Korea	• Improved quality of life. • Higher walking and cycling rates.

Criterion	Description	Country/Example	Outcome
	• Creation of green public spaces and urban gathering areas. • Design of TOD districts with accessible layouts.		• Stronger integration between public spaces and public transport.

In Switzerland, the government has implemented a range of policies to optimise urban space and promote the use of public transport. Planning is concentrated around major stations, encouraging high-density and mixed use development within a 400 to 800 meter walking radius of tram and urban rail stations, thereby creating pedestrian and bicycle friendly districts. The government also applies measures such as tax incentives for TOD real estate projects and reduced parking fees in central areas to encourage a modal shift toward public transport. Zurich's policy framework emphasises the development of high-density urban districts around public transport stations and the integration of transport modes with urban [37]. In the Netherlands, the government has introduced urban planning initiatives based on TOD principles with the dual objectives of reducing environmental impacts and increasing public transport ridership [6]. At the same time, it has adopted measures to restrict private vehicle traffic in central districts by raising parking fees and reducing the amount of road space dedicated to cars [38]. Lyon provides a notable example of successful TOD policy implementation in France, where strict urban planning regulations have been applied to promote development around public transport stations. The French approach focuses on optimising land use through high-density mixed use construction near metro and high-speed rail stations [4].

The Japanese government has concentrated on constructing high-density urban districts around railway and metro stations. Its policy framework emphasises the planning of walkable urban areas within the catchment of stations, supported by high frequency and reliable public transport services [19]. The Chinese government has provided financial support and tax incentives for TOD-oriented urban projects, while encouraging public transport use by raising parking fees in central districts and restricting new road construction. At the same time, it has invested heavily in the expansion of metro systems, thereby creating a multimodal transport network that connects central areas with suburban zones [17]. The government of Korea has developed high-density urban areas around metro and high-speed rail stations, encouraging public transport ridership through investments in modern infrastructure, reduced parking fees in

TOD districts, and the provision of green public spaces to foster sustainable environments [7].

3.4. Experience in transport organisation at representative stations

Developed countries have implemented a variety of successful TOD models, particularly in high-speed rail and metro station areas. A comparative summary of station experiences according to key criteria is presented in Table 5.

Table 5. Comparative experience of selected stations by criterion.

Criterion	Berlin Hauptbahnhof (Germany)	Shibuya (Tokyo, Japan)	Hongqiao (Shanghai, China)
Scale	Largest central station in Berlin, serving interregional and international traffic	Major commercial, entertainment, and transport hub of Tokyo	One of the largest integrated transport-urban complexes in China
Transport modes	High-speed rail, U-Bahn, trams, buses	Urban rail, metro, buses, taxis, bicycles	High-speed rail, metro, buses, taxis, Hongqiao Airport
TOD model	High-density mixed use urban development integrating offices, housing, commerce, and hotels	High rise integrated development combining commerce, entertainment, and residential uses around the station	Multi-centred TOD model linking commerce, residential development, transport, and airport facilities
Transport organisation and connectivity	Directly connected public transport system; clear wayfinding; optimised transfer operations	Strong multimodal integration; short transfer corridors; high accessibility for pedestrians	Intermodal hub integrating metro, high-speed rail, airport, taxis, and buses under a hub-based system
Operational outcomes	Reduced transfer time; enhanced passenger experience; optimised spatial utilisation	Increased accessibility to public transport; high modal share of transit	Reduced airport congestion; improved regional and international connectivity

Berlin Hauptbahnhof in Germany is one of the largest and most modern stations in Europe, functioning as the principal transport hub for Berlin and its surrounding region. The TOD model at Berlin emphasises the integration of functional areas such as offices, residential districts, hotels, and commercial spaces within a walkable catchment of the station [21, 22]. This approach forms part of Berlin's broader strategy to develop high-density, mixed use urban areas that enhance the efficiency of public transport corridors. Berlin Hauptbahnhof incorporates a fully integrated transport network consisting of high-speed rail, suburban rail (S-Bahn), metro (U-Bahn), buses, and trams. These modes are directly connected, reducing transfer times and improving the passenger experience [39].

Shibuya Station in Tokyo demonstrates a highly integrated model of transport and urban development. The station area functions as a hub of commercial, cultural, and entertainment activities, with high rise buildings, shopping centres, and office complexes. This dynamic development attracts both residents and visitors, creating a vibrant and diverse urban environment. Shibuya Station is connected to multiple suburban and metro rail lines, as well as bus routes, enabling passengers to transfer easily across modes [19].

Hongqiao Station in Shanghai serves five high-speed rail lines and three metro lines, representing one of China's most successful TOD cases [40]. It integrates public transport with urban development and plays a critical role in the city's development strategy. The station area has been developed into a modern urban centre with commercial districts, office towers, and high end residential complexes. Hongqiao Station also connects directly to Shanghai Hongqiao International Airport and high-speed rail services, forming a major multimodal hub. The station integrates metro, bus, and taxi services, enabling passengers to transfer conveniently among modes [41].

4. Policies and plans for TOD development at railway stations in Ho Chi Minh city

4.1. Policies supporting TOD development at railway stations

The TOD model has been receiving increasing attention in urban and transport planning, particularly in the context of expanding metro and high-speed rail systems. Vietnam is gradually strengthening its policies and legal framework (Table 6) to implement TOD, with the aim of fostering sustainable transport, alleviating congestion, and reducing environmental pollution. The study employs a five-point Likert scale (1-5) to quantify assessments of Vietnam's policies on TOD-based transport organisation and planning at railway stations, and their implications for Ho Chi Minh city [32].

Table 6. Vietnam's policies for TOD-based transport planning at stations and influence for Ho Chi Minh city.

No.	Policy/ Resolution	Main content related to TOD and transport organisation	Influence on TOD	Influence on Ho Chi Minh city's transport	Notes
1	Resolution No. 172/2024/QH15	Policy direction for investment in the North-South high-speed rail, linking urban development, environmental protection, and climate change adaptation.	★★★★☆	★★★★☆	Macro-level orientation policy, foundation for nationwide TOD.
2	Resolution No. 178/NQ-CP (2023)	Prioritisation of land around stations, urban development under TOD, and reinvestment of revenues from urban development into railway infrastructure.	★★★★★	★★★★☆	Direct impact on public transport organisation integrated with urban planning.
3	Conclusion No. 72-KL/TW (2024)	Emphasis on refining the TOD model, creating dedicated financial mechanisms, promoting public transport, and developing integrated urban areas around stations.	★★★★☆	★★★★☆	Coordinated policy facilitating TOD implementation.
4	Resolution No. 98/2023/QH15	Authorisation for Ho Chi Minh city to pilot TOD, allocate local budgets for station area development, and carry out land acquisition and resettlement	★★★★★	★★★★☆	Legal framework enabling Ho Chi Minh city to proactively implement TOD

		for TOD-based urban development.			at the urban scale.
5	Resolution No. 188/2025/QH15	Authorisation to adjust land use indicators, prepare and approve metro projects linked with TOD, mobilise diverse funding sources, promote technology transfer, and train specialised human resources.	★★★★☆	★★★★★	Strong support for TOD integrated with metro development, increasing autonomy in financing and technology.

Resolution No. 172/2024/QH15 dated 30 November 2024 on the investment policy for the North-South high-speed railway project [42]. The resolution to proceed with this project aims to establish a modern and integrated railway corridor to meet transport demand, provide a major driver for rapid and sustainable socio-economic development, and leverage the advantages of the North-South economic corridor. The project is also expected to ensure effective connectivity with East-West corridors and neighbouring countries, while contributing to national defence, security, and international integration, as well as environmental protection, climate change adaptation, and the advancement of national industrialisation and modernisation.

Resolution No. 178/NQ-CP of 2023, issued by the Government to implement the Action Program of Conclusion No. 49-KL/TW, sets the orientation for the development of Vietnam's railway sector to 2030 with a vision to 2045 [43]. Conclusion No. 72-KL/TW of 2024, adopted as a continuation of Resolution No. 13-NQ/TW, focuses on the development of modern and synchronised infrastructure to support national industrialisation and modernisation by 2030 [44]. This conclusion highlights the promotion and refinement of the TOD model in Vietnam, especially in rapidly growing metropolitan areas such as Hanoi and Ho Chi Minh city. By advancing TOD, the policy creates a favourable environment for investment in public transport projects and integrated urban districts, thereby alleviating congestion, encouraging the use of public transport, and improving the efficiency of urban transport systems. Land surrounding major railway stations, high-speed rail terminals, and urban rail

stations is to be prioritised for TOD-based urban development, with revenues from such development reinvested into railway infrastructure.

Resolution No. 98/2023/QH15 of the National Assembly on piloting special mechanisms and policies for the development of Ho Chi Minh city establishes a legal foundation and favourable conditions for the city to implement specific policies that foster socio-economic development [2]. Among the notable measures is the pilot application of TOD as an urban development model, designed to improve the effectiveness of the urban transport system, particularly through the development of areas surrounding railway stations and key transport nodes. The resolution authorises the use of local budgets for independent public investment projects related to land acquisition, compensation, resettlement, and the development of TOD-based urban districts.

Resolution No. 188/2025/QH15 of the National Assembly introduces a pilot framework of special mechanisms and policies for the development of the urban rail network in Hanoi and Ho Chi Minh city [3]. This resolution emphasises TOD-based development, prioritisation of public transport in transport organisation, and optimisation of land use planning around transport hubs. It stipulates procedures for the preparation, appraisal, and approval of metro projects in conjunction with TOD area development, while permitting adjustments to land use indicators. The resolution also enables the mobilisation of diverse funding sources (including revenue increases, budget savings, and concessional loans) and creates favourable conditions for technology transfer and the training of specialised human resources.

4.2. TOD development plans in railway station areas

The People's Committee of Ho Chi Minh city has formulated a development plan for 11 compact urban centres based on the TOD model, strategically located along Metro Line 1, Metro Line 2, and the Ring Road 3 corridor [45]. These policies foster integrated planning between transportation systems and urban development, optimise land-use efficiency, and generate fiscal revenues through the capture of land value uplift [46].

As a key node of the North-South HSR, Thu Thiem station is the focus of comprehensive planning efforts led by the Ho Chi Minh city department of construction in collaboration with relevant agencies. The station (Fig. 2), with a planned area of 17.2 hectares, is envisioned as a major multimodal hub, enabling seamless passenger transfers between the railway and other public transport modes, including metro lines, buses, taxis, and private vehicle parking facilities [47].

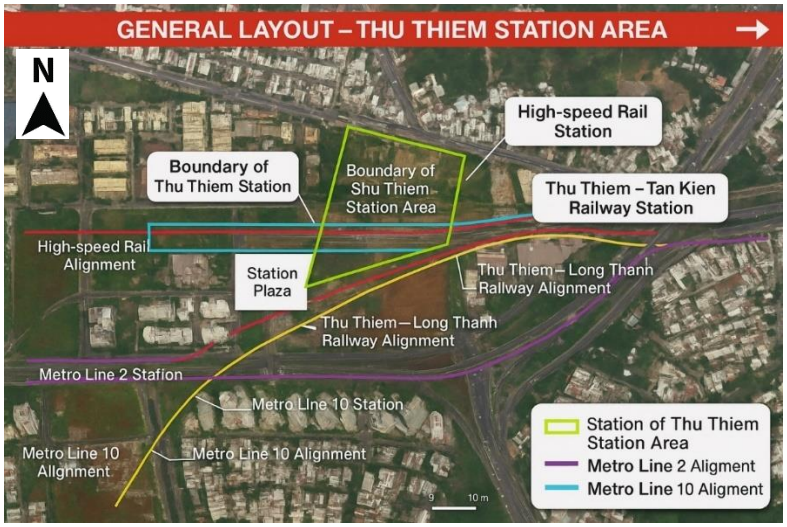

Fig. 2. General layout of Thu Thiem station [47].

The development of urban areas surrounding railway stations under the TOD model has been identified by Ho Chi Minh city as a strategic solution to optimise land use, enhance the efficiency of public investment, and foster sustainable urban development.

5. Orientation for TOD-based transport organisation at HSR and metro stations in Ho Chi Minh city

5.1. Evaluation framework and proposed transport organisation under the TOD model at HSR and metro stations

This study develops an analytical framework to evaluate TOD-based transport organisation at railway stations in Ho Chi Minh city. The framework is constructed from a systematic synthesis of key factors identified in the literature review and international station experiences, as presented in Table 7.

Table 7. Evaluation framework and proposed TOD-based transport organisation at HSR and metro stations in Ho Chi Minh city.

Component	Description of evaluation content
Intermodal transport connectivity	Assessment of integration among metro, urban rail, high-speed rail, buses, bicycles, pedestrians, taxis, and feeder modes.
Land use structure and mixed urban development	Evaluation of building density, mixed functions (residential, commercial, services), and the integration of public spaces within the service catchment of stations.

Policies and institutional support for TOD	Assessment of the applicability of special policies (e.g., Resolution No. 98/2023/QH15, Resolution No. 178/NQ-CP, Resolution No. 188/2025/QH15), land access rights, investment capital, and cross-sectoral coordination.
Station accessibility	Evaluation of safe walking distances, barrier-free access, and transfer facilities such as overpasses, waiting areas, bicycle parking, and covered walkways.
Quality of the urban environment	Degree of pedestrian friendliness, presence of greenery and open spaces, and urban amenities that support daily activities and reduce pollution.
Operational efficiency and modelling tools	Application of transport models, GIS data, and simulations to quantify passenger flows and optimise the integrated transport network.

The analytical framework not only clarifies the criteria for evaluating the effectiveness of intermodal transport organisation at stations, but also highlights the relationship between transport organisation and the structure of urban development around stations under TOD principles. This provides a critical scientific basis for proposing feasible and context-specific solutions that can be applied within the current planning and investment framework of Ho Chi Minh city, particularly at metro and high-speed rail stations.

5.2. Application of international experience in transport organisation at stations in Ho Chi Minh city

Compared with other rapidly developing cities in the region such as Bangkok (Thailand) and Taipei (Taiwan, China), Ho Chi Minh city records relatively low transport infrastructure indicators, including road density and the ratio of transport land area to total urban construction land [48]. The share of transport land in Ho Chi Minh city is only about 12.2 percent, which is approximately 10 percent lower than the standard benchmark. By organising high-density urban spaces around public transport nodes, TOD encourages residents to shift from private vehicles to public transport, thereby reducing road traffic volumes, congestion, and air pollution. Drawing on international experience, relevant studies, and Ho Chi Minh City's TOD development strategy, several key lessons can be identified for transport organisation under TOD. These lessons provide a foundation for the city to

optimise the effectiveness of its public transport system, particularly in the context of expanding high-speed and urban rail networks.

First, planning for high-density and multifunctional urban development.

The development of high-density districts around public transport stations should not only include high rise residential buildings but also integrate multiple functions such as housing, shopping centres, office complexes, and entertainment services. These areas will serve as vital economic and commercial hubs that attract a significant population to live and work nearby. This approach enhances residents' accessibility to public transport and reduces reliance on private vehicles.

The integration of diverse urban functions also improves land use efficiency and creates dynamic, vibrant urban environments. Mixed functions in station areas increase land value, attract both residents and visitors, and strengthen the effectiveness of public transport utilisation while reducing dependence on private cars.

Ho Chi Minh city can leverage the areas surrounding metro stations to establish high-density, multifunctional urban districts that combine commercial, office, and recreational services. Planning must ensure sufficient flexibility to attract private sector investment and achieve balanced development between residential and commercial areas. Infrastructure, especially public transport, must be upgraded to support high-density development and ensure a convenient and liveable environment for residents.

Second, optimising connectivity and multimodal integration.

Central stations should be developed as multimodal transport hubs, ensuring seamless connections among the national railway, metro lines, buses, and other modes of transport (Fig. 3).

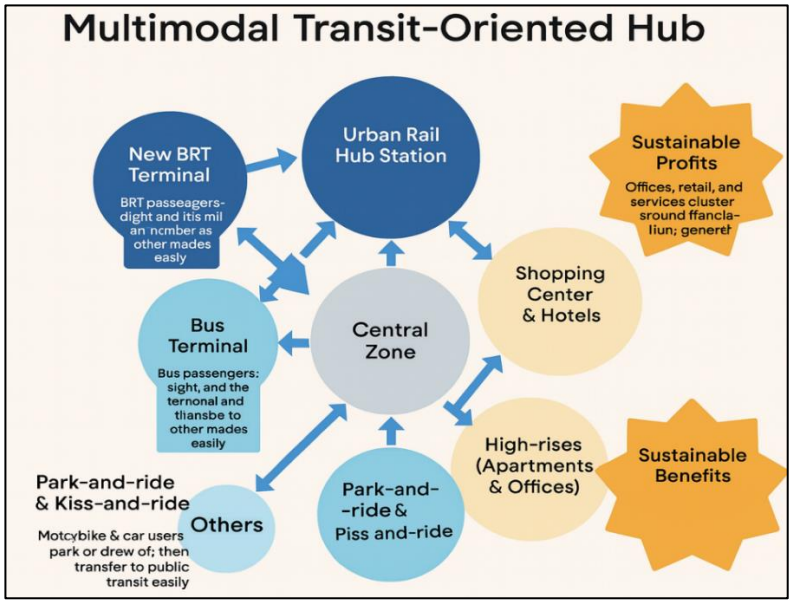

Fig. 3. Model of metro connectivity with other modes of transport.

Optimising these connections reduces waiting times, minimises walking distances, and enhances convenience for passengers. Shanghai's Hongqiao Station offers a representative example of how seamless transfers between different transport modes can encourage the use of public transport over private vehicles. The integration of national railways, metro lines, buses, and other modes at major stations creates a continuous and convenient transport system.

Stations are not merely stopping points for trains but function as transport hubs where passengers can transfer easily between modes. Clear signage and well-designed transfer areas reduce waiting times and improve mobility. Ho Chi Minh city can adopt this model by developing multimodal hubs at major metro and high-speed rail stations, ensuring convenient connections with bus networks and rail services. Signage systems should be designed to be clear and easily understandable, while transfer spaces must be organised efficiently. Facilities such as parking areas, waiting lounges, and passenger amenities should be invested in to provide a comfortable travel experience, thereby encouraging greater public transport use.

Third, promoting green and non-motorised transport.

In pursuit of green mobility, Ho Chi Minh city should encourage walking and cycling as complementary modes to public transport. This requires the provision of extensive bicycle parking facilities at stations, enabling residents to transfer conveniently between personal bicycles and public transport. The development of green public spaces, pedestrian paths, and dedicated cycling lanes around stations helps to create an urban environment that is safe, friendly, and sustainable.

Establishing dedicated bicycle lanes, bicycle parking areas at stations, and pedestrian-friendly infrastructure will reduce environmental pollution, ease traffic congestion, and promote sustainable urban development. Ho Chi Minh city could implement bicycle lanes in central districts and around metro stations, supported by well-designed green public spaces, parks, and pedestrian corridors that enhance comfort for residents while also attracting more public transport users.

Fourth, investment in modern public transport infrastructure and services.

Investment in modern public transport infrastructure not only improves connectivity within and beyond the city but also enhances the overall quality of services. TOD emphasises user experience, which includes amenities at stations such as free Wi-Fi, commercial services, restaurants, and rest areas. In addition, maintaining hygiene, ensuring security, and providing attentive staff support all contribute to better service quality.

Ho Chi Minh city should continue to expand and complete its metro network while ensuring compliance with safety and quality standards in operations. Investment in modern systems such as metro, high-speed rail, and bus rapid transit can help alleviate urban traffic congestion and improve mobility. The adoption of electronic ticketing systems should be expanded to facilitate convenient transfers across multiple public transport modes. Amenities such as shopping areas, food services, and resting facilities will enrich the user experience and encourage greater use of public transport. Attention to safety and cleanliness at stations and on vehicles is also critical to providing a secure and comfortable travel environment.

Fifth, planning environmentally friendly spaces and transport infrastructure.

The development of green public spaces around stations creates high quality living environments and attracts residents to participate in community activities, thereby increasing the use of public transport. Investments in green spaces around metro stations - such as small parks, pedestrian areas, and community facilities - should be integrated into urban planning in order to improve the quality of public space and promote greater reliance on public transport. These projects must be implemented in parallel with public transport infrastructure development to ensure long-term sustainability.

Sixth, effective traffic management and operations.

Effective traffic management and operations are essential for the successful functioning of TOD systems. Cities that have successfully applied TOD typically maintain strong governance mechanisms and deploy advanced technologies to monitor and coordinate traffic flows. Synchronisation of transport schedules and the integration of monitoring and traffic control systems help minimise congestion and enhance operational efficiency.

Leading cities also adopt strong policy measures to support TOD, including tax incentives for investors, assistance in transport infrastructure development, and land-use regulations aligned with TOD principles. Ho Chi Minh city can apply intelligent traffic management systems, using modern technologies to monitor and control metro lines and other public transport services. Tools such as GPS-based monitoring, real-time information displays, and mobile applications can assist passengers in tracking schedules and adjusting travel plans, thereby reducing congestion and improving the efficiency of the public transport system.

Seventh, supportive policies and enabling conditions for TOD development.

Strong policy support is essential to accelerate TOD implementation. This includes tax incentives for investors, support for transport infrastructure projects, and the establishment of appropriate land-use regulations. Investment promotion policies around station areas help synchronise urban

development with public transport systems. A common approach is the provision of tax reductions for investors, particularly for housing, office, and commercial projects located near public transport stations. Such policies not only attract private investment but also create strong incentives for businesses to participate in infrastructure and real estate development within TOD districts.

In addition, policies that support public transport infrastructure development play a critical role in establishing an efficient and integrated transport system. Investment in railways, bus networks, and other public transport modes enhances connectivity and convenience for residents, encouraging a shift away from private vehicles. Urban land-use regulations should also be adapted to guide development around stations into high-density urban districts with diverse functions such as housing, commerce, and services. These regulations ensure that TOD development meets residents' living and working needs, while improving land-use efficiency and optimising public transport infrastructure.

Ho Chi Minh city can apply such policies by encouraging high-density urban development around metro stations through tax incentives and financial support for infrastructure projects. Adjustments to land-use regulations will create favourable conditions for TOD implementation, balancing the needs of urban growth with environmental protection. Policy frameworks should also include public awareness initiatives to highlight the benefits of public transport use and sustainable urban development.

The set of proposed solutions demonstrates that applying the TOD model at metro and high-speed rail stations can enable Ho Chi Minh city to achieve sustainable development, reduce traffic congestion, and enhance residents' quality of life. To realise this vision, the city must implement a comprehensive approach that integrates urban planning, investment in public transport infrastructure, the creation of green public spaces, and the establishment of effective policy support. Such a holistic strategy not only contributes to the development of a smart city but also secures a greener and more sustainable future for Ho Chi Minh city.

5.3. Application of transport organisation under the TOD model: The case of Phuoc Long station

The study conducts simulations of a representative railway station to evaluate passenger flow, transport organisation, and impacts on the surrounding traffic system. Phuoc Long station, included in Ho Chi Minh city's TOD development plan, is one of the key stations along Metro Line 1 (Ben Thanh - Suoi Tien). Drawing on international experiences in station transport management, several important lessons can be derived to optimise operations and traffic organisation at Phuoc Long station.

The traffic system parameters within the Phuoc Long station area were incorporated into the VISSIM microsimulation model to analyse the performance of the urban rail system, bus services, and the surrounding road network. These parameters include roadway traffic volumes on approaches to and from the station, public transport passenger demand, parking facilities; and the geometric characteristics of each intersection approach such as the number of lanes, lane widths, curb radii, stop-line locations, pedestrian crossings, and traffic signal positions. The model assumptions, calibration, and validation are presented in Table 8 [49].

Table 8. Calibrated parameters for driver behaviour in the VISSIM model.

Characteristic	Value	Note
Lateral		
- Minimum lateral distance		
+ At 0 km/h	0.15 m	Observed at the field
+ At 50 km/h	0.8 m	Taken same as dynamic motorcycle lane
- Desired position at free flow	Free	
Lane change		
- General behaviour	Free lane section	
- Maximum deceleration (own)	-2.28 m/s^2	T.H. Van, et al (2009) [49]
- Maximum deceleration (trailing)	-1.72 m/s^2	T.H. Van, et al (2009) [49]
- 1 m/s^2 per distance (own)	5 m	Assumed
- 1 m/s^2 per distance (trailing)	5 m	Assumed
- Accepted deceleration (own) (mean value)	-1.15 m/s^2	T.H. Van, et al (2009) [49]
- Accepted deceleration (trailing) (mean value)	-0.8 m/s^2	T.H. Van, et al (2009) [49]
- Maximum deceleration for cooperative braking	-1.72 m/s^2	T.H. Van, et al (2009) [49]
Car following model (Wiedemann 74)		
- Looking ahead distance	20-30 m	Assumed
- Number of observed vehicles	3-4	Assigned
- Average standstill distance	0.25 m	Observed at the field

Characteristic	Value	Note
- Additive part of safety distance	0.5 m	Assumed
- Multiple part of safety distance	0.75 m	Assumed

Simulation and evaluation are carried out in the following sequence: (1) microsimulation of individual traffic flows, public transport systems, and pedestrian movements; (2) simulation of mixed traffic flows comprising cars, trucks, bicycles, buses, rail, and pedestrians [50], as illustrated in Fig. 4.

Fig. 4. Simulation of transport organisation at Phuoc Long station.

The configuration of transport modes is modelled through two main functions: (i) defining input parameters, and (ii) allocating traffic flows by turning movements. The traffic signal control program specifies cycle length, as well as the green, red, and yellow times for each phase [51]. The model's output is used to compare scenarios based on a range of indicators, including station passenger volumes, average travel speed, average delay time, total travel distance, total travel time, total delay time, and number of stops [52, 53]. The analysis was conducted under two scenarios:

- Scenario 1: No additional interventions beyond the existing infrastructure and current transport organisation.

- Scenario 2: A proposed TOD-based transport organisation plan for the Phuoc Long station area and its surroundings.

Based on field assessments of existing conditions, several TOD-oriented measures were proposed for Phuoc Long station (Scenario 2), including:

- Developing covered pedestrian pathways to enhance comfort, particularly under Ho Chi Minh city's hot and humid climate.

- Constructing pedestrian bridges or underpasses to connect the station with residential areas, shopping centres, and bus stops.

- Allocating space for bicycles and small personal vehicles to encourage sustainable mobility.

- Differentiating station entry and exit points by zone to mitigate congestion.

- Introducing mobile applications or digital maps to guide passengers within the station and connect them with other public transport modes (buses, taxis, shared bicycles).

- Encouraging the development of commercial centres, office spaces, and service facilities adjacent to the station, enabling passengers to combine multiple activities (shopping, working, leisure) without extensive travel.

- Designing open public spaces with amenities such as parks, playgrounds, and cafés integrated into the station area to enhance the passenger experience.

- Establishing nearby bus parking bays to ensure seamless transfers between metro and bus services.

- Developing smart bicycle parking facilities or public bike-sharing systems to provide flexible last-mile connectivity in the Phuoc Long area.

- Designating dedicated lanes for taxis and ride-hailing vehicles to reduce congestion at the station entrance.

On the basis of existing conditions and the proposed measures, the efficiency of the transport system was evaluated, identifying bottlenecks and proposing strategies to optimise passenger and vehicle flows [38]. The findings from this model can be applied to improve traffic organisation at other stations across the city's metro system.

The results indicate that Scenario 2 significantly increases passenger demand for public transport. Key performance indicators-including average travel speed, average delay time, total travel distance, total travel time, total delay time, and number of stops-show marked improvements due to the TOD-based transport organisation measures (Table 9).

Table 9. Evaluation results of the transport network at Phuoc Long station.

No.	Parameters	Scenario 1	Scenario 2
1	Number of passengers through the station (persons/day)	903	3,100
2	Average travel speed (km/h)	21.02	21.86
3	Average delay time (s/veh)	19.05	18.32

4	Total travel distance (km)	20,125	19,747
5	Total travel time (h)	957	903
6	Total delay time (h)	184	173
7	Number of stops	2,704	2,600

Phuoc Long station has the potential to become a major transport hub within Ho Chi Minh city's TOD framework. Lessons drawn from international best practices, such as Shibuya station in Tokyo, Berlin Hauptbahnhof, and Hongqiao station, help optimise transport organisation, mitigate congestion, and enhance the passenger experience. Key strategies include high-density land-use planning, improvements to multimodal transport integration, enhanced pedestrian connectivity, and the application of advanced technologies for efficient operations management.

6. Conclusions

Evidence from related studies and international experience demonstrates that TOD plays a critical role in shaping transport structures and urban spatial form in major cities. The application of TOD not only mitigates traffic congestion and reduces the negative impacts of private vehicle use but also fosters the development of modern, convenient, and sustainable living environments.

Based on a synthesis of theoretical foundations, global experience, and local practice, this study reaches three key conclusions: (1) the effectiveness of TOD at stations depends heavily on intermodal transport organisation, station accessibility, and the surrounding urban spatial structure; (2) policies and institutional frameworks provide the foundation, particularly flexible mechanisms for land use, finance, and integrated governance; and (3) successful transport organisation models must be developed in a multi-level manner, from strategic orientation and spatial design to micro-level operational arrangements at individual stations.

The quantitative results obtained from the VISSIM simulation at Phuoc Long station provide empirical support for the proposed approach. A comparison between the existing condition (Scenario 1) and the TOD-oriented scenario (Scenario 2) indicates consistent improvements across all evaluated performance indicators. Specifically, Scenario 2 shows higher passenger throughput and average operating speed, while key efficiency-related indicators-namely delay, travel time, travel distance, and number of stops-are reduced simultaneously. The magnitude and consistency of these improvements across multiple indicators suggest that the observed performance gains are not isolated effects but result from an overall enhancement of station-area transport organisation.

Importantly, the quantitative evidence demonstrates that TOD-oriented measures improve both mobility efficiency and network operation quality. In the simulation, station passenger throughput increases from 903 to 3,100 persons/day (+243%), and the average travel speed rises from 21.02 to 21.86 km/h (+4.0%). At the same time, efficiency-related indicators improve. For example, average delay decreases from 19.05 to 18.32 s/veh (-3.8%), total travel time drops from 957 to 903 h (-5.6%), total delay declines from 184 to 173 h (-6.0%), total travel distance reduces from 20,125 to 19,747 km (-1.9%), and the number of stops falls from 2,704 to 2,600 (-3.8%). Collectively, these consistent gains indicate that the proposed TOD-based station-area transport organisation can effectively address operational inefficiencies under existing conditions.

As the study is conceived as lesson-learned and application-oriented, emphasising evidence synthesis and scenario-based illustration, it does not provide an exhaustive account of the data collection and processing procedures, nor of the full calibration and validation workflow that would be expected in a purely modelling-driven study. Accordingly, the reported outcomes should be further verified when as-built TOD implementation data become available for the Ho Chi Minh city metro system.

CRediT author statement

Nguyen Hong Thai: Methodology, Conceptualisation, Visualisation, Writing - Original Draft, Writing - Review and Editing; Tran Quang Phu: Conceptualisation, Visualisation, Writing - Review and Editing; Bui Quoc An: Data curation, Formal analysis, Software, Methodology, Writing - Original Draft, Writing - Review and Editing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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