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# Investigating Transit-Oriented Development to Improve Heritage Conservation and Accessibility: A Study of Ayutthaya World Heritage City

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## Abstract

This study investigates the framework of Transit-Oriented Development (TOD) for heritage conservation and accessibility in Ayutthaya, Thailand, a UNESCO World Heritage City. Ayutthaya is facing problems of urban growth, tourism, and transportation. As an old traditional city, Ayutthaya needs to keep its history while also developing. Ayutthaya is a key example where TOD ideas -normally used in new city planning- can be used to protect cultural heritage and improve accessibility for tourists and locals moving around and their quality of life. Using a mix of methods like looking at maps, talking to people involved, assessing how heritage is affected, and modeling transport, this study looks at how planning around transit stations can help reduce car traffic in important heritage areas, encourage walking and other non-car travel, and help sustainably manage tourism. The results show that a TOD model that cares about heritage, which includes low-impact transit options, smart density, and design rules that fit the context, can help lower the risks of damage while also making it fairer for everyone to access cultural sites. This study suggests the TOD framework for heritage sites that connects transit systems with conservation goals, limits harmful development, and helps local communities become more economically stable. To manage heritage sustainably, TOD is a helpful way to balance preserving history with urban spaces that are inclusive and easy to access in historic city areas.

**Discipline**: Civil Engineering, Architecture, Urban Planning.



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# 1 Introduction

Transit-Oriented Development (TOD) is an urban planning method used to find a balance between development and conservation. TOD applies compact, multi-use developments within walking distance from public transport stations. This strategy increases walking and cycling and decreases car dependency. Also, this increases the urban areas' connection (Calthorpe, 1993; Dittmar & Ohland, 2004).

Ayutthaya was the capital of Thailand. It has been accepted since 1991 as a UNESCO World Heritage Site. The city is rich in history and culture. However, Ayutthaya is facing limited access to heritage sites, environmental damage, flooding, and land subsidence (Bhadrakom & Poovarodom, 2017). These have endangered the physical state of heritage sites and the living conditions of local communities in the area.

Recently, Ayutthaya station has been a major station on the plan of the North-eastern high-speed rail project and intercity rail (Department of Rail Transport, 2023). The projects will improve mobility and accessibility in the city. Transportation raises concerns about possible impacts on the historical site.

TOD has been widely used in many areas in Thailand, as well as in other countries. There is not much research focusing on the integration of TOD in the world heritage cities. The heritage zone is complex, with strict legal conservation regulations, sacred sites, and strong local cultures. Therefore, TOD in such contexts requires careful and context-sensitive planning.

This study investigates lessons learned from international best practices of TOD and reviews relevant academic literature to develop a framework of TOD indicators to develop TOD indicators which are suitable for Ayutthaya. The proposed framework seeks to improve accessibility while supporting heritage conservation, in line with Sustainable Development Goal 11: making cities inclusive, safe, resilient, and sustainable (United Nations, 2015).

# 2 Literature Review

Transit-Oriented Development (TOD) is a method in urban planning. The method is used to improve compact, mixed-use development of walkability around transport stations. TOD was developed by Calthorpe in 1993. He studied high-density urban planning, pedestrian-friendly design, and reducing on using private vehicles. Calthorpe classified TOD into 2 categories.

1. Urban TOD: Urban TOD is in central business district areas where there is high density and intensive land use.

2. Neighborhood TOD, which is for suburban areas that have medium density, is more related to community life and walkability.

Since Agenda 21 (1992), the idea of sustainable development has been used, and later it was extended to Sustainable Development Goal 11 (SDG 11). TOD is a tool to achieve sustainability by integrating transport, land use, environmental protection, and social well-being.

Ayutthaya and the Relevance of TOD

Ayutthaya is a UNESCO World Heritage city. It is facing urban change, urban sprawl, traffic congestion, and private car use. Rail development projects are a national infrastructure policy to accelerate these changes. From the recent report of the Department of Rail Transport (2023), Ayutthaya is one of the hubs on the Bangkok–Nong Khai high-speed rail project. TOD is an important method to balance urban growth, heritage conservation, and transit accessible development.

However, TOD in Ayutthaya is facing challenges due to sensitive heritage sites, strong local traditions, and complex governance structures that involve multiple agencies. As a result, TOD strategies must be designed to suit the local conditions rather than being adopted from other cities.

Previous studies suggest that TOD should be evaluated using multiple dimensions. According to Lyu et al. (2016), Dittmar & Ohland (2004), and Suzuki et al. (2013), TOD can be grouped into five categories as shown in Table 1.

**Table 1:** TOD Evaluation Indicator

| Category | Evaluation Indicator |
|---|---|
| Urban Form and Physical Environment | density, land use mix, building design, and spatial layout |
| Accessibility and Mobility | walkability, transit access, and last-mile connections |
| Economic Activity | land value, local businesses, and investment around stations |
| Social and Cultural Compatibility | community satisfaction, cultural identity, and lifestyle compatibility |
| Environmental Sustainability | green spaces, flood resilience, and emission reduction |

In a World Heritage city like Ayutthaya, TOD should support livability and long-term conservation. It should not damage historical integrity, visual corridors, or cultural meaning. Thus, the indicators must be carefully adjusted.

Many studies show the relationship between transit-oriented development (TOD) and heritage conservation. This research provides an important view on how transport infrastructure can be developed while protecting cultural and historical assets.

Bhadrakom and Poovarodom (2017) examined the structural dynamics of the main stupa at Wat Yai Chaimongkol. They conducted structural monitoring and engineering sensitivity in the vicinity of heritage landmarks. The implications for TOD are that any new infrastructure near such historical assets must consider vibrations, load-bearing pressures, and the physical integrity of ancient structures.

Phra Sithtisinghasanee et al. (2019) investigated the administrative and policy landscape around Ayutthaya's World Heritage. They found a fragmented governance structure, missing inter-agency collaboration, limited funding, and a problem with tourism integration. These factors present obstacles to TOD implementation, particularly in ensuring coordination across local government bodies, transit agencies, and heritage institutions.

Renne and Listokin's (2021) showed that in the US, 50% of all fixed-transit station areas intersect with designated historic districts. It showed that TOD & heritage preservation can go together. The results are thoughtful urban design, context-sensitive planning, and stakeholder engagement.

Daungthima and Hokao (2013) studied the spatial vulnerability of 84 historic sites in Ayutthaya using GIS. Their research studied topographic elevation, proximity to water bodies, and cultural impact. The study identified priority zones that are highly vulnerable to flooding and environmental stress.

Martinez and Viegas (2017) examine assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal. The work explores two different self-driving vehicle concepts. The results suggest that a full implementation scenario — keeping the existing metro service and replacing private car, bus, and taxi mobility with shared modes — would significantly reduce vehicle kilometers traveled and $CO_2$ emissions. Fatmawati et al. (2026) applied TOD to heritage preservation in Indonesia, based on a multi-method approach. ElSerafi (2025) applied TOD concepts to the ElMosky historic district in Cairo to improve urban mobility, conserve cultural heritage, and increase the overall quality of life in the district. His study used a qualitative technique, involving literature review, semi-structured interviews, field observations (i.e., traffic conditions, pedestrians, and public spaces), and document analysis.

According to Krismawanti & Destiawan (2025), TOD catalysts for creating spaces in historic cities. Using TOD ideas and designs that respect culture, structures can connect today's urban requirements with the need to keep our historical identity safe, making sure that development is comprehensive and sustainable.

## 3 Method

This study uses a qualitative research design based on literature and document review. The main objective is to develop a TOD evaluation framework that suits the heritage context of Ayutthaya. The study does not measure actual TOD outcomes but focuses on identifying suitable indicators and planning principles.

The study area includes the Ayutthaya Island historical zone, which is designated as a UNESCO World Heritage Site, and the surrounding areas near Ayutthaya Railway Station. Areas within 800 to 1,000 meters from the station are considered TOD influence zones, following international standards.

During mid-2025, data were collected from academic publications, policy documents, planning reports, and spatial information from relevant organizations such as UNESCO, the Fine Arts Department, and the State Railway of Thailand. The analysis uses content analysis and thematic synthesis to identify key TOD indicators suitable for heritage cities.

# 4 Result and Discussion

The results refer to analytical findings from literature synthesis rather than empirical measurement. The literature and document reviews show that TOD can support heritage conservation if it is carefully planned.

## 4.1 TOD Evaluation Framework for Heritage Contexts

According to this study, the indicators of Transit-Oriented Development (TOD) for Ayutthaya World Heritage City are organized into seven dimensions, see Table 2. Each dimension is supported by well-established academic studies and policy documents. They provide a structured basis for evaluating the potential and limitations of TOD in heritage-sensitive environments. Frequency refers to the number of studies in which the indicator appears, not to statistical measurement.

**Table 2:** TOD Framework Dimension for Ayutthaya World Heritage City

| Dimension | Description | Number of References (n) | Key Source |
|---|---|---|---|
| TOD Core Principles | Principles of density, mixed land use, walkability, and compact urban form in transit-linked areas. | 8 | Calthorpe (1993); ITDP (2017); Dittmar & Ohland (2004) |
| TOD in Heritage Cities | Specialized considerations for TOD in cities with cultural/historical assets (e.g., visual harmony). | 6 | Lyu et al. (2016); Martinez & Viegas (2017); Silva et al. (2020) |
| Compatibility with World Heritage | Evaluation of TOD through UNESCO's heritage criteria, such as authenticity, integrity, and zoning. | 5 | UNESCO (2011); WHC Guidelines |
| Vulnerability and Risk Mapping | Risk assessment of heritage sites due to flooding, urban pressure, and infrastructural threats. | 4 | Daungthima & Hokao (2013); Bhadrakom & Poovarodom (2017) |
| Ayutthaya Urban Morphology | Unique urban features of Ayutthaya such as canals, temples, narrow roads, and water-based orientation. | 6 | Fine Arts Department (2021); AIT-ML (2020) |
| Rail/HSR Connectivity | Opportunities and concerns regarding high-speed rail development near heritage zones. | 3 | OTTPP (2020); Ministry of Transport Reports |
| Policy Gaps and Constraints | Issues related to zoning conflicts, fragmented governance, and weak inter-agency planning. | 5 | DPT (2022); Phra Sithtisinghasanee et al. (2019); UNESCO-TH |

Table 2 shows that TOD in Ayutthaya cannot rely only on standard TOD principles. Heritage protection, environmental risk, urban form, and policy coordination are also essential. This means TOD planning must include conservation rules and governance issues from the start. TOD assessment in historic cities needs to consider accessibility to risk management. These findings support the need for a context-sensitive approach to TOD planning in the World Heritage City.

In addition to the international TOD frameworks previously discussed, this study also integrated local insights, particularly from Thai heritage contexts. Table 3 presents the frequency of TOD evaluation indicators derived from both global and local literature.

Table 3, urban form and social–cultural factors are the most mentioned in TOD studies for heritage contexts, followed by accessibility and economic issues. Environmental sustainability and policy coordination receive less attention but remain important. This suggests that TOD evaluation should balance physical design with cultural protection and governance from the early planning stage.

**Table 3**: The frequency of TOD evaluation indicators

| TOD Dimension | Indicator | Frequency | Key Source |
|---|---|---|---|
| Urban Form and Physical Environment | - Density of development- Mixed land use- Building design compatibility- Conservation zoning | 6 | Calthorpe (1993); Dittmar & Ohland (2004); Anuchid (2020); Suzuki et al. (2013) |
| Accessibility and Mobility | - Walkability- Transit proximity- Last-mile connectivity- Access to public open space | 5 | Lyu et al. (2016); Anuchid (2020); ITDP (2017) |
| Economic Vitality | - Local economic development- Land value appreciation- Station-area economy- Traditional business zones | 4 | Suzuki et al. (2013); Anuchid (2020) |
| Social and Cultural Compatibility | - Community engagement- Cultural landscape integration- Preservation of local identity | 6 | Phra Sithtisinghasanee et al. (2019); Anuchid (2020); UNESCO (2011) |
| Environmental Sustainability | - Flood resilience- Green infrastructure- Water-sensitive design | 3 | Daungthima & Hokao (2013); Anuchid (2020) |
| Institutional and Policy Dimension | - Integrated governance- Stakeholder participation- Policy alignment across agencies | 4 | Phra Sithtisinghasanee et al. (2019); DPT (2022); Anuchid (2020) |

## 4.2 Stakeholder Concerns

The study of Phra Sithtisinghasanee et al. (2019) shows that fragmented governance and budgetary limitations are major challenges. A recommendation is proposed to establish the Ayutthaya Heritage Mobility Committee to collaborate on the platform for local agencies, the State Railway of Thailand (SRT), the Fine Arts Department, and community representatives. UNESCO (2011) has reported that institutional coordination and unclear regulations increase pressure on sensitive heritage zones. Martinez and Viegas (2017) reported that stakeholder conflict and limited communication between transport authorities and cultural agencies resulted in the delay of TOD projects in the historical zone. The planning for rail-based development often faces challenges from overlapping zoning regulations and insufficient public participation.

## 4.3 Policy and Design Recommendations

This section outlines policy and design recommendations based on the synthesized TOD evaluation framework and its context, applying to Ayutthaya. The objective is to balance between accessibility, economic vitality, and heritage preservation, as shown in Table 4.

Table 4 summarizes integrated policy and design recommendations for Ayutthaya based on the TOD evaluation framework. The results show that accessibility through EV systems and walkable streets, while protecting cultural areas with clear buffer zones, and local architectural styles. Economic measures focus on supporting local businesses and creative clusters. Environmental actions create green infrastructure and ecological connections between heritage sites. Together, these strategies aim to balance mobility, development, and heritage conservation.

**Table 4:** Policy and Design Recommendation for Ayutthaya.

| Dimension | Policy Recommendations | Design Recommendations |
|---|---|---|
| Accessibility | Implement EV loops and park-and-ride systems | Retrofit secondary roads for walkability |
| Culture | Define buffer zones with legal clarity | Apply local architectural materials and styles |
| Economy | Support local entrepreneurs and artisans | Zone areas for cultural/ creative economy clusters |
| Environment | Create absorbent green areas in low-lying zones | Connect heritage clusters through ecological corridors |

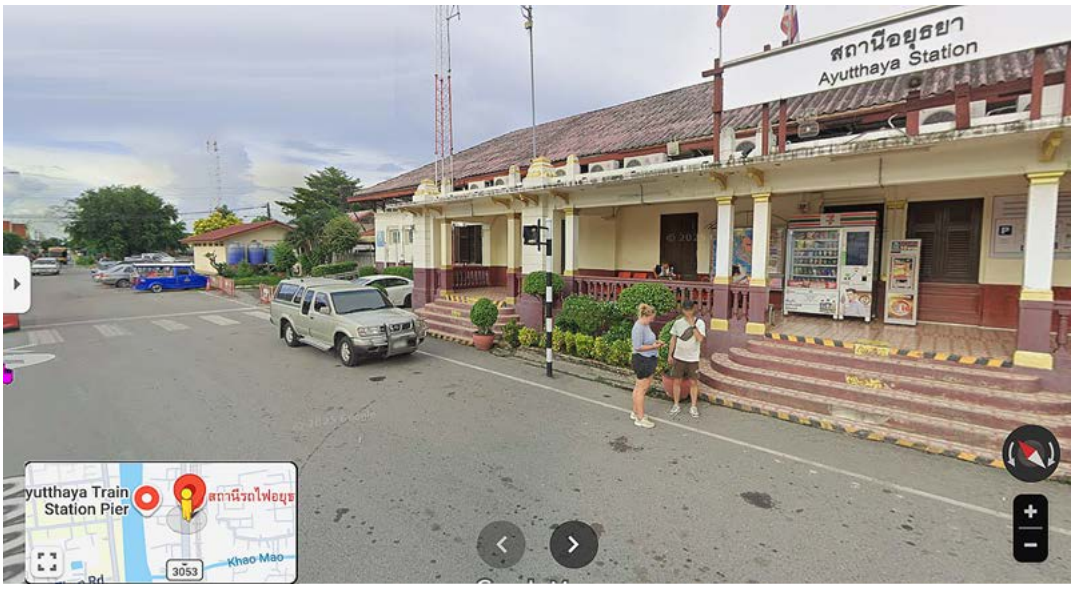


**Figure 1**: The TOD problem without pedestrians' sidewalks in front of Ayutthaya Train Station. Geolocation: 14.35669, 100.58295. (Image Courtesy of Google Street View).

The TOD observation is that the pedestrians' sidewalks are not provided, like the area in front of Ayutthaya train station (Figure 1). Thus, it is vital to have friendly sidewalks. Figure 2 shows various TOD times for going by car, motorcycle, and on foot from Ayutthaya train station to

Wat Mahathat. A straightforward route (like the AB path) needs to be created to shorten TOD travel time.

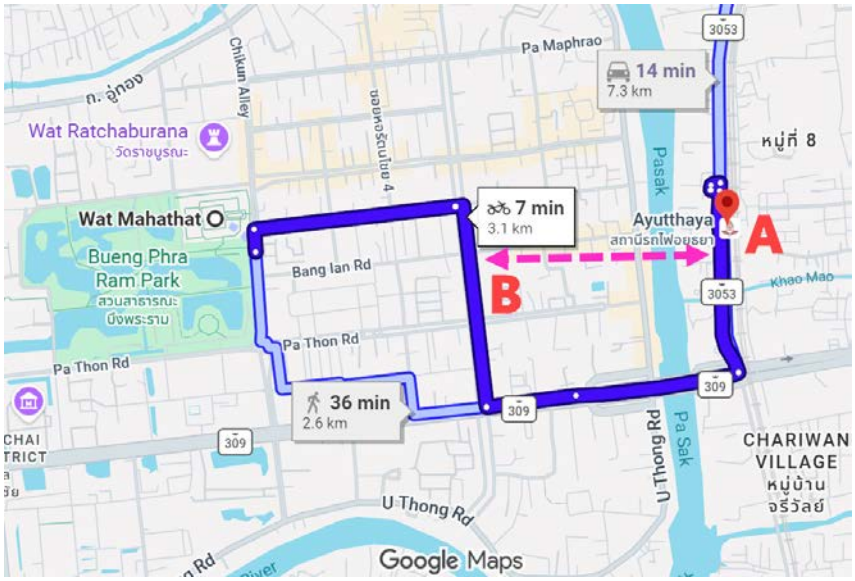


**Figure 2**: Examples of different travel methods taking different times, from Ayutthaya train station to Wat Mahathat, part of Ayutthaya World Heritage City. (Image Courtesy of Google Maps).

These recommendations highlight the need for low-rise mixed-use development outside the heritage core, improved walking & cycling links, electric shuttle systems with park-and-ride facilities, and stronger coordination among transport, planning & cultural agencies. Overall, this study supported TOD that improves accessibility while protecting Ayutthaya's cultural value.

## 5 Conclusion

This study develops a qualitative TOD evaluation framework for Ayutthaya. The results show that standard principles of TOD cannot only be used to determine TOD in World Heritage cities. It is necessary to consider heritage protection, environmental risk, local urban form, and institutional coordination. This study also forms a multidisciplinary foundation for understanding TOD opportunities and limitations for heritage cities. It recommends that TOD in Ayutthaya should follow a balanced approach that improves accessibility and maintaining cultural integrity, strengthening environmental resilience, and promoting coordinated governance.

## 6 Availability of Data and Material

All information is included in this article.

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