

Determination of Factors in Developing Urban Forests into Transit-Oriented Development Areas

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ABSTRACT

The Velodrome forest area is located in the suburbs of Malang City. The Ki Ageng Gribig road corridor on the border of Malang City and Malang Regency supports this area. This area has a fairly complex function and is a transportation hub for the eastern part of Malang City, connected to other important hubs. The hub that can be used as a transit is the Madyopuro sub-terminal. This terminal can be developed more optimally in its function and role with various transportation interests that serve the community inside and outside the area. This article determines the nine factors contributing to developing the Transit Oriented Development (TOD) area in the Velodrome City Forest area. The determination refers to Transit Oriented Development (TOD) standards, previous studies, and identifying the area's potential. These factors include Walk, Cycle, Connect, Traditional, Transit, Mix, Densify, Compact, and Shift. These factors are arranged in an assessment instrument that can be carried out further and in-depth in the next research stage. This study also obtained 53 sub-factors, which technically explain the nine factors that have been determined. The assessment is carried out by accommodating respondents' opinions, namely users and parties involved in the Velodrome City Forest area and its surroundings. Further research needs to consider integration with other areas that have the potential to be developed into TOD areas.

KEYWORDS: Area; development; factors; transit-oriented development; urban forest

INTRODUCTION

The Transit Oriented Development concept is one of the solutions in reducing the movement of transportation from private vehicles, which causes complex problems. The TOD concept has been widely applied in various countries. Among these applications, some have succeeded, some have failed, and some have just started developing their ideas and concepts. Indonesia has begun to develop the concept in several dense and busy urban areas (Kalangie et al, 2023). Malang is one of the cities heading towards metropolitan status and has opportunities to develop TOD. This study determines the factors that contribute to developing the TOD concept in the Velodrome city forest area of Malang City. Several potentials can be developed into TOD to solve transportation problems in Malang and its surroundings, called Malang Raya (Agustin et al, 2022). Hubs supported by many road corridors can be further considered regarding this TOD concept. Environmental problems and socio-economic conflicts caused by increasing transportation problems require a concept of solution. Although not easy, efforts to implement the TOD concept are starting to be thought about and implemented by considering many factors. The velodrome forest area is one of the zones that accommodate complex functions and activities, is supported by a sub-terminal, and is connected to other public facilities (Sedayu, 2025). This area is located in the eastern suburban area of Malang City, which borders Malang Regency and is an important connection in the form of the Malang-Pandaan-Surabaya Toll interchange. The implementation of TOD in an area can be done gradually and according to the capabilities of the area. The assessment score according to the TOD Standard from the Institute for Transportation and Development Policy (ITDP) can determine the level of capability of an area to implement TOD. In addition to functioning to protect and preserve the environment (Sedayu, 2024), urban forests supported by public transportation terminals and shelters can reduce the impact of losses due to transportation activities.

METHODOLOGY

This study continues the previous stage, which identified the potential of urban forests to be developed into TOD areas (Sedayu, 2025). At this stage, the study collects factors to be used as an assessment of the Development of the TOD. The research location is the Velodrome Forest Area in Madyopuro Village, Kedung Kandang District, Malang City, East Java Province, Indonesia. In the next stage, these factors are arranged as a research instrument distributed to respondents. Respondents consist of users and residents of urban forest areas. This research is a basic preliminary study using a conceptual literature review method. The stages of obtaining data include collecting factors by conducting literature studies using standards, regulations, theories, and previous research. The research stages are carried out continuously to obtain comprehensive data and information that meets all stakeholders' interests. The service and performance of a transportation infrastructure can be studied by synchronizing technical aspects with user aspects, so that the results of the analysis of a study can be optimal (Sedayu, 2018).

RESULTS AND DISCUSSION

1. Overview of the Velodrome Forest Area

The Velodrome City Forest is located in Madyopuro Village, Kedung Kandang District, Malang City, East Java Province. The area is one of Malang City's forests with an area of $\pm 12,500$ m² (Sedayu, 2024). This forest is located on the Velodrome circuit land as a bicycle racing sports infrastructure. The velodrome area is also used for other leisure sports activities, namely jogging, gymnastics, and cycling. Around the city forest is Sawojajar housing, a very dense and spacious area; other housing and residential areas are called kampung. Kampung is a settlement that grows independently and is managed by residents. A village is different from housing managed by the private sector, namely developers. This housing and settlement area is in the form of residential areas with various demographics, namely jobs and activities.

Figure 1

Velodrome Forest is in the middle of dense residential and non-residential areas
(Source: Sedayu, 2025)

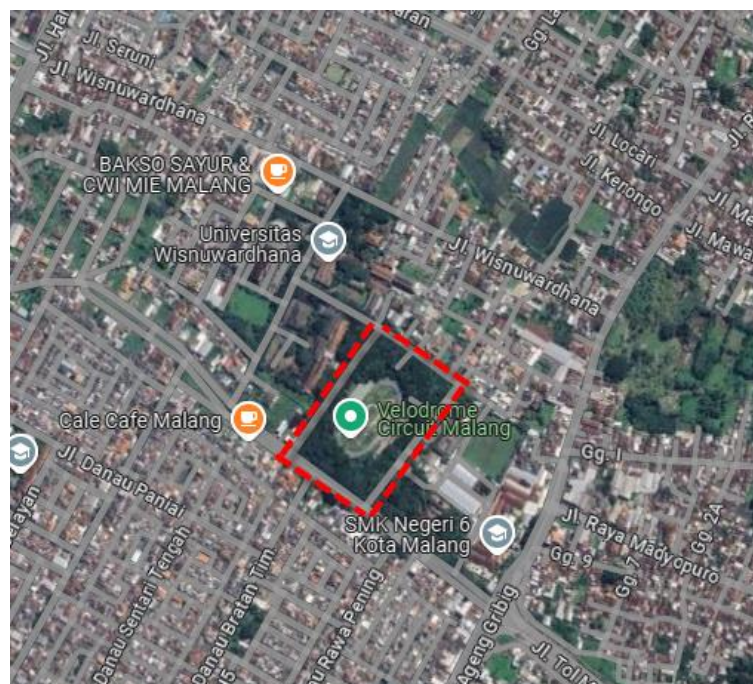


Figure 2

The Velodrome Forest Area is supported by complex functions and activities
(Source: Sedayu, 2025)

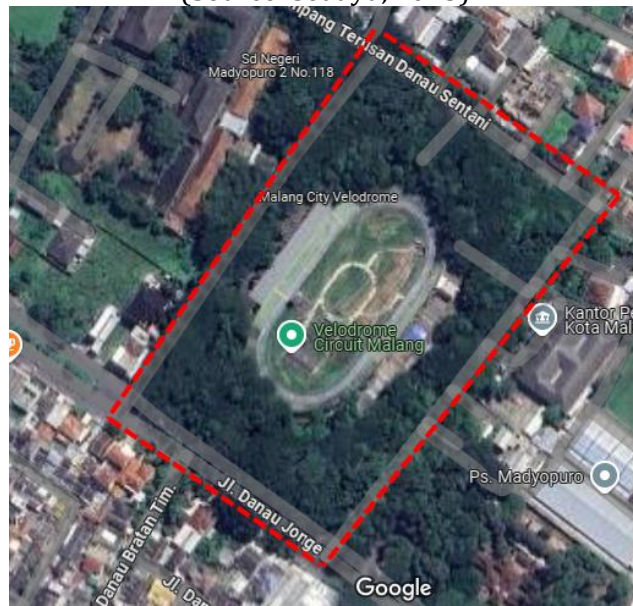


Figure 1 shows the location of the Velodrome urban forest, with its surrounding areas being densely residential and non-residential. The busy daily activities allow for high-intensity vehicle movement. Figure 2 explains the green open space in the Velodrome forest adjacent to the Madyopuro sub-terminal, which can become a transit node for private transportation to public transportation. Some of the facilities available in this area are markets, malls, business centers, shops, office houses, and offices. The Velodrome city forest area is strategically connected to the Malang-Pandaan-Surabaya toll gate, Madyopuro interchange, Malang City (Sedayu, 2025). This great potential can be used as a foothold to develop the area into a TOD area according to its assessment of services and scale. Every Sunday, the Velodrome area becomes a Sunday market that becomes a transaction for buying and selling UMKM, a place to play, for tourism, sports, and entertainment. Figure 3 explains the front entrance of the Velodrome city forest, which functions as an air freshener, shade, cooler, water conservation, and preservation of the urban environment. This city forest has retail, kiosks, parks, playgrounds, jogging tracks, and bicycle racing circuits. This variety of busy functions and activities can be connected by providing for pedestrians, cyclists, traditional transportation (pedicabs and horse-drawn carriages), and public transportation transit.

Figure 3

The front of the Velodrome sports building is a bicycle racing circuit



Figure 4*Traditional market and sub-terminal around the Velodrome city forest*

Figure 4 shows the traditional market and sub-terminal located east of the Velodrome forest. The main road in front of it is the main access to the Madyopuro toll gate connecting Malang, Pandaan, and Surabaya. The sub-terminal can serve as a mode shift from private vehicles to public transportation. The vast land allows for Parking for bicycles and traditional transportation. Pedestrian paths can be improved so that public transportation is easily accessible. In addition, city tour bus transportation services and school buses can transit here. Its location on the eastern border of Malang City and Malang Regency makes this area a suburb so that it can serve tourism to the Malang Regency area including Tumpang, Pakis, and Taman Nasional Bromo Tengger Semeru (TNBTS) or Bromo Tengger Semeru National Park. The Madyopuro sub-terminal can also function as a mode transfer hub for private vehicles to public transportation outside Malang city via toll roads (Madyopuro gate) and non-toll roads.

2. Determination of Transit-Oriented Development Factors

The determination of TOD development factors in the Velodrome forest area can be seen in Table 1. These factors are determined by studying previous theories and research and referring to the TOD Standard from the Institute for Transportation and Development Policy 2017 (ITDP 2017). This determination is also strengthened by the results of surveys and field observations aimed at collecting data and information on the potential of the Velodrome forest area to become a TOD area.

Table 1
Factors of Transit-Oriented Development in the Velodrome City Forest

No	Factor	Sub Factors
1	Walk	1a. Safe, complete, and easily accessible pedestrian paths 1b. Comfortable and pleasant pedestrian paths during the day and night 1c. Safe and easily accessible pedestrian crossings in all directions 1d. Completeness of security and safety for disabled pedestrians 1e. Connection of pedestrian paths to the yard and building facade 1f. Visualization of the building facade to the pedestrian path
2	Cycle	2a. Complete, safe, and secure cycling path network 2b. Access to a safe and secure cycling path network 2c. Adequate bicycle parking and storage at public transport shelters 2d. Adequate bicycle parking and storage in buildings 2e. Bicycle accessibility into building zones
3	Connect	3a. Short, direct, and varied walking and cycling routes 3b. Connectivity between walking and cycling routes 3c. Walking and cycling routes are shorter than motorized routes 3d. Adequacy of pedestrian and bicycle intersections with motorized vehicles 3e. Walking and cycling distance to public transportation shelters
4	Traditional	4a. Safe and easily accessible traditional vehicle routes (riksaw and cab)

No	Factor	Sub Factors
		4b. The longest Distance accessed in traditional vehicle routes (riksaw and cab) 4c. Parking and shelter for traditional vehicles (riksaw and cab) 4d. Distance of traditional vehicle routes (riksaw and cab) to public transportation shelters 4e. Accessibility of traditional vehicles (riksaw and cab) to buildings
5	Transit	5a. High-quality public transportation is accessible by walking 5b. Short walking distances and routes to public transportation terminals and shelters 5c. Short walking distance and route to the tourist bus shelter 5d. Short walking distance and route to the school bus shelter 5e. Parking area for private vehicle mode shift from the toll exit to public transportation
6	Mix	6a. Short walking distances between residences, workplaces, places of worship, health centers, schools, universities, pharmacies, malls, business centers, shops, markets, parks, playgrounds, sports facilities, and public facilities. 6b. Diverse and balanced area functions and activities, including. 6c. Diverse professions and income levels in the local population 6d. Land use for residential and non-residential areas in one block area or adjacent
7	Densify	7a. Density of settlements and activities supported by high-quality public transportation 7b. Density of non-residential activities supported by high-quality public transportation 7c. Residential and non-residential Density is balanced with public transportation shelter terminal services 7d. Residential and non-residential Density is balanced with the Availability of public transportation options
8	Compact	8a. Development and construction of new areas in and around old areas 8b. Connection and integration of new areas are built with old areas by walking and cycling. 8c. Connection and integration of new areas are built with the old areas using traditional transportation. 8d. Connection and integration of new areas are built with the previous areas, with public transportation.
9	Shift	9a. Reduction of motor vehicle traffic on land 9b. Reduction of land for off-street and on-street Parking of motor vehicles 9c. Ratio of land for motor vehicles to area 9d. Land ratio between motor vehicles and pedestrian and bicycle paths 9e. Land ratio for green open space and water conservation

The Development of TOD areas must consider the requirements of the transportation system, which is composed of three main elements: activity, movement, and network (Tamin, 2008). A TOD area has diverse and complex functions and activities that will cause the movement and displacement of people and goods. This movement requires the support of a network system, including facilities and infrastructure, integrated with the land use of the area connected to other areas. The transportation system with these three elements is summarized in an instrument that includes TOD development factors. Table 1 shows nine factors explained in more detail with several sub-factors. The Walk factor (No.1) consists of the Availability of safe, complete, and easily accessible pedestrian paths (No.1a), the Availability of comfortable and pleasant pedestrian paths during the day and night (No.1b), the existence of safe and easily accessible pedestrian crossings in all directions (No. 1c), complete security and safety for disabled pedestrians (No. 1d), there is a connection between the pedestrian path and the yard and the front of the building (No. 1e), and the Visualization of the building's front can be seen by pedestrians on their path (No. 1f). Everyone can do walking activities. In the TOD area, walking movement is prioritized. Connectivity between origin and destination points that can be reached comfortably by walking can reduce the use of private vehicles (Zafira & Puspitasari, 2022; Pratiwi & Fitrianto, 2023). The Availability of walking infrastructure, especially for people with disabilities, is a top priority in TOD areas. In addition to realizing green transportation that is in harmony with the environment, a healthy lifestyle by

walking improves the quality of life of someone living in a TOD area. Factor No. 2, namely Cycle, includes the existence of a complete, safe and secure bicycle path network (No. 2A), easy access to a safe and secure bicycle path network (No. 2B), Availability of adequate bicycle parking and storage areas at public transport shelters (No.2c), Availability of adequate bicycle parking and storage areas in buildings (No.2d), and ease of bicycle accessibility into building zones (No.2e). Similar to walking, cycling is one of the efforts towards green transportation. In addition to exercising, cycling can be used as a mode of movement for daily activities, including working, shopping, and simply interacting with others (Zafira & Puspitasari, 2022). Factor No. 3, namely Connect, consists of the Availability of short, direct and varied walking and cycling routes (no. 3a), the existence of connectivity between pedestrian and cycling paths (no. 3b), the existence of walking and cycling routes that are shorter than motorized vehicles (no. 3c), the existence of sufficient intersections between pedestrian and cycling paths and motorized vehicles (no. 3d), and walking and cycling distance to public transport shelters (No.3e). The connectivity between walking and cycling routes with movement goals enables active areas with all their activities (Prawira, Prabowo, & Tundono, 2024). Compared to using motorized vehicles, routes with short, comfortable, and safe distances for walking and cycling are influenced by spatial planning and regional infrastructure. The infrastructure of paths for walking and cycling is made separately and separated from motorized vehicle roads, which will determine a person's choice of mode of movement. Factor No. 4, namely Traditional, includes the Availability of safe and easily accessible traditional vehicle routes (riksaw and cab) (No. 4a), the longest Distance accessed on traditional vehicle routes (riksaw and cab) (No. 4b), there is Parking and shelter for traditional vehicles (riksaw and cab) (No. 4c), the Distance of traditional vehicle routes (riksaw and cab) to public transportation shelters (No.4d), and the ease of Accessibility of traditional vehicles (riksaw and cab) to buildings (No.4e). The use of non-motorized vehicles such as traditional transportation in the form of riksaw and cab supports the achievement of sustainable green transportation (Jababeka Residence, 2024). This kind of traditional vehicle is the local wisdom of each region that can be applied in a TOD area. The socio-cultural aspect shows the habits and preferences of the people in the area. This is to balance technical studies based on standards with the voice of users, namely the community with its socio-culture. Previously, on Sunday, in the city forest velodrome, a people's market was held, where people used this type of traditional vehicle as tourist transportation around the area and its surroundings. Factor No. 5, namely TransitTransit, consists of having high-quality public transportation that can be accessed by walking (No. 5a), short distances and routes for walking to the terminal and public transportation shelter (No. 5b), short walking distance and route to the tourist bus shelter (No.5c), short walking distance and route to the school bus shelter (No.5d), and the Availability of parking areas for private vehicle mode shifts from toll exits to public transportation (No.5e). The Availability of high-quality public transportation will affect connectivity between zones within the TOD area and the TOD area with other areas (Legowo & Sumadio, 2021). Factor No. 6, namely Mix, consists of short walking distances between residences, workplaces, places of worship, health services, schools, universities, pharmacies, malls, business centers, shops, markets, parks, playgrounds, sports facilities, and public facilities (No. 6a), the existence of diverse and balanced regional functions and activities including (No. 6b), professions and income levels of the local population (No.6c), and land use for residential and non-residential areas in one block or adjacent (No.6d). Areas that combine multiple functions and activities allow for active and dynamic resident interactions. The balance between TOD zones avoids the negative impacts of individualistic transportation and prioritizes healthy lifestyles and environmentally friendly transportation for everyone (Atmawidjaja et al., 2016; Primadani, Pratama, & Dwiputri, 2024). Factor No.7, namely Densify, includes residential and activity density supported by high-quality public transportation (No.7a), non-residential activity density supported by high-quality public transportation (No.7b), the Density of residential and non-residential areas is balanced with the services of public transportation shelter terminals (No.7c), and the Density of residential and non-residential areas is balanced with the Availability of public transportation options (No.7d). TOD areas accommodate complex functions and activities with complex demographic characteristics. There is no dominant activity compared to other activities. Every resident gets the same opportunity to do activities, so they move evenly in each block in the TOD area (Priadmaja, Anisa, & Prayogi, 2017; Apriliyani & Mardiansjah, 2020). The Density of activities in settlements in line with non-residential activities will allow people to move around by walking and bicycle within

the TOD area, and choose public transportation to destinations outside the TOD area (Tufail, Nugroho, & Syafitri, 2019). Factor No. 8, namely Compact, consists of the Development and construction of new areas in and around old areas (No. 8a), the connection and integration of newly built areas with old areas by walking and cycling (No. 8b), the Connection and integration of newly built areas with old areas by traditional transportation (No. 8c), and the existence of connections and integration of newly built areas with old areas with public transportation (No.8d). Active and dynamic areas will always be evolving and in need of development. Development patterns between existing and new areas must be well-integrated and connected. Development in TOD areas must also adhere to sustainable principles that balance social, economic, and environmental aspects. Efforts to minimize the impact of damage to these three areas are essential (Sanusi, Waloejo, & Yudono, 2023; Wicaksono & Chandra, 2023; Priwiratama & Yola, 2023). Factor No.9, namely Shift, includes reducing motor vehicle traffic areas (No.9a), reducing land for off and on street parking of motor vehicles (No.9b), Ratio of land for motor vehicles to area area (No.9c), ratio of land between motor vehicles and pedestrian and bicycle paths (No.9d), and the Ratio of land for green open space and water conservation (No.9e). The TOD area can allow for the Development and construction of new areas both inside and outside the adjacent area. This Development will require new land, which will exacerbate the land crisis. Land cleared is prioritized more on programs that support sustainable principles by favoring pedestrian infrastructure, cycling, and environmentally friendly alternative transportation (Herlambang, Purba, & Septiana, 2023). In addition, the newly opened land also provides environmental protection and preservation. With the comprehensive implementation of the TOD area, it is expected to realize a transportation system with an integrated system of activities, movements, and networks that positively impact the environment and continue to be sustainable at present and in the future.

CONCLUSION

The Velodrome Forest and its surroundings have the potential to be developed into a TOD Area. However, a study is required based on the assessment criteria of the TOD Standard compiled by the Institute for Transportation and Development Policy (ITDP) in 2017 (ITDP 2017). The determination of TOD area development factors is based on technical studies (TOD Standard and literature review) combined with user voices, namely the community. Eight factors refer to the Standard TOD: Walk, Cycle, Connect, Transit, Mix, Densify, Compact, and Shift. The eight factors are clarified with several sub-factors. In addition to referring to the Standard TOD, the eight factors with several sub-factors were also developed from literature reviews, theoretical studies, previous research, and observations at the Velodrome city forest location. One additional factor, namely Traditional, including local wisdom that shows the identity and socio-culture of the Velodrome forest area community, is the use of traditional vehicles in the form of rickshaws and cabs. The activity system, movement, and network influence the transportation system in a TOD area. The diverse and complex functions and activities cause the movement and displacement of people or goods. This movement requires a network system that includes facilities and infrastructure. The planning of the network system must, of course, be integrated with the land use of the area connected to other areas. Nine factors (8 factors from standard TOD and one traditional factor), which are clarified with several sub-factors, can be used as instruments to obtain data and information regarding the level of potential and ability of the velodrome forest to be developed into a TOD area to realize a sustainable, environmentally friendly transportation system.

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