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The Challenges of New Town Development at High-Speed Rail Transit Oriented Development: Case of Jakarta–Bandung HSR

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Abstract: This study examines the development of a sustainable new town based on Transit-Oriented Development (TOD) in Tegalluar to address urban sprawl, inefficient land use, and social inequality. Using a mixed-method approach, data were collected through field surveys, questionnaires, and interviews. Spatial and SWOT analyses were employed to evaluate the characteristics, socio-economic conditions, and community perceptions. The findings reveal Tegalluar's potential as a hub for sustainable activities, supported by adequate transport infrastructure, although public accessibility and supporting facilities remain limited. The SWOT analysis identifies strengths such as strategic location and policy support, weaknesses in public services, opportunities for economic investment, and threats from social inequality. This research recommends strategies to enhance infrastructure, foster community engagement, and integrate public policy with spatial planning to realise sustainable TOD. The model could serve as a reference for new town development in Indonesia to support sustainable urban development.

Keywords: High speed rail; Jakarta-Bandung; Sustainable urban development; Tegalluar station; Transit oriented development

Introduction

Urbanization has led to increased population mobility, pollution, and inefficient land use in urban areas worldwide. In Indonesia, this phenomenon is a growing concern, particularly due to the increasing use of private vehicles, which is not matched by adequate public transportation infrastructure. One solution widely discussed in the context of urbanism is Transit-Oriented Development (TOD), a concept that aims to create sustainable cities through the integration of public transportation and structured land use (Bevilacqua et al., 2013). TOD offers an urban planning approach that not only reduces dependence on private vehicles but also improves accessibility and reduces carbon emissions through sustainable environmental design (UNDP, 2022).

Various studies have highlighted the successful implementation of TOD in major cities worldwide, such as Tokyo, Seoul, and several European cities. In Tokyo, TOD has proven effective in reducing urban sprawl and integrating public transportation with land-use planning (Ibraeva et al., 2020). Furthermore, TOD not only facilitates community mobility but also stimulates local economic growth in transit-driven areas. Although this concept has been widely adopted in developed countries, its implementation in Indonesia, particularly in developing areas like Tegalluar, requires specific adjustments to suit local socio-economic, cultural, and policy conditions. The scientific novelty of this study lies in its integrative approach in exploring the potential and challenges of TOD implementation in Tegalluar as part of the development of new urbanism in Indonesia.

However, the implementation of TOD in Tegalluar faces several challenges, including inadequate public infrastructure and suboptimal accessibility for the community (Lyu et al., 2020; Priadmaja et al., 2017). Social issues such as economic inequality and limited access to education also pose obstacles that need to be addressed. This study aims to answer the main

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questions: how can the TOD concept be implemented sustainably in Tegalluar, and how can the roles of the community and stakeholders be integrated in the management of the area? The research questions include: (1) What are the physical and socio-economic characteristics that support the implementation of TOD in Tegalluar? (2) What are the social and economic impacts of the implementation of TOD in Tegalluar? (3) What are the appropriate strategies to ensure the sustainability of TOD in Tegalluar?

This study aims to analyze the potential for new urban development and the implementation of TOD in Tegalluar, identify and evaluate potential socio-economic impacts, and formulate sustainable development strategies. This article contributes by presenting an urban development concept that integrates physical, social, economic, and disaster-related aspects into TOD-based new urbanism in Indonesia. This research offers insights for the development of sustainable urban policies and presents important findings for stakeholders in the urban planning sector.

Method

Study Area

This research was conducted in the Tegalluar Transit-Oriented Development (TOD) area, located in the administrative area of Bandung Regency (Cibiru Hilir, Cimekar, Cinunuk, Cileunyi Kulon, Tegalsumedang, and Tegalluar villages) and Bandung City (Mekar Mulya sub-district). Geographically, this location is located at coordinates 107˚42′54″ East Longitude and 6˚57′50″ South Latitude, with its status as a city service center in the eastern development area ofGreater Bandung. Tegalluar functions as a strategic transit center with adequate accessibility to transportation modes such as the Jakarta–Bandung High-Speed Train, interprovincial trains, toll gates, and bus terminals (Minister of Transportation Regulation Number PM 43 of 2011). This area is included in the railway network development plan in accordance with the Bandung Regency Spatial Plan (RTRW) 2016–2036. See (Figure 1) for a location map.

The Tegalluar region has a diverse population, with the majority working in the informal sector, such as agriculture, entrepreneurship, and freelance work. According to 2023 data, the region recorded 4,490 unemployed individuals, reflecting the challenges in providing employment opportunities. However, the presence of 1,922 entrepreneurs demonstrates economic potential through the development of micro and medium enterprises. Furthermore, a 79.68-hectare industrial area (see Figure 2), which includes automotive, processed food, and recycling industries, contributes to the local economy.

Figure 1. Location of Tegalluar TOD

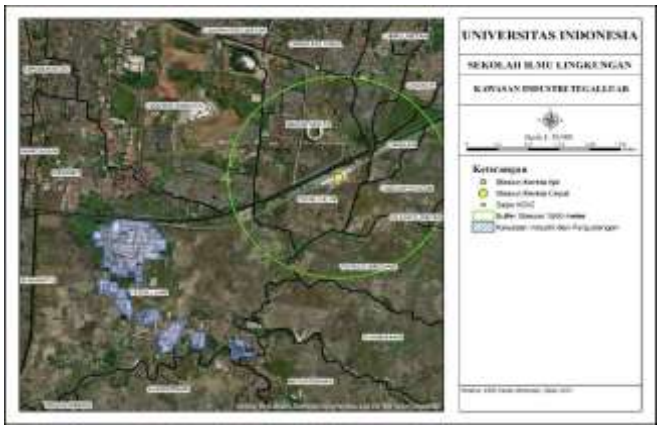

Figure 2. Tegalluar industrial area

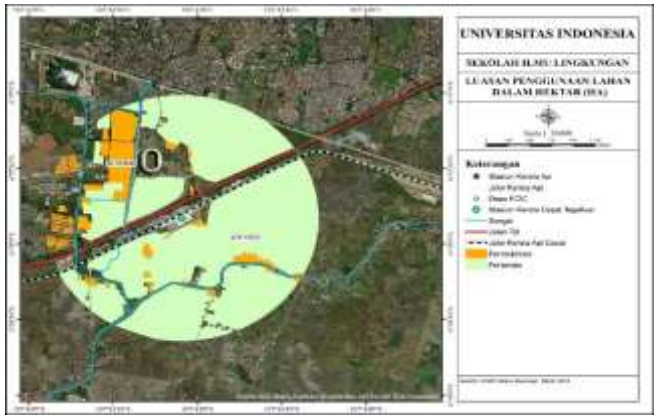

Figure 3. Land use area

The TOD area in Tegalluar, centered around the high-speed train station, has land uses dominated by agriculture and housing, with 479.1 hectares designated for agriculture and 55.7 hectares for housing (see Figure 3). This zone can be maximized to support environmental sustainability by improving accessibility to public transportation.

Tegalluar has significant economic potential through the development of industrial zones and micro-enterprises. However, a high reliance on the informal sector reflects the risk of economic uncertainty. Land conversion for industrial and residential purposes is also beginning to impact community livelihoods. Furthermore, the large number of students in the area offers hope for better human resource development.

Data Collection

The data for this study consisted of primary and secondary data collected at specific points in time. Primary data were obtained through field observations, mapping, questionnaires, and in-depth interviews. Field observations focused on mapping land use functions around the TOD area and tracking human movement using various modes of transportation, including cyclists, pedestrians, online motorcycle taxi users, and public transportation users. Questionnaires and interviews were used to capture community perceptions regarding mobility behavior and its impact on social aspects.

Secondary data includes statistical reports, maps, and documentation sourced from government agencies, previous research, and satellite imagery. The primary secondary data includes regional development maps, demographic and economic data, and spatial data related to the Gedebage Technopolis area. This dataset is essential for understanding the geographic, socio-economic, and infrastructure characteristics of the study area.

The collected data was processed and analyzed to address the research objectives. This process involved the use of GIS software for land cover mapping, thematic clustering of literature for contextual analysis, and descriptive analysis for social and economic aspects (Refiyanni, 2016). The analysis results are presented in narrative form, tables, graphs, maps, and diagrams to provide a comprehensive understanding of TOD development in Tegalluar.

Method of Analysis

Economic aspects are a key consideration in the development of Tegalluar, as TOD implementation is expected to stimulate the local economy by integrating public transportation infrastructure and improving accessibility to key economic centers. Furthermore, TOD development is expected to support the growth of local businesses.

To analyze this, an assessment was conducted by identifying existing economic activities prior to the TOD development. A SWOT analysis was then used to identify the strengths, weaknesses, opportunities, and threats within the Tegalluar TOD area, which were then formulated into a strategy to optimize local economic performance. In-depth interviews with local residents were conducted to gain insight into perceptions regarding regional development and its impact on the local economy.

Quantifying SWOT Factors

SWOT factors are quantified using a scoring system to measure the importance and performance of each factor:

a) Weight (0-1): Indicates the importance of the factor to success.
b) Score (1-5): Measures the performance or impact of the factor, with 1 representing "Strongly Agree" and 5 representing "Strongly Disagree."
c) Total Score: Obtained by multiplying the weight and score to determine factors that require immediate attention and optimization.

SWOT Matrix Analysis with Quantitative Priorities

A quantitative SWOT analysis prioritizes strategies based on the highest total scores of internal and external factors. This analysis uses a Cartesian diagram (SWOT Matrix) to illustrate the strategies:

a) Quadrant 1 (SO): A combination of strengths and opportunities that support aggressive growth and expansion strategies.
b) Quadrant 2 (ST): Strengths used to address threats, leading to defensive strategies.
c) Quadrant 3 (WO): Weaknesses that need to be addressed to capitalize on existing opportunities.
d) Quadrant 4 (WT): Weaknesses confronted with threats, requiring defensive strategies.

After quantifying the factors and assigning them to the SWOT diagram, development strategies and objectives were established. This process ensured objective prioritization based on the factors with the highest total scores.

Descriptive analysis was used to answer research questions related to the characteristics of the Tegalluar area and its social conditions. This analysis included an evaluation of aspects such as geomorphology, ecosystem diversity, existing land use, population distribution, public transportation conditions, utility networks, and community perceptions. The approach used was a descriptive method based on literature review, spatial mapping, and direct interviews. Regarding the existing regional characteristics, a geomorphological analysis was conducted to identify potential geological disaster risks to support disaster mitigation and management planning. Land use and population distribution were analyzed using ArcGIS software to assess the development's compliance with applicable policies. Public transportation and utility

networks were identified as key components supporting the development of the TOD area, using a multimodal approach to ensure intermodal integration and the sustainability of the transportation system.

Regarding social aspects and community perceptions, the analysis focused on evaluating equal access to public services, including education, health care, and safety. Data was collected through direct interviews with local residents to understand the challenges they face and their perceptions of the high-speed rail station development. The analysis also explored the positive and negative impacts of the development, as well as community expectations for the sustainability of the area.

Result and Discussion

Sustainable City

Sustainable cities are a concept derived from and developed within the spatial sector. As outlined in the Sustainable Development Goals (SDGs), Goal 11 specifically focuses on sustainable cities and communities. Sustainable cities encompass three dimensions: environmental, social, and economic, all of which aim to safeguard the natural, physical, and social environment. Key indicators of sustainable cities include pollution reduction, effective sanitation management, adaptation to climate change, and eco-friendly mobility (European Commission, 1996; Balova, 2021).

To achieve inclusive, regenerative, and sustainable cities in the context of urbanization, economic priorities, and uncontrolled urban development, it is essential to build an inclusive framework to describe, classify, and guide urban development towards sustainability in spatial, logical, and temporal dimensions (Ding et al., 2015). Several principles are necessary to create a sustainable city. First, cities must be social/community-based, guided by complexity, and rooted in the landscape (Rogema, 2017).

Environmental externalities caused by population growth, urbanization, and people's dependence on private vehicles have raised concerns about the future and well-being. Efforts are needed to responsibly and efficiently mitigate environmental externalities. Furthermore, sustainable development has become a popular topic, particularly in the fields of environmental economics, technology, urban planning, development, and management (Trindade et al., 2017).

Socio Economic Inclusion

Inclusivity is the opposite of exclusivity, and social exclusion is defined as a form of poverty, discrimination, lack of participation, and lack of government legitimacy (J. Beall, 2000). Poverty, injustice, conflict, and environmental degradation interact in complex ways. This growing concern for the international community is partly due to the decline in natural resources and their capacity to support populations. In many regions of the world, population growth cannot be supported by available resources such as housing, access to health services, food security, and energy supplies. Issues of population, poverty, and social injustice require special attention. Governments need to develop policies that increase equitable access to resources, education, and basic services to strengthen social inclusiveness and empower communities (Brundtland, 1987; Keeble, 1988).

There are 12 goals with 54 targets proposed for post-2015 development, as follows: end poverty, empower people, provide quality education and lifelong learning, ensure healthy lives, achieve food security and good nutrition, ensure universal access to water and sanitation, ensure sustainable energy, create jobs, sustainable livelihoods and inclusive growth, manage natural resources sustainably, ensure good governance and effective institutions, ensure stable and peaceful societies, and create an enabling environment for long-term global financing (New Global Partnership Report: Ending Poverty and Transforming Economies Through Sustainable Development; Renne & Newman, 2002).

Transit Oriented Development

Transit-Oriented Development (TOD) is a concept that provides innovation for metropolitan or urban areas across generations, integrating mixed-use land use and interconnected spatial components. Essentially, TOD is a land-use and transportation planning framework that makes transportation modes sustainable and convenient, maximizing service efficiency by concentrating urban development around transit stations (Al-Harami & Furlan, 2020; Ibraeva et al., 2020). The TOD index focuses on the integration of socio-environmental characteristics, economic vitality, and development potential of TOD projects within the context of the transportation system (Cucuzzella et al., 2022).

Transit-Oriented Development (TOD) emphasizes urban development that supports the use of public transportation, reduces dependence on private vehicles, and reduces CO2 emissions. TOD improves accessibility and connectivity in urban areas while minimizing environmental impacts (Ashik et al., 2022; Kamruzzaman et al., 2015). TOD environments offer better spatial accessibility to urban amenities compared to non-TOD areas (Rahman et al., 2022). In addition to transportation, urban planners must also consider other aspects, such as ecological diversity, energy recycling, and livable space, to achieve a better quality of life in new urban areas (Huang & Wey, 2019). In practice, TOD requires appropriate policies to effectively manage urban sprawl (Liu et al., 2022; Maibach et al., 2007).

To reduce carbon emissions caused by mobility, attention is needed to industrial and real estate development. Furthermore, feeder bus services and public bicycle systems need to be improved to reduce travel time between satellite cities and residential areas, providing empirical evidence and a reference for other cities (Chen et al., 2017).

In its implementation, integration between institutions and land-based assessment mechanisms for TOD areas is needed, as well as discussions on potential solutions to problems such as inefficient governance, rigid financial regulations, and inadequate planning. Informal planning strategies, including rail strategies around transit stations, are needed to overcome development barriers (Wang et al., 2019). Bottom-up policies can be applied to address spatial issues and can be combined with top-down policies using agent-based modeling to create TOD policies and public transportation infrastructure aimed at ensuring the efficiency and feasibility of the model (Motieyan & Mesgari, 2018; Kadarisman, 2017; Efriana et al., 2019).

New Town

New city development aims to utilize land more efficiently, integrate infrastructure, and anticipate the impacts of rapid urbanization. The focus is on creating sustainable cities by prioritizing livability and providing basic needs (Li & Chiu, 2018; Xu et al., 2016). The implications of sustainable cities aim to increase public knowledge about urban development, particularly in economic aspects, encourage innovation, emphasize efficiency, and optimize. Furthermore, it highlights the benefits of large-scale planning, testing, and implementation (Evans et al., 2019), although findings still show a weak correlation between policymakers and theory (Hong et al., 2022).

How TOD Contributes to Promoting a Sustainable City and Inclusion in a New Town and the Challenges of Implementation

Transit-Oriented Development plays a role in sustainable cities and promotes socio-economic inclusion in new urban developments. TOD integrates land-use planning with transportation, encouraging the use of public transportation and reducing reliance on private vehicles. This approach not only supports environmental sustainability by reducing CO2 emissions but also improves accessibility and connectivity in urban areas, contributing to inclusive communities. TOD improves accessibility in urban areas while reducing adverse environmental impacts (Ashik et al., 2022).

A sustainable city is the ability to balance environmental, social, and economic dimensions, as outlined in Sustainable Development Goals (SDGs) Goal 11, which focuses on sustainable cities and communities, reducing urban sprawl, and supporting the regeneration of underdeveloped areas. TOD areas offer good spatial accessibility to urban amenities, supporting the creation of inclusive and sustainable cities (Rahman et al., 2022).

However, its implementation faces several challenges. In emerging cities, where urbanization pressures are high, effectively integrating TOD requires addressing barriers such as government inefficiency, financial regulation, and inadequate planning. Effectively managing urban sprawl is crucial, which is a major implementation challenge (Kamruzzaman et al., 2015). The success of TOD depends on collaboration between various stakeholders, including government agencies, urban planners, and private developers. Top-down policy strategies can address spatial challenges, ensuring efficient TOD implementation while promoting an inclusive and sustainable urban environment (Motieyam & Mesgari, 2018; Kadarisman, 2017).

In addition, new cities should prioritize the integration of essential services, such as affordable housing, healthcare, and education, to enhance social inclusion. TOD provides an opportunity to create more equitable cities by improving access to these services and empowering marginalized communities. Policies that increase equitable access to basic resources and services are essential for strengthening social inclusiveness. However, to fully realize TOD's potential in promoting sustainability and inclusion, effective policy frameworks, investment in infrastructure, and meeting local needs are essential to address implementation challenges (Brundtland, 1987).

Existing Conditions and Infrastructure Development Aspects in Development Area

This analysis includes an evaluation of geographic conditions, land use, transportation, and utility networks to understand the potential and challenges of regional development. The Tegalluar area is located in the Bandung Basin, with a landscape formed by ancient lake deposits. Geologically, this area is vulnerable to earthquakes, volcanic eruptions, and has the potential for liquefaction due to seismic activity (Handayani & Harjono, 2009; Koesuma et al., 2022; Yatini et al., 2023). These conditions are important to consider in urban planning and disaster mitigation. The Tegalluar TOD area is dominated by agricultural land, with only 11% of the land used for residential purposes. Existing land use can be optimized to support environmental sustainability, with a focus on public transportation accessibility and the development of commercial and residential areas.

The development of Tegalluar aims to make the Jakarta-Bandung high-speed rail network a driver of

regional growth (see Figure 4). Transportation facilities such as high-speed rail stations and local trains are available; however, connecting infrastructure between modes of transportation still needs improvement (Presidential Regulation No. 3 of 2016; Presidential Regulation No. 107 of 2015). Utilities in Tegalluar include clean water, telecommunications, and electricity. Although residents have adequate access to clean water, inconsistent supply is a concern. The telecommunications network is supported by several BTS towers, and electricity is available throughout the area (Simbolon, 2022). Understanding these existing conditions is crucial for urban planning and infrastructure development that supports sustainability and disaster mitigation.

Figure 4. Tegalluar TOD constellation with surrounding areas

Social Dynamics and Community Perceptions of High-Speed Rail Station Development

This section examines social aspects and community perceptions in the Tegalluar area, a key pillar of sustainable development. The analysis focuses on three key indicators: security, education, and health, as well as community responses to the development of the High-Speed Train Station and its surrounding area. From a security perspective, community participation through activities such as routine patrols and social transparency is crucial to maintaining neighborhood stability. However, there are dynamics of changing participation, such as the dependence of some areas on formal security personnel.

Regarding access to education, although the community has easy access to formal education, challenges remain, such as distance to schools, poor road conditions, and limited public transportation. These factors hinder ensuring equitable access to education for all levels of society. Healthcare facilities in Tegalluar, while adequate, still face several challenges, such as poor road access, limited service capacity, and disparities in the quality of care for patients with health insurance.

Public perceptions of the development of the High-Speed Rail Station include positive impacts such as increased local income and improved social interaction, as well as negative impacts such as pollution, congestion, and changes in work patterns (Giantara et al., 2018). The community hopes this development will bring more equitable benefits, including increased employment, improved infrastructure, and improved environmental quality. This analysis emphasizes the importance of considering the community's social needs to support the sustainability of Tegalluar's development.

SWOT Analysis Result

A SWOT analysis was conducted to evaluate the economic position of the Tegalluar region by considering internal and external factors influencing TOD development. Internal factors include location and resources, while external factors encompass opportunities and threats in the surrounding area.

SWOT Analysis of Tegalluar's Economy

The SWOT analysis for the Tegalluar region shows that internal weaknesses outweigh strengths, with a score of -0.108 compared to 1.972 for strengths. This indicates that the region faces more internal challenges than potential, requiring greater attention to address these weaknesses. Externally, opportunities outweigh threats, with a score of 1.25 on the Y-axis. This indicates that the region is strategically positioned to capitalize on available opportunities, such as favorable geographic conditions and transportation accessibility.

This analysis places the Tegalluar region in the "WO" (Weaknesses-Opportunities) quadrant, recommending improvement strategies (see Figure 5). This approach aims to mitigate the impact of internal weaknesses by capitalizing on external opportunities. Furthermore, the importance of location and resources, including human resources, water, food, and energy, is emphasized as key factors in implementing improvement strategies and achieving sustainable development in the region. Overall, this analysis aligns with the basic principles of SWOT, which identify key internal and external factors and recommend strategies appropriate to the region's position in the SWOT matrix.

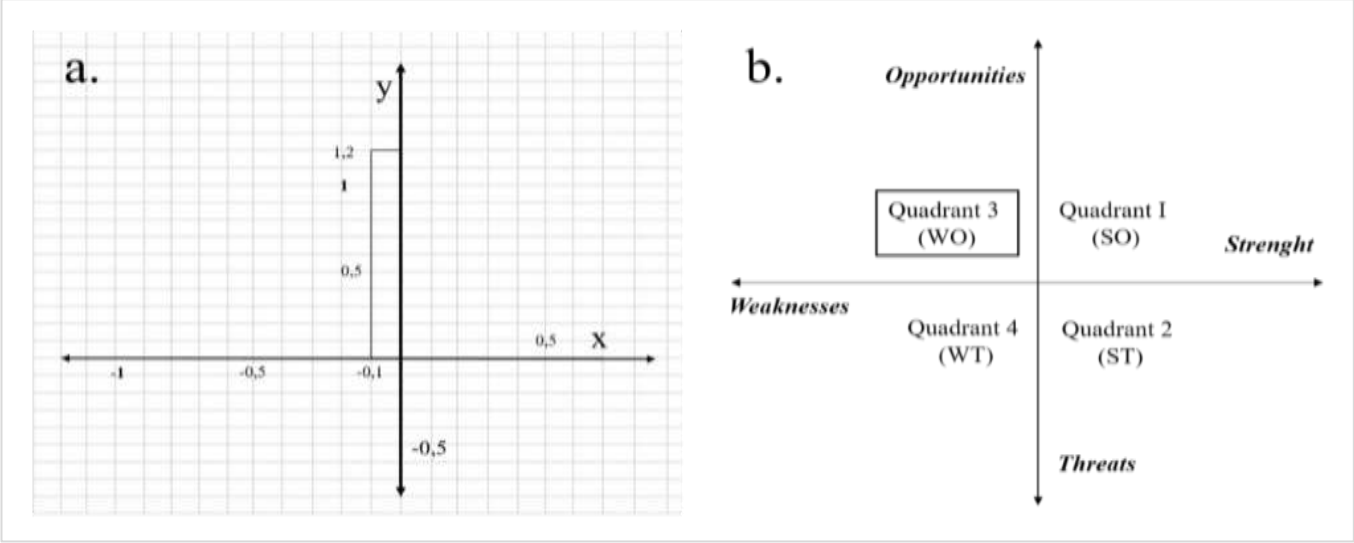

Figure 5. SWOT analysis matrix and Tegalluar's position in the SWOT quadrant

Economic Development Strategy

Based on the SWOT analysis, the proposed strategy is a "WO" (Weaknesses-Opportunities) strategy, where internal weaknesses are addressed by capitalizing on external opportunities. This strategy aims to address weaknesses by maximizing opportunities. First, the development of an infrastructure-based trade and service area is recommended, driven by the limited micro and small facilities and the lack of specific characteristics in this sector in the Tegalluar area. Opportunities include Tegalluar's strategic location and public facilities that support inter-regional mobility. Interventions include the development of small industrial facilities and trade areas with supporting infrastructure, as well as innovation in local potential, particularly in the agricultural sector. Partnerships with the private sector and government are crucial to encourage investment, create jobs, and support the growth of the micro and small sector (De Rus, 2008).

Second, a youth workforce skills development program is proposed, given the shortage of relevant skills, particularly in the agricultural and industrial sectors. Sector-based training programs and formal education are expected to improve the skills of the youth workforce and create job opportunities. Overall, this strategy aims to promote sustainable economic growth and improve the quality of life of the Tegalluar community. The next subsection will focus on economic growth strategies and further analysis leading to the concept of a sustainable new city, considering economic, social, and physical environmental aspects.

Sustainable New Town Concept

This section discusses the concept of a sustainable new city in Tegalluar, integrating key elements to create a city that considers economic, social, and environmental aspects, based on the previous analysis. One of the key concepts implemented in this plan is the Transit-Oriented Development (TOD) principle, which encompasses five key elements: density, diversity, design, purpose, and accessibility. To support the economy, a development strategy is needed, while equitable access to services is a key focus in the social aspect.

The application of TOD principles in the Tegalluar development area begins with creating high density around stations and transportation terminals, which will create an interconnected environment, facilitate access to public transportation, and reduce dependence on private vehicles. This high density can be achieved by making the high-speed train station a central point (see Figure 6). The second principle, diversity, integrates various land uses such as residential areas, commercial spaces, and public facilities in one location, making it easier for residents to meet their daily needs.

Figure 6. Transportation infrastructure of Tegalluar TOD area

Design elements focus on creating pedestrian-friendly infrastructure, such as walkways and bicycle paths, and ensuring the presence of public spaces such as parks and open areas to encourage social interaction. Designing pedestrian paths that are accessible to all users, including people with disabilities, is a primary concern. This design aims to improve the physical environment to make it more functional and attractive. The principle of transportation proximity requires the development of residential and commercial areas within walking distance of public transportation, thus facilitating access and encouraging the use of public transportation.

Accessibility in TODs ensures connectivity between destinations through mobility infrastructure such as pedestrian paths, bicycle paths, and public transportation routes. The planning and provision of these facilities encourages reduced private vehicle use, promotes healthy lifestyles, and contributes to economic growth by improving the accessibility of commercial areas. Furthermore, development plans take into account the region's topography and disaster risks such as flooding, earthquakes, and liquefaction, which require resilient infrastructure planning and wise land use. Raising public awareness of these risks through education and preparedness programs is crucial. Development plans also include comprehensive utility provision for basic services such as clean water, telecommunications, and electricity, all of which are essential for urban sustainability.

Economic growth emphasizes the development of strategic infrastructure, with human resources being key. This includes improving transportation systems, access to services, and encouraging innovation in local industries. Supporting partnerships and attracting investment are also crucial to stimulating economic growth. The development plan emphasizes the importance of inclusivity by ensuring equal opportunities and access to resources, services, and opportunities for all residents, especially vulnerable groups. This approach ensures the holistic and sustainable development of Tegalluar as a new city.

Conclusion

The Tegalluar region shows significant development potential, particularly with the presence of supporting infrastructure such as a high-speed train station and public transportation access. This infrastructure provides opportunities to improve connectivity and position the area as a strategic transit and trade hub. The development of this area has improved accessibility and mobility for local communities, positively impacting community well-being. However, challenges remain, including educational disparities and community concerns about changing livelihoods, which impact inclusiveness as part of social sustainability. Based on the SWOT analysis, the Tegalluar region requires the implementation of a development strategy (WO), which emphasizes the dominance of internal weaknesses and external opportunities. This strategy includes the development of infrastructure-based trade and service areas, as well as improving the skills of the young workforce to support the agricultural and industrial sectors. The concept of a sustainable new city in Tegalluar emphasizes a balance between economic, social, and environmental aspects, with the application of TOD principles, which include density, diversity, design, proximity to public transportation, and ease of accessibility. The implementation of TOD principles aims to improve mobility efficiency, reduce dependence on private vehicles, and strengthen partnerships between the government and the private sector.

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Research design and manuscript preparation, R.A.; data collection, analysis, and interpretation, H.S.H.; reviewing, editing, and validating the manuscript, C.T.P. All authors have read and approved the final version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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