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A Systematic Review of Transportation Rail Networks: Impacts on Urban Development and Sustainability

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Abstract

The high-speed train was designed to address traffic congestion and support sustainable urban mobility. Rapid urbanization profoundly impacts transportation systems and land use patterns, creating opportunities for sustainable urban mobility and sustainable development. A systematic literature review was performed to assess the impact of high-speed trains on urban development and how trains contribute to environmental sustainability. Approximately 21 related studies were found based on the systematic review. According to the results of the study, the impact of the high-speed train was divided into three sub-themes: social impact, environmental impact, and economic impact. The findings also identified the gaps in understanding the impact of the high-speed train on the social impact. This study is important because it will improve the sustainability of urban areas and societies by advocating for sustainable urban transportation and effective land utilization that aligns with Sustainable Development Goal 11. In addition, it offers valuable lessons for policymakers, planners, and transportation managers in the country.

Keywords: Transportation Trains, Urban Development, Environmental Sustainability, Systematic Literature Review

Introduction

In recent decades, there has been a significant increase in urbanization worldwide, leading to profound changes in our urban lifestyle, work dynamics, and social interactions. This rapid urbanization, driven by population growth, economic progress, and technological advancements, has presented urban areas with both challenges and opportunities. Reliable and efficient infrastructure becomes increasingly critical and well-designed urban transport systems are vital for sustainable development, to aid in alleviating traffic congestion and enhancing residents' quality of life (United Nations, 2018; 2024). In Kuala Lumpur, Malaysia's bustling capital city, the Mass Rapid Transit (MRT) development system is a notable achievement in the advancement of modern urban transportation. Kuala Lumpur is largely

influenced by the MRT system and this transformation over the last decade has exciting developments.

Sustainable urban development prioritizes environmental conservation and social fairness to harmonize with economic expansion. Sustainable urban transport involves establishing transportation systems that address present needs while supporting enduring environmental objectives like reducing greenhouse gas emissions and limiting sprawl. This network is expected to continue to grow quickly and have a lasting impact on the country's overall economic and social progress. However, the building of the high-speed rail infrastructure necessitates the heavy use of resources like concrete and steel, whose manufacturing produces a lot of pollutants. Hence, the MRT project offers a chance to examine the impact of sustainable urban transport. To make lucrative investments on both an economic and social level, European countries recommend that the development of high-speed rail (HSR) infrastructure be carefully tailored to the unique demands, taking into account all demands currently in the impacted corridor (Chang, et al., 2019).

In Malaysia's most popular and economically dynamic region, Kuala Lumpur accommodates a diverse population and functions as the nation's primary center for commerce, industry, and finance. Recent estimates show that Kuala Lumpur's population exceeds 7 million, making it a densely populated urban area. The region has undergone significant demographic changes due to rapid urbanization, economic opportunities, and internal migration in recent decades. This population growth has resulted in increased pressure on existing urban transport systems, infrastructure, housing, and public services. The main goals of the MRT line are to improve public transport capacity, reduce traffic congestion, encourage sustainable development, and promote economic growth. It also aims to cater to the growing number of commuters in Kuala Lumpur and ease traffic congestion in Kuala Lumpur and its surroundings by offering a reliable and efficient mode of transport. Furthermore, the advantages of this rail transportation for the environment are threatened by Malaysia's prevalent electrical power generation system. Therefore, a thorough assessment of the energy and environmental footprints related to Malaysia's upcoming large-scale building of high-speed rail infrastructure and the usage of high-speed rail in the future needs to be done in the context of resource consumption, energy use, and environmental considerations.

In recent decades, Kuala Lumpur has evolved into a vibrant city, fueled by extensive infrastructure enhancements, such as the expansion of the Mass Rapid Transit (MRT) system. The transformation in the capital city, driving economic advancement in Malaysia. However, these advancements have also introduced environmental issues such as urban sprawl, depletion of green spaces, traffic congestion, heightened pollution, and the depletion of natural habitats. The urgency for sustainable environmental planning in Kuala Lumpur is crucial to safeguard the city's environmental well-being from being compromised by its growth. The establishment of the MRT in Malaysia marks a crucial advancement in realizing a more connected and eco-friendly urban transportation system in Kuala Lumpur. By offering a feasible option to driving private vehicles, the MRT aims to support efficient land utilization, improve urban life quality, and decrease carbon emissions. The influence of the MRT line is able to stimulate harmonious spatial planning and sustainable growth, ultimately benefiting both the environment and the local community it serves. The MRT may impact population growth, economic progress, and infrastructure development, often leading to environmental

harm (Albalate and Bel, 2012), biodiversity loss, and increased carbon emissions, presenting challenges to sustainable urban growth on a worldwide scale. Urgent environmental planning is necessary for cities to achieve a balance between growth and sustainability, especially in Asia where rapid urbanization is transforming landscapes, particularly in major cities like Shanghai, Bangkok, and Jakarta. Asian cities are experiencing increasing challenges due to growing populations, economic development, and infrastructure needs, leading to expansive urban areas and stressed natural resources. This has led to higher levels of pollution, reduced green spaces, and heightened susceptibility to climate-related disasters, emphasizing the importance of sustainable urban planning. Examining the effects of sustainable urban transportation by the MRT is crucial. This is because the Chinese government recognizes that the past growth model of high-energy consumption, high pollution, high input, and low output is unsustainable. In Malaysia, there is a gap in understanding the full scope of the Mass Rail Train (MRT) impact. This difference underscores the need for further investigation into the impact on urban development remains underexplored.

Our study aims to bridge this gap by providing empirical insights into the broader and longer-term impacts of MRT to provide sustainable urban development in the cities. The United States and Europe suggest that the development of the highspeed rail infrastructure should be meticulously customized to the specific needs, taking into account every demand currently in the impacted corridor to make the financially and socially advantageous investment (Button 2012, Rus 2007). It is acknowledged that the green transportation infrastructure with the highest level of environmental degradation and energy consumption are both products of economic expansion (Zhang et al., 2021). To tackle these challenges, utilizing systematic review to grasp the MRT impact is essential. This review seeks to methodically examine the literature on train transportation, exploring research inquiries on the impact of trains on urban development and how the trains promote environmental sustainability. The review covers studies published from 2010 to 2023 that investigate train transportation on a global scale across different settings such as urban, suburban, and rural areas. While the influence of MRT on regional disparity is relatively well-known, there remains a significant gap in understanding whether and how MRT impacts the surrounding area and the technological innovations have been implemented to provide sustainable cities. By examining a systematic review, the research aims to understand the impact of the MRT. This analysis will offer insights into the wider implications of urban transportation projects on urban planning and development, providing valuable lessons for future initiatives in Kuala Lumpur and other rapidly urbanizing cities globally.

Methodology

According to (Dewey and Drahota, 2016) An approach to examining the literature that entails finding, picking, and assessing papers to answer research questions is called a systematic literature review (SLR). In contrast to a conventional literature review (LR), an SLR necessitates the application of certain methodologies and procedures. According to Mohamed Shaffril et al. (2021), the technique used in this study is based on "The ABC of systematic literature review: the basic methodological guidance for beginners." As illustrated in Figure 1, the document outlines seven essential procedures, including the following: (1) creating and verifying criteria; (2) formulating research questions; (3) employing organized search techniques; (4) assessing quality; (5) collecting data; (6) merging data; and (7) reporting results.

Figure 1. The ABC of systematic literature review

Creating and Verifying Criteria

Guidelines for the review process, publication standards, reporting criteria, or guidelines must be developed and validated before a systematic review can begin. Since existing standards primarily address health-related research, these guidelines—which were taken from Mohamed Shaffril et al. (2021) in their article "The ABC of Systematic Literature Review: The Basic Methodological Guidance for Beginners"—were chosen as a reference for this study to provide methodological support for health-related studies.

Formulating Research Questions

The population or problem (P), interest (I), and context (Co) of the PICo formulation are used to construct the research questions for this study. The systematic review procedure is greatly aided by these inquiries. The influence of MRT operations, how trains support environmental sustainability, new technical developments in rail travel, and upcoming trends are all covered under the study question in this article.

Employing Organized Search Techniques

The three primary procedures for the systematic searching strategies were eligibility, screening, and identification. Figure 2 is a modified flow diagram for the search process that helps clarify the steps involved in finding, vetting, and assessing the articles.

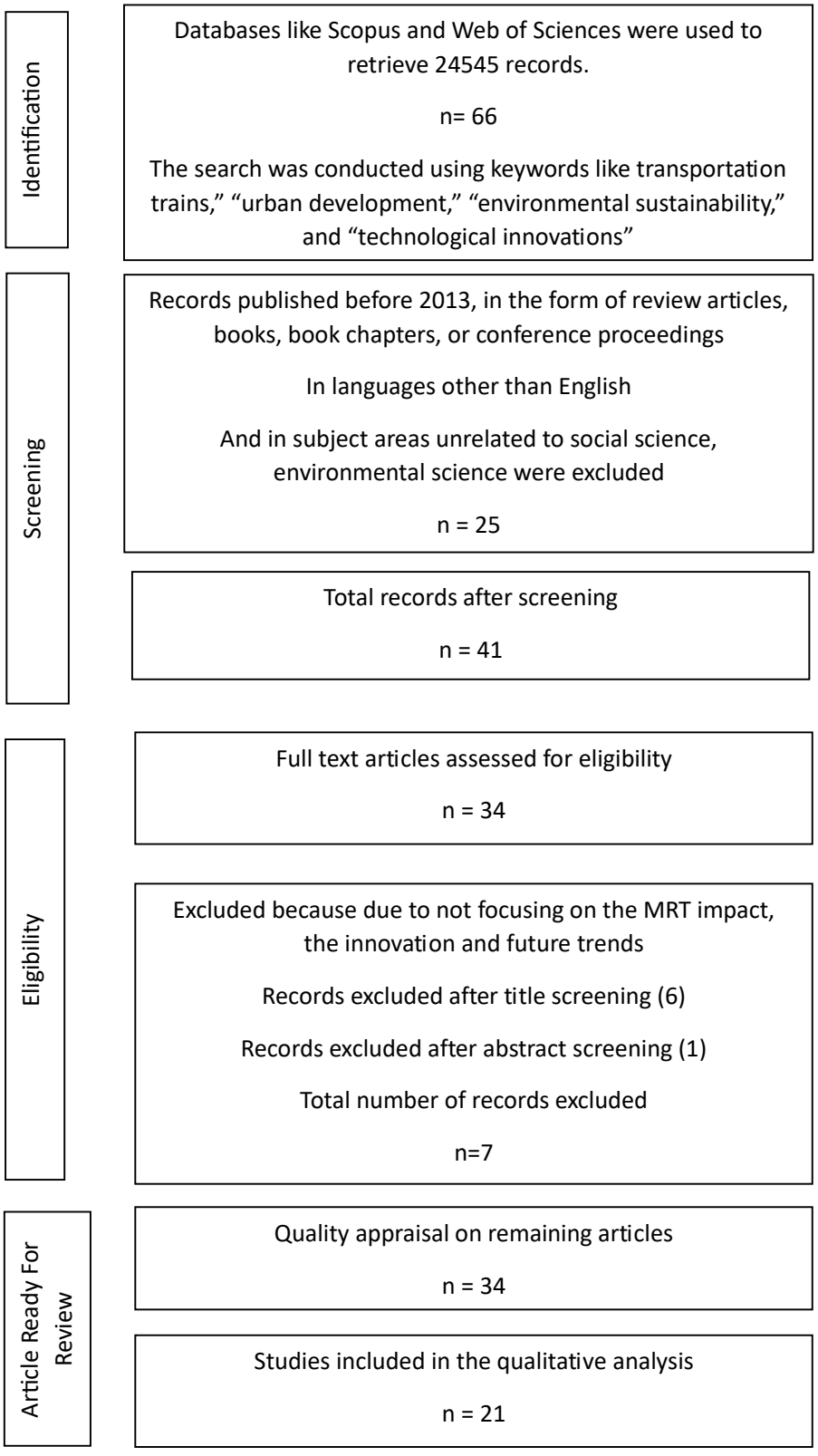

Figure 2. Flow Diagram of the Search Process

Identification

Finding synonymous, related, or comparable keywords to utilize when looking for relevant articles is known as identification. To increase the number of papers for the study, keywords are essential when creating searches for databases such as Scopus. This approach is emphasized by three main points: increasing the use of databases, improving the use of keywords, and improving article search tactics. Keywords like "transportation trains," "urban development, "environmental sustainability," and "technological innovations" were used to examine how high-speed trains affect urban development. As shown in Table 1, broadening the range of keywords used in the search can improve the finding of pertinent articles for the investigation. Scopus databases were utilized to gather the required articles, resulting in the identification of 66 articles during the identification process using these databases Figure 2.

Table 1
Search String

Database	Keywords
Scopus	TITLE-ABS-KEY(Transportation trains) AND (urban development) AND (environmental sustainability) AND (technological innovations)

Table 2
Inclusion and exclusion criteria

Criteria	Include	Exclude
Literature type	Journal (Research article only)	Journal (review article), book, Chapter in book, conference proceeding
Language	English only	Non-English
Timeline	2013 to 2023	< 2013
Countries & territories	Globally	
Subject area	Social science, environmental	Other than social science, environmental science, agriculture, sociology, climate change, economics

Screening

Screening involves filtering identified articles based on specific criteria outlined in Table 2. This initial filtration process is crucial for researchers to exclude irrelevant articles and focus on those that meet the five main criteria: literature type, language, timeline, countries and territories, and subject area. By screening out unnecessary articles, researchers can ensure that only relevant research articles from journals are included in the study while excluding review articles from various sources such as books, chapters, or conference proceedings. Excluded from the process were individuals not meeting the specified criteria. Additionally, the article must be written in English. Only studies conducted between 2013 and 2024 are considered suitable for inclusion. The study will focus on the countries that implemented transportation trains. Furthermore, only articles within the fields of environmental science and social science are deemed appropriate for this study. A total of 25 articles were eliminated based on the established criteria during the screening process.

Eligibility

The next step is the eligibility procedure, which is the second filtering or screening step. Forty-one full-text publications were evaluated for eligibility, as shown in Figure 2. In this step, the article was assessed using three main criteria: the article's focus, its abstract, and its title. Seven of the reviewed publications were disqualified because they had nothing to do with the topic of study. The remaining publications were subjected to a quality appraisal evaluation before data extraction and synthesis, as will be covered in the part that follows.

Assessing Quality

To ensure the quality of the articles, quality assessments must be carried out after systematic searches. Systematic literature reviews of chosen articles, in contrast to conventional literature reviews, need to go through quality assessment to guarantee their caliber. To facilitate the quality appraisal process, Hong et al. (2018) developed the Mix Method Appraisal Tool (MMAT). This tool covers the assessment of five different study types: qualitative research, randomized controlled trials, non-randomized studies, quantitative studies, and mixed-methods studies. It helps researchers evaluate systematic mixed-studies reviews. Depending on the type of article, the MMAT quality criteria are divided into five types (Hong et al., 2018). The quality of empirical studies or primary research based on observation, experimentation, or simulation can be evaluated using the MMAT (Abbott, 1998; Porta et al., 2014). Reviews and theoretical research are examples of non-empirical works with which they cannot be utilized. Additionally, the MMAT facilitates the evaluation of the majority of popular study designs and methodologies. Nevertheless, the MMAT is not appropriate for evaluating certain specific designs, such as studies on economic and diagnostic accuracy. For certain designs, additional critical evaluation methods could be useful.

Just 21 of the 34 articles that were evaluated for quality were chosen for qualitative synthesis (Figure 2). Twenty-one articles were deemed suitable for inclusion in the systematic review after the quality rating (Table 3). For an article to be taken into consideration for the study, it had to fulfill three of the five quality appraisal criteria on average. As a result, data extraction and synthesis were conducted using 21 papers written by different writers.

Table 3
Quality Assessment table

No	Study	Author	Research Design	QA1	QA2	QA3	QA4	QA5
1	The energy use and environmental emissions of high-speed rail transportation in China: A bottom-up modeling	Chang et al. (2019)	Quantitative descriptives studies	/	/	/	/	/
2	High-speed rail accessibility and haze pollution in China: A spatial econometrics perspective	Zhang et al. (2021)	Quantitative descriptives studies	/	/	/	/	
3	Development and application of a life cycle energy consumption and CO2 emissions analysis model for high-speed railway transport in China	Yan Zhee et al. (2021)	Quantitative descriptives studies	/	/	/		
4	Does the development of China's high-speed rail improve the total carbon productivity of cities?	Lin & Jia (2022)	Quantitative descriptives studies	/	/		/	/
5	Evaluating the Impact of High speed Rail on county-level Air Quality in China	Zhao et al. (2020).	Quantitative descriptives studies	/	/	/		
6	Sustainability by high-speed rail: The reduction mechanisms of transportation infrastructure on haze pollution	Chen et al. (2020)	Quantitative descriptives studies	/	/	/		

7	Impact of high-speed railway on gentrification and regional inequality in Japan	Yoo et al., (2024)	Quantitative descriptives studies	/	/	/		
8	How can HSR promote inter-city collaborative innovation across regional borders?	Yang & Ma (2023)	Quantitative descriptives studies		/	/	/	/
9	The impact of high-speed rail on urban carbon emissions: Evidence from the Yangtze River Delta	Tang et al. (2023)	Quantitative descriptives studies		/	/	/	
10	High-Speed Railway Opening and High-Quality Development of Cities in China: Does Environmental Regulation Enhance the Effects?	Jiang et al. (2022)	Qualitative studies			/	/	/
11	Riding the green rails: Exploring the nexus between high-speed trains, green innovation, and carbon emissions	Chen et al. (2023)	Qualitative studies	/	/	/		
12	The influence and spatial effects of high-speed railway construction on urban industrial upgrading: Based on an industrial transfer perspective	Shi & Wang (2024)	Quantitative descriptives studies	/	/	/		
13	Does China–Europe Railway Express Improve Green Total Factor Productivity in China?	Wang et al. (2023)	Quantitative descriptives studies	/	/	/		

14	A Key to Stimulate Green Technology Innovation in China: The Expansion of High-Speed Railways	Chen & He (2023)	Quantitative descriptives studies	/	/	/	
15	Impact of High-Speed Rail on the Development Efficiency of Low-Carbon Tourism: A Case Study of an Agglomeration in China	Li et al. (2024)	Quantitative descriptives studies	/	/	/	
16	How does high-speed railway affect green technology innovation? A perspective of high-quality human capital	He et al., (2023)	Quantitative descriptives studies	/	/	/	
17	Development patterns, material metabolism, and greenhouse gas emissions of high-speed railway in China	Mao et al. (2023)	Quantitative descriptives studies	/	/		/
18	Particulate Matter (PM10 and PM2.5) and Greenhouse Gas Emissions of UAV Delivery Systems on Metropolitan Subway Tracks	Choi et al., (2022)	Qualitative studies	/	/	/	
19	Do high-speed railways have an impact on population change? evidence from Japan	Wang et al., (2024)	Quantitative descriptives studies				
20	Bridging the gap between high-speed rail transport studies and cluster	Russel et al. (2024)	Qualitative studies	/	/		/

	economics through social knowledge exchange: future research potential					
21	Residents' support for Hyperloop development and their travel intention: a case study of Gyeongnam Province, South Korea	Kang et al. (2024)	Qualitative studies	/	/	/

Keywords: **QA** - Quality Assessment Criteria

Discussion

The purpose of this study is to determine the impact of transportation trains on urban development and sustainability. Through the analysis, we found that the sub-theme of the impact is divided into three themes, which are social impact, environmental impact, and economic impact. Table 4 describes the 21 studies' themes. Despite the wealth of literature on the train's impact, significant gaps remain. Particularly regarding the long-term socio-economic impacts of train systems and the integration of trains with other modes of transportation. This research is significant to explore how to increase collaborative creativity in regions with economic, cultural, policy, and administrative borders in addition to typical geographical barriers and validate the negative superposition effect of regional borders to give suitable references for policymakers.

Table 4
Subthemes of 21 studies

NO	Author	Social Impact	Environmental Impact	Economical Impact
1	Chang et al., 2019	/	/	/
2	Zhang et al., 2021	/	/	
3	Yan Zhee et al., 2021	/	/	/
4	Lin & Jia, (2022)	/	/	
5	Zhao et al. (2020)		/	
6	Chen et al., 2020		/	
7	Yoo et al., 2024	/		/
8	Yang & Ma (2023)			/
9	Tang et al. (2023)		/	

10	Jiang et al. (2022)	/	/	/
11	Chen et al. (2023)		/	
12	Shi & Wang (2024)			/
13	Wang et al. (2023)		/	
14	Chen & He (2023)		/	
15	Li et al. (2024)		/	
16	HeHe et al., (2023)		/	
17	Mao et al. (2023)		/	
18	Choi et al., (2022)		/	
19	Wang et al., (2024)	/		
20	Russel et al. (2024)	/		/
21	Kang et al. (2024)	/		

Conclusion

Ongoing improvement in transportation infrastructure is vital for achieving high-quality development, which in turn plays a crucial role in advancing social and economic sustainability. The development of transportation systems, particularly rail networks, can contribute to the modernization of industrial structures and the enhancement of social employment levels, which are essential for the growth of high-quality urban areas. Furthermore, the role of environmental regulation is paramount in guiding the effectiveness of these processes. The focus must shift from simple expansion to structural optimization in development, and restructuring the industrial sector is a key step in unlocking sustainable economic growth.

In Malaysia, the Mass Rapid Transit (MRT) project is a cornerstone of the long-term development strategy, with the potential to drive industrial upgrades, enhance social employment, and improve the transportation network. Compared to other transportation options, the MRT offers superior speed, efficiency, low energy consumption, cleanliness, and capacity, which facilitates greater connectivity and accessibility between cities. This, in turn, supports the movement of capital, labor, technology, and information, thus fostering improved quality of life and business opportunities. While high-quality development emphasizes sustainability, the features of this development also serve as essential enablers for long-term social and economic stability. Therefore, aligning global sustainable development goals with high-quality development frameworks is crucial.

However, there is a noticeable gap in the existing literature on the impact of high-speed rail on social and economic sustainability from the perspective of high-quality development. A key question remains: Can transportation infrastructure development be a tool for supporting high-quality growth in cities like Kuala Lumpur, especially within a condensed

global market? With rising resource constraints and environmental pressures, local governments in Malaysia have increasingly implemented environmental regulations to reduce urban and industrial emissions. As such, the sustainability of the social and economic effects of MRT openings must be critically assessed, particularly in light of these local environmental policies. The key issue, therefore, is to explore how environmental regulation interacts with the MRT development process and its implications for creating high-quality cities.

This research makes significant contributions both theoretically and contextually. From a theoretical standpoint, it expands the understanding of how infrastructure development, specifically MRT systems, influences sustainable urban development through industrial upgrades, employment growth, and environmental regulation. By introducing the concept of high-quality development as a framework, this study challenges conventional views of infrastructure development, focusing not only on economic growth but also on the sustainability and structural transformation of cities. Contextually, this study is highly relevant to Malaysia's urban and economic policy-making, particularly in the context of Kuala Lumpur. As the city continues to grow within a competitive global space, the findings of this research provide valuable insights into how the MRT can be leveraged to enhance regional integration, urban sustainability, and social resilience. Furthermore, it offers practical guidance for local governments in Malaysia, emphasizing the importance of aligning transportation development with environmental policies to ensure a balance between economic growth and sustainability. This research, therefore, serves as an important resource for future infrastructure planning and sustainable urban development strategies in Malaysia and beyond**.**

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