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RAILWAY MODERNIZATION IN INDONESIA: A COMPARATIVE STUDY OF FOUR COUNTRIES AND ITS POLICY IMPLICATIONS

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Abstract

This study examines structural and spatial gaps in Indonesia's railway network through a comparative analysis with Japan, India, the Philippines, and Uzbekistan, aiming to formulate adaptive, efficient, and sustainable railway modernization strategies. Using a qualitative descriptive-comparative approach grounded in pragmatism, the research emphasizes the policy relevance of global best practices adapted to Indonesia's context. Lessons from Japan and India highlight network integration, business diversification, and logistics efficiency, while the Philippines and Uzbekistan demonstrate the importance of adaptive governance, technological innovation, and institutional reform in strengthening interregional connectivity. In Indonesia, modernization should integrate the roles of PT Kereta Api Indonesia (KAI), the Directorate General of Railways, and local governments to enhance connectivity, improve logistics efficiency, and promote **equitable** regional development. These findings provide a conceptual and managerial reference for designing inclusive, adaptive, and **equitable** national public transport policies.

Keywords: Railway Modernization, Public Transport, Comparative Study, Regional Integration, Transport Policy, Equitable Development.

1. INTRODUCTION

The development and modernization of Indonesia's railway network represent a strategic effort to strengthen national connectivity and address rising mobility demands. This urgency is rooted in the country's long-standing railway legacy from the Dutch colonial period, when companies such as Staatsspoorwegen built extensive lines across Java and Sumatra in the late nineteenth and early twentieth centuries. However, much of this infrastructure has become outdated, with thousands of kilometers reported abandoned (Detik Finance, 2017). The key challenge lies in revitalizing these historical assets to meet current needs for efficiency, speed, and sustainable transport.

According to the Directorate General of Railways (2024), Indonesia's active railway length totals around 6,945 km across Java, Sumatra, and parts of Sulawesi. This figure remains modest compared with Japan's approximately 27,000 km and India's 68,000 km of operational railways (GoodStats, 2023). With a population of 286.7 million and a total area of 5.18 million km² (BPS, 2025), Indonesia's rail density remains relatively low. Therefore, expanding and modernizing the rail system is essential to enhance national connectivity, reduce logistics costs, and promote balanced regional development. Comparative insights from Japan, India, the

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Philippines, and Uzbekistan further reveal that modernization success depends on institutional reform, technological innovation, and adaptive governance.

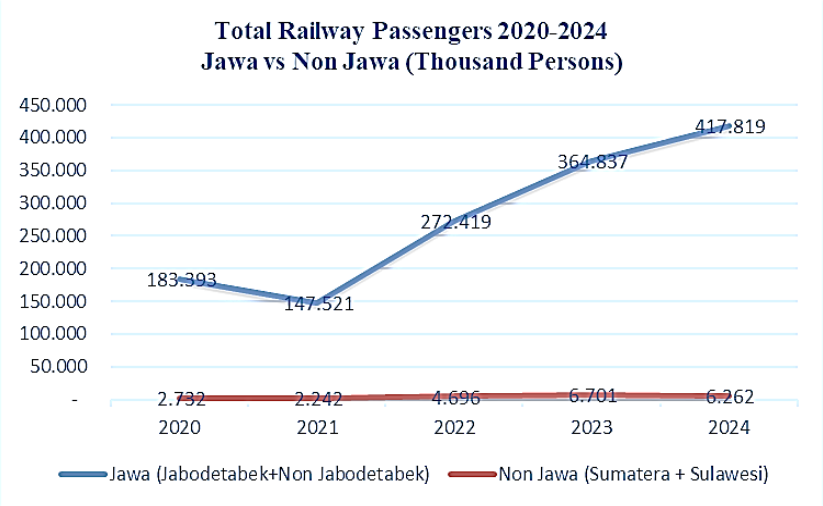

Figure 1: Total Railways Passenger 2020-2024
Source: BPS (2025), Data processed

Railway transportation in Indonesia has exhibited a consistent growth trajectory in both passenger volume. According to Statistics Indonesia (BPS, 2025), the total number of rail passengers has steadily increased over the past five years. As shown in Figure 1, in Java, combining Jabodetabek and non-Jabodetabek regions, the total passenger count rose markedly from 183.39 million in 2020 to 417.82 million in 2024, reflecting a growth of over 128% during this period. Meanwhile, non-Java regions, including Sumatra and Sulawesi, also experienced growth, albeit on a smaller scale, from 2.73 million passengers in 2020 to 6.26 million in 2024, representing a 129% increase.

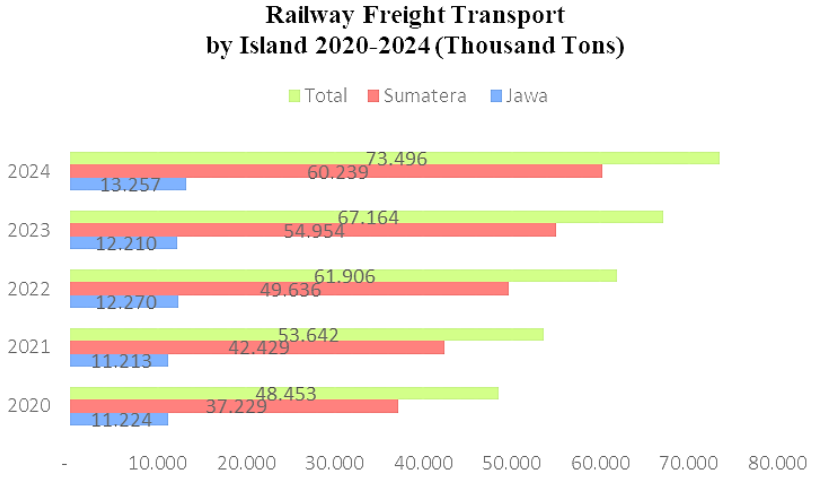

Figure 2: Total Freight Transport by Island 2020-2024
Source: BPS (2025), Data processed

Railway freight transport in Indonesia has shown a steady upward trend across all major islands between 2020 and 2024. As illustrated in Figure 2, total freight volume increased from 48,453 thousand tons in 2020 to 73,496 thousand tons in 2024, representing a growth of approximately 52% over the five-year period. Java consistently contributed a smaller portion

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of the total freight compared to Sumatra, with its volume rising modestly from 11,224 thousand tons in 2020 to 13,257 thousand tons in 2024. In contrast, Sumatra accounted for the largest share of freight transport, increasing from 37,229 thousand tons in 2020 to 60,239 thousand tons in 2024. This pattern highlights the dominant role of Sumatra in Indonesia's rail freight operations while indicating gradual growth in Java. These trends underscore Java's increasing dependence on rail transport for both goods and passenger movement, reflecting its central role in the country's economy.

Despite Indonesia's growing rail network, it remains heavily concentrated on Java, which covers only about 128,297 km² (Britannica, 2025), less than 7% of the country's total land area of 1.92 million km² (BIG, 2025). According to the Directorate General of Railways, Ministry of Transportation (2025), the national active railway length totals 6,945 km, with approximately 4,930 km, or about 71%, located in Java, 1,620 km in Sumatra, and 395 km in Sulawesi. This concentration highlights a significant imbalance in network distribution. Geographically, Sumatra spans roughly 473,481 km² (Adjar, 2024), nearly 3.7 times the size of Java, while Sulawesi covers around 189,216 km² (Britannica, 2025). This disparity underscores the need to expand and modernize rail infrastructure outside Java to improve logistics efficiency, strengthen inter-island economic integration, and support sustainable regional development.

Modernizing Indonesia's railway network is therefore a strategic imperative to address connectivity gaps, enhance logistics efficiency, and reduce spatial disparities. With a population exceeding 286 million, improving capacity, speed, and integration across transport modes is essential for efficient and equitable mobility of people and goods. Lessons from other countries provide guidance: Japan's integrated railway system based on Transit-Oriented Development (TOD) is efficient and sustainable; India positions railways as its logistics backbone; the Philippines struggles with governance and financing; and Uzbekistan combines physical modernization with institutional reform to strengthen regional connectivity. These examples suggest that effective railway modernization requires not only network expansion or fleet renewal, but also integration of physical, institutional, and socio-economic dimensions.

This study analyzes structural and spatial gaps in Indonesia's rail network through cross-country comparisons, aiming to formulate strategies suited to national geography and demographics. Using a descriptive-comparative qualitative approach grounded in pragmatism, it emphasizes practical policy relevance while drawing lessons from international experiences to develop adaptive, efficient, and sustainable modernization strategies.

The study's novelty lies in its comparative, cross-country perspective applied to Indonesia's transport and regional development context, an approach rarely addressed in national literature. Previous research has often been partial, focusing on railway history (Fauzi, 2023), user satisfaction (Jumardi et al., 2020), economic and social benefits in Java (Andiyan & Rachmat, 2021), or the role of PT Kereta Api Indonesia (Persero) in urban development (Biomantara & Herdiansyah, 2019). This study emphasizes strategic lessons from international experiences to guide adaptive, sustainable, and equitable railway policies, while providing a conceptual and managerial foundation for the Ministry of Transportation and PT Kereta Api Indonesia (Persero).

2. RESEARCH METHOD

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This study employs a qualitative approach with a cross-country comparative design grounded in a pragmatist paradigm. This paradigm allows flexibility in method selection according to the relevance of the research problem and objectives. From a pragmatist perspective, truth is contextual and measured by its practical effectiveness, making this approach common in public policy studies (Umi Rusilowati et al., 2025). The study is descriptive-exploratory, aiming to uncover patterns, strategies, and experiences of railway modernization in four countries, Japan, India, the Philippines, and Uzbekistan, selected through purposive sampling for their socio-economic, geographical, and transport policy contexts relevant to Indonesia. These countries offer diverse perspectives: Japan excels in efficiency and modal integration; India stands out for its large-scale mass network; the Philippines presents challenges typical of archipelagic infrastructure and financing; while Uzbekistan demonstrates the integration of physical modernization with institutional reform to strengthen regional connectivity.

Data were collected from 24 scholarly articles indexed in Google Scholar, as well as official reports and documents from multilateral organizations and government agencies, including the Ministry of Transportation of the Republic of Indonesia and Statistics Indonesia (BPS). Analysis was conducted in stages through reduction, classification, and thematic interpretation using a cross-case analysis approach (Shultz et al., 2020), comparing policies, technological innovations, governance, and economic impacts across countries. The results are not intended for statistical generalization, but to build conceptual understanding and managerial implications that can guide policymakers and transport industry stakeholders, particularly the Ministry of Transportation and PT Kereta Api Indonesia (Persero), in designing adaptive, sustainable, and equitable national railway modernization strategies.

3. RESULTS AND DISCUSSION

Japan: Post-War Modernization Model in an Archipelagic Nation

The comparative analysis of Japan's railway system provides a conceptual foundation for national railway modernization. Literature review of seven key publications shows that Japan's rail transformation has progressed continuously from post-war reconstruction, through deregulation, to the era of smart transport digitalization. The study highlights the integration of public policy, technological innovation, and institutional governance that has made Japan's railway system a long-term benchmark of efficiency and reliability. As a densely populated archipelagic nation, Japan has successfully positioned railways as the backbone of national transport through integrated management, a strong emphasis on safety and punctuality, and asset commercialization based on Transit-Oriented Development (TOD). This experience offers empirically relevant insights for Indonesia in restructuring its national railway system to serve as the backbone for both passenger mobility and inter-island logistics.

Table 1: Literature on Railway Modernization in Japan

No	Author, Year & Source	Approach & Focus	Key Findings	Relevance to Indonesia
1	Okada, H. (1994), *Japan Railway & Transport*	Descriptive-empirical: Socio-economic	Shinkansen enhances mobility	Provides historical context and

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	Review, Volume 3, pp. 9–16	impacts of Shinkansen, including interregional mobility, labor market expansion, and stimulation of domestic tourism	and economic activity across regions	justification for the importance of speed and connectivity in national railway development
2	Mizutani, F., & Nakamura, R. (2004), *Japanese Experience with Railway Restructuring*, University of Chicago Press	Historical policy analysis: JNR restructuring & regulatory reforms toward market-based efficiency through decentralization and privatization	Improved SOE efficiency and service quality	Relevant for designing governance and transforming state-owned enterprises in Indonesia's transport sector
3	Wetwitoo, S., & Kato, H. (2017), *City Science & Transport Planning*, Volume 5, Issue 4, pp. 549–559	Regional economic data analysis: Cross-regional economic impacts of high-speed rail (HSR)	HSR increases agglomeration and productivity through transport network externalities	Demonstrates potential long-term economic effects of HSR projects like Jakarta–Surabaya
4	Kim, J., & Huang, Y. (2021), *Privatisation of Japan Railways and Japan Post*, Springer	Policy analysis: Institutional reform & JR privatization, discussing rationale, process, and outcomes	Effective SOE (State-Owned Enterprise) governance model	Benchmark for privatization policy design or strategic partnerships in Indonesia's rail sector
5	Cao, Z. (2022), *Urban Rail Transit*, Volume 8	Case study: Transit-Oriented Development (TOD) and integration of station land use with railway networks	Improves land-use efficiency and economic value	Guides TOD development in Indonesian cities to support urban rail demand
6	Tomikawa, T., & Goto, Y. (2025), *Economies*, Volume 13, Issue 2	Quantitative, DEA & Malmquist Index: Operator efficiency & business diversification	Operators diversifying into retail and real estate are more efficient and sustainable	Model for performance enhancement and business innovation for national rail operators (KAI Group)
7	Bhatt, K., Kato, H., & Kurosaki, T. (2025), *High-Speed Rail Development in Japan*, Edward Elgar Publishing	Literature & policy synthesis: HSR modernization & national policy, safety regulations, digital technology integration	Highlights HSR modernization phases and policy strategies	Benchmark for long-term policy and strategy development for national railway modernization

Based on seven key publications summarized in Table 1, Japan's railway modernization shows a gradual evolution from physical infrastructure development to institutional reform and socio-spatial-economic integration. Post-war reconstruction reorganized the national transport system to support industrialization and regional growth, with modernization understood not merely as network expansion or speed improvement, but as a strategic combination of public policy, technological innovation, and institutional efficiency. The Shinkansen system exemplifies this approach, acting as a catalyst for socio-economic integration by accelerating mobility, expanding tourism, and reducing regional disparities (Okada, 1994). Institutional reform through the privatization of Japan National Railways (JNR) in the late 1980s further

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enhanced operational efficiency and business diversification via the creation of the JR Group (Mizutani & Nakamura, 2004). Well-planned spatial development, a focus on safety and punctuality, and modern corporate governance together have established Japan as a model for state-owned enterprise transformation that balances public service with sustainable economic performance.

High-speed rail also produces multiple effects on regional productivity through agglomeration and network externalities, where efficiency gains depend not only on speed but also on connectivity among hubs (Wetwitoo & Kato, 2017). Institutional transparency in privatization and public asset management is critical (Kim & Huang, 2021), while TOD-based spatial integration enhances economic value and urban transport sustainability (Cao, 2022). Railway operators combining transport services with non-transport sectors, such as real estate and hospitality, show greater resilience (Tomikawa & Goto, 2025). Digitalization, data-driven safety systems, and performance-based operational management are key pillars for long-term industry sustainability (Bhatt, Kato, & Kurosaki, 2025). For Indonesia, these findings emphasize the importance of integrating railway networks with industrial zones, ports, and urban centers to strengthen national competitiveness, reduce inter-regional disparities, and develop urban rail systems connected to commercial and residential areas.

India: A Large Country with a Similar Colonial History

The second stage of the analysis focuses on India, which shares a colonial history and a railway network structure similar to Indonesia. As one of the world's largest railway systems, India inherited rail infrastructure from Britain and has gradually modernized through electrification, service digitalization, and the development of Dedicated Freight Corridors (DFC) as the backbone of national logistics. This approach aligns with the pragmatist paradigm of this study, where policy success is evaluated based on practical effectiveness and empirical outcomes in a complex socio-economic context. A review of five key publications provides the conceptual foundation for understanding India's railway modernization strategies, offering insights relevant to the transformation of Indonesia's national railway system**.**

Table 2: Literature on Railway Modernization in India

No	Author, Year & Source	Approach & Focus	Key Findings	Relevance to Indonesia
1	Srivastava, S. C., Mathur, S. S., & Teo, T. S. (2007), *Journal of Information Technology*	Qualitative, case study: Digitalization of passenger reservation system in Indian Railways	Digital transformation improves public service efficiency and transparency	Provides a basis for ticketing and information system digitalization in PT KAI
2	Shrivastva, C. (2021), *Railway Transportation in South Asia: Infrastructure Planning, Regional Development and Economic Impacts*, Springer	Qualitative, policy analysis: Indian railway modernization and private sector operation challenges	Public–private collaboration accelerates infrastructure and service modernization	Relevant for establishing private investment partnerships in Indonesia
3	Sahu, P. K., Pani, A., & Santos, G. (2022), *Transportation in Developing Economies*	Quantitative, empirical study: Urban logistics and sustainable freight transport	Dedicated Freight Corridors reduce congestion and improve logistics	Important to support a national rail-based logistics system

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			efficiency	
4	Marik, G., & Dutta, A. (2023), *Journal of Transactions in Systems Engineering*	Qualitative, policy & literature analysis: Sustainable evolution of rail systems and energy technologies	Electrification and energy efficiency strategies in large, aged networks	Supports electrification programs for Indonesia's railway lines
5	Chandra, S., & Mishra, V. (2024), *Sustainability*	Quantitative, spatial/statistical analysis: Inter-zonal transport access gaps	Transport access influences socio-economic equity	Serves as a basis for infrastructure equity policies outside Java

India's railway modernization (see Table 2) presents a unique model of structural reform applied to a large, complex, and historically old system. Initial modernization efforts focused on public service, exemplified by the digitalization of the Passenger Reservation System (Srivastava et al., 2007), marking a key step toward operational efficiency and service transparency. Srivastava (2021) further highlights challenges in liberalizing the transport sector, where collaboration between government and private operators has driven infrastructure modernization, increased competition, and optimized public assets.

Subsequent transformation was supported by national logistics policies. Dedicated Freight Corridors (DFC) have strategically shifted freight from road to rail, significantly reducing distribution costs and time across regions (Sahu et al., 2022). This corridor-based approach reflects a pragmatist transport policy emphasizing systemic effectiveness over mere network expansion. Sustainability has also been central, with electrification and energy efficiency forming the core of India's move toward green transport (Marik & Dutta, 2023). From a spatial and development equity perspective, modernizing networks and equalizing infrastructure investment are crucial to reduce inter-regional access disparities (Chandra & Mishra, 2024).

India's railway modernization illustrates a balance between technical upgrades and institutional reform. Strategies emphasizing public–private collaboration, electrification, and corridor-based logistics offer strategic lessons for Indonesia in restructuring its national railway system. Within a pragmatist framework, India's experience shows that policy effectiveness depends not merely on the speed of modernization but on the system's ability to adapt to dynamic social, geographic, and economic contexts.

Philippines: An Archipelagic Nation with Similar Challenges

The Philippines was selected for comparative study due to its characteristic archipelagic challenges, including limited inter-regional land connectivity, weak governance, and constrained financing and railway network expansion—issues also relevant to Indonesia. These complexities often result in delayed or suboptimal transport projects, making the Philippine experience an important lesson on the consequences of treating railway modernization as a non-strategic national agenda. This perspective provides valuable guidance for designing Indonesia's railway modernization strategies that are efficient, inclusive, and supportive of inter-regional development equity.

Table 3: Literature on Railway Modernization in the Philippines

No	Author, Year & Source	Approach & Focus	Key Findings	Relevance to Indonesia

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1	Orbon, G., & Dungca, J. (2015), *The Philippine Railway System*	Descriptive-historical: Condition and history of the Philippine railway system	Limited rail infrastructure, inconsistent operations, and failure to expand the network	Highlights the risk of failed railway modernization if it is not a national priority
2	Francisco, K. A. (2024), *Transport Infrastructure in the Philippines: From Plans to Actual Allocation*, PIDS Discussion Paper Series No. 2024-51	Policy & budget analysis: Discrepancy between project planning and implementation	Budget allocation gaps caused many projects to be delayed or abandoned	Emphasizes the importance of funding allocation and oversight in national railway modernization
3	Navarro, A. M., & Latigar, J. S. (2022), *Road and Rail Transport Infrastructure in the Philippines: Current State, Issues, and Challenges*, PIDS Discussion Paper Series No. 2022-34	Empirical & survey analysis: Status and challenges of road and rail infrastructure	Low transport integration and limited rail coverage in remote areas	Provides insight into geographical and managerial consequences for developing a national rail network
4	Sunio, V., Argamosa, P., Caswang, J., & Vinoya, C. (2021), *The State in the Governance of Sustainable Mobility Transitions in the Informal Transport Sector*, Research in Transportation Business & Management, 38, 100522	Qualitative, case study: Governance of sustainable mobility in the informal transport sector	Weak institutions and inconsistent regulations hinder transition to integrated transport systems	Serves as a lesson on the importance of governance in railway modernization and urban mobility
5	Lamberte, A. E. (2022), *Market Report: Philippines Business Opportunities in Rail Transport*	Market & investment analysis: Economic potential and investment opportunities in rail	Business potential is underutilized due to lack of coordination and regulatory certainty	Shows the relevance of investment strategy and regulation for national railway d

Several studies (see Table 3) indicate that the Philippine railway system faces significant limitations in both infrastructure and governance. Historically, the country's rail network has been limited, and operations have been inconsistent, resulting in frequent failures in network expansion (Orbon & Dungca, 2015). Policy and budget analyses reveal a gap between transport project planning and actual budget allocations, causing many infrastructure projects to be delayed or abandoned (Francisco, 2024).

Empirical studies on road and rail infrastructure further highlight poor transport integration and limited rail coverage to remote areas, exacerbating inter-regional mobility barriers (Navarro & Latigar, 2022). Institutional and regulatory factors also pose major obstacles, as transitions toward more sustainable and integrated transport systems are often hindered by weak governance and inconsistent regulations (Sunio, Argamosa, Caswang, & Vinoya, 2021). From an economic and investment perspective, the rail transport market

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potential remains underutilized, with regulatory uncertainty and inter-agency coordination gaps limiting opportunities for business development and network modernization (Lamberte, 2022). Overall, the Philippine experience demonstrates that railway modernization requires not only physical planning but also strengthened governance, consistent budget allocation, and regulatory certainty to ensure effective implementation.

Uzbekistan: Railway Modernization, Economic Integration, and Institutional Reform

Uzbekistan provides valuable insights for analyzing national railway modernization policies, particularly due to the synergy between institutional reform and strategic investment in physical rail infrastructure. For example, the USD 150 million locomotive fleet renewal plan through 2033 reflects a systemic approach rather than mere physical expansion (Kun.uz, 2025). This modernization aligns with findings from ESCAP (2021) and UNESCAP (2024), which emphasize the importance of strengthening cross-border connectivity within Central Asia's logistics chains and positioning railways as instruments of economic integration and regional sustainability. The ITF (2022) report also highlights that transport modernization in Central Asia is only effective when accompanied by governance reform, digitalization, and cross-sector institutional coordination. Lessons from Uzbekistan can therefore inform Indonesia in developing a more comprehensive railway modernization strategy that integrates physical, institutional, and socio-economic dimensions within the national transport development agenda.

Table 4: Literature on Railway Modernization in Uzbekistan

No	Author, Year & Source	Approach & Focus	Key Findings	Relevance to Indonesia
1	World Bank (2019), *Uzbekistan: Building blocks for integrated transport and logistics sector development*	Policy analysis; focus on national logistics system integration	Highlights the need for synergy between railways, roads, and ports to support national connectivity and exports	Provides lessons on the importance of multimodal planning and integrated logistics policies to support connectivity-driven economic growth
2	Asian Development Bank (ADB) (2019), *Republic of Uzbekistan: Preparing railway modernization projects*	Project and investment readiness study; focus on electrification and network modernization	Identifies initial investment needs for electrification and mainline upgrades to accelerate passenger and freight mobility	Serves as a reference for infrastructure investment planning based on priority needs and multilateral support
3	Yusufov, A. (2023), *Analysis of the state and prospects for the development of the locomotive fleet JSC "O'zbekiston Temir Yo'llari"*	Technical and analytical study; focus on national locomotive fleet	Shows the need for fleet renewal and energy efficiency improvements in the national railway system	Emphasizes the importance of fleet renewal strategy and operational efficiency for state-owned transport companies in Indonesia
4	Azimov, N. (2023), *Expanding digital services in the Uzbekistan railway*	Normative and legal policy approach; focus on digitalization of services	Outlines strengthening the legal framework for digital services and	Relevant for Indonesia in promoting digitalization of

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	transportation sector		transport system security	public transport services with adaptive legal foundations
5	Abdazimov, S. K., & Tukhtabaev, S. T. (2024), *Importance of railway safety of the Republic of Uzbekistan*	Descriptive approach; focus on operational safety and risk management	Highlights the need to improve safety systems and personnel training to support modernization	Provides an important reference for strengthening safety culture in national railway modernization projects
6	Mukhamedova, Z., Mukhamedova, D., Fuzailova, G., Ergasheva, Z., & Yakupbaey, K. (2024), *A review of railway transportation in Central Asia for corridors and the revival of the Great Silk Road*	Regional study; focus on trade corridors and cross-border integration	Illustrates Uzbekistan's strategic position in Eurasian transport networks through international rail corridor development	Offers a comparative basis for Indonesia to integrate railway policy with regional connectivity strategies in ASEAN
7	Turaev, B., Shodiev, K., & Atamuradov, U. (2024), *Problems and prospects of developing railway infrastructure in New Uzbekistan*	Policy and infrastructure development analysis; focus on long-term prospects	Identifies funding challenges and institutional coordination issues in large-scale infrastructure projects	Relevant for understanding the importance of governance and cross-sector coordination in national railway modernization projects

Table 4 shows that railway modernization in Uzbekistan reflects a comprehensive structural transformation encompassing policy, technical, digital, and institutional aspects. An initial study by the World Bank (2019) positioned rail system development as part of a broader national transport integration strategy. The proposed multimodal approach emphasizes the synergy between railways, land logistics, and ports as a foundation for efficient economic connectivity. This perspective is reinforced by the Asian Development Bank (2019), which highlights the readiness of electrification projects and capacity upgrades of main networks as milestones for shifting Uzbekistan's transport system toward modern energy-efficient and high-speed standards.

Technical transformation has progressed into operational domains. Yusufov (2023) underscores the strategic importance of renewing the national locomotive fleet to enhance operational efficiency and reduce reliance on outdated technology. Complementarily, Azimov (2023) emphasizes the need for railway service digitalization and updated legal frameworks to support data security and efficient digital services. These studies illustrate that physical modernization must proceed alongside regulatory innovation and digital service integration, reflecting a comprehensive reform pattern.

From the perspective of safety and operational governance, Abdazimov and Tukhtabaev (2024) stress that successful modernization depends not only on physical infrastructure but also on enhanced safety management systems and human resource competencies. Mukhamedova et al. (2024) extend this view by positioning Uzbekistan as a strategic hub within the Eurasian

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transport corridor, highlighting the role of rail modernization in economic diplomacy and regional integration, particularly in the context of the revived "New Silk Road." Finally, Turaev, Shodiev, and Atamuradov (2024) emphasize institutional and long-term financing dimensions, demonstrating that cross-sector coordination is crucial to sustaining national-scale modernization projects.

The integration of these findings shows that railway modernization in Uzbekistan is not merely physical development but a structural reform uniting technical, institutional, and digital dimensions within a long-term development framework. For Indonesia, Uzbekistan's experience is relevant in three main aspects. First, adaptive institutional design is necessary to ensure that railway reform is sustainable systemically, not just project-oriented. Second, digitalization and modal integration are key to enhancing operational efficiency and safety. Third, Uzbekistan's use of railway projects as a driver for regional connectivity offers a model for Indonesia to strengthen inter-regional integration and promote logistics-based economic growth. Thus, the Uzbekistan case enriches the policy analysis dimension for Indonesia's railway modernization, highlighting the balance between physical transformation and institutional reform.

Discussion

Cross-national analysis indicates that railway modernization is a multidimensional process requiring synergy among infrastructure, institutions, economy, and technology. This synthesis offers valuable lessons for Indonesia in formulating adaptive and sustainable railway modernization policies, including policy transfer to adapt global best practices to the national context, particularly in developing Transit-Oriented Development (TOD) as a tool for spatial integration and sustainable mobility.

First, railway modernization encompasses not only physical infrastructure but also institutional reform, system digitalization, socio-economic integration, and business diversification. Japan emphasizes institutional reform and network integration as part of national development strategies (Okada, 1994; Tomikawa & Goto, 2025), while India highlights passenger reservation system digitalization to improve service efficiency and transparency (Srivastava et al., 2007). Second, integrating rail networks with industrial zones, ports, and logistics hubs has proven to enhance regional productivity and national competitiveness. Japan's high-speed rail strengthens regional economic integration (Wetwitoo & Kato, 2017), whereas India's Dedicated Freight Corridors reduce distribution costs and improve inter-regional efficiency (Sahu et al., 2022).

Third, governance and regulation are critical determinants of modernization success. Institutional reforms and the privatization of Japan National Railways enhanced efficiency and business diversification (Kim & Huang, 2021), while public–private partnerships in India accelerated modernization and optimized public assets (Shrivastva, 2021). Weak governance and institutional coordination in the Philippines have caused inconsistent railway operations and frequent failures in infrastructure expansion (Orbon & Dungca, 2015). Policy and budget analyses further highlight gaps between planning and fund allocation, leading to delayed transport projects despite available physical resources (Francisco, 2024). Fourth, digitalization, data-driven safety systems, and technological innovation underpin sustainable railway modernization. In Uzbekistan, railways are positioned at the core of national logistics integration, emphasizing cross-modal connectivity as a basis for economic efficiency (World Bank, 2019). Asian Development Bank (2019) reports underscore electrification of main lines

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as a transition to low-emission, high-speed transport. Operationally, locomotive fleet modernization improves capacity and reduces maintenance costs (Yusufov, 2023), while service digitalization and updated legal frameworks ensure data security and operational efficiency (Azimov, 2023).

From a safety and governance perspective, system management reform and technical workforce development are essential for long-term sustainability (Abdazimov & Tukhtabaev, 2024). On a broader scale, Uzbekistan's strategic position in the revived Eurasian transport corridor links railway modernization with regional economic diplomacy (Mukhamedova et al., 2024), reinforced by long-term financing and cross-sector coordination as determinants of sustained success (Turaev, Shodiev, & Atamuradov, 2024).

The synthesis across Japan, India, the Philippines, and Uzbekistan demonstrates that railway modernization is a structured, layered process encompassing technical upgrades, system digitalization, safety enhancement, and strengthened governance. This comprehensive approach confirms that railway development is not solely infrastructure-oriented but serves as a tool for economic and institutional reform. For Indonesia, these international experiences highlight the importance of integrating technological innovation, adaptive institutions, and connectivity-focused policies to enhance national transport competitiveness and promote equitable regional development.

Indonesia's railway modernization strategy aligns with international practices while emphasizing adaptation to national socio-economic contexts. PT Kereta Api Indonesia (KAI) plays a central role in urban development and inter-regional connectivity (Biomantara & Herdiansyah, 2019). Urban planning and service efficiency in Jakarta are highlighted as critical for integrated transport (Jumardi et al., 2020), and railway infrastructure development in Java improves accessibility and economic productivity (Andiyan & Rachmat, 2021). Historically, railways have catalyzed local socio-economic transformation, reinforcing their relevance in regional development (Fauzi, 2023).

Policy Implications

The implementation of railway modernization in Indonesia carries strategic implications for PT Kereta Api Indonesia (KAI), the Directorate General of Railways, and regional governments expanding rail-based transport networks. Modernization goes beyond infrastructure, serving as a tool for regional development, economic integration, and long-term spatial planning. Policy should focus on strengthening inter-island connectivity through integrated rail networks linking ports, industrial zones, logistics hubs, and tourism and trade centers. Lessons from Uzbekistan highlight the importance of linking rail development to economic corridors beyond Java, while Japan demonstrates that institutional reform, network integration, and high-speed rail systems enhance efficiency and regional competitiveness. India emphasizes digitalized services and public–private collaboration to improve efficiency and transparency, whereas the Philippines underscores that weak governance, inconsistent regulation, and budget gaps can undermine modernization efforts. Transit-Oriented Development (TOD) should be optimized to create productive satellite cities in Sumatra, Kalimantan, Sulawesi, and eastern Indonesia, generating strategic value through improved distribution efficiency, reduced spatial disparities, and stronger regional economic integration.

From a governance perspective, modernization requires adaptive organizations, digitalization, data integration, and cross-sector collaboration. PT KAI and the Directorate General of Railways should strengthen coordination with local governments under integrated

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urban–regional governance and expand partnerships with the private sector through Public Private Partnerships (PPP) to ensure sustainable financing. Following lessons from Uzbekistan, Japan, and India, enhancing human resource capacity and implementing data-driven systems, such as predictive maintenance, energy-efficient locomotives, and centralized railway control centers, is critical for safety, efficiency, and service competitiveness. By integrating railway modernization, TOD, and industrial and tourism zones into the "Indonesia Emas 2045" (Golden Indonesia) vision, the national transport system can deliver efficient, green, and spatially equitable mobility, reinforce national competitiveness, and accelerate decentralized, sustainable economic growth across the archipelago.

4. CONCLUSION

The synthesis of cross-country studies and the analysis of policy implications confirm that the proposition regarding the effectiveness of railway modernization remains valid and relevant. Effectiveness is not determined solely by network expansion or fleet renewal but depends on the integration of physical, institutional, and regional economic dimensions that sustain public transport functionality. Lessons from Japan, India, the Philippines, and Uzbekistan demonstrate that railway modernization achieves greater impact when accompanied by institutional reform, service digitalization, and alignment with regional development policies. Accordingly, the railway system functions not merely as a means of transport but as an instrument of national development that strengthens connectivity and spatial equity.

Railway modernization in Indonesia should be understood as a long-term transformative process requiring cross-sector collaboration, technological innovation, and adaptive governance. Its success depends on the ability of government institutions (the Directorate General of Railways, local governments) and state-owned enterprises (notably PT KAI) to integrate the rail system with economic growth centers, logistics hubs, industrial zones, and Transit-Oriented Development (TOD). Lessons from Uzbekistan underscore the importance of digitalization and institutional reform to ensure that modernization projects go beyond physical construction toward operational efficiency, enhanced safety, and decentralized economic growth across islands.

Future research is recommended to focus on institutional analysis and collaborative governance that supports the sustainability of modernization programs. In-depth studies on inter-agency coordination—including government bodies, SOEs, and private partners—are necessary to understand the dynamics of effective institutional synergy in the context of decentralized development. Furthermore, research on the integration of technology such as the Internet of Things (IoT), predictive maintenance, and data-driven safety systems will be essential to strengthen the efficiency and reliability of the national rail network.

Subsequent studies should also explore the socio-economic and spatial impacts of railway modernization on communities along the rail corridors. Participatory and region-based approaches can enrich understanding of how modernization projects drive local economic transformation, reduce interregional disparities, and enhance social mobility. Therefore, future research is expected not only to deepen theoretical insights into railway modernization but also to provide inclusive, contextually grounded, and adaptive policy recommendations aligned with the national sustainable development agenda.

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