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Article

The current situation and the directions of changes in rail freight transport in Thailand

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Abstract: The purpose of the article is to present the current situation in the rail freight transport in Thailand and the direction of changes in this area. Firstly, Thailand statistics in volume of freight transport by rail and modal share of freight transport have been presented. Afterwards, problems and obstacles in railway operational practices and in using rail transport services have been identified to improve railway system in Thailand and the outcome was assessed in terms of railway capacity and utilization. The findings were used to outline the direction of changes in rail freight transport. The results show that the rail transport capacity in double-track would increase by 48% (at present by 15.5% and as plan by 30%) and the ratio by rail transport to total freight transport would increase from at present by 1.87% to 10% in 2037.

Keywords: freight transport; modal share; rail transport; railway operational; Thailand

1. Introduction

Nowadays, the pursuit of technological progress, innovation, and the desire for faster and more cost-effective solutions has driven significant changes in the transport industry. These changes have not only reshaped the way goods and people are moved but have also contributed to economic growth, urban development, and societal transformation. The volume of trade in Asia has greatly increased due to export-oriented policies. The region has seen acceleration towards globalization of domestic economies, reflecting the rise of e-commerce which has propelled a significant transformation in the transport sector. The rapid evolution of technology has raised customer expectations for convenience, speed, and reliability in transportation services. This has spurred continuous innovation to meet and exceed these expectations.

Infrastructure development in the transport and logistics sector in Thailand to serve globalization and transformation relates to the improvement and expansion of transportation networks, including roads, railways, waterways, and airways, as well as the enhancement of supporting facilities and systems. Evolving demands of the 21st century, need to develop a seamless and integrated multimodal transportation system that encompasses roads, railways, waterways, and airways in order to create a robust network capable of accommodating the growing needs of both people and goods transportation. It is known that intermodal transport must be able to compete on the vital middle distances of 200 to 500 km and lower transport cost by rail (Baht/tonne-km), would enhance the development of intermodal transport as a competitive alternative to modally based operations (OECD, 2002). Rail transport serves as a vital link in the multimodal transportation network. It connects with other modes of transport, such as trucks and ships, to create a seamless and integrated intermodal transport system. In addition, intermodal transport utilizing rail can contribute to sustainability goals and reduce the carbon footprint of freight transport.

There are several literatures that have studied the directions of changes in rail freight transport. The key points are reviewed and summarized as follows:

1.1. Transport infrastructure, technological innovations, and policy frameworks

Transport infrastructure and policy frameworks play a foundational role in the development and efficiency of rail freight transport. Significant investments in infrastructure, such as enhancements to substructures, bridges, ports, tunnels, and track systems, are necessary to meet the increasing demands of freight transport (Cohen-Blankshtain, 2021; Gonzalez-Aregall et al., 2021; Morales-Gamiz et al., 2016; Woodburn, 2017) and to support longer, heavier trains, thus improving operational efficiency and reliability (Morales-Gamiz et al., 2016). Upgrading existing rail infrastructure to accommodate increased freight volumes and modern demands is essential, as are strategic investments in intermodal facilities to support seamless transfers between transport modes (Engström, 2016; Luathep et al., 2016; Morales-Gamiz et al., 2016; Mutlu et al., 2017). Effective policy frameworks, such as the European Commission's White Paper, aim to shift a significant portion of road freight to rail and inland waterways by 2030, highlighting the importance of regulatory support in promoting modal shift (Islam et al., 2016; Troch et al., 2017). Additionally, technological innovations like autonomous rail systems, IoT for real-time tracking, blockchain for supply chain transparency, and predictive maintenance are revolutionizing the industry by enhancing efficiency and reliability (Grimaldi, 2016; Yusoff, et al., 2021). Additionally, predictive maintenance technologies, leveraging big data and machine learning, are enabling rail operators to anticipate equipment failures and perform maintenance proactively, thereby reducing downtime and operational disruptions (EU, 2020) as well as using system dynamics models to support strategic planning and policy-making aimed at decarbonizing the freight transport sector (Ghisolfi et al., 2022). Public-private partnerships also play a critical role, aligning the interests of public agencies and private rail companies for successful planning, funding, and implementation of rail projects (Bryan et al., 2007) leading to a more efficient and sustainable freight transport system (Daramola, 2022). Railroad infrastructure investments significantly boost GDP, private investment, and job creation, with substantial long-term benefits (Rodrigues et al., 2024). The importance of strategic investments and policy measures to enhance the competitiveness and sustainability of rail freight transport, promoting a balanced and efficient transportation system (Bouchery and Fransoo, 2014; Minárik, 2021; Moora et al., 2023; Troch et al. 2017; Wangai et al., 2020; Zimmer and Schmied, 2008). Coordinated policy efforts at local, national, and international levels are needed to facilitate modal shift, harmonize regulations, and promote public-private partnerships, ensuring a seamless and efficient transport system (Gonzalez-Aregall et al., 2021;

Lasserre et al., 2020; Yusoff et al., 2021).

1.2. Environmental and economic impacts of modal shift

The desirability of shifting freight from road to rail is driven by its significant environmental and economic benefits. Rail freight transport produces considerably lower greenhouse gas or CO_2 emissions compared to road transport, making it a more sustainable option (EU, 2020; Engström, 2016; Moora et al., 2023; Minárik, 2021; Zimmer and Schmied, 2008). The green credit policy can encourage environmentally friendly practices, promote sustainable development, and improve financial performance (Chen et al., 2024). Rail transport is inherently more energy-efficient and capable of handling larger volumes of freight, which contributes to its environmental benefits (Daramola, 2022; Moora et al., 2023). The social benefits of rail freight include reduced traffic accidents and fatalities, as rail transport is statistically safer than road transport. Studies have also highlighted the positive land use impacts of rail freight, such as the potential for revitalizing industrial areas and promoting sustainable urban development (Kramarz and Przybylska, 2021). Economically, modal shifts improve efficiency by reducing fuel costs and congestion-related expenses, making rail transport a cost-effective alternative (Jonkeren et al., 2019). The broader economic impacts of rail investments include stimulating economic growth, enhancing connectivity, and improving access to markets, as evidenced by transport investment in Thailand which positively impacted GDP (Pechdin and Swangsilp, 2024). Comprehensive cost-benefit analyses are crucial to justify public investments in rail infrastructure by considering direct transportation cost savings, environmental benefits, and broader economic impacts (Bryan et al., 2007; Halim, 2023).

1.3. Policy evaluation, market dynamics, and best practices

Evaluating and implementing effective policies are crucial for the success of rail freight transport. Supportive policies and incentives, such as financial incentives and streamlined administrative procedures, are necessary to encourage modal shifts (Moora et al., 2023; Zimmer and Schmied, 2008). Measures like Eco bonus schemes and increased road tolls have been successful in promoting shifts to rail and sea transport in regions like the Nordics (Pinchasik et al., 2020) and other modal shift measures are essential to achieve the desired impact on reducing greenhouse gas emissions and promoting sustainable transport (Beila and Putz, 2023; Winkler and Mocanu, 2020). Analyzing market dynamics and competition within the rail freight sector provides insights into the industry's competitive landscape and regulatory challenges. Efforts to liberalize markets aim to increase competition within the rail sector, potentially leading to improved service quality and lower costs (Lasserre et al., 2020) including the need for harmonized regulations and policies to facilitate fair competition and efficient operations across different transport modes (Bryan et al., 2007). Policy evaluation tools, such as shift-share analysis, are useful in assessing the impact of modal shifts on CO_2 emissions and economic performance, helping policymakers understand the potential benefits of shifting freight from road to rail (Bouchery and Fransoo, 2014; Jonkeren et al., 2019; Kaack et al., 2018). Successful intermodal transport systems leverage the strengths of each transport mode to reduce overall transportation costs, minimize handling times, and improve logistical efficiency (Kramarz and Przybylska, 2021; Lin et al., 2024; Meers and Macharis, 2015; Yusoff et al., 2021). Container yards (CY), Inland Container Depots (ICD), and inland ports significantly enhance the efficiency, sustainability, and resilience of freight transport by enabling seamless transitions between transport modes, minimizing delays, and increasing supply chain flexibility (Ansah et al., 2020; Ghaderi et al., 2016; Yu et al., 2022; Zhang et al., 2015). Successful examples of multimodal transport systems can be seen in regions where strategic investments in infrastructure and policy support have fostered efficient and sustainable transport networks (Kramarz and Przybylska, 2021). Notably, case studies from Switzerland, China, Malaysia, Indonesia and Thailand demonstrate that robust infrastructure, supportive policies, and effective stakeholder collaboration are key strategies for enhancing rail freight systems, offering valuable lessons that can be adopted by other regions (Guo and Thanathawee, 2019; Halim, 2023; Lasserre et al., 2020; Peetawan and Suthiwartnarueput, 2018; Yusoff et al., 2021).

In conclusion, strategic investments in infrastructure, technological advancements, and effective policy frameworks for promoting rail freight transport are important. Modal shift from road to rail offers significant environmental, economic, and operational benefits. Coordinated policy efforts, public-private partnerships, and strategic planning are crucial for achieving these goals. The success of rail freight transport depends on a comprehensive approach that integrates technological innovation, infrastructure development, and robust policy measures.

In the context of rail freight transport, Thailand aims to drive its economy while being mindful of energy use and environmental impact through rail systems. This research significantly contributes to promoting rail freight transport by analyzing problems and obstacles identified through meetings and in-deep interviews with actual freight operators and business organizations. It offers strategic directions to shift freight transport towards rail, aiming to achieve the country’s targeted rail transport proportions.

2. The situation of rail freight transport

2.1. The current railway network of Thailand

The current railway network of Thailand has a total currently distance of 4044 km, serving both passenger and freight transport 3310 km consist of single tracks, accounting for 81.85%. Double tracks cover around 627 km, amounting for 15.50%, and the remaining triple track covers about 107 km, amounting for 2.65% (Department of Rail Transport, 2023). Thailand has been actively investing in its rail infrastructure to enhance the efficiency and capacity of its rail freight transport system. Projects like the double-track rail system and the Eastern Economic Corridor (EEC) railway development are aimed at modernizing and expanding the rail network. To be Thailand’s strategic location in Southeast Asia, Thailand has been improving in rail freight that could facilitate cross-border trade and connectivity with neighboring countries, promoting economic growth and regional integration.

2.2. Rail transport of goods in Thailand

Rail transport in Thailand is previously used for bulk goods such as agricultural products (rice, tapioca, sugar), minerals, construction materials, and industrial products. In **Figure 1**, in 2022 LPG gas, crude oil, general oil, cement, containers are presently transported in total volume of 11.08 million tonne or 2672 million tonne-kilometres, CAGR of 0.11% between 2012–2022. Volume of freight transport by rail in Thailand expressed in tonne and tonne-kilometres are shown in **Figure 2**.

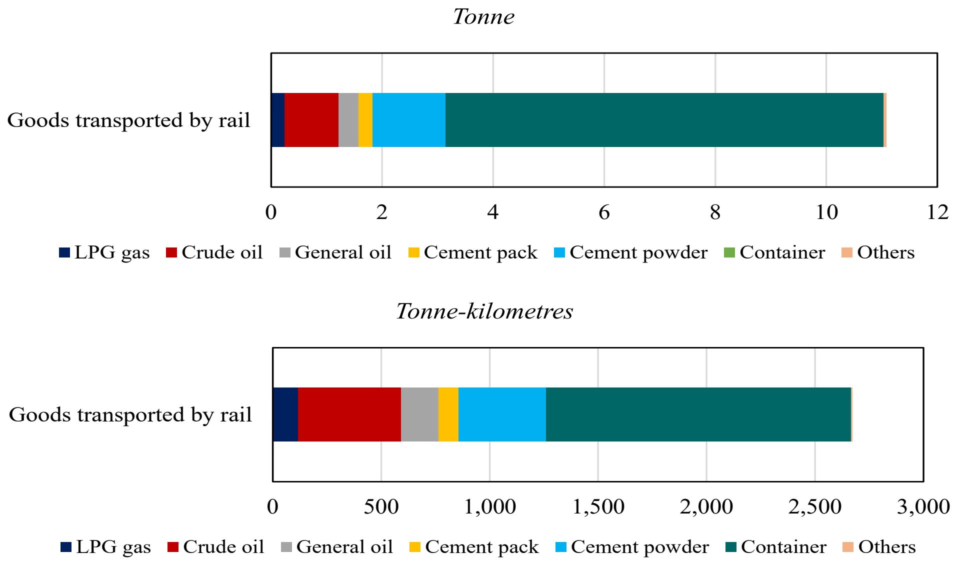

Figure 1. Type of goods transported by rail in Thailand 2022 in tonne and tonne-kilometres.

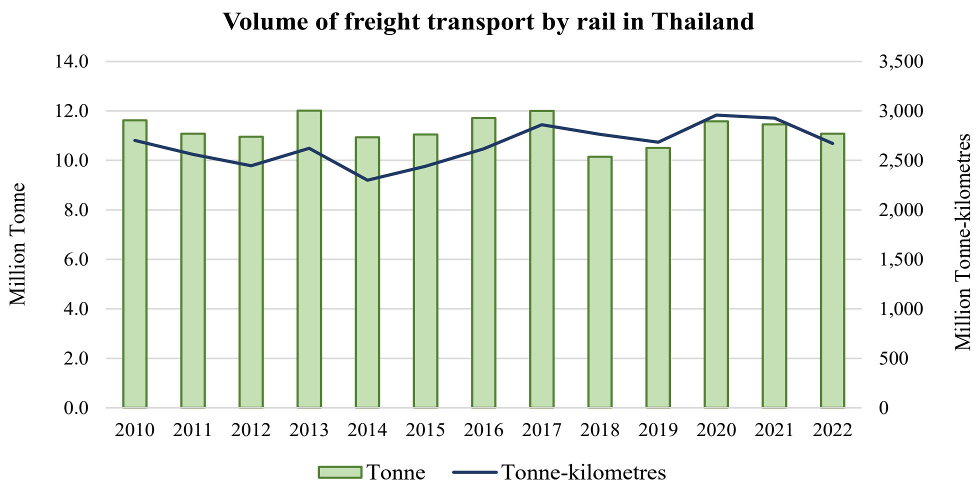

Figure 2. Volume of freight transport by rail in Thailand (tonne and tonne-kilometres).

2.3. Modal share of freight transport in Thailand

Existing modal-share data show that in most countries' road transport is the predominant freight transport mode. The Russian Federation and Australia, out of 8 countries, is a rail transport mode the dominant transport mode (ITF, 2022).

Thailand has top 2 high share of road freight mode among countries. Road transport currently represents approximately 76% of the tonne-kilometres transported in Thailand, a significantly larger modal share than freight transport via rail (2.3%), coastal shipping (9.2%), inland waterways (8.4%) and pipelines (4.0%). Non-road transport as the Russian Federation and Australia represents nearly 60% in rail freight transport (**Figure 3**).

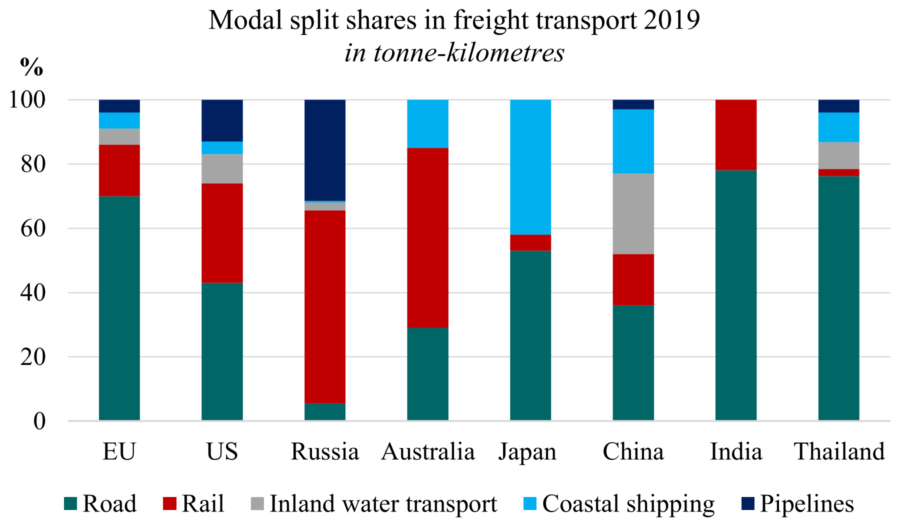

Figure 3. Modal split shares in freight transport 2019.

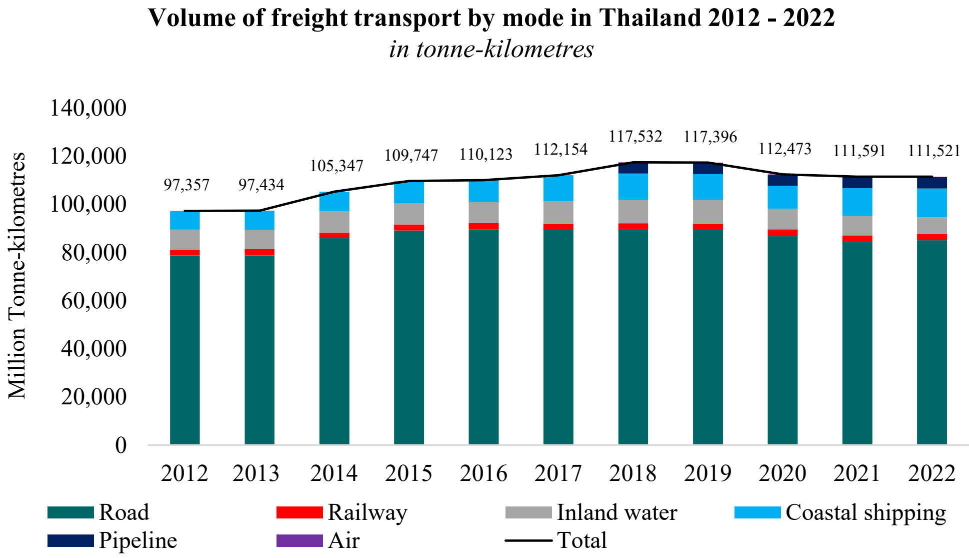

Figure 4. Volume of freight transport by mode in Thailand 2012–2022 (in tonne-kilometres).

Volume of freight transport by mode (include air mode) and modal split shares in freight transport in Thailand during 2012–2022 are shown in **Figures 4** and **5**, respectively. In 2012, the total freight transport was 97,357 million tonne-kilometres and the volume by rail is approximately 2447 million tonne-kilometres (10.96 million tonne), an increase to 2672 million tonne-kilometres (11.08 million tonne) in 2022 (**Figure 4**). This represents a growth rate of 0.11%. However, when comparing the proportion of rail transport to other modes of transport, it is found that rail transport accounts for 2.51% of the total freight transport in 2012, or 2.40% in 2022 (**Figure 5**).

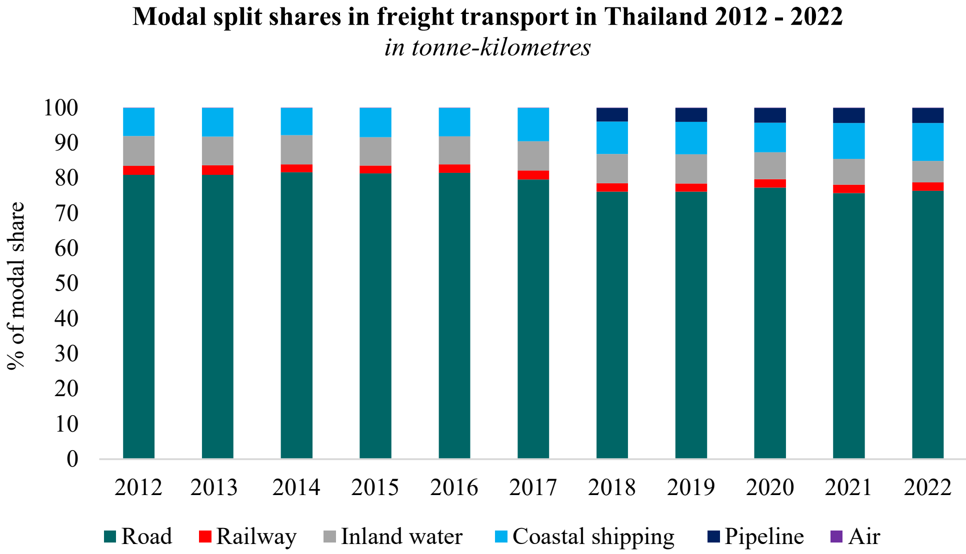

Figure 5. Modal split shares in freight transport in Thailand 2012–2022 (percentage).

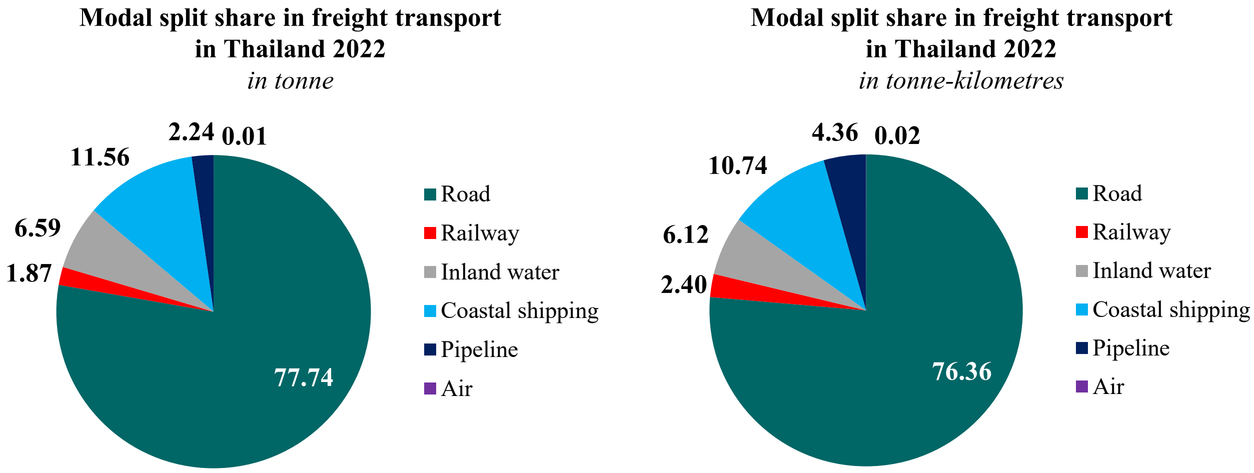

Figure 6. Modal split share in freight transport in Thailand 2022 (in tonne and tonne-kilometres).

Despite the increase in the volume of goods transported by rail from 10.96 million tonnes to 11.08 million tonnes in 2022, there remains significant proportion for growth in rail freight transport. **Figure 6** shows that rail transport accounts for just 1.87% of the total freight transport in tonnes, or 2.40% in tonne-kilometres in 2022. The modal split of freight transport in Thailand reveals that road transport dominates with approximately 76% of the tonne-kilometres, followed by coastal shipping (10.7%), inland waterways (6.1%), pipelines (4.4%), and air (0.02%). Given that rail transport only accounts for 2.4% of tonne-kilometres, there is a clear gap and substantial potential for rail to increase its share in the freight transport.

3. Materials and methods

3.1. Sample group

This research divides data collection into two forms: qualitative data and quantitative data, to understand the problems and obstacles in rail freight transport. The qualitative data analysis involved group meetings and discussions with 124 stakeholders in railway operational practices, selected through purposive sampling. Subsequently, the same sample was used for in-depth interviews with 99 stakeholders who are experts and hold high positions in the rail industry to delve deeper into current issues and challenges in rail transport services and to gather suggestions for the future development of the rail transport system, also selected through purposive sampling. The stakeholders involved are direct users of the rail system and are directly related to rail freight transport. Since the number of operators in Thailand using the rail system is limited, it was necessary to select them through purposive sampling. For quantitative data analysis, the line capacity method was used to analyze the performance of Thailand's rail freight transport system, focusing on critical issues in operations and services to develop strategies to increase rail's share in freight transport and achieve national targets. The research then provides directions for changes to rail freight transport, addressing the identified problems to achieve national targets. The method and conceptual framework are shown in **Figure 7**.

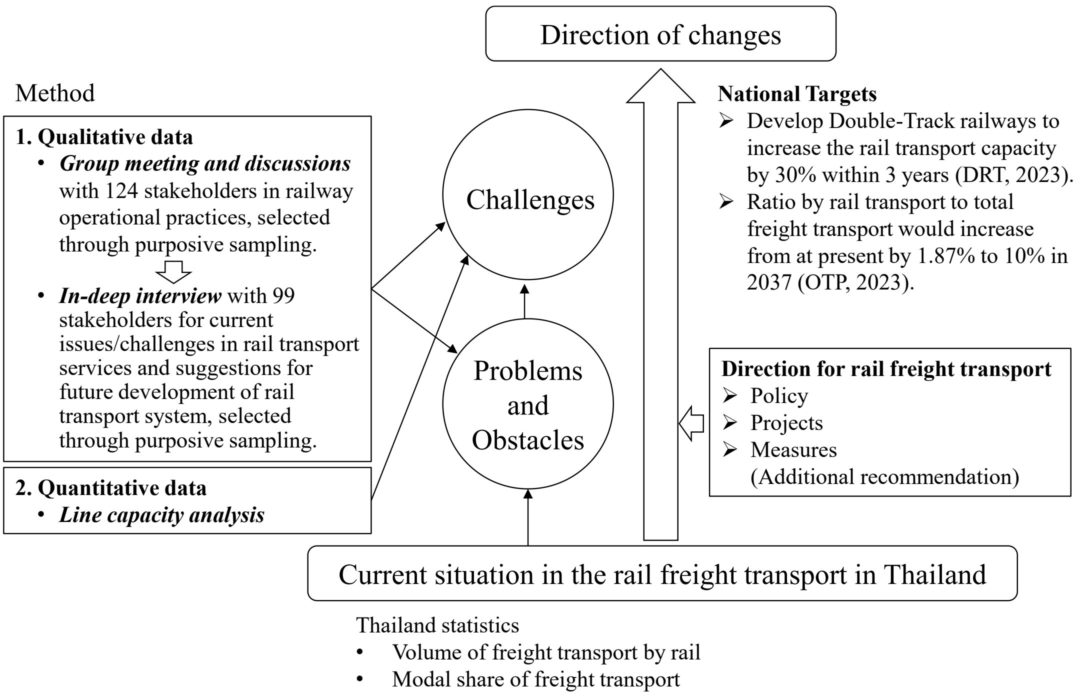

Figure 7. Method and conceptual framework.

Problems and obstacles, as well as current issues and challenges in rail transport services, have been comprehensively summarized from meetings and interviews with stakeholders. However, these issues have not been prioritized. This research will present all identified issues and highlight the gaps that need to be addressed to shift the transportation mode towards rail transport, following the best practices from countries that have successfully increased their rail transport share, for example, a study in Malaysia conducted interviews with all experts, who highlighted several issues that could potentially be barriers to achieving sustainable railway development (Yusoff et al., 2021).

In order to identify trends and patterns of changes in rail freight volume over different periods, quantitative data is important. Line capacity analysis is used to measure existing capacity and utilization statistically, supporting effective and informed decision-making at the national level.

3.2. Data analysis method

Line capacity analysis

Line capacity analysis is used to assess the improvement of railway operations for several key reasons. Firstly, it helps to determine how effectively the current rail infrastructure is being utilized, including identifying bottlenecks and underutilized segments. This allows for the pinpointing of capacity constraints that cause delays or inefficiencies, enabling targeted improvements. Additionally, it aids in developing more efficient train schedules, reducing wait times, and improving overall service reliability. Line capacity analysis is also essential for forecasting future capacity requirements based on projected increases in freight volumes, supporting long-term planning and investment decisions. It provides data for making informed decisions on infrastructure upgrades, such as adding tracks, improving signaling systems, or enhancing station facilities. By understanding capacity limits, railway operators can implement strategies to maximize the throughput of existing infrastructure, thus enhancing operational efficiency. Furthermore, it allows for benchmarking current performance against best practices and standards, identifying areas for improvement, and tracking progress over time. Overall, line capacity analysis is a crucial tool for optimizing railway operations, ensuring efficient use of resources, and planning for future growth.

To assess the railway operations improvement, Scott's formula (Sangphong et al., 2017) which determines line capacity was used (Abril et al., 2008) and expressed as:

$$\text{Line capacity, } C = 1440/(T + t) \times E$$

where T is the running time of the slowest freight train over the critical block section, t is the block operation time, and E is the efficiency factor (used 70% × type of track; single-track = 1, double-track = 2, triple-track = 3).

4. Results and discussion

4.1. Railway operational practices

The Thailand railway operations management mainly uses practice and timetables between the structure of the track and the capacity of lines and stations. Simple operations cause a low proportion of modal share in rail freight transport. Problems and obstacles in railway operational practices, classified by issues collected through meetings and discussions with different groups of 124 stakeholders, have been identified and summarized in **Table 1**.

Table 1. Problems and obstacles in railway operational practices.

Issue	Problems and obstacles
1) Travel time	The transit time cannot be accurately determined, and the overall delivery time being slower than other transport methods. They can be attributed to the following reasons: • Single track railway network causing train delays due to route switching. • The availability of locomotives and trains is low, which leads to inadequate support for customer needs. • The condition of the railway tracks and routes prevents the train from reaching the specified speed.
2) Container yard	• The container yard area is far from the industrial area and production sources. • The container yard area is not of the appropriate size and lacks suitable space characteristics. • The access to the container yard is inconvenient and there are limited routes available. • The container yard has no infrastructure and equipment, requiring the operator to provide them, which leads to increased costs.
3) Availability of carriages and locomotives	• The quantity of locomotives and carriages available for transporting goods is limited and insufficient to meet the demand. • Delayed maintenance of locomotives and carriages has reduced their capacity to provide service, resulting in a low proportion and inability to fully meet the operators' ability to deliver goods.
4) Restrictions on investment participation	Many entrepreneurs are interested in investing in rail transport infrastructure, including locomotives, carriages, and various container yards. However, they encounter challenges related to laws and regulations, particularly difficulties in establishing joint ventures and limitations in providing transportation services to third parties or entities. As a result, operators face limitations in terms of the feasibility of their business decisions regarding joint ventures or operating rail transport.
5) Total transport cost	Rail freight is often cheaper than road freight, but the cost of handling containers between different modes, the total transportation cost can be equal to or even higher than road transport.

After obtaining issues in railway operational practices from 124 stakeholders through group meetings and discussions, the current issues and challenges in rail transport services, as well as suggestions for the future development of the rail transport system, were conducted through in-depth interviews with 99 stakeholders. The results are summarized in **Table 2**.

To improve Thailand's rail freight transport system, it is essential to address the critical issues in operations and services. One solution to enhance the rail system is to increase line capacity and utilization. By analyzing current line capacity and utilization, we can identify existing usage and develop strategies to increase rail's share in freight transport. This approach will help tackle problems such as single-track limitations, outdated infrastructure, double handling costs, and inadequate rolling stock, ultimately improving the overall performance of the rail freight system.

Table 2. Problems and obstacles in using rail transport services, as well as recommendations for future rail transport system development.

Group of stakeholder/organization name	Current issues/challenges in rail transport services	Suggestions for future development of rail transport system
Business organization 1) The Thai Chamber of Commerce (6) 2) The Federation of Thai Industries (6) 3) The Thai Shipper's Council (5) 4) The Association of Importers and Exporters (6) 5) The Thai Freight and Logistics Association (6) 6) The Thai Rice Exporters Association (6) 7) The Thai Rubber Association (5) 8) The Thai Sugar Millers Corporation (5) 9) The Thai Pulp and Paper Industries Association (4) 10) The Thai Cassava Product Manufacturers Association (6) 11) The Air Cargo Association of Thailand (6) **Freight Transport Operator** 12) Laem Chabang Port (4) 13) Map Ta Phut Industrial Port (3) 14) Songkhla Port (3) **Industrial Estate** 15) Map Ta Phut Industrial Estate (3) 16) Udon Thani Industrial Estate (3) 17) Electricity Generating Authority of Thailand, Mae Mo, Lampang (3) 18) Nava Nakorn Industrial Estate (1) 19) Amata City Industrial Estate, Chonburi (2) **Manufacturer** 20) Bangsaphan Steel Industrial Zone and Prachuap Port (6) 21) PTT Public Company Limited (4) 22) PTT Exploration and Production Public Company Limited (1) 23) TP &I Polyene Company Limited (2) 24) SCG Logistics Company Limited (1) 25) Sri Trang Logistics Company Limited (2) **Mix-group of stakeholders** 26) Provincial Industrial Federation and Private Sectors in Amnat Charoen, Lampang, and Krabi (124)	1) Punctuality in service delivery • Freight transport by rail faces issues with punctuality in service delivery. The frequent stopping and waiting of trains to avoid congestion, along with schedule adjustments due to infrastructure limitations, impact service efficiency and customer satisfaction. 2) Double handling costs • Double handling is a problem that increases the freight transport cost by rail compared to trucks. Additional handling charges make rail transport costs comparable to road transport, negating potential cost savings. 3) Lack of modern technology implementation • There is a lack of modern technology implementation, particularly in real-time tracking systems for freight transport. This technological gap affects operational efficiency and customer confidence in rail transport services. 4) Limited capacity of rail freight wagons • The capacity of rail freight wagons is limited and insufficient to meet the current demand for freight transport. The State Railway of Thailand has an aging fleet, with many locomotives and wagons past their prime, leading to a shortage of available rolling stock. 5) Deterioration and outdated infrastructure • Deterioration and outdated infrastructure and equipment in rail transport, such as locomotives and rolling stocks, require improvements. Single-track railways, inadequate container yards, and limited handling facilities further exacerbate the capacity problem. 6) Excessive and unsuitable regulations • Existing regulations for freight transport are often excessive and not suitable for the current transport conditions. These regulations can hinder operational flexibility and efficiency. 7) Return trip inefficiencies • Rail freight service users are unable to transport goods from other companies on their return trips, resulting in higher transport costs compared to trucks. This inefficiency increases the overall cost burden for rail transport users. 8) Inflexible organizational structure • The organizational structure of the rail industry lacks flexibility in management and operations. This rigidity affects the ability to adapt to changing demands and improve service delivery.	1) The Government should take action to amend regulations regarding rail transport, allowing private sector involvement in locomotive and freight wagon investment, as well as enabling the freight transport from other companies to address existing problems and limitations in freight transport. 2) The Government should establish guidelines for public-private partnerships in locomotives, freight wagons, and lifting equipment, through the creation of a joint fund between the rail industry and the private sector. 3) Create the development of railway connections to various industrial estates. 4) Expedit the establishment of a bilateral trade agreement between Thailand and China to facilitate trade and transportation along the Thailand-Laos-China route, such as streamlining customs procedures, cargo inspection and release, and allowing advance cargo inspection, to facilitate faster cross-border freight transport. 5) Integrate multi-modal connectivity, there should be coordination among relevant agencies to ensure a unified direction. 6) Provide opportunities for private sector participation in the development and management of dry ports, inland container depots (ICDs), and container yards (CYs). 7) Establish a research and development institution for rail system technology in collaboration with relevant agencies, educational institutions, and public/private research institutes.

Table 2. (*Continued*).

Group of stakeholder/organization name	Current issues/challenges in rail transport services	Suggestions for future development of rail transport system
	9) Railway capacity issues • Most railway lines in Thailand are single-track (81.85%), with limited double-track (15.50%) and triple-track (2.65%) railways. This limitation causes congestion and lower-than-standard average train speeds, affecting the capacity and efficiency of train operations. 10) Railway bridge bearing capacity • The average speed of freight trains in Thailand is 60 km/h with a load capacity of 20 tons per axle. However, railway bridges with a capacity of only 16 tons per axle reduce train speeds to 30 km/h, highlighting the need for infrastructure improvements to handle higher axle loads and increase traffic capacity. 11) Freight transport service problems • Insufficient locomotives and wagons—A significant portion of the locomotive fleet is over 30 years old, leading to decreased availability. The shortage of wagons also limits the volume of freight transport. • Inadequate container yards (CY) and handling facilities—The layout and facilities of container yards are not user-friendly, lacking essential equipment, which hinders small operators from shifting to rail transport. • High transport costs—The inability to transport goods from other companies on return trips and additional handling charges make rail transport less cost-effective compared to road transport. 12) Train operation problems • Incomplete or damaged equipment—Many locomotives and trailers are not operational due to damage or are insufficient during peak times. • Track limitations—speed reductions at various points, non-standard station sizes, and inclines affect train speed and capacity. • Unstandardized intersections—non-standard intersections between roads and railways increase the risk of accidents and delays. • Malfunctioning equipment—Signaling devices require repair and replacement, affecting train operation efficiency. Insufficient personnel—A lack of trained workforce and slow personnel development impact operational capabilities.	

Note: () are number of in-depth interview and meeting participants.

4.2. Line capacity and utilization

Rail infrastructure projects are determined in the national plan at the policy level. As the development of rail infrastructure system projects, line capacity is used to estimate the increase of utilization regarding demands in cases of existing and future rail infrastructure projects. In the future, when there is an increasing demand for rail freight transport, it may lead to issues of delays in transportation. One approach to address the potential problem is to develop the current single-track railways into double-track railways, which is a crucial factor that will increase the capacity of the rail system in various segments and enhance the transportation capacity of the rail system.

The majority of railway lines are single-track, accounting for 81.85%, while double-track railways account for 15.50% of the total, and triple-track railways constitute only 2.65%. Currently, double tracks cover around 627 km and it would cover 1939 km or accounting for 48% of total current railway network of Thailand in 2037. In 2037, the additional railway network will increase to 4778 km, consisting of high-speed railways about 1993 km and new line railways about 2785 km.

Table 3. Existing line capacity and utilization of Thailand railways.

Region	Line name	Existing railways					
		Existing capacity	No. of train				Existing utilization
			Train car	Wagon	Extra wagon	Total	
Northern Line	Ban Phachi Junction-Lopburi	212	35	14	14	63	29.72%
	Lopburi-Pak Nam Pho	80	28	14	14	56	70.00%
	Pak Nam Pho-Den Chai	64	16	2	8	26	40.63%
	Denchai-Chiang Mai	47	12	2	8	22	46.81%
Northeast Line	Ayuthaya-Ban Phachi	511	67	12	6	85	16.63%
	Ban Phachi-Keng Koi	263	40	18	38	96	36.50%
	Keng Koi-Thanon Chira Junction	95	24	0	28	52	54.74%
	Thanon Chira Junction-Khon Khan	84	14	2	25	41	48.81%
	Khon Kaen-Nong Khai	36	14	2	10	26	72.22%
	Thanon Chira Junction-Ubon Ratchathani	58	26	0	10	36	62.07%
Southern Line	Nakorn Pathom-Hua Hin	67	38	2	10	50	74.63%
	Hua Hin-Prachuap Khiri Khan	72	28	2	8	38	52.78%
	Prachuap Khiri Khan-Chumphon	59	26	2	8	36	61.02%
	Chumphon-Surat Thani	63	26	2	10	38	60.32%
	Surat Thani-Hat Yai	51	30	6	10	46	90.20%
	Hat Yai Junction-Padang Besar	36	8	4	2	14	38.89%
	Hat Yai Junction-Su-ngai Kolok	48	20	2	0	22	45.83%
Eastern Line	Hua Takhe-Chachoengsao	374	24	22	12	58	15.51%
	Chachoengsao-Si Racha Junction	170	4	44	25	73	42.94%
	Si Racha Junction-Map Ta Phut	48	0	0	20	20	41.67%
	Chachoengsao-Keng Koi	106	10	20	29	59	55.66%

Presently, single-track railways have an impact on the rail system's capacity to handle daily train operations. Rolling stocks were designed enough for current utilization as shown in **Table 3**. However, as increasing demands, developing double-track railways, especially in densely trafficked routes, is important to serve the freight transport capacity and increase the ratio of rail freight transport to total freight transport.

Table 4. Line capacity and utilization in 2037 (in case of without improvement of railway projects).

Region	Line name	Railway projects					
		Capacity without railway projects	No. of train			Total (exising + added slots)	Utilization
			Train car	Wagon	Total		
Northern Line	Ban Phachi Junction-Lopburi	212	28	20	48	111	52.4%
	Lopburi-Pak Nam Pho	160	32	20	52	108	67.5%
	Pak Nam Pho-Den Chai	64	44	20	64	90	140.6%
	Denchai-Chiang Mai	47	27	11	38	60	127.7%
Northeast Line	Ayuthaya-Ban Phachi	511	20	8	28	113	22.1%
	Ban Phachi-Keng Koi	263	32	10	42	138	52.5%
	Keng Koi-Thanon Chira Junction	190	60	48	108	160	84.2%
	Thanon Chira Junction-Khon Khan	144	32	42	74	115	79.9%
	Khon Kaen-Nong Khai	36	24	36	60	86	238.9%
	Thanon Chira Junction-Ubon Ratchathani	58	35	6	41	77	132.8%
Southern Line	Nakorn Pathom-Hua Hin	134	24	10	34	84	62.7%
	Hua Hin-Prachuap Khiri Khan	144	40	10	50	88	61.1%
	Prachuap Khiri Khan-Chumphon	118	40	15	55	91	77.1%
	Chumphon-Surat Thani	63	40	15	55	93	147.6%
	Surat Thani-Hat Yai	51	44	12	56	102	200.0%
	Hat Yai Junction-Padang Besar	36	3	6	9	23	63.9%
	Hat Yai Junction-Su-ngai Kolok	48	17	1	18	40	83.3%
Eastern Line	Hua Takhe-Chachoengsao	374	8	56	64	122	32.6%
	Chachoengsao-Si Racha Junction	170	10	106	116	189	111.2%
	Si Racha Junction-Map Ta Phut	48	14	1	15	35	72.9%
	Chachoengsao-Keng Koi	106	8	52	60	119	112.3%

Railway operation is organizing, planning and managing the train movement in a network relatively between the structure of the track and the capacity of lines and stations. One way to assess the railway operations improvement is comparative consideration of line capacity and utilization between without and with improvement of railways and balance between the infrastructure (the permanent way, tracks, stations, freight facilities, etc.) and the rolling stock (the locomotives, passenger cars, wagons, etc.). In the case of without improvement of railways, more than 50% of total length are over capacities while in the case of with improvement of single-track to double-track railways, most line capacities are still served the demands as shown in **Tables 4** and **5** and **Figure 8**. In 2037, the rail freight transport was predicted about

24,027 million tonne-kilometres, accounting for approximately 10.1% from the total freight transport of 224,048 million tonne-kilometres.

Table 5. Line capacity and utilization in 2037 (in case of with improvement of railway projects).

Region	Line name	Railway projects					
		Capacity with railway projects	No. of train			Total (exising + added slots)	Utilization
			Train car	Wagon	Total		
Northern Line	Ban Phachi Junction-Lopburi	212	28	20	48	111	52.4%
	Lopburi-Pak Nam Pho	160	32	20	52	108	67.5%
	Pak Nam Pho-Den Chai	128	44	20	64	90	70.3%
	Denchai-Chiang Mai	130	27	11	38	60	46.2%
Northeast Line	Ayuthaya-Ban Phachi	511	20	8	28	113	22.1%
	Ban Phachi-Keng Koi	263	32	10	42	138	52.5%
	Keng Koi-Thanon Chira Junction	190	60	48	108	160	84.2%
	Thanon Chira Junction-Khon Khan	144	32	42	74	115	79.9%
	Khon Kaen-Nong Khai	112	24	36	60	86	76.8%
	Thanon Chira Junction-Ubon Ratchathani	116	35	6	41	77	66.4%
Southern Line	Nakorn Pathom-Hua Hin	134	24	10	34	84	62.7%
	Hua Hin-Prachuap Khiri Khan	144	40	10	50	88	61.1%
	Prachuap Khiri Khan-Chumphon	118	40	15	55	91	77.1%
	Chumphon-Surat Thani	126	40	15	55	93	73.8%
	Surat Thani-Hat Yai	102	44	12	56	102	100.0%
	Hat Yai Junction-Padang Besar	72	3	6	9	23	31.9%
	Hat Yai Junction-Su-ngai Kolok	96	17	1	18	40	41.7%
Eastern Line	Hua Takhe-Chachoengsao	374	8	56	64	122	32.6%
	Chachoengsao-Si Racha Junction	170	10	68	78	151	88.8%
	Si Racha Junction-Map Ta Phut	96	14	13	27	47	49.0%
	Chachoengsao-Keng Koi	106	8	14	22	81	76.4%
New line	Sriracha-Prachinburi-Non Sung	120	0	38	38	38	31.7%

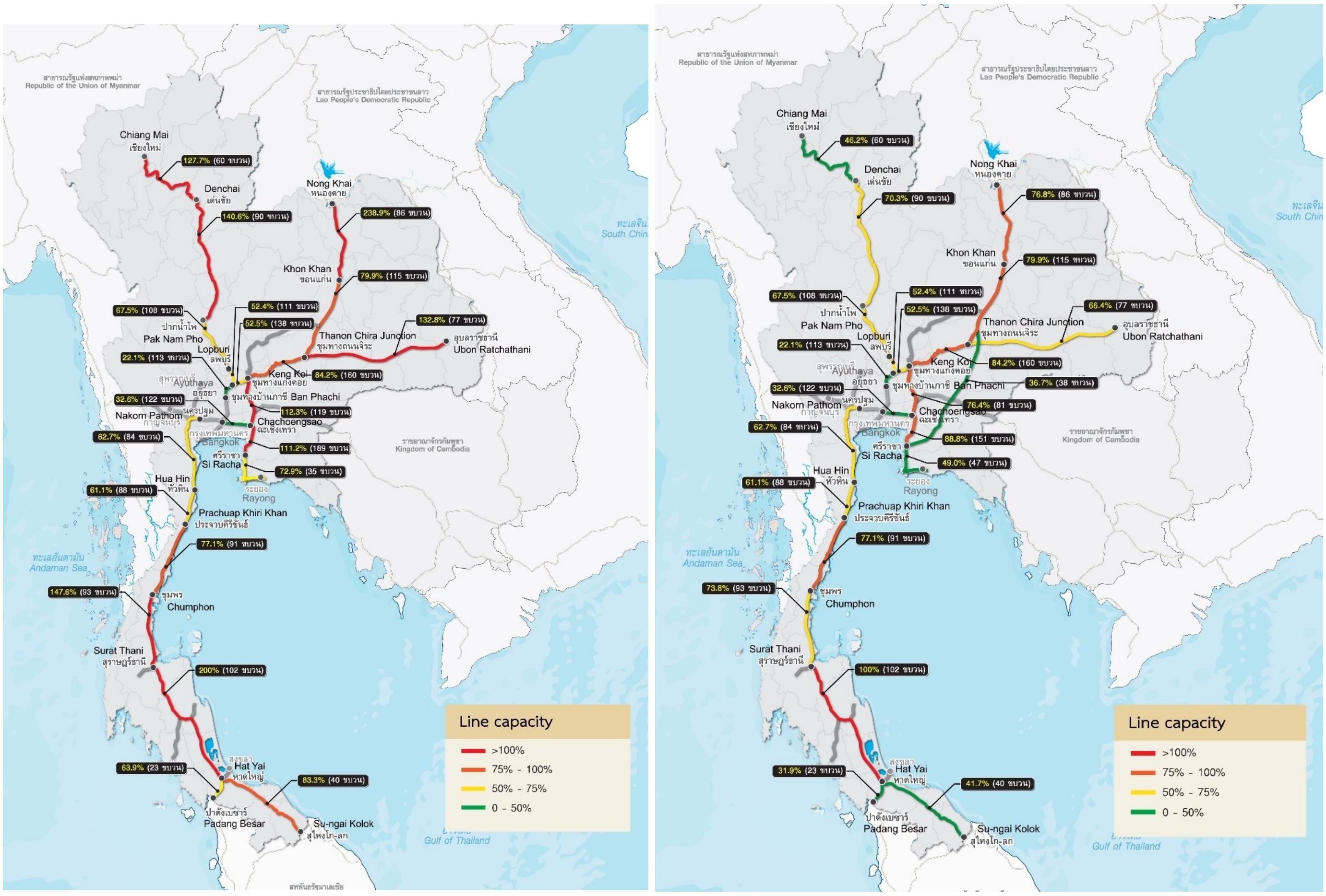

Figure 8. Line capacity and utilization of Thailand railways in 2037 (in cases of without and with improvement of railway projects).

From problem identification and analysis of railway system improvement, the direction of changes in rail freight transport can be outlined as follows.

4.3. Directions of changes in rail freight transport in Thailand

Directions of changes in rail freight transport in Thailand can be subjected the framework into 3 issues: policy, project and measures. Firstly, the policy of the Minister of Transport, specifically related to the development of rail transportation systems, is outlined as follows:

a) Develop Double-Track railways to increase the rail transport capacity by 30% within 3 years as a backbone of logistics system for freight transport.

b) Support Private Sector Participation to encourage involvement of private sector by providing railway services to maximize benefits for the public and reduce the burden on organizations.

c) Determine the targets of the ratio by rail transport to total freight transport (average percentage), see **Table 6**.

Table 6. Targets, aggregate indicators and target values under the Government policy.

Target	Indicator	Target value		
		2023–2027	2028–2032	2033–2037
Increased freight transport by rail	The ratio of rail freight transport to total freight transport (average percentage)	7%	8%	10%

Remark: Target value refer from the master plan under the national strategy (2023–2037).

Secondly, rail infrastructure projects for increasing double-track railway capacity by 30% (DRT, 2023) and achieving the target value of rail freight transport to total freight transport by 10% (OTP, 2023) are addressed in the policy plan shown as follows:

- Double-track railways network development 10 projects.
- New railways network development 19 projects.
- High-speed railway network development 6 projects.
- Spur line industrial network development 11 projects.
- CY, dry ports, and inland container depot (ICD) development.
- Locomotives and rolling stock procurement.
- Electric-powered rail system development.

Thirdly, measures to enhance rail freight transport to achieve the target value of rail freight transport to total freight transport by 10% are summarized as follows.

- According to the policy to drive the development of sustainable transport, the Thai government has been working to improve the multimodal connectivity between different modes of transportation, including integrating rail, road, and maritime transport. This could lead to more efficient movement of goods across different regions and countries.
- Upgrading rail lines and introducing modern locomotives and rolling stocks can lead to increased freight capacity and faster transit times. High-speed rail networks might also be explored for freight transport, reducing delivery times for goods.
- The adoption of digital technologies such as Internet of Things (IoT), smart sensors, and data analytics can optimize operations, track shipments in real-time, and provide insights for better decision-making.
- A growing emphasis on environmentally friendly practices in rail freight is considered, such as the use of cleaner fuels, electrification of rail lines, and initiatives to reduce emissions.
- Encouraging private sector participation in using railway system by providing and subsidizing spur line railways to industries and private areas to increase railway utilization.
- Encouraging private sector participation and investment in locomotives, freight wagons, and lifting equipment in rail freight operations and providing opportunities for private sector participation in the development and management of dry ports, inland container depots (ICDs), and container yards (CYs) can lead to increased efficiency, innovation, and competition in the sector.
- Streamlining and reforming regulations and improving customs procedures can expedite the movement of goods through rail freight, making it a more attractive option for businesses.

- Training and developing a skilled workforce for rail freight operations and maintenance will be crucial to ensure the smooth functioning of the system.

5. Conclusion

Currently, rail freight transport in Thailand is still considered to have a relatively small share compared to other modes of transportation. This is primarily because Thailand has not invested as much as it should have in the development of rail freight transport in the past. The predominant focus has been on road infrastructure development. The main challenge is that many business operators are not inclined to use the rail system due to issues such as slow transit times, high shipping costs, inadequate rolling stock, underutilized container yards (CY), and limitations in private sector investment. Nevertheless, there is significant potential for the further development of rail freight transport in the country because the development of waterway infrastructure is constrained, particularly in the central region, and surface main roadways is quite stagnant. Therefore, a key priority should be the improvement of connections between waterways and railways, such as the development of railway connections and the integration of seamless multi-modal connectivity. Enhancing convenience for businesses, such as upgrading CYs and ICDs to better serve the needs of operators, utilizing modern transportation technologies, and fostering a sense of involvement among business operators in the rail system are essential steps. These actions will allow the country to grow alongside the evolving mode of transportation. Analyzing line capacity is crucial for estimating the increased utilization in response to demands. One effective approach to address this potential problem is to convert the existing single-track railways into double-track railways. This is a key factor that will significantly increase the capacity of the rail system in various segments and enhance overall transportation capacity.

Therefore, a significant recommendation for government agencies is to collaborate on the development of rail infrastructure concurrently with addressing the soft side aspects, which include establishing clear rail policies and ensuring consistent monitoring and evaluation of the direction of changes in rail system development to enable the country achieving the goal of increasing the share of rail transport effectively.

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