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Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective

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ABSTRACT

The volume of international trade and freight transport in Asia has witnessed fast growth in recent decades. The resulting environmental impact of freight transport operations has become a major cause of concern. Intermodal transport has gained prominence recently due to its potential to offer door-to-door service through the integration of various modes of transport in the logistics chain, improved coordination and services, and the development of intermodal interfaces. However, few studies have focused on this development in Asia.

The development of intermodal transport requires transport links, nodes, and services. The development of dry ports, an important component of intermodal transport, could play a major role in promoting intermodal transport in Asia, including its twelve landlocked countries. Dry ports located in deep inland areas, as opposed to near the sea, would incorporate customs and other related facilities and rail links, as well as provide for transfer, transshipment, and distribution functions for cargo. By encouraging a modal shift, such dry ports would help to ease road traffic congestion and reduce emissions.

This study reviews the status of intermodal freight transport in Asia from an environmental perspective. It examines intermodal transport opportunities presented by the development of inland dry ports in hinterland locations. This paper also reviews selected case studies of dry port development in Asia. Finally, we present the lessons to be learned for the promotion of intermodal freight transport from selected Asian countries as well as the policy options available.

1. Introduction

Intraregional exports and imports are increasing throughout Asia. Exports and imports grew by over 15% year-over-year from 2007 to 2008 [1]. Asia's share of world containerized exports and imports are expected to rise to 68% and 56%, respectively, by 2015. The total number of containers handled in Asian ports is estimated to reach 492 million twenty-foot equivalent unit (TEU) by 2015, and the transshipment volume will comprise 109 million TEU of this total [2]. The growth of intraregional trade and the expected growth of containerized transport in Asia clearly demonstrate the need for improved intermodal freight transport in the region.

Earlier models of transport development have adopted a unimodal approach in which road and rail projects were planned and constructed separately without much consideration for their possible future integration. Intermodal/multimodal transport uses more than one mode of transport and delivery of goods from origin to destination. Such transport has been studied in detail by policy makers and transport planners, who are undertaking various policy initiatives to promote the concept and implementation of intermodal/multimodal transport.

The development of intermodalism requires the consideration of three of its attributes: transport links, transport nodes, and the provision of efficient services. While there have been efforts in Asia to develop regional highways, railways, and seaports, inland dry ports remain at an early stage of development. Since Asia is home to twelve of the world's landlocked countries, the development of dry ports could play a major role in promoting intermodal transport. It could also contribute to the improved transshipment and distribution of goods in wider inland areas by improving operational efficiency. Many studies have focused on the development of dry ports, inland terminals, and intermodal transport in Europe and other developed countries [3,4]. Few studies, however, have focused on intermodal transport and the development of dry ports in Asia.

In this context, the present study aims to review (i) the current state of development of dry ports and intermodal transport in Asia, (ii) the role this development can play in addressing environmental concerns, and (iii) some potential modal shift opportunities. Our research takes a case study approach to presenting selected cases of intermodal transport and dry port development in Asia. Key insights

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and policy lessons learned from the development and operation of intermodal transport are also discussed.

2. Intermodal transport and dry ports

Intermodal transport refers to the movement of goods in the same single loading unit or road vehicle that successively uses two or more modes of transport, without the goods being handled in a change of transport mode [5]. Intermodal transport is also defined as the use of at least two different modes of transport in an integrated manner, in a door-to-door transport chain [6].

In order to promote intermodal transport, it is essential to develop transport links and nodes, which include ports, airports, river ports, and inland dry ports, as well as to improve the efficiency of transport services. Intermodal transport nodes provide opportunities for a modal shift, as implied by its definition. In the following sections, we outline the development of transport links, nodes, and services in Asia and review the environmental benefits that can be derived from improved intermodal transport.

2.1. Transport links

In order to promote intermodal transport, it is essential to improve transport links such as highways, railway networks, and inland waterways. In Asia, there has been good development of transport networks such as the Asian Highway and the Trans-Asian Railway [7,8]. The Master Plan on ASEAN Connectivity [9], which includes the Singapore–Kunming Rail Link and other transport corridors, is an example of the attention that national governments are giving to transport links. Asia includes major countries like China, India, and the Russian Federation, which have extensive railway and highway networks; however, these countries need to upgrade their railways and highways to provide seamless transport connectivity. In addition, certain routes lack capacity and proper maintenance. Therefore, considerable investment will be needed for periodic maintenance if they are to provide efficient services.

Railways were first invented to carry freight, and they now run on clean forms of energy [10]. The energy intensity and long life cycle of rail cars, along with new innovations that offer increased speed, have put railways in a competitive position to fulfill a major share of the growing transport demands in terms of both freight and passengers. Efforts by policy makers and railway operators are needed, though, to maintain railways' environmental superiority over other modes of transport. Common factors likely to influence consumers' choice of transport mode are the relative cost, time and reliability, and for passenger services, the degree of comfort.

Another important issue related to international railway transport is break-of-gauge. Railway tracks in many Asian countries have been developed using different track gauges, for instance, 1676 mm; 1520 mm; 1435 mm; 1067 mm; and 1000 mm. Different gauges at borders of countries prevent rolling stock from passing through and create the need for goods to be transferred across these borders in a separate operation. These operations include the manual or mechanical transshipment of goods from wagons of one gauge to wagons of a different gauge, the change of bogies, and the use of "variable-gauge" wagons [11].

2.2. Dry ports as transport nodes

Transport nodes such as airports, seaports, logistics intermodal terminals, and dry ports need to be developed in order to promote intermodal transport. From among these, seaports have developed rapidly in Asia, as evidenced by the fact that 19 of the top 30 container ports in the world are located in Asia [12]. Inland dry ports are also important transport nodes, particularly for landlocked countries. The development of these dry ports in hinterland areas can promote intermodal transport and provide transfer and transshipment functions along with customs-clearance facilities.

Various interchangeable terms are used to refer to dry ports: inland ports, inland container depots, freight terminals, etc. Several definitions have been established for inland transfer points/dry ports and inland terminals [13]. The Economic and Social Commission for Asia and the Pacific (ESCAP) proposed the following working definition of dry ports during a regional meeting of dry ports in Asia [14].

> *A dry port provides services for the handling and temporary storage of containers, and general and/or bulk cargoes that enter or leave the dry port by any mode of transport, including roads, railways, inland waterways or airports. Full customs-related services and other related services, such as essential inspections for cargo export and import, should be put in place in a dry port whenever possible.*

Discussions are still taking place to develop an agreeable definition of dry ports in the Asian context.

Dry ports/freight stations are a key component of intermodal transport. Existing government policies and regulations associated with dry ports influence their development. ESCAP is working to develop an intergovernmental agreement on dry ports to promote coordinated development. Fig. 1 shows the links between dry ports and various sectoral policies that may be relevant to the development of dry ports [15].

The abovementioned policies presented in Fig. 1 are those affiliated with various sectors and ministries. In addition, different levels of government—central, provincial, and local—will also have different policies. For these reasons, coordination among the various sectors and different levels of government is essential. Designating a lead or coordinating agency and thus providing potential developers of dry port projects with "one stop" services and advice, including all necessary government approvals during both planning and operation, will facilitate the development of dry ports.

There are also many actors and issues that need to be considered in the planning and development of dry ports. A lack of clear policies and institutional arrangements, or competing interests among actors, can pose severe threats to the selection of locations for inland dry ports. Some common factors that affect the location of dry ports are proximity to seaports; connections to other modes of transport; cost of development, operation, and transport; potential for encouraging

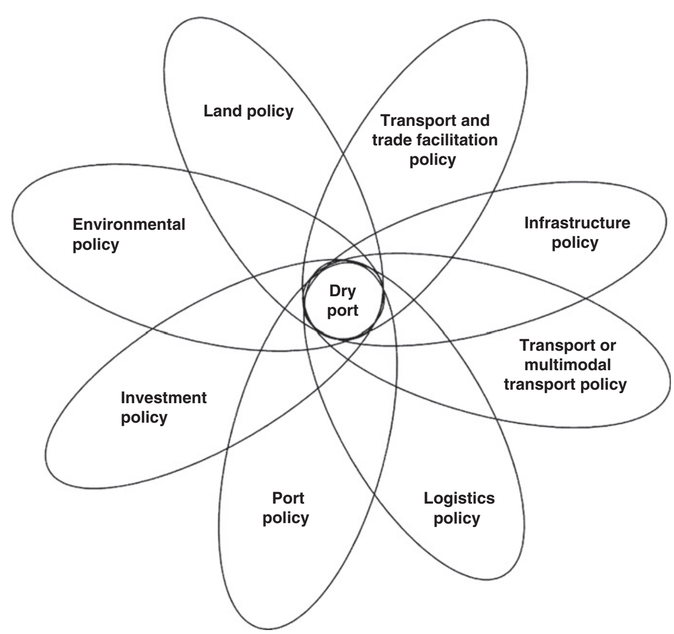

Fig. 1. Policies and regulations related to dry ports [15].

mode shift; environmental concerns; potential for attracting manufacturing and distribution facilities; and economic stimulus for regional economic development. Furthermore, special economic zones and free trade areas that provide special tax incentives are also being created adjacent to dry port locations.

ESCAP has recognized the importance of dry port locations and suggests that the following criteria be considered when deciding upon a location: (a) inland capitals, provincial/state capitals; (b) existing and potential industrial and agriculture centers; (c) major intersections of railways, highways, and inland waterways; and (d) intersections along trunk railways lines, major highways, inland waterways, and at airports.[2]

2.3. Transport services

Intermodal transport requires improvement in the efficiency of transport services. The logistic performance index (LPI), which indicates the quality of trade, transport, and services, varies widely among Asian countries. For example, Asian countries with a high LPI for 2010 include Singapore (4.09), Japan (3.97), and the Republic of Korea (3.64), while Mongolia (2.25), Afghanistan (2.24), Nepal (2.20) and most landlocked countries had a low LPI [16].

Road transport, which is the most flexible transport mode, is usually operated and managed by the private sector, and in certain limited cases, by public sector subsidiaries. Most railway route operations in Asia are still handled by public sector railway companies under overall government control. Quality is the single most significant problem in railway freight operations. In order to attract a greater share of freight, therefore, the quality and reliability of service must be improved, and the punctuality of freight services must be maintained. This requires both a reform of existing railway operation systems and new approaches to railway marketing. Ballis and Golias [17] have examined ways of improving the efficiency of railroad terminals. If private-sector freight forwarders can provide quality service, public sector railway companies would also be able to improve their services. Service quality and price are important factors in encouraging a modal shift [18].

In order to provide door-to-door service, railways must be integrated with existing logistical networks. Interfaces between railways and other transport modes are essential in order to encourage a modal shift. It has been suggested that government policies can help increase rail freight share by developing rail freight as a business, encouraging a level playing field as well as private sector involvement and competition, and reducing barriers at borders [19].

2.4. Environmental benefits of intermodal transport/dry ports

Intermodal transport facilitates modal shifts from one mode to another. In order to receive net environmental benefits from intermodal transport, we need to explore approaches and measures that will encourage shifts to more environmentally friendly modes. The planning and development of freight terminals, freight villages, dry ports, and inland container depots (ICDs) can extend the reach of the rail mode through intermodal services. Rail-based intermodal freight transport is more environmentally friendly than truck-only transport, particularly in terms of CO_2 emissions and other pollutants produced by long-distance hauling [20]. Rail is considered an ideal mode of connection between seaports and dry ports [21].

The construction of consolidation centers/dry ports near strategic urban locations can also help reduce the number of freight trips. One example of this is the Freight Construction Consolidation Center in London. Established to consolidate construction freight and minimize construction traffic for building and development, it has resulted in fewer freight trucks and a 75% reduction in CO_2 emissions [22].

The location of dry port and freight hubs, therefore, is an important consideration. When analyzing intermodal transport and the location of dry ports or freight hubs, many studies have considered the potential environmental impact to be an important factor for analysis [23,24]. The implementation of a dry port concept in Sweden—in which freight transported from seaport to dry port by truck was replaced by railway transport—led to as much as a 25% reduction in CO_2 emissions as well as reduced port congestion [25].

Activity-based emission modeling of an intermodal transfer point in north Taiwan compared distribution by intermodal transport using coastal shipping and trucks to distribution by trucks alone. The results indicated that the efficiency of coastal shipping led to 60% less emissions [26]. Other study showed greater reductions in CO_2 when transshipment routes are changed from the established ports to the emerging port of Taipei [27]. Other study of freight emissions in London revealed that the establishment of consolidation and distribution centers led to combined 25.7% reduction in emissions [28]. Freight and consolidation centers/dry ports also have the potential to reduce empty truck trips. For example, 12%–30% of trucks run empty in Pakistan and 43% run empty in China [29]. Improved logistical organization, coordination, and route planning could reduce CO_2 emissions by as much as 10–20% worldwide [30].

The promotion and development of intermodal transport and a modal shift to rail transport can help reduce emissions of pollutants and environmental impacts. Freight carried by rail emits much less CO_2 than freight transported by heavy goods vehicles (HGV). In the UK, for example, the average CO_2 emission per ton/km is 28.3 g for rail freight, 118.6 g for HGV, and 400 g for light goods vehicles [31].

As outlined in Section 2.2, dry ports that are established near manufacturing and distribution facilities can offer positive environmental benefits due to the reduced travel distance for manufacturing goods that are distributed through dry ports and raw material that are transported to factories.

In some instances, however, dry ports may generate an increase in cargo, leading to the possibility of increased truck hauling that increases both noise and the emission of pollutants such as CO, NO_x, SO_2, volatile organic compounds (VOCs) and hydrocarbons that contribute to local air pollution. The noise and vibrations generated by freight vehicles, and the operation of handling equipment, may also be a nuisance to locals living in the area. The quality of fuel used by transport modes and vehicle congestion on roads as well as at dry ports can have additional environmental impacts. Therefore, consideration should be given to the utilization of cleaner and greener forms of fuel/energy in transport and to the improvement of the operational efficiency of transport services and dry ports by adopting an integrated and holistic approach. Environmental impact assessment undertaken for the development and operation of dry ports should consider all potential impacts and develop a mitigation plan for likely impacts, including emissions of pollutants, noise, and vibrations. Although we must clearly understand that inland intermodal freight transport cannot be made emissions-free, efforts should nonetheless be directed toward making intermodal transport more sustainable.

3. Development of dry ports in Asia

Countries in Asia are at different stages in the development of dry ports. At present, both road- and rail-based intermodal dry ports are nearing production, and industrial centers are being developed with the aim of effectively consolidating and distributing cargo. Some countries have established well-functioning dry ports, while other countries are still at an early stage of development. The following sections present selected case studies of the development and operation of dry ports in Asia and discuss the key financial, operational, environmental, regulatory and institutional factors involved in their development and

[2] Technical and operational issues related to the development of dry ports, ESCAP, 2010.

operation. A summary of our key findings then provides guidance for the planning, development and operation of such dry ports.

3.1. Uiwang ICD, Republic of Korea

Rapid growth in Korea's export and import volumes has led to an expansion of the nation's ports. The pace of port expansion, however, was slower than the growth of trade: this led to congestion at gateway ports such as Busan, Gwangyang, and Inchon, which handled the majority of the Republic of Korea's foreign trade. In response, in 1980, the government initiated a policy to develop inland logistics centers.

The Uiwang ICD, which is located 25 km from Seoul, was developed by a public–private partnership (PPP) in 1993. The Korean Railroad Company and private transportation companies have invested in the Uiwang ICD. It has a capacity of 1.3 million TEU and spans 417,000 m^2. In addition to private-sector facilities and operating companies, customs, food inspection, plant quarantine, and railway operations are located within the ICD. Shippers send goods by road to the ICD, where they are consolidated and sent to seaports by rail. With a rail capacity of 36 trains per day, the ICD utilizes both modes of transport, which help ease road congestion and enable the facility to serve as a clearance depot.

Fig. 2 shows the containers handled at Uiwang ICD, which exceeded 2 million TEU in 2006 [32]. As can be seen in the figure, there was a decrease in the volume of containers handled after 2008 due to the economic recession. Further, the road mode share was approximately 75%, except for a drop in 2008. Fig. 2 also shows that the rail mode share of throughput handled by the ICD was about 25% in 2010, even though the ICD was running over capacity. This use of railways for transport from the ICD to seaports has helped ease road traffic congestion and reduce vehicle emissions. An expansion of the ICD's capacity would further enhance the environmental benefits, as would an increase in the rail mode share of freight.

The Ministry of Land, Transport and Maritime Affairs (MLTM) is the regulatory authority responsible for the planning, construction, and management of dry ports in the Republic of Korea. MLTM encourages private sector investment in the development of dry ports and logistics centers. Large-scale infrastructure project proposals from the private sector are reviewed by the Public and Private Infrastructure Investment Management Center (PIMAC) to determine whether they are consistent with the government's long-term plans and investment priorities. The government provides some support for the development of dry ports by assuming part of the land acquisition and

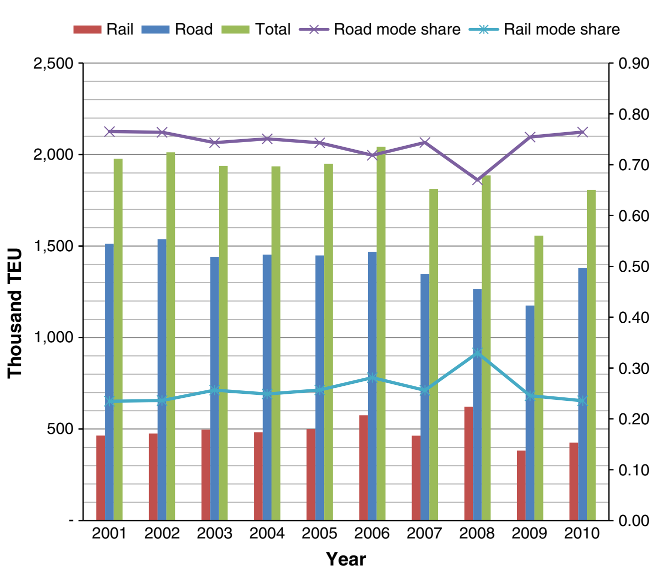

Fig. 2. Container throughput at Uiwang ICD and mode share of road and rail [32].

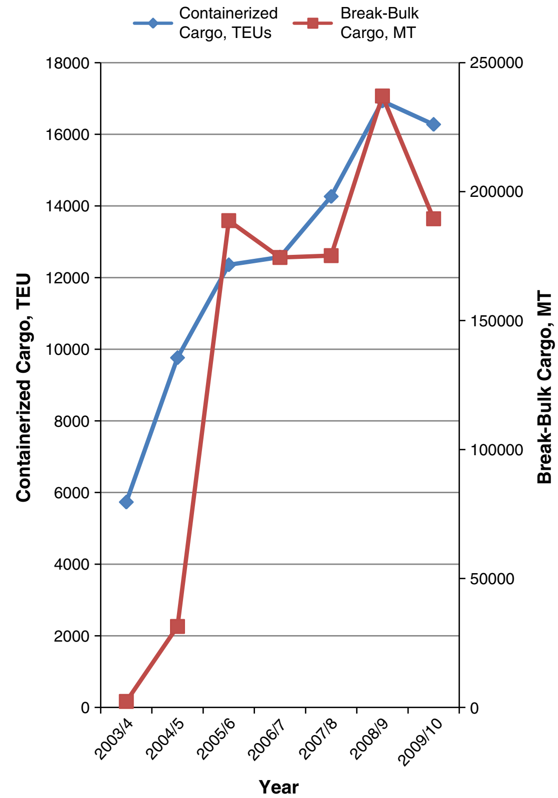

Fig. 3. Cargo handled at Birgunj ICD [33].

project costs. Infrastructure projects under PPP are either selected by the government or proposed by the private sector. Uiwang ICD presents an interesting case of market-driven dry port development that uses PPP for both financing and the improvement of operational efficiency. Government logistics policies and PIMAC have played a supportive role in this development.

3.2. Birgunj ICD, Nepal

The Birgunj ICD was developed by the government of Nepal with the support of the World Bank. It has a 12 km rail link to the ICD from the Raxaul railhead near the border with India, and it connects further to the Kolkata/Haldia ports in India. The length of the road from Kolkata, India, is 924 km, and that of the railway is 704 km. The ICD facilities include a broad gauge railway yard with six full-length lines, a container stacking yard, a covered container freight station, goods sheds, and parking space. It is equipped with the automated system for customs data (ASYCUDA). Since majority of rail links are in India, it took the government of Nepal some time to conclude a rail service agreement with India for the operation of dry ports. The Birgunj ICD, which was commissioned in July 2004, but whose operations began 2 years later, is leased to the private sector for operation. It now handles containers, tank wagons for liquid cargo, and flat wagons for bilateral break-bulk cargo, following amendments that were made to the service agreement.

The Nepal Intermodal Transport Development Board (NITDB), which has representatives from the public as well as the private sector, is the regulatory body overseeing all ICDs in Nepal. As envisaged in Trade Policy 2009, the Nepal Intermodal Transport Development Authority (NITDA) will be established to regulate operational issues, including the issuance of licenses for the development and management of dry ports, container freight stations, and integrated customs points in the country.

The Birgunj ICD currently receives an average of around 15–16 freight trains per month. The volume of container and cargo handled

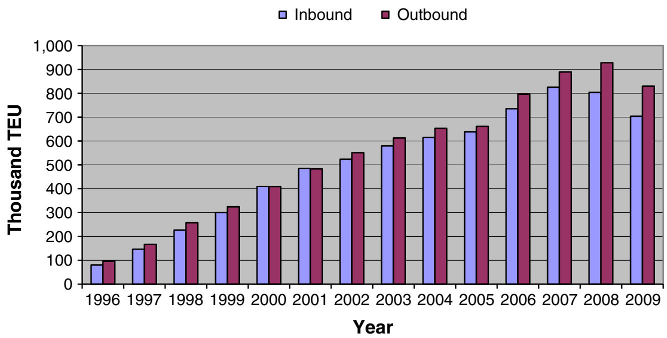

Fig. 4. Containers handled at Lat Krabang ICD [34].

there is shown in Fig. 3[33]. The sharp increase in volume for break-bulk and container cargo from 2004/5 to 2005/6 was due to the expansion of the railway service agreement to allow covered wagons and bilateral trade through the dry port. Prior to this, only transit trade with containers had been handled at the ICD. The drop in volume during 2009/10 can be attributed to the global economic recession.

Fig. 3 shows that the freight handled at Birgunj ICD in 2008/09 comprised 16,928 TEU (equivalent to 406,272 MT[3]) and 237,104 MT of cargo. The following scenario illustrates the emissions reduction potential of the rail-based Birgunj ICD: had there been no dry port, all freight from Kolkata[4] would have been transported to the dry port by HGV. Using the emission factors outlined in Section 2.4, the resulting CO_2 savings would have been 57,687 MT for 2008/9, which accounts for about 82% of the total road emissions.

The lessons learned from the case of Nepal show that it is relatively easy to develop an ICD infrastructure but that more effort is required to put it into operation. In any event, this ICD is a unique case, in the sense that it is located near the border, its main railway connection is from the Kolkata port in India, and most of its freight route is in India. The conclusion and expansion of the railway service agreement to include open break-bulk and freight wagons took more time than anticipated. We see here that it is worth considering operational issues during the development of infrastructure. The case of this Birgunj ICD underscores the importance of operational and facilitation issues, and the need to initiate and discuss operational agreements in advance.

Other dry ports in Nepal are in Biratnagar, Bhairahawa, and Kakarbhitta, which are near the India border, and at Kodari, near the China border. Recent initiatives to promote intermodal transport rail included a feasibility study of an east–west railway, a 60-km-long Kathmandu–Birgunj railway, and connections to the four railheads in India. Furthermore, talks are underway to extend the railway line from Lhasa in the Tibet region of China to the dry port at Kodari and further south to Kathmandu.

3.3. Lat Krabang ICD, Thailand

The Lat Krabang ICD was developed by the State Railway of Thailand (SRT) and operations started in 1996. It is located about 27 km east of Bangkok and 118 km north of Laem Chabang Port, with cargo carried by both railway and road between the Lat Krabang ICD and Laem Chabang Port. Terminal operations are managed by six private-sector concessionaires who provide services related to cargo consolidation, distribution, warehousing, customs clearance, and empty container storage.

Thailand is giving priority to the development of dry ports in order to help shift the movement of freight from road-based transport to intermodal transport. The existing Lat Krabang ICD has a full electronic data interchange (EDI) link and handled around 1.7 million TEU in 2008, far more than its initial design capacity of 500,000 TEU. Because of the resulting congestion, many containers from Laem Chabang Port are now bypassing the Lat Krabang ICD and proceeding directly to external facilities for consolidation and deconsolidation.

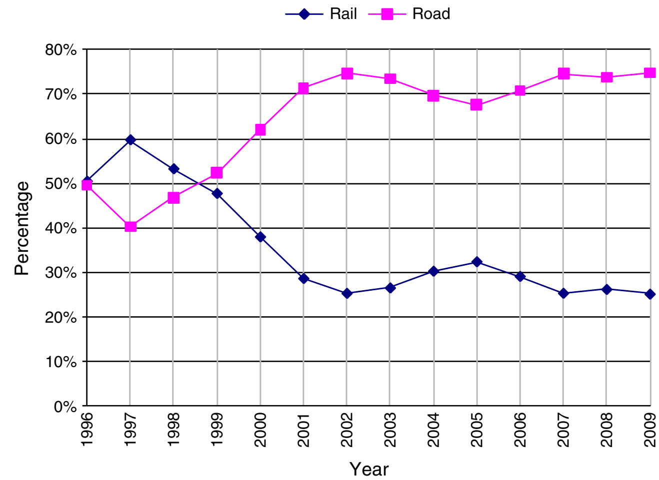

Fig. 5. Mode share of containers handled at Lat Krabang ICD [34].

Fig. 4 shows the continuous increase in containers handled at the Lat Krabang ICD. Fig. 5 shows the modal share of containers handled by truck and rail [34]. Although it was designed for a rail-to-road mode share ratio of 40:60, the rail share has been decreasing due to limited rail link capacity, congestion at the ICD, and the greater flexibility of road transport. On weekdays, 26 freight trains with 30 bogie container flat wagons capable of carrying 60 TEU operate between Laem Chabang Port and Lat Krabang ICD.

Fig. 5 shows that the rail mode share of the throughput handled by the ICD was about 25% in 2009, contributing to an overall reduction in congestion and emissions, since this reduced throughput would otherwise have been transported by road. The ICD is currently running at nearly twice its capacity, and therefore, SRT's planned expansion of the ICD capacity will contribute further positive environmental benefits.

SRT is planning a future expansion of the Lat Krabang facility in addition to the construction of new dry ports. Thailand is also working to enhance the country's logistics capabilities through the development of intermodal facilities to encourage a modal shift from road transport to the more environmentally friendly rail and water transport.

3.4. Dry port development in China

China is developing 18 large inland container rail transfer and logistics distribution centers [35] as part of its “Go West” strategy to encourage investment in, and the industrialization of, the country's interior. The China Railway Container Transport Center (CRCTC) was established by the Ministry of Railways as a container rail operator that can attract foreign investment. CRCTC has also attracted other companies to invest in a number of specific ventures. These facilities will be operated by China United International Rail Container Co., Ltd, a special-purpose entity set up by the Ministry of Railways in 2007.

Dry ports play an important role in stimulating economic development and facilitating international trade and transport in China's central and western inland areas. In this regard, three aspects of this initiative need careful consideration: (1) the role of the national government in promotion and coordination; (2) the development of dry port infrastructure, including other transport infrastructure that links to dry ports; and (3) the streamlining of institutional and regulatory frameworks [36].

[3] Using maximum allowed weight, 1 TEU = 24 MT.
[4] Kolkata–Birgunj: road distance, 924 km; railway distance, 704 km.

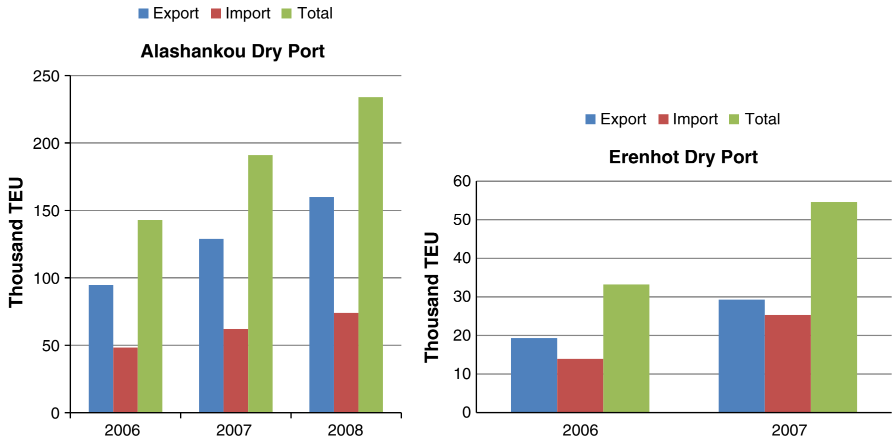

Fig. 6. Container traffic through border dry ports in China [35].

The Shijiazhuang dry port, with a design capacity of 205,000 TEU per year, is one of the largest dry ports in China. This dry port has both rail and road access. Customs, inspection, and quarantine are available here. This dry port has direct links with Tianjin seaport and mainly serves as a feeder for that port.

China also has a road-based dry port in Urumqi. A number of small-scale dry port facilities are under construction near the Urumqi railway station. All these dry ports in Urumqi mainly serve markets in Xinjiang and are not used for international trade. International cargo to and from Lianyungang to Alashankou normally bypasses Urumqi.

In terms of cargo volume, Alashankou is the second largest border station in China; it connects to the Dostyk station in Kazakhstan. It can handle all types of cargo: containers, break-bulk, oil, etc. On average, the Alashankou dry port handles about 20 freight trains daily. The Erenhot dry port near the border with Zammin-Uud in Mongolia also handles containerized and bulk cargo. Fig. 6 presents the volume of containers handled by Alashankou and Erenhot, showing growth of 36% and 52%, respectively, between 2006 and 2007 [35].

An international free trade economic zone (FTEZ) whose aim is to attract the construction of manufacturing factories is being established in Horgos, near the border between China and Kazakhstan. A logistics center is also planned within the FTEZ. Currently, border crossing and transport at Horgos are conducted by road. The average wait-time for trucks to cross the border is 2–3 days. Around 75–100 trucks cross the border each day from China to Kazakhstan, and a similar number travel from Kazakhstan to China. Trucks from Kazakhstan that receive special permission are allowed to operate in specified areas in China. An equal number of permits are issued to Chinese trucks operating in Kazakhstan. A railway linking Jinghe, Yining, and Horgos has recently been completed. A railway connection on the Kazakhstan side from the border of Khorgos to Almaty is also being planned.

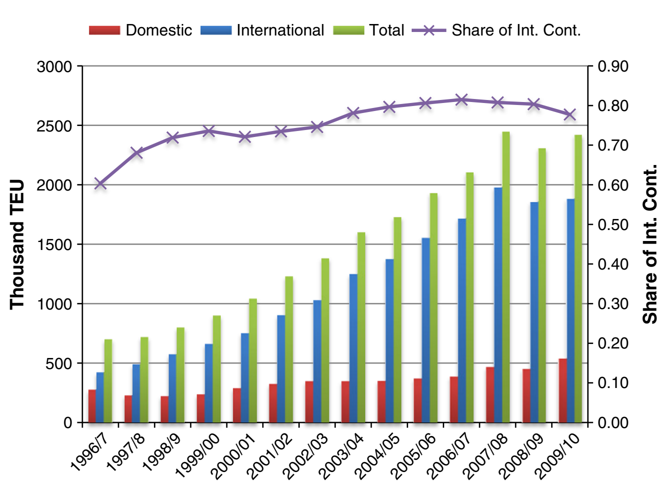

Fig. 7. Containers handled by CONCOR, India [38].

In order to improve rail freight efficiency, China has been running double-stack container train services to and from the main coastal ports on selected routes, using new specialized wagons and powerful locomotives. In 2007, Chinese Railways operated 680 double-stack trains that carried 53,161 TEU, compared to 2005, when it operated 454 trains that carried 39,437 TEU [37].

Development of dry ports, improvement of railway links and efficiency of double-stack trains mentioned above would improve overall efficiency of the intermodal transport and contribute to overall environmental benefits.

3.5. Dry port development in India

India has an extensive network of 59 ICDs, 49 of which can handle export–import. These inland dry ports provide customs clearance, warehousing, container parking, repair facilities, and office facilities. In almost all cases, these terminals are linked by rail to the Indian railway network. The operation is handled by the Container Corporation of India, Ltd. (CONCOR), a subsidiary of Indian Railways. Fig. 7 presents the volume of containers handled by CONCOR and shows that the share of international containers has grown gradually from 60% in 1996/97 to 81% in 2008/09. The decrease in container volume beginning in 2007/08 could be due to the economic recession. CONCOR is investing in the modernization of facilities and improved efficiency by improving its fleet and developing dedicated container platforms, advanced information systems, e-Business, and the use of information and communication technology (ICT) for container tracking.

The Tughlakabad ICD, which is located 17 km to the southwest of Delhi, has an area of 55 ha and is the largest rail-linked ICD in North India. It has a handling capacity of 400,000 TEU per year. It has good links to the Mumbai and Jawaharlal Nehru ports through the Delhi–Mumbai arterial trunk corridor and national highways. The ICD is equipped with completely modern facilities that include EDI, export and import warehouses, radio-frequency identification (RFID) container tracking, and customs clearance. In 2009/10, Tughlakabad ICD handled 413,384 TEU [38].

India is also implementing a project to develop dedicated freight corridors with an investment of about US$10 billion. One of these is the Mumbai–Delhi corridor, which is receiving assistance from the Japanese government. This freight corridor will segregate freight from

Table 1
Comparison of key features of selected dry ports.

	Uiwang Republic of Korea	Birgunj Nepal	Lat Krabang Thailand	Alashankou China	Tughlakabad India
Modes served	Rail, road	Rail, road	Rail, road	Rail, road	Rail, road
Environmental benefits/concerns, potential for modal shift	The use of railway to transport freight to/from ports to ICD contributes to a reduction in road congestion and vehicle emissions.	The modal shift to railway for transport between port and ICD, with collection and distribution of cargo by truck, contributes to emission reduction.	Contributes to reduced road congestion and vehicle emissions, but the share of rail freight is decreasing due to vehicle queues, ICD congestion and limited railway capacity.	Long-haul freight is mainly by rail. Development of dry ports, improvement of railway links and efficiency would contribute to environmental benefits.	Transportation to/from ports is mainly by rail, with roads used for collection and distribution. Increasing trend of container handled at ICDs and transport to ports by railways shows overall positive environmental benefits
Ownership	Public–private partnership (PPP)	Government	Public–private partnership	Chinese Railway, CRCTC	CONCOR, a subsidiary of Indian Railway
Operational arrangement	Private	Private (leased)	Private (concession)	Public–private CRCTC	Public
Government policies and incentives	Promotion of PPP projects through PIMAC.	Government investing in facility and has developed other dry ports as well.	Concessions to private sector for development and operation. Considering capacity enhancement.	Operations entrusted to CRCTC, a public–private venture.	CONCOR investing in the modernization of facilities and better efficiency through fleet improvements, dedicated platforms, and the use of ICT for container tracking.
Lessons learned from the development and operation of intermodal transport	Good example of PPP. The role of PIMAC in connecting port and ICD with high-capacity railway can reduce road congestion.	Operation delayed due to delays in concluding rail service agreement with Indian Railways.	Congestion at ICD and limited rail capacity connecting to port.	Government policy in developing railways and dry ports attract a higher share of freight to railways. Capacity enhancement ongoing. Starting double stack freight trains.	Good ICD and railway network. Dedicated freight corridors to enhance efficiency.

passengers and be a state-of-the-art system with a high axle load and capacity [39].

The increasing trend of container handled at ICDs and transport to ports by railways shows overall positive environmental benefits. These environmental benefits would be further augmented when the efforts to improve operational efficiency of ICDs and dedicated freight corridors would be completed.

3.6. A comparison of selected issues related to dry port development

Table 1 summarizes some characteristics of dry ports related to their development and operation. All dry ports included in the case studies were evaluated in terms of modes served; environmental benefits/concerns; potential for modeshift opportunities; ownership; operational arrangements; government policies and incentives for the development of dry ports; and lessons learned from the development and operation of intermodal transport.

4. Conclusions

This paper has reviewed the emergence of intermodal transport in Asia, highlighting the role of transport links, nodes, and services. It elucidated the potential environmental benefits of intermodal integration through the development of dry ports. Case studies of operations in Asia provided insight into the role of governments, markets, and the private sector in developing successful dry ports/ICDs. The case studies also served to emphasize various factors that have influenced the development and operation of dry ports and intermodal transport. Strong policy commitments by governments—aiming to bring together all facilities and services, including customs clearance, inspection, and consolidation, along with market-driven development—are some of the important factors that need to be considered. In addition, we have seen examples of dry ports/ICDs that are being developed as growth centers near FTEZs in order to attract investment and other services. Governments are able to initiate and promote such development, as shown by the case of the Republic of Korea. As we have also seen, at times, governments need to "push" the facilitation of new developments via the implementation of new policies and by liberalization and deregulation.

In addition to focusing upon infrastructural development, this paper also revealed the need to consider operational issues in coordination with infrastructure development. The discussion of road/rail service and international transit agreements takes considerable time, as shown by the case in Nepal. Here, dry port operation began 2 years after construction was completed because the conclusion of a rail service agreement with Indian Railway took longer than anticipated.

Railway connections to dry ports can reduce freight emissions of CO_2 and local air pollution through a modal shift that reduces the number of long-haul trucks plying on roads. The cases of Birgunj, Uiwang, and Thailand demonstrate this potential. Moreover, the current congestion and pollution at Uiwang and Lat Krabang are isolated cases that will be eased once the capacity of the ICDs is expanded and the share of rail freight is increased. Investment in railway infrastructure/dry ports can encourage modal shifts to greener modes of transport. In order to improve operational efficiency, the modernization of facilities and the use of cleaner and greener fuels are necessary. The use of modern ICT technology is also important, as can be seen at the Tughlakabad ICD in India. Detailed studies of the environmental benefits of dry ports are needed for future research.

One policy issue that needs to be addressed is coordination among the various government agencies involved in the development of dry ports, including those responsible for licensing, investment, promotion of private-sector initiatives, etc. Both government and the private sector need to work together to develop intermodal transport in Asia that not only provides access to inland and landlocked areas but also promotes environmentally friendly freight transport.

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