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A Multi-Criteria Approach to Dry Port Location in Developing Economies with Application to Vietnam

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ABSTRACT

This paper presents a conceptual framework for the inclusion of multiple criteria in the evaluation of dry port location in developing countries from a multiple stakeholder perspective. We present the framework in four steps. The first step encompasses preliminary research to filter the alternative locations for dry port development. In the second step, the stakeholders are clustered in three groups: dry port users, dry port service providers and the wider community. Then, we present the sub-criteria related to dry port location including the associated measuring methods. The third step includes an explanation on the methods used for weighing these criteria and sub-criteria. A multi-criteria analysis is carried out in the final step. We apply the methodological framework to Vietnam. The location of a new dry port project in Vinh Phuc province will be evaluated against two existing inland clearance depots (ICD) in Lao Cai and Phu Tho province.

1. Introduction

Dry ports are commonly defined as inland terminals that have strong connections to gateway seaports by high capacity and frequent transport services. Within a supply chain setting, dry ports might work as extensions of seaports or inland hubs to facilitate the movement of cargo between seaports and the hinterland. In advanced economies, such as North America or Europe, seaport authority and operators are the main drivers of dry port development with the purpose of solving the problems of limited capacity, natural constraints and externalities at seaports or improving hinterland access particularly for import cargoes. In contrast, dry ports in developing economies are naturally land-driven, established for consolidating (export) cargoes from regional economic zones and forwarding them to gateway seaports. In developing economies, dry port development is accelerating to improve the inland logistics efficiency (Ng and Cetin, 2012). One of the imperative issues of dry port development in

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developing economies is location planning. While the minimization of set up costs and total logistics costs are key factors in dry port location analysis, there are also other more qualitative location factors driven by multiple stakeholders involved like operators, users and the community.

This paper aims at building a conceptual framework for the inclusion of multiple criteria in dry port location for developing countries by taking into account the objectives of different stakeholders. Inspired by the LAMBIT model (Macharis and Verbeke, 2002), the paper provides a framework for proposing alternative locations, defining stakeholder groups, their criteria and sub-criteria in a hierarchical system as well as the methods to measure and weigh location factors.

The conceptual framework is applied to the developing country Vietnam. The location of a new dry port project in Vinh Phuc province will be evaluated against two existing inland clearance depots (ICDs) in Lao Cai and Phu Tho province. The results will take into account the relevant criteria for each stakeholder group and the specific setting in developing countries. Finally, a sensitivity analysis will be performed before turning to the conclusions.

2. The Characteristics of Dry Ports in Developing Countries

A variety of dry port terminologies is being used in the extant literature such as inland clearance depot (ICD) or inland custom depot (Beresford and Dubey, 1990, Economic Commission for Europe, 1998), inland terminals (UNCTAD, 1982), inland container depot (Roso, 2005), and inland port (Economic Commission for Europe, 2001). The term dry port is defined as: "an inland intermodal terminal that is directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport" (Roso et al., 2009).

A full range-service dry port covers a wide range of functions including customs clearance; storage; cargo consolidation; cargo handling for different transport modes; depot function; container maintenance and repair and value added services. Roso et al. (2009) classified inland nodes as close, mid-range and distance dry ports, based on the distance to seaports and the position in the hinterland supply chain. This typology is similar to the concept of satellite terminals, transmodal centers and inland load centers (Notteboom and Rodrigue, 2009). Another way to classify dry ports is based on the directional development (Wilmsmeier et al., 2011). An outside-in or sea-driven dry port means that its development is driven by a seaport actor, such as a port authority or terminal operator. This is mainly the case in developed systems like Europe and North America where seaports have reached the phase of regionalization (Notteboom and Rodrigue, 2005) through a strong cooperation and coordination with inland logistics locations. In contrast, inside-out or land-driven inland terminals are developed by inland parties, such as a local government or transportation companies, mainly in view of serving the local market.

Most inland terminals in developing economies are land-driven as they have been established to serve the export-based industrial zones. Thus, inland locations in developing economies are dominated by land-based players' interests and generally lack a high level of intermodal integration with seaports through high capacity, reliable and flexible train or inland waterway shuttles.

Dry ports in developing economies differ from dry ports in developed systems also in other ways. First, they are likely to be situated close to production bases, or even inside economic zones, as illustrated in the case studies of India (Ng and Gujar, 2009), Indochina region (UNESCAP, 2014) and South Africa (Cronje et al., 2009). According to Ng and Cetin (2012), the least-cost model for dry port positioning, which is working well in advanced economies, might therefore be insufficient for a developing system. They argue that inland nodes in developing countries might be more "cluster-oriented" than "supply chain-oriented". Next to a location at the end node of an inland supply chain, dry ports in developing countries could also be situated in the middle of the chain for transloading between two transportation networks. Such type of dry port is easily seen at border locations. Inland terminals in close proximity of seaports are rarely found in developing systems as such kind of dry ports are mostly sea-driven.

Second, production bases in developing nations are numerous but scattered across a large area. This supports the creation of numerous small ICDs which further complicates cargo bundling for intermodal services and results in a high reliance on road transport to transport cargo from/to seaports over mid-range or long distances.

Third, dry ports in developing countries have more chance of facing a lack of trained/experienced human resources and a poor information system support for inland transportation (see e.g. Garnwa et al., 2009 for a case on Nigeria).

Finally, dry ports in developing nations are frequently used by smaller shippers with less experience in global supply chain management. Using the transaction cost theory introduced by Williamson (1979), we argue that the problem of bounded rationality and bounded reliability lead to a higher transaction cost with distant dry ports. This makes local inland terminals more preferable for shippers to receive higher control and flexibility, therefore reducing uncertainty and lowering transaction costs.

We argue that the specific characteristics of dry ports in developing countries should in some way be reflected in dry port location analysis. Before introducing a conceptual framework on dry port location in developing countries, we briefly discuss existing approaches to dry port location.

3. Conceptual Framework to Evaluate Dry Port Location in Developing Countries

3.1. *Methodological Considerations for Dry Port Location Planning in Developing Countries*

Dry port location planning requires a thorough decision making process as it is too costly to relocate the facility in the short term. Many models used for facility location attach a substantial role to transport costs in view of finding the optimal location. Least transportation cost approaches as listed by Ng and Cetin (2012) include conditional logit model, mixed-integer programming, the dynamic programming model and the center of gravity model. We argue that dry port location analysis in developing countries can benefit from a methodological approach based on (a) the inclusion of multiple stakeholders' perspectives; (b) the inclusion of softer location factors and indicators; (c) an explicit consideration of the dry port environment in developing countries as outlined in the previous section.

First, location analysis should follow a multiple stakeholder perspective. Stakeholder theory has received increasing attention in transportation (De Brucker and Verbeke, 2008; Aerts et al., 2015). More specifically, the increasing integration between ports and their hinterland as captured by notions such as port regionalization and extended gates (Rodrigue and Notteboom, 2009, Veenstra et al., 2012) has led to a stronger involvement of a range of stakeholders in the further geographic reach of seaports (Haezendonck et al., 2014). In a dynamic world in which stakeholders do not act in a deterministic way, optimization techniques have their limitations in view of decision making (Bhushan and Rai, 2004). The least cost model has its limitations as it does not consider all stakeholders involved. In the light of stakeholder theory (Freeman, 2010), the only way to create value for shareholders is taking care of their stakeholders simultaneously. The main stakeholders in a dry port setting include seaport actors, shippers, forwarders, investors, terminal operators, central and local government, infrastructure managers, local residents and road users. Each stakeholder has its own interest, which leads to different demands for site selection. Any new dry port facility project should meet the demand of the market, or dry port users; be compliant with public planning and create value for the community in order to receive public support; and in the end be financially viable for investors and operators.

Second, there is room for the inclusion of softer indicators in location analysis. The factors influencing dry port site selection can be economic or non-economic, quantitative or qualitative. Dry port planning should take into account a number of softer more qualitative factors such environmental factors, land and labour availability, information technology level, regional trade facilitation level, reliability to name but a few (see e.g. Nunez, 2013; Notteboom and Rodrigue, 2007). The need for the inclusion of soft criteria in a multi-stakeholder environment is echoed in the work of Dooms (2014) who illustrated the importance of aiming for the high triple 'P' (people, planet and prosperity) bottom line performance while maintaining a high public trust or 'social license to operate'.

Third, we argue that location analysis techniques used in developing countries should acknowledge the specific dry port environment in these countries at the level of spatial, economic and institutional characteristics and criteria such at the functional profile of dry ports in developing countries, the role they play for scattered production centres, their relative disconnection to seaports and moderate to low intermodal connectivity, etc.

3.2. *Conceptual Framework based on the MADM Approach*

In this paper we use multi-criteria decision-making (MCDM) as we are dealing with various and diverse factors measured using different units and driven by various stakeholders (Mustajoki et al., 2004; Bhushan and Rai, 2004). We follow the multi-attribute decision-making (MADM) approach as the number of potential locations for dry port planning is finite due to the high requirements linked to a dry port site in terms of land availability and suitability.

The most important goal of the analysis is to find out whether one alternative is preferred over another, not their exact value. The inclusion of soft criteria is possible in MADM since the preference among alternatives could be shown in a ratio based on a more qualitative evaluation, such as a Likert scale or a pairwise comparison.

In order to apply the MADM approach we classify the stakeholders in rather homogenous groups with the members of each group sharing similar key objectives and concerns (Saaty, 2005). The LAMBIT model (Macharis and Verbeke, 2002) helps to organize the hierarchy of criteria. The model clusters stakeholders into three groups: terminal users, terminal service providers and the community. Notteboom (2011) used a similar approach when evaluating the best location to develop a new large-scale container facility in south Africa. The parties in the same group are homogenous since they have similar interests when it comes to terminal location. Terminal users include actors that are concerned with the logistics desirability of the project. The service providers are investors and operators who care about the financial viability of the project. Finally the parties in the community group share the same interests in terms of environmental protection, low congestion and employment creation.

Inspired by the LAMBIT model (Macharis and Verbeke, 2002), we further specify a conceptual framework based on the MADM approach for evaluating dry port locations in developing countries. The framework considers four steps (figure. 1).

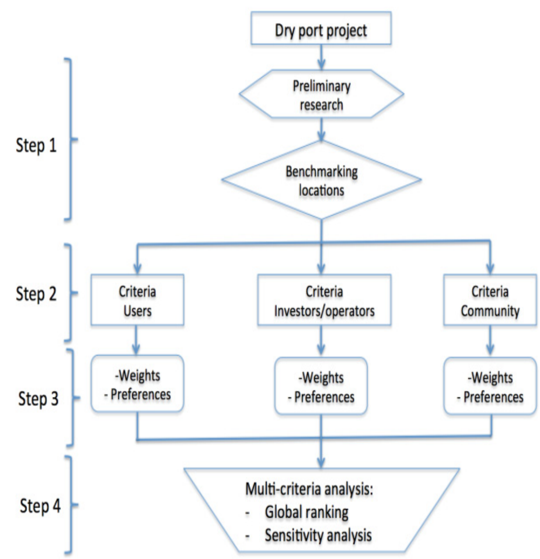

Fig. 1. A four-step conceptual framework to evaluate dry port locations
Source: Authors, adapted from Macharis and Verbeke (2002).

By including all stakeholders and clustering them in groups, the framework aims to cover all factors that influence dry port site selection, including softer non-economic criteria and criteria specifically relevant to developing countries. This framework allows the inclusion of both quantitative and qualitative methods to measure and weigh criteria. The framework, when applied to a concrete case, is hoped to provide detailed conclusions that can support decision makers in selecting a site.

3.3. *Step 1: Preliminary Research to Identify Location Alternatives*

This step is needed when no discrete set of existing dry port locations has been pre-selected by public or private actors. Possible options are screened and unlikely locations are removed based on restriction criteria, such as freight demand, overall capacity, expansion ability, connectivity, natural and society restrictions, international importance and users' special needs. This step results in a set of discrete choices for potential location assessment, which serves as a basis for the next steps.

3.4. *Step 2: Determination of Criteria, Sub-criteria and Measuring Methods and Clustering Stakeholders*

In this step, all stakeholders involved in or affected by dry port planning are clustered in groups. Then we define criteria and sub-criteria that have an influence on the site selection of each group. The classification of stakeholders is imperative for directing a questionnaire for interviews in order to find out the weights and scores for the criteria (Dooms and Macharis, 2003). We consider three main dry port stakeholders: the community, dry port service providers and dry port users.

Dry port service providers include dry port investors and operators, who show great interest in financial viability and the development potential of the location (e.g. room for further growth). The group of the dry port users includes shippers, logistics providers, transport companies and freight forwarders. Their primary attractiveness in hub locations is logistics efficiency in cargo movements from the regional economic zones to gateway seaports. Finally, the community stakeholder group includes the local government (which should be the prime defender of the local community interests), local residents and road users who care about the regional economy impact, job creation and the reduction of externalities.

After grouping stakeholders, we define criteria and sub criteria for each stakeholder group based on insights gathered from Ng & Gujar (2009), Ka (2011), Padilha and Ng (2012), Núñez et al. (2013), Macharis and Verbeke (2002), Garnwa et al. (2009), Sirikijpanichkul et al. (2007), Wilmsmeier et al. (2011) and in-depth interviews with local stakeholders from Vietnam. Apart from criteria based on each separate group's needs and objectives, criteria describing the interactions between these stakeholders are added. The defined criteria should be independent from each other to avoid double counting, which causes bias for the model.

Table 1
Criteria relevant to dry port users.

Criteria	Indicators	Measuring method	Measuring units
Reduction of transportation cost	Cost saved by using intermodal service in dry port	Compare intermodal transport cost with the road system	USD per route per TEU
Reduction of transportation time	Time saved by using intermodal service in dry port	Compare intermodal transport time with the road system	Hours per route per TEU
Accessibility to road infrastructure:	- Proximity to highway - Average Daily Traffic - Level of Service	Expert evaluation	Likert scale: 1- very bad; 5 - very good
Accessibility to railway infrastructure	- Proximity; - Capacity - Frequency; - Reliability	Expert evaluation	Likert scale: 1- very bad; 5 - very good
Accessibility to inland waterway infrastructure	- Proximity; - Capacity - Frequency; - Reliability	Expert evaluation	Likert scale: 1- very bad; 5 - very good
Range of service	- Service available	Expert evaluation	Likert scale: 1- very bad; 5 - very good
Proximity to the production base	- Distance to target production bases	Expert evaluation	Likert scale: 1- very close; 5 – too far
Proximity to other logistics platform	- Distance		Km

Source: Own compilation based on various sources

Criteria relevant to the dry port users are listed in Table 1. The reduction of transport cost and time refers the savings dry port users can make when using the intermodal service of the dry port. Assuming that the cargo handling cost is the same in all locations, the ratings of these criteria are based on the differences in time and cost between using intermodal transport and road transport. The longer distance the trip by train, the more transport cost and time saved by the shippers.

The criteria related to the accessibility to a transport mode measure how easily different inland transport infrastructures can be accessed from the dry port location. For road transport, we consider the distance to the nearest highway exit, average daily traffic and level of service (Núñez et al., 2013). Rail and barge integration concern the distance to the nearest system, daily capacity, frequency and reliability of the connection. The next criterion compares the range of services provided by each location. Dry ports can provide a wide range of services, including cargo receipt and dispatch; packing and unpacking of LCL export containers; container storage; container repair; railhead/shunting operation; provision of customs clearance; provision of office space for relevant commercial activities; provision of cargo handling equipment; provision of appropriate security; provision of communication facility (Beresford and Dubey, 1990). The rating is based on the service available at each location.

As explained, shippers in developing countries prefer local dry ports to have a better connection with and control to their cargo movements. The criterion of proximity to the production base refers to the distance between the dry port location and the target industrial zones. The ratings/scores on this criterion then is obtained by consulting local experts. The last criterion is the proximity to other logistics platforms. The distance to other logistics center shows the potential of the dry port to interact with the whole logistics system of the country (Núñez et al., 2013). Being situated close to a logistics center or similar logistic platforms will guarantee a good basis for dry port success.

Table 2 presents criteria relevant to dry port service providers. The demand for dry port services in the location is one of the most important concerns to investors. Its rating/score can be obtained from demand forecasts related to the dry port project. The investment and operating cost is another imperative criterion. In terms of cost factors, the model considers land cost, energy cost, labor cost and the cost to relocate the railway station for rail network accessibility. Another factor is the room for expansion at the site, here measured by the maximum area allocated to the project. The next criterion is the investment and operational climate, which is indicated by the banking environment, government support and existing competition in the area. They reflect the ease of doing business, economic governance and administrative management and reform of local government, or in other words, the interaction between investors/operators with government and local players. Available indices such as the PCI (Provincial Competitiveness Index) can be used for rating this criterion. The last criterion of inter-project explains that some investments are made despite of theirs negative net project value if they generate positive inter-project effects for other projects (De Schepper et al., 2015). This could be seen in contracting with government in order to provide a public service. This criterion could be identified by reputation enhancement and capability upgrade of the investors after making the investment.

Table 2
Criteria relevant to dry port service providers

Criteria	Indicators	Measuring method	Measuring unit
Demand for dry port services	Forecasting container flow	Acquired from the dry port planning project	TEU
Investing & operating cost	- Land cost - Labor cost - Energy cost - Railway relocation cost	Acquired from the dry port planning project and local government	USD
Room for expansion	Maximum area for dry port expansion	Acquired from the dry port planning project	Ha
Investment & operational climate	- Banking environment - Government support - Competition	Expert evaluation or using existing index if available	Likert scale: 1- very bad; 5 - very good
Inter-project spillover effect	- reputation enhancement - capability upgrading	Expert evaluation	Likert scale: 1- very bad; 5 - very good

Source: Own compilation based on various sources

Lastly, criteria relevant to the community are shown in Table 3. The first factor that influences the site selection of the community is the efficiency of the transport network, or how the new dry ports could complement seaports and other inland transport planning. The second public concern is how the dry port project supports land use reorganization policy, such as the relocation of companies/industries from a high-density area to a less urban area. Another factor is the impact of value added and return to local government from the new site, but taken into account the loss from the involved land reclamation (Kapros et al., 2005). The employment creation is another criterion highly relevant to the local government and residents. The next consideration of the community is pollution. There are two main sources of pollution, including pollution on route caused by moving vehicles and pollution caused by dry port related activities. The former one could be estimated based on the modal shift when using a dry port, while the latter could be evaluated by looking at the population density in the surrounding area, which might be affected by the pollution generated by dry-port activity. Noise might be considered in many cities due to its long-term influences over natural environment and urban environment (Núñez et al., 2013). The simplest way to benchmark noise effects is giving the expert judgments based on the distance to the influenced subjects. However, in many cases of developing countries, this criterion should not matter since their dry ports are mostly located in the proximity of remote industrial zones. Visual intrusion and congestion reduction are other considerations relevant to the community.

Table 3
Criteria relevant to the community

Criteria	Indicators	Measuring method	Measuring units
Complementary with other inland transport & seaport planning		Expert evaluation	Likert scale: 1- very bad; 5 - very good
Contribution to land use reorganization		Expert evaluation	Likert scale: 1- very bad; 5 - very good
Maximizing value added services and return to government	- Tax paid - Value added	Expert evaluation	Likert scale: 1- very bad; 5 - very good
Employment generation	Number of estimated employees	Estimation based on dry port planning project	Employees
Minimizing transportation pollution	CO2 reduced per TEU per route by modal shift	Estimation	Gram CO2 per TEU per route
Dry port related pollution created	Affected population	Population in resident areas within a certain radius of the location	People
Noise		Expert evaluation	Likert scale: 1- very bad; 5 - very good
Minimizing visual intrusion		Expert evaluation	Likert scale: 1-strong violation, 5- no violation
Minimizing road congestion	Local traffic and road used	Analysis of local traffic	Likert scale: 1- very bad; 5 - very good

Source: Own compilation based on various sources

3.5. *Step 3: Weighing Methods*

In order to carry out the multi criteria analysis, it is required that each defined factor is assigned a weight of importance. The weights are often collected from groups of stakeholders' preferences through questionnaires using different methods. There are several popular methodologies for obtaining attribute weights, including analytical hierarchy process (AHP) (Saaty, 2008), SWING (Von Winterfeldt and Edwards, 1986), direct point allocation and the simple multi-attribute rating technique or SMART (Edwards, 1977). Those methods are discussed and compared in the work of Pöyhönen and Hämäläinen (2001). In short, AHP weighing is based on the pairwise comparison of criteria. Direct point allocation inquires the decision maker to allocate points to each criterion corresponding to the attribute's importance. The SWING technique requires the participants firstly choose the most important attribute and give it a score of 100, before allocating a score of less than 100 to other attributes. In the SMART technique the decision maker is asked to start with the least important factor, giving it a score of 10, and then to grade other factors based on their relative importance compared to the former.

3.6. *Step 4: MADM Analysis*

The obtained value for each criterion and each alternative and their respective weights are pooled in the multi-criteria technique to rank the alternatives. We use the HIPRE software in the empirical part of this paper. By putting the value of alternatives into a hierarchical tree, the additive value function is applied to calculate the overall rating of each alternative (Mustajoki et al., 2004):

$$v(x) = \sum_{i=1}^{n} w_i v_i(x), \qquad (1)$$

where n: the number of criteria,
i: the consequence of the criterion
w_i: the weight of criterion i
$v_i(x)$: the value of alternative x in terms of criterion i, between 0 and 1

The ranking of alternatives is obtained by comparing the overall ratings. Furthermore, the software provides tools for visual representation of the results and for performing sensitivity analysis to show how the global rankings change when a local rating varies.

4. Application to a Case in Northern Vietnam

4.1. *Background to the Case Study*

The development of the dry port system is one of the essential targets of the Vietnamese government in order to improve the logistics efficiency of the whole country. The demand for containerized cargo in the country has been increasing from 100,000 TEU in 1991 to 6,588,805 TEU in 2013 (The World Bank, 2014). This strong growth is putting pressure on the Vietnamese transportation system. Roughly two thirds of the container cargo goes through the seaport system in Southern Vietnam, one third visits the system in the North, while the amount using the Central Vietnam is rather insignificant. In Northern Vietnam, ICDs tend to be located far away from the seaports. Most of them are small and heavily rely on road connections. Lao Cai ICD is the first inland node which has a rail connection to serve the adjacent region and cargo coming from or going to Southwest China.

In this paper, we specifically develop a location analysis for Vinh Phuc ICD, Thuy Van ICD and Lao Cai ICD in Northern Vietnam (figure 2). The three ICDs are situated along the Kunming (China) - Lao Cai - Hanoi - Hai Phong economic corridor, with accessibility to the Trans-Asia AH14 highway and the existing railway line between Lao Cai and Hai Phong.

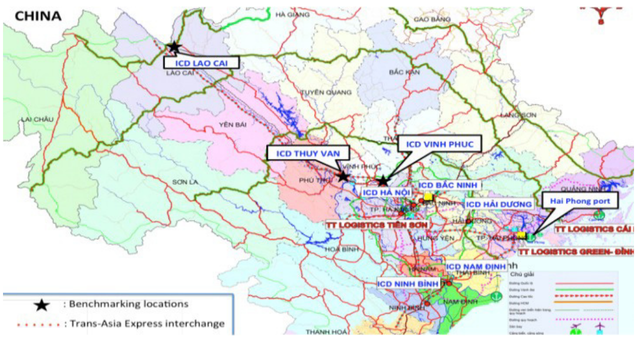

Fig. 2. Locations of Lao Cai ICD, Thuy Van ICD and Vinh Phuc ICD
Source: Vietnam Ministry of Transport

Vinh Phuc ICD is a project authorized by Vinh Phuc Provincial People's Committee. The local government assigned an area of 100 ha in Huong Canh town (Vinh Phuc province) for dry port planning, making it the largest dry port in Northern Vietnam if successful. The location is 18 km away from the Noi Bai international airport and 140km from Hai Phong seaport. Located in the proximity of numerous industrial zones in Vinh Phuc province, the ICD is expected to serve the very promising market of enterprises in Vinh Phuc and nearby provinces, such as Tuyen Quang, Thai Nguyen, Ha Giang and Phu Tho. The container flow in the area is forecasted to reach more than 500,000 TEU in 2015 (Vietnam Ministry of Transport, 2010). Another advantage of the ICD is the good accessibility to the road and railway system. The location is close to National highway No 2 and several provincial roads. Vinh Phuc ICD is projected to connect to the Lao Cai – Hai Phong railway system by investing USD 8.5 million to relocate an existing railway station in Vinh Phuc to the proximity of the ICD. Additionally, the ICD has the potential for easy inland waterway access as it is located close to the road which links to Vinh Thinh port along the Red River.

Both Thuy Van and Lao Cai ICD are existing dry ports. Thuy Van ICD is being operated over only 2.7 ha out of the 10 ha planned, while Lao Cai ICD's land use is 4.7 ha out of a total of 13.5 ha. Thuy Van ICD (Phu Tho province) is located around 40 km away from Vinh Phuc ICD, which would lead to competition if Vinh Phuc ICD would be developed. The railway connection is being upgraded via a 2 million USD investment in a new transit railway system. The ICD is located within the industrial zones of the Phu Tho province, which serves enterprises in Phu Tho and neighboring provinces, including Tuyen Quang, Yen Bai, Ha Giang. Container demand in the region is estimated at 191,772 TEU per year.

Lao Cai ICD is located in Lao Cai province, 400 km away from Hai Phong seaport and more than 250km away from the Vinh Phuc ICD. It has a unique location at the border with China. The ICD is also serving the local industrial zones in its proximity with a container demand of around 85,000 TEU per year. The ICD is located in a remote and less urban area which results in the lowest land costs and the lowest environmental effects. At the moment, there is one train operated daily between Lao Cai ICD and Hai Phong port.

The three locations share quite a lot of similarities. First of all, they have a similar accessibility to the road and rail system, which is part of Tran-Asia Express interchange. All three ICDs are located inside large industrial zones and do not have much difference in terms of labor cost and energy cost. They offer or will offer a full range of services, including customs clearance, cargo handling, distribution, storage and container maintenance and repair. Since all three locations are located in the proximity of local industrial zones that have long distances to urban area, noise influence from dry port activities is not considered. Their influences on visual intrusions are all insignificant.

4.2. *Specification of the MADM Model*

Based on the conceptual framework presented earlier in this paper, a model was created for evaluating dry port locations Lao Cai ICD, Vinh Phuc ICD and Thuy Van ICD (figure. 3).

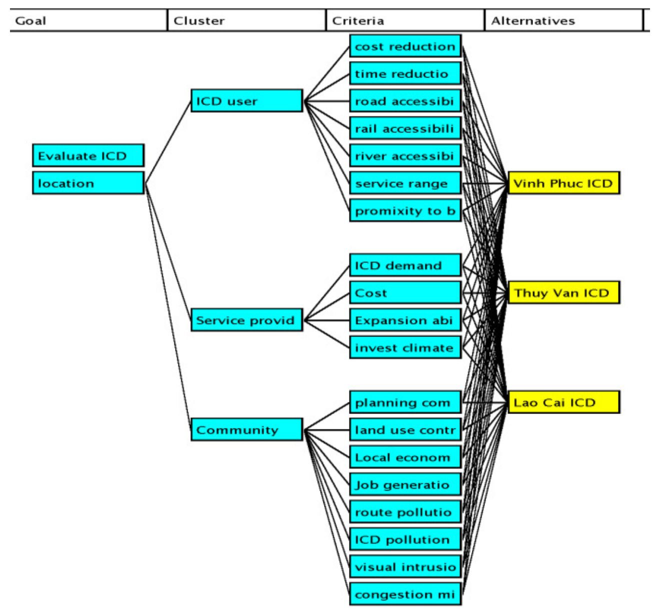

Fig. 3. MADM evaluation model used in the case study on northern Vietnam
Source: authors using Web-HIPRE software

The weights for each criterion in the model were gathered through a survey. There were 23 respondents in total, including experts and managers from the three main stakeholder groups (i.e. dry port users, dry port service providers and the community). In terms of education, 52.2% have a master degree or higher and the remaining 48.8% have a bachelor degree. All respondents have more than 5 years of experience in their working fields related to dry ports.

The weighing methods used are SWING and pairwise comparison based on AHP. For the pairwise comparison, the surveys that have a consistency ratio of more than 10% are considered as inconsistent and were eliminated. The results of this weighing exercise can be found in Appendix A.

The input data for the case study was gathered for 19 criteria and three stakeholder clusters as summarized in Appendix B. The quantitative data were collected from the ICD projects, statistics reports and own calculations. The qualitative data were obtained from expert evaluations based on collected indicator data.

4.3. *Model results*

We first run the model to see which location is the most preferred under the assumption that the three stakeholder groups are equally important (i.e. weight of each group is 0.33).

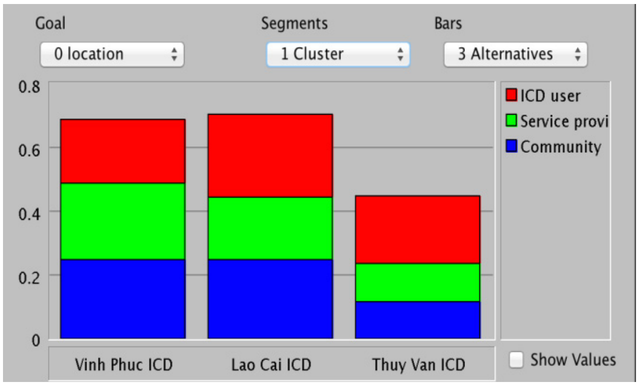

Fig. 4. Ranking in the case the three stakeholder groups are equally important

Source: Authors, created by Web-HIPRE software

As shown in Figure 4, Lao Cai ICD is slightly preferred over Vinh Phuc ICD while Thuy Van ICD is the least preferred location out of the three ICDs. In short, Lao Cai ICD benefits its users and community the best thanks to the longest rail connection to the seaport, which offsets its limitation in land expansion. Vinh Phuc ICD has huge advantages in abundant land planning and high market demand, but has the shortest distance to seaport. Thuy Van ICD scores the least due to its limited land, short distance to seaports and low complementarity with other transport planning initiatives. More detailed results on the comparison between the ICD locations in terms of each stakeholder groups are shown in Appendix C.

We carry out a sensitivity analysis to have deeper insights in the results. Table 4 shows the results of a sensitivity analysis carried out at the level of the weight of each stakeholder group. The value in the cell shows the range of weights in terms of the stakeholder group in the corresponding row when the location in the column scores the best. For example, Vinh Phuc ICD will be the best choice when dry port users' weight is less than 0.25. If it is more than 0.25, Lao Cai ICD becomes the best choice while Thuy Van ICD never obtains the best score at any weight for dry port users.

Table 4
Sensitivity analysis in terms of 3 stakeholder groups

	Vinh Phuc ICD	Lao Cai ICD	Thuy Van ICD
Dry port users	0 - 0.25	0.25 - 1	N/A
Dry port service provider	0.4 - 1	0 - 0.4	N/A
Community	N/A	All value	N/A

Source: Authors

Similarly, Table 5 shows how the global rating changes when the weights of each criterion change in the case the three stakeholder groups are equally important. For example, as long as the relative weight of the criterion 'Accessibility to railway infrastructure' stays below 0.39, Lao Cai ICD remains the best location (weights of all other ciriteria kept at current level). Another way to carry out a sensitivity analysis is by assessing how the global rating changes when the value of one criterion for one location changes. Table 6 shows an example by changing the score for investment climate of each location. If Vinh Phuc ICD can increase its PCI index from 58.9 to 64.3, or the score of Lao Cai ICD drops below 53.9, Vinh Phuc ICD will become the best option overall.

Table 5
Sensitivity analysis in terms of each criterion's weight in case the three stakeholder groups are equally important

Stakeholder group	Criteria	Current weights	Vinh Phuc ICD	Lao Cai ICD	Thuy Van ICD
Dry port users (0.33)	Reduction of transportation cost	0.16	<0.06	>0.06	N/A
	Reduction of transportation time	0.15	<0.05	>0.05	N/A
	Accessibility to road infrastructure	0.14	>0.39	<0.39	N/A
	Accessibility to railway infrastructure	0.14	>0.39	<0.39	N/A
	Accessibility to inland waterway	0.13	>0.3	<0.3	N/A
	Range of service	0.15	>0.39	<0.39	N/A
	Proximity to the production base	0.14	>0.39	<0.39	N/A
Dry port service provider (0.33)	Demand for dry port services	0.36	>0.62	<0.62	N/A
	Investing & operating cost	0.32	<0.22	>0.22	N/A
	Room for expansion	0.14	>0.21	<0.21	N/A
	Investment & operational climate	0.17	N/A	All value	N/A
Community (0.33)	Complementary with other inland transport & seaport planning	0.23	<0.05	>0.05	N/A
	Contribution to land use reorganization	0.1	>0.3	<0.3	N/A
	Maximizing the local economic benefits	0.15	>0.33	<0.33	N/A
	Employment generation	0.13	>0.2	<0.2	N/A
	Minimizing transportation pollution	0.1	<0.02	>0.02	N/A
	Dry port related pollution created	0.11	N/A	All value	N/A
	Minimizing visual intrusion	0.05	N/A	All value	N/A
	Minimizing road congestion	0.14	N/A	All value	N/A

Source: Authors

Table 6
Sensitivity analysis in terms of changing scores on investment climate

	Current score	Vinh Phuc ICD	Lao Cai ICD	Thuy Van ICD
Vinh Phuc ICD	58.9	>64.3	<64.3	n/a
Lao Cai ICD	59.4	<53.9	>53.9	n/a
Thuy Van ICD	53.9	n/a	All value	n/a

Source: Authors

5. Conclusions

This paper dealt with the location of dry ports in developing countries. In contrast to more advanced systems, where dry port development is often driven by seaport interests, inland terminal planning in developing countries seems to be triggered by land parties to facilitate the movement of cargo from the interior to seaports. In many observed cases, dry ports in those countries are located at the end of the supply chain, close to production bases so as to benefit local shippers; or in the middle point between markets and ports to facilitate cross-border transportation.

We presented a conceptual framework for the application of multi-criteria analysis to dry port location in developing countries that takes into account both quantitative and qualitative/softer criteria relevant to a range of stakeholders. The model encompasses several steps: a preliminary research on alternatives for evaluation, the identification of evaluation criteria and the associated measuring methods, the clustering of stakeholders in groups, determining the weighing method for each factor and finally the execution of the multi-criteria analysis in view of ranking the alternatives. The framework was applied to evaluate 3 ICD locations in Northern Vietnam.

The biggest potential bias when applying this model is at the stage of allocating the weight for each criterion since it relies on subjective judgements. The empirical results from the survey in the Vietnam case showed a wide range of difference in respondents' opinions on several criteria, such as contribution to land use relocation, investment climate or expansion ability. If one sole party wants to apply the model to support its site selection, the judgement should be gathered from the decision-making groups with serious consideration and understanding of potential bias. For the multiple stakeholders involved, the weight allocation should achieve consensus of all stakeholders' opinions to reduce bias. For example, the survey could be run multiple times to create a forum for respondents to revise the final results in order to approach a certain degree of consensus on the weights and ratings of the individual criteria.

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Appendix A. Empirical result of weights of each stakeholder groups’ criteria

Table A1
Empirical result of weights of dry port user’s criteria using SWING

	Criteria	Maximum	Minimum	Average	Normalized average weight
1	Transport cost reduction	100.00	70.00	90.59	0.157
2	Transport time reduction	100.00	70.00	87.65	0.152
3	Accessibility to road	90.00	60.00	79.41	0.138
4	Accessibility to rail	100.00	60.00	79.41	0.138
5	Accessibility to inland waterway	100.00	60.00	76.47	0.133
6	Service range	100.00	60.00	83.53	0.145
7	Proximity to the production base/market	90.00	50.00	78.82	0.136
Total					1.000

Table A2
Empirical result of weights of dry operator/investor’s criteria using pairwise comparison

	Criteria	Maximum	Minimum	Average	Normalized average weight
1	Market demand for dry port services	0.45	0.274	0.3632	0.363
2	Investing & operation cost	0.45	0.13	0.3178	0.318
3	Investment climate	0.389	0.05	0.1436	0.144
4	Expansion ability	0.392	0.05	0.1754	0.175
Total					1.000

Table A3
Empirical result of weights of community’s criteria using SWING

No	Criteria	Maximum	Minimum	Average	Normalized average weight
1	Complement with other transport planning	100.00	80.00	97.50	0.227
2	Contribution to land use reorganization	90.00	20.00	65.00	0.102
3	Maximizing value added services and return to government	100.00	50.00	70.00	0.148
4	Employment generation	80.00	30.00	57.50	0.131
5	Minimizing pollution per route	70.00	30.00	50.00	0.097
6	Dry port related pollution	80.00	40.00	51.25	0.114
7	Minimizing visual intrusion	50.00	10.00	30.00	0.045
8	Minimizing road congestion	80.00	40.00	66.25	0.136
Total					1.000

Source: Authors’ presentation of data compiled by own survey

Appendix B. Input data for the model of the three ICDs in Vietnam

Group	Criteria	Vinh Phuc ICD	Thuy Van ICD	Lao Cai ICD	Unit
User	Reduction of transport cost	135.8	183.33	388	USD per route per TEU
	Reduction of transport time	7	9.45	20	Hour per route
	Accessibility to road	3.5	3.5	3.5	1-very poor, 5-very good
	Accessibility to rail	4	3.5	4	1-very poor, 5-very good
	Accessibility to inland water way	1.5	2	1	1-very poor, 5-very good
	Range of service	5	5	5	1-very poor, 5-very good
	Proximity to the production base	5	5	5	1-too far, 5-very close
Service provider	Market demand	500346	191772	365035	TEU
	Cost (negative)	3.5	3	2.5	1-very low, 5-very high
	Room for expansion	100	10	13.5	ha
	Investment atmosphere	58.86	53.91	59.43	PCI index
Community	Complement with other transport planning	4	2	5	1-very weak, 5-very strong
	Contribution to land use reorganization	5	2.5	4	1-very weak, 5-very strong
	Maximize local economy	4.5	2.5	3.5	1-very low, 5-very high
	Employment generation	1500	150	202	Employee
	Minimize pollution per route	37380	50463	106800	Gram CO2 reduction per TEU per route
	Dry port related pollution (negative)	768	1239	444	People/km2
	Minimize visual intrusion	5	5	5	1-strong violation, 5- no violation
	Minimize road congestion	3.5	2	4	1-very low, 5-very high

Source: Own compilation based on various sources

Appendix C

Fig. C1. Ranking of the three locations in terms of dry port users' interest

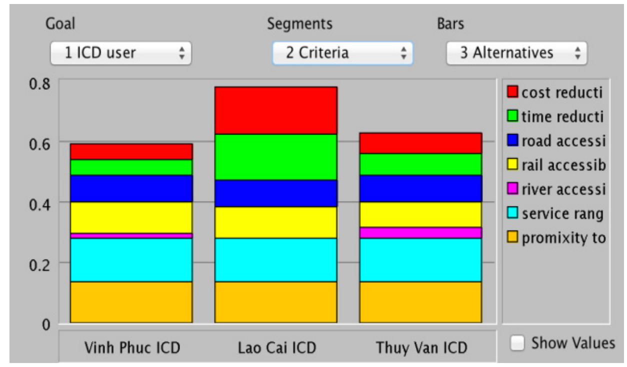


Fig. C2. Ranking of the three locations in terms of dry port service provider's interest

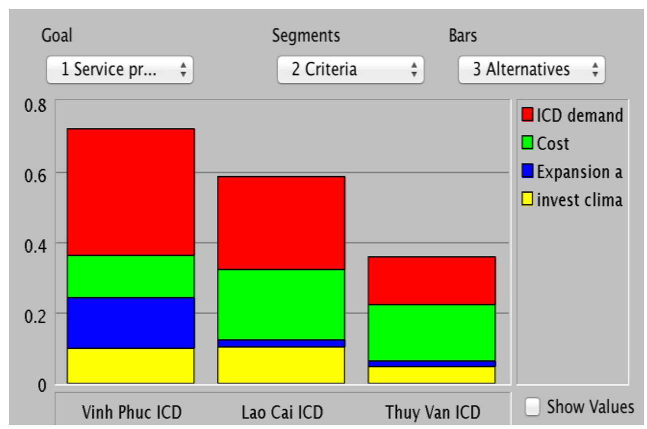
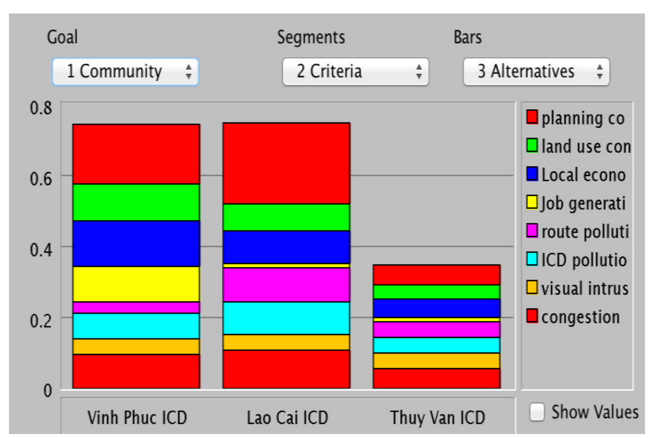


Fig. C3. Ranking of the three locations in terms of community' interest



Source: Authors, created by Web-HIPRE software