Received: 24 August 2015 Accepted: 23 November 2015 *DOI ID: 10.5505/jems.2016.81300*

Journal of ETA Maritime Science JEMS JOURNAL

Original Research (AR)

Dry Port Location Problem: A Hybrid Multi-Criteria Approach

BENTALEB Fatimazahra[1], MABROUKI Charif[1], SEMMA Alami[1]

[1] Laboratory of Engineering, Industrial Management and Innovation, FST, HASSAN 1st University, Morocco, *fatimazahra.bentaleb@gmail.com; charif.uh1.fst@gmail.com*

Abstract

Choosing a location for a dry port is a problem which becomes more essential and crucial. This study deals with the problem of locating dry ports. On this matter, a model combining multi-criteria (MACBETH) and mono-criteria (BARYCENTER) methods to find a solution to dry port location problem has been proposed. In the first phase, a systematic literature review was carried out on dry port location problem and then a methodological classification was presented for this research. In the second phase, a hybrid multi-criteria approach was developed in order to determine the best dry port location taking different criteria into account. A Computational practice and a qualitative analysis from a case study in the Moroccan context have been provided. The results show that the optimal location is very convenient with the geographical region and the government policies.

Keywords: *Dry port, Seaport, Location problem, MACBETH, BARYCENTER, Multimodal transport*

Kara Limanı için Yer Problemi: Çok Kriterli Bütünleşik Bir Yaklaşım

Öz

Kara limanı için yer seçimi, daha da önemli ve kritik hale gelen bir sorundur. Mevcut çalışma, kara limanları için yer bulma problemini ele almaktadır. Bu konuda, kara limanı yer problemine çözüm getirmek amacıyla çok kriterli (MACBETH) ve tek kriterli (BARYCENTER) yöntemleri birleştiren bir model önerilmiştir. İlk aşamada, kara limanı yer problemi ile ilgili yapılmış makaleleri incelemek üzere sistematik bir derleme çalışması yürütülmüş ve daha sonra bu araştırmalar için metodolojik bir sınıflandırma sunulmuştur. İkinci aşamada, farklı kriterleri dikkate alarak en iyi kara liman konumunu belirlemek üzere çok kriterli bütünleşik bir yaklaşım yöntemi geliştirilmiştir. Fas bağlamında bir örnek olay çalışması ile ilgili hesaba dayalı uygulama ve nitel bir analiz sunulmuştur. Sonuçlar, en iyi konumun coğrafi bölge ve hükümet politikalarına oldukça uygun olduğunu göstermektedir.

Anahtar Kelimeler: *Kara limanı, Deniz limanı, Yer problemi, MACBETH, BARYCENTER, Çok modlu taşımacılık*

1.Introduction

The increase of containerized maritime transport has caused a requirement for better efficiency and improved capacity in the transshipment through seaports as well as in the transport to and from seaports in the hinterland [1]. The steeply rising container flows have resulted congestion in seaports. For some seaports, the feeblest link in the multimodal transport is the storage zone. In addition, delays and transportation costs increase proportionally with increase of congestions [2]. Many seaports control hinterland transport. Seaports are not competing only with seaports in their local area but also with distant seaports attempting to serve the same hinterland. Dry ports should become new client for seaports, which will assist to reduce costs and take advantage of the added value of the whole multimodal transport [3]. Dry ports are predictable to progress the performance of the seaport and the performance of the dry port-seaport system in general [4]. Hence, the idea of creating dry port is to mitigate seaport congestion [5]. Implementation of a dry port in a seaport's immediate hinterland increases the seaport's terminal capacity and with it comes the potential to increase productivity since bigger container ships will be able to call at the seaport. With dry port implementation, a seaport's congestion from numerous trucks is avoided. With a reduced number of trucks on the roads, congestion, accidents, road maintenance costs and local pollution are reduced as well. The concept of the dry port is relatively new. It aims to improve the cost-effectiveness and environmental friendliness. It has been studied since the end of last century. Roso [6]; Roso [7]; Roso et al. [8] and Woxenius et al. [9] have done some significant research on dry port concept, impacts resulting and factors influencing its execution. Bentaleb et al. [10] presented the existing researches that aimed to study dry port concept via a systematic review. Roso [7] defined the dry port concept as an inland port directly connected to seaport by rail, where customers can put down and/or gather their goods in multimodal loading units as if at the seaport. Dry port provides services such as: transshipment, storage, consolidation, depot, maintenance of containers and customs clearance. The development of dry ports is consequently a crucial tool to encourage sustainability and efficiency of maritime transport related transport networks. Therefore, the concept of dry port can help to identify less harmful means of transfer for the environment, to relieve seaports cities from congestion, to handle goods in a more efficient manner as in seaports and to facilitate improved logistics solutions for shippers in the hinterland of the seaport in order to satisfy customers [11]. The construction and operation of dry ports have gated great interest from seaport authorities, inland public bodies and market players [12]. Dry ports are created for the purpose of relieving seaports congestion. As we know the volume of transported containers continues to grow. As a result, access to the seaport becomes a critical factor for the competitiveness of seaports [6]. So, it is important to optimize seaport management in order to accelerate and reduce the cost of moving containers [13]. Dry port offers services similar to those available in seaports. They improve the efficiency of the freight system by allowing the freight movement without delays due to congestion in the seaport area. Multimodal transport is the solution to connect dry port and seaport, consequently a perfect transportation network is the condition of dry port's development [14]. Multimodal transportation is playing an important role in global supply chains [13]. Therefore, the construction of a dry ports network increases the efficiency of multimodal transport. Dry ports are designed to reduce traffic on the roads and move it on railway networks, so they are particularly suggested when terminals are located near urban and suburban areas that are characterized by heavy traffic

[11]. There are many factors that need to be considered in dry ports location. Lack of clear policies and institutional planning pose greater problem in selecting location of a dry port [16]. Actually, they is little research about dry port location problem in the literature. The location of the dry port where the modal transshipment takes place is one of the most important elements in the assessment of the multimodal transport competitiveness. The location of the dry port can solve the congestion by connecting seaport to their hinterland, ameliorating the seaport access and improving regional economic development. The paper therefore has two interlinked aims. First, it provides research overview on dry port location. In this context, the objectives of literature review of this paper are: (i) to consolidate existent researches on dry port location and its methodology through an interpretative framework of published literature on the topic, and (ii) to classify dry ports location from methodological perspective. These objectives are achieved through a systematic review. The second aim is to combine multi and mono-criteria methods in order to find an optimal dry port location. As a result, the paper proposes a case study applying this approach in order to find an optimal location. This paper is structured as follows. First, methodological procedures employed in the systematic literature review are discussed and results of the systematic literature review on dry port location problem and their methodological classification in Section 2. Section 3 determines the best dry port location by combining MACBETH and BARYCENTER methods. Finally, conclusion is presented in Section 4.

2. Literature review

2.1. Methodology

Systematic reviews have more and more substituted usual narrative reviews [17]. According to Kitchenham and Charters [18], a systematic review aims to identify, assess and maintain all relevant studies presently available for a definite research question. The definition of a protocol is essential and necessary because the protocol specifies the methods used to conduct the systematic review. We will apply a systematic review methodology in our research project. The systematic review of the literature methodology is based on five-steps which included: (i) problem delimitation; (ii) selection of journals; (iii) selection of studies; (iv) evaluation and (v) synthesis [19][17][20][21]. First, problem definition, it is a delimitation of the subject area or topic. The aim of the systematic review in our task is to identify researches in dry port location problem.

Second, this systematic review evaluation was performed by two researchers. The keyword was used as selection criteria for the 'title', 'keywords', and 'abstract' fields in each paper. Types of documents included in the search were 'articles' and 'reviews', as results we have found a total of 371 991 articles and reviews in different data bases (SCOPUS; SCIENCE DIRECT, GOOGLE SCHOLAR, etc.). After duplicates were removed, the abstracts of all papers were analyzed to select only papers whose research questions were directly related to our aim, as results we have found 321 articles. Then, an analysis of the articles was performed according to inclusion and exclusion criteria. The following inclusion criteria were utilized: (i) the identification of the term 'dry port' in the title, abstract or article body; (ii) the existence of comprehensive studies that considered dry port location problem. The exclusion criteria were studies focusing exclusively on air transport, passenger terminals, road transport, as results we have found 13 articles. We had found journals (Table 1) like Transportation Planning and Technology; The Asian Journal of Shipping and Logistics; Discrete Dynamics in Nature and Society and Procedia - Social and Behavioral Sciences.

Finally, for the data synthesis stage, an aggregative approach was employed in

Table 1. *Presents Papers in Each Searches and Journals*

Journals, Books, Conferences	Search by « Dry port »	Search by « Dry port location»	Search by « Hub location»	Number of selected papers	Selected papers (Authors)
Transportation Planning and Technology	14	10	68	01	Chang et al. [10]
The Asian Journal of Shipping and Logistics	16	7	14	01	Ka [45]
Discrete Dynamics in Nature and Society	1	1	0	01	Feng et al. [34]
Procedia - Social and Behavioral Sciences	74	39	178	02	Ambrosino and Sciomachen [21]; Nunez et al. [47]
Conferences, books and reports (Google scholar, Scopus, Science Direct…)	20	11	161	08	Lv and Li [42]; Wang and Wei [41]; Wei et al. [44]; Wang and Wang [12]; Zhang et al. [43]; Li et al. [46]; Chang et al. [32]; Zeng et al. [33]
Total searched papers				13	

order to summarize findings of the reviewed studies. Such aggregative approach relies heavily on the researcher's subjective interpretation about the reviewed papers [22].

2.2. Overview of Research on Dry Port Location

In this section, results from the systematic review are presented. In particular, this section presents a general overview of the research on methods in dry port location problem. We notice that dry port location is not sufficiently studied in literature at the present time as we found a few references in this sense (13 papers). The dry ports location problem can be analyzed as a particular case of the hub location problem, which has recently received a great number of attentions in the scientific literature [23]. The hub location problem is focused on locating hub services. The problem of hub location has attracted many researchers. We can find huge number of papers on hub location problem and methodologies used to facilitate finding the optimal location. The research on hub location started with the revolutionary works of O'Kelly [24][25][26]. O'Kelly [26] studied airline passenger networks and presented the first standard mathematical formulation for a hub location problem. The literature on hub location problems has increased significantly in the last years as can be observed in the survey paper by Alamur and Kara [27] Also, Farahani et al. [28] reviewed multi-criteria approaches to hub location problems. Next, Farahani et al. [29] focuses on reviewing the most recent hub location problems from 2007 up to 2012. The problem of hub location has attracted many researchers. Many studies in hub location problem deals with exact methods, for example [30][31][32][33] etc. In this paper, we recap studies that have been done and give a synthesis of the existing literature related to use in dry port location problem.

2.2.1. Research on Dry Port Location Using Mono-Criteria Approaches

The first dimension of the analytical framework corresponds to studies whose main goal was to use mathematical formulation in order to resolve location problem for dry port.

However, studies concerning dry port location are very few. Table 2 shows all founded studies using mono-criteria approaches (Fuzzy C- Means Clustering method; Greedy algorithm and a genetic algorithm; mixed integer linear programming) in order to resolve dry port location problem.

Table 2. *Papers Use Mono-Criteria Approaches in Dry Port Location Problem*

Authors	Objectives	Methodology
Chang et al. [34]	Choose optimal dry port locations for the seaport of Tianjin in China.	Fuzzy C- Means Clustering method
Zeng et al. [35]	Develop models for dry port and intermodal terminal locations.	Mathematical model
Feng et al. [36]	Construct a location-allocation model for the regional seaport-dry port network.	Greedy algorithm and a genetic algorithm
Ambrosino and Sciomachen [23]	Deal with the problem of locating dry ports for freight mobility in intermodal networks.	Mixed integer linear programming

We noticed that articles aim to study the dry port location problem and using mono-criteria method are very few. We can just find 4 articles in the literature [34][35][36]. It is concluded that the dry port location field could play a very interesting and important role in the seaport performance and will be an interesting area for future research.

2.2.2. Research On Dry Port Location Using Multi-Criteria Approaches

The second dimension of the analytical framework corresponds to studies aimed at using multi-criteria approaches in order to resolve location problem either for dry port or hub (Table3): We can find many studies in hub location problem deals with multi-criteria methods (Analytic Network Process (ANP); ELECTRE) for example Guy and Urli [37]; Costa et al. [38]; Menou et al. [39]; Yu et al. [40]; Notteboom [41] and Long and Grasman [42], etc.

We have also noticed that articles aim to study the dry port location problem using multi-criteria methods are very few. From the systematic review, we can just find 8 articles in the literature [41][42][43][44][12][45][46][47]. We have also concluded that this field is very interesting and it should receive more attention and works by researchers and will be an interesting area for future research.

2.2.3. Research On Dry Port Location Combining Mono And Multi-Criteria Approaches

The third research dimension refers to articles use both multi-criteria and mono-criteria approaches in order to resolve location problem for dry port (Table 4). It has been observed that in literature review,

Table 3. *Papers Use Multi-Criteria Approaches*

Authors	Article objective	Methodology
Wang and Wei [43]	Find out which city is the best selection for the dry port location.	Analytic Network Process (ANP)
Lv and Li [44]	Discuss location selection of the dry port for Tianjin seaport.	Analytic Network Process (ANP)
Zhang et al. [45]	Construct model of location planning for a dry port.	Fuzzy Clustering
Wei et al. [46]	Selection of dry port location with the method of Fuzzy-ANP.	Fuzzy ANP method

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Table 3. *Papers Use Multi-Criteria Approaches (Cont')*

Authors	Article objective	Methodology
Wang and Wang [14]	Choose and lay out the optimal location of dry port.	Fuzzy Clustering
Ka [47]	Selection of optimal dry ports construction projects.	Fuzzy AHP and ELECTRE
Li et al. [48]	Selection of the optimal dry port location for Shanghai seaport.	AP (Affinity Propagation) Clustering
Nunez et al. [49]	Provide a decision-making methodology.	Multi-criteria Analysis

hub location problem deals with multi-criteria and mono-criteria methods, for examples Chou [50] and Ding and Chou [51].

3. Dry Port Location Problem:

3.1 The Need to Locate A Dry Port

Nowadays, a prospective solution that is emerging increasingly in the literature

Table 4. *Papers Use Mono-Criteria and Multi-Criteria Approaches*

Authors	Article objective	Methodology
Chang et al. [12]	Selection of optimal dry port layout for the seaport of Dalian in China.	Fuzzy C-Means (FCM) Clustering and linear programming model

Besides, it can be stated that articles which aim to study dry port location problem and just combining multi-criteria and mono-criteria methods are very rare. In the systematic review, just one article in the literature was found [12]. Also that field is very interesting and it should receive more attention and works by researchers and will be an interesting area for future research. In general, a large number of researches approaches for solving hub location have been proposed. However, research in dry port location problem is very few; namely, 13 articles in our previous systematic review. Most of these approaches focused on developing mono or multi-criteria models for dealing with this problem. For many years, papers on multi-criteria location problems were few, but in the past decade, solving location problems using multi-criteria methods have had a significant augmentation in location problems. Dealing with both multi and mono-criteria approaches in research is very few. Our objective is to fill this gap in existing literature by using an integrated multi and mono-criteria model for dealing with dry port location problem.

for relieving activities in seaports is the concept of "dry port". Dry ports are created to reduce traffic on the roads and move it on railways [11]. According to Schrank and Lomax [52], congestion has augmented than before considerably over the past two decades. Congestion in seaports means an increase in queues. The queues occur when demand exceeds the instantaneous capacity of the transmission network [53]. The main source of congestion is road transport. According to Parola and Sciomachen [54], the strategic decision to decrease congestion is to move from road to rail traffic. Hence, the need to outsource the storage area and subsequently relieve the seaport storage areas and access is necessary. After the detection of this need, comes the step of dry port location which an important step since the location will influence the relevance and role of the dry port and then respond to the expected objective of its implementation. In fact, the dry port location must consider several aspects, such as the presence of industrial agglomeration, minimizing delivery times and cost, etc.

In this paper, the location decision

process for the optimal dry port location is conducted via two main steps:

- Evaluation of candidate locations in the hinterland from a macro-economic perspective with multi-criteria method.
- Application of a mono-criteria method in order to obtain exact localization in map.

The main purpose of this paper is to give a more efficient way for managers to select sites for dry port development.

3.2 Dry Port Location Hybrid Model Overview

Many researchers have proposed a number of methods for solving location problems, most of them focused on developing mono or multi-criteria models. Few researchers presented methods for dealing with dry port location problem using both mono and multi-criteria models. Accordingly, this paper fills this gap in existing literature by developing a hybrid model for dealing with dry port location. Lastly, we illustrate the application of the proposed model with a case study on selection of the dry port location. The methodology will consist of six main steps (Figure 1): Step (1) criteria selection system: based on accessible literature and through interviews with experts. The key criteria and sub-criteria are determined. The criteria must be collected for assessment of alternative sites or options. Based on this, several questionnaires were then designed and answered by the specialists who are engaged in multimodal transport management, seaport economics, etc. Step (2) decision maker's selection system: multi-criteria analysis is based on ratings and the choice of criteria made by the experts who will be the decision maker's group. To constitute this group, the evaluation team may choose from the actors involved in research question. In general, the group members are selected from the problem area, which is justified to limit the risks of incompetence and misunderstanding in order to facilitate the identification of those experts and researchers. Step (3) Options selection system: Identification of potential feasible locations based on studies and Ministry reports of the involved case study. A minimum number of feasible options should be identified on the basis of these reports and studies. Step (4): multi-criteria method selection system: this step depends on the problem nature. We must select and apply multi-criteria method to the problem under reflection in order to classify options. Numerous methods have been developed. Guitouni and Martel [55] provided a theoretical guideline, to assist researchers to select a suitable MCDM method. MCDM is a collection of concepts, methods and techniques developed to help decision makers to make complex decisions in a systematic and structured way [56]; table 5 identifies some multi-criteria methods used in location problem based on available literature.

Actually, there is a variety of methods which has been developed. Therefore, we collect some of the existing MCDM methods, in order to select the more adequate method for our involved area in order to take appropriate decision. Step (5) optimization criteria selection system: in classifications of optimization criteria in location models, Eiselt and Laporte [63] is one of the most excellent references. In location problems, the considered objectives can be different. According to Farahani et al. [28], some of them can be as follows: (1) Minimizing the total setup cost; (2) Minimizing the longest distance from the existing facilities; (3) Minimizing fixed cost; (4) Minimizing total annual operating cost; (5) Maximizing service (6) Minimizing average time/ distance traveled; (7) Minimizing maximum time/ distance traveled; (8) Minimizing the number of located facilities; (9) Maximizing responsiveness etc. Currently there are various optimization criteria. Thus, we

Table 5. *Examples of Some Multi-Criteria Method*

Character-istics	AHP	TOPSIS	MACBETH	ELECTRE	PROMETHEE	MAUT Methods
Descriptions	Creating hierarchical structure and pair-wise comparison matrices.	Calculating distance to positive and negative ideal point.	Requires only qualitative judgments about the relative attractiveness of options.	Comparing each pair of actions then determining concordance and discordance indexes.	Based on a set of prerequisites.	Requires the identification of utility functions and weights for each attribute.
Criteria nature	Tangible or intangible	Tangible	Tangible or intangible	Tangible or intangible	Tangible or intangible	Tangible
Software	EXPERT CHOICE	TOPSIS SOLVER	CA-MACBETH	ELECTRE IS	PROMCALC	LOGICAL DECISIONS
References	Saaty [57]	Hwang and Yoon [58]	Bana e Costa and Vansnick [59]	Roy [60]	Brans [61]	Keeney and Raiffa [62]

Table 6. *Presents Examples of Some Mono-Criteria Methods*

Characteristics	Linear programming	Tabu search	Branch and bound	Genetic algorithm	BARYCENTRE method
Descriptions	Maximize or minimize a linear function.	Explore the solution space beyond local optimality.	An algorithm design paradigm.	Generate useful solutions to optimization and search problems.	Determine the centric of a mid-point network.
Method classification	Exact method	Heuristic method	Exact method	Heuristic method	Exact method
Strengths	Give the optimal solution.	Reasonable resolution time.	Give the optimal solution.	Reasonable resolution time.	Provide a direct localization in reasonable resolution time.
Weaknesses	None adapted for big problems structure while the numerical resolution.	Don't guarantee the optimality of the result.	High running time.	Don't guarantee the optimality of the result.	Sometimes it is necessary to modify the mathematical optimal implementation.
Application Areas	Manufacturing; Marketing; Finance (investment); Advertising; Agriculture	Scheduling; Global Optimization; Network design; Telecommunication Network; location problems; ...	Location problems; scheduling; computing; global optimization; ...	Mechanical Engineering; Computing; scheduling; location problems	Location problems; mechanical engineering; ...
References	Kantorovich [64]	Glover [65]	Land and Doig [66]	Melanie [67]	Jin and Rousseau [68]

collect some of the existing optimization criteria, in order to choose one for the given problem for making better location. Step (6): mono-criteria method selection system: a large number of mono-criteria methods were developed in order to resolve optimization problem like dry port location problem. Based on literature, some well known examples are cited in Table 6.

Choosing the more adequate mono-criteria method for the problem situation in hands is very important, and it can assure the optimal solution in short time.

Finally we present some benefits from combining multi-criteria and mono-criteria methods in Table 7:

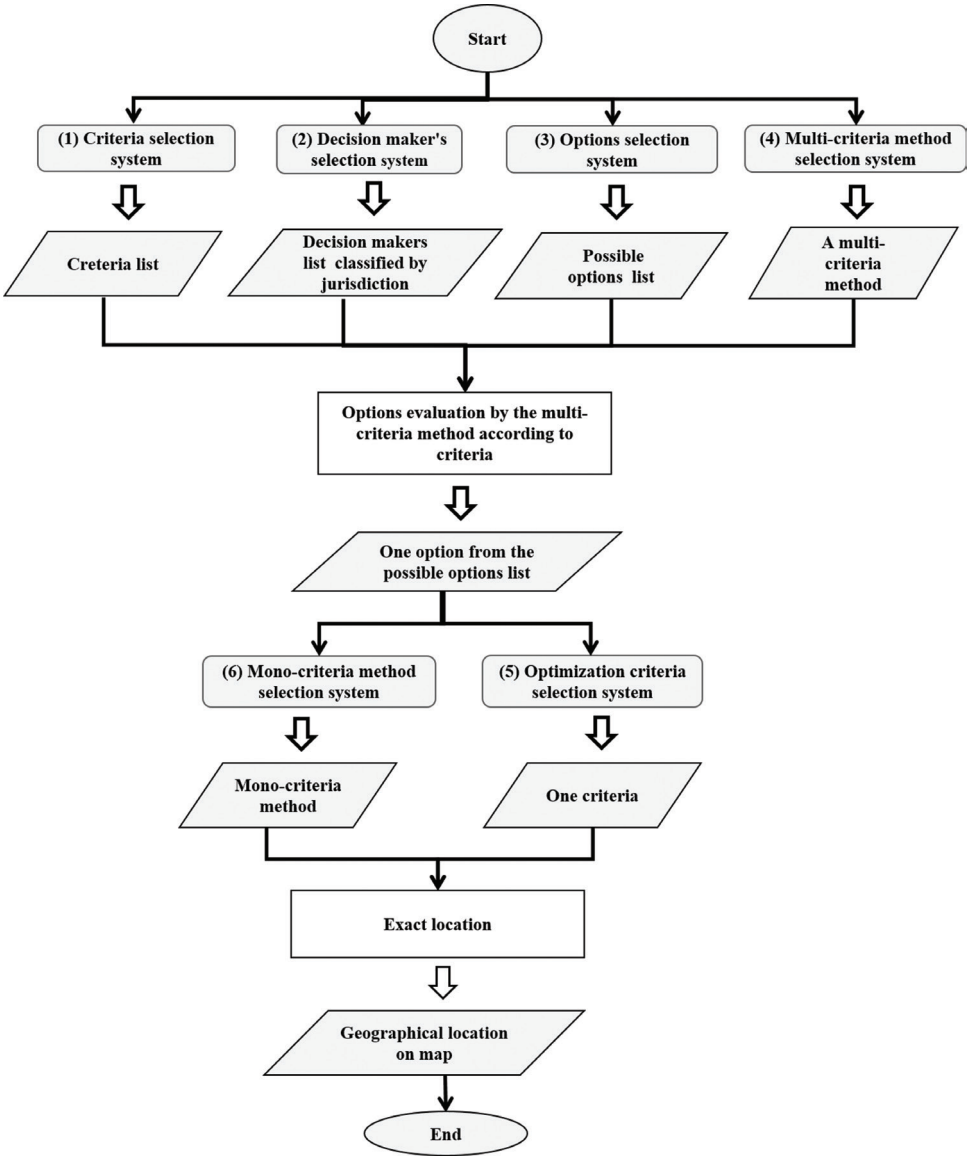

Figure1. *Dry Port Location Hybrid Model Combining Multi-Criteria and Mono-Criteria Methods*

Table 7. *Presents Some Benefits from Combining Multi and Mono-Criteria Methods*

	Multi-criteria method	Mono-criteria method	Hybrid method
Objectivity	-	✓	✓
Subjectivity	✓	-	✓
Qualitative data	✓	-	✓
Quantitative data	✓	✓	✓
Disadvantages	Lack of objectivity and bias by researcher	Should only be used if data can be measured by numbers	-
Advantages	Involvement of human subjects	Can be verified by observation and experimentation	both
Role of Researcher	Researcher & their biases may be known to participants in the study	Researcher & their biases are not known to participants in the study	both
Specific results	✓	-	✓
Generic results	-	✓	✓

As we can conclude combining mono and multi-criteria methods can provide a better result with considerable advantages to deal with dry port location problem.

3.3 Experimental Framework

Locating dry ports is very real matter for Morocco. The geographical location of Morocco with two important seas and among four different continents makes Morocco a brilliant country in multimodal transport development. Morocco becomes an important element in maritime transport with Tangier Med Port who has grown to be the principal seaport on the Mediterranean Sea and directly connected to Casablanca seaport, [39]. The evolution of the traffic port has been marked by strong growth (+ 6% per year on average over the last 10 years) due to the Moroccan economic development policy and the integration of the Moroccan economy into regional and international markets [70]. We try to give a support for Moroccan managers in order to locate optimally a dry port. So for that, we will apply our proposed model on Moroccan context and we began by completing the first step. Step (1) Criteria selection: the decision of locating a dry port must take into account several parameters and criteria considering available literature [43][44][45][46][14][47][48][49] and through interviews with experts, Data were collected using mail survey, web survey, and field visits. A combination of interviews and questionnaires were prepared for experts, consisting of: An on-line questionnaire was designed for Casablanca seaport managers in order to investigate their perception of criteria in selecting dry port location (Table 8). In some cases, surveys were conducted and administered over the telephone.

Table 8. *Presents Details in Each Panel of Experts*

Experts	Number of participants	Number of responses	Responses as percentage	Time and place	Interviewed specifications
Seaports experts	12	10	83	March, 2014; Casablanca Seaport	Operations director; financial director...

The criteria determined for evaluation of alternative locations are presented in table 9:

Table 9. *Criteria Determined for Evaluation of Alternative Locations*

Criteria family	Criteria
Geographical	Geographical accessibility (geographical nature of the region) (N8)
	Geographical limitations (natural and artificial limitations) (N9)
Policies	Government support (the country's political support) (N10)
	Regional support and exemptions (N11)
Industrial	Size of industrial agglomerations (trade volume) (N12)
	Possibility of future industrial activity development (N13)
Operational	Infrastructure state (N14)
	Travel time to and from the seaport (N15)
	Routing cost to and from the seaport (N16)
	Accessibility and quality of administrative and support services (N17)
	Availability of rail and highway connection (N18)
Environmental	Existing environmental restrictions in the region (N19)
	Future direction of environmental policy (N20)
Social	Availability of skilled human capital (N21)
	Average social level of the population of the region (N22)
	Syndicate movements orientations in the region (N23)
Economical	Availability of land (land acquisition cost) (N24)
	Trade volume in the region (N25)
	Investment volume required (N26)
	Long-term financial profitability (N29)

Step (2) decision makers: a group from the professional and academic field was invited in order to participate in criteria evaluation. Step (3) options: a minimum number of possible sites (the whole regions, not only the city) are listed based on reports of Moroccan context [68]. This will facilitate the mission for decision makers to imagine the situation and choosing their favorites [69]. Based on Moroccan Ministry reports [68], we perform detailed analysis on seven alternative locations. In the first choice of most potential options then, we consider the following aspects based in literature [39]: (1) Current traffic volume; (2) Connectivity to existing road transport networks; (3) Connectivity to existing rail transport networks; (4) Freight traffic potential. Results are presented in table 10:

Table 10. *Alternative Locations*

Options	Traffic	Connectivity by road	Connectivity by rail	Freight potential
Agadir	**	**		***
Casablanca	***	***	***	***
Fez	**	***	***	**
Marrakesh	**	***	***	**
Oujda	**	**	**	**
Rabat	**	***	***	***
Tangier	**	***	**	***

These aspects are estimated in Table 10 by assigning to the option from 0 to 3 *-marks, where "no mark" is the lowest level and "***" is the best level. By analyzing in depth the table 10 we can eliminate "Agadir" because it hasn't a rail connection and "Rabat" because government does not support industrial infrastructure in Rabat (Capital of Morocco). So we can consider five options to rank: Casablanca; Fez; Marrakesh; Oujda and Tangier. Step (4) multi-criteria method: among many multiple criteria decision making (MCDM) methods, MACBETH is a practical and useful technique for ranking and selecting a number of possible options. It can class the sites based on their general performance, since it may recognize the best site. MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) is an approach to multi-criteria decision aid whose improvement was set in movement in the early 1990's by Bana e Costa and Vansnick. It is an interactive approach that permits a decision maker or a group of experts to assess options by only a production of qualitative evaluation concerning their dissimilarities of attractiveness in multiple criteria. Figure 2 shows the results of the qualitative comparisons concerning dissimilarities of attractiveness in multiple criteria of our case study.

Therefore, what differentiates MACBETH from the other multi-criteria approaches is that it requires only qualitative opinions about the distinction of attractiveness between two criteria simultaneously; with the purpose of produce numerical scores for the alternatives in every criterion and to weight the criteria [59]. MACBETH software confirms automatically the regularity of the choices created by the decision-maker and suggests to choose inconsistencies if they began. Criteria weights are given from the decision-makers semantic choices by using the options presented by the software. By considering all the criteria, the scores of the alternatives are, after that, combined additively to generate the general scores that presented their ranking.

Here are a number of motivations that guided us to select MACBETH: It is mainly easy to use; it is good acknowledged; its technical parameters have a understandable and simple explicable substantive elucidation; it permits to deal with complex problem of relative value of criteria in an exact manner; it led the avoidance of the complexities that are intrinsic in each ordinal aggregation.

MACBETH method has been applied to the dry port location options selection in the Moroccan context. Results provided by MACBETH software (shown in Figure 3) suggest the following ranking: Casablanca ->

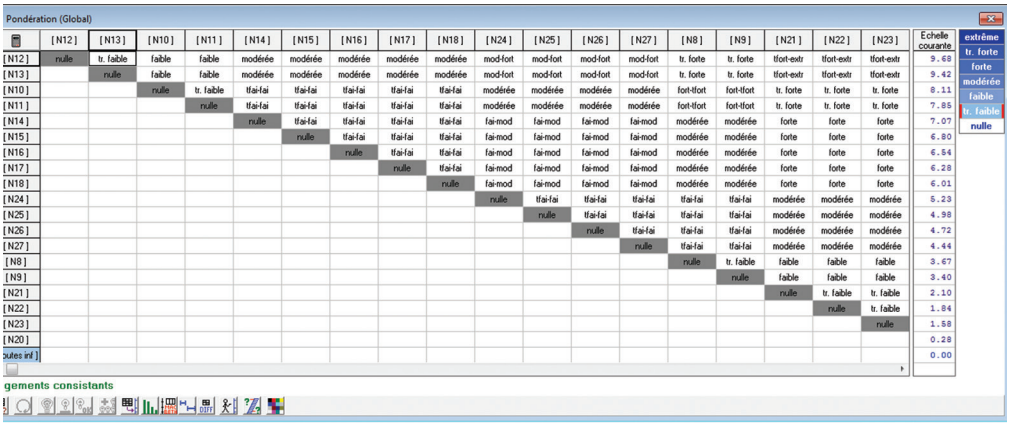

Figure 2. *The Results of the Qualitative Comparisons of the Case Study*

Table of scores

Options	Overall	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N20	N21	N22	N23	N24	N25	N26	N27
[toutes sup]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Casablanca	85.21	188.89	100.00	100.00	50.00	100.00	81.25	90.91	100.00	100.00	100.00	100.00	33.33	100.00	100.00	0.00	0.00	100.00	0.00	100.00
Tangier	71.08	100.00	66.00	68.75	100.00	69.23	100.00	100.00	61.54	71.43	0.00	64.29	100.00	77.78	66.67	100.00	44.44	69.23	45.45	72.73
Fez	59.47	77.79	50.00	50.00	75.00	46.15	62.50	63.64	53.85	50.00	80.00	50.00	66.67	44.44	44.44	88.89	77.78	46.15	72.73	45.45
Marrakesh	33.58	33.34	35.00	25.00	25.00	23.08	43.75	45.45	46.15	28.57	60.00	35.71	0.00	22.22	33.33	77.78	22.22	23.08	18.18	27.27
Oujda	13.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	66.67	0.00	0.00	44.44	100.00	0.00	100.00	0.00
[toutes inf]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weights :		0.0367	0.0340	0.0811	0.0785	0.0968	0.0942	0.0707	0.0680	0.0654	0.0628	0.0601	0.0028	0.0210	0.0184	0.0158	0.0523	0.0498	0.0472	0.0444

Figure 3. *Options Ranking Results*

Tangier -> Fez -> Marrakesh -> Oujda. As we know Casablanca (first options with score of: 85, 21) already have a dry port and this confirmed the consistency of the decision process. So, we will focus on the second options (Tangier with score of: 71, 08) and we will locate the dry port exactly in the map. Step (5) optimization criteria: we choose to adopt the Minimizing global distance traveled as our optimization criteria. Step (6) Mono-criteria method selection system: among mono-criteria methods, we choose BARYCENTER method because it is practical and faster. Mathematically, the BARYCENTER is obtained by cancelling a vectorial relationship. This notion generalizes the construction of the midpoint of a segment. It consists of: Calculate the sum of the coefficients; Plot points in an ortho-normal; Raise the coordinates of known points; Coordinated by weighting the value of coefficients and total; Calculate the coordinates of the point of optimal implementation; Locate the point of implantation.

Table 11 present the trade volume in each trade activity zone (future trend included) in Tangier and their coordinate on the map.

In order to find x- and y-coordinates of dry port location, we use follow formulate:

$$X = [\sum_i^n (Ti*Xi)] / [\sum_i^n Ti];$$
$$Y = [\sum_i^n (Ti*Yi)] / [\sum_i^n Ti]$$

X: abscissa of the dry port; Y: ordinate of the dry port; Ti: the trade volume in each trade activity zone (future trend included); i: trade activity zone; Xi abscissa of the trade activity zone; Yi: ordinate of the trade activity zone. Exact dry port location coordinate:

Dry port location { X:14,50
Y: 05,10

Finally, we determine the coordinate of the exact dry port location on map (Figure4)

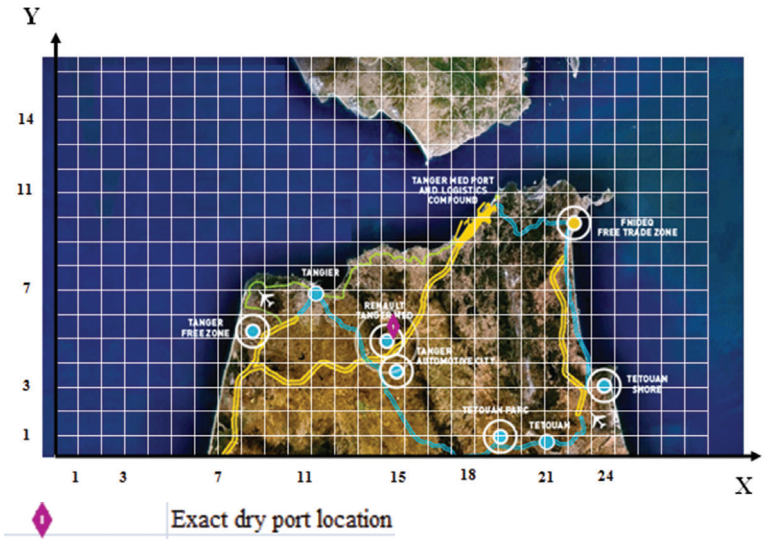

Figure 4. *Tangier Trade Activity Zone Map*

Table 11. *Trade Volume in Each Trade Activity Zone (Future Trend Included) in Tangier*

i	Ti	Xi	Yi	Ti*Xi	Ti*Yi
Tangier MED port and logistics compound	6%	18	10	1,1	0,6
Tangier free zone	26%	8,5	5,3	2,2	1,4
Renault Tangier MED	25%	14,3	4,8	3,6	1,2
Tangier automotive city	22%	14,7	3,6	3,2	0,8
Tetouan park	11%	19,1	0,9	2,1	0,1
Fnideq free trade zone	10%	22,3	9,8	2,3	1,0
Total	100%			**14,5**	**5,1**

via BARYCENTER method.

The objective of the model developed is to permit studying the potential location of a dry port of multimodal transport. As results, we obtain the exact location of our case study using our methodology, which can help managers to take decisions and determine the optimal location from many sites. We are based in our study in academic researches and expert's judgments in involved area. So, we can judge the reliability of the previous model in location problem. The method as such is useful but its strong and weak point simultaneously is the expert's performance (a good choice of experts led to obtain a valid and reliable location but a bad choice led to get a more limited study). Therefore, the main limitation of this study originates from the fact that the experts' judgments presented are subjective and depend on their performance. With the availability of added dry port-seaport data and the inclusion of more facilities, applying this methodology to other dry port location based on a larger sample size represents an interesting area for future research. We regarded the approach as a whole to be reliable and valid, because the choice of a group can approximately not at all be entirely inappropriate. Which leads always and in any situation a realistic assessment and therefore we can judge it as the strongest aspect of this study. With this paper, we have only highlighted a first step in the question on whether a gap exists in dry port location problem research and practice.

4. Conclusion

Determining a best possible location is a complex topic in literature. We should select locations with good performance at the present and maintain to be beneficial, even as the condition changes in future. We should consider many criteria require when making location decisions. Therefore, multi-criteria analysis is an ultimate method for sites ranking and evaluation. Nevertheless, the analysis results are not continually the optimal locations. From the perception of other experts in the system, we need to consider mono-criteria method in order to obtain an exact and more perfect location. A perfect and effective dry port location will positively affect a number of actors in multimodal transport, for example shippers, seaport, rail operators, industrial agglomerations, etc. We have presented an application of the dry port location problem aimed at finding the best location of a dry port. We can consider the problem as a particular case of the hub location problem that is massively considered in the literature as regard the dry port location problem that is not get it yet his part of researches. We present previous research on dry port location problem via a detailed systematic review. We build a hybrid model via combining multi and mono-criteria methods in order to determine an exact location on map. We present a direction for

an optimal and effective dry port location for Morocco seaports. Then we intend to apply this model in other case studies from other international seaports. The results show that the proposal model for dealing with dry port location problem can complete the unhelpful sides of multi-criteria or mono-criteria approaches. The experimental results obtained and illustrated in the paper confirm that the hybrid model is a good solution for dry port location problem. One other possible future research direction which will enhance the model is to apply this model framework to other international dry port locations.

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