Selecting Optimal Logistics Center Locations to Enhance Arab African Trade: A Multi-Criteria Decision Making Methodology

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ملخص البحث

كثيرا ما تتأثر التجارة بين البلدان المجاورة في أفريقيا بالحالة المتردية للبنية التحتية والخدمات اللوجستية المقدمة. وهذا يسلط الضوء على أهمية قرار اختيار المواقع الجغرافية للمراكز اللوجستية (LCs) كعنصر أساسي في تعزيز وصول الأسواق الأفريقية. تهدف هذه الورقة إلى تعزيز التجارة بين الدول العربية الإفريقية وبقية الدول الأفريقية من خلال اختيار أنسب المواقع لوضع المراكز اللوجستية .(LCs) تم تطبيق منهجية صنع القرار متعدد المعايير (MCDM) مع الاخذ في الاعتبار ثلاثة معايير، وهي الاقتصادية والتجارية والقدرة. تظهر النتائج إمكانية إنشاء 18 مركز لوجستي في إفريقيا. ويتضح من النتائج ان بعض الدول الافريقية لديها أكثر من موقع LC محتمل مثل ليبيا والجزائر، في حين أن بعض مواقع LC المحتملة تقريبية من حيث المسافة كما هو الحال في توجو وغانا. بالإضافة إلى ذلك، تم اقتراح مواقع LC المحتملة في 10 دول فقط من أصل 54 دولة في إفريقيا، وترسم مواقع LC الـ 18 المحتملة مثلثًا

حيث تقع قاعدته بين شرق وغرب إفريقيا ويقع رأسه في شمال إفريقيا. وقد تم استخدام العديد من العوامل لتقييم هذه المواقع السبعة المحتملة والتي تتضمن ملاءمة وجاهزية المواقع، قرب المواقع لشبكات النقل، ومقارنة المواقع بمواقع LC الحالية والمرافق. وفقًا لذلك، تم اقتراح دمج مواقع المراكز اللوجستية المقترحة القريبة لبعضها وتلك الموجودة في نفس البلد. وهذا يقلل من عدد مواقع المراكز اللوجستية المقترحة إلى سبعة مواقع لوجستية فقط موزعة في شرق وغرب ووسط إفريقيا. علاوة على ذلك، لم يشير مركز الثقل إلى إنشاء LCs في جنوب القارة الافريقية. بالإضافة إلى ذلك، تظهر النتائج أن مواقع LC المحتملة تتماشى مع الموانئ البحرية الرئيسية والطرق السريعة عبر أفريقيا.

الكلمات المفتاحية

الدول الأفريقية، الدول العربية، التجارة العربية الأفريقية، عملية التسلسل الهرمي التحليلي، مركز الثقل، نموذج الجاذبية، المراكز اللوجستية، الأنشطة اللوجستية، الإحداثيات القياسية للدرجات العشرية البسيطة

Abstract

Trade between neighbouring countries in Africa is frequently affected by the impoverished state of the infrastructure and provided logistics services. This highlights the importance of logistics centers (LCs) geographic location selection decision as a key element in enhancing African markets’ access. This paper aims to enhance the trade between Arab African and the rest of African countries by selecting the most appropriate locations for placing Logistics Centres (LCs). A multi-criteria decision making (MCDM) methodology has been applied with three criteria, namely economic, trade, and capacity. The centre of gravity results show the potential of establishing 18 LCs in Africa. Some countries have more than one potential LC location such as Libya and Algeria, while some potential LCs locations are approximate in term of distance such as in Togo and Ghana. In addition, the potential LC locations are proposed in only 10 countries out of 54 countries in Africa, and the 18 potential LC locations draw a triangle where its base is between East and West Africa and its head is located in North Africa. Several factors are used to evaluate these potential locations including site suitability, near locations, compared with existing LC locations and the facilities available in these locations. Accordingly, it has been suggested to merge the nearby proposed LCs and those located in the same country. This reduces the number of proposed LCs to only seven proposed LCs distributed in East, West, and middle of Africa. Furthermore, the center of gravity did not indicate the establishment of LCs in the south of Africa. In addition, the findings show that potential LC locations are aligned with the major seaports and trans-African highways.

Keywords

African countries, Arab countries, Arab African Trade, Analytical Hierarchy Process, Center of Gravity, Gravity Model, Logistics Centers, Logistics activities, Simple Decimal Degree Standard Coordinates

1. Introduction

Cargo owners, shippers, carriers and operators always aim to reduce costs, traffic congestion and environmental pollution levels. This can be achieved by providing the required services and activities in one place that is known as a logistics centre/hub (LC). LC is a defined area within which all activities associating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators on a commercial basis (Uyanik *et al.*, 2018; Önden *et al.*, 2018). Various names are generated common for the concept of LC in the literature such as distribution centre, freight village, dry port, inland port, warehouse, logistics platform, logistics depot and distripark. The location of LC is a key element in enhancing the efficiency of logistics and supply chain activities. Right LC locations enhance the flow of trade and minimise distance, cost, congestion and bottleneck (Erkayman *et al.*, 2011). Thus, the location of LC should be selected strategically.

In Africa, the continent is inhabited by about 17.2 per cent of the world's population (ranked as the second after Asia) and makes up 20 per cent of the world's landmass. Africa as a whole has abundance of natural resources. However, most of the African countries are classified as poor countries. Several factors combine leading to weak economic performance. Some of these factors are related directly to the efficiency of logistics activities. First, being numerous small markets with 16 landlocked countries makes Africa the most fragmented continent. This results in diseconomies of scale and accordingly restricts industrial growth. Second, poor logistics markets contribute to increasing costs of trade that is reflected on increasing trade deficit of most of the African countries. Third, poor functioning logistics markets are preeminent barrier to trade that restrict the trials to effectively benefit from economic integration. Breaking the downturns and improving economic performance in the majority of the African countries requires dealing with the previous factors.

One of the leading supporters can be relying on economic development opportunities based on regional integration. Regional integration can help to optimise the size of interior markets of the countries in the continent. Nonetheless, trade between neighbouring countries in Africa is frequently affected by the impoverished state of the infrastructure and provided logistics services. This requires unifying the multinational procedures and directing investments in all countries to reinforce regional integration and enable safer and more efficient both people's and cargo's movement across borders and link landlocked countries to seaports. It is necessary to focus on the importance of efficient trade-related logistics and supply chain services provided while examining ways to accelerate the steps of regional integration and increasing the share of countries in Global Value Chain (GVC). The efficiency of logistical and supply chain activities in Africa is becoming highly significant (AfDB, 2019). Some African countries are becoming outsourcing hubs for global supply chains of automobile and electronic consumer goods (El Baz et al., 2019).

This highlights the importance of LC geographic location selection decision as a key element in enhancing the efficiency of logistics and supply chain activities in Africa. Such a decision is related to selecting the most convenient location for LC to provide integrated logistics services, minimise cost and distance, and maximise geographic coverage and market shares (Zak and Weglinski, 2014). The LC location selection problem can be considered as a MCDM problem (Pramanik *et al.*, 2016). Considering more than one factor or measure transforms decision making problem to a multi-objective decision making (MODM) problem or a multi-attribute decision making (MADM) problem. Both problems come together in one category, named multi-criteria decision making (MCDM) problems (Farahani, *et al.*, 2010). The considered decision problem aims at selecting the most appropriate location for placing the LCs in Africa. It is formulated as a multiple criterion ranking problem and involves a multiple dimensional evaluations of the considered region. The decision under consideration is momentous for many groups of interest, including: governments, importers, exporters, airlines, shipping lines, and freight forwarders; considering the distance, and values of trade between countries.

As a research motivation and important contribution to the field of logistics, this paper aims to enhance the trade between Arab African and the rest of African countries by selecting the most appropriate locations for placing Logistics Centres (LCs). A multi-criteria decision making (MCDM) methodology has applied with three criteria, namely economic, trade, and capacity. The originality of this paper is based on three contributions. First, macro-region-analysis carried out between each Arab country and the rest of the African countries, with 828 developed matrixes. This helps to understand the trade flows (exports and imports) between countries. Second, logistics factors in affecting the flows of trade are examined, producing three main criteria, namely economic, trade and capacity. Third, a group of main criteria are applied in determining the potential LC locations in Africa.

The structure of the paper includes eight sections. Section 1 includes an introduction. Section 2 reviews the literature regarding LCs, decision methods and decision criteria of locating LCs in general and more specifically in Africa. Section 3 underlines the problem statement and presents the research approach. Section 4 analyses the structure of the Arab African (hereafter denoted by Arab) trade structure. Section 5 examines the significance of logistics factors in affecting trade in Africa using a gravity model. Section 6 applies the AHP method to effectively evaluate the most significant criteria that can be applied in selecting the LC locations. Section 7 uses centre of gravity for proposing the most suitable LCs in Africa and evaluating their transport connectivity. Section 8 involves conclusions and policy implications.

2. Literature Review

This section reviews the related literature of interpreting: the LC concept, investigating those criteria applied in LC location selection and studying the key determinants of designating the most suitable locations for LCs in Africa.

2.1 LCs Concept

A LC is a comparatively recent phenomenon offered by logistics service providers to reduce costs, increase customer satisfaction and perform the required services by trade partners (Pham *et al.*, 2017). The LC aims to provide comprehensive and value-added services in large geographical areas. Kaynak *et al.* (2014) defined LC as “the hub of a specific area where all the activities relating to transport, logistics and goods distribution are carried out on a commercial basis by various operators.” Essaadi *et al.* (2019) identified the LC as a location that enables consolidating material flows coming from different origins, sorting their following destination and preparing their shipment, using unimodal or multimodal transportation resources. Based on these definitions, it can be summarised that LC is the hub of a specific area where all activities related to transport, logistics and goods distribution, both for national and international transit, are carried out on a commercial basis by various operators.

2.2 Decision Methods for LC Locations

LC location has received broad attention in the literature. Selecting appropriate locations is subjected to various allocation multi-criteria methods, where each method comprises different criteria. Farahani *et al.* (2010) categorised methods into:

- Ranking and mathematical programming –optimisation problems
- Single and multiple - objective location problems
- Deterministic and non-deterministic problems
- Continuous and discrete location problems
- Single and multiple facility location problems

On the other hand, Zak and Weglinski (2014) classified multi-criteria methods according to several criteria including:

- Overall objective of the decision process, choice (optimisation) methods, classification (sorting) methods, ranking methods.
- Methods with apriority defined preferences, methods with apriority defined preferences, interactive methods
- Utility function, outranking relation

As a multi-criteria decision analysis method, Li *et al.* (2011) applied Axiomatic Fuzzy Set Clustering and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). This helped to evaluate factors of LC location. Zak and Weglinski (2014) adhered two-stage procedure for selection of the most desirable location of the LCs, including macro-analysis and multiple criteria evaluations of technological, infrastructural, economic, social and environmental. On the other hand, there are various categorisations for location problems that are derived from location science as shown in Figure 1.

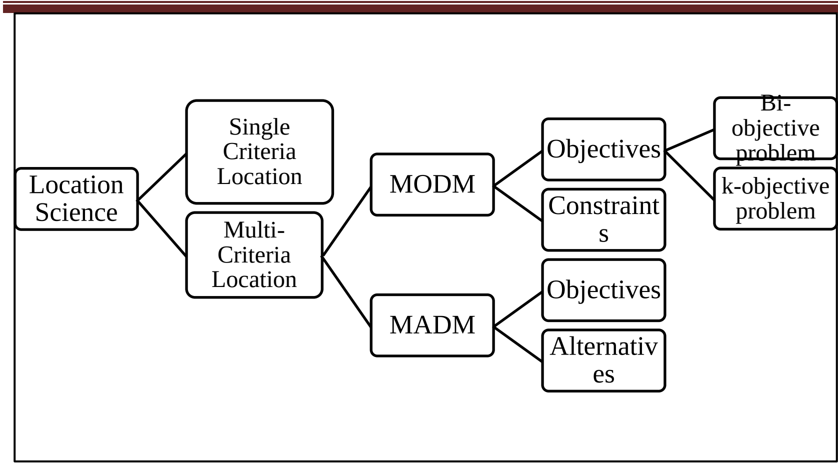

Figure 1 -Multi-Criteria Location Problem
Source: Adopted from Farahani, et al. (2010)

Erkayman *et al.* (2011) categorised the fundamental criteria for LC location selection into four groups including; geographical, cost, physical and socio-economic standards. Erkayman *et al.* proposed distinctive techniques for location selection such as AHP, TOPSIS, linear programming, integer programming and heuristic methods. Pramanik *et al.* (2016) claimed that LC location selection is a multi-criteria decision-making process involving subjectivity, impression and fuzziness that can be represented by single-valued neutrosophic sets. Önden *et al.* (2018) focused on a multi-stage methodology that combines the fuzzy analytic hierarchy process, spatial statistics and analysis approaches to evaluate the suitability degrees of the LCs. Uyanik *et al.* (2018) summarised that the most commonly used decision methods for LC location are primarily divided into two groups; namely MCDM and mathematical model solution techniques. In MCDM, the AHP is the most commonly used method in the available literature, as shown in Figure 2. While in mathematical models, linear programming is the most commonly applied technique used for facility locations. On the other hand, Yu

(2020) highlighted that there are two broad categories of methods to solve LC location problem, namely; accurate algorithm and heuristic algorithm.

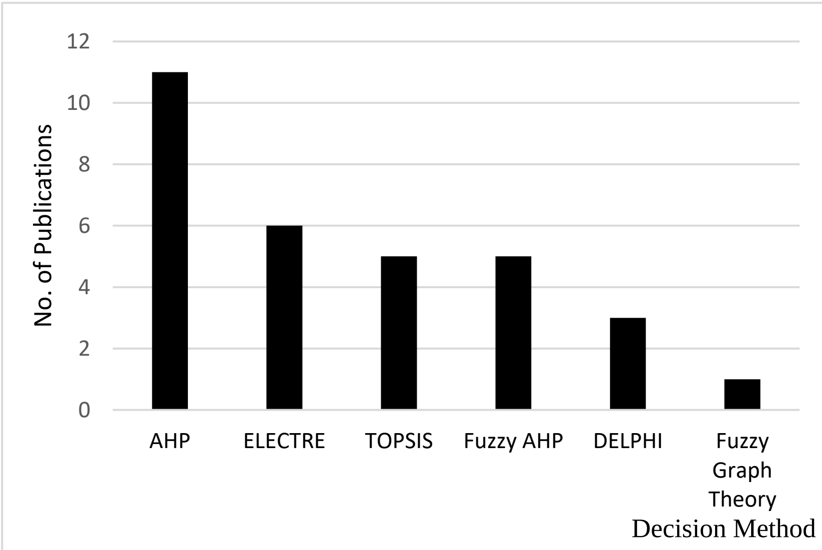

Figure 2- Common Decision Methods for LC Locations in Literature

Source: Uyanik et al. (2018)

2.3 Decision Criteria for LC Locations

Location selection problems of the LCs are mainly handled by using Multi-Criteria Decision Making Models as discussed earlier. Multiple criteria methods take into account the trade-offs between criteria (Zak and Weglinski, 2014). Pramanik *et al.* (2016) claimed that the most appropriate location need to put into consideration six criteria namely; cost, distance to suppliers, distance to customers, conformance to governmental regulations and laws, quality of service and environmental impact. Uyanik *et al.* (2018) listed 453 criteria and sub-criteria applied for location selection in the available literature. All criteria were classified into five categories including Cost, Cargo Capacity/Economic Reflections, Environment, Location and Social Factors.

Önden *et al.* (2018) applied seven criteria for selecting the right locations of LCs in Turkey; including volume of international trade, proximity to highways, proximity to railways, proximity to airports, proximity to seaports, population, and handling capabilities of seaports.

Yavas and Ozkan-Ozen (2020) proposed a framework for important criteria for selecting LCs location in Industry 4.0 (the fourth industrial revolution combines traditional industrial practices with the latest smart technology), such as smart handling and smart warehouse. Table 1 displays the decision criteria for LC locations.

Table 1 – LC Location Selection Criteria

Author	Criteria
Ou and Chou (2009)	• valued added service • transportation and distribution systems • market potential environment • infrastructure
Farahani, et al. (2010)	• Coverage • Profits • Resource accessibility • Social, political and environmental risks • Capacity • Regulations • Competition • Economic criteria • Population
Haralambides *et al.* (2011)	• Trade and maritime links • Main container transport routes • Costs of deviation from the trade path vis-a-vis the economies of scale

	• transport infrastructure
Kuo (2011)	• trade volume • location resistance • information abilities • port operation and warehouse facilities
Li et al. (2011)	• landform • water and power supply • communication • fundamental construction investment
Elevli (2014)	• site suitability • background activities/facilities • access to transportation/networks connection • interconnected business activities
Awasthi et al. (2016)	• security • proximity to customers and suppliers, • resource availability
Yavas and Ozkan-Ozen (2020)	• smart warehouses, handling and mobility • digital information platforms and connectivity • intelligent transportation systems • information security • logistics centre alliances

Source: Prepared by the authors

2.4 LC Locations in Africa

Access of African countries, especially landlocked ones, to world markets are restricted by several barriers including high transit time, high freight costs, lack of storage spaces, high dwell times, uncertainty in lead time and lack of efficient infrastructure (Marteau *et al.*, 2007). Kunaka and Carruthers (2014) highlighted that some African countries suffer from high lead time, informal payment, high degree of risk associated with goods distribution, and safety challenges against loss, damage and delay. This highlights the importance of the availability of LCs, trade corridors and transit systems to encourage world markets' access. Haralambides *et al.* (2011) used three criteria to select the most advantageous locations for logistics hub and distribution center in Africa, namely: cost-effective and efficient servicing of the country's external trade, transshipment revenue and regional and national economic development. The study concluded that seaports could only function as regional logistics hubs and distribution centres according to the trade pattern of Tanzania, Kenya, and landlocked countries ranging from Uganda in the north to Zambia in the south. Not only this, but Haralambides *et al.* also proposed Dar El Salam ports that serve as a regional hub in East Africa.

Zeng (2015) investigated the lessons to Africa from the Chinese experience in developing special economic zones. Zeng underpinned that there are several requirements for the success of special economic zones in Africa including the existence of the supportive and sustained macro-environment for reform, investment incentives, location advantages and strong links with the domestic economy. The study focused on infrastructure development in Africa as a potential for developing special economic zones. Accordingly, the study supported the existence of success factors to three locations of Chinese investment in Africa. Initially, the Lekki Zone as part of the urban development of Lagos, the zone and its associated (planned) port and airport are intended to form a coastal city in the Gulf of Guinea and the LC of West Africa. Second, the Chambishi Zone in Zambia as it is located in the country's industrial hub which displays it the potential of providing a value chain of copper/cobalt mining and processing, using the Tanzam Railway and Central Africa. Third, the Chinese Suez zone in Egypt as it is located near the new deepwater Sokhna Port in Egypt and it is only 40 km away from the South entrance of the Suez Canal. This gives it the potential to be integrated with the port facility and the canal to be part of the regional industrial and logistics hub in Egypt.

Lee (2016) highlighted the role of China in developing the construction of ports in East Africa to strengthen economic relations with Tanzania and landlocked countries, namely: Malawi, Zambia, Democratic Republic of Congo, Burundi, Rwanda, and Uganda. This is one of the steps of moving China forward into BRICS, the economic bloc comprising Brazil, Russia, India, China, and South Africa, which is expected to generate more flows of maritime cargo on the China–Africa–South America (CASA) routes. Additionally, another international trade takes place not only between the African and the Southern American regions, but also among the members of the African and South American regions and between the members of the association of Southeast Asian Nations (ASEAN) and the ASEAN–Australia–New Zealand Free Trade Area (AANZFTA), which requires maritime connectivity with the CASA route. Therefore, a proposal of the most convenient location for a distribution LC (DLC) was suggested in South Africa to promote China's engagement in sub-Saharan Africa (SSA), serving the sub-Saharan region and relaying container cargoes to South America.

Dufour *et al.* (2018) analyses the feasibility of establishing a regional distribution centre in East Africa. Five locations selecting criteria were applied; namely ease of doing business, corruption percentage, worldwide governance, available storage capacity, and logistics performance index. Accordingly, they proposed adding a regional distribution centre in a centralised strategic location such as Kampala, Uganda. Havenga and Simpson (2018) highlighted that trade flows, logistics costs, increasing exports, and gaining access to underdeveloped areas in Africa constitutes the urgent implications for emerging economies, which requires identification of key development LCs/nodes.

Essaadi *et al.* (2019) analyse the possibility of establishing a global logistics hub in Africa using a fuzzy multi-criteria approach. Six candidate locations are proposed for the regional logistic hub, namely: Djibouti (Djibouti), Mombasa (Kenya), Dar Es Salam (Tanzania), Walvis Bay (Namibia), Durban (South Africa) and Maputo (Mozambique). El Baz et al. (2019) highlighted that the focus of companies in Africa is related to operational aspects of logistics and products-specific supply chain operations. This is to provide a more efficient flow of goods and to avoid risks of loss, delay and damage.

It is explicit from the previous review of the literature that there is a recent global trend to establish criteria for specifying the locations of LCs. Additionally, despite the proof of many studies that there is a dire need in Africa to establish numerous LCs, studies that have examined choosing the optimal places to establish LCs in Africa are scant. To the best of our knowledge, there are no studies that have applied the select of LC locations from Arab countries point of view which represents the fundamental contribution to this paper.

3. Problem Statement and Research Methodology

In order to advance theory and research on African logistics practices, El Baz et al. (2019) raised as to what extent can consider the whole African continent as a single context. Hence, this paper aims to enhance the trade flows between Arab and the rest of African countries. This can be achieved by addressing the following research problem: *studying the relative importance of logistics factors in affecting trade between Arab and the rest of the African countries followed by selecting the most appropriate location for placing the LCs where logistics activities are carried out*.

The research methodology is formulated as a multiple criteria ranking problem and involves multiple dimensional evaluations of the considered region. Hence, the problems' statement can be phrased as follows: In reference to the trade structure and infrastructure abilities, the selection of the suitable LC locations is required for enhancing the trade flows between the Arab countries and other countries in Africa.

A three-level hierarchical problem adopted in Zak and Weglinski (2014) is applied in this paper as a research approach. Figure 3 displays the research approach as follows:

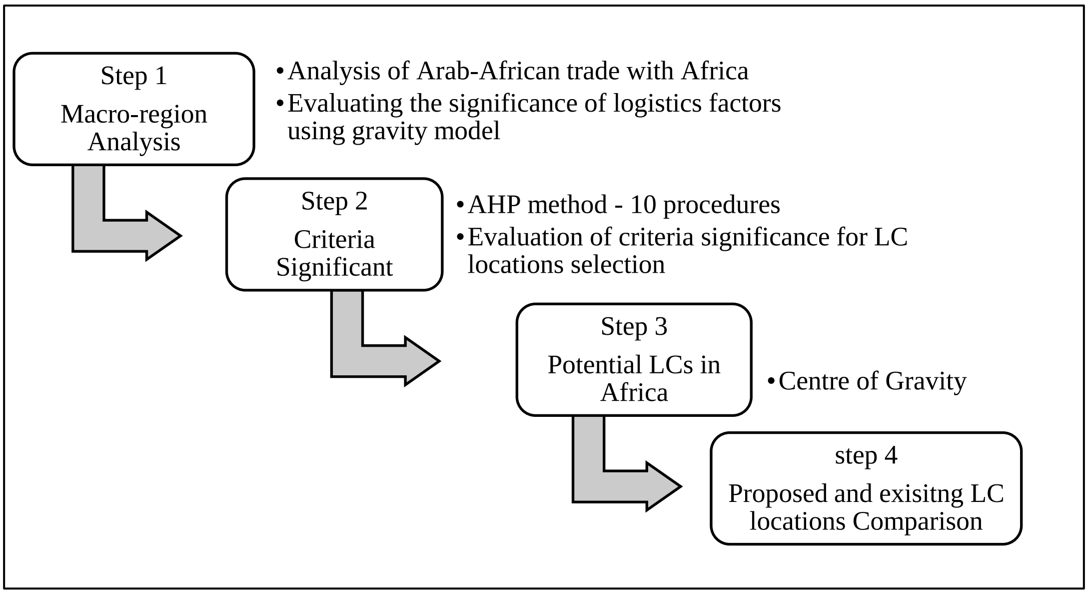

Figure 3- Research Approach
Source: Prepared by the authors

- In step 1; the macro-region-analysis has carried out to understanding the trade flows between each Arab country and the rest of the African countries. This has been followed by analysing the key determinants of Arab exports to African markets using a gravity model to examine the significance of logistics factors in affecting the flows of trade.
- In step 2; as a multi-attribute' (MADM) location problem, AHP has been applied as the most popular decision method useful

for examining the significance of applied criteria (Saaty, 2000; de FSM Russo and Camanho, 2015; Uyanik et al., 2018).

- In step 3; Based on methodological principles of multiple criteria decision making/aiding (MCDM/A), LCs locations are proposed with the application of the centre of gravity method; using simple decimal degree standard coordinates (hereafter denoted by DD).
- In step 4; the proposed LC locations are compared with the existing LC locations in Africa, putting into account their proximity to existing land roads, seaports and airports.

Working on the three levels hierarchical problem, both of macroeconomic and logistics indicators data are used for 54 African countries, divided into two groups namely; nine Arab countries and 45 non-Arab countries, for the period 2004-2018. This depends on the availability of logistics indicators data in the selected countries and taking into account that data is scattered in some of these countries.

4. The Analysis of Arab Trade Structure

Arab countries started focusing on developing trade within their resources abundant continent as they believe that building regional value chains (RVCs) for the production of common products can help to improve their gains from the integration on the world economy. This trend is accelerated by the reliance on the continent as a whole on establishing regional arrangements to help to build RVCs. Accordingly; several regional arrangements are established for this purpose such as the Common Market for East and Southern Africa (COMESA), the East African Community (EAC) and the Southern African Development Community (SADC). Also, members in these three regional arrangements announce the establishment of the Tripartite Free Trade Area (TFTA) to assemble the three arrangements.

4.1 General framework for foreign trade in Africa

Africa’s general economic performance continues to improve, with gross domestic product growth reaching an estimated 3.5 per cent in 2018, about the same as in 2017 and up 1.4 percentage points compared to 2.1 per cent in 2016 (AfDB, 2019). Withal, these arrangements, the improvements in economic performance, and the abundance of resources and labour were not enough to increase significantly intra-trade and build RVCs within the continent. No improvements are generally recorded neither in intra-trade in Africa nor in intra-trade between the Arab countries and the rest of African countries.

According to African Development Bank statistics, net exports as a percentage of GDP in Africa have taken a downward trend since 2006, which reached about 8 per cent, the highest level since 2000. However, it began to decline after that, to reach about -7 per cent in 2016 and then it improves to reach -4 per cent in 2018. The poor position of the African continent in this percentage is clear when compared to its counterparts in Latin American and Caribbean countries, as well as developing and emerging countries in Asia. Although this rate in Africa exceeded that of the other two groups until 2006, the decline that has occurred since then in Africa has exceeded that of the other two groups, so that the decline exceeds that of the developing and emerging countries in Asia since 2012 and Latin American and Caribbean countries since 2013 [(1)]. In 2018, this rate reaches 1 per cent in developing and emerging countries in Asia, -1 per cent in Latin American and Caribbean countries, and -4 per cent, as previously indicated, in Africa (AfDB, 2019).

By dividing the African continent into sub-regions, it is clear that, despite the relative improvement in North Africa’s status of the current account balance as a percentage of GDP before 2010; its share has been declining since 2010. Hence, North Africa has the largest current account deficit as a share of GDP in 2017, followed by East Africa whereas West and South Africa had the best records for this rate in 2017. This shows the decline of Arab countries with the rest of the African countries in this rate.

Concerning the commodity composition of Africa's commodity trade, the African continent, in general, is still suffering from the concentration of its most important exports in raw materials with low employment and low complexity, as fossil fuels control most of the exports of oil-exporting countries. Africa, especially sub-Saharan Africa, is the most exporting region of raw materials in the world (AfDB, 2019). At the same time, North Africa's share of imports of capital goods increases. This maximizes opportunities for possible gains from the entry of Arab countries into GVC through more integration with African countries.

4.2 The international trade of Arab countries within the continent

The available data for trade indicates the disparity in the trade performance of Arab countries with the rest of African countries. Only four of the Arab countries recorded surpluses in merchandise trade with the rest of the African countries; namely Morocco, Egypt, Algeria and Tunisia. Figure 4 shows that the rate of coverage of imports from exports with Africa ranges between 463 per cent in Morocco and 6 per cent in Djibouti.

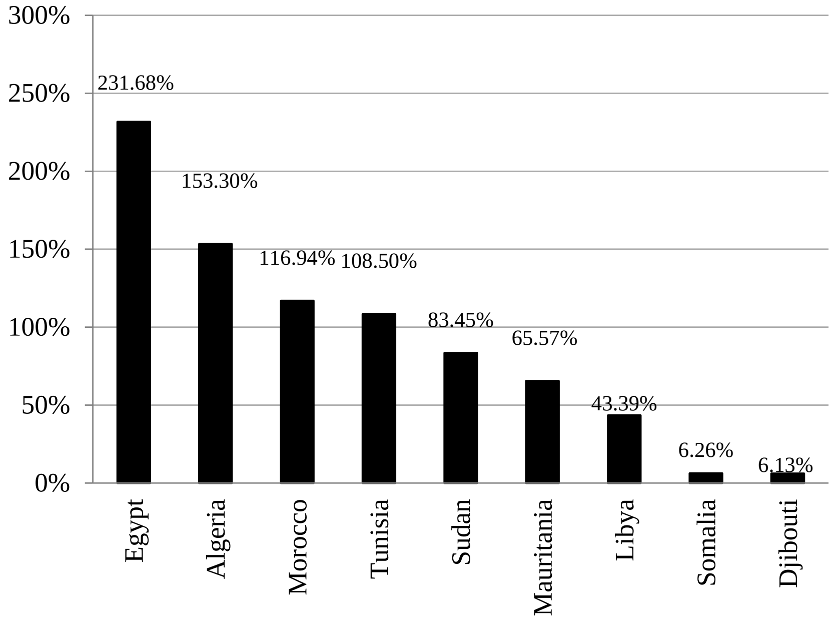

Figure 4- The Coverage Rate of Imports by Exports with Africa in 2019
Source: Authors' compilation based on data of UN Comtrade data, UN, 2020

The average trade data for the latest available 10 years shows that few markets dominate trade of Arab countries in African markets. Predominantly, imports are less diversified than exports in most of the Arab countries. According to the Gini-Hirschman Index, the highest concentration of exports of Arab countries to African markets was in Libya, while the lowest was in Morocco. For imports, the most elevated concentration of Arab countries from the rest of African markets was in Somalia, while the lowest was in Egypt. It is generally noted that the trade of Arab countries is primarily concentrated in the countries of geographical proximity. This gives an indication of the importance of logistical factors in supporting their trade with Africa.

According to The World Trade Organization (WTO), manufactures dominate exports of Tunisia, Morocco, and Egypt. Fuels and mining products dominate exports of Algeria and Libya. On the other hand, Agricultural products dominate exports of Sudan. Agricultural, fuels and mining products are relative crucial to the exports of Mauritania. Although manufactures dominate most of the imports of the Arab countries, agricultural imports have exceeded 20 per cent in Sudan, Libya, Algeria, Morocco, Egypt and Mauritania.

Figure 5 shows that intermediate goods dominate intra-trade of most of the Arab countries with Africa. Intermediate goods dominate intra-exports of Algeria, Sudan, Morocco, and Egypt. It dominates intra-imports of all Arab countries those possess data of commodity composition with Africa. Despite the relatively vast volume of trade in some Arab countries within the continent, the share of manufactures remains modest. Manufactures intra-exports of Arab countries within the continent are concentrated as a volume in Egypt, Morocco and Tunisia. Manufactures intra-imports of Arab countries within the continent are concentrated as a volume in Algeria, Sudan, Morocco, Tunisia and Egypt. It is also noted that the exports of Arab countries are concentrated within the continent in a limited number of commodities namely: textiles, apparel, clothing accessories, footwear and ceramic products. These commodities do not differ considerably from one country to another.

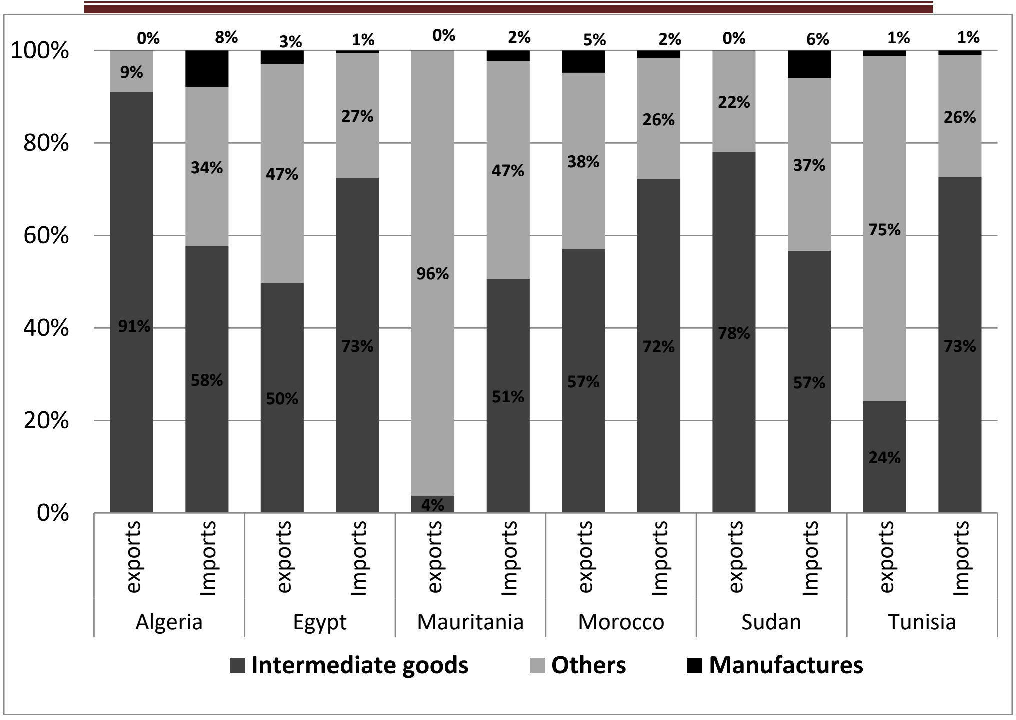

Figure 5- Intra-trade of Arab Countries in African Markets by Product Groups in 2019
Source: Authors' compilation based on data of UN Comtrade data, UN, 2020.

To ensure the modest share of the exports of Arab countries' exports of manufactures to total trade with Africa, the share of Arab countries' manufactured exports has been studied as a proportion of total manufactured imports in Africa. Figure 5 shows the share of Arab countries in Africa's total imports from the most critical items of manufactures in which Arab countries enjoy a comparative advantage. Figure 6 confirmed the modest share of Arab countries in total manufactured imports of Africa from these items. This proves the existence of potential trade opportunities for Arab countries within the African market.

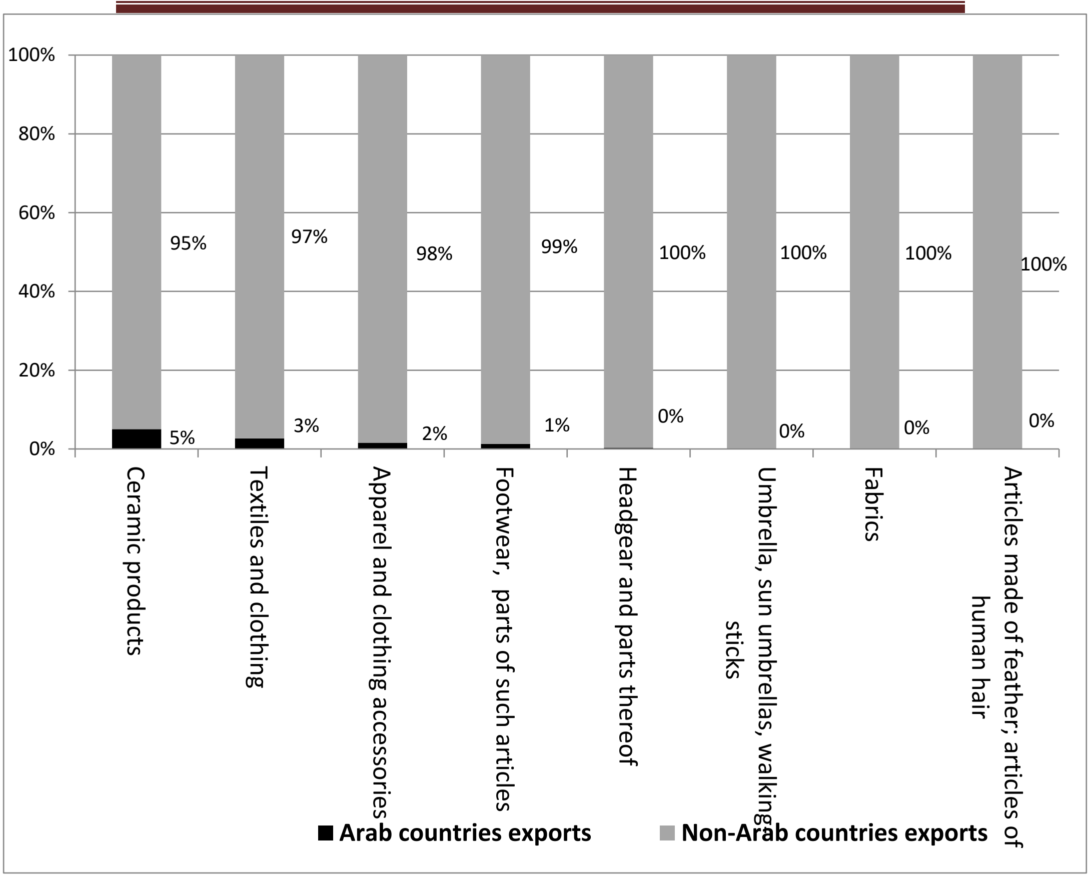

Figure 6- Intra-trade of Arab countries in African markets by product groups in 2019
Source: Authors' compilation based on data of UN Comtrade data, UN, 2020.

5. Significance of Logistics factors in Intra-Arab Trade Using Gravity Model

The gravity model approach is used to analyse the crucial determinants of Arab exports to African markets[(2)]. Gravity model is commonly used in explaining the patterns of bilateral trade as it is found to be rarely associated with problems such as the two-way causality and omitted variable biases, those affect the efficiency of the model estimation, (Ngepah and Udeagha, 2018). Several modifications are allowed to support its theoretical roots. As a result, the generalised equation of gravity is produced to include variables to refer to the factor proportion theory, Linder's model and theories of economies of scale and monopolistic competition (Anderson, 1979; Negasi, 2009; Ngepah and Udeagha, 2018).

After including some variable to reflect the nature of the case of the African countries, the generalised gravity model of international trade is shown as follows:

$$\ln(X_{ijt}) = \beta_0 + \beta_1 \ln(Y_{it}) + \beta_2 \ln(Y_{jt}) + \beta_3 \ln(y_{it}) + \beta_4 \ln(y_{jt}) + \beta_5 \ln(D_{ij}) + \beta_6 Bor_{ij} + \beta_7 Agr_{ijt} + \beta_8 \ln(ydif_{ijt}) + \beta_9 Infr_{it} + \beta_{10} Infr_{jt} + \beta_{11} \ln(IQ_{it}) + \beta_{12} \ln(IQ_{jt}) + \beta_{13} \ln(XDTF_{it}) + \beta_{14} \ln(MDTF_{jt}) + \beta_{15} \ln(Open_{it}) + \beta_{15} \ln(Open_{jt}) + u_{ij}) \quad \ldots (1)$$

where,

X_{ijt} is the value of exports from country i to country j at time t,

Y_{it} (Y_{jt}) is the value of GDP in the exporting (importing) country at time t,

y_{it} (y_{jt}) is the value of per capita GDP in the exporting (importing) country at time t,

D_{ij} is the geographical distance between the 2 partners,

Bor_{ij} is a dummy variable for being neighbouring country pairs,

Agr_{ij} is a dummy variable for being members in at least one trade blocks at time t,

$ydif_{ijt}$ is the per capita GDP difference between the 2 partners at time t,

$Infr_{it}$ ($Infr_{jt}$) is an index for the infrastructural level in the exporting (importing) country at time t (3),

IQ_{it} (IQ_{jt}) is an index for the institutional quality in the exporting (importing) country (4),

$XDTF_{it}$ ($MDTF_{jt}$) is an index for ease of trading across borders index in both countries (5) which is used as a proxy for documents and costs of trade across borders.

$Open_{it}$ ($Open_{jt}$) is the sum of merchandise exports and imports divided by the value of GDP of the exporting (importing) country at time t as a proxy for openness.

Several hypotheses are investigated in the gravity model. As for the purpose of this research paper, the focus will be more on testing hypotheses these are more closed to logistics performance.

1. The inverse relation between the distance between the 2 partners and bilateral exports as distance can represent an indirect measure of trade costs.
2. The direct relation between having a high infrastructure and institutional quality in the 2 partners and the ability to facilitate bilateral trade.
3. The direct relation between having borders and agreements between the 2 partners and enhancing bilateral exports as they facilitate trade.
4. The direct relation between ease of trading across borders and openness in the 2 partners and the ability to facilitate bilateral trade.

The data used to estimate the model cover trade of the nine Arab countries with the rest of African countries. Sources of Data are derived from the United Nations Conference on Trade and Development database (UN Comtrade) for bilateral export. The World Development Indicators database of the World Bank is used to collect data of GDP, per capita GDP, per capita GDP differences, infrastructure quality and openness. Data on the geographical distance between the major cities in members are collected from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database. The Worldwide Governance Indicators (WGI) project is used to have IQ data[(6)] and Doing Business reports for DTF data.

Data of the variables included in the model are considered to be cointegrated. Testing the nature of data included in the model shows the existence of a source of cross-sectional heterogeneity. This is justified in the case of African countries with the modest data quality (Ngepah and Udeagha, 2018). In this case, the OLS estimator generates biased and inconsistent results, especially putting into account the possibility for the biasness of sample selection in case of having cross-sectional data and producing the endogeneity problem. In order to obtain consistent and asymptotically unbiased estimates of the cointegrating vectors, three recently used appropriate estimators are employed, namely: the group mean fully modified OLS (FMOLS), the parametric panel Dynamic OLS (DOLS) and Conical Cointegration Regression (CCR) estimators for cointegrated panels. Table no. (2) summarises the results of estimators.

Table 2 – Results of Gravity Model Estimation

Estimator	FMOLS	DOLS	CCR	OLS
Dependent variable	Ln (X_{ijt})	Ln (X_{ijt})	Ln (X_{ijt})	Ln (X_{ijt})
AGR_{ijt}	1.548*** (0.116)	1.089*** (0.119)	1.489*** (0.068)	1.076*** (0.099)
BOR_{ij}	0.590*** (0.221)	0.757*** (0.229)	0.923*** (0.125)	0.784*** (0.191)
ln (D_{ij})	-1.417*** (0.119)	-1.508*** (0.123)	-0.990*** (0.063)	-1.543*** (0.103)
ln ($MDTF_{ijt}$)	0.961*** (0.095)	0.726*** (0.097)	0.921*** (0.049)	0.658*** (0.081)
ln ($XDTF_{ijt}$)	4.977*** (0.324)	4.511*** (0.334)	4.971*** (0.255)	3.798*** (0.263)
ln (Y_{imp})	0.886*** (0.036)	0.857*** (0.036)	0.935*** (0.018)	0.846*** (0.03)
ln (y_{imp})	-0.101 (0.079)	-0.162** (0.081)	-0.131*** (0.041)	-0.129* (0.068)
ln (y_{exp})	-2.464*** (0.156)	-2.355*** (0.16)	-2.507*** (0.123)	-2.509*** (0.133)
ln (Y_{exp})	1.580*** (0.059)	1.499*** (0.06)	1.584*** (0.047)	1.582*** (0.049)
ln ($INFR_{imp}$)	-0.318*** (0.098)	-0.129 (0.101)	-0.161*** (0.049)	-0.270*** (0.083)
ln ($INFR_{exp}$)	0.473***	0.638***	0.400***	0.368***

	(0.141)	(0.145)	(0.125)	(0.116)
ln (IQ_{imp})	-0.062 (0.19)	-0.266 (0.196)	-0.351*** (0.099)	-0.144 (0.164)
ln (IQ_{exp})	1.221*** (0.304)	1.207*** (0.314)	1.619*** (0.221)	2.233*** (0.224)
ln ($OPEN_{imp}$)	0.400*** (0.119)	0.536*** (0.123)	0.354*** (0.065)	0.612*** (0.102)
ln ($OPEN_{exp}$)	1.315*** (0.104)	1.227*** (0.108)	1.282*** (0.093)	1.216*** (0.09)
ln ($YDIF_{ijt}$)	-0.108** (0.052)	-0.190*** (0.053)	-0.090*** (0.027)	-0.163 (0.044)
C	12.615*** (1.71)	15.925*** (1.764)	9.552*** (1.176)	19.821*** (1.382)
@TREND	0.000	0.000	0.000	
N	3714	3740	3714	3740
R^2	0.55	0.56	0.55	0.55
F-statistic	134.553	129.101	431.132	286.407
Prob(F-statistic)	0.000	0.000	0.000	0.000

(Note) *, **, and *** denote significance at 10%, 5%, and 1%, respectively. Heteroscedastic-consistent standard errors are in parentheses.
Source: Prepared by the authors

The results of estimating the gravity model confirmed the theory as all of them have the theoretically expected signs. The focus, as mentioned before will be on the variables; those are more closed to logistics performance. First, distance as a proxy for trade logistics cost is significantly restricted trade in all of the estimators. Secondly, having high infrastructure and institutional quality in the exporting country encourages trade, while having high infrastructure and institutional quality in the importing country impedes trade because of having competitors in these markets. Thirdly, being neighbours and having agreements between the Arab country and the rest of African countries facilitates trade. Finally, ease of trading across borders and openness in both partners are statistically significant to encourage trade. Accordingly, all the variables used as proxies for logistics efficiency are statistically significant determinants of accelerating trade.

6. A Significance of LC Location Criteria

As a second step in the research approach, AHP is applied as one of the fundamental mathematical models currently applicable to support the decision of selecting the significant criteria for LC locations selection (Tu *et al.*, 2010; de FSM Russo and Camanho, 2015; Uyanik *et al.*, 2018). According to Saaty (2000), a hierarchy can be constructed by creative thinking, recollection and using people's perspectives. In this paper, a simple three-level hierarchical structure is first constructed as shown in Figure 7. Based on reviewing the related literature, a proposed hierarchy is constructed as follows: The ultimate level of the hierarchy is the overall goal: to evaluate the significance of location selection criteria in Africa. Under the overreaching goal, the second level represents the criteria (i.e., factors) affecting LC location selection, including economic, trade and capacity criteria. Various sets of sub-criteria (i.e., attributes) associated with each criterion in the second level are linked to the third level. As seen in figure 7, there are 6 sub-criteria in total in the third level. The economic criteria consist of two sub-criteria (GDP and trade openness). The trade criteria are divided into two sub-criteria (distance and trade flow). The capacity criteria include two sub-criteria (infrastructure and country location).

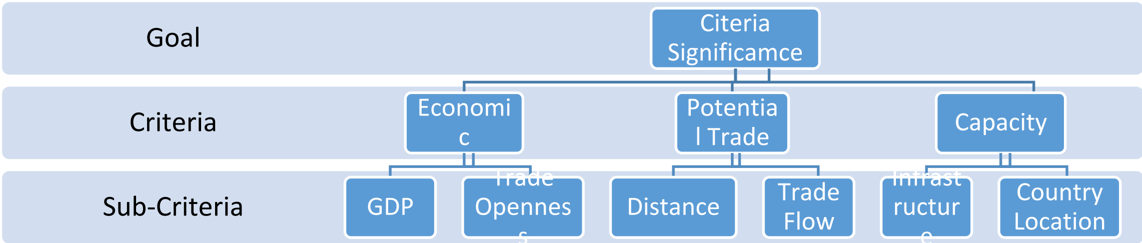

Figure 7 – Decision Hierarchy for LCs Selection Criteria in Africa
Source: Prepared by the authors

The following step was to determine the Comparison Matrix where the criteria must be evaluated in pairs and determined to the relative importance between them and their relative weight to the global goal. As the AHP approach is a subjective methodology, the priority weights of criteria can be obtained from a decision-maker using direct questioning or a questionnaire method (Atthirawong and MacCarthy, 2002). Hence, to obtain the criteria scale, information is provided by a total of 20 participants from the International Collaboration Unit, Ministry of Transport in Egypt and from the African Union in Ethiopia.
The consistency ratio illustrates how consistent the results are. A consistency ratio is applied to make sure that the responses to the original pairwise comparison matrix are consistent and desirable. In general, if the consistency ratio is 0.10 or less, the decision maker answers are relatively consistent (Render *et al.*, 2006; Chen, 2006). The (CR) results illustrate that the three criteria are consistent with ration less than 0.10 as follows: the economic (0.024), the trade (0.005) and the capacity (0.074).

7. Potential LC Locations in Africa

As a third step of the applied methodology, a centre of gravity is used for proposing potential LC locations. For this purpose, the African continent is divided into two groups including Arab countries and non-Arab countries. Additionally, both exports and imports values are considered separately to capture the direction of trade flows among countries. Accordingly, trade flows between each Arab country and the rest of African countries have been developed as shown in Figure 8.

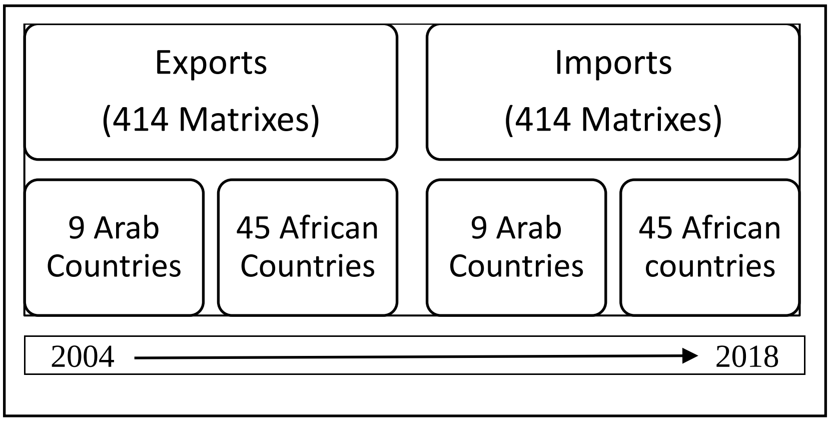

Figure 8- Arab-African Trade Flow Analysis
Source: Prepared by the authors

A center of gravity method is applied to determine the adequate LC locations. The following steps have been developed in order to identify the LC locations in Africa:

1- The astronomical locations of all 54 African countries are considered using DD.

2- The trade values are considered between each Arab country and the rest of African countries (Arab and non-Arab).

3- A centre of gravity is developed for each Arab country and the rest of African countries twice including; exports, and imports.

4- Using a centre of gravity, a total of 18 potential locations is identified for establishing LCs in the African continent as shown in Table 3.

Table 3- Proposed Locations Results of LCs in Africa

Country	Trade Flow (s)	Potential LC Locations			
		(DD)		Degrees, minutes, and seconds (DMS)	
Algeria	Exports	33.88690301	9.537461641	33°53'12"N	9°32'14"E
	Imports	27.22731852	13.29453542	27°13'38"N	13°17'40"E
Egypt	Exports	23.31851871	16.21693141	23°19'06"N	16°13'00"E
	Imports	16.84718869	12.44664759	16°50'49"N	12°26'47"E
Djibouti	Exports	26.82052735	30.80251007	26°49'13"N	30°48'09"E
	Imports	9.144902645	40.48969312	9°08'41"N	40°29'22"E
Libya	Exports	33.88681286	9.537464153	33°53'12"N	9°32'14"E
	Imports	26.82050589	30.80227004	26°49'13"N	30°48'08"E
Mauritania	Exports	7.714474991	0	7°42'52"N	0°00'00"E
	Imports	25.10362542	0	25°06'13"N	0°00'00"E
Morocco	Exports	8.619274296	0.824702657	8°37'09"N	0°49'28"E
	Imports	0	11.66529927	0°00'00"N	11°39'55"E
Somalia	Exports	9.081906405	8.675358648	9°04'54"N	8°40'31"E

	Imports	9.145052027	40.48966748	9°08'42"N	40°29'22"E
Sudan	Exports	26.82050702	30.80260962	26°49'13"N	30°48'09"E
	Imports	26.82054423	30.80249021	26°49'13"N	30°48'08"E
Tunisia	Exports	25.87942715	11.9842267	25°52'45"N	11°59'03"E
	Imports	28.03390756	1.659669864	28°02'02"N	1°39'34"E

Source: Prepared by the authors

It is obvious from the results that:

- Some countries have more than one potential LC location such as Libya and Algeria.
- Some potential LCs locations are approximate in term of distance such as in Togo and Ghana.

The potential locations are located on the Map of Africa as shown in Figure 9. It shows that most of the LC locations are proposed to be located in North and West Africa, while very few of LC locations are proposed in East Africa and with absence of proposed LC locations in South Africa. As displayed in Table 4, North Africa retains the highest number of potential LC locations.

Table 4- Distribution of Potential LC Locations in Africa

Region	No. of Potential LC	Detailed potential locations
North Africa	11	Egypt (4), Libya (3), Tunisia (2), Algeria (2)
East Africa	2	Ethiopia (2)
West Africa	5	Ghana (1), Togo (1), Gabon (1), Nigeria (1), Niger (1)
South Africa	0	
Total Potential LCs	18	18

Source: Prepared by the authors

Reviewing the distribution of potential LC locations per country, tables 3 and 4 show that:

1. The potential LC locations are proposed in only 10 countries out of 54 countries in Africa.
2. The 18 potential LC locations draw a triangle where its base is between East and West Africa and its head is located in North Africa.

In case of the potential LC locations that are located in the corresponding countries or near coordinates in other countries, a centralised hub LC can be established to enhance a trade flow for a region as indicated in Figure 9. This will reduce the number of potential LCs. By reviewing Figure 9, it can be accentuated that:

1. The four potential LCs in Egypt can be merged into one LC in Asyut city alongside Nile River; 329 km south Cairo, 308 km west Safaga port, and 345 km south-west Ain Sokhna port.
2. The three potential LCs in Libya have occupy adjacent locations in south-west Libya, where they can be merged into one LC near Sabha; 557 km south Tripoli port, and 594 km south Zuara port.
3. The two LCs proposed in Tunisia are located at the similar locations, where they can be merged into one LC in Ben Ghilouf; 47 km west Gabes port, and 140 km south west Sfax port.
4. The two Ethiopian LCs are located at the same place, where they can be merged into one LC in Asebot; 181 km east Addis Ababa.
5. The two Algerian potential LCs can be merged into one LC in Salah; 906 km south Algiers port.
6. One LC can be established between Togo and Ghana; 276 km north Lome port and 351 km north Accra port.
7. One LC can be established in the following countries: Niger, Nigeria and Gabon.

Thereof, based on site suitability and near locations, the 18 potential LCs in Africa can be reduced into 9 LCs as discussed above. This will reduce the cost of establishing LCs and enhance the trade flows through concentrated hub LCs. It is apparent that the proposed 9 LCs are nearly distributed in Africa; East, West, and at the middle in Africa. Furthermore, the center of gravity did not indicate the establishment of LCs in the south of Africa.

As a fourth step of the applied methodology, the proposed LC locations in Africa are compared with: existing LC locations, airports, seaports, railways and roads, as shown in Figure 9. This helps to underpin the significance of the capacity criteria in proposing the LC locations in Africa.

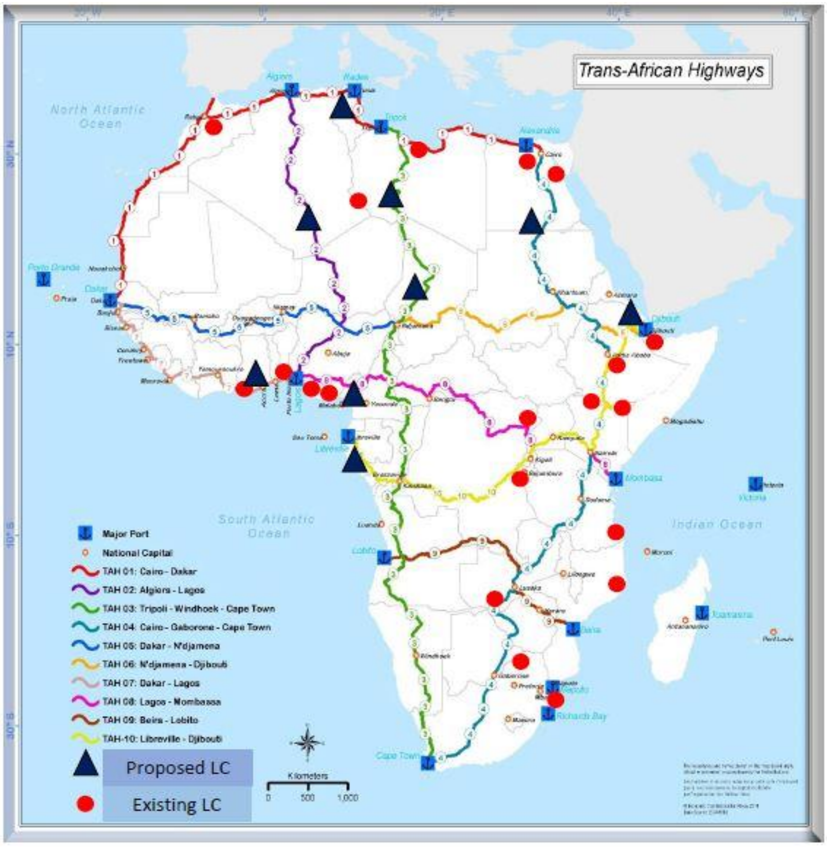

Figure 9- Proposed and Existing LCs Locations in Africa
Source: Prepared by the authors

According to the existing LCs and their transport connectivity, it is distinct that the proposed LCs are aligned with the transport connectivity in Africa, while other proposed LC locations are approximate to existing LCs. As illustrated in Figure 9, it can be summarised as follows:

1. There are two proposed LC locations that are approximate to existing LC locations, namely Lagos in Nigeria, and Accra in Ghana. Hence, it is recommended to extend existing LCs instead of establishing the proposed LCs in the 2 areas. These proposed locations have accessibility as follows:

▪ Lagos in Nigeria; (Lagos airport; Apapa seaport; Lagos – Mombasa, Algiers – Lagos, and Dakar – Lagos highways)

▪ Accra in Ghana; (Accra airport; Tema seaport; Dakar – Lagos highway)

2. There are five proposed LC locations in area that have no existing LCs, including Sabha in Libya, Ben Ghilouf in Tunisia; In Salah in Algeria, Agadez in Niger and Libreville in Gabon. These proposed LC locations can enhance the trade flows, particularly for landlocked countries such as Niger. These proposed locations have accessibility as follows:

▪ Sabha, Libya; (Sabha airport; Tripoli - Cape Town highway)

▪ Ben Ghilouf, Tunisia; (Matmata airport; Sfax seaport; Cairo – Dakar highway)

▪ In Salah, Algeria; (Aéroport Régional Amguid airport; Algiers – Lagos highway)

▪ Agadez, Niger; (Agadez airport; Algiers – Lagos highway)

▪ Libreville, Gabon; (Libreville airport; Krib seaport; Tripoli - Cape Town highway)

3. There are two proposed LCs in countries that have already existing LCs in various locations namely: Asyut in Egypt and Asebot in Ethiopia. These proposed locations can be integrated with existing LCs for providing comprehensive and value-added services in large geographical areas. These proposed locations have accessibility as follows:

- Asyut, Egypt; (Asyut airport; Safaga seaport; Cairo - Cape Town highway)
- Asebot; Ethiopia; (Jijiga airport; Cairo - Cape Town, and N'Djamena – Djibouti highways)

4. It is noticeable that all proposed LC locations provide accessibility to road transport, Trans-African Highway network and airports. Regarding the seaports, two proposed LC locations have no accessibility as they are positioned in landlocked countries such as Niger and Ethiopia. While other two proposed LC locations have no accessibility to seaports as they are located far away from the coast such as South Libya, and south Algeria.

8. Conclusion and Practical Implication

Right LC locations enhance the flow of trade between places and minimise distance, cost, congestion and bottleneck. Thus, the location of LC should be strategically selected. In Africa, the efficiency of logistical and supply chain activities is becoming more prominent. Based on related literature, three criteria are applied in proposing suitable LC locations to enhance the trade flow among Arab countries and the rest of African countries, namely: the economic criteria, the trade criteria and the capacity criteria. As a result, eighteen LC locations are proposed to achieve the objective of the research. After comparing these proposed locations with what was already achieved, priority was given to seven potential locations for establishing LCs in Africa. It is concluded that all proposed LC locations provide accessibility to road transport, Trans-African Highway network and major seaports and airports. This contributes in enhancing the flow of goods and to the region's development. The findings reveal that the proposed LC locations are located mainly in North Africa, where less number of LC locations are located in East and West Africa. The proposed seven LC locations aim to serve the landlocked countries such as Niger and Ethiopia, and the West African countries that suffer from poor infrastructures, limited seaports' capacities and poor logistics services and activities.

As a further research, the selection of LC locations can be determined using other criteria such as infrastructure, trade openness and index to frontier. Moreover, other factors can be applied such as land cost, construction costs, cost and qualification of labour and local regulations and laws. Decision concerning the selection of the LC location and the choice of regions is left for investors. It aims to balance certain trade-offs and search for the most satisfactory locations for local authorities and companies conducting logistics activities.

Notes

1. Some African countries received largely a sharp decline in the share of oil- and hydrocarbon as a component of Africa's exports, notably Algeria and Angola. The share of oil as a per cent age of gross domestic product reached about 23 per cent in 2006 and then its share declined, turning Africa into a net oil importer since 2013. In addition, the continent has become a net importer of food and raw materials since 2012.
2. Tinbergen was the first to use the gravity model to study the flow of trade in 1962. He stated that the volume of bilateral trade is affected by two opposite forces. First, the positive relation with economic size of the two countries measured as GDP or national income. Second, the negative relation with a vector of obstacles to trade including distance, contrast cultures and trade policies.
3. The index for the infrastructural level is calculated as the arithmetic average of the normalized values of four variables included in the WDI database; namely: kilometers of roads density, kilometers of paved roads density, kilometer of railways density and the number of telephone lines per capita.
4. The index for the institutional quality is calculated as the arithmetic average of the country’s scores on all six governance dimensions published by the World Bank, since these dimensions are highly correlated.
5. Distance to Frontier (DTF) is generated by The World Bank - Doing Business report.

6. The country's institutional quality is measured as the arithmetic average of the country's scores on all six governance dimensions of the governance infrastructure quality (Linders et al., 2005).

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