DETERMINATION OF FREIGHT VILLAGE LOCATION AND ITS TRANSPORTATION NETWORK IN A LANDLOCKED COUNTRY: THE CASE OF OUAGADOUGOU

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Herhangi bir zamanda, çalışmamla ilgili yaptığım bu beyana aykırı bir durumun saptanması durumunda, ortaya çıkacak tüm ahlaki ve hukuki sonuçlara razı olduğumu bildiririm.

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PREFACE

This PhD is dedicated to my father who passed away when I was starting the journey. However, it would not have been possible to achieve it without the support of some people.

Firstly, my thanks go to my advisor Prof. Dr. Mehmet Tanyas in the Department of International Trade and Logistics at Maltepe University for all the support and encouragement, his patience, motivation, and immense knowledge. This PhD was achieved thanks to his guidance and constant feedback. Furthermore, I extend my gratitude to my committee members, Prof. Dr. Umut Tuzkaya in the Department of Industrial Engineering at Yildiz Technical University, Asst. Prof. Burak Kucuk in the Department of International Trade and Logistics at Maltepe University, for their insightful comments and encouragement.

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Bouama Arnaud Ouali

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ABSTRACT

DETERMINATION OF FREIGHT VILLAGE LOCATION AND ITS TRANSPORTATION NETWORK IN A LANDLOCKED COUNTRY: THE CASE OF OUAGADOUGOU

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Burkina Faso's landlocked state, coupled with its geographical position in West Africa, makes it a hub of regional corridors. Its landlockedness imposes a markup on the costs of imports and exports, but also Burkina Faso's distances from gateway ports are longer than average (about 1,000 kilometers to a gateway ports). As a result, the costs of transport are very sensitive to any inefficiency in customs administration, cross-border waiting times and in the transit chain. The geographic location of the country however, positions him as a natural transit hub for West Africa. Burkina is a transit point for the landlocked countries of Niger and Mali and has the potential to take advantage of its geographical position; it also supports trade development with its neighboring countries (Togo, Niger, Mali, Benin, Ghana, and Ivory Coast). When it comes to trade, Burkina Faso has four alternative corridors for shipment. Its capital city Ouagadougou strategically lies at the intersection point of those corridors. As a result of being a transit point for national and regional freight movement, Ouagadougou is facing many city logistics problems like increasing trucks accidents, congestion in the traffic, air pollution and noise etc.…

Given these circumstances, the concept of freight village is introduced in the African context with focus on landlocked country. This study aims to simultaneously select a freight village location and its transportation network for the city of Ouagadougou. The research proposes an AHP model to evaluate both the potential freight village locations and their transportation network. The aim of the proposed framework is to alleviate city logistics problems in Ouagadougou and to leverage the potential of Burkina Faso to benefit from its geographic position. The findings of this research maybe an inspirational guide for policy makers, practitioners, and academicians. It will also contribute to enrich the existing literature on landlocked countries and more specifically on Burkina Faso.

Keywords: 1. City Logistics; 2. Freight Village; 3. Transportation Corridor; 4 Landlocked Country.

ÖZ

DENİZLE BAĞLANTISI OLMAYAN BİR ÜLKEDE LOJİSTİK KÖYÜ YERLEŞİMİ VE ULAŞIM AĞININ BELİRLENMESİ: OUAGADOUGOU'NUN ÖRNEĞİ

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Burkina Faso'nun deniz kıyısı bulunmamaktadır ve Batı Afrika'daki konumuyla bölgesel koridorların merkezi konumundadır. Burkina Faso'nun sadece karasal yapısı değil ayrıca gümrük çıkış noktalarına olan uzaklığı ortalamadan fazla olduğu için (yaklaşık 1.000 km limana uzaklık) ithalat ve ihracat maliyetlerine bir yük getirmektedir. Dolayısıyla, taşıma maliyetleri, transit zincirindeki herhangi bir verimsizliğin hassasiyetinin artmasına, gümrük idaresinde sınır ötesi bekleme sürelerini ve lojistik maliyetlerini artırmaktadır. Ancak aynı coğrafi konum Burkina Faso'yu, Batı Afrika için doğal bir geçiş merkezi olarak konumlandırmaktadır. Burkina Faso, karasal ülkeler olan Mali ve Nijer'e hizmet etmekte ve komşu ülkeleriyle (Togo, Nijer, Mali, Benin, Gana ve Fildişi Sahili) bölgesel ticaretin gelişimini desteklemektedir.

Ticaret açısından baktığımızda Burkina Faso'nun sevkiyat için dört alternatif koridoru bulunmaktadır. Başkent Ouagadougou stratejik olarak bu koridorların kesişme noktasında yer almaktadır. Ulusal ve bölgesel yük taşımacılığı için bir geçiş noktası olmasının bir sonucu olarak, Ouagadougou, artan kamyon trafik kazaları, trafik sıkışıklığı, hava kirliliği ve gürültülü çevre gibi birçok kentsel lojistik sorunuyla karşı karşıya bulunmaktadır.

Bu tez kapsamında, tüm bu faktörler göz önüne alınarak lojistik köyü kavramı Afrika bağlamında kara ülkesine odaklanılmıştırr. Bu çalışma aynı anda bir lojistik köyü yeri ve Ouagadougou şehri için ulaşım ağını seçmeyi amaçlamaktadır. Araştırma, hem potansiyel lojistik köyü konumlarını hem de ulaşım ağlarını değerlendirmek için bir AHP modeli önermektedir. Önerilen sistemin amacı Ouagadougou'daki kentsel lojistik problemlerini hafifletmek ve Burkina Faso'nun coğrafi konumundan faydalanma potansiyelini arttırmaktır. Bu araştırmanın bulguları, politika yön verenler, uygulayanlar ve akademisyenler için ilham verici bir rehber olabilir. Ayrıca kara ülkesi Burkina Faso'daki mevcut literatürün zenginleştirilmesine belirli bir biçimde katkıda bulunacaktır.

Anahtar Sözcükler: 1. Kentsel Lojistik; 2. Lojistik Köyü; 3. Ulaştırma Koridoru; 4. Kara Ülkesi.

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ABBREVIATION

AHP : Analytical Hierarchy Process

B2C : Business to Consumer

C1 : Criterion n^{o} 1

C2 : Criterion n^{o} 2

C3 : Criterion n^{o} 3

C4 : Criterion n^{o} 4

C5 : Criterion n^{o} 5

C6 : Criterion n^{o} 6

C7 : Criterion n^{o} 7

C8 : Criterion n^{o} 8

CFA : African Financial Community

CFTS : Cooperative Freight Transport Systems

CI : Consistency Index

CO_2 :Carbon Dioxide

CR : Consistency Ratio

ELECTRE : Elimination and Choice Expressing Reality

FCFA : Franc of the African Financial Community

FTZs : Free Trade Zones

GDP : Gross Domestic Product

GIS : Geographic Information System GIS

GVZ : Güterverkehrszentrum

ICL : Institute for City Logistics

KM : Kilometer

LLACs : Landlocked African Countries

LLCs : Landlocked Countries

LLDCs : Landlocked Developing Countries

LPI : Logistics Performance Index

LTL : Less Than Truck Load

LWR : Lighthill Whitham Richards

M2 : Category of Vehicle Having a Maximum Mass not Exceeding 5 Tons

M3 : Category of Vehicle Having a Maximum Mass Exceeding 5 Tons

MCDM : Multi Criteria Decision Making

MILP : Mixed-Integer Linear Programming

NO_2 : Nitrogen Dioxide

NOX :Nitrogen Oxides

OUAGAINTER : Gare Routière Internationale de Ouagadougou

OWA : Ordered Weighted Averaging

PNDES : Economic and Social Development Plan

PPPs : Public-Private Partnerships

PROMETHEE : Preference Ranking Organization Method for Enrichment Evaluations

SONABHY : National Company of Burkina Faso Hydrocarbons

SPM : Suspended Particle Material

SSA : Sub-Saharan Africa

TCDD : Turkish State Railways

TEU : Twenty-foot Equivalent Unit

TL : Truck Load

TOPSIS : Technique for Order Preference by Similarity to Ideal Solution

UEMOA : West African Economic and Monetary Union

UNCTAD : United Nation Conference on Trade and Development

UNECA : United Nation Economic Commission for Africa

VRPSTWSPD :Vehicle Routing Problem with Soft Time Windows and Simultaneous Pickups and Deliveries

WGI : Worldwide Governance Indicators

ÖZGEÇMİŞ

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CHAPTER 1 INTRODUCTION

In the heart of West Africa, lies the landlocked country of Burkina Faso. It is surrounded by six countries are namely Ghana, Togo, and Benin to the South, Ivory Coast to the West, Mali to the North and Niger to the East. Like most regions in West Africa, Burkina Faso is experiencing a rapid urban growth. Its population is estimated at about 20.32 million in 2019 and the average growing rate is 3.1% annually. The large part of that growth happened in the capital city of Ouagadougou. When it comes to trade, Burkina Faso has four alternative transport corridors for shipment. Traders have the choice between four main ports for goods shipment. These ports are located in the cities of Cotonou in Benin, Lome in Togo, Tema in Ghana and Abidjan in Ivory Coast.

Moreover, Burkina Faso is mainly an agricultural country with an embryonic industrial sector. It imports a lot of capital goods and complementary food products. Cotton and gold represent Burkina Faso's key exports; about three-quarters of Burkina Faso's total export revenues come from gold. The economic growth and revenue of the country significantly relies on global prices and production levels for the two commodities. Over the past few years, the country's economy has witnessed a high levels of growth and the country has seen a boom in mining activities (gold exploration, production, and exports) (Cia, 2017). In fact, it is the leading cotton producer in Africa. In the mining sector, it takes the second place as most attractive country in Africa. Burkina Faso alone accounts for over 20% of the mineral potential in West Africa, its main ores being gold, silver, zinc, manganese, iron, bauxite. The country is the fourth largest producer of gold in Africa and its underground contains other useful minerals such as limestone, dolomite, phosphate, marble, talc, clay, silica, antimony (Pndes, 2017).

The country attractiveness for investment keeps freights movement increasing every passing day. However, the long distances to sea and to the world markets, the lack of proper transportation infrastructures, the country is suffering from high transportation

costs and city logistics issues and will likely suffer more from them if nothing is done to change the status quo. In fact, according to the LPI (Logistics Performance Index) 2018, Burkina Faso is among the lower performers when it comes to logistics. Burkina Faso was ranked in the LPI 2018, 91st out of 160 countries with a score of 2.68 (1=low to 5=high). Furthermore, according to the World Bank, projected growth of container throughput in West Africa indicates that activity at port terminals will likely be up fourfold by 2025. Such growth in container trade is expected to strain existing capacities and even though productivity is low by international standards, capacity reserves that could be unlocked by improved performances would be insufficient to accommodate growth of this magnitude (World Bank, 2017). Consequently, Burkina-Faso as a hub for transport corridors in West Africa will need modernized logistics infrastructures to efficiently cope with the rapidly growing freights movement and urban growth.

Nevertheless, one of the most promising solutions to the increasing freight movement is the concept of freight village. The concept has gained a huge attention recently due to its potential to alleviate city logistics problems and port congestion issues. This study will try to investigate the concept of freight village with focus on landlocked countries and specifically on the city of Ouagadougou. The pursued aim is to apply the concept of freight village to alleviate city logistics issues in Ouagadougou, and to transform the city as the hub of the economy, the crossroads of exchanges throughout the country in the field of freight and the support of international transit for neighboring countries of Mali, Niger, Togo, Ghana, Benin, and Ivory Coast.

Problem Statement

Ouagadougou the capital of Burkina Faso is economically, culturally and administratively the center of the country. Like most African capital cities, Ouagadougou is experiencing a rapid urban growth. Its population is growing on average at 7% per year and is forecasted to be more than 4 million by the horizon 2025. The city is the main center of Burkina Faso’s economy. Besides, from being the country’s largest city, it is home to more than 80% of companies in the country. The

main economic activities are industry (construction, processing and packaging of food products etc...), agriculture, livestock, trade (from wholesalers to traditional small businesses) banks, crafts, transport, hotels and tourism.

Furthermore, the city lies at the intersection point of the nation's transport corridors. Imported goods from the neighboring coastal countries of Ghana, Togo, and Benin are cleared in Ouagadougou as well as some goods from Ivory Coast. In the recent years, the city is experiencing an increasing freight movement due to an accelerated urban growth and the upswing of mining activities. However, the city has a single logistics platform for the clearance of international and national flow of imported and exported freight by road, called Ouagainter (Gare Routière Internationale de Ouagadougou).

Established in 1980, Ouagainter, which has tree warehouses with a surface area of 5,000 m^2 , a 28,800 m^2 of land and a 10,000 m^2 maneuvering and parking area, was one of the few logistics terminal in the sub- region allowing the rationalization of inter-state road transit operations; and a large possibility for the temporary storage of heavy goods. Ouagainter that had the advantage of being close to the city's outskirts is currently engulfed by continued urbanization. The current site and capacity of Ouagainter is in a position that no longer meets the growing needs of demand. As a result, the urban city of Ouagadougou is facing the following city logistics problems:

- ✓ the increase in traffic congestion at Ouagainter entrances.
- ✓ slowness and bureaucracy of foreign trade transactions
- ✓ high logistics costs
- ✓ increasing trucks accidents and traffic congestion in the city
- ✓ the degradation caused by truck overloads on roads
- ✓ the lack of a railway service in Ouagainter
- ✓ air pollution in the city
- ✓ noisy environment
- ✓ safety issue for residents

In the light of that, the city of Ouagadougou is in need of a sophisticated logistics platform that will reduce traffic congestion, enhance freight processing efficiency, and bring down the over whole logistics lead-time on the four corridors. One of the modern approaches to alleviate the above-mentioned urban problems is the freight village concept.

Freight villages built up in landlocked countries and linked to seaports via an efficient rail is economically a powerful tool to minimize the challenges over seaport access and to promote economic growth and competitiveness in landlocked countries. As transportation network or corridors play a key role in opening up landlocked countries, a framework is proposed in this thesis for the simultaneous selection of a freight village location and its transportation network for the city of Ouagadougou.

When it comes to freight village location, many studies dealt with that issue using multi-criteria methods. Examples of these studies can be found in the literature such as (Zheng, Jing, & Zhuang, 2011), (Nguyen & Notteboom, 2016), (Yavas, Volkan, Sakar, & Denktas, 2017), (Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015), (Shahryar & Reza, 2008) (Shahryar & Reza, 2008), (Dimitrios & Seraphim, 2003), (Okan & Özyörük, 2015), (Li, Dong, & Sun, 2015) etc... However, those studies addressed the freight village location problem with criteria specific to coastal countries mainly from Europe and Asia. Indeed, no research of that kind was carried out on landlocked countries. In other words, the concept of freight village applied to landlocked countries and on African areas is still an empty field in the literature. Moreover, as far as we know, no study has addressed both the selection of a freight village location and its transportation network problem simultaneously in a landlocked country. Given the identified gap, our study will come to enrich the literature.

Objective and Significance of the Study

In a general way, the objective for this research consists in developing a framework to simultaneously select a freight village location and its transportation network for the city of Ouagadougou. The following specific objectives are thus formulated:

- ✓ highlight the potential of freight village to open up African landlocked countries and to alleviate their city logistics problems
- ✓ promote Burkina Faso's foreign trade by improving Burkinabe and transit freight processing
- ✓ simplified customs procedures and operations
- ✓ achieve economies of scale resulting from the consolidation of cargo
- ✓ reduced trucks accidents and traffic congestion in the city of Ouagadougou
- ✓ transform the city of Ouagadougou as an intermodal hub, the crossroads of exchanges throughout the country in the field of freight and the support of international transit for Mali, Niger, Togo, Ghana, Benin, and Ivory Coast.

The thesis will differentiate itself with others, as one of the few thesis to examine the freight village's concept on landlocked countries and especially on Burkina-Faso. It will be one of the first research to address both the selection of a freight village location and its transportation network problem simultaneously in a landlocked country. Furthermore, it is expected that practitioners can use this study as a guide in other landlocked countries. However, the main expected outcome is to establish the city of Ouagadougou as an intermodal hub in West Africa. A freight village in the city is expected to bring more efficiency in the integration and connectivity of the city's freight transportation system.

Study Limitations

This research is in an attempt of elaborating a framework to select simultaneously a suitable location for a freight village and its transportation network for the city of Ouagadougou. One of the particularities of the city is that it lies at the intersection of the nation's transport corridors. This fact significantly influenced the design of the proposed framework. Moreover, the new planning scheme of the city of Ouagadougou has been taking into account in the assessment process of the freight village potential site. Since each city and landlocked country has different features, the

outcome of this study may not be generalized to other landlocked countries and the proposed framework cannot stand as a standard path to be followed for a freight village location projects in landlocked countries. The Framework is therefore subject to potential modifications or opened to further studies aiming at enhancing the framework.

Conceptual Definitions

Landlocked Country: In the United Nations Convention on the Law of the Sea, a landlocked country is defined as a state that has no sea coast. practically, landlocked countries are located in the interior of continents, hundreds, or even thousands of kilometers from sea ports (UNCTAD, 2003). Landlocked countries besides, the challenge they faced over distance, they also faced the challenge of depending on a transit country for passage, one through which trade from a landlocked country must go through to access international markets (Faye, Mcarthur, Sachs, & Snow, 2004). Other challenges are related to border delays, cartels in the trucking industry, cumbersome clearance processes, all of which rise up transport costs (World Bank, 2019). Landlocked developing countries then, support a huge cost for not having their own seaport. Their trade relies on other countries' ports. On top of that, landlocked countries have to face some fees and road tolls imposed by many transit countries (Sipangule, 2017).

Transport Corridor: The term corridor is used to identify transport routes, describe processes for opening up hinterlands and to express a network of interdependent urban intersections displaying important movements, links, and exchanges between them. The term is also used to describe roads at different geographical scales (Comtois, 2019). Transport corridors represent the pillars for transportation networks, connecting main centers (e.g. gateways and hubs) and facing the flows of both freight and passenger. Most often, they perform both market- and market-serving functions (Rodrigue, Slack, & Blank, 2019) .

City Logistics: Freight movement is capital for metropolitan cities, yet it brings much inconveniency, like air pollution, congestion, noise, and greenhouse gas emissions (Dablanc, Giuliano, Holliday, & Obrien, 2014). The concept of "City Logistics" evolved for tackling many of those urban problems. City logistics is the

process for totally optimizing the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy savings within the framework of a market economy (Taniguchi & Thompson, 2015). Benjelloun and Gabriel (2009) highlight that city logistics aims to decrease the nuisances related to freight movement while supporting the sustainable development of urban areas. Generally, it proceeds by the coordination of different stakeholders and consolidating their loads into the same environment-friendly vehicles.

There are specific solutions for each city logistics problem; however, some solutions can be suitable for more than one problem. Among the solution are:

- ✓ Night deliveries
- ✓ Vehicle weight restrictions and time windows
- ✓ Low emission zones
- ✓ Congestion pricing
- ✓ Developing rail system for urban freight transportation
- ✓ Cross-docking centers
- ✓ Transshipment centers
- ✓ Industrial clustering
- ✓ Freight villages etc…

The concept of freight village is part of the promising solution that has gained a huge attention recently.

Freight Village: Freight villages are considered specific locations where many logistics activities take place by bringing various operators together. The 'freight' side contains traditional infrastructure dedicated to freight and logistics, while the 'village' side represents a set of additional services together with the freight infrastructure for the purpose of facilitating and expediting freight and logistics processes in the site. (Higgins & Ferguson, 2011). In the literature, there is a lack of general agreement on the terminology. As a result, a variety of terms including dry ports, inland terminals, inland ports, inland hubs, inland logistics centers, inland freight villages, etc... (Hofstra, University, 2017).

CHAPTER 2 LITERATURE REVIEW

In recent years, academic research with focus on freight villages increased in many countries. To better apprehend the issue of freight villages location, we carried out a research using Proquest; EBSCO; Science Direct and SCOPUS academic databases with the key words “Selection of freight village location” and “Selection of dry ports location.” These key words allowed the limitation of the scope of papers to the logistics center area, as the literature on location is extensive. In the same manner, in order to grasp the literature review on transportation network selection, the key words “Transportation network selection”; “Transportation corridor selection”; “Route selection” and “Transportation corridor performance measurement” has been used. Moreover, only the papers published over the past decade and dealing with freight village location problems were taken into account. Annex 1 shows the findings on freight village location problems and the annex 2 shows the findings on transportation network selection problem.

The review of literature leads to the conclusion that over the past decade very few researches were conducted on freight village location issues. Moreover, as it can be seen on the annex 1 all article addresses the freight village concept with a focus on coastal countries mainly from Europe and Asia. Indeed, no article has addressed the applicability of the concept on a landlocked African country. In other words, the concept of freight village applied to landlocked countries and on African areas is still an empty field. The literature review also shows that over the past decade academic researches on the issue of selecting a transportation network for a freight village is still an empty field as no article in the annex 2 has addressed that issue. The present study will fill up the above-mentioned gaps in the literature and inspire further researches.

2.1. Review of City Logistics Literature

Urban economies keep evolving at a face pace towards a higher level of material intensiveness. Freight movement in urbanized area is a common urban transportation

issue that affects many large metropolitan areas. In ancient times, those challenges were also prevalent. For instance, the Roman Emperor Julius Caesar through an edict prohibited of goods deliveries in daytime in Rome. It is likely that other cities in ancient time were facing the same restrictions, underlining the huge challenges of supplying urban area with goods. What has changed today is the scale and scope of the problem (Rodrigue & Dablanc, 2017). Globally, there are more people living in urban areas than in rural areas. Since 2007, the population in urban area turned larger than the one in rural area. The urban population is expected to keep growing, so that the world will become one-third rural (34 per cent) and two-thirds urban (66 per cent), by 2050, approximately the reverse of the distribution of the global rural-urban population of the mid-twentieth century (UNilibrary, 2017). The increasing number of "mega-cities" defined as cities with more than 10 million people will keep on as the motion from rural to urban areas continues in a fast pace (Christopher, 2001).

In addition, the aging society we face is requiring more costs for medical, nursing and rehabilitation service. Furthermore, commodities have to be delivered daily to elderly people (Taniguchi E. , 2012). Metropolitan areas with their overpopulations and extensive commercial establishments, consume huge quantities of goods and services for commercial and domestic purpose (Browne & Allen, 2011). Moreover, many complicated problems exist in the transportation of urban freight. Carriers for example are required to provide good levels of service at a low cost and within the Just-In-Time transport systems framework. The increasing levels of traffic demand, led to a constant growing levels of congested urban roads. The environmental problems resulting from traffic have turned to a big issue in several cities. Large trucks produce a substantial amount of air pollution in urban areas by emitting NOX SPM (Suspended Particle Material) and other gases. Energy conservation is also an important issue not only because the natural resources available are limited but also for reducing CO_2 emissions to prevent global warming. Sometime, community undergo trauma resulting from truck crashes. The concept of "City Logistics" has the potential for solving many of these difficult and complicated city problems (Taniguchi & Thompson, 2001). Terminologies like last mile logistics, urban (freight) distribution, urban logistics, or city distribution are also used to refer to City logistics (Savelsbergh & Woensel, 2016).

The concept of city logistics is defined as the process for totally optimizing the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy savings within the framework of a market economy (Taniguchi & Thompson, 2015). Another definition points that city logistics aims to decrease the nuisances related to freight movement while supporting the sustainable development of urban areas. Generally, it proceeds by the coordination of different stakeholders and consolidating their loads into the same environment-friendly vehicles (Benjelloun & Gabriel, 2009).

2.1.1. Challenges of City Logistics

Addressing urban logistics requires a good understanding of the present challenges facing urbanize cities. Some of the most significant challenges of city logistics are: (1) Congestion, (2) E-commerce (3) Land use and.

1. Congestion takes place when transport supply does not meet transport demand in a specific part of the transport system. Within such circumstances, each vehicle obstructs the mobility of others. Urban congestion is essentially concerns with passengers and freight, sharing more often the same infrastructures:
    - ✓ Passengers: in many countries of the world, incomes increased up to the point that one or more automobile per household became a common thing. Access to an automobile leads to a flexibility when it comes to the choice of origin, destination, and travel time. The automobile is privileged for most trips at other modes expense, notably for single occupancy commuting.
    - ✓ Freight: many industries shifted their reliance on trucking, increasing road infrastructure usage by trucks. Since urban areas are the principal destination for freight flows (either for consumption or for transfer to other locations), trucking is related to congestion in urban areas (Rodrigue, Comtois, & Slack, 2006).

2. In the business using internet, E-commerce became very popular. The rise of internet shopping Business to Consumer (B2C) impacts delivery system in urban area (Taniguchi, Thompson, & Yamada, 2016). In recent years, many e-tailers started offering their clients the option of a same-day delivery, sometimes even 1-hour and 2-hour delivery options are offered. The essence in offering these options is principally to compete with bricks-and-mortar retailers that provide product delivery instantaneously. In a context of urban logistics, the frequency of freight movements will go up as a result of offering rapid delivery options, as it will make the coordination and consolidation of direct-to-consumer deliveries even more challenging (Savelsbergh & Woensel, 2016).

3. Land use: a common issue in the planning of city involves the inappropriate location of logistics facilities. Freight carriers have hard time to find appropriate land for logistics terminals in urban areas due to zoning regulations and the cost of land. If they set their logistics terminals far from an expressway interchange and if the area between the logistics terminals and the interchange is developed as a residential area, safety and environmental problems will rise due to large trucks travelling through the residential area. This type of issue can be solved by the incorporation of freight transportion plans within land use planning processes (Taniguchi, Thompson, & Yamada, 2003).

For instance, cities in the world have different concerns:

- Paris is concerned with limiting the environmental footprint resulting from freight delivery so that to improve residents' quality of life.

- Mexico City, by the mean of infrastructure provision and regulations, struggles to tackle the conflicting demands of both modern (motorized) and traditional forms of urban distribution.

- Chicago aims to maintain its role of major freight distribution platform and rail hub for North America with concentration of distribution and manufacturing activities.

- Los Angeles concerns are the limitation of congestion and environmental problems such as air pollution and noise.

- Istanbul is coping with fast economic and urbanization growth, alongside with unique geographical constraints, namely a scarcity of flat land and the division of the city by the strait of Bosporus (Rodrigue & Dablanc, 2017).

Nowadays, each city according to its concerns is looking for efficient and sustainable instruments to ensure mobility of freight and passengers. Consequently, the concept of city logistics keep growing in popularity and especially since prof. E. Taniguchi from Kyoto University in Japan has established the Institute for City Logistics (ICL) (Maja, 2017). The Institute for City Logistics (ICL) was established in 1999 in Kyoto, Japan with the objective of being the center of excellence for research and development in city logistics and urban freight transport. ICL leads fundamental research and applied investigations associated with problems in society. ICL also aims to provide a platform for exchanging knowledge, experience, and information related to urban logistics and urban freight transport (ICL, 2017). Japan and Western Europe countries are the places where most of the first applications of city logistics were undertaken as these countries were more concerned with a lack of land availability and had an established tradition pertaining to urban planning (Rodrigue & Dablanc, 2017).

Although there is a growing experimentation in tackling urban freight issues, the related literature is limited and fragmented. The lack of data is the main challenge for research. For example in US urban areas, data is almost non-existent for truck and van movements; as a result the scale of the urban freight issue is unknown (Dablanc, Giuliano, Holliday, & Obrien, 2014). Recently, many research proposed some solution on urban logistics in the literature. (Taniguchi, Thompson, & Yamadaa, 2014) described new solution methodologies and modeling techniques for areas related to healthcare emissions, and mega-cities. (Bhusiria, Qureshia, & Taniguchi, 2014) applied the Just-In-Time concept on vehicle routing problem with soft time windows and simultaneous pickups and deliveries (VRPSTWSPD). (Navarro, Roca-riu, Furio, & Estrada, 2016)

proposed a smart city solutions for the cities of Barcelona and Valencia. (João & Romano, 2017), proposed a structural equations modeling framework to explore the urban freight delivery parking issues. (Sánchez-Díaz, 2017) developed a set of statistical models to study urban commercial establishments freight needs in the city of Gothenburg (Sweden). (Simoni & Claudel, 2017) proposed a fast numerical scheme as a solution to fixed and moving bottlenecks in the scope of road modeled by the Lighthill–Whitham–Richards (LWR) model. (Masson, et al., 2017) tackled a two–tiered transportation problem using a mathematical model.

2.1.2. Policies Regarding City Logistics

There are specific solutions for each city logistics problem however; some solutions can be suitable for more than one problem. Some solutions can be successful in a city and can be inefficient in another. Consequently, each policy needs to be analyzed with its advantages and drawbacks and design for the need of a specific city. Below are some of the policies applicable in city logistics:

Night deliveries, time windows, and vehicle weight restrictions: most of the local authorities plan and regulate urban freight transport with city regulations on the maximum allowed vehicle size, or weight, and delivery time-windows. Big retailer stores have to receive the product at night or early in morning because of the size of deliveries. Local authorities need to regulate deliveries to take place at non-traffic peak hours to eliminate small trucks from traffic as well.

Cooperative freight transport systems: cooperative freight transport systems (CFTS) are powerful in solving urban freight problems. CFTS is defined as a "systems whereby several entities cooperatively get involved in the usage and operation of their logistics activities as a whole or partially." The implication of the definition is that, CFTS could be a tool to reduce the number of freight vehicles in usage and bring more efficiency in their utilization, and decrease their travel time as well. Therefore, these systems have a huge potential in meeting many aims of urban logistics (Taniguchi & Thompson, 2015).

Low emission deliveries: hybrid, e-vehicles and bikes will not consume fuel; therefore they reduce NO_2, CO_2 or particles and noise. Their low range makes them

feasible to be used in city logistics. Low fuel cost, low maintenance, and repair cost are other reasons that make them attractive (Doğu & Albayrak, 2016).

Vehicle load factor controls: in the principle of vehicle's load factor, access to area, such as the city center is allowed only for fully (or at least to a certain extent) loaded vehicles. The idea is to reduce the number of freight vehicles entering and driving in downtown. Local authorities use vehicle load factor controls to improve urban areas living and accessibility conditions. The main objective is to improve vehicle utilization by stimulating consolidation outside the city center (Taniguchi & Thompson, 2015).

Low emission zone: air pollution is part of the problems caused by freight movement. Low emission zones are set by governments to improve air quality by forcing people to use green vehicles. Low emission zones are well defined areas; where polluting vehicles are prohibited from entering or charged with a fee. Low emission zones are also called environmental zones. Euro emission standards are used to measure vehicles' emission. There is a terminology "environmentally friendly vehicle" meaning clean vehicle over 3.5 tons in the category M2 and M3 with the emission standards between Euro 5 and 6 (Erdinch & Huang, 2014).

Organizing logistic centers and the integration of logistics system: logistic centers are collective of warehouses, customs, loading and off-loading areas, truck parks and gas stations. They are located out of city but they have connections to main high ways and railways. The logistics centers cumulate the city's load density together and decrease the city's load traffic (Doğu & Albayrak, 2016).some of the logistics center are:

- ✓ **Cross-docking centers:** of the four major functions of warehousing - receiving, storage, order picking, and shipping, the middle two are typically the most costly (storage because of inventory holding costs, and order picking because it is labor intensive). Crossdocking is a logistics technique that eliminates the storage and order picking functions of a warehouse while still allowing it to serve its receiving and shipping functions. The idea is to transfer shipments directly from inbound to outbound trailers without storage in between. Shipments typically spend less than 24 hours in a crossdock, sometimes less than an hour (Barthold & Gue, 2004).

- ✓ **Consolidation Center**: consolidation center are used to collect the shipments of a large numbers of LTL (Less than truck load) from nearby regional points of supply, where these are then consolidated and transported in TL (Truck Load) to a manufacturing or user facility distant from the consolidation center (Wisner, Tan, & Leong, 2012).
- ✓ **Freight villages:** they are considered specific locations where many logistics activities take place by bringing various operators together (Higgins & Ferguson, 2011).

2.2. Review of Freight Village Literature

The rise of intermodal logistics centers' is closely linked to the emergence of overseas container shipping in the late 70's and 80's of the last century (Wagener, 2017).Since then, it became the pillar of global trade and account nearly for 13% of seaborne trade in volume and 49% by value (Violeta, Woxenius, & Kenth, 2009). Due to the increasing containerized transport, seaports face today a scarcity of space (Violeta R. , 2009). The increase of port capacity can be done by expanding existing ones physically but this will require a significant cost and effort. Other options are the use of new technology and equipment (Violeta, Woxenius, & Kenth, 2009). However, the issues arising from the increase in container flows are better outline through the idea of inland port. As the inland terminal represents an extension of part of port activities inland, the term "dry port" has gained acceptance. The term is not a new one (Violeta, Woxenius, & Kenth, 2009). A United Nations text of 1982 provided one of the first definition of the dry port concept: 'an inland terminal to which shipping companies issue their own import bills of lading for import cargoes assuming full responsibility of costs and conditions and from which shipping companies issue their own bills of lading for export cargos' (Rodrigue & Notteboom, 2012). Nevertheless, the usage of this term in defining an inland terminal is opened to debate, as many inland terminals are in fact 'wet' due to their connection to inland waterway systems. Moreover, if a barge service is provided the inland location can effectively be a port, but fundamentally cannot be considered as a port if it involves a rail terminal or more simply truck depots. Thus, there seems to be no consensus on the terminology resulting in a variety of terms

including dry ports, inland terminals, inland ports, inland hubs, inland logistics centers, inland freight villages, etc. (Hofstra, University, 2017). This diversity shows the dynamic of the logistics sector but also the immaturity of the research field and the semantic segmentation between different countries and regions. For instance, the European Association Europlatforms uses the term Transport-logistics centers or logistics center. Freight village is used in the U.K., Güterverkehrszentrum (GVZ) in Germany, also translated as freight village. In France, the term Platform Multimodales/Logistiques prevail while in Italy the term Interporti and in Spain the term Ciudad Del Transporte are used (Wagener, 2017).

In the literature, many definitions have been made using different terminology in order to explain the concept of freight villages. The terminology of "freight village" generally represents specially organized sites where logistics activities are carried out (Ballis, 2006). According to (Dimitrios & Seraphim, 2003) , a freight village is seen today as an integrator of different transportation modes. It is essentially an intermodal terminal, which is the intermodal transport chain's principal component, and also the node where goods are transshipped from one mode to the other. Furthermore, (Adolf, Gujar, & Girish, 2009) highlight that a dry port is an inland location where the distribution of cargoes and consolidation are carried out, with functions similar to those of seaports, including information exchange the handling of cargoes, the provision of intermodal transport connectivity, and other services, such as customs inspections, storage, the maintenance and repair of empty containers, and tax payments. (Shahryar & Reza, 2008) defined a freight village as an area where all activities related to logistics and distribution, cargo transportation, domestic and international transportation are carried out by its different managers. In addition, (Ballis, 2006) points out that a freight village is a hub of a specific area where different stakeholders undertake all the activities related to transport, logistics and goods distribution both for national and international transit on a commercial basis. In addition, services like insurance, bank, and postal, and in some cases customs infrastructures may be provided. (Wiegmans, Masurel, & Nijkamp, 1999) highlighted that in an hinterland terminal, small continental cargo shipments are brought to the hinterland terminal and consolidated into bigger freight flows. These bigger freight flows are further transported by larger transport

means such as trains or barges. The corresponding bundling model is the trunk line with a collection and distribution network. According to Europlatforms (European Association of Freight Villages) ; a freight village is a well-defined area where all the activities relating to transport, logistics and goods distribution both for national and international transit are carried out by various operators (Europlatforms, 2017).

The different definitions and terminologies show clearly that there are different views and understanding of the concept of freight village in our study, we follow the definition of Europlatforms (European Association of Freight Villages) and the term freight village, and dry port will be used interchangeably. However, irrespective of the term used, an inland node has three fundamental characteristics:

- An **intermodal terminal**, either rail or barge that has been built or expanded.
- **Connectivity with a port terminal** via a barge, rail, or truck services, sometime via a corridor with high capacity.
- An array of **logistics activities** that support and organize the freight transited, often co-located with the intermodal terminal (Hofstra University , 2017).

The concept of freight villages did gain a huge attention recently due to its potential to alleviate city logistics problems. Academic research on freight villages has grown exponentially in many countries. (Yavas, Volkan, Sakar, & Denktas, 2017) investigated the existing situation of freight villages in terms of their operations, potential markets and provided an evaluation of a potential freight village in the Aliağa region./Turkey. (Nguyen & Notteboom, 2016) focused on developing countries by developing a conceptual framework including multiple criteria in evaluating a dry port location from multiple stakeholder perspective with an application on Vietnam. (Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015) evaluated freight villages potential locations in Turkey using a geographic information system (GIS)-based MCDM model. Moreover, (Okan & Özyörük, 2015) analyzed the impact of 12 freight villages planned to be built by the Turkish State Railways (TCDD). (Jeevan & Eon-seong, 2015) explored the Malaysian dry ports development by interviewing stakeholders of dry port. (Li, Dong, & Sun, 2015) proposed a new framework for dry port development based on a study undertaken on Chinese dry port development.

Nevertheless, even though the focus on freight villages is increasing, we have to bear in mind that two freight villages are not the same. Each freight village is facing different setting that may be geographical, local/regional economic, or regulatory. The relative uniqueness of each dry port setting has to be taking into account, then, practices can successfully be applied (Hofstra, University, 2017).

2.2.1. Typology of Freight Villages

When it comes to freight villages' typology, there is no standard typology in the literature. However, the most encountered typologies are locational, functional and directional development based. (Violeta, Woxenius, & Kenth, 2009) used a locational development based to classified dry ports. They can be classified as distant, midrange and close dry ports. The distant dry port is the most conventional of them and in term of history, it has the longest one. The main reason to implement it is because that, the distance and the size of the flow make rail viable from a strict cost perspective. The figure below gives a description of a distant dry port.

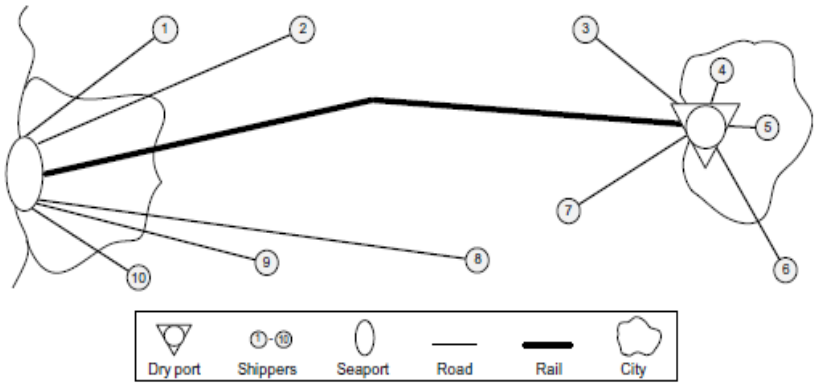


Figure 2.1. A Seaport with a Distant Dry port (Violeta, Woxenius, & Kenth, 2009)

A midrange dry port plays the role of consolidation point and lies within a distance from the port generally covered by road transport as shown in figure below.

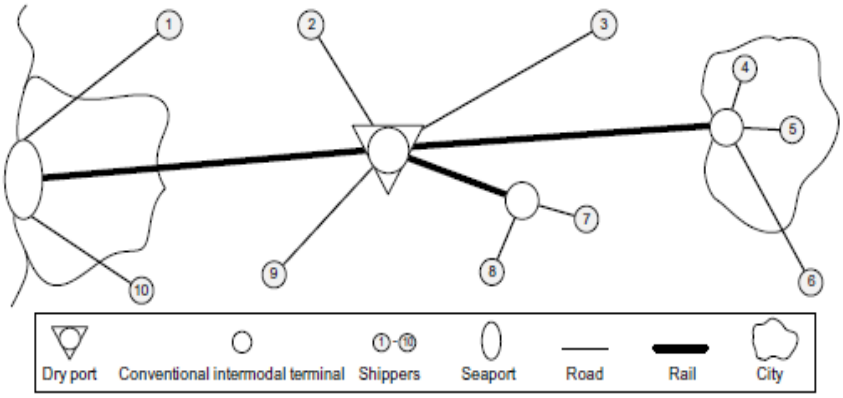


Figure 2.2. A Seaport with a Midrange Dry port (Violeta, Woxenius, & Kenth, 2009)

In addition, most ports are facing a lack of capacity and space issues. One of the solutions is the introduction of a close dry port at the rim of the seaport city. The close dry port allows the consolidation outside the city area of road transport to and from shippers then, offering a rail shuttle service to the port relieving the city streets and the port gates as shown below.

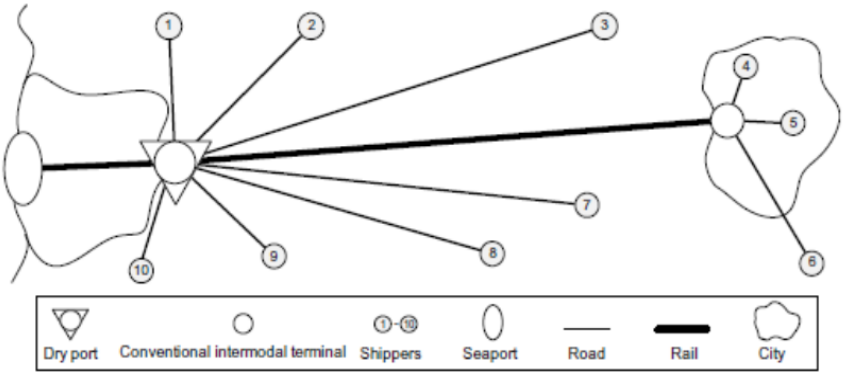


Figure 2.3. A Seaport with a Close Dry Port (Violeta, Woxenius, & Kenth, 2009)

Though similar to the typology of (Violeta, Woxenius, & Kenth, 2009) , (Rodrigue & Notteboom, 2012) developed a typology on a functional based. They

classified dry ports as satellite terminals, load centers, and transshipment facilities. (Rodrigue & Notteboom, 2012) defined they typology as following:

Satellite terminals: they lie at the vicinity of a port facility, but principally at the peripheral area of the metropolis (often less than 100 km), since they mainly provide a service function to the seaport facilities. They accommodate excessive traffic and carry out functions that became too expensive at the port such as warehousing and empty container.

Load centers: they are major intermodal facilities providing access to specific regional markets that include production and consumption functions. It commonly refers to a metropolitan area where different type of terminals concomitantly serves the functions of intermodal, warehousing, distribution, and logistics.

Transshipment facilities: they connect large systems of freight movement either through the same mode (e.g. rail-to-rail) or through intermodalism (rail-to-truck, or even rail-to-barge). In the latter case, the inland terminal functions as a load center. The figure below clearly summarized the typology of (Rodrigue & Notteboom, 2012).

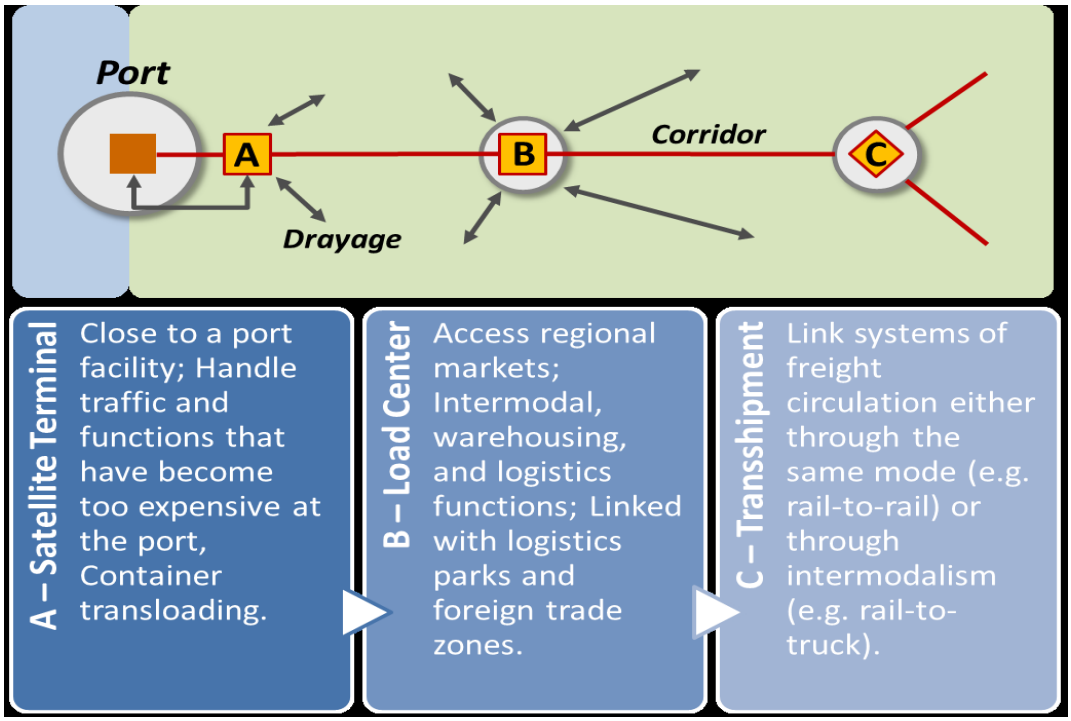


Figure 2.4. Functions of Inland Terminal (Rodrigue & Notteboom, 2012)

(Wilmsmeier, Monios, & Lambert, 2011) unlike classified dry ports based on the directional development. They defined two types of development: Inside-Out and Outside-In. Inside-Out is a situation where the inland facility's development may come from an inland carriage company (e.g. railroad, barge, logistics service provider) or a public entity while an Outside-In arrangement may emanate from port authorities, port terminal operators or ocean carriers.

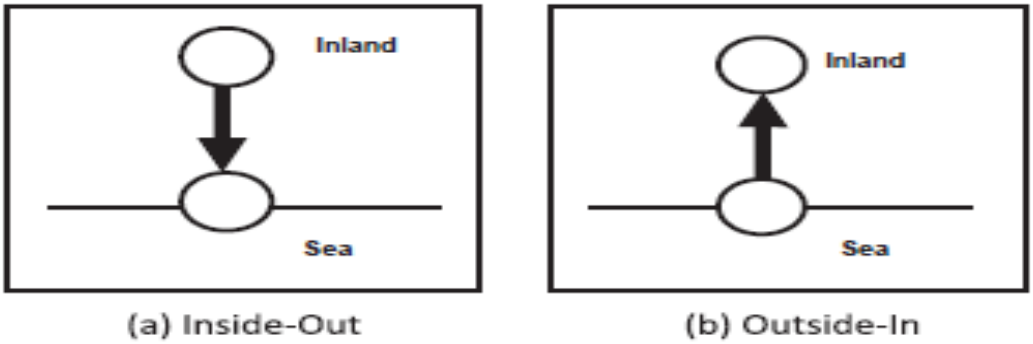


Figure 2.5. Two Directions of Development (Wilmsmeier, Monios, & Lambert, 2011)

2.2.2. Freight Village Features

In essence, freight villages are called freight villages due to the variety of features existing on the site. These features can be categorized in two part that make up the 'freight' and 'village' roots of the term. The 'freight' side contains traditional infrastructure dedicated to freight and logistics, while the 'village' side represents a set of additional services together with the freight infrastructure for the purpose of facilitating and expediting freight and logistics processes in the site. (Higgins & Ferguson, 2011). According to (Tanyaş, 2015), the most important freight infrastructures that can be found in a freight village are:

- Open and closed warehouses,
- Cold storage warehouses,
- Hazardous materials warehouses
- Licensed warehouses,
- Distribution and consolidation centers,

- Transshipment facilities.

Beyond freight infrastructure, the village element of a freight village contains the necessary services to respond and meet its tenants' requirements. Parts of the basic logistics services commonly present in a freight village are:

- Loading / unloading primary modes
- Storage
- Transferring to secondary modes
- Hazardous materials services
- Cross-docking / merging in transit
- Freight forwarding
- Distribution / final delivery
- Freight consolidation / deconsolidation
- Security environments
- Cold storage areas
- Warehousing
- 24-hour accessibility (Higgins & Ferguson, 2011)

However, what distinguishes a freight village from traditional intermodal terminals and other logistics hubs is the presence onsite of additionally services to support freight and logistics activities. These include:

- Customs offices
- Banks
- Post Office
- Insurance offices
- Office space for rent
- Land for further development

While this infrastructure is linked primarily to freight and logistics, other services in the literature tend to fit into the larger 'community integrated' model of a freight village. These may include:

- Residential development

- Restaurant
- Hospital
- School
- Conference center
- Supermarket
- Daycare
- Hotel
- Other commercial development

In addition to the precedents, customs districts or Free Trade Zones (FTZs) are now integrated in many logistics centers to increase international trade's efficiency as well as the tenants' competitive advantage. FTZs help in eliminating or reducing costs or obstacles in international trade by enabling a logistics center to act as an international major port terminal, at least from a customs perspective (Higgins & Ferguson, 2011).

2.2.3. Importance of Freight Village

Freight villages are important since they are significant centers for realizing efficient logistics, transport, and distribution services. Two general objectives ensure the effectiveness of freight village operations: consolidating maritime goods in short and long distance intermodal transport flows and the collection and distribution of local, regional and international transports. To reach these objectives, it is imperative for the terminal to undertake the following functions: hinterland warehousing; management of container flows to different ports based on consolidation of individual container flows; offering special- and extra services; reducing transport costs; increasing the firms of ship owners and the port influence to ensure the intensification of the transport chains effectiveness (Yavas, Volkan, Sakar, & Denktas, 2017). From a city logistics perspective, (Smith, 2013) highlighted that freight village operations benefits reside in generating economic activity, reducing congestion, improving the quality of air, and easing the growing highway maintenance costs. Even though more hard to quantify, public benefits also exist with the shifts of freight transport from highways to other

modes. These include benefits associated to congestion, greenhouse gas emissions, safety and highway maintenance and infrastructure spending. It is well understood that shifting freight to other modes can reduce the publicly borne costs of freight transportation. According to (Adolf, Gujar, & Girish, 2009), in some situations, the presence of a dry port even acts as a prerequisite for the exportation of certain products, especially for the logistics sector often disorganized and inefficient in developing economies, but also very fragmented, thus leading to high logistics costs. In this circumstance, a dry port can play capital role, which may have different positive impacts on exportation potentials, including: (i) the preservation (and even improvement) of a product's quality, thus sustaining its value; and (ii) the reduction of transport costs (through consolidation) and damage to cargoes. Moreover, (Ramunas & Darius, 2004) point out that freight villages provide benefits for stakeholders as sum up below.

Table 2.1 Freight Villages Benefits for Stakeholders (Ramunas & Darius, 2004)

Stakeholders	**Expected Benefits**
Shipping Companies	New product development and new markets penetration (earnings & employment)
Existing Shippers	Decrease in transport costs, more alternatives for transport /, greater reliability and safety
Potential Shippers	Better market accessibility, emergence of new markets, more transport opportunities, decreased logistics costs.
Railways	Market and segments potential growth where competition with road transport can be succeeded
Road Haulage Companies	Enhanced economies, larger flexibility for drivers operations (within constraints of prevailing driving and resting regulations).
Forwarding Industry	Larger range of opportunities in transport, lower costs (earnings & employment).
Intermodal Transport Operators	Enhance economics, larger transport alternatives, lower costs (earnings & employment).
Authorities, Policy Makers (the society at large)	Extra business opportunities / alternatives, enabling limitation / control of congestion in traffic and dangers, emission of hazardous materials and energy use. Increased competition, resulting in cost effectiveness, (and accelerated introduction of market principles).

2.2.3.1. Importance of Freight Village on Trade and Equipment Balance

Trade and equipment balance concept has enormous implications in logistics efficiency. Equipment balance is a situation whereby the same amount of cargo or equipment is going in both direction of a trade lane (see figure2.6).

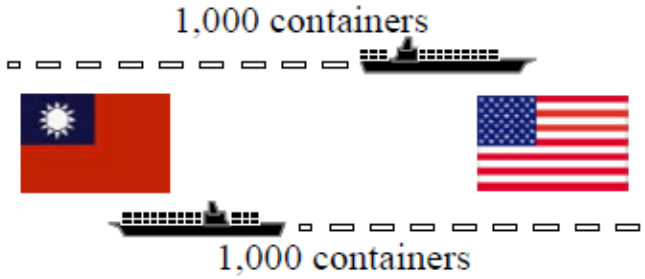


Figure 2.6. Equipment Balance (Long, 2003).

Balanced trade brings more efficiency in the use of transportation assets. When more cargo is going in one direction than the reverse, either cargo is left behind (excess demand), or the vehicle is moving at less than capacity. In both case, this inefficiency result in losing money. The consequence of imbalanced movement can be outlined with intermodal containers. In containerized cargo, an imbalanced trade demonstrates a surplus of containers on one side, and a deficit on the other side. Meeting the demand on the deficit side requires the empty containers need to be moved from the surplus side, known as empty repositioning. This can be very expensive (Long, 2003).

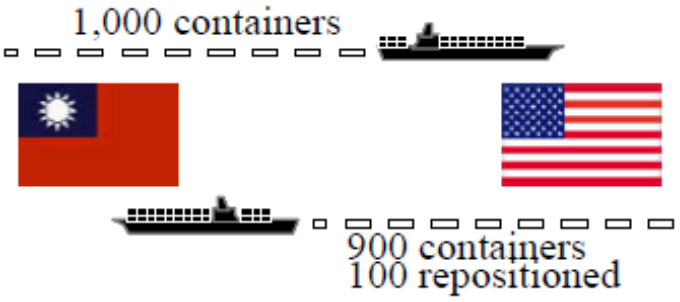


Figure 2.7. Imbalanced Trade in Containerized Cargo (Long, 2003).

Nevertheless, freight village as an inland port can mitigate imbalanced trade in containerized cargo. As most trade, flows are imbalanced, gateways and inland ports are experiencing challenges related to the repositioning of empty containers as well as their availability at inland locations. Since one of the objectives of inland ports is to promote their regional economies, a proactive strategy concerns the functional pairing of an inland port with other ones so that additional cargo flows, both inbound and outbound, can be generated. Under such circumstances, a better reciprocity in trade flows is expected to be achieved. Functional pairing concerns:

- ✓ The identification of main trade partners for the importers and exporters using the inland port. This enables the assessment of the concerned supply chains and their volumes.
- ✓ The evaluation of the commercial potential of pairing with new inland ports and in which way this can results in additional volumes.
- ✓ Joint marketing strategies as paired inland ports seek to reinforce their respective traffic by finding customers that could set new functional relations and establish activities such as distribution centers at both locations.
- ✓ Pending sufficient volumes, container pools can be established to support specific trade relations as an inbound container becomes an outbound container after cargo rotation. This would help improve the availability of containers at inland locations.
- ✓ The inland port acting as a clearinghouse for transactions remains a potential strategy, particularly for commodities. This implies that an exporter establish a facility at the paired inland port and sells to customers at a spot rate as transport costs and delivery to the inland port is now assumed by the exporter (Hofstra University , 2017).

2.3. Landlockedness and Challenges Faced by Burkina Faso as a Landlocked Country

Landlocked may be defined as a situation where geographically a country has no direct access to the sea (Fanou & Wang, 2018). Landlocked definition from an economic point of view is much more complex than the geographic one. Economically,

countries are landlocked when their economic development is constrained by many factors like remoteness from major markets, poor infrastructure, and difficulties in border crossing, which imply high transportation costs (Raballand, 2003). Forty-nine or about one-fifth of the countries worldwide is landlocked. By area, the largest landlocked country is Kazakhstan. The smallest by area is Vatican City. By population, the largest landlocked country is Ethiopia, which has a population of over 101 million people. Vatican City is the smallest by population, with a total population of less than 1,000 people (World Population Review, 2019).

Africa is made up of 15 landlocked countries: Botswana, Burkina Faso, Burundi, Chad, Central African Republic, Ethiopia, Lesotho, Malawi, Mali, the Niger, Rwanda, Swaziland, Uganda, Zambia, and Zimbabwe (Bidisha & Feroz, 2012). Due to the absence of direct access to the sea, landlocked African countries (LLACs) are marginalized when it comes to transportation and services (e.g. logistics, information technology) networks (Fanou & Wang, 2018).

Burkina Faso like most of landlocked nations faces challenges with access to sea transport. Shippers in Burkina Faso travel long distances to access seaports in neighboring countries. Consequently, long distances result in higher transport costs and higher transport costs in turn negatively impact trade. Table 2.2 highlights the transport corridors and distances from gateway ports for Burkina Faso. Ouagadougou its capital city is taken as a point of reference.

Table 2.2 Transport Corridors and Distances from Gateway Ports (Cbc, 2018)

Corridor	**Distance in km**	**Portion of the corridor in Burkina-Faso in km**	**Ports**	**Port country**
Tema-Ouagadougou	1040	170	Tema	Ghana
Lomé-Ouagadougou	948	281	Lome	Togo
Abidjan-Ouagadougou	1148	510	Abidjan	Ivory Coast
Cotonou-Ouagadougou	1060	370	Cotonou	Benin

Table 2.2 outlines the long distances travelled by Burkinabe to reach seaports. This challenge of distance has huge implications on the socio-economic development of Burkina Faso. In the literature, many authors have explained the reasons why the

distance challenge is a burden for the development of landlocked countries. According to the World Bank, landlocked developing countries (LLDCs) have difficulties in exporting. As a result, they are trading less and growing more slowly compared to their coastal neighbors (World Bank , 2017).When it comes to transport costs, LLDCs pay about 50 percent more than coastal countries, and about 60 percent lower volumes of trade. Inefficiencies on customs and transit transport procedures are the major cause of delays and high transport costs and represent a greater barrier to trade for LLDCs than tariffs. As a result of the precedent, LLDCs are dealing with serious constraints on their overall socio-economic development, including their trade competitiveness (Un-ohrlls, 2017).

According to (Faye, McArthur, Sachs, & Snow, 2004), in overall development and external trade, landlocked countries often lag behind their coastal neighbors. They also argue that, while many of landlocked countries underperformance may arise from distance from coast, some aspects of dependency on transit neighbors are also important. Four kind of dependence are highlighted: dependence on sound cross-border political relations; dependence over neighbors' infrastructure; dependence on peace and stability of neighbors; and dependence on administrative practices of neighbors. These factors put together generate different array of priorities and challenges for each landlocked country. (Gallup, Sachs, & Mellinger, 1999) highlighted three reasons to explain landlocked countries disadvantage : cross-border migration of labor is more difficult than internal migration, development of infrastructure across national borders present more difficulties than similar investments within a country, and coastal countries may have economic or military incentives to impose costs on landlocked countries. Furthermore, (Kacana, 2017) noted that the higher living cost in LLDCs is due to the high costs of trade reflected in the prices of food. Additionally, another major issue for landlocked countries is delays at borders. Delays impact especially the trade of perishable or time-sensitive goods like agricultural products. In the same manner, (Arvis, Mustra, Orjala, Shepherd, & Saslavsky, 2012) explained that as a result of increasing lead times, uncertainty in supply chain is predominantly a problematic issue for shippers in LLDCs. As lead times increased, high inventory costs resulting from the costs of stockholding and in-transit inventory bring up the cost of the final products in

the market. Delays in transit occur as a result of long delays at border posts, road tolls and weigh bridges.

In the light of what landlocked countries faced as challenges, it is clear that they are experiencing a very complex logistics. However, complex logistics have negative impacts on the performance of logistics. The logistics performance index (LPI) of the World Bank is a tool for interactive benchmarking created to guide countries in identifying the opportunities and challenges they face in their performance on trade logistics and what they can do to enhance their performance. In order to show how Burkina Faso is performing in logistics, the table 2.3 analyses the trend of Burkina Faso's LPI.

Table 2.3 Burkina Faso's Logistics Performance Index: 2012-2018 (World Bank, 2019)

Country	**2012 LPI**		**2014 LPI**		**2016 LPI**		**2018 LPI**	
Burkina Faso	Rank	Score	Rank	Score	Rank	Score	Rank	Score
	134	2.32	98	2.64	81	2.73	91	2.68

Table 2.3 reveals that Burkina Faso's logistics performance has been improving from 2012 to 2016. However, in 2018, a decline in performance occurred. The best rank and score for Burkina Faso over the past 5 years occurred in 2016 with a rank of 81 and a score of 2.73. Despite the fact that Burkina Faso's logistics performance has been improving over time; the country remains a lower performer when compared with 160 countries. Consequently, Burkina Faso still has to overcome many challenges in order to reach high performance logistics.

2.4. Review on the Concept of Transportation Corridors

The word corridor first appeared in 1814 and was originally used for fortifications meaning 'long hallway'. The etymology of the word corridor goes back to the Italian word corridore, a 'gallery', and the Latin word currere (current, 'to run'). It is used to denote 'a belt of land linking two other areas or following a road or river' or 'long hall-way' (Pynnöniemi, 2005). More recently, a corridor is a geographical

concept. This concept comes mainly from studies in spatial analysis and topology. The term is used to identify transport routes, describe processes for opening up hinterlands and to express a network of interdependent urban intersections displaying important movements, links, and exchanges between them. The term is also used to describe roads at different geographical scales (Comtois, 2019).

Transport corridors are understood as one or more than one route that connects the centers where economic activities take place (Hilal, 2015). There are many definitions of transport corridors in the literature. (Rodrigue, Slack, & Blank, 2019) point out that transport corridors represent the pillars for transportation networks, connecting main centers (e.g. gateways and hubs) and facing the flows of both freight and passenger. Most often, they perform both market- and market-serving functions. Furthermore, international transport corridors, in other words transport networks, link one or more than one neighboring countries together; through one or more transit countries, landlocked countries benefit from coast connection. Transport corridors are primarily intended for achieve regional development by providing logistics services and transportation the cities and countries on the route (Hilal, 2015).

Thus, the corridor as a notion is neither temporally nor spatially immutable, but rather dynamic, contingent on the key factors as economic context, investments in technological changes, infrastructures and policies (Rodrigue, Slack, & Blank, 2019). Moreover, transport corridors include both physical infrastructure and institutional frameworks built on agreements between governments. These agreements define policies to lessen transit and border (Peterson, 2019). Corridors come in two principal types:

- **Formal corridors**. They are built trying to expand the planning and investment framework of public and private actors along them. On several occasions a kind of governance, is put in place to address some of its challenges.
- **Functional corridors**. They represent an existing structure of flows along some infrastructure. The corridor is thus an operational reality.

The corridors that present both formal and functional characteristics are the most structured ones. Transport corridors can also display physical variations on a modal

basis, as infrastructure layout becomes a determining factor (Rodrigue, Slack, & Blank, 2019).

2.4.1. Transport Corridor and Landlocked Countries

A critical issue for landlocked countries is either to privilege a single major corridor attached to a hub port or to encourage several alternative transit corridors to reach different seaports. UNCTAD has recommended several transit corridors not only to reduce vulnerability to disruption in the transit countries due to natural or human disasters but also to get some level of bargaining power by introducing competition between transit neighbors to improve their overall access to the sea. However, notwithstanding that such diversification of competitive access to several sea ports might reduce the landlocked country vulnerability and thus reduce trade uncertainties, it is not sure that this strategy could always be a winning one. Generally, in term of traffic, landlocked countries volumes are insufficient to sustain additional infrastructure required for two or several corridors. As a result, developing several transit corridors through different transit countries and encouraging active competition between them may not be a practical or a sustainable solution. It may, on the contrary, result in diseconomies of scale in infrastructure and logistic services (African Union , 2017). Consequently, landlocked countries need to assess thoroughly their corridors performances and opt for multiple transit corridors or one major transit corridor.

2.4.2. Importance of Transport Corridor on Sub-Saharan African Landlocked Countries

A landlocked country can mitigate its access problem to global market by developing transport corridors towards maritime gateways. While possible in some cases, fluvial navigation systems servicing landlocked countries exist mostly in Europe (e.g. Switzerland and Austria can be serviced by barges). The most effective freight services are established by rail corridors. No particular connectivity obstacles exist for landlocked countries to access air transportation (e.g. Zurich is a major air transport hub

in Europe), but due to their lower levels of development, landlocked countries tend to be less connected (Rodrigue, Slack, & Blank, 2019). In the case of Sub-Saharan Africa (SSA), goods shipment to landlocked countries is still a main impediment, especially because to the extent of local barriers. Poor domestic infrastructures, remote areas that is difficult to reach by road. According to (Peterson, 2019), the transport of goods take place every year along routes of more than 10,000 km , chiefly roadways that represent the main geographic corridors in SSA. These shipments concern goods traded between foreign countries and SSA, making transport corridors a capital conduit for the region's international trade. Therefore, upgrading the standard of transport infrastructure on corridors is in term of efficiency a good policy-measure for economic development enhancement. In SSA, several transport corridors are developed under Public-Private Partnerships (PPPs) between local governments and private entities; the focus of these PPPs is the enhancement of roads and railways physical infrastructure, improving customs efficiency at border crossings and decreasing transport costs for promoting trade and development in the region.

SSA's principal corridors are split up among its four geographic regions (central, south, east, and west). Each corridor is made up of many smaller transport routes that link inland destinations to seaports. Although these corridors principally remain disconnected to one another, the African Development Bank, the African Union, and the UN Economic Commission for Africa (UNECA) are working together to frame the development of a trans-African highway network. The network would link each main corridors of SSA by filling the infrastructural gaps within the region's transport network. Planners estimate that about 7,000 km of additional roadways and 10,000 km of railways will be needed to achieve the highway network, at a total cost of roughly $32 billion (Peterson, 2019).

2.4.3. Overview of Burkina Faso's International Transportation Corridors

Burkina Faso's landlocked state, coupled with its geographical position in West Africa, makes it a hub of regional corridors. Its landlockedness imposes a markup on the costs of imports and exports, but also Burkina Faso's distances from gateway ports

are longer than average (about 1,000 kilometers to a gateway ports). As a result, the costs of transport are very sensitive to any inefficiency in customs administration, cross-border waiting times and in the transit chain. The geographic location of the country however, positions him as a natural transit hub for West Africa. Burkina is a transit point for the landlocked countries of Niger and Mali and has the potential to take advantage of its geographical position (Briceño-Garmendia & Domínguez-Torres, 2011). The figure 2.3 gives an overview of locations of gateway ports and Landlocked Countries (LLCs) in West Africa.

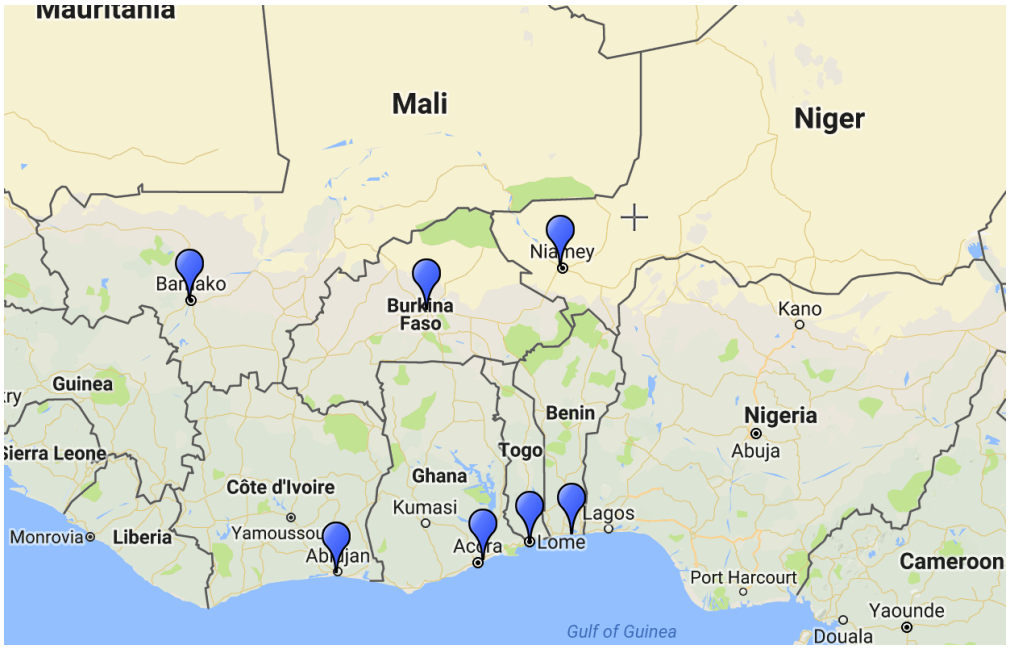


Figure 2.8 Specific Locations of Gateway Ports and LLCs in West Africa (VanDyck & Domfeh, 2017)

As it can be seen on Figure 2.8, the location of Burkina-Faso is strategically a transit point for inter-country commerce in West Africa**.** Transportation corridors in Burkina Faso support the development of four major traffic flows that are:

- Burkina Faso's domestic trade
- Burkina Faso's trade with the overseas territories
- Burkina Faso's trade with neighboring countries (Ivory Coast, Ghana, Togo, Benin, Mali, Niger et Nigeria)

- Transit traffic and regional neighborhood traffic between neighboring countries (Togo, Niger, Mali, Benin, Ghana, Ivory Coast) (Yankene, 2013).

Burkina Faso made tremendous efforts to overcome its landlockedness and take advantage of its central position. Throughout four corridors (corridors of Abidjan, Lome, Tema, and Cotonou) that compete with each other, it has developed connectivity and provides alternatives for Burkina's accessibility to international ports (Briceño-Garmendia & Domínguez-Torres, 2011). Burkina Faso's capital city Ouagadougou is located at the intersection point of the corridors. Taking Ouagadougou as a reference point (each corridor having a different starting node (a seaport) but one ending node (Ouagadougou)), the corridors are as following:

- Tema-Ouagadougou corridor: the starting node of the corridor is the Tema port in Ghana and the ending node is the city of Ouagadougou in Burkina Faso.
- Lome-Ouagadougou corridor: the starting node of the corridor is the port of Lome in Togo and the ending node is the city of Ouagadougou in Burkina Faso.
- Abidjan-Ouagadougou corridor: the starting node of the corridor is the Abidjan port in Ivory Coast and the ending node is the city of Ouagadougou in Burkina Faso.
- Cotonou-Ouagadougou corridor: the starting node of the corridor is the port of Cotonou in Benin and the ending node is the city of Ouagadougou in Burkina Faso.

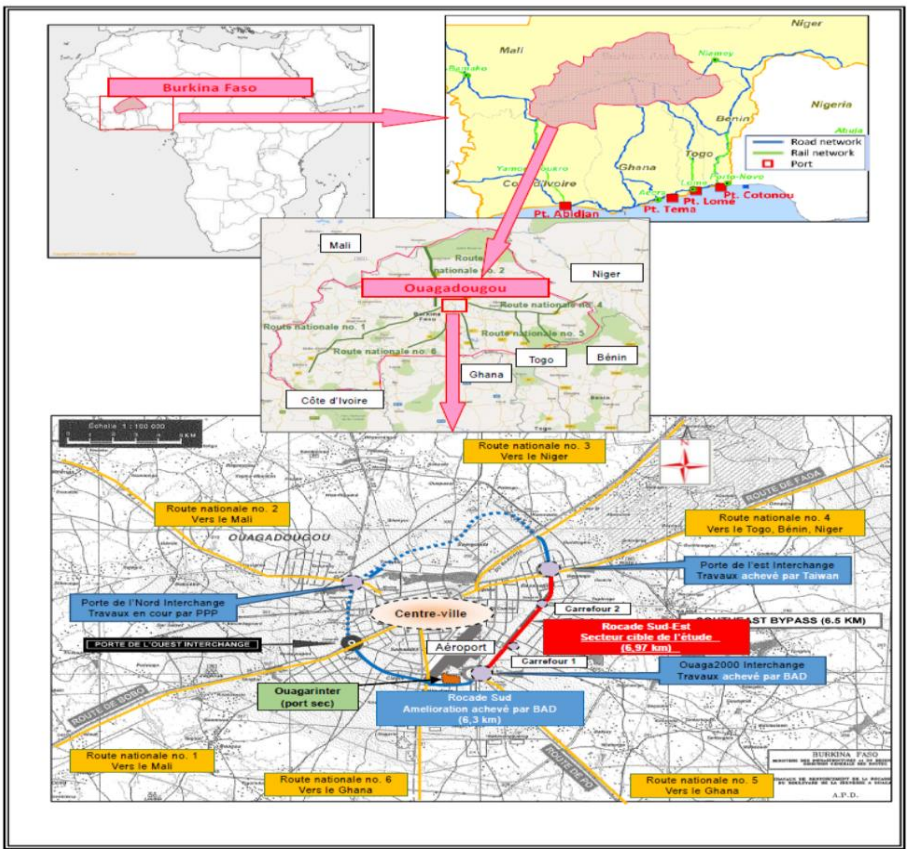


Figure 2.9. International Corridors Linking the City of Ouagadougou to Gateway Ports (JICA, 2017).

2.4.3.1. Tema (Ghana) Corridor

Ghana's corridor serves the three LLCs (Mali, Niger, and Burkina Faso) by road only as the country lacks rail connection to her northern borders (Luguje, 2004). It is covering a distance of 1,040 km from Tema to Ouagadougou. After the conflict in Ivory Coast, Ghana has become one of the main routes for cargo in transit. One of the reasons for this change was the increased efficiency and improved facilities of Ghanaian ports, which allowed it to compete better at the regional level (Cbc, 2018).

2.4.3.2. Lome (Togo) Corridor

Togo's corridor serves the LLCs (Mali, Niger, and Burkina Faso) by road only. Lome to Ouagadougou in Burkina Faso covers a distance of 990 km, while Lome to Niamey has to pass through Burkina Faso territory covering a distance of 1,234 km (Luguje, 2004). The Lome corridor is therefore the shortest to Ouagadougou in Burkina Faso. Moreover, in West Africa the Lome port is the only port through which one can reach several capitals in one day. The Port of Lome offers the advantage of transporting goods at very competitive time (Cbc, 2018).

2.4.3.3. Abidjan (Ivory Coast) Corridor

The Ivorian corridor has two modes of transport serving Burkina Faso. The rail/road corridors. Each mode passes through the industrial region and city of this LLC, Bobo Dioulasso (Luguje, 2004).The railway line includes a 622 km portion on the Burkinabe territory, interconnected to the Ivorian railway network of the same characteristics. This constitutes an international line of 1,260 km connecting Abidjan to Bobo-Dioulasso, Ouagadougou, and Kaya (Cbc, 2018). The road corridor makes up a distance of 793 km from Abidjan to Bobo and 1,148 km from Abidjan to Ouagadougou. Abidjan is the nearest port for the Bobo region of Burkina Faso. The Abidjan corridor serves Mali and Niger by road only. Generally, the road and rail networks linking the Ivory Coast-Burkina Faso corridor are in very good condition (Luguje, 2004).

2.4.3.4. Cotonou (Benin) Corridor

This corridor serves Niger by two modes; road and rail. The rail corridor ends at Parakou in central Benin midway to the border with Niger, where cargo is then transferred by road to Niamey in Niger. This combined rail/road corridor to Niger covers a distance of 1,056 km. The all road corridor covers an equal distance from Cotonou to Niamey. The Benin corridor is also the nearest to Niamey. The road/rail corridor network linking Benin to Niamey is good except for the inefficiency of the rail

system due to old stock of rail coaches. On the other hand, Burkina Faso and Mali are linked to Cotonou Port by road only (Luguje, 2004).

CHAPTER 3 METHODOLOGY AND DATA PRESENTATION

3.1. Selection of a Freight Village Location and its Transportation Network Process

In this thesis' study, the Analytical Hierarchy Process (AHP) technique was used the select simultaneously a freight village location and its transportation network for the city of Ouagadougou. This section is meant to describe the process of finding the inputs' values used in the application of AHP method. In order to reach that aim we will first attempt to determine the criteria to take into account in the selection process and then, the process of determining the criteria data will be explained. The all process is presented in the Figure below.

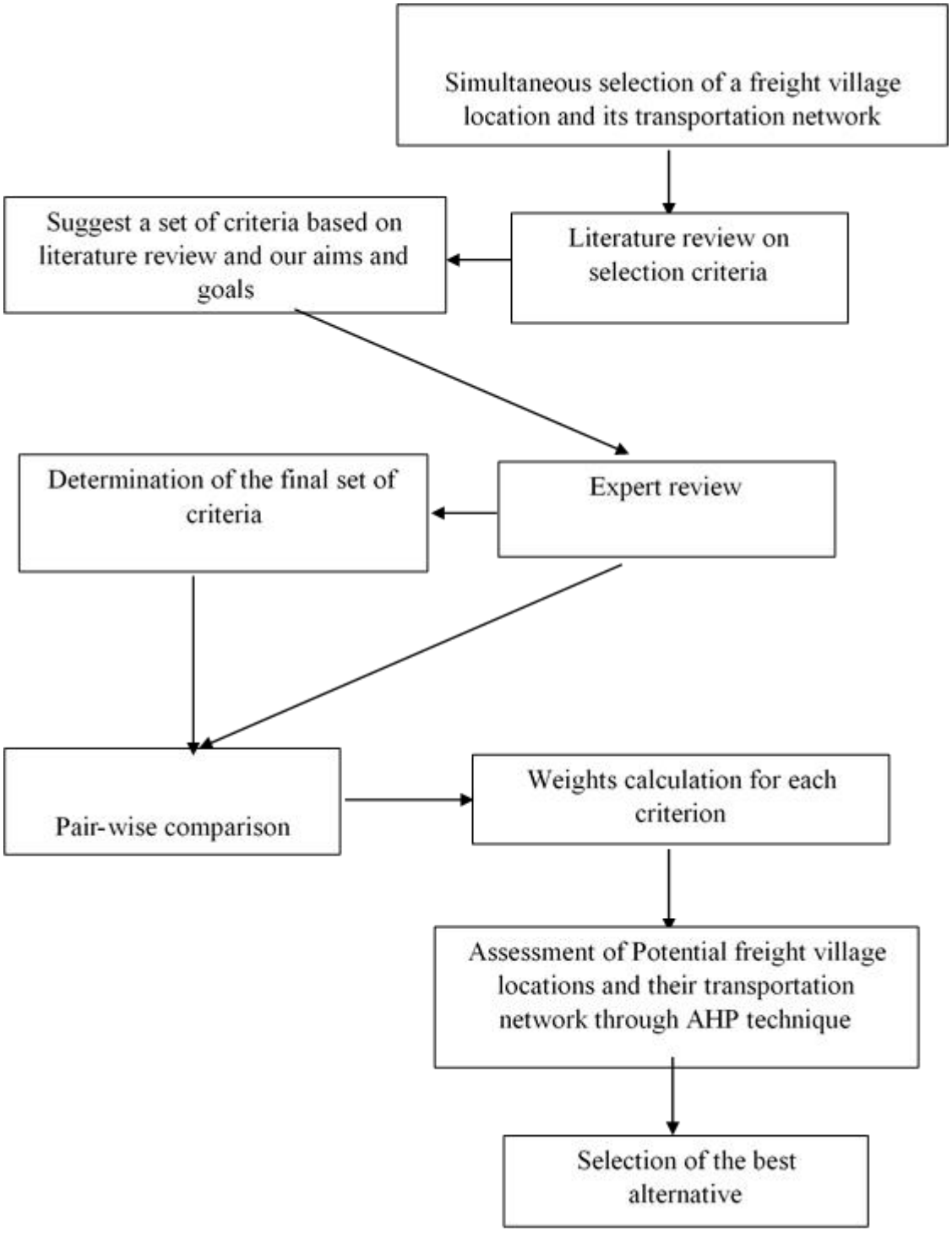


Figure 3.1 Simultaneous Selection of a Freight Village Location and its Transportation Network Flow Chart

3.1.1. Selection Criteria Determination Process

The criteria determination process is threefold. Firstly, a review of literature allowed the collection of the most used criteria for the selection of both logistics center location and transport corridor/network (see annex 6 and 7). Taking the criteria collected from the literature and the aims and goals of our research into account, fifteen (15) main criteria have been proposed and adapted to our context (see annex 8). Then, the proposed criteria have been introduced to experts review and eight (8) criteria have been retained for our study. Overall, the experts involved in the study included two town planners, one environmentalist, two economist of transport, three academicians expert in logistics and supply chain (two professors, one assistant professor) and two PhD candidates in logistics an supply chain. However, in the process of identifying the criteria, two assumptions were made on the transportation network:

- ✓ The transportation networks are considered to be four existing transport corridors connected to a freight village potential location.
- ✓ All corridors have different starting nodes (a seaport) but one ending node, i.e. a freight village.

3.1.2 Selection Criteria

Taking the criteria collected from the literature, and taking the state of Burkina-Faso' landlocked condition, existing transport corridors, and considering our aim of simultaneously selecting a freight village location and its transportation network into account we have suggested eight (8) selection criteria and grouped them into four groups as following:

1. Joint criteria: they are the criteria that can be used to simultaneously evaluate both existing corridors and potential freight village location. The joint criteria is composed of two main criteria :
    - ✓ Time and cost (C1)
    - ✓ Average distance to Seaport/Airport and neighboring landlocked countries' capital cities (C2)

2. Criteria specific to potential freight village locations: those criteria can be used only to assess the potential freight village locations. This group is made up of two main criteria :
    - ✓ Opportunities for possible site expansion (C3).
    - ✓ Impacts on urban environment (C4).
3. Criteria specific to corridors: those criteria are intended to only assess the existing transport corridors. This group is made up of only one criterion :
    - ✓ Multimodal transportation (C5).
4. Criteria specific to port country: they are used to assess the existing port countries. This group is made up of three main criteria:
    - ✓ Economic development (GDP) (C6)
    - ✓ Common currency (C7)
    - ✓ Political stability (C8)

3.1.2.1 Joint Criteria

- **Time and cost (C1):** the time criterion considers the time taken to get a product out of the transit ports to the freight village location. Meanwhile, the cost criterion considers the investment cost i.e. the cost of establishing a freight village, road corridors rehabilitating cost and transit cost or the costs taken to get a product out of the transit ports to the freight village location.
- **Average distance to Seaport/Airport and neighboring landlocked countries 'capital cities (C2):** due to its landlockedness, Burkina Faso counts on its neighbors' seaports for importation and exportation. The proximity to seaport is therefore, an important criterion. The criterion refers to the distance from the seaport to the freight village location site. Likewise, the proximity to the airport is important both for the transportation of passengers and freight cargo and should be considered in the selection. The proximity to the airport considers the distance from the seaport to the freight village location and from there to the airport. As far as the distance to neighboring landlocked countries 'capital cities is concerned, Burkina Faso is a transit point for its neighboring landlocked countries of Niger and Mali; it makes sense to take into account the proximity to

those countries. Overall, this study will consider the distance from seaport to the freight village location and the average distance from the freight village to the airport and the neighboring landlocked countries' capital cities.

3.1.2.2 Criteria Specific to Potential Freight Village Locations

- **Opportunities for possible site expansion (C3):** sufficient lands may be found, however, they may not be able to respond to long-term expansion opportunities. Therefore, the expansion opportunity of the land is also an important place selection criterion.
- **Impacts on urban environment (C4):** it refers to the impact on environmental issues like air pollution, noise, congestion and any form of environmental impact.

3.1.2.3 Criteria Specific to Corridors

- **Multimodal transportation (C5):** for the sake of our study, the multimodal transportation criterion will refer to the presence of both road and rail mode of transportation along the corridor.

3.1.2.4 Criteria Specific to Port Country

- **Economic development (GDP) (C6):** the more the port country is economically developed the greater the trade exchange with the landlocked country .Consequently, it is important to consider that criterion in our evaluation process.
- **Common currency (C7):** common currency between a coastal and landlocked country will have the advantage of reducing exchange rate uncertainties, and reduces transaction costs.

- **Political stability (C8):** political stability is a key factor for a flourishing trade exchange between two nations; it then makes sense to consider that criterion in our evaluation process.

3.2 Data Collection on Selection Criteria

The data on selection criteria were collected from both secondary and primary data. The Table 3.1 gives the type and source of data for each selection criterion.

Table 3.1 Type and Source of Selection Criteria's Data

Criteria	Type of Data	Source
C1-Time and cost	Primary data	Survey
	Secondary data	Ministry of Commerce/Ministry of infrastructure
C2-Average distance to Seaport/Airport and neighboring landlocked countries 'capital cities	Secondary data	Ministry of Commerce
C3-Opportunities for possible site expansion	Primary data	Expert Opinion
C4-Impacts on urban environment	Primary data	Expert Opinion
C5-Multimodal transportation	Primary data	Expert Opinion
C6-Economic development (GDP)	Secondary data	World Bank
C7-Common currency	Primary data	Expert Opinion
C8-Political stability	Secondary data	World Bank: Worldwide Governance Indicators (WGI) - Political Stability and Absence of Violence

3.2.1 Data Determination on Time and Cost Criterion

The process of determining data on cost and time criterion is meant to determine the best transport corridor based on the overall cost and time involved on each transport corridor with regards to each potential freight village location site. Data on cost and time were obtained from both primary and secondary sources, then a joint cost and time

matrix has been used to evaluate each corridor. The figure below presents the selection process.

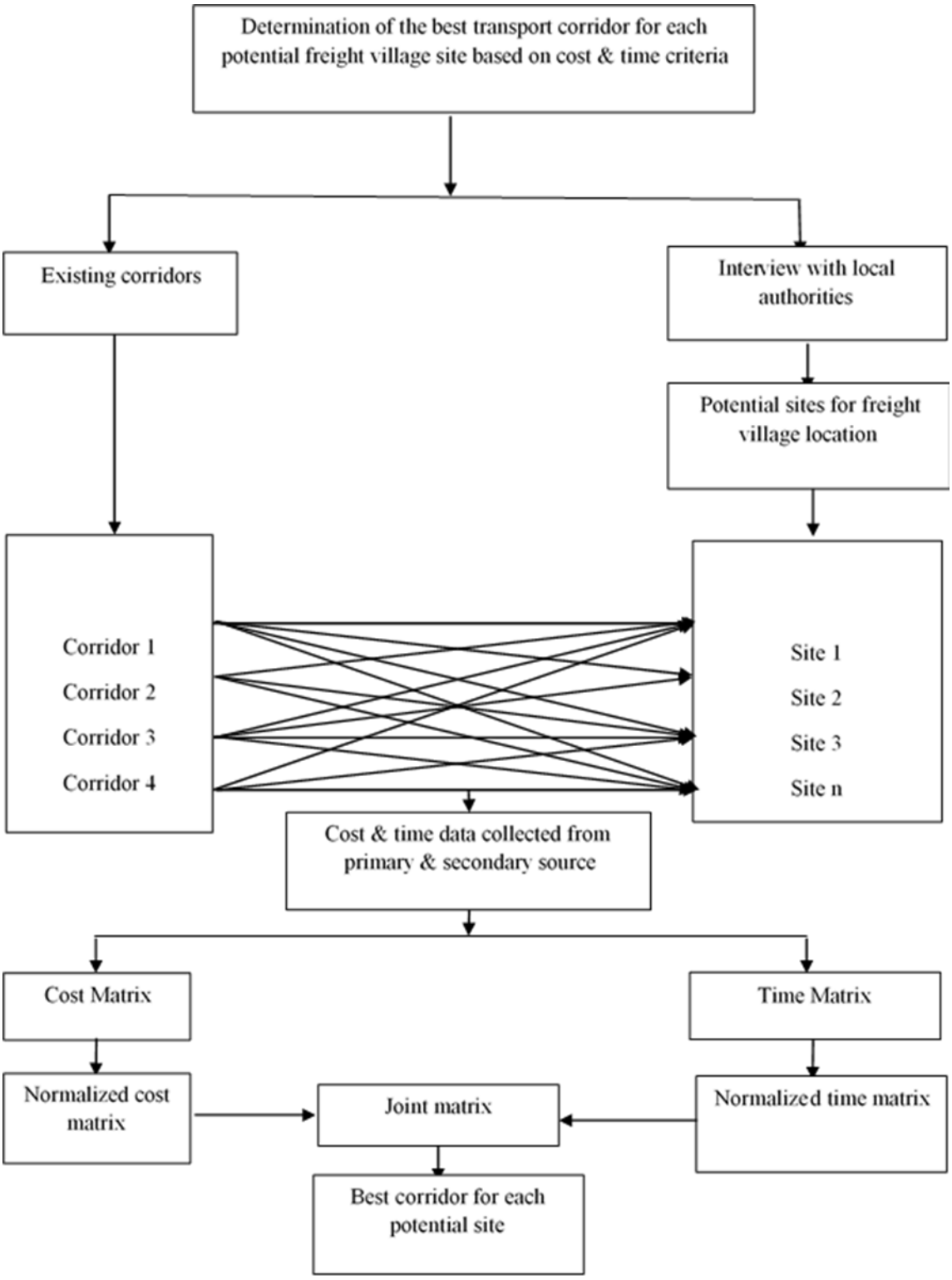


Figure 3.2 Flow Chart of Transport Corridor Selection Process

3.2.1.1 Process of Potential Sites Determination for a Freight Village Location

To determine the potential sites for a freight village in the city of Ouagadougou, semi-structured interviews have been used. Face-to-face interviews were carried out with local authorities. The interviewees involved were from the Ministry of Commerce and Industry, and the Directorate General of Urban Planning. An example of the questions administered to participants can be found in annex 3.

3.2.1.2 Process of Time and Cost Data Determination

For most LLDCs, it is difficult to balance their trade. Imports exceed exports in both aggregate value, and volume. As dutiable goods, imports go through a higher level of control and cost and time penalties in transit than exports. Nevertheless, in the perspective of enhancing the service delivery, putting import and export apart is irrelevant as in practice, the same service providers is used by both exports and imports. Therefore, improving the cost or quality of service increase competition, benefitting both directions of trade. The same is true for, the improvement of implementation capacities in customs and other agencies. Hence, most trade facilitation measures in ports or on trade corridors principally target facilitation of importing (Arvis, Carruthers, Smith, & Willoughby, 2011). Considering those facts, our cost and time analysis focuses on imports and especially on the main imported goods. The tables below present the value and tonnage of Burkina Faso's main imported goods over the past 5 years.

Table 3.2 Burkina Faso's Main Imported Products (Tons) (INSD, 2018)

Products	2013	2014	2015	2016	2017
Cement	1,058,607	953,931	1,175,333	1,382,525	1,682,505
Fertilizer	221,139	209,666	223,771	305,050	269,272
Wheat and wheat flour	134,792	140,480	185,427	198,731	221,829
Oil products	831,612	850,642	996,446	1,015,900	1,191,467
Pharmaceutical product	9,606	6,400	6,933	9,778	7,590
Motocycles	21,421	20,813	22,988	22,303	30,576
Parts of machinery	3,809	1,565	4,799	5,078	5,728
Rice	440,320	361,740	379,592	484,577	515,977
Tobacco and manufactured tobacco substitutes	3,570	3,334	3,515	3,317	3,617
Transport vehicles for people	30,146	27,818	30,266	30,449	37,534
TOTAL	2,755,022	2,576,390	3,029,069	3,457,706	3,966,095

Table 3.3 Burkina Faso's Main Imported Products (Euro) (INSD, 2018)

Products	2013	2014	2015	2016	2017
Cement	81,968,175	71,034,179	88,396,961	96,877,060	126,389,298
Fertilizer	103,268,224	77,797,410	89,983,037	119,713,847	91,798,114
Wheat and wheat flour	40,965,402	37,898,882	48,181,002	55,761,004	61,404,079
Oil products	669,417,046	653,048,954	618,136,916	528,858,476	646,169,375
Pharmaceutical product	133,278,483	117,207,947	122,388,599	150,817,486	136,369,481
Motorcycles	52,590,575	41,218,179	44,959,036	51,090,348	60,688,696
Parts of machinery	55,532,114	17,725,564	43,587,822	49,662,736	81,894,614
Rice	94,421,442	74,571,066	79,820,605	96,953,086	104,462,615
Tobacco and manufactured tobacco substitutes	43,714,778	45,414,485	49,065,696	47,698,693	55,309,780
Transport vehicles for people	66,413,222	66,160,611	60,080,182	57,225,985	84,293,148
TOTAL	1,341,569,462	1,202,077,277	1,244,599,856	1,254,658,721	1,448,779,200

In term of value, oil products remain the Burkinabe leading imported goods and in term of tonnage, cement remains the leading imported goods. However, for the sake of our study we suggested five goods from the main imported good. In order to ensure that the estimate time and cost made for different corridors are consistent, the study choses fast moving goods imported by sea or transiting through a port. The suggested goods are the following:

- Wheat and wheat flour
- Pharmaceutical product
- Parts of machinery
- Rice
- Tobacco and manufactured tobacco substitutes

Although oil products and cement are also fast moving goods, they were not included in our survey. Indeed the import of oil products in Burkina Faso is under the monopoly of the state, which through the National Company of Burkina Faso Hydrocarbons (SONABHY) ensures the supply of oil products. SONABHY therefore, has special agreements with neighboring coastal countries for the import of oil products. Cement also, has been excluded from our survey because cement imports are sub-regional imports and do not transit through ports. Moreover, one type of handling mode is also considered in importation cargo, i.e. containerized up to Ouagadougou. Table 3.4 present the selected products for the survey.

Table 3.4: Imported Products Selected for the Survey (Tons) (INSD, 2018)

Products	**2013**	**2014**	**2015**	**2016**	**2017**
Wheat and wheat flour	134,792	140,480	185,427	198,731	221,829
Pharmaceutical product	9,606	6,400	6,933	9,778	7,590
Parts of machinery	3,809	1,565	4,799	5,078	5,728
Rice	440,320	361,740	379,592	484,577	515,977
Tobacco and manufactured tobacco substitutes	3,570	3,334	3,515	3,317	3,617

3.2.1.2.1 Time Analysis

The transit transport flow connecting Burkina Faso and ports is graphically shown in the Figure 3.3. With the port assumed as a starting point, freight departing from the port passes through a boundary customs house of a coastal country, then goes through the transit procedure at the boundary customs house of the landlocked country, and finally arrives at the customs house of the final destination. The route is reversed for export (JICA, 2018).

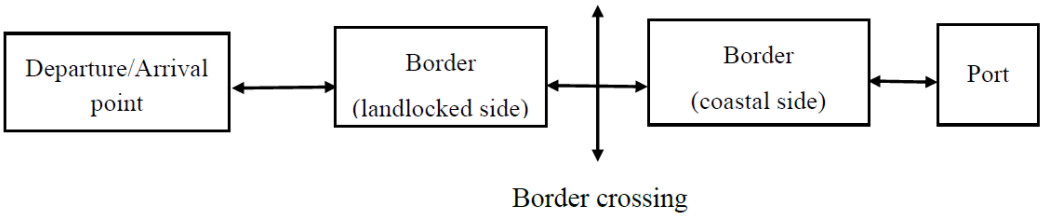


Figure 3.3: Transit transport flow (JICA, 2018).

Based on the transit transport flow described in figure 3.3, the time analysis approach takes into account port clearance time inland transportation time, border-crossing time, and clearance time at the final destination. The whole time components are represented in the Figure 3.4.

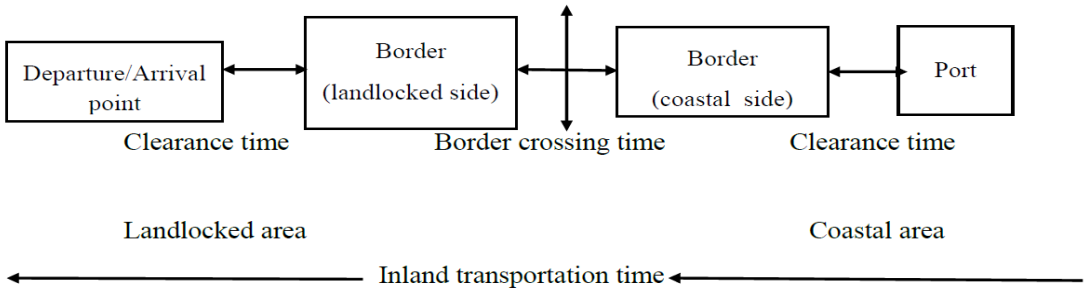


Figure 3.4: Time Components Flow Chart

3.2.1.2.1.1 Data Collection on Time

Using a survey, the study collected primary data on the time taken to get a product out of the transit ports to Burkina Faso's Capital city (Ouagadougou). Data were collected through 100 interviews. The stakeholders that took part to the interview included forwarders/customs brokers, and private companies (companies involved in trading of goods listed in Table 3.4).The interviews were conducted using a structured, closed-ended questionnaire. A sample questionnaire is provided in annex 4.

3.2.1.2.2 Cost Analysis

The cost analysis in this section aligns with our objective of determining the best site for a freight village and its transportation network. Therefore, the cost analysis takes into account the transit costs on each corridor to determine the best corridor in terms of cost and the investment costs of establishing a freight village on one of the potential sites and the road rehabilitation cost of each corridor. The road rehabilitation cost has been taken into account in our cost analysis because; road transport is the dominant mode in Sub-Saharan Africa and carries over 75% of passengers and freight. It is capital for poverty reduction and economic growth. Unfortunately, the conditions of these roads are poor for more than 50% of them (Zietlow, 2018). However, in this study, duties and taxes are not taken into account in the cost as they are not part of logistics costs. The cost elements are represented in the Figure below.

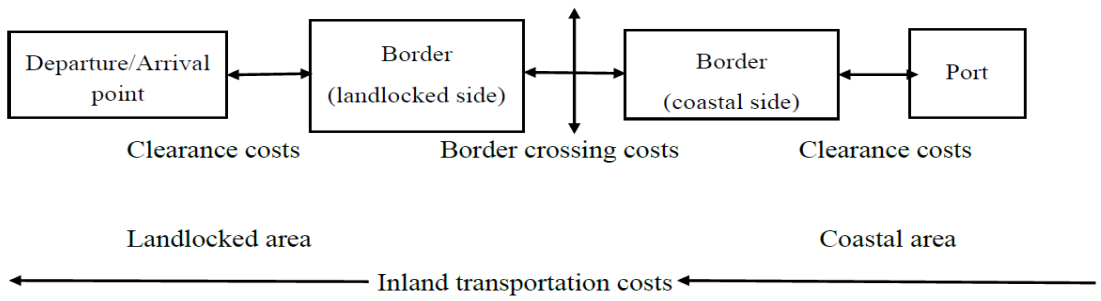


Figure 3.5: Transit Costs Components

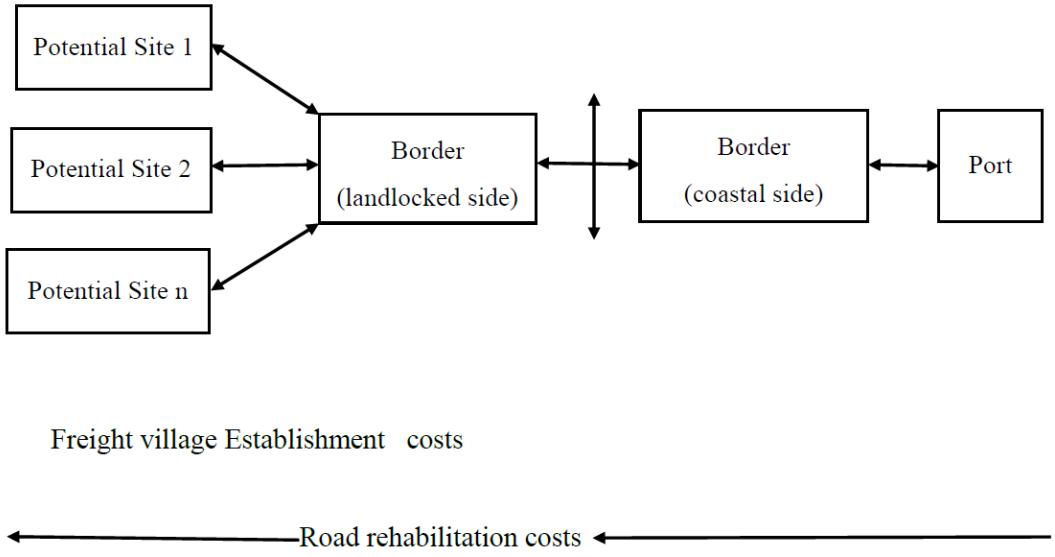


Figure 3.6: Investment Costs Components

3.2.1.2.2.1 Transit and Investment Costs

Investment cost in this study considers the cost of establishing a freight village and the cost of rehabilitating road corridors. The transit cost on the other hand, considers the costs taken to get a product out of the transit ports to Burkina Faso's capital city (Ouagadougou). It is not easy to give exact and complete figures for the transit costs. However, to enable us to have some idea of the transit costs in the various transport corridors; we shall confine ourselves to port operation costs, trucking costs , border crossing costs and Ouagainter terminal Operation costs. Hence, the transit costs can be represented as:

Transit costs: port operations costs + trucking costs + border crossing costs + Ouagainter terminal Operation costs

3.2.1.2.2.2 Data Collection on Costs

Primary data on the costs of taking a product out of the transit ports to Burkina Faso's Capital city (Ouagadougou) were collected through 100 interviews undertaken on forwarders/customs brokers, and private companies (companies involved in trading

of goods listed in table 3.4). The interviews were conducted using a structured, open-ended questionnaire. A sample questionnaire is provided in annex 5. On the other hand, secondary data has been used to determine the investment cost.

3.2.1.3 Joint Matrix

The joint matrix uses as an input the normalized time and cost matrix. In this study, the joint matrix has been used to evaluate each corridor with regards to each potential freight village location.

3.2.1.4 Findings on Corridors Selection Process

Following the methodology described in the figure 3.2 and using the data collected from the field survey and secondary data, this section gives an overview of the corridor selection process findings.

3.2.1.4.1 Findings on Potential Sites Determination Process

To determine the potential sites for the freight village location, we carried out interviews with local authorities. Our series of interviews first took place at the Chamber of Commerce that acknowledged the need for a freight village in Ouagadougou. However, they revealed to us that a project for a freight village construction in Ouagadougou was underway and the feasibility studies would begin in the near future. Moreover, three potential sites have been suggested for a freight village. It has been suggested to be located imperatively in one of the municipalities intended to host the industrial clusters or the economic clusters zones envisaged in the new development plan of the city of Ougadougou named “Planning scheme of Grand Ouaga.” Then, to find out the potential sites we have held an interview at the Directorate General of Urban Planning to better understand the new development plan of Ouagadougou’s city. The information collected on the “Planning scheme of Grand Ouaga” is summarized in the next section.

3.2.1.4.1.1 Planning Scheme of Grand Ouaga

Burkina Faso's first city and state capital Ouagadougou combines the function of political, economic, and service command. At the beginning of the 1980s, the pace of urban growth of 9% per year, consuming space, hampered urban management by disrupting land control. This rate, around 6% in 1985, rose to 4.5% in 1996. It is currently around 4.62% for the city of Ouagadougou. Galloping demography is the consequence of exaggerated spatial extensions following the development of spontaneous habitat. This uncontrolled growth has resulted in:

- ✓ Insufficient resources in water, forests, building materials, etc.
- ✓ The growth of Ouagadougou under conditions in which the economy generates few modern salaried jobs;
- ✓ Weak and insufficient access to basic urban services.

The resolution of these problems prompted the project of the planning scheme of Grand Ouaga. The Grand Ouaga can be considered as the territory covering the urban municipality of Ouagadougou, the rural municipalities of Kadiogo province (Central region) which are Koubri, Komsilga, Komki Ipala, Saaba, Pabré and Tanghin-Dassouri Dassouri and the rural municipality of Loumbila in the province of Oubritenga (Central Plateau region). This territory covers approximately 3,300 km² (see the map in Figure3.7).

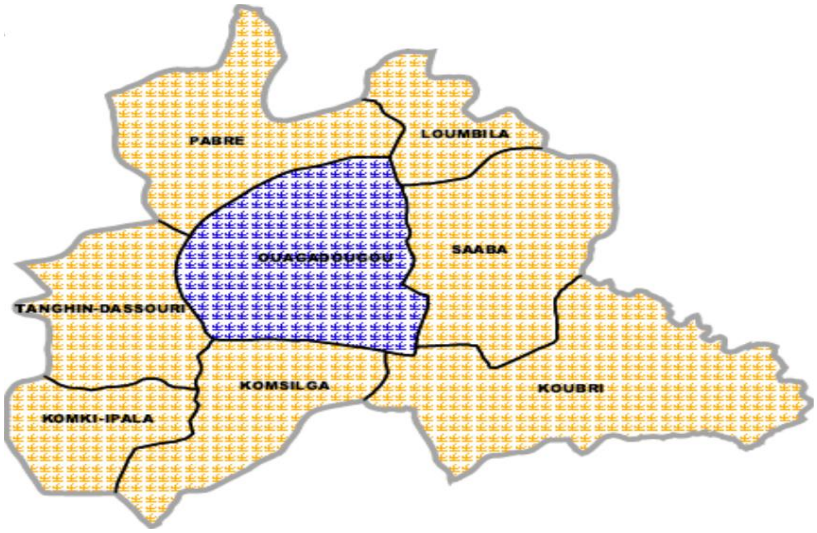


Figure 3.7: Municipalities of Grand Ouaga (MHU, 2010).

Grand Ouaga is a comprehensive project for the 2025 horizon to give the territory hosting the capital of Burkina Faso, a status of a metropolis worthy of the country's ambitions to make its capital a reference center in Western Africa (MHU, 2010). The Grand Ouaga planning scheme comprises many huge projects such as the construction of industrial clusters, technopole, ecotourism and horticulture development zone, military camps, freight village, healthcare facilities, roads, rails, airport, highway interchanges, roundabouts etc... While some of those projects have been completed, some others are still ongoing and some yet have to be started. The Figure 3.8 gives an overview of the planning scheme of Grand Ouaga on a map.

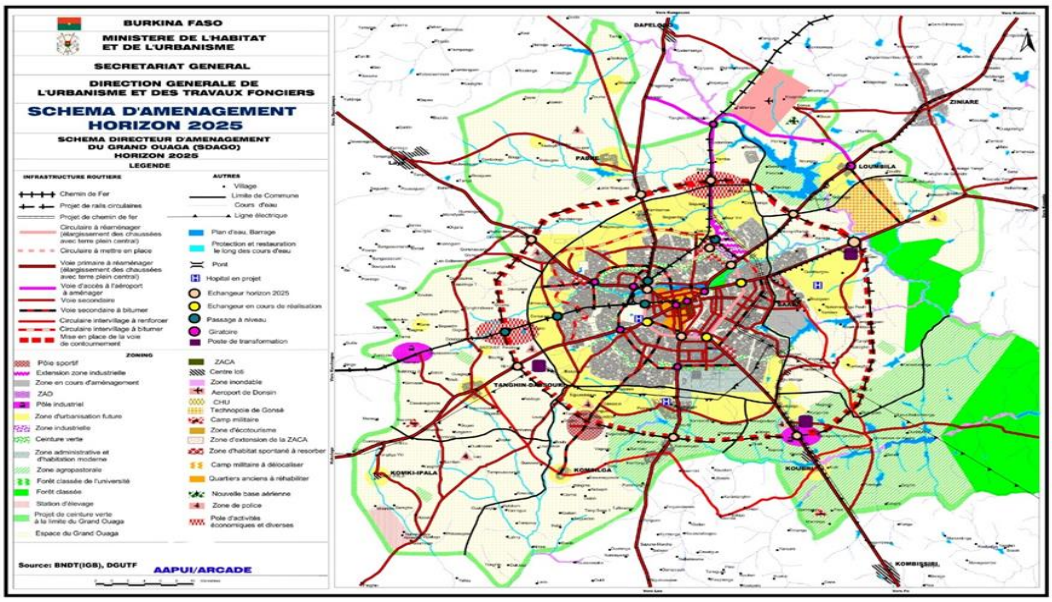


Figure 3.8: Planning scheme of Grand Ouaga Horizon 2025 (MHU, 2010).

As stated before, local authorities have suggested three (3) potential sites suitable for hosting a freight village based on the Planning scheme of Grand Ouaga. The Figures 3.9 and 3.10 show where each potential site is located in the Grand Ouaga.

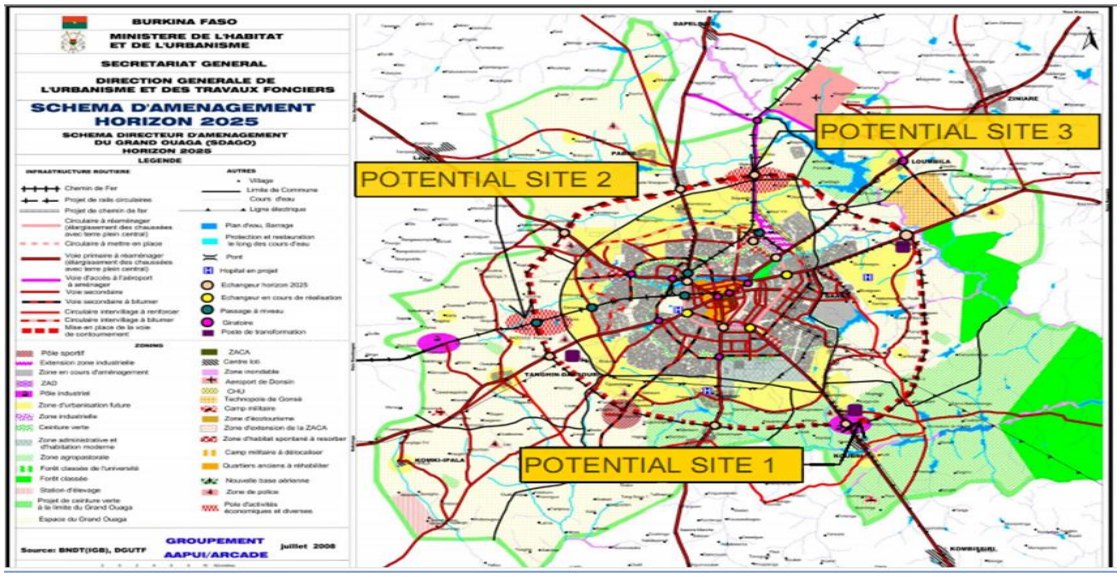


Figure 3.9: Potential Site Location on the Scheme of Grand Ouaga Horizon 2025

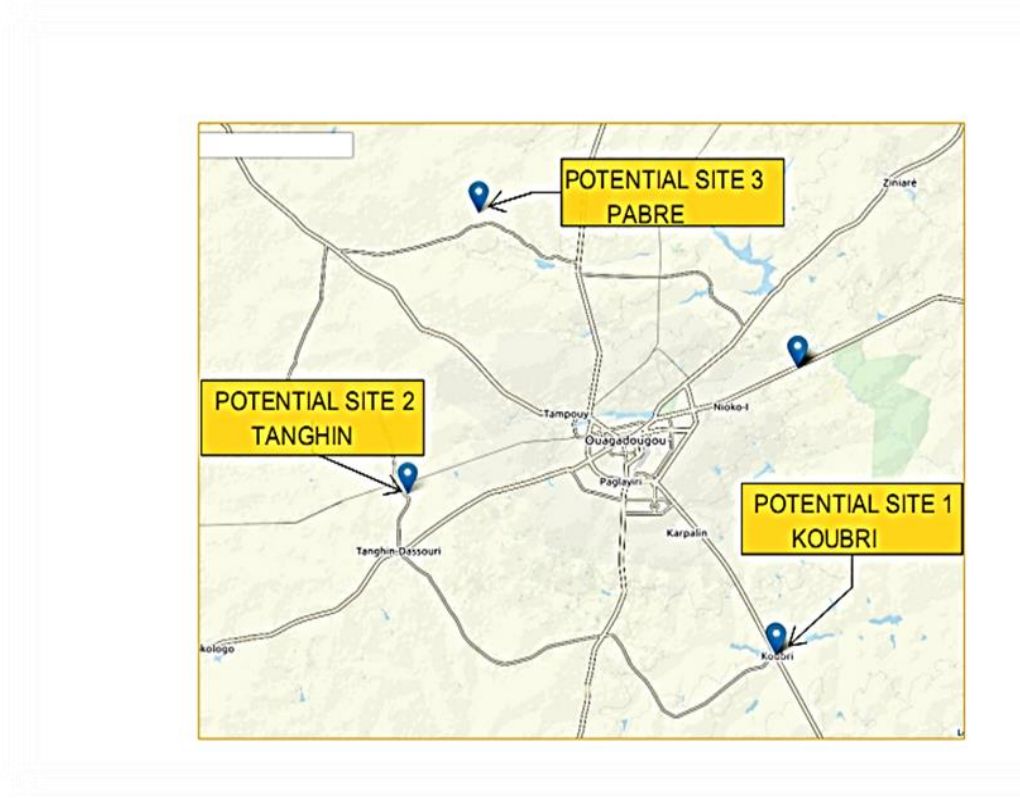


Figure 3.10: Location of Potential Sites on Google Map. (Google Maps, 2018)

3.2.1.4.2 Findings on Transit Cost and Time

In order to determine transit cost and time, a survey was conducted in August 2018. One hundred (100) stakeholders including forwarders/customs brokers, as well as private companies were interviewed. Through the interviews, we collected the average transit cost and time on each road corridor. As sometimes, the questions answered varied widely (given figures are exaggerated compared to the average figures), seventy (70) responses judged as the most representative were selected for the study. Moreover, many fees and charges are included in transit cost, while some of them derived from transaction other are from the weight. To get a representative view of the transit cost, we standardized the unit cost of analysis to standard 20 foot container (TEU) assuming a maximum weight of 15 tons. Table below presents the characteristics of the selected products for the survey.

Table 3.5. Characteristic of Selected Products for the Survey

Product	Container Type	Weight (ton)	Average Annual Volume (ton) 2013-2017	Weight on Annual Volume
Wheat and wheat flour	20’	15	176,252	0.280
Pharmaceutical product	20’	15	8,061	0.013
Parts of machinery	20’	15	4,196	0.007
Rice	20’	15	436,441	0.695
Tobacco	20’	15	3,471	0.006
Total			628,421	1.000

In order to be consistent with the share of each product in the total annual volume imported, in calculating the transit cost, the weighted average cost was first calculated based on the response of each respondent and then the simple average was computed. On the other hand, in calculating the average time we asked to respondents to provide for each activity the average time spent. The findings on the average transit cost and time on each corridor are as following:

Table 3.6 Average Transit Cost and Time

Cost & time Component/Corridor	Corridor No 1 (Tema - Ouagadougou)	Corridor No 2 (Lome- Ouagadougou)	Corridor No 3 (Abidjan- Ouagadougou)	Corridor No 4 (Cotonou - Ouagadougou)
Average port cost (Euro)	441	453	703	684
Average transport cost (Euro)	1584	1626	1710	1635
Average Border Crossing cost (Euro)	90	64	98	89
Average OUAGAINTER Operation cost (Euro)	607	607	607	607
Average transit cost (Euro)	2722	2750	3118	3015
Average port operation time (Day)	9.69	9.16	8.16	11.11
Average inland transport time (Day)	3.81	2.78	4.96	5.07
Average Ouagainter Terminal operations time (Day)	6.94	6.94	6.94	6.94
Average Transit time (Day)	20.44	18.88	20.06	23.13

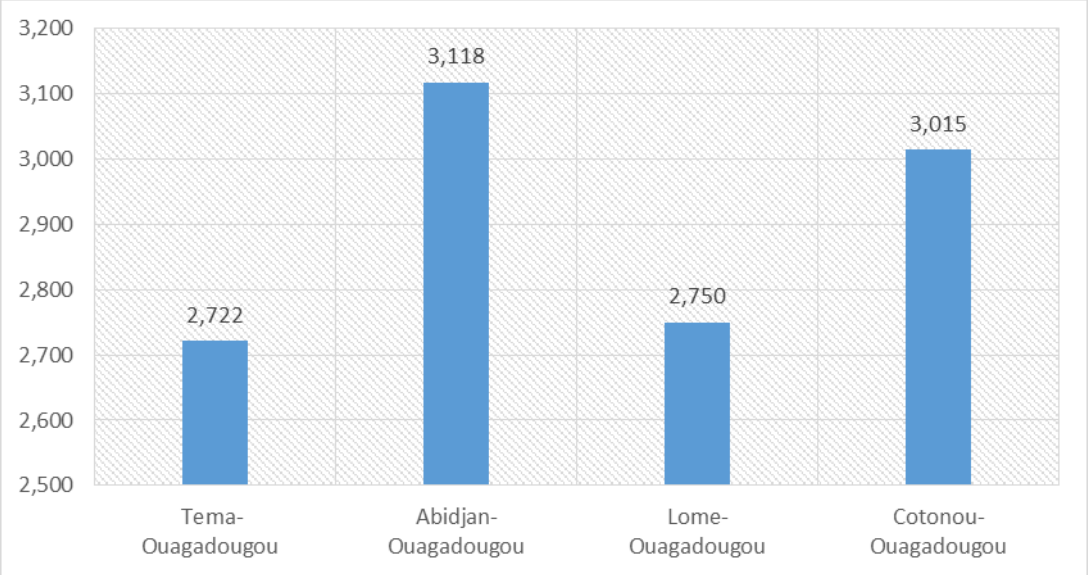


Figure 3.11 Average Transit cost per Corridor

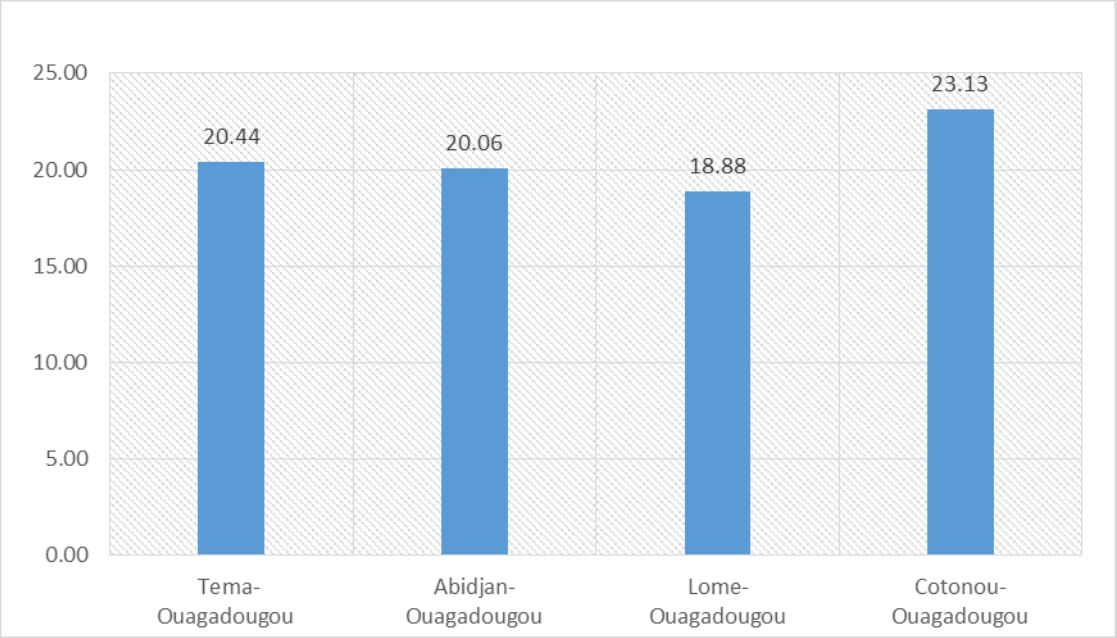


Figure 3.12 Average Transit Time per Corridor

Table 3.6 presents the average transit cost and time on each corridor. Overall, the corridor Lome-Ouagadougou and Abidjan-Ouagadougou present the shortest transit time (respectively 18.88 days and 20.06 days).On the other hand, the corridor Tema-Ouagadougou and Lome Ouagadougou , present the lowest import cost (respectively 2722 Euro and 2750 Euro). The corridor Cotonou-Ouagadougou is the least advantageous with the highest import time of 23.13 days. Moreover, in term of port operations efficiency, the port of Abidjan and Lome are better off with respectively a clearance time of 8.16 and 9.16 days. When it comes to the transport time, the corridor Lome-Ouagadougou and Tema-Ouagadougou present the shortest time with respectively 2.78 and 3.81 days.

3.2.1.4.2.1 Transit Cost and Time of each Corridor Linked to each Potential Site

The findings on transit cost and time summarized in table 3.6 are true for the present corridors' characteristics highlighted in the Table below.

Table 3.7. Characteristics of Corridors

	Port Country	Road Distance in km	Average Transport Cost (Euro)	Transport Cost per /km (Euro)	Other Transit Cost (Euro) (Port & Border Crossing & Ouagainter)	Average Transit Time (Days)
Corridor No 1 (Tema - Ouagadougou)	Ghana	1,040	1,584	1.523	1,138	20.44
Corridor No 2 (Lome-Ouagadougou)	Togo	948	1,626	1.715	1,124	18.88
Corridor No 3 (Abidjan-Ouagadougou)	Ivory Coast	1,148	1,710	1.489	1,408	20.06
Corridor No 4 (Cotonou Ouagadougou)	Benin	1,060	1,635	1.542	1,380	23.13

Table 3.7 gives the data on transit cost and time under the assumption that final destination of all inbound trucks is Ouaginter located in Ouagadougou. However, linking each corridor to each potential site for a freight village will bring some changes on the cost and time data. The Table 3.8 presents the distance of each corridor linked to each potential site.

Table 3.8 Distance of each Corridor Linked to each Potential Site (Km) (Cbc, 2018).

	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)	Ports	Port country
Corridor No 1 (Tema - Ouagadougou)	1015	1066.6	1120.5	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	965.8	1017.4	963.8	Lomé	Togo
Corridor No 3 (Abidjan-Ouagadougou)	1171.6	1126	1179.9	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	1077.8	1129.4	1075.8	Cotonou	Benin

Knowing the distances of each corridor linked to each potential site, the transport cost on each corridor is computed (see Table 3.9), based on the value of the transport cost /km provided in Table 3.7.

Table 3.9 Transport Cost of each Corridor Linked to each Potential Site (Euro)

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	1,546	1,625	1,707	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	1,657	1,745	1,653	Lomé	Togo
Corridor No 3 (Abidjan -Ouagadougou)	1,745	1,677	1,758	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	1,662	1,742	1,659	Cotonou	Benin

Table 3.9 gives the new transport cost of each corridor assuming that all inbound trucks final destination will be one of the potential sites of Koubri, Tanghin-Dassouri - and Pabre. Based on the new data on transport cost the new data on transit cost and time of each corridor linked to each potential site is computed and the findings are in the Tables below.

Table 3.10 Transit Cost of each Corridor Linked to each Potential Site (Euro)

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	2,684	2,763	2,845	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	2,781	2,869	2,777	Lomé	Togo
Corridor No 3 (Abidjan -Ouagadougou)	3,153	3,085	3,166	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	3,042	3,122	3,039	Cotonou	Benin

Table 3.11 Transit Time of each Corridor Linked to each Potential Site (Day)

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	19.91	20.92	21.98	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	19.23	20.26	19.19	Lomé	Togo
Corridor No 3 (Abidjan -Ouagadougou)	20.46	19.67	20.61	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	23.51	24.63	23.46	Cotonou	Benin

3.2.1.4.2.2 Investment Cost

As mentioned before, investment cost in this study considers the cost of establishing a freight village and the cost of rehabilitating road corridors. Secondary data have been used to determine those costs.

3.2.1.4.2.2.1 Road Rehabilitation Costs

This section is intended for the estimation of Burkinabe's road corridors rehabilitation cost. To achieve our goal we made use of secondary data collected from the government official data. In fact, we have established the cost average from road construction projects planned by the National Economic and Social Development Plan (PNDES) (the PNDES aims to accelerate economic growth and lower the poverty rate to below 35 percent by 2020.The plan is premised on scaled up public investment, notably to improve the electricity supply and transportation infrastructure (Pndes, 2018).) for the period of 2016-2025. The Table 3.12 presents the list of structuring road infrastructure.

Table 3.12 List of Structuring Road Infrastructure Projects for the Period of 2016-2025 (Pndes, 2018).

Project title	Supervising ministry	Distance in KM	Cost in FCFA	Cost in Euros	Current status
Research project, control and construction and asphalting of the highway Ouagadougou -Yamoussoukro (section Ouagadougou - Koudougou)	Ministry of infrastructures	100	200,000,000,000	304,898,034	Already engaged
Development works and asphalting of 220km of urban roads in 40 cities in 36 provinces of Burkina Faso	Ministry of infrastructures	220	14,481,016,000	22,076,167	
Construction and asphalting project Orodara-Banfora road -border Ivory Coast (365 Km)	Ministry of infrastructures	365	109,500,000,000	166,931,674	
Development works and asphalting of bypass roads of the city of Ouagadougou (130Km)	Ministry of infrastructures	130	75,781,000,000	115,527,390	Already engaged
Project of construction and asphalting of the road Taparko-Mani-Bogande-Bilanga-Fada N'Gourma (198Km)	Ministry of infrastructures	198	59,400,000,000	90,554,716	
Project construction and asphalting of country road N 108 Koudougou Mossi-Sanaba (34Km) and regional road N 24 Sanaba-Solenzo-Koudougou (113 Km)	Ministry of infrastructures	147	44,620,000,000	68,022,751	
Building and Asphalting project for the Dande-Kourouma-N'Dorola -Temetemesso regional road (120Km)	Ministry of infrastructures	120	36,550,000,000	55,720,116	
Building and asphaling project of Tenkodogo-Ouargaye road (110 Km)	Ministry of infrastructures	110	33,452,000,000	50,997,245	
Construction and asphalting project of Tougan-Ouahigouya road (96Km)	Ministry of infrastructures	96	30,500,000,000	46,496,950	
Rehabilitation and strengthening of the road Pa - Dano - Gaoua - Frontier Ivory Coast	Ministry of infrastructures	170	70,000,000,000	106,714,312	
Project of development of 8 Km of urban roads in Bobo-Dioulasso and interchange	Ministry of infrastructures	8	26,500,000,000	40,398,990	Already engaged
TOTAL		1,664	700,784,016,000	1,068,338,345	
AVERAGE UNIT COST/KM			421,144,240	642,030	

Based on the data on the Table 3.12, the average unit cost for road infrastructure projected for the period of 2016-2025 is 421,144,240 FCFA/km or 642,030 Euro/km. These unit costs are indicative as it is obvious that even for two roads of the same type, unit cost may experience deviations depending on the nature of the ground, the distance and the number of structures to be built or rehabilitated. Therefore, for the sake of estimating the cost of rehabilitating road corridors, the unit cost of 421,144,240 FCFA/km is considered. Then, the unit cost is time by the estimated distance of each corridor portion in Burkina Faso linked to the each potential site (see table 3.13) to get the estimated rehabilitation cost of each corridor linked to each potential site (see table 3.14).

Table 3.13. Estimated Distance of each Corridor Linked to each Potential Site (Km)

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	145	196.6	250.5	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	298.8	350.4	296.8	Lomé	Togo
Corridor No 3 (Abidjan -Ouagadougou)	533.6	488	541.9	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	387.8	439.4	385.8	Cotonou	Benin

Table 3.14 Estimated Rehabilitation Cost of each Corridor linked to each Potential Site (Euro)

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	93,094,350	126,223,098	160,828,515	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	191,838,564	224,967,312	190,554,504	Lome	Togo
Corridor No 3 (Abidjan -Ouagadougou)	342,587,208	313,310,640	347,916,057	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	248,979,234	282,107,982	247,695,174	Cotonou	Benin

3.2.1.4.2.2.2 Freight Village Establishment Cost

Secondary data collected from the government official data have been used for the estimated cost of a freight village. In fact, the National Economic and Social

Development Plan (PNDES) Structuring Industrial and Artisanal Transformations project for the period of 2016-2025 has forecasted a budget of Euro 118,507,176 to build a multimodal dry port in the agglomeration of Ouagadougou. The feasibility studies are yet to start in the near future. The Table 3.15 presents the list of Structuring Industrial and Artisanal Transformations projects for the period of 2016-2025.

Table 3.15 List of Structuring Industrial and Artisanal Transformations Project for the Period of 2016-2025 (Pndes, 2018)

Project title	Supervising ministry	Budget in FCFA	Budget in Euros
Project to create two Special Economic Zones in Ouagadougou and Bobo-Dioulasso	Ministry of Commerce, Industry and Handicraft	100 000 000 000	152 449 017
Project to create a multimodal dry port in the agglomeration of Ouagadougou	Ministry of Commerce, Industry and Handicraft	77 735 611 800	118 507 176
Project of implantation of a classical spinning mill in Bobo-Dioulasso	Ministry of Commerce, Industry and Handicraft	24 250 000 000	36 968 887
Support Project for the Creation of Small and Medium-Sized business	Ministry of Commerce, Industry and Handicraft	19 684 500 000	30 008 827
Natural Phosphate Mineral Fertilizer Production Project	Ministry of Agriculture and Water Supply	19 000 000 000	28 965 313
Project to develop the new industrial zone of Bobo-Dioulasso	Ministry of Commerce, Industry and Handicraft	14 500 000 000	22 105 107
Refrigerated Slaughterhouse Construction Project for Bobo-Dioulasso	Ministry of Animal and Fish Resources	10 000 000 000	15 244 902
Project to install slaughterhouses in 5 main cities of Burkina Faso	Ministry of Animal and Fish Resources	10 000 000 000	15 244 902
Project to build a dairy in the Bobo-Dioulasso dairy basin	Ministry of Animal and Fish Resources	10 000 000 000	15 244 902
Construction and equipment project of the National Cotton Processing Support Center in Bobo-Dioulasso	Ministry of Commerce, Industry and Handicraft	3 000 000 000	4 573 471

3.2.1.4.3 Findings on Cost and Time Matrix

This section is intended to exploit the time and cost data collected in the previous section in order to determine the best road corridor for each potential site for a freight village. The cost and time joint matrix has been used to reach that goal.

3.2.1.4.3.1 Findings on Cost Matrix

In the previous section, cost component and related data has been presented. Table 3.16 provides a summary of those cost components and they related data.

Table 3.16. Detailed Cost Components

Corridors	Cost Component	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)	Port	Port Country
Corridor No 1 (Tema - Ouagadougou)	Transit cost	2,684	2,763	2,845	Tema	Ghana
	Road rehabilitation cost	93,094,350	126,223,098	160,828,515		
	freight village establishment cost	118,507,176	118,507,176	118,507,176		
	TOTAL COST	211,604,210	244,733,037	279,338,536		
Corridor No 2 (Lome-Ouagadougou)	Transit cost	2,781	2,869	2,777	Lome	Togo
	Road rehabilitation cost	191,838,564	224,967,312	190,554,504		
	freight village establishment cost	118,507,176	118,507,176	118,507,176		
	TOTAL COST	310,348,521	343,477,357	309,064,457		
Corridor No 3 (Abidjan - Ouagadougou)	Transit cost	3,153	3,085	3,166	Abidjan	Ivory Coast
	Road rehabilitation cost	342,587,208	313,310,640	347,916,057		
	freight village establishment cost	118,507,176	118,507,176	118,507,176		
	TOTAL COST	461,097,537	431,820,901	466,426,399		
Corridor No 4 (Cotonou - Ouagadougou)4	Transit cost	3,042	3,122	3,039	Cotonou	Benin
	Road rehabilitation cost	248,979,234	282,107,982	247,695,174		
	freight village establishment cost	118,507,176	118,507,176	118,507,176		
	TOTAL COST	367,489,452	400,618,280	366,205,389		

Taking the total costs' data from table 3.16, into account, the cost matrix is sum up in table 3.17.

Table 3.17 Cost Matrix

Corridor/Site	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)
Corridor No 1 (Tema - Ouagadougou)	211,604,210	244,733,037	279,338,536
Corridor No 2 (Lome-Ouagadougou)	310,348,521	343,477,357	309,064,457
Corridor No 3 (Abidjan -Ouagadougou)	461,097,537	431,820,901	466,426,399
Corridor No 4 (Cotonou -Ouagadougou)	367,489,452	400,618,280	366,205,389

From the Table 3.7, the normalized cost matrix is provided by dividing the values on each line by the highest value (see the values highlighted in green on table 3.17) on the same line. Table 3.18 provides the data on the normalized cost matrix.

Table 3.18 Normalized Cost Matrix

Corridor/Site	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)
Corridor No 1 (Tema - Ouagadougou)	0.76	0.88	1.00
Corridor No 2 (Lome-Ouagadougou)	0.90	1.00	0.90
Corridor No 3 (Abidjan -Ouagadougou)	0.99	0.93	1.00
Corridor No 4 (Cotonou -Ouagadougou)	0.92	1.00	0.91

3.2.1.4.3.2 Findings on Time Matrix

The data on time matrix provided in table 3.19 are the same with the data on the transit time of each corridor linked to each potential site provided previously in Table 3.11.

Table 3.19 Time Matrix

Corridor/Site	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)
Corridor No 1 (Tema - Ouagadougou)	19.91	20.92	21.98
Corridor No 2 (Lome-Ouagadougou)	19.23	20.26	19.19
Corridor No 3 (Abidjan -Ouagadougou)	20.46	19.67	20.61
Corridor No 4 (Cotonou -Ouagadougou)	23.51	24.63	23.46

From the Table 3.19, the normalized time matrix is provided by dividing the values on each line by the highest value (see the values highlighted in yellow on table 3.20) on the same line. Table 3.20 provides the data on the normalized time matrix.

Table 3.20 Normalized Time Matrix.

Corridor/Site	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)
Corridor No 1 (Tema - Ouagadougou)	0.91	0.95	1.00
Corridor No 2 (Lome-Ouagadougou)	0.95	1.00	0.95
Corridor No 3 (Abidjan -Ouagadougou)	0.99	0.95	1.00
Corridor No 4 (Cotonou -Ouagadougou)	0.95	1.00	0.95

3.2.1.4.3.3 Findings on Joint Matrix

The joint matrix provided in table 3.21 is a matrix that combines both the normalized time and cost matrix assuming and equal weight of 0.5 given to both the cost and time criterion. Mathematically the data in the joint matrix calculation is presented as followed:

$Di = Wc \times Xi + Wt \times Yi$ Where,

Di: data in cell n^{o} i,

Wc: cost weight,

Wt: time weight

Xi: data of the cell n^{o} i in the normalized cost matrix

Yi: data of the cell n^{o} i in the normalized time matrix

Table 3.21 Joint Matrix

Corridor/Site	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)
Corridor No 1 (Tema - Ouagadougou)	0.83	0.91	1.00
Corridor No 2 (Lome-Ouagadougou)	0.93	1.00	0.92
Corridor No 3 (Abidjan -Ouagadougou)	0.99	0.94	1.00
Corridor No 4 (Cotonou -Ouagadougou)	0.94	1.00	0.93

A high value from the joint matrix represents a high cost and time spent on the corridor with regards to the potential freight village location site. In other words, a high value from the joint matrix represents a high cost and time spent between the start node of the corridor (port) and the end node (one of the potential freight village location site). Based on the data obtained from the joint matrix, the best corridor for each site is as following:

Alternatives**:**

- **Corridor 1 : Site 1- Koubri**
- **Corridor 2 : Site 3 - Pabre**
- **Corridor 3 : Site 2 – Tanghin-Dassouri Dassouri**
- **Corridor 4 : Site 3 – Pabre**

3.2.2 Data Determination on Average Distance to Seaport/Airport and Neighboring Landlocked Countries' Capital Cities

This criterion considers the distance in kilometer from seaport to the freight village location and the average distance from the freight village to neighboring landlocked countries' capital cities and airport. Table 3.22 provides the related distances.

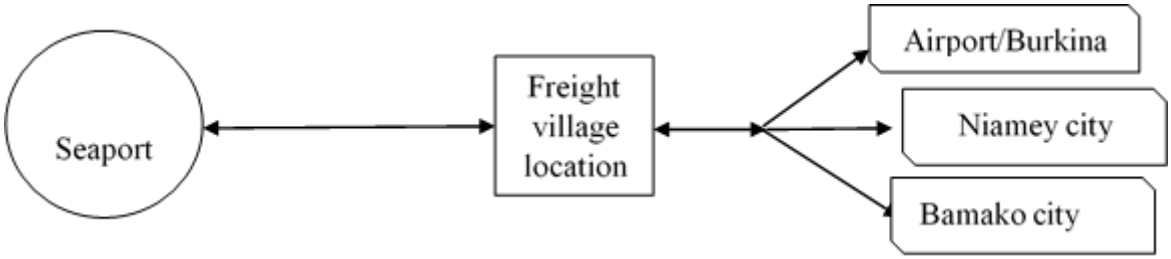


Figure 3.13 Presentation of the Average Distance to Seaport/Airport and Neighboring Landlocked Countries' Capital Cities Determination Process

Table 3.22 Average Distance to Seaport/Airport and Neighboring Landlocked Countries' Capital Cities

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	1511.7	1557.6	1665.5	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	1463.5	1508.4	1446.2	Lomé	Togo
Corridor No 3 (Abidjan -Ouagadougou)	1668.3	1617	1662.3	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	1574.5	1620.4	1558.2	Cotonou	Benin

3.2.3 Data Determination on Site Expansion Opportunities

In order to assess the site expansion opportunities of each potential site on a numerical basis, a rating scale has been used. A scale of 1-5, where 1 is less important (lack of expansion opportunities) and 5 the most important (presence of expansion opportunities) has been suggested. Then, a town planner expert was asked to rate each alternative taken into account the surface area of each potential site and the new planning scheme of Grand Ouaga. Using some data collected from the National Institute of Statistics, the land availability was computed and the findings are sum up as following:

Table 3.23 Estimated Land Availability of Potential Sites (km^2) (INSD, 2018)

	Population	Area (km2)	Average Household/km2	Average Person/Household	Occupied Area (km2)	Available Area (km2)
Koubri	52, 923	621	1, 700	5	6.23	614.77
Tanghin-dassouri	62, 682	334	1, 700	5	7.37	326.63
Pabre	36, 968	386	1, 700	5	4.35	381.65

When it comes to land availability, Koubri has the largest area with 614.77 km^2 follow by Pabre and Tanghin-dassouri with respectively 381.5 and 326.63 km^2. Based on those figures and the position of each potential site on the planning scheme of Grand Ouaga, the data on site expansion opportunities were determined.

Table 3.24 Data on Site Expansion Opportunities

	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)	Ports	Port country
Corridor No 1 (Tema - Ouagadougou)	5	3	3	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	4	2	4	Lome	Togo
Corridor No 3 (Abidjan -Ouagadougou)	4	3	3	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	4	2	4	Cotonou	Benin

3.2.4 Data Determination on the Impact on Urban Environment

For the purpose of assessing the impact on urban environment on a numerical basis an environmentalist expert was requested to rate each alternative. A scale of 1-5, where 1 is most important (no negative impact on noise, pollution, congestion reduction and any potential threat to environment) and 5 the less important (negative impact on noise, pollution , congestion reduction and any potential threat to environment) has been suggested. Furthermore, as part of the transport development strategy, the Grand Ouaga project has initiated the construction of both rail and asphalted road to bypass the city of Ouagadougou. Once the bypassing roads constructed, incoming trucks carrying

imported goods will no longer pass through the city. That will reduce considerably congestion, noise, pollution and traffic accidents issues in the city of Ouagadougou. According to the map of the planning scheme of Grand Ouaga, each potential site for the freight village will be connected to the bypassing road (see the map in Figure 3.6). The potential sites (Koubri, Tanghin-Dassouri, and Pabre) are all rural communes dominated by agricultural and vegetal areas. However, according to the environmentalist, road or rail construction will have some negative impact on vegetation, air quality, noise level etc... Furthermore, compared to other potential site, Koubri is environmentally less suitable as it is an intensive agro pastoral zone with about 20 farms and 6 dams. Based on the precedents, the following rates were given:

Table 3.25 Data on the Impact on Urban Environment

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	4	3	4	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	5	3	2	Lome	Togo
Corridor No 3 (Abidjan -Ouagadougou)	5	2	3	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	5	3	2	Cotonou	Benin

3.2.5 Data Determination on Multimodal Transportation

This criterion in our context considers the presence of both road and rail mode of transportation along the corridor. In order to assess the multimodality of each corridor on a numerical basis, a rating scale has been used. A scale of 1-5, where 1 is less important (absence of multimodality) and 5 the most important (presence of multimodality) has been suggested. However, in the current state of Burkina Faso' transport corridors, only the Abidjan-Ouagadougou corridor presents both a road and rail mode of transportation. Likewise, the Tema-Ouagadougou corridor will be granted a rail transport mode according to the new planning scheme of Grand Ouaga. Taking

those facts into account a transport expert was consulted and the following rate has been provided.

Table 3.26 Data on Multimodal Transportation

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port country**
Corridor No 1 (Tema - Ouagadougou)	4	2	3	Tema	Ghana
Corridor No 2 (Lome-Ouagadougou)	2	3	3	Lome	Togo
Corridor No 3 (Abidjan -Ouagadougou)	2	5	4	Abidjan	Ivory Coast
Corridor No 4 (Cotonou -Ouagadougou)	2	3	3	Cotonou	Benin

3.2.6 Data Determination on Economic Development

Economic development assessment is a difficult task. Many attempts of assessment are still facing conceptual and measurement challenges (Abdalla, 2009). However, for the sake of our study, the port countries' economic development was measured based on the Gross Domestic Product (GDP) indicator. When it comes to economic activity measurement, GDP is the most used indicator. It is defined as the value of the total market for all final goods and services produced in a given period within a country (Focuseconomics, 2019). The table below shows the GDP of the concerned countries for the year 2017.

Table 3.27 GDP of Burkina Faso's Neighboring Coastal Countries (World Bank, 2018)

Country	**GDP (million) US**
Ivory Coast	40,389
Benin	9,274
Ghana	47,330
Togo	4,813

3.2.7 Data Determination on Common Currency

This criterion considers the commonality of the currency in use between Burkina-Faso and its neighboring coastal countries. In order to assess the coastal countries on a numerical basis, a rating scale of 1-5, where 1 is less important (presence of exchange rate uncertainties) and 5 the most important (no exchange rate uncertainties) has been suggested. However, Burkina Faso belongs to the West African Economic and Monetary Union (also known by its French-language acronym UEMOA). UEMOA represents eight mainly French-speaking countries, sharing both a customs and currency union. The member states are Burkina Faso, Benin, Ivory Coast, Mali, Niger, Senegal, Guinea-Bissau, and Togo. Most of UEMOA members are former French territories and they all use the same currency, which is the CFA franc (Wikipedia, 2019). Consequently, except Ghana, Burkina Faso shares a common currency with its neighboring coastal countries. Then, for those countries using the CFA franc, a rate of 5 where given as no exchange rate uncertainties will occur. Nevertheless, a different currency between a coastal and landlocked country will increase exchange rate uncertainties, and transaction costs. According to the transport expert consulted, the more the transport corridor is long the higher the transaction costs related to exchange rate uncertainties. In the case of Burkina Faso and Ghana, the distance of the corridor linked to each potential site is as following:

Table 3.28 Distance of Ghanaian Corridor Linked to Each Potential Site

	Site No 1 (Koubri)	**Site No 2 (Tanghin-Dassouri)**	**Site No 3 (Pabre)**	**Ports**	**Port Country**
Corridor No1 (Tema - Ouagadougou)	1, 015	1, 066.6	1, 120.5	Tema	Ghana

The rating of the Ghanaian corridor was done based on the distances on the precedent table. The following rates are provided for each corridor:

Table 3.29 Data on Common Currency

	Site No 1 (Koubri)	Site No 2 (Tanghin-Dassouri)	Site No 3 (Pabre)	Ports	Port country	Currency
Corridor No 1 (Tema - Ouagadougou)	4	3	2	Tema	Ghana	CEDI
Corridor No 2 (Lome-Ouagadougou)	5	5	5	Lome	Togo	CFA FRANC
Corridor No 3 (Abidjan -Ouagadougou)	5	5	5	Abidjan	Ivory Coast	CFA FRANC
Corridor No 4 (Cotonou -Ouagadougou)	5	5	5	Cotonou	Benin	CFA FRANC

3.2.8 Data Determination on Political Stability

The political stability index is a measure of perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism (Worldbank, 2019). To assess the political stability of Burkina Faso‘s neighboring coastal countries, we have chosen the index of the World Bank’s Worldwide Governance Indicators (WGI). A high score of that index represent a good state of political stability. The table below provides the scores of Burkina Faso‘s neighboring coastal countries for the year 2017.

Table 3.30 Political Stability Score of Burkina Faso Neighboring Coastal Countries (Worldbank, 2019)

Country	Score
Ivory Coast	11.90
Benin	48.10
Ghana	49.52
Togo	19.52

3.3 Analytic Hierarchy Process (AHP) Presentation

Developed in 1980 by Thomas L. Saaty, the AHP is used for problems with multiple criteria. AHP aims to define the optimum alternative and to categorize the

others considering the criteria that describe them. (Athanasios, Varvara, Estivaliz, & Konstantinos, 2016). This method allows the determination of the weights (significances) of hierarchically non-structured or particular hierarchical level criteria in respect of those belonging to a higher level. Furthermore, the method is based on the pairwise comparison matrix. All the evaluation criteria are subject to experts' comparisons that indicate the significance of each criterion. The technique allows the conversion of experts' qualitative estimates into quantitative ones (Podvezko, 2009).The steps of the AHP method go as following:

Step 1. The decision problem is formed as a hierarchy that goal at the top level, criteria with sub-criteria at the middle level and alternatives at the bottom level. The formation of hierarchy constitutes the AHP method's significant step. The hierarchical structure gives a relationship between top, middle and bottom levels.

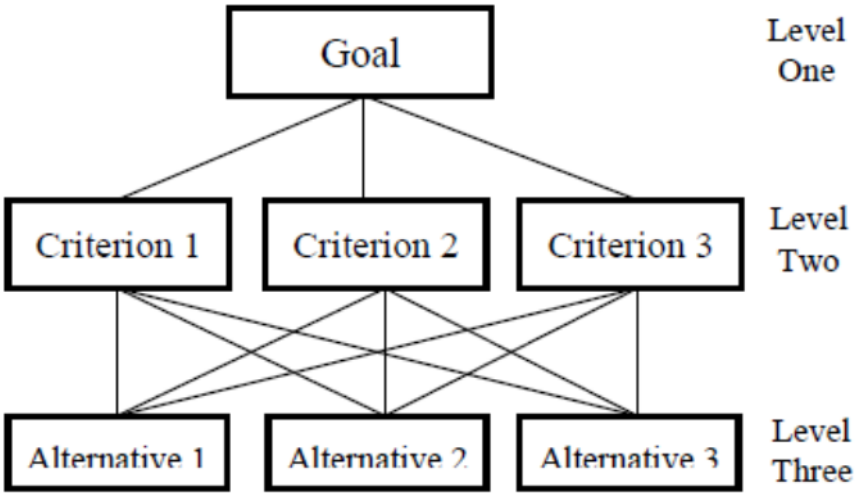


Figure 3.14. Hierarchic Structure (Taherdoost, 2017)

Step 2. Data collection from experts. The comparison rating is done as equal, high importance, strong importance, very strong importance and extreme importance.

Step 3. The square matrix from the pair wise comparisons of different criteria is determined. While preparing comparison matrix, factors in the rows are compared to factors in the columns by their importance levels. Cell value should be 1 when comparing the same factors. For example, if the importance of the first factor at the row has higher importance than the second factor at the column, cell value should be set as

3. The value should be set 1/3 vice versa (Büyükselçuk, 2017). Comparison of alternatives is made according to the Table 3.31.

Table 3.31 Importance Value(s) for Situations in Comparison Process (Saaty T. , 2008).

Importance	Definition	Explanation
1	Equally Importance	Each factor is equally important
3	Moderate Importance	Experience and judgement slightly favour over another
5	Strong Importance	Experience and judgement strongly favour over another
7	Very strong Importance	An activity is favoured very strongly over another
9	Extreme Importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	These are used when the differences between two factors are too small

Step 4. Normalized pair wise comparison matrices are computed by dividing each column value to column summary. After that, priority vector is determined for each row by calculating rows' average.

Step 5. This step consists in evaluating the consistency of the matrix. In the AHP method, comparisons are subjective and inconsistency is tolerated through the amount of redundancy in the approach. The consistency index CI, is mathematically explained below:

$CI = (\lambda max - n) \div (n - 1)$

Where λmax is the maximum eigenvalue of the judgement matrix. This CI can be compared with that of a random matrix, RI. The term of consistency ratio is derived from CI / RI and CR value has to be less than 0.1

Step 6. In this step, each alternative's degree is multiplied with the weights of the sub-criteria and aggregation is made to obtain local ratings according to all criteria. After that, they are multiplied by the weights of the criteria then; aggregation is made to get global ratings (Büyükselçuk, 2017).

CHAPTER 4 RESEARCH FINDINGS

4.1. Simultaneous Selection of a Freight Village Location and its Transportation Network for the City of Ouagadougou

This section is meant to present the findings upon the AHP method application. In the previous chapters, eight selection criteria have been defined and three locations were chosen to be the most suitable location for a freight village. The transportation networks were considered to be four existing transport corridors with each corridor having a different starting nodes (a seaport) but ending at one node, i.e. one of the potential location for a freight village. The concerned starting nodes (a seaport) are:

- Tema /Ghana
- Lome/Togo
- Abidjan/ Ivory Coast
- Cotonou/ Benin

Likewise, the concerned end node is one of the potential location for the freight village:

- Location 1 : Koubri/Burkina Faso
- Location 2 : Tanghin-Dassouri /Burkina Faso
- Location 3 : Pabre /Burkina Faso

Based on the starting nodes and ending nodes defined, the best alternative will be the best transport corridor linked to the best location for a freight village. The alternatives for our selection process can be summarized as following:

- Alternative 1 : Tema - Koubri
- Alternative 2 : Tema -Tanghin-Dassouri
- Alternative 3 : Tema - Pabre
- Alternative 4 : Lome- Koubri
- Alternative 5 : Lome - Tanghin-Dassouri
- Alternative 6 : Lome - Pabre
- Alternative 7 : Abidjan - Koubri
- Alternative 8 : Abidjan -Tanghin-Dassouri

- Alternative 9 : Abidjan – Pabre
- Alternative 10 : Cotonou - Koubri
- Alternative 11 : Cotonou - Tanghin-Dassouri
- Alternative 12 : Cotonou - Pabre

The all selection process is presented as an hierarchy below.

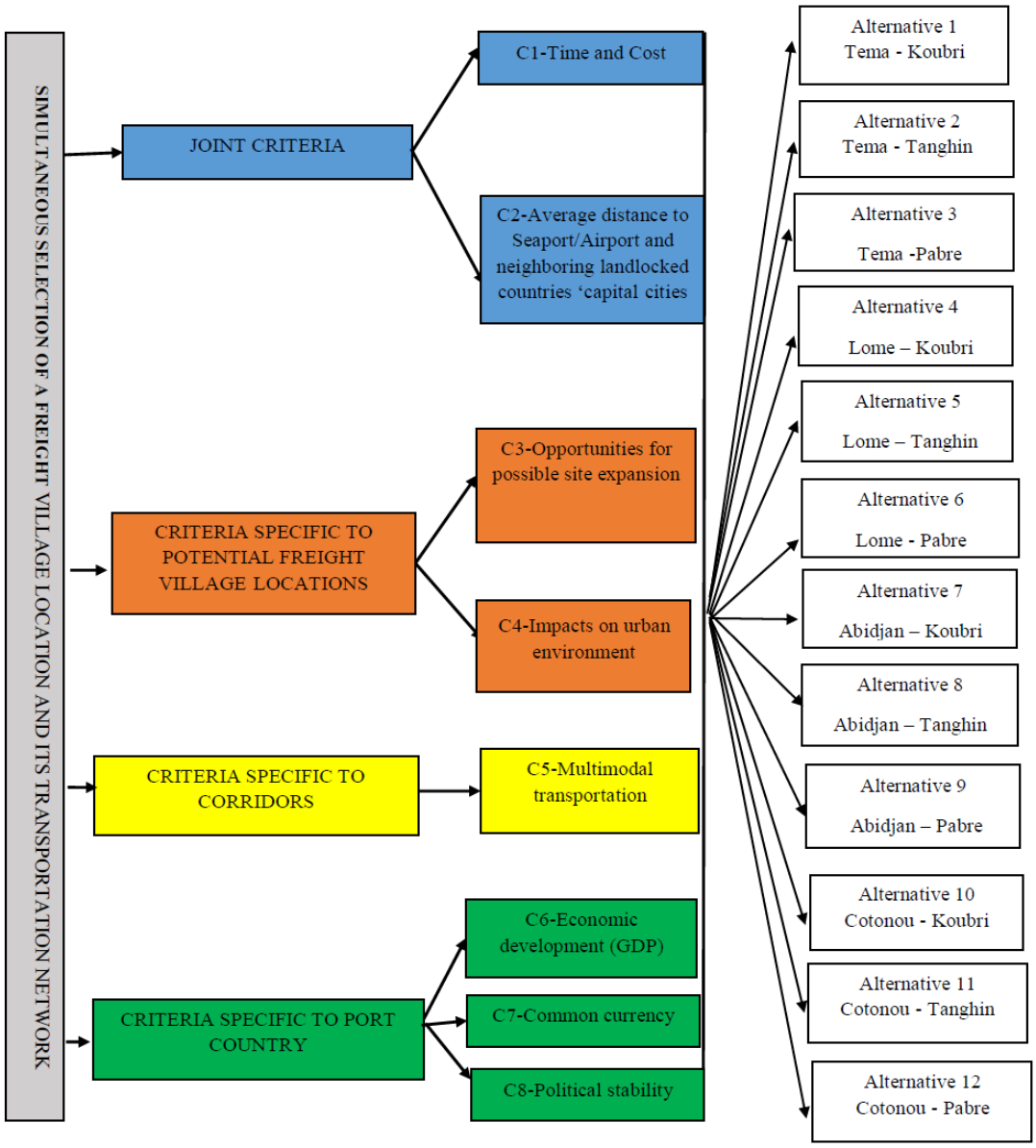


Figure 4.1 Hierarchy Structure of the Selection Process

4.2 Analytic Hierarchy Process (AHP) Application

The AHP method is meant for selecting the best alternative for the simultaneous selection of a freight village location and its transportation network based on eight main criteria. The AHP application starts with a pairwise comparison of selection criteria .The pairwise matrix was constructed based on data collected from expert's opinions. The data were consolidated by taking the geometric means. The CR value for the consolidated comparison matrix is 0.02. This value is below 0.1, which is considered as consistent. The findings on the pairwise comparison are shown in Figure 4.2 and 4.3.

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*
C1	*1.000*	*4.271*	*4.871*	*3.134*	*3.500*	*3.425*	*3.323*	*1.440*
C2	*0.234*	*1.000*	*1.000*	*0.843*	*0.743*	*0.669*	*1.957*	*0.640*
C3	*0.205*	*1.000*	*1.000*	*0.578*	*0.738*	*0.670*	*1.210*	*0.561*
C4	*0.319*	*1.186*	*1.730*	*1.000*	*1.114*	*1.434*	*2.114*	*1.277*
C5	*0.286*	*1.346*	*1.354*	*0.898*	*1.000*	*1.000*	*3.216*	*0.822*
C6	*0.292*	*1.496*	*1.493*	*0.697*	*1.000*	*1.000*	*3.141*	*1.220*
C7	*0.301*	*0.511*	*0.827*	*0.473*	*0.311*	*0.318*	*1.000*	*0.371*
C8	*0.694*	*1.561*	*1.783*	*0.783*	*1.216*	*0.819*	*2.699*	*1.000*

Figure 4.2 Pairwise Comparison of Selection Criteria

	C1	C2	C3	C4	C5	C6	C7	C8	WEIGHT	CONSISTENCY		RATIO
C1	0.300	0.345	0.347	0.373	0.364	0.367	0.178	0.196	0.309	2.556		8.281
C2	0.070	0.081	0.071	0.100	0.077	0.072	0.105	0.087	0.083	0.679		8.186
C3	0.062	0.081	0.071	0.069	0.077	0.072	0.065	0.076	0.072	0.588		8.215
C4	0.096	0.096	0.123	0.119	0.116	0.154	0.113	0.174	0.124	1.016		8.204
C5	0.086	0.109	0.096	0.107	0.104	0.107	0.172	0.112	0.112	0.913		8.178
C6	0.088	0.121	0.106	0.083	0.104	0.107	0.168	0.166	0.118	0.961		8.147
C7	0.090	0.041	0.059	0.056	0.032	0.034	0.054	0.051	0.052	0.426		8.168
C8	0.208	0.126	0.127	0.093	0.126	0.088	0.145	0.136	0.131	1.073		8.175
											CI	0.028
											RI	1.410
											CR	0.020

Figure 4.3. Weight & CI and CR Values

The next step for AHP analysis is evaluating each alternative with respect to each criteria based on data on potential alternative with regard to selection criteria (see Figure 4.4).

	Tema - Kouhri	Tema -Tungshin	Tema - Pubre	Lome - Kouhri	Lome -Tunstain	Lome - Pubre	Abidjan - Kouhri	Abidjan - Tunshin	Abidjan - Pubre	Cotonou - Kouhri	Cotonou - Tungshin	Cotonou - Pubre
C1-Time and cost	0.830	0.910	1.000	0.930	1.000	0.920	0.990	0.940	1.000	0.940	1.000	0.930
C2-Average distance	1511.700	1557.600	1665.500	1463.500	1508.400	1446.200	1668.300	1617.000	1662.300	1574.500	1620.400	1558.200
C3-Opportunities for possible site expansion	5.000	3.000	3.000	4.000	2.000	4.000	4.000	3.000	3.000	4.000	2.000	4.000
C4-Impacts on urban environmen	4.000	3.000	4.000	5.000	3.000	2.000	5.000	2.000	3.000	5.000	3.000	2.000
C5-Multimodal transportation	4.000	2.000	3.000	2.000	3.000	3.000	2.000	5.000	4.000	2.000	3.000	3.000
C6-Economic development (GDP,	47330.000	47330.000	47330.000	4813.000	4813.000	4813.000	40389.000	40389.000	40389.000	9274.000	9274.000	9274.000
C7-Common currency	1.000	1.000	1.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
C8-Political stability	49.520	49.520	49.520	19.520	19.520	19.520	11.900	11.900	11.900	48.100	48.100	48.100

Figure 4.4: Data on Potential Alternative

The remaining steps of the application consist in pairwise comparisons among alternatives. All the steps are summarize as following:

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	5.000	9.000	7.000	9.000	5.000	8.000	7.000	9.000	7.000	9.000	7.000
Tema -Tanghin	0.200	1.000	5.000	3.000	5.000	7.000	5.000	3.000	5.000	3.000	5.000	3.000
Tema - Pabre	0.111	0.200	1.000	0.200	1.000	0.200	0.333	0.200	1.000	0.333	1.000	0.200
Lome - Koubri	0.143	0.333	5.000	1.000	5.000	0.333	5.000	3.000	5.000	3.000	5.000	1.000
Lome -Tanghin	0.111	0.200	1.000	0.200	1.000	0.200	0.333	0.200	1.000	0.333	1.000	0.200
Lome - Pabre	0.200	0.143	5.000	3.000	5.000	1.000	5.000	3.000	5.000	3.000	5.000	3.000
Abidjan - Koubri	0.125	0.200	3.000	0.200	3.000	0.200	1.000	0.200	3.000	0.200	3.000	0.200
Abidjan -Tanghin	0.143	0.333	5.000	0.333	5.000	0.333	5.000	1.000	5.000	1.000	5.000	0.333
Abidjan - Pabre	0.111	0.200	1.000	0.200	1.000	0.200	0.333	0.200	1.000	0.333	1.000	0.200
Cotonou - Koubri	0.143	0.333	3.000	0.333	3.000	0.333	5.000	1.000	3.000	1.000	5.000	0.333
Cotonou -Tanghin	0.111	0.200	1.000	0.200	1.000	0.200	0.333	0.200	1.000	0.200	1.000	0.200
Cotonou - Pabre	0.143	0.333	5.000	1.000	5.000	0.333	5.000	3.000	5.000	3.000	5.000	1.000

Figure 4.5. Alternatives Comparison with First Criterion (C1)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.394	0.590	0.205	0.420	0.205	0.326	0.198	0.318	0.205	0.313	0.196	0.420	0.316	4.754		15.062
Tema -Tanghin	0.079	0.118	0.114	0.180	0.114	0.457	0.124	0.136	0.114	0.134	0.109	0.180	0.155	2.482		16.038
Tema - Pabre	0.044	0.024	0.023	0.012	0.023	0.013	0.008	0.009	0.023	0.015	0.022	0.012	0.019	0.244		12.939
Lome - Koubri	0.056	0.039	0.114	0.060	0.114	0.022	0.124	0.136	0.114	0.134	0.109	0.060	0.090	1.242		13.788
Lome -Tanghin	0.044	0.024	0.023	0.012	0.023	0.013	0.008	0.009	0.023	0.015	0.022	0.012	0.019	0.244		12.939
Lome - Pabre	0.079	0.017	0.114	0.180	0.114	0.065	0.124	0.136	0.114	0.134	0.109	0.180	0.114	1.667		14.659
Abidjan - Koubri	0.049	0.024	0.068	0.012	0.068	0.013	0.025	0.009	0.068	0.009	0.065	0.012	0.035	0.415		11.776
Abidjan - Tanghin	0.056	0.039	0.114	0.020	0.114	0.022	0.124	0.045	0.114	0.045	0.109	0.020	0.068	0.871		12.734
Abidjan - Pabre	0.044	0.024	0.023	0.012	0.023	0.013	0.008	0.009	0.023	0.015	0.022	0.012	0.019	0.244		12.939
Cotonou - Koubri	0.056	0.039	0.068	0.020	0.068	0.022	0.124	0.045	0.068	0.045	0.109	0.020	0.057	0.758		13.285
Cotonou -Tanghin	0.044	0.024	0.023	0.012	0.023	0.013	0.008	0.009	0.023	0.009	0.022	0.012	0.018	0.237		12.874
Cotonou - Pabre	0.056	0.039	0.114	0.060	0.114	0.022	0.124	0.136	0.114	0.134	0.109	0.060	0.090	1.242		13.788
															CI	0.143
															RI	1.540
															CR	0.093

Figure 4.6. Weight & CI and CR Values of Alternatives Comparison with First Criterion (C1)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	2.000	5.000	0.500	0.500	0.333	5.000	4.000	5.000	3.000	4.000	2.000
Tema -Tanghin	0.500	1.000	4.000	0.333	0.500	0.250	0.250	3.000	4.000	2.000	3.000	2.000
Tema - Pabre	0.200	0.200	1.000	0.143	0.200	0.143	2.000	0.500	0.500	0.333	0.500	0.250
Lome - Koubri	2.000	3.000	5.000	1.000	2.000	0.500	7.000	5.000	5.000	4.000	5.000	3.000
Lome -Tanghin	2.000	2.000	5.000	0.500	1.000	0.333	5.000	4.000	5.000	3.000	4.000	3.000
Lome - Pabre	3.000	5.000	5.000	2.000	3.000	1.000	7.000	5.000	7.000	4.000	5.000	4.000
Abidjan - Koubri	0.200	0.200	0.500	0.200	0.200	0.200	1.000	0.333	0.500	0.333	0.500	0.250
Abidjan - Tanghin	0.200	0.333	2.000	0.200	0.200	0.200	3.000	1.000	2.000	0.500	2.000	0.333
Abidjan - Pabre	0.200	0.200	2.000	0.200	0.200	0.200	2.000	0.500	1.000	0.250	0.500	0.250
Cotonou - Koubri	0.333	0.500	3.000	0.200	0.333	0.200	3.000	2.000	3.000	1.000	2.000	2.000
Cotonou -Tanghin	0.200	0.333	2.000	0.200	0.200	0.200	2.000	0.500	2.000	0.500	1.000	0.250
Cotonou - Pabre	0.500	0.500	5.000	0.333	0.500	0.200	5.000	3.000	5.000	2.000	3.000	1.000

Figure 4.7. Alternatives Comparison with Second Criterion (C2)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.097	0.131	0.127	0.086	0.057	0.089	0.118	0.139	0.125	0.143	0.131	0.109	0.113	1.463		12.991
Tema -Tanghin	0.048	0.066	0.101	0.057	0.057	0.066	0.006	0.104	0.100	0.096	0.098	0.109	0.076	1.006		13.284
Tema - Pabre	0.019	0.013	0.025	0.025	0.023	0.038	0.047	0.017	0.013	0.016	0.016	0.014	0.022	0.273		12.331
Lome - Koubri	0.194	0.197	0.127	0.172	0.226	0.133	0.166	0.173	0.125	0.191	0.164	0.164	0.169	2.222		13.126
Lome -Tanghin	0.194	0.131	0.127	0.086	0.113	0.089	0.118	0.139	0.125	0.143	0.131	0.164	0.130	1.722		13.248
Lome - Pabre	0.290	0.328	0.127	0.344	0.340	0.266	0.166	0.173	0.175	0.191	0.164	0.218	0.232	3.036		13.097
Abidjan - Koubri	0.019	0.013	0.013	0.034	0.023	0.053	0.024	0.012	0.013	0.016	0.016	0.014	0.021	0.258		12.435
Abidjan - Tanghin	0.019	0.022	0.051	0.034	0.023	0.053	0.071	0.035	0.050	0.024	0.066	0.018	0.039	0.474		12.230
Abidjan - Pabre	0.019	0.013	0.051	0.034	0.023	0.053	0.047	0.017	0.025	0.012	0.016	0.014	0.027	0.327		12.082
Cotonou - Koubri	0.032	0.033	0.076	0.034	0.038	0.053	0.071	0.069	0.075	0.048	0.066	0.109	0.059	0.772		13.149
Cotonou -Tanghin	0.019	0.022	0.051	0.034	0.023	0.053	0.047	0.017	0.050	0.024	0.033	0.014	0.032	0.395		12.252
Cotonou - Pabre	0.048	0.033	0.127	0.057	0.057	0.053	0.118	0.104	0.125	0.096	0.098	0.055	0.081	1.023		12.650
															CI	0.067
															RI	1.540
															CR	0.044

Figure 4.8. Weight & CI and CR of Alternatives Comparison with Second Criterion (C2)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	7.000	7.000	5.000	9.000	5.000	5.000	7.000	7.000	5.000	9.000	5.000
Tema -Tanghin	0.143	1.000	1.000	0.200	5.000	0.200	0.200	1.000	1.000	0.200	5.000	0.200
Tema - Pabre	0.143	1.000	1.000	0.200	5.000	0.200	0.200	1.000	1.000	0.200	5.000	0.200
Lome - Koubri	0.200	5.000	5.000	1.000	7.000	1.000	1.000	5.000	5.000	1.000	7.000	1.000
Lome -Tanghin	0.111	0.200	0.200	0.143	1.000	0.143	0.143	0.200	0.200	0.143	1.000	0.143
Lome - Pabre	0.200	5.000	5.000	1.000	7.000	1.000	1.000	5.000	5.000	1.000	7.000	1.000
Abidjan - Koubri	0.200	5.000	5.000	1.000	7.000	1.000	1.000	5.000	5.000	1.000	7.000	1.000
Abidjan - Tanghin	0.143	1.000	1.000	0.200	5.000	0.200	0.200	1.000	1.000	0.200	5.000	0.200
Abidjan - Pabre	0.143	1.000	1.000	0.200	5.000	0.200	0.200	1.000	1.000	0.200	5.000	0.200
Cotonou - Koubri	0.200	5.000	5.000	1.000	7.000	1.000	1.000	5.000	5.000	1.000	7.000	1.000
Cotonou -Tanghin	0.111	0.200	0.200	0.143	1.000	0.143	0.143	0.200	0.200	0.143	1.000	0.143
Cotonou - Pabre	0.200	5.000	5.000	1.000	7.000	1.000	1.000	5.000	5.000	1.000	7.000	1.000

Figure 4.9. Alternatives Comparison with Third Criterion (C3)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.358	0.192	0.192	0.451	0.136	0.451	0.451	0.192	0.192	0.451	0.136	0.451	0.305	4.154		13.640
Tema -Tanghin	0.051	0.027	0.027	0.018	0.076	0.018	0.018	0.027	0.027	0.018	0.076	0.018	0.034	0.415		12.371
Tema - Pabre	0.051	0.027	0.027	0.018	0.076	0.018	0.018	0.027	0.027	0.018	0.076	0.018	0.034	0.415		12.371
Lome - Koubri	0.072	0.137	0.137	0.090	0.106	0.090	0.090	0.137	0.137	0.090	0.106	0.090	0.107	1.450		13.548
Lome -Tanghin	0.040	0.005	0.005	0.013	0.015	0.013	0.013	0.005	0.005	0.013	0.015	0.013	0.013	0.163		12.516
Lome - Pabre	0.072	0.137	0.137	0.090	0.106	0.090	0.090	0.137	0.137	0.090	0.106	0.090	0.107	1.450		13.548
Abidjan - Koubri	0.072	0.137	0.137	0.090	0.106	0.090	0.090	0.137	0.137	0.090	0.106	0.090	0.107	1.450		13.548
Abidjan - Tanghin	0.051	0.027	0.027	0.018	0.076	0.018	0.018	0.027	0.027	0.018	0.076	0.018	0.034	0.415		12.371
Abidjan - Pabre	0.051	0.027	0.027	0.018	0.076	0.018	0.018	0.027	0.027	0.018	0.076	0.018	0.034	0.415		12.371
Cotonou - Koubri	0.072	0.137	0.137	0.090	0.106	0.090	0.090	0.137	0.137	0.090	0.106	0.090	0.107	1.450		13.548
Cotonou -Tanghin	0.040	0.005	0.005	0.013	0.015	0.013	0.013	0.005	0.005	0.013	0.015	0.013	0.013	0.163		12.516
Cotonou - Pabre	0.072	0.137	0.137	0.090	0.106	0.090	0.090	0.137	0.137	0.090	0.106	0.090	0.107	1.450		13.548
															CI	0.090
															RI	1.540
															CR	0.058

Figure 4.10. Weight & CI and CR Values of Alternatives Comparison with Third Criterion (C3)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	0.200	1.000	5.000	0.200	0.143	5.000	0.143	0.200	5.000	0.200	0.143
Tema -Tanghin	5.000	1.000	5.000	7.000	1.000	0.200	7.000	0.200	1.000	7.000	1.000	0.200
Tema - Pabre	1.000	0.200	1.000	5.000	0.200	0.143	5.000	0.143	0.200	5.000	0.200	0.143
Lome - Koubri	0.200	0.143	0.200	1.000	0.143	0.111	1.000	0.111	0.143	1.000	0.143	0.111
Lome -Tanghin	5.000	1.000	5.000	7.000	1.000	0.200	7.000	0.200	1.000	7.000	1.000	0.200
Lome - Pabre	7.000	5.000	7.000	9.000	5.000	1.000	9.000	1.000	5.000	9.000	5.000	1.000
Abidjan - Koubri	0.200	0.143	0.200	1.000	0.143	0.111	1.000	0.111	0.143	1.000	0.143	0.111
Abidjan - Tanghin	7.000	5.000	7.000	9.000	5.000	1.000	9.000	1.000	5.000	9.000	5.000	1.000
Abidjan - Pabre	5.000	1.000	5.000	7.000	1.000	0.200	7.000	0.200	1.000	7.000	1.000	0.200
Cotonou - Koubri	0.200	0.143	0.200	1.000	0.143	0.111	1.000	0.111	0.143	1.000	0.143	0.111
Cotonou -Tanghin	5.000	1.000	5.000	7.000	1.000	0.200	7.000	0.200	1.000	7.000	1.000	0.200
Cotonou - Pabre	7.000	5.000	7.000	9.000	5.000	1.000	9.000	1.000	5.000	9.000	5.000	1.000

Figure 4.11. Alternatives Comparison with Fourth Criterion (C4)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.023	0.010	0.023	0.074	0.010	0.032	0.074	0.032	0.010	0.074	0.010	0.032	0.034	0.409		12.141
Tema -Tanghin	0.115	0.050	0.115	0.103	0.050	0.045	0.103	0.045	0.050	0.103	0.050	0.045	0.073	1.024		14.037
Tema - Pabre	0.023	0.010	0.023	0.074	0.010	0.032	0.074	0.032	0.010	0.074	0.010	0.032	0.034	0.409		12.141
Lome - Koubri	0.005	0.007	0.005	0.015	0.007	0.025	0.015	0.025	0.007	0.015	0.007	0.025	0.013	0.161		12.292
Lome -Tanghin	0.115	0.050	0.115	0.103	0.050	0.045	0.103	0.045	0.050	0.103	0.050	0.045	0.073	1.024		14.037
Lome - Pabre	0.161	0.252	0.161	0.132	0.252	0.226	0.132	0.226	0.252	0.132	0.252	0.226	0.200	2.886		14.398
Abidjan - Koubri	0.005	0.007	0.005	0.015	0.007	0.025	0.015	0.025	0.007	0.015	0.007	0.025	0.013	0.161		12.292
Abidjan - Tanghin	0.161	0.252	0.161	0.132	0.252	0.226	0.132	0.226	0.252	0.132	0.252	0.226	0.200	2.886		14.398
Abidjan - Pabre	0.115	0.050	0.115	0.103	0.050	0.045	0.103	0.045	0.050	0.103	0.050	0.045	0.073	1.024		14.037
Cotonou - Koubri	0.005	0.007	0.005	0.015	0.007	0.025	0.015	0.025	0.007	0.015	0.007	0.025	0.013	0.161		12.292
Cotonou -Tanghin	0.115	0.050	0.115	0.103	0.050	0.045	0.103	0.045	0.050	0.103	0.050	0.045	0.073	1.024		14.037
Cotonou - Pabre	0.161	0.252	0.161	0.132	0.252	0.226	0.132	0.226	0.252	0.132	0.252	0.226	0.200	2.886		14.398
															CI	0.125
															RI	1.540
															CR	0.081

Figure 4.12. Weight & CI and CR Values of Alternatives Comparison with Fourth Criterion (C4)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	7.000	5.000	7.000	5.000	5.000	7.000	0.200	1.000	5.000	5.000	5.000
Tema -Tanghin	0.143	1.000	0.200	1.000	0.200	0.200	1.000	0.111	0.143	1.000	0.200	0.200
Tema - Pabre	0.200	5.000	1.000	5.000	1.000	1.000	5.000	0.143	0.200	5.000	1.000	1.000
Lome - Koubri	0.143	1.000	0.200	1.000	0.200	0.200	1.000	0.111	0.143	1.000	0.200	0.200
Lome -Tanghin	0.200	5.000	1.000	5.000	1.000	1.000	5.000	0.143	0.200	5.000	1.000	1.000
Lome - Pabre	0.200	5.000	1.000	5.000	1.000	1.000	5.000	0.143	0.200	5.000	1.000	1.000
Abidjan - Koubri	0.143	1.000	0.200	1.000	0.200	0.200	1.000	0.111	0.143	1.000	0.200	0.200
Abidjan - Tanghin	5.000	9.000	7.000	9.000	7.000	7.000	9.000	1.000	5.000	9.000	7.000	7.000
Abidjan - Pabre	1.000	7.000	5.000	7.000	5.000	5.000	7.000	0.200	1.000	7.000	5.000	5.000
Cotonou - Koubri	0.200	1.000	0.200	1.000	0.200	0.200	1.000	0.111	0.143	1.000	0.200	0.200
Cotonou -Tanghin	0.200	5.000	1.000	5.000	1.000	1.000	5.000	0.143	0.200	5.000	1.000	1.000
Cotonou - Pabre	0.200	5.000	1.000	5.000	1.000	1.000	5.000	0.143	0.200	5.000	1.000	1.000

Figure 4.13. Alternatives Comparison with Fifth Criterion (C5)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.116	0.135	0.219	0.135	0.219	0.219	0.135	0.078	0.117	0.100	0.219	0.219	0.159	2.297		14.421
Tema -Tanghin	0.017	0.019	0.009	0.019	0.009	0.009	0.019	0.043	0.017	0.020	0.009	0.009	0.017	0.207		12.523
Tema - Pabre	0.023	0.096	0.044	0.096	0.044	0.044	0.096	0.056	0.023	0.100	0.044	0.044	0.059	0.738		12.479
Lome - Koubri	0.017	0.019	0.009	0.019	0.009	0.009	0.019	0.043	0.017	0.020	0.009	0.009	0.017	0.207		12.523
Lome -Tanghin	0.023	0.096	0.044	0.096	0.044	0.044	0.096	0.056	0.023	0.100	0.044	0.044	0.059	0.738		12.479
Lome - Pabre	0.023	0.096	0.044	0.096	0.044	0.044	0.096	0.056	0.023	0.100	0.044	0.044	0.059	0.738		12.479
Abidjan - Koubri	0.017	0.019	0.009	0.019	0.009	0.009	0.019	0.043	0.017	0.020	0.009	0.009	0.017	0.207		12.523
Abidjan - Tanghin	0.579	0.173	0.307	0.173	0.307	0.307	0.173	0.391	0.583	0.180	0.307	0.307	0.316	4.596		14.559
Abidjan - Pabre	0.116	0.135	0.219	0.135	0.219	0.219	0.135	0.078	0.117	0.140	0.219	0.219	0.163	2.331		14.335
Cotonou - Koubri	0.023	0.019	0.009	0.019	0.009	0.009	0.019	0.043	0.017	0.020	0.009	0.009	0.017	0.216		12.652
Cotonou -Tanghin	0.023	0.096	0.044	0.096	0.044	0.044	0.096	0.056	0.023	0.100	0.044	0.044	0.059	0.738		12.479
Cotonou - Pabre	0.023	0.096	0.044	0.096	0.044	0.044	0.096	0.056	0.023	0.100	0.044	0.044	0.059	0.738		12.479
															CI	0.090
															RI	1.540
															CR	0.059

Figure 4.14. Weight & CI and CR Values of Alternatives Comparison with Fifth Criterion (C5)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	5.000	7.000	6.000	8.000	9.000	5.000	5.000	8.000	7.000	8.000	9.000
Tema -Tanghin	0.200	1.000	5.000	2.000	6.000	7.000	1.000	1.000	6.000	5.000	6.000	7.000
Tema - Pabre	0.143	0.200	1.000	0.500	2.000	5.000	0.200	0.200	2.000	1.000	2.000	5.000
Lome - Koubri	0.167	0.500	2.000	1.000	5.000	6.000	0.500	0.500	5.000	2.000	5.000	6.000
Lome -Tanghin	0.125	0.167	0.500	0.200	1.000	2.000	0.167	0.167	1.000	0.500	1.000	0.500
Lome - Pabre	0.111	0.143	0.200	0.167	0.500	1.000	0.143	0.143	0.500	0.200	0.500	1.000
Abidjan - Koubri	0.200	1.000	5.000	2.000	6.000	7.000	1.000	1.000	6.000	5.000	6.000	7.000
Abidjan - Tanghin	0.200	1.000	5.000	2.000	6.000	7.000	1.000	1.000	6.000	5.000	6.000	7.000
Abidjan - Pabre	0.125	0.167	0.500	0.200	1.000	2.000	0.167	0.167	1.000	0.500	1.000	0.500
Cotonou - Koubri	0.143	0.200	1.000	0.500	2.000	5.000	0.200	0.200	2.000	1.000	0.500	5.000
Cotonou -Tanghin	0.125	0.167	0.500	0.200	1.000	2.000	0.167	0.167	1.000	2.000	1.000	0.500
Cotonou - Pabre	0.111	0.143	0.200	0.167	2.000	1.000	0.143	0.143	2.000	0.200	2.000	1.000

Figure 4.15. Alternatives Comparison with Sixth Criterion (C6)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.377	0.516	0.251	0.402	0.198	0.167	0.516	0.516	0.198	0.238	0.205	0.182	0.314	4.389		13.988
Tema -Tanghin	0.075	0.103	0.179	0.134	0.148	0.130	0.103	0.103	0.148	0.170	0.154	0.141	0.132	1.799		13.581
Tema - Pabre	0.054	0.021	0.036	0.033	0.049	0.093	0.021	0.021	0.049	0.034	0.051	0.101	0.047	0.604		12.882
Lome - Koubri	0.063	0.052	0.072	0.067	0.123	0.111	0.052	0.052	0.123	0.068	0.128	0.121	0.086	1.120		13.023
Lome -Tanghin	0.047	0.017	0.018	0.013	0.025	0.037	0.017	0.017	0.025	0.017	0.026	0.010	0.022	0.283		12.624
Lome - Pabre	0.042	0.015	0.007	0.011	0.012	0.019	0.015	0.015	0.012	0.007	0.013	0.020	0.016	0.201		12.830
Abidjan - Koubri	0.075	0.103	0.179	0.134	0.148	0.130	0.103	0.103	0.148	0.170	0.154	0.141	0.132	1.799		13.581
Abidjan - Tanghin	0.075	0.103	0.179	0.134	0.148	0.130	0.103	0.103	0.148	0.170	0.154	0.141	0.132	1.799		13.581
Abidjan - Pabre	0.047	0.017	0.018	0.013	0.025	0.037	0.017	0.017	0.025	0.017	0.026	0.010	0.022	0.283		12.624
Cotonou - Koubri	0.054	0.021	0.036	0.033	0.049	0.093	0.021	0.021	0.049	0.034	0.013	0.101	0.044	0.564		12.911
Cotonou -Tanghin	0.047	0.017	0.018	0.013	0.025	0.037	0.017	0.017	0.025	0.068	0.026	0.010	0.027	0.349		13.069
Cotonou - Pabre	0.042	0.015	0.007	0.011	0.049	0.019	0.015	0.015	0.049	0.007	0.051	0.020	0.025	0.308		12.311
															CI	0.099
															RI	1.540
															CR	0.064

Figure 4.16. Weight & CI and CR Values of Alternatives Comparison with Sixth Criterion (C6)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	5.000	7.000	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Tema -Tanghin	0.200	1.000	5.000	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
Tema - Pabre	0.143	0.200	1.000	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
Lome - Koubri	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lome -Tanghin	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lome - Pabre	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Abidjan - Koubri	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Abidjan - Tanghin	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Abidjan - Pabre	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cotonou - Koubri	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cotonou -Tanghin	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Cotonou - Pabre	5.000	7.000	9.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Figure 4.17. Alternatives Comparison with Seventh Criterion (C7)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.022	0.072	0.074	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.030	0.376		12.594
Tema -Tanghin	0.004	0.014	0.053	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.017	0.209		12.058
Tema - Pabre	0.003	0.003	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.010	0.123		12.027
Lome - Koubri	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Lome -Tanghin	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Lome - Pabre	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Abidjan - Koubri	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Abidjan - Tanghin	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Abidjan - Pabre	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Cotonou - Koubri	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Cotonou -Tanghin	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
Cotonou - Pabre	0.108	0.101	0.096	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.105	1.305		12.462
															CI	0.037
															RI	1.540
															CR	0.024

Figure 4.18. Weight & CI and CR Values of Alternatives Comparison with Seventh Criterion (C7)

CRITERIA	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre
Tema - Koubri	1.000	3.000	2.000	5.000	9.000	7.000	9.000	9.000	9.000	2.000	3.000	2.000
Tema -Tanghin	0.333	1.000	0.500	4.000	5.000	5.000	7.000	9.000	7.000	0.500	2.000	0.500
Tema - Pabre	0.500	2.000	1.000	9.000	7.000	5.000	5.000	9.000	9.000	0.500	0.500	0.500
Lome - Koubri	0.200	0.250	0.111	1.000	3.000	2.000	3.000	3.000	3.000	0.200	0.250	0.200
Lome -Tanghin	0.111	0.200	0.143	0.333	1.000	0.500	2.000	3.000	2.000	0.143	0.200	0.143
Lome - Pabre	0.143	0.200	0.200	0.500	2.000	1.000	2.000	3.000	3.000	0.143	0.250	0.143
Abidjan - Koubri	0.111	0.143	0.200	0.333	0.500	0.500	1.000	3.000	2.000	0.111	0.200	0.143
Abidjan - Tanghin	0.111	0.111	0.111	0.333	0.333	0.333	0.333	1.000	0.500	0.111	0.111	0.111
Abidjan - Pabre	0.111	0.143	0.111	0.333	0.500	0.333	0.500	2.000	1.000	0.111	0.143	0.111
Cotonou - Koubri	0.500	2.000	2.000	5.000	7.000	7.000	9.000	9.000	9.000	1.000	3.000	2.000
Cotonou -Tanghin	0.333	0.500	2.000	4.000	5.000	4.000	5.000	9.000	7.000	0.333	1.000	0.500
Cotonou - Pabre	0.500	2.000	2.000	5.000	7.000	7.000	7.000	9.000	9.000	0.500	2.000	1.000

Figure 4.19. Alternatives Comparison with Eighth Criterion (C8)

	Tema - Koubri	Tema -Tanghin	Tema - Pabre	Lome - Koubri	Lome -Tanghin	Lome - Pabre	Abidjan - Koubri	Abidjan -Tanghin	Abidjan - Pabre	Cotonou - Koubri	Cotonou -Tanghin	Cotonou - Pabre	WEIGHT	CONSISTENCY		RATIO
Tema - Koubri	0.253	0.260	0.193	0.144	0.190	0.176	0.177	0.130	0.146	0.354	0.237	0.272	0.211	2.749		13.027
Tema -Tanghin	0.084	0.087	0.048	0.115	0.106	0.126	0.138	0.130	0.114	0.088	0.158	0.068	0.105	1.369		13.018
Tema - Pabre	0.126	0.173	0.096	0.258	0.148	0.126	0.098	0.130	0.146	0.088	0.040	0.068	0.125	1.650		13.208
Lome - Koubri	0.051	0.022	0.011	0.029	0.063	0.050	0.059	0.043	0.049	0.035	0.020	0.027	0.038	0.480		12.554
Lome -Tanghin	0.028	0.017	0.014	0.010	0.021	0.013	0.039	0.043	0.033	0.025	0.016	0.019	0.023	0.286		12.323
Lome - Pabre	0.036	0.017	0.019	0.014	0.042	0.025	0.039	0.043	0.049	0.025	0.020	0.019	0.029	0.364		12.455
Abidjan - Koubri	0.028	0.012	0.019	0.010	0.011	0.013	0.020	0.043	0.033	0.020	0.016	0.019	0.020	0.250		12.322
Abidjan - Tanghin	0.028	0.010	0.011	0.010	0.007	0.008	0.007	0.014	0.008	0.020	0.009	0.015	0.012	0.152		12.515
Abidjan - Pabre	0.028	0.012	0.011	0.010	0.011	0.008	0.010	0.029	0.016	0.020	0.011	0.015	0.015	0.186		12.334
Cotonou - Koubri	0.126	0.173	0.193	0.144	0.148	0.176	0.177	0.130	0.146	0.177	0.237	0.272	0.175	2.317		13.239
Cotonou -Tanghin	0.084	0.043	0.193	0.115	0.106	0.101	0.098	0.130	0.114	0.059	0.079	0.068	0.099	1.306		13.165
Cotonou - Pabre	0.126	0.173	0.193	0.144	0.148	0.176	0.138	0.130	0.146	0.088	0.158	0.136	0.146	1.943		13.270
															CI	0.071
															RI	1.540
															CR	0.046

Figure 4.20. Weight & CI and CR Values of Alternatives Comparison with Eighth Criterion (C8)

As a result of the precedent comparisons, the overall composite weight of the alternatives is provided in figure 4.20.

Weight	0.309	0.083	0.072	0.124	0.112	0.118	0.052	0.131	
Alternative/ Criteria	C1	C2	C3	C4	C5	C6	C7	C8	Composite Weight
Tema - Koubri	0.316	0.113	0.305	0.034	0.159	0.314	0.030	0.211	0.217
Tema -Tanghin	0.155	0.076	0.034	0.073	0.017	0.132	0.017	0.105	0.098
Tema - Pabre	0.019	0.022	0.034	0.034	0.059	0.047	0.010	0.125	0.043
Lome - Koubri	0.090	0.169	0.107	0.013	0.017	0.086	0.105	0.038	0.074
Lome -Tanghin	0.019	0.130	0.013	0.073	0.059	0.022	0.105	0.023	0.044
Lome - Pabre	0.114	0.232	0.107	0.200	0.059	0.016	0.105	0.029	0.105
Abidjan - Koubri	0.035	0.021	0.107	0.013	0.017	0.132	0.105	0.020	0.048
Abidjan - Tanghin	0.068	0.039	0.034	0.200	0.316	0.132	0.105	0.012	0.110
Abidjan - Pabre	0.019	0.027	0.034	0.073	0.163	0.022	0.105	0.015	0.048
Cotonou - Koubri	0.057	0.059	0.107	0.013	0.017	0.044	0.105	0.175	0.067
Cotonou -Tanghin	0.018	0.032	0.013	0.073	0.059	0.027	0.105	0.099	0.047
Cotonou - Pabre	0.090	0.081	0.107	0.200	0.059	0.025	0.105	0.146	0.101

Figure 4.21. Overall Composite Weight

In the light of the composite weight, we get the results that the alternative Tema-Koubri is the best choice, followed by Abidjan-Tanghin as the second. In other word, Koubri will be the best location for our freight village and the corridor of Tema will be the best transportation network for the freight village.

CONCLUSIONS

Burkina Faso due to its landlocked condition is facing many challenges like, long distances to coastal gateway, long transit time, border delays etc... However, the geographic location of Burkina, positions him in West Africa as a natural transit center. In order to leverage the potential of Burkina Faso to be a transit hub for West Africa, modernized logistics infrastructures is needed. This thesis explored the concept of freight village as a potential mean to overcome the landlocked related problems faced by Burkina Faso. A freight village located in Burkina Faso , connected to the seaports with efficient rail will has the power to reduce trucking distances to bring down transport cost , to promote transshipment, strengthened regional trade and positions the country as a transit hub for West Africa. Burkina' capital city Ouagadougou is at strategic location for a freight village. Freight movement is increasing in the city of Ouagadougou located at the intersection point of the country's corridors. The increase in freight movement in Ouagadougou comes along with urban logistics problems.

As a result of the precedents, this study proposed an AHP model to simultaneously select a freight village location and its transportation network for the city of Ouagadougou. Three potential locations (Koubri, Tanghin-Dassouri, and Pabre) were taken into account for the freight village location and the transportation networks were considered to be four transport corridors (Tema, Lome, Abidjan and Cotonou corridors). The selection process considered 12 alternatives that are:

- Alternative 1: Tema - Koubri
- Alternative 2: Tema -Tanghin-Dassouri
- Alternative 3: Tema - Pabre
- Alternative 4: Lome- Koubri
- Alternative 5: Lome - Tanghin-Dassouri
- Alternative 6: Lome - Pabre
- Alternative 7: Abidjan - Koubri
- Alternative 8: Abidjan -Tanghin-Dassouri
- Alternative 9: Abidjan - Pabre

- Alternative 10: Cotonou - Koubri
- Alternative 11: Cotonou - Tanghin-Dassouri
- Alternative 12: Cotonou - Pabre

Each alternative represents one transport corridor linked to one freight village potential location. Then, the optimal alternative is expected to be the optimal transport corridor linked to the optimal freight village potential location.

The research findings present the alternative 1 (Tema – Koubri) as the optimal one with an importance of 21.7% followed by the alternative 8 (Abidjan -Tanghin-Dassouri) with an importance of 11%. In other word, Koubri will be the best location for a freight village and the corridor of Tema will be the best transportation network for the freight village.

The outcome of this study brings some implications. Indeed, a freight village construction project is a huge scale project that involved many stakeholders. The government should lead all stakeholders for an economic, social, technical, environmental and operational feasibility studies to ensure a successful implementation. In addition, the government should develop good policy in other to ensure a good partnership with the neighboring countries, both coastal and landlocked.

Nevertheless, this study is significant as it fills up an empty field in the literature. In fact, it is one of the first research to address both the selection of a freight village location and its transportation network problem simultaneously in a landlocked country. However, the research also presents some limitation. One limitation is that the proposed framework was designed based on the features of the city of Ouagadougou. Since each city and landlocked country has different features, the framework may not be generalized to other landlocked countries. Furthermore, the World Bank's Worldwide Governance Indicator used to assess the political stability of coastal countries may be limited in representing the political relationship of Burkina Faso and its neighboring coastal countries. For a future research perspective, the view of a political expert may be taken into account. Likewise, the study did not consider several alternative ports while applying the AHP method. It will also make sense to consider

several alternative ports at short distance for future researches in order to reduce vulnerability to disruption in the transit country.

Moreover, for a future research perspective, the proposed framework in this study is opened to potential modifications or to further studies aiming at enhancing the framework. Further studies can be carried out using different MCDM techniques such as TOPSIS, ELECTRE, and PROMETHEE etc…

ANNEXES

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
1	(Okan & Özyörük, 2015)	analyzed the impact of 12 freight villages planned to be built by the Turkish State Railways (TCDD)	*		*	
2	(Dimitrios & Seraphim, 2003)	Presented a freight village financial viability evaluation method. A case study was carried on the district of Kilkis/Greece	*		*	
3	(Shahryar & Reza, 2008)	Studied a freight village establishment feasibility in Iran	*		*	

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
4	(Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015)	Evaluated freight villages' potential locations in Turkey using a geographic information system (GIS)-based MCDM model.	*		*	
5	(Yildirim & Onder, 2014)	Attempted a freight village analysis model for the city of Istanbul/Turkey	*		*	
6	(Yavas, Volkan, Sakar, & Denktas, 2017)	Investigated the existing situation of freight villages in terms of their operations, potential markets and provided an evaluation of a potential freight village in the Aliağa region./Turkey	*		*	
7	(Nguyen & Notteboom, 2016)	Presented a conceptual framework to include multiple criteria and multiple stakeholders to evaluate dry port location in developing countries with an application on Vietnam.	*		*	
8	(Jeevan & Eon-seong, 2015)	Explored through 11 face-to-face interviews with dry port stakeholders, the challenges, and functions of dry ports development in Malaysia.		*	*	

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
9	(Violeta & Kenth, 2009)	Extended the theory behind the dry port idea and defined three type of dry port: distant, midrange and close.		*		
10	(Zheng, Jing, & Zhuang, 2011)	Focused on dry ports optimal location problems for seaport. FCM is applied to tackle the problem. The model is used for selecting an optimal location for inland terminals of port Tianjin in China.	*		*	
11	(Li, Dong, & Sun, 2015)	Proposed a new dry port development strategic layout with a case study on China		*	*	
12	(Garnwa, Beresford, & Pettit, 2009)	Reviewed dry ports development in the United Kingdom of Great Britain and Northern Ireland and in Nigeria.		*	*	
14	(Fang, Xiaoning, & Hao, 2011)	Proposed an AP (Affinity Propagation) Clustering method for solving dry port (number and location) location problem. A case study was carried out on Shanghai port from its 8 hinterland provinces	*		*	

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
15	(Ehsan, Seyedalizadeh, & Mohammad, 2011)	Designed a methodological approach for the evaluation of the impacts and potential benefits of dry ports for multiple stakeholders in Iran	*		*	
16	(Komchornrit, 2017)	Used a Hybrid CFA-MACBETH-PROMETHEE technique for the selection of a dry port in Thailand.	*		*	
17	(Pham, Ma, & Yeo, 2017)	Used an hybrid fuzzy and the technique for order of preference by similarity to ideal solution (TOPSIS) method to choose logistics centers locations in Vietnam.	*		*	
18	(Kwame, Archibald, & Abdul, 2017)	Proposed a gravitational model to assess a dry port location in Ghana.	*		*	

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
19	(Ambrosino & Sciomachen, 2014)	Proposed a two level-weighted multimodal graph for dry port location problem.	*		*	
20	(Qitao, Hongou, & Wang, 2017)	Used the AHP to establish a system of dry port index in the evaluation of potential location of dry ports linked to the port system in the Pan Pearl River Delta.	*		*	
21	(Núñez, Cancelas, & Orive, 2013)	Proposed a DELPHI methodology and Multicriteria Analysis to assess the Spanish Dry Ports location in term of quality	*		*	
22	(Macharis, Pekin, & Rietveld, 2011)	Developed the LAMBIT-model (Location Analysis Model for Belgian Intermodal Terminals) to analyze Belgian Intermodal Terminals'	* *		* *	

Annex 1: Research Findings on Freight Village Location Problems

	Authors	Contents	Case study	Non-case study	Coastal Area	Landlocked Area
23	(Macharis & Pekin, 2013)	Proposed a geographic information system (GIS) in analyzing the landscape of Turkish intermodal terminal	*		*	

Annex 2: Research Findings on Transportation Network Selection Problems

	Authors	Problem Addressed	Solution Method
1	(Hairui & Zhaohan, 2017)	Optimization of logistics network in China	Bi-objective location-allocation (MILP) model & the ordered weighted averaging (OWA)
2	(Panagakos & Psaraftis, 2017)	Corridor performance analysis- European case	Assessing through a set of KPIs,
3	(Mohd & Jesus, 2015)	Selection of a high-speed rail itinerary in Malaysia	ELECTRE I multicriteria method
4	(Jan & Anneke, 2016)	performance measurement of South Africa Freight corridor	Assessing through a set of KPIs
5	(Haichuan, Brennan, Xiaoyun, Qingyuan, & Christopher, 2016)	Selection of optimal projects to enhance operating cost efficiency on rail corridors	Genetic algorithms model

Annex 2: Research Findings on Transportation Network Selection Problems

	Authors	**Problem Addressed**	**Solution Method**
6	(Almetova, Shepelev, & Shepelev, 2016)	Determining for cargo a transit terminal locations	Modified centre of gravity method
7	(Ambrosino & Sciomachen, 2014)	Locating a mid-range dry ports on multimodal logistic networks	Mathematical programming model: two level weighted multimodal graph.
8	(Ningkui, Xianming, & Daijun, 2017)	Selection of optimal route under uncertain environment	Monte Carlo method and adaptive amoeba algorithm
9	(Kojic, Reljin, & Reljin, 2013)	Route selection problem	Hopfield neural network

Annex 3: Interview Questions on Freight Village Site Selection

	Questions
1	What is your position in the company and what do you do exactly?
2	Are you familiar with the concept of freight village?
3	What are the advantages of freight village?
4	As the terminal of OUAGAINTER is getting congested every passing day with a very slow clearance process of imported good, do you think that a freight village in Ouagadougou can be the solution?
5	Do you think that the city of Ouagadougou has the necessary assets for a freight village?
6	Do you think that a freight village in Ouagadougou will positively affect the economy of the country and the sub region?
7	What area do you think to be the most appropriate for establishing a freight village in Ouagadougou?
8	Do you have additional comments about establishing a freight village in Ouagadougou?

Annex 4: Questionnaire for Import Time

As part of a scientific study, we are currently conducting a study to better understand transit times on Burkina Faso's main transport corridors. We are therefore soliciting a few minutes of your precious time to answer the following question. Thank you in advance for your kind collaboration

General information about the company

Company Name	
Field Of Activity	
Number of employees	
Annual sales	

Respondent information

Sexe : ☐ M ☐ F **Function :**

Level of studies: ☐ University ☐ Secondary ☐ Primary ☐ None

Age: ☐ 20-34 years ☐ 35-44years ☐ 45-55yearss ☐ 55+

Please tick the right square that defines transit times in days for each type of operation

	Abidjan –Ouagadougou Corridor										
OPERATION / TIME IN DAYS	*1/2*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Port operations time											
Time spent in port by the container between unloading the boat and leaving the port											
Inland transport time											
Road transport to Ouagadougou (not including time spent at borders)											
Border crossing											
Ouagainter Terminal operations time											
Complete clearance procedures											
	Cotonou –Ouagadougou Corridor										
OPERATION / TIME IN DAYS	*1/2*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Port operations time											
Time spent in port by the container between unloading the boat and leaving the port											
Inland transport time											
Road transport to Ouagadougou (not including time spent at borders)											
Border crossing											
Ouagainter Terminal operations time											
Complete clearance procedures											
	Lomé –Ouagadougou Corridor										
OPERATION / TIME IN DAYS	*1/2*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Port operations time											
Time spent in port by the container between unloading the boat and leaving the port											

Inland transport time											
Road transport to Ouagadougou (not including time spent at borders)											
Border crossing											
Ouagainter Terminal operations time											
Complete clearance procedures											
	Tema –Ouagadougou Corridor										
OPERATION / TIME IN DAYS	*1/2*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Port operations time											
Time spent in port by the container between unloading the boat and leaving the port											
Inland transport time											
Road transport to Ouagadougou (not including time spent at borders)											
Border crossing											
Ouagainter Terminal operations time											
Complete clearance procedures											

Annex 5: Questionnaire for Import Cost

As part of a scientific study, we are currently conducting a study to better understand transit costs on Burkina Faso's main transport corridors. We are therefore soliciting a few minutes of your precious time to answer the following question. Thank you in advance for your kind collaboration.

General information about the company

Company Name	
Field Of Activity	
Number of employees	
Annual sales	

Respondent information

Sexe : ☐ M ☐ F Function :

Level of studies: ☐ University ☐ Secondary ☐ Primary ☐ None

Age: ☐ 20-34 years ☐ 35-44years ☐ 45-55yearss ☐

		Abidjan –Ouagadougou Corridor				
TRANSPORT MODE		CONTAINER				
Cost component/ Commodity		Pharmaceutical product 20’	Parts of machinery 20'	Tobacco20'	Rice 20'	Wheat and wheat flour 20'
Port costs (EURO)	Formal					
	Other					
Trucking costs (EURO)	Formal					
	Other					
Border crossing costs (EURO)	Formal					
	Other					
Ouagainter terminal costs (EURO)	Formal					
	Other					
Total formal costs (EURO)						
Total Other cost (EURO)						
Grand total (EURO)						
		Cotonou –Ouagadougou Corridor				
TRANSPORT MODE		CONTAINER				
Cost component/ Commodity		Pharmaceutical product 20’	Parts of machinery 20'	Tobacco20'	Rice 20'	Wheat and wheat flour 20'

Port costs (EURO)	Formal					
	Other					
Trucking costs (EURO)	Formal					
	Other					
Border crossing costs (EURO)	Formal					
	Other					
Ouagainter terminal costs (EURO)	Formal					
	Other					
Total formal costs (EURO)						
Total Other cost (EURO)						
Grand total (EURO)						

		Lome –Ouagadougou Corridor				
TRANSPORT MODE		CONTAINER				
Cost component/ Commodity		Pharmaceutical product 20’	Parts of machinery 20'	Tobacco20'	Rice 20'	Wheat and wheat flour 20'
Port costs (EURO)	Formal					
	Other					
Trucking costs (EURO)	Formal					
	Other					
Border crossing costs	Formal					

(EURO)	Other					
Ouagainter terminal costs (EURO)	Formal					
	Other					
Total formal costs (EURO)						
Total Other cost (EURO)						
Grand total (EURO)						
		Tema –Ouagadougou Corridor				
TRANSPORT MODE		CONTAINER				
Cost component/ Commodity		Pharmaceutical product 20'	Parts of machinery 20'	Tobacco20'	Rice 20'	Wheat and wheat flour 20'
Port costs (EURO)	Formal					
	Other					
Trucking costs (EURO)	Formal					
	Other					
Border crossing costs (EURO)	Formal					
	Other					
Ouagainter terminal costs (EURO)	Formal					
	Other					

Total formal costs (EURO)						
Total Other cost (EURO)						
Grand total (EURO)						

Annex 6: Literature Review on Selection Criteria of Logistics Center Location

	Decision Criteria	**Category**	**Authors**
1	Proximity to highway system	Location	(Yildirim & Onder, 2014); (Onden, Acar, & Eldemir, 2018); (Núñez, Cancelas, & Orive, 2013); (Bentaleb, Mabrouki, & Semma, 2016), (Nguyen & Notteboom, 2016); (Sirikijpanichkul & Ferreira, 2005)
2	Proximity to railroad system	Location	(Yildirim & Onder, 2014) (Onden, Acar, & Eldemir, 2018); (Núñez, Cancelas, & Orive, 2013); (Bentaleb, Mabrouki, & Semma, 2016) ;(Zheng, Jing, & Zhuang, 2011); (Nguyen & Notteboom, 2016) (Sirikijpanichkul & Ferreira, 2005)
3	Proximity to Seaport	Location	(Yildirim & Onder, 2014) ; (Onden, Acar, & Eldemir, 2018); (Núñez, Cancelas, & Orive, 2013) ; (Bentaleb, Mabrouki, & Semma, 2016) (Zheng, Jing, & Zhuang, 2011) ;(Tanyaş & Bamyacı, 2008)

Annex 6: Literature Review on Selection Criteria of Logistics Center Location

	Decision Criteria	**Category**	**Authors**
4	Proximity to airport	Location	(Yildirim & Onder, 2014) ; (Onden, Acar, & Eldemir, 2018);(Núñez, Cancelas, & Orive, 2013) ; (Bentaleb, Mabrouki, & Semma, 2016); (Sirikijpanichkul & Ferreira, 2005) (Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015); (Tanyaş & Bamyacı, 2008)
5	Proximity to city center	Location	(Tanyaş & Bamyacı, 2008)
6	Road/Rail/Port interface	Location	(Fraser & Notteboom, 2014)
7	Accessibility to supplies and services	Location	(Núñez, Cancelas, & Orive, 2013)
8	Proximity to inland waterways	Location	(Tanyaş & Bamyacı, 2008); (Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015)
9	Proximity to industrial zone	Location	(Yildirim & Onder, 2014) ;(Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015); (Tanyaş & Bamyacı, 2008)
10	Cost of land	Cost	(Yildirim & Onder, 2014); (Núñez, Cancelas, & Orive, 2013); (Bentaleb, Mabrouki, & Semma, 2016) (Zak & Węglinski, 2014) ;(Tanyaş & Bamyacı, 2008)

Annex 6: Literature Review on Selection Criteria of Logistics Center Location

	Decision Criteria	**Category**	**Authors**
11	Opportunities for possible site expansion	Location	(Yildirim & Onder, 2014); (Nguyen & Notteboom, 2016) (Sirikijpanichkul & Ferreira, 2005)
12	Regional economic Development (GDP)	Economic	(Qitao, Hongou, & Yang, 2017); (Zheng, Jing, & Zhuang, 2011) (Zak & Węglinski, 2014)
13	Weather	Environment	(Núñez, Cancelas, & Orive, 2013)
14	Hydrology	Environment	(Núñez, Cancelas, & Orive, 2013) (Yu, Zhang, & Mu, 2009)
	Trade volume in the region	Economic	(Bentaleb, Mabrouki, & Semma, 2016)
	Availability of skilled human capital	Social	(Bentaleb, Mabrouki, & Semma, 2016) (Zheng, Jing, & Zhuang, 2011)
	Effect on traffic	Environment	(Tanyaş & Bamyacı, 2008)
	Freight village related pollution created	Environment	(Nguyen & Notteboom, 2016) ; (Sirikijpanichkul & Ferreira, 2005) ; (Zak & Węglinski, 2014)
	Safety and security	Social	(Zak & Węglinski, 2014)
	Demography	Social	(Demiroğlu & Elener, 2004)
	Investing cost	Cost	(Nguyen & Notteboom, 2016); (Zak & Węglinski, 2014) ;(Ozceylan, Erbas, Tolon, Kabak, & Durgut, 2015)
	Bribery and Corruption	Social	(Okan & Özyörük, 2015)
	Attitude of neighboring communities	Social	(Okan & Özyörük, 2015)

Annex 7: Literature Review on Selection Criteria of Transport Corridor/Network

	Decision Criteria	**Authors**
1	Physical infrastructure	(John, Gerald, & Arvis, 2005); (Olivier, 2013); (Havenga & Anneke, 2016); (Madan, Shinya, & Hanaoka, 2012)
2	Transit time	(John, Gerald, & Arvis, 2005); (Havenga & Anneke, 2016) ;(Olivier, 2013); (Madan, Shinya, & Hanaoka, 2012); (Carec, 2010); (Jacek & Barbara, 2018)
3	Trade volume	(Olivier, 2013)|; (Havenga & Anneke, 2016)
4	Transit cost	(Olivier, 2013); (Havenga & Anneke, 2016); (Madan, Shinya, & Hanaoka, 2012); (Carec, 2010); (Jacek & Barbara, 2018)
5	Distance from gateway to market	(Pelletier & Alix, 2011)
6	Political stability	(Pelletier & Alix, 2011)
7	Security issues	(Pelletier & Alix, 2011)
8	Environmental conditions	(Pelletier & Alix, 2011)
9	Reliability	(Jacek & Barbara, 2018)
10	Safety	(Jacek & Barbara, 2018)
11	Flexibility	(Jacek & Barbara, 2018)

Annex 8: List of Criteria Submitted to Expert Review

Joint Criteria	**Criteria Specific to Potential Freight Village Locations**
- Proximity to Seaport - Proximity to Airport - Proximity to city center - Proximity to industrial zone - Proximity to neighboring landlocked countries 'capital cities - Time and cost	- Opportunities for possible site expansion - Proximity to rail network - Impacts on urban environment
Criteria Specific to Corridors	**Criteria Specific to Port Country**
- Multimodal transportation - Trade volume	- Economic development (GDP) - Common currency - Political stability -

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