

## ***Rail-road terminals location with interconnected rail network of West African countries***

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**Abstract:** *From 2006 to 2012, the port of Cotonou improves its performance thanks to the Millennium Challenge Account program, through modernization of port facilities and management systems. But the project not concerns transport corridors and hinterland access. However, no port can develop without its links with its hinterland. That's why we analyse the issues relating to the hinterland transport development with respect to the with interconnected rail network of West African countries. This network project allows us to build up a multimodal/intermodal transport network from and to the port of Cotonou since inland terminals may have an important role in enlarging port market areas through enhancing hinterland penetration capacity. Our findings show that if two rail-road terminals are located, one in Dosso and the other one in Parakou, it will allow a saving of about 112 million euro, promote local economies and sustainability.*

**Keywords:** rail-road terminals, optimal location, hinterland, port of Cotonou.

### **1. Introduction**

West African ports (Dakar, Abidjan, Tema, Lome and Cotonou) invest heavily in port infrastructure to conquer the inland common market (Burkina Faso, Chad, Mali, Niger, Nigeria) and become a regional hub (Alix, 2013; Lihoussou, 2014). Port competition closely explains ports hinterland development through transport corridors (Taaffe et al, 1963; Bird, 1983; Notteboom and Rodrigue, 2004; Steck, 2015) and becomes hard. However, less interest is giving to hinterland network design, sustainability and traffic generation. Since 2006 to 2014, Benin first Millennium Challenge Account Program (MCAP) has enhanced berth capacity, productivity, ships call time and traffic growth at the port of Cotonou. But it mainly concerns the port development, not hinterland facilities. Indeed, no port can develop without good links with its hinterland. Our main purpose is to determine how to optimise the traffic growth of flows to and from hinterland countries in order to avoid congestion, increase market share, make economies of scale, enhance port performance and promote sustainability. This research is very interesting with respect to ECOWAS (Economic COMMunity of West African States) rail interconnection and competitive edge. Of course, rail network project will connect Abidjan (Ivory Coast), Bamako (Mali), Cotonou (Benin), Lome (Togo), Niamey (Niger) and Ouagadougou (Burkina Faso) (Lihoussou, 2016). The big challenge is related to African data availability and reliability. To tackle it, we collect statistics from Cotonou Port Authority, landlocked countries data and field surveys in 2013.

Hence, this study aims to determine the rail-road optimal location terminals in the hinterland of the port of Cotonou thanks to future interconnected network, decisive in the hub strategic positioning with respect to cost, delay and sustainability. This paper is organised as follows: the next section highlights state of the art, Section 3 presents and analyses terminals location results. Finally, some conclusions are drawn in Section 4.

### **2. State of the art**

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Inter-port competition closely explains ports hinterland development. Hoyle and Charlier (1995) studying the inter-port competition in East Africa by using ports traffic volumes, highlight little competition between the two major ports of the region (Mombasa and Dar es Salaam), but argue that the real competition is further inland. The authors stress that intermodalism has become a key issue in hinterland competition (see also Janguo (1994) and Mumba (1994)). These findings are consistent with Ferrari et al. (2011) who address Lugirian port hinterland accessibility and show that inland terminals confirm their primary role in enlarging port market areas, as their strategic location may represent an attractive gravitational factor, reducing the frictions generated by the distance.

Lihoussou and Limbourg (2012) develop a model mixed integer linear programming model that aims to minimize the total transportation cost associated of distributing the commodities flows from and to the port. In order to build up origin-destination (O-D) matrixes for the year 2010, they use a real-world data set provided from the port of Cotonou statistics, i.e. data concerning the total quantities of goods transported from and to the port (imports and exports) and the shares of each hinterland country (Burkina Faso, Mali, Niger and Nigeria). On one hand, the main categories of commodities sent are wood; cotton; others products & uranium; cottonseed; hydrocarbons & liquid bulk; cashew nuts; shea nuts; perishable products; cakes; various goods. On the other hand, the main categories of commodities received by the hinterland of the port of Cotonou are: grains, clinker, gypsum, limestone and slag; fertilizers and insecticides; hydrocarbons; lubricants and bitumen; building materials; equipment; food; sulfur; vehicles and parts; various goods. The authors consider rail stations as potential locations for terminals: Bohicon, Dassa, Parakou and Savè.

The results of their research is summarize in Figure 1. If one terminal has to be opened, it should be located in Parakou, its market area, includes Burkina Faso, Mali, Niger and the blue area (Benin) represented in Figure 1a. If two terminals have to be opened, they should be located in Parakou and in Dassa. In this case, a part of the market area of the terminal located in Parakou is cannibalized by the market area of Dassa, represented in red (Figure 1b). If three terminals have to be opened, they should be located in Parakou, Dassa and Bohicon which has a very little market area represented in yellow (Figure 1b). The total transportation cost cannot be reduced by adding another terminal.

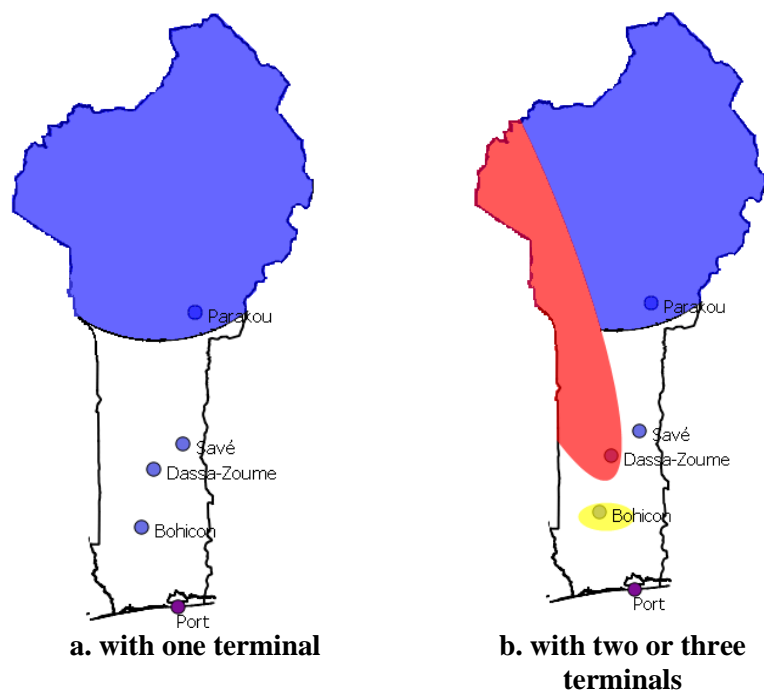


Figure 1. Market areas

### 3. Terminals location with interconnected rail network

Transshipment, road and rail transportation costs in West Africa are not available or not reliable. That's why, a survey of 37 drivers in Cotonou-Maradi corridor was conducted between January and March 2013, to determine road transportation costs. Regarding rail transportation costs, we rely on according to Benin rail office called OCBN operating charges from 1993 to 1997, 2008 to 2011, and African rail costs (Foster et Briceño-Garmendia, 2010). Transshipment costs are assessed thanks to local terminals operators (SOBEMAP and Bolloré terminal). The results are in the table 1 below.

**Table1. Rail, road and transshipment costs estimation (surveys data)**

Transportation costs in €/km		road	rail
import		0.057	0.0266
export		0.025	0.0276

Transshipment costs in €/ ton	sea-road	sea-rail	rail-road	rail-sea	road-rail	road-sea
	5.82	3.49	2.91	2.18	1.46	4.37

With these global costs, we estimate short and long haulage, each cost by commodity, thanks to density, nature, quality and quantity. Rail stations are considered as potential locations for terminals and located in Bohicon, Dassa-Zoumè, Kandi, Parakou, Savè (Benin) and Gaya, Dosso, Niamey, Tillabéri (Niger). Origin destination cities are presented in the table 2.

**Table 2. Origin destination cities for O-D flows**

Benin	Burkina Faso	Mali	Niger
Kandi	Dédougou	Kayes	Arlit
Natitingou	Banfora	Koulikoro	Diffa
Abomey-Calavi	Ouagadougou	Sikasso	Dosso
Parakou	Tenkodogo	Ségou	Maradi
Dassa-Zoumè	Kaya	Mopti	Birni N’Konni
Klouékanmè	Koudougou	Tombouctou	Tillabéri
Djougou	Manga	Ansongo	Zinder
Cotonou	Fada N’Gourma	Kidal	Niamey
Lokossa	Bobo Dioulasso	Bamako	
Porto-Novo	Ouahigouya		
Pobè	Ziniaré		
Bohicon	Dori		
	Gaoua		

Indeed, a large railway interconnection network project has to link Economic Community Of West African States (ECOWAS) countries with two major bands across these countries, one coastal and the other Sahelian, insuring West African countries interconnection. This project of 2,970 km and more than 1.5 billion euros, consists to rehabilitate 1,794 km of old railway network (Cotonou - Parakou, 436 km and Abidjan - Ouagadougou - Kaya, 1,248 km) and build 1,176 km (Parakou - Dosso – Niamey: 625 km; Kaya – Niamey: 398 km) of new railways (Lihoussou, 2016).

In the case of interconnected rail network, if one terminal is opened, it will be located in Dosso (Niger) with a market area as : Fada N’Gourma and Ouagadougou (Burkina Faso), Ansongo (Mali), Arlit, Birni N’Konni, Diffa, Dosso, Gaya, Maradi, Niamey, Tillabéri and Zinder (Niger); Katsina, Sokoto (Northwest Nigeria). This multimodal solution will allow to save about 92 million euros per year and shifts 40 % of the total traffic from road to rail (Figure 2).

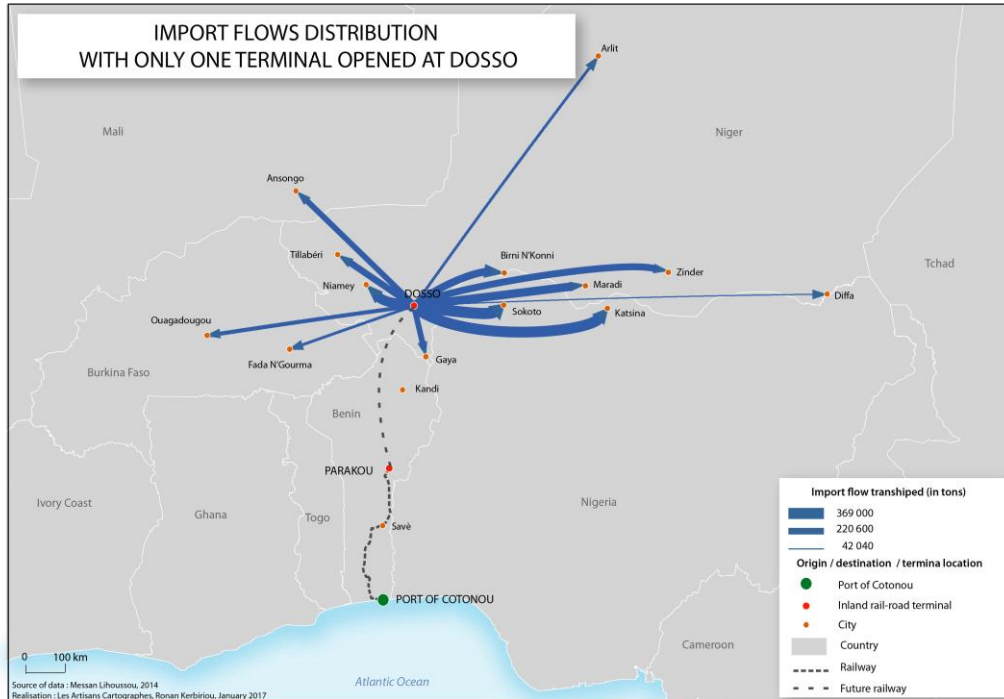


Figure 2. Only on terminal located in Dosso

If two terminals are opened, these will be located in Dosso (Niger) and Parakou (Benin). Dosso terminal market area includes Ansongo (Mali), Arlit, Birni N’Konni, Diffa, Dosso, Gaya, Maradi, Niamey, Tillabéri and Zinder (Niger); Katsina, Sokoto (Northwest Nigeria). Parakou terminal market area includes Kandì, Parakou, Savè (Benin) and Fada N’Gourma, Ouagadougou (Burkina Faso). Two terminals solution will allow to save about 112 million euros per year and shifts 53% of the total traffic from road to rail (Figure 3).

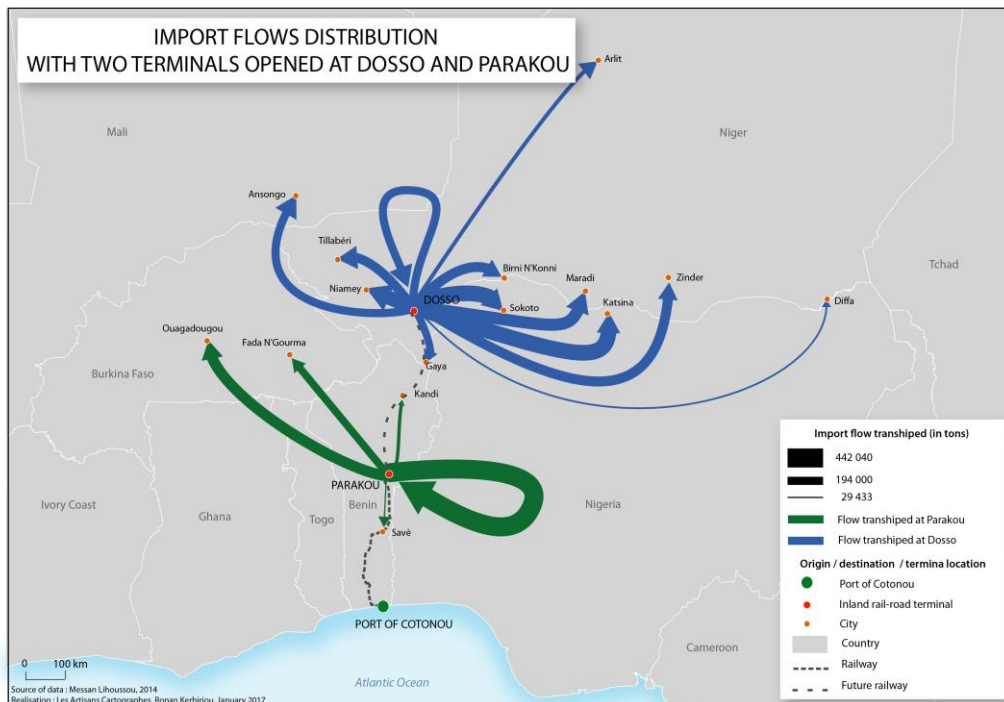


Figure 4. Two terminals respectively located in Dosso and Parakou

A configuration with more than two terminals doesn't reduce significantly the total transportation cost. Interconnected network enhances total transportation cost than actual solution ending railway network in Parakou. Multimodal solution, thanks to railway, seems better than only road transport, for cost, security, sustainability but not delay. Parakou terminal location remains a good solution according to its geographic location in the hinterland. Of course, for the port development, Petrolin group projects to build there inland terminal so calls "Parakou dry port". In Niger also, Bollore Transport Logistics (BTL) is charged to build and operate Dosso dry port, but has not yet built the railway from Dosso to Parakou.

#### 4. Conclusion

The main objective of our research is to find out how the port of Cotonou can achieve and maintain its competitive advantage in transit traffic with hinterland countries. Indeed, high hinterland connectivity improves the competitive position of port and because intermodal transportation generates significant advantages such as sustainability. With interconnected rail network of West African countries, we find that opening terminals in Dosso and Parakou shifts 53% of total traffic from road to rail and reduces 112 million euros compared to full road option and could promote local economies in port hinterlands through the creation of logistic units. Our findings also allow us to present terminals design, flows of each commodity transhipped and moved from and to the port of Cotonou (see Lihoussou, 2014). Besides the saving, it possible to reduce West African trade cost and by the way poverty.

#### 5. References

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